Lincoln National Forest Plan Draft Assessment Report

Volume I. Ecological Resources

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Forest Plan Assessment Report

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Volume I. Ecological Resources

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Abstract: The Assessment Report presents and evaluates existing information about relevant ecological, economic, and social conditions, trends, and risks to sustainability and their relationship to the 1986 Lincoln National Forest Land and Resource Management Plan (forest plan), within the context of the broader landscape.

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List of Commonly used Acronyms

BASI	Best Available Scientific Information
BBER	Bureau of Business and Economic Research
BISON	Biota Information System of New Mexico
BLM	Bureau of Land Management
BMP	Best Management Practice
CAA	Clean Air Act
CCVA	Climate Change Vulnerability Assessment
CDS	Chihuahuan Desert Scrub (ecological response unit)
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CWCS	Comprehensive Wildlife Conservation Strategy
CWD	Coarse Woody Debris
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
EA	Environmental Assessment
EPA	Environmental Protection Agency
ERU	Ecological Response Unit
FAR	Functioning at Risk
FEIS	Final Environmental Impact Statement
FIA	Forest Inventory and Analysis
FPM	Fine Particulate Matter
FRCC	Fire Regime Condition Class
FRI	Fire Rotation Interval
FSH	Forest Service Handbook
FVS	Forest Vegetation Simulator
FWS	Fish & Wildlife Service
GAMB	Gambel Oak Shrubland (ecological response unit)
GCM	Global Circulation Model
HUC	Hydrologic Unit Code
IBA	Important Bird Area
IF	Impaired Function
ILAP	Integrated Lands Assessment Project
IMPROVE	Interagency Monitoring of Protected Visual Environments
JUG	Juniper Grassland (ecological response unit)
LNF	Lincoln National Forest
LSRS	Land Status Records System
MCD	Mixed Conifer, with Frequent Fire (ecological response unit)
MCW	Mixed Conifer, with Aspen (ecological response unit)
MDN	Mercury Deposition Network
ML	Maintenance Level
MMCF	million cubic feet
MMS	Mountain Mahogany Mixed Shrubland (ecological response unit)

MOU	Memorandum of Understanding
MSG	Montane Subalpine Grassland (ecological response unit)
MTBS	Monitoring Trends in Burn Severity Records
MVUM	motor vehicle use map
NAAQS	national ambient air quality standards
NADP	National Atmospheric Deposition Program
NEI	National Emission Inventory
NEPA	National Environmental Policy Act
NF	National Forest
NFMA	National Forest Management Act
NFS	National Forest System
NHD	National Hydrography Dataset
NM	New Mexico
NMAAQS	New Mexico ambient air quality standards
NMCHAT	New Mexico Crucial Habitat Assessment Tool
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NMED-AQB	New Mexico Environment Department, Air Quality Bureau
NMRPTC	New Mexico Rare Plants Technical Council
NPS	National Park Service
NRV	Natural Range of Variation
NTN	National Trends Network
OHV	Off-Highway Vehicle
PFC	proper functioning condition
PHA	priority heritage asset
PILT	payment in lieu of taxes
PJC	Piñon-Juniper Evergreen Shrub (ecological response unit)
PJG	Piñon-Juniper Grasssland (ecological response unit)
PJO	Piñon-Juniper Woodland (ecological response unit)
PM	Particulate Matter
PPF	Ponderosa Pine Forest (ecological response unit)
PSD	Prevention of Significant Deterioration
RD	Ranger District
RHR	Regional Haze Rule
ROD	Record of Decision
SCC	Species of Conservation Concern
SDG	Semi-Desert Grassland
SEINet	Southwest Environmental Information Network
SFF	Spruce-Fir Forest (ecological response unit)
SIP	state implementation plan
SMS	Scenic Management System

TES	Terrestrial Ecosystem Survey
TEU	Terrestrial Ecosystem Unit
USDA	United States Department of Agriculture
USGS	US Geological Survey
VDDT	Vegetation Dynamics Development Tool
VQO	Visual Quality Objective
VOC	Volatile Organic Compounds
WUI	Wildland-Urban Interface

Chapter 1 - Assessment Overview

Purpose

The Lincoln National Forest is in the process of revising a land and resource management plan that has been in place since 1986. The 2012 Planning Rule (36 CFR 219) provides the framework to create local land management plans for national forests and grasslands across the nation. The rule establishes an ongoing, three-phase process: 1) assessment; 2) plan development or revision; and 3) implementation and monitoring.

The 2012 Planning Rule is intended to create a plan that guides resource management on the Lincoln National Forest within the context of the broader landscape. It takes an integrated and holistic approach that recognizes the interdependence of ecological, social, cultural and economic systems. Collaboration with stakeholders and process transparency are key components of this approach.

This document represents the assessment phase of the process. It is designed to rapidly evaluate information about ecological, economic and social conditions, trends, and sustainability relative to the 15 assessment topics listed in 36 CFR 219.6(b), and their relationships to the current land management plan. The approach uses the best available scientific information and local knowledge to inform the process. This assessment report is not a decision making document, but provides current information on assessment topics. The conditions and trends found in the assessment report will help to identify the current Forest Plan's need for change, and aid in the development of the revised plan. The revised Lincoln National Forest's Land and Resource Management Plan, also known as the Forest Plan, will consider a full range of multiple uses.

Throughout this document, the Lincoln National Forest is referred to as "Lincoln NF", the "Forest", or the "Plan Area". The Lincoln National Forest Land and Resource Management Plan (USDA Forest Service 1986a) is referred to as the "Lincoln NF Plan" or "Forest Plan".

Structure of the Assessment Report

This introductory chapter includes an ecosystem services framework section that describes how the ecological, social, cultural and economic assessments are interrelated and dependent on one another to provide for multiple use and sustained yield. An explanation of what is considered to be the best available scientific information follows. The public participation and tribal engagement sections describe the variety of ways the Lincoln NF has interacted with tribes and stakeholders in the early stages of the Forest Plan Revision process

Volume I. Ecological Integrity and Sustainability examines the conditions, trends and risks to integrity and sustainability for ecological resource areas identified in the 2012 Planning Rule (36 CFR 219.6(b)). Within this section, an ecological assessment of upland vegetation, soils, carbon, air, water, riparian, aquatic and at-risk species is conducted to understand current conditions and trends. These assessments conclude with an evaluation of risk for loss of integrity and sustainability which forms the basis for determining whether or not there is a need for change in management from the current Forest Plan.

Volume II. Social, Economic and Cultural Sustainability assesses conditions, trends and risks to sustainability for the social, cultural and economic based topic areas identified in the 2012 Planning Rule (36 CFR 219.6(b)). It assesses the goods and services obtained from the Lincoln NF which provide social, economic and cultural benefits to people and communities. It considers the current condition of the goods and/or services, drivers or stressors affecting demand or availability, the current ecological condition and trend of the resource(s) providing the goods and/or services, and the relationship between on and off Forest conditions. Each chapter concludes by identifying issues of concern, or risks that may prevent the sustainability of the goods and/or service, which forms the basis for determining whether or not there is a need for change in management from the current Forest Plan.

Ecological integrity and sustainability on the Lincoln NF, and the Forest's ability to contribute to social, cultural and economic conditions are intricately connected and interdependent. Because of this connection and interdependence, there is considerable cross-referencing between chapters. References can be found toward the end of the report.

Forest Setting and Distinctive Features

The Lincoln National Forest (Figure 1) is a recreation destination for New Mexico residents and visitors from neighboring states, especially west Texas, and northern Mexico. The 1.1 million acre forest is located in Chavez, Eddy, Lincoln, and Otero counties in south central New Mexico. It is comprised of four major mountain ranges: Sacramento, Guadalupe, Capitan and Jicarilla Mountains, and ranges from about 4,000 to 12,000 feet. These mountain ranges provide a visual backdrop to cities and roads in the surrounding deserts and include five different life zones from Chihuahuan desert to sub-alpine forest. The Forest includes the White Mountain and Capitan Mountain Wildernesses.

People are drawn to the area for its open spaces, outdoor recreation activities, cool climate, beautiful scenery, stunning views, and spirit of the west. Known as the birthplace of Smokey Bear and backdrop to the historic Lincoln County War, the scenery is diverse including mountains with snow-capped peaks, desert canyons and mesas, piñon-juniper woodlands and subalpine forests, high mountain meadows, rugged canyons and escarpments, world class caves, and water play areas including Bonito Lake and Sitting Bull Falls. This spectrum of contrasts provides for sweeping, expansive views and uncrowded spaces. The variety of historic elements are rich in character and culture. Excellent wildlife viewing and hunting opportunities are found throughout the landscape. The Lincoln NF is predominately a naturally appearing landscape with vegetation shaped by recent and historic fires. Winding through various parts of the Forest, travelers enjoy viewing scenery and reliving history on scenic byways and auto tours including the Billy the Kid Scenic Byway, the road to Ski Apache, Sunspot Scenic Byway, and the Rim Road on the Guadalupe Ranger District.. These routes and several National Recreation Trails offer stunning views of the Forest and surrounding lands.

The Forest provides habitat for elk, deer, pronghorn, turkey, bear, mountain lion and many other wildlife species. Habitats across the Forest also support many endangered, threatened or candidate species such as Mexican spotted owl, New Mexico meadow jumping mouse, Sacramento salamander, and others.

The Forest has a rich cultural history with archaeological resources reflecting a 13,000 year occupational time period. The Lincoln NF serves the roughly 208,000 residents of its four counties and 3,000,000 neighbors in adjacent areas who rely on the Forest to varying degrees as a source of sustenance. This is manifested through various means ranging from utilizing the natural resources on the Forest for livelihood; creating community synergy around issues and events; offering a place for groups to commune, work, and recreate together; to providing solitude, peace, and relaxation for individuals who want to get away from the social pressures and pace of their everyday world. While ways and means may have changed over time, people enjoy all manners of activities on the Forest. Firewood gathering is an important traditional activity as many local residents still rely on wood to heat their homes during the cold winter months. Permitted livestock grazing, hunting and outfitting and guiding are also long-standing traditions. The Forest also provides outdoor recreational activities for both area residents and tourists. Forest management continues to bring communities together over issues that affect them or to foster involvement through volunteer work on their favorite part of the Forest. All of these uses help maintain social cultures and longstanding traditions.

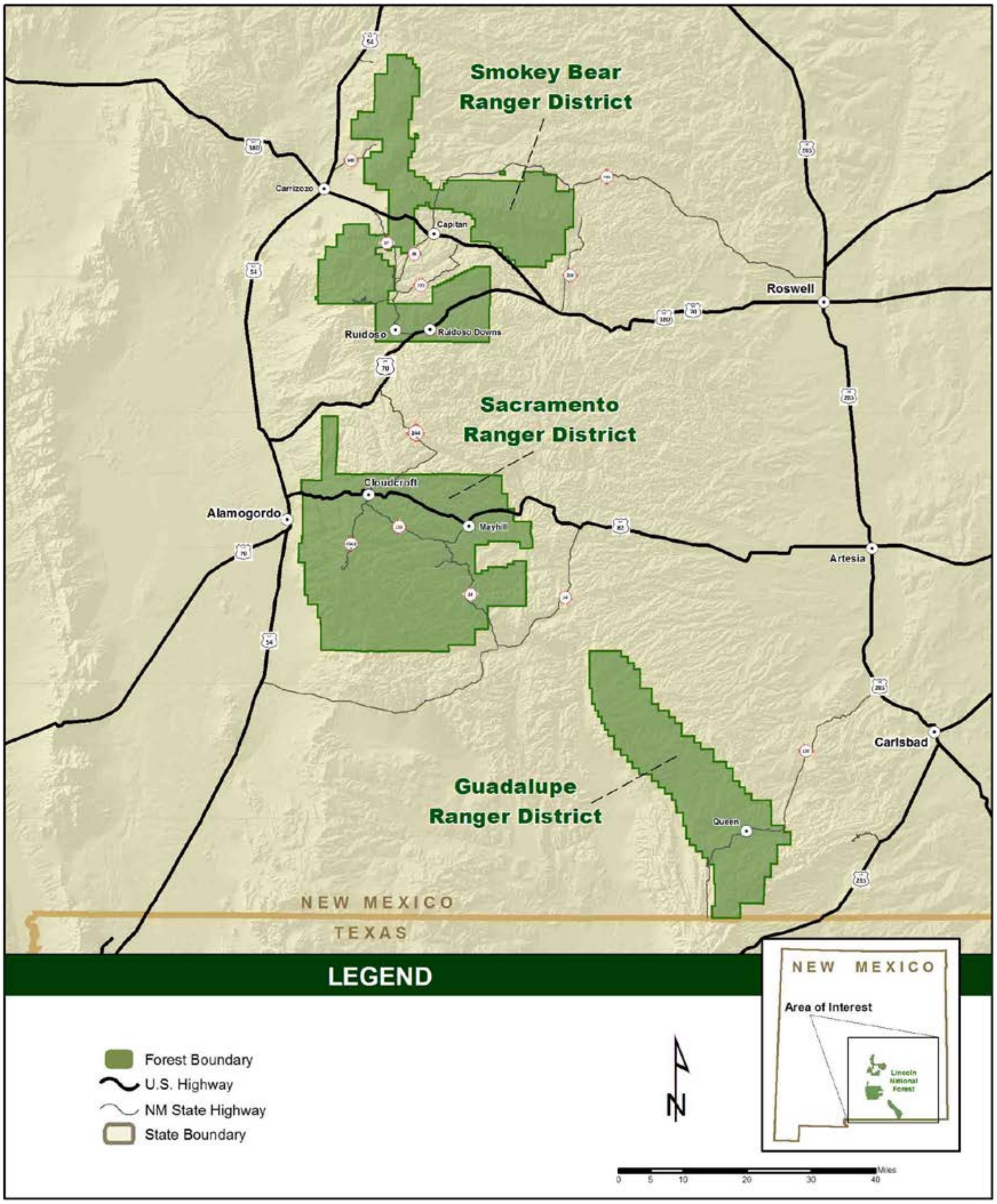

Figure 1. Lincoln NF Vicinity Map and Plan Area

Ecosystem Services Framework

Ecosystem services are a product of functioning ecosystems that affect social, cultural and economic conditions. They are the goods and services that people enjoy or benefit from, including but not limited to scenic views, fish and wildlife, recreation opportunities, food, forage, fiber, fuel, energy, clean water, timber, carbon storage, flood control, and disease regulation. The Millennium Ecosystem Assessment (MEA 2005) has served as the motivation for applying the ecosystem services concept to national forest and grassland management. Ecosystem services are grouped into four broad categories:

> Supporting ecosystem services are those that are necessary for the production of other ecosystem services, such as pollination, seed dispersal, soil formation and nutrient cycling.
>
> Regulating ecosystem services are the benefits people obtain from the regulation of ecosystem processes. Climate regulation, water filtration and purification, soil stabilization, flood control, and disease regulation are a few examples.
>
> Provisioning ecosystem services are the products people obtain from ecosystems, such as clean air, fresh water, energy, food, fuel, forage, wood products and minerals.
>
> Cultural ecosystem services are the nonmaterial benefits people obtain from ecosystems such as educational, aesthetic, spiritual and cultural heritage values, and recreational experiences.

Management of the ecological systems on the Lincoln NF will influence its ability to support some ecosystem services. For example, a regulating service such as flood control, can have important consequences both within and beyond the Plan Area. Ecosystem services that are important within the broader landscape and are likely to be influenced by the land management plan are the focus of the assessment and ultimately, plan revision (FSH 1909.12, Chap. 10, Sec. 13.12). Use of the ecosystem services concept and analysis of ecosystem services are integrated throughout the assessment.

Best Available Scientific Information

In developing this assessment, Forest Service experts provide information supported by the best available scientific information (BASI) relevant to the Lincoln NF Plan Area and management to inform the evaluation of conditions, trends and risks to sustainability for the topics of the assessment addressed in volumes one and two. This includes conditions and trends or the sustainability of social, economic, or ecological systems found on the Forest. Accuracy and reliability of relevant information was determined by comparing the scientific certainty and quality of the information, and using the most scientifically certain information available. Although the BASI is commonly available in the form of peer-reviewed literature, other forms of the BASI may include gray literature, expert opinion, federal agency inventory and monitoring data, and specialist observations, as long as the responsible official has a reasonable basis for relying on that scientific information as the best available. Gray literature is scientific or technical information not available through usual sources, typically created by government agencies, universities, corporations, research centers, associations and societies, and professional organizations. The six factors that were considered when identifying the BASI include:

1. The science uses well-developed scientific methods that are clearly described.
2. Logical conclusions and reasonable inferences were drawn.
3. The information has been appropriately peer reviewed.
4. A quantitative analysis was performed using appropriate statistical or quantitative methods.
5. The information is placed in proper context including spatial and temporal scales.
6. References are appropriately cited.

In the context of the BASI, “available” means that the information is currently available in a form useful for the planning process without further data collection, modification, or validation. Analysis or interpretation of the BASI may be needed to place it in the appropriate context for planning but because limited time is allotted to complete the Assessment, BASI must be readily available and exhaustive searches for this information are limited by time. Public and stakeholder feedback regarding the accuracy, reliability, and relevance of scientific information can help ensure the use and documentation of the BASI. The BASI is cited throughout the assessment document along with lists of references found at the end of each volume and the origin of data analyzed in the assessment. References included in this assessment reflect the most relevant documents, given the scope and scale of the assessment and determined to be the BASI.

Some uncertainty exists especially in situations relevant to global climate change and has been appropriately documented in the assessment. Similarly, throughout the assessment when assumptions are made, they are stated as such. The scientific knowledge base is dynamic and ever expanding and significant findings may be updated in the final assessment to reflect evolving scientific information. While the BASI informs the planning process, plan components, and other plan content, it does not dictate what the decisions must be. First, there may be competing scientific perspectives and uncertainty in the available science. In addition, decisions may consider other relevant factors such as budget, legal authorities, traditional ecological knowledge, Agency policies, public input, and the experience of land managers.

Public Participation

Public participation in the planning process began prior to the May 2015 publication of a Public Notice in the Federal Register that marked the official start of the assessment. A series of community conversations were held in March 2015 at Alamogordo, Cloudcroft, Ruidoso, Carlsbad, and Las Cruces, NM. The desired outcomes of these conversations were to build and enhance relationships between the Lincoln National Forest and its stakeholders, identify values and expectations for public participation, encourage shared learning, increase knowledge of forest plan revision, and explore opportunities and preferred methods for engagement in forest planning.

These initial conversations were facilitated by the National Collaboration Cadre. The Cadre is a network of people from around the United States who provide coaching and training assistance to national forests and their communities who are interested in understanding, developing and improving collaborative processes. Cadre members' experience range from Forest Service staff in all types of positions; local municipal and county government, both elected and staff; non-profit regional associations; to academics and project consultants. All members have worked for and/or with the Forest Service at varying points in their careers and from different perspectives.

Participants shared ideas, concerns, facts and dates related to the Lincoln NF that were significant to their communities and important for the Lincoln NF staff to be aware of through small group discussions. This exercise helped create an open dialog and provided the Lincoln NF staff a better understanding of local perspectives on national, regional and local Forest Service management history, values, current conditions, trends, threats and future desired conditions as they relate to the Lincoln NF and its communities. Expectations related to communication and engagement in the revision process were discussed in small groups including the expectations participants have of the Lincoln NF, expectations the Lincoln NF has of stakeholders, and the expectations stakeholders have of each other. Participants were asked to identify the best ways to engage them and their communities in the plan revision process and the preferred methods of sharing information and keeping people informed. They were also asked to identify any individuals or groups that were not in attendance or not represented and how those connections might be made. The information shared during these meetings was used to develop the Forest's Pubic Participation Strategy. The Public Participation Strategy and summaries of these conversations are available on the Lincoln NF's Plan Revision Web page at https://www.fs.usda.gov/detail/lincoln/landmanagement/planning/?cid=stelprd3814310.

Since March 2015, the Lincoln NF has presented on plan revision at 21 governmental and organizational meetings at the request of those self-convening groups. Informational booths at 5 special events such as county fairs have been an ongoing way to share materials summarizing the plan revision process. Interactive classroom sessions to engage Otero County youth and educators were conducted at the New Mexico State University-Alamogordo branch.

Another round of public meetings at the same locations was held in November 2015 to gather input for the assessment phase of plan revision. These meetings were facilitated by Lincoln NF Staff. Participants were provided an overview of the assessment process, including the 15 topics identified in the 2012 Planning Rule and were asked ten questions:

What is your concern about your chosen area of interest?

Please rate the current overall condition of your item of concern from #1 above. Choices included: Good, Fair, Poor, or Other.

Please briefly describe why you rated the current condition with your choice:

In the past, were conditions different? Choices included: Yes or No.

How would you rate the past overall condition? Choices included: Good, Fair, or Poor.

Approximately what timeframes are you referring to in questions #4 and #5? Choices included: 2010, 2000, 1990, 1980, or other.

Please describe why you feel the conditions were better or worse in the past below.

In reference to your concern in question 1 above do you see you concern: Getting worse, remaining the same, or improving?

What has the Lincoln National Forest done well in managing your area of interest?

Do you have suggestions for the Lincoln National Forest on how to manage this issue?

Any other information that the public would like to provide was also sought during this time. Opportunities were also provided for stakeholders to share knowledge, plans, and data for the assessment. These meeting materials and questions also went out in emails or newsletters to stakeholders on the Lincoln NF's plan revision contact list that were not able to attend any of the meetings. The input gathered at these meetings and received via email or written response is available on the Lincoln NF's Plan Revision Webpage in the document titled "November 2015: Listing of Received Concerns with Suggestions Provided". It is also used in the development of parts of the ecological, and social, cultural and economic sections of the assessment including a section devoted to stakeholder input in most chapters. These summaries build on the March 2015 conversations, describing how stakeholders value and use the Forest, how they understand Forest Service management and how they see the Lincoln NF of the future. Where there is broad agreement between stakeholder perspectives and assessment findings, there is confidence in moving forward. Whereas disagreement between stakeholder perspectives and assessment findings indicate potential opportunities for additional dialogue.

The Forest expects to release the draft assessment report to the public and other stakeholders for feedback in early 2018, after which the next round of community meetings are planned. These meetings will focus on discussing key findings from the assessment and developing needs for change statements for the 1986 Forest Plan.

Tribal Engagement

The Lincoln National Forest (Forest) maintains a government-to-government relationship and routinely consults with three federally recognized tribes based in New Mexico and Arizona: the Pueblo of Zuni, the Hopi Tribe, and the Mescalero Apache Tribe (MAT). The Lincoln NF consults with them on policy development, proposed plans, projects, programs, and Forest activities that have the potential to affect tribal interests or natural or cultural resources of importance to the tribes. The Lincoln NF developed a consultation program in the late 1990s and continues to build and enhance its working relationship with these tribes.

All three tribes have expressed some level of interest in the resources and management of the Forest and sometimes provide input to the Forest pursuant to Section 106 of the National Historic Preservation Act and the National Environmental Policy Act. These tribes recognize the lands managed by the Forest as part of their aboriginal or traditional use areas and acknowledge contemporary use of these lands for traditional cultural and religious activities.

Consideration of Existing Plans

The Lincoln NF will consider relevant, existing plans when developing the revised plan to look for opportunities to increase compatibility and reduce conflict. Plans and plan assessments identified for consideration include, but are not limited to:

Eddy, Chavez, Lincoln Otero County Master Plans

Cities of Alamogordo, Cloudcroft, Ruidoso, and Roswell Comprehensive Plans

New Mexico Department of Game and Fish Comprehensive Wildlife Conservation Strategy

New Mexico State Wildlife Action Plan

New Mexico Statewide Fisheries Management Plan

U.S. Fish and Wildlife Service Recovery Plans

New Mexico State Implementation Plan (Air Quality)

New Mexico Forest and Watershed Health Plan

New Mexico Statewide Natural Resources Assessment & Strategy and Response Plan

New Mexico Regional Water Plans

New Mexico State Water Plan

New Mexico Statewide Water Quality Management Plan and Nonpoint Source Management Plan

Soil and Water Conservation District Plans

Bureau of Land Management Resource Management Plans

Community Wildfire Protection Plans

New Mexico Statewide Outdoor Recreation Plan

New Mexico Department of Transportation Long Range Transportation Plan

Other National Forests' Land and Resource Management Plans and Plan Revisions

Chapter 2 - Ecological Assessment Introduction

Purpose

The purpose of this assessment is to document whether or not the ecological resource characteristics analyzed are at ecological risk or not, and explore contributing factors. Risk is defined by the likelihood and severity of a negative ecological outcome. Ecological risk is the product of departure, trends and stressors (threats). Risk is assessed on NFS lands, as it relates to systems and processes that are under agency control and/or authority. However, to understand risk to those lands, systems, and processes, they are assessed in the context of the larger landscape to the extent possible.

Risk is assessed for ecosystem characteristics by determining the extent that current conditions depart from reference conditions. Where departure trends are greater, risks to ecosystem characteristics are indicated. Individual ecosystem characteristic risk assessments are conducted at multiple spatial scales. Where there is risk, there is an ecological need for change. Risk can be mitigated if the characteristic is within agency authority and control, and the trend and condition can be improved or reversed.

Structure of the Ecological Assessment

This chapter defines and describes the general concepts and approach to the ecological assessment outlined in the Forest Service directives that accompany the 2012 Planning Rule including: defining ecosystems, key ecosystem characteristics; reference conditions, departure and trend; risk to ecological integrity and sustainability; system drivers and stressors; and spatial scales of analysis. The Ecological Response Unit (ERU) framework for terrestrial systems developed and employed by the Forest Service Southwestern Region is also presented. After the introductory chapter, the section proceeds with the description and analytic example of key ecosystem characteristics relative to terrestrial and riparian vegetation, terrestrial soils, water, baseline carbon stocks, air, and aquatic and at-risk species (i.e., resource areas). Each resource area chapter describes: ecosystem services; key ecological characteristics specific to the resource; the data and analysis approach, including disclosure of assumptions, limitations and uncertainty; reference and current conditions, and trends related to key ecosystem characteristics; pertinent system drivers and stressors; and evaluation of risk related to each characteristic; and stakeholder input received during the assessment. The structure of each of these chapter varies to accommodate the data and analysis methods and requirements of the 2012 planning rule and directives.

Ecological Conditions, Trends, and Sustainability

Assessing ecological integrity involves looking at the current condition of an ecosystem, comparing it to some reference condition, and measuring departure of the current condition from reference conditions. Reference conditions are the environmental conditions that infer ecological sustainability. In order to manage the ecosystems of today, it is important to know as much as possible about past ecosystem conditions, especially the conditions that existed before forest structure, composition, function, processes and disturbances were altered by Euro-American settlers (Moore et al. 1999; Friederici 2004). Such conditions were not unchanging, but were sustained across what has been called a “natural range of variability” (NRV) (Landres et al. 1999). According to Schussman and Smith (2006), NRV is a description of change over time and space in the ecological condition of an ecosystem type, and the ecological processes that shape those types. NRV, also known as

Historical Range of Variation, or HRV, generally estimate pre-European settlement conditions (Dillon et al. 2005; Winthers et al. 2005). NRV is the reference condition for many of the ecosystem characteristics analyzed.

Reference conditions can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions. Where the characteristic or the data describing it do not compare well to the NRV reference condition, alternative reference conditions are defined based on the current understanding of conditions that would sustain ecological integrity (FSH 1909.12, Chap. 10, Sec. 12.15b). Those reference conditions are described in the sections where they are used.

Reference conditions are a tool for assessing ecological integrity and do not necessarily constitute a management target or desired condition. The comparison between reference and current conditions is used to determine the degree of departure and whether the trend is away or toward reference. Trends are a projection of future conditions under current disturbance and management activities. In some cases, the trend may be stable or not discernible given the nature of the data. Where this is the case, assumptions are made and discussed.

Departure measures the degree to which the current condition of a key ecosystem characteristic is unlike the reference condition. When departure can be quantified, it is rated in this assessment on a scale from 0 to 100 percent, where 0 to 33 percent is considered “low”, and within reference condition. The “moderate” (34 to 66 percent) and “high” (67 to 100 percent) classes are outside of reference condition, are uncharacteristic for the system and are considered significant in terms of risk.

Key Ecosystem Characteristics

Ecological integrity is a relatively simple concept to define, but more difficult in practice to assess. Ecosystem characteristics are specific components of ecological conditions that sustain ecological integrity (FSH 1909.12, Chap. 10). A key ecosystem characteristic describes the composition, structure, connectivity, and/or function of an ecosystem. Key ecosystem characteristics are identified and evaluated for each resource area, as applicable. Only those characteristics needed to provide the conditions necessary to maintain or restore the ecological integrity of terrestrial, aquatic, and riparian ecosystems in the Plan Area are considered in the assessment (36 CFR 219.8). A limited suite of characteristics are selected to assess ecological integrity based on whether or not the characteristic is relevant and/or needed to assess other characteristics (e.g. at-risk species and habitat), and if information is readily available. Characteristics for different resources are described in their respective chapters.

Key Ecosystem Characteristics identified and evaluated include:

Seral state proportion
Fire Interval (i.e., rotation, frequency
Fire severity
Fire Regime Condition Class (FRCC)
Snags and Coarse Woody Debris (CWD)
Ecological status (species composition)
Ground cover
Patch size
Insect and Disease
Soil condition
Soil erosion hazard
Soil loss

Streams
Spring seeps
Water Quality
Riparian/Wetland condition Water uses/rights
Watershed condition
Air Quality
Carbon Stocks
At Risk Species (Species of Conservation Concern)
System Drivers and Stressors

System drivers are factors or processes that act on ecosystem characteristics and contribute to the range of variability in conditions. Examples include natural vegetation succession, predominant climatic regime, and broad-scale disturbance regimes such as wildfire, flooding and insects and disease. Stressors are natural or human caused alterations in system drivers that may directly or indirectly threaten ecological integrity and sustainability. Examples include invasive species, altered fire regimes, and climate change.

Management actions may act as system drivers or stressors depending on the duration, intensity and magnitude of those actions. These may include timber harvest, prescribed burning, permitted grazing, water developments, seeding, and road construction among others including legacy management that is no longer currently practiced. Examining system drivers and stressors across the reference and current time periods provides the “why” to the departure and trend analysis and informs the preliminary ecological need for change.

The System Drivers and Stressors Chapter is dedicated to that discussion and is referred to throughout this section. Drivers and stressors that may exist but are not included in that chapter are identified and discussed relative to the specific characteristic(s) to which they apply.

Data, Methods and Scales of Analyses

Spatial scales to be considered in the analysis by topic should: 1) be sufficiently large to adequately address the interrelationships between conditions in the Lincoln NF and the broader landscape, but not so large that these interrelationships lose relevance in guiding land management planning; and 2) consider the extent to which ecological attributes of the broader landscape support, or are supported by, conditions in the Lincoln NF. The area of analysis for the assessment should also be large enough to capture: 1) characteristics (composition, structure, function, and connectivity) and geographic scale of relevant ecosystems; 2) fire and other forms or patterns of disturbance; 3) landform patterns or land type associations; and 4) plant, animal, species, or community distribution and abundance (FSH 1909.12, Chap. 10). In addition, the area of analysis should also be large enough to capture broad-scale trends and encompass the natural range of variation in disturbance intensity, frequency, and areal extent. For most characteristics, it is possible and valuable to consider multiple scales for the assessment.

As described by Bailey (1980, 1983, 1985 and 1998), Ecoregions distinguish areas that share common climatic and vegetation characteristics (Cleland et al. 1997). Ecoregions are subdivided into provinces, which are controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soils. Sections are a subdivision of provinces, described by broad areas of similar sub-regional climate, geomorphic process, geology, geologic origin, topography, and drainage networks. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings such as those mapped by Küchler (1964). Ecological subsections are a further division of sections, and described by areas with similar surface geology, geomorphic process, soil groups, sub-regional climate, and potential natural vegetation communities (McNab and Avers 1994).

This assessment utilizes three spatial scales: Context, Plan and Local.

Context scale is needed to put the Forest's conditions in perspective with the surrounding landscape, including lands beyond the Forest boundary, and is necessary for determining the opportunities or limitation of the Lincoln NF to contribute to the sustainability of broader ecological systems. In some instances, a unique role or "spatial niche" of the Lincoln NF may become apparent at this scale. Context scale analysis can also identify impacts of the broader landscape on the sustainability of resources within the Plan Area (FSH 1909.12, Chap. 10).

The Plan Scale displays current conditions and trends as an average of conditions across the Lincoln NF. This scale drives the ecological need for change. Local scale subdivides the plan scale to identify any patterns that could inform priority setting. The local scale may drive Forest Plan components, but is not as likely to drive ecological need for change.

Water and air resource data and analysis do not lend themselves well to the ECOMAP delineations and instead, use watersheds and airsheds. The water analysis uses sub-basins (4th level watersheds) for Context scale analysis and watersheds and sub-watersheds (5th and 6th level watersheds) for plan scale analysis. The local scale analysis uses the same units described above. The air analysis identifies a single relevant airshed. These spatial scales are described in more detail in those chapters.

Chapter 3 - System Drivers and Stressors

Introduction

Drivers and stressors are recurring events, processes or actions that affect ecosystems. These effects are important to ecosystem condition. For example, fire creates variation in habitat which is important for biodiversity; it is a “driver” of ecosystem condition. Fire can be a stressor when it is of high severity and outside the natural range of variation (NRV), either occurring less frequently or more frequently than in the past. Similarly, other ecosystem drivers can act as stressors where they exceed the NRV. Other important drivers and stressors on the Lincoln NF are insects and pathogens, climate change, grazing, invasive species and more localized floods, winds, vegetative succession, vegetation management or other physical factors.

Stressors are natural or human caused alterations in system drivers that may directly or indirectly threaten resource sustainability. It is the combination of and interactions between system drivers and stressors that have resulted in current conditions discussed throughout the ecological volume of the assessment. There are two main questions that are asked to evaluate the sustainability of ecosystems: are drivers and the effects of stressors operating within the NRV, and are ecosystems “resilient” to drivers and stressors. Resilience is a measure of the extent to which an ecosystem can be exposed to stressors yet still recover to the pre-stressor condition. Climate, fire, insects and pathogens, invasive species, grazing, vegetation succession, and vegetation management all occur simultaneously on the landscapes of the Lincoln NF. All of these factors interact. When considering ecological sustainability as influenced by drivers and stressors, it is important to consider them all together.

This chapter identifies and evaluates the reference and current status of system drivers and stressors common to terrestrial ecosystems. Effects of these drivers and stressors are also addressed in the appropriate chapters of this assessment. Climate change is covered predominantly in this chapter. Drivers and stressors in hydrological systems are covered in the Water Resources chapter.

Vegetation Succession, Land Use and Management

Succession is defined as the progressive, broadly predictable replacement of species by other species over time in an ecosystem, usually in reference to the period following a disturbance, such as fire. Natural succession of vegetation is a system driver in ecosystems. It is the progressive change in species composition and structure over time, from earliest establishment on unvegetated soils (primary succession, such as on landslides or lava flows) or after disturbance such as floods or fire, to a climax state, or end of succession, with a plant community that should persist in the absence of further disturbance. Early successional stages, or seral states, are often dominated by ruderal species such as annual forbs and grasses, or resprouts of existing woody vegetation. These species take advantage of newly available space, nutrients, moisture and sunlight after disturbance. As succession proceeds, ruderal species are replaced by longer lived grasses, forbs and shrubs. In shrub, woodland and forest systems, later seral woody species can occur in early seral states as regeneration, and in later seral states as different age and size structural classes, as well as progression from shade-intolerant to shade-tolerant species. For example, in forested systems this progression might include a shift to shrubs, then to shade-intolerant tree species, and eventually shade-tolerant tree species. Disturbances like wildland fire, drought and grazing can alter, interrupt or reverse succession. For any described ecosystem, there can be multiple seral states occurring simultaneously across the landscape from small localized disturbances such as tree fall to larger scale disturbances such as fires, insect and disease mortality and windthrow (Barbour et al. 1987).

Vegetation management can be considered both a driver and stressor to ecosystems. Depending on the nature and extent of the uses, management can either increase or decrease departure of a system from its historic condition. Changes in land use have shifted over time from early settlement activities, to fire suppression and timber harvest in the early and middle part of the 20th century. In recent decades, more emphasis has been placed on protecting the wildland-urban interface, wildlife habitat and other land uses such as recreation. All of these changes have affected vegetation succession. This history of vegetation management is important to understanding current patterns of vegetation succession and future trends. European settlement in the mid-1800s brought several key changes to the area affecting succession. This included disruption of Native American traditional management, intense grazing, agriculture, mining and logging.

The influx of Euro-American settlers in the 1800s, with hundreds of thousands of sheep and cattle created a significant impact on the landscape, through alterations to plant cover, soil erosion, and streambanks (Rowley 1985). Grazing during that time was very intense and not as carefully managed as it is now. The initial establishment of invasive annuals may be linked to this period. Intensive grazing removes herbaceous plant cover, thereby influencing fine fuels and the fire regime. There were two big changes in management that affected vegetation succession in the early and mid-1900s. First was fire suppression. Second was rangeland improvement for grazing. Over the last century, with good intent but unforeseen consequences, most fires have been rigorously and successfully suppressed. The outcomes of fire suppression are discussed below, and include increased tree density in mixed conifer forests, and potential contribution to expansion of juniper in some areas.

Current management has changed substantially. Vegetation management for wildlife habitat improvement, ecological restoration, and reducing fire hazard in the wildland-urban interface (WUI) are the primary focus. There has been an increase in efforts to remove trees and other fuels through cutting and prescribed fire for ecological restoration. Some thinning of forests in the WUI has occurred, with much of the material going for use as fuelwood. Recreation affects vegetation succession in localized areas and depending on intensity. Mechanical treatment and restoration activities of all kinds have occurred primarily at middle elevation areas on the Lincoln NF. Thinning has occurred on more than 11,000 acres between 2007 and 2017. Mastication, mowing or chipping have occurred on about 2,000 acres since 2005. Just over 12,000 acres had yarding of fuels or piling since 2001. Prescribed burning has occurred on about 50,000 acres, either as piles or broadcast burning. Some of these areas overlap with the thinned areas and others are separate. Most of the thinning is funded by stewardship or other contracts for fuelwood. There are few mills in southeastern New Mexico. These limited markets make it difficult to accomplish mechanical thinning for the restoration of lower forest densities.

The most apparent examples of forest use and management influences on the integrity of ecosystems on the Lincoln NF are fire management, including suppression and fuels management, and vegetation management, including timber harvesting and grazing management. Water use and management constitute another major factor, with most effects on streams, springs, riparian systems and meadows. Where groundwater depth is lowered, once wet-meadow covered terraces often convert to drier meadows with terrestrial vegetation, often including woody encroachment. Hydrological drivers and stressors are discussed in the Water Resources chapter. Recreational use can keep locations in a perpetually disturbed condition (see Water Resources, Recreation section), such as at both developed and undeveloped (dispersed) camp sites. Unmanaged recreation has been identified by the Forest

Service as a key threat to the Nation's forests and grasslands. The use of off-highway vehicles is seen as a major component of unmanaged use (USDA Forest Service 2006). Off-highway vehicle use trends may impact recreational settings by factors including a proliferation of unauthorized routes, spread of noxious weeds, and damage to soil and vegetation. Unauthorized routes often leave tracks and ruts that can remain visible for years. For example, the area between Timberon and Cloudcroft on the Sacramento Ranger District has many braided or crisscrossed routes developed by unauthorized motorized use. In the Chihuahuan Desert, vegetation is slow to become established or reestablished after it has been damaged. In these areas with fragile soils, the repetitive passage of vehicles has created or expanded bare areas, which lack vegetation and are quite visible to the casual observer. All of these drivers, and both natural and managed aspects, interact.

Vegetation management objectives and methodology have changed over time to accommodate changes in desired socio-economic and ecological conditions. Vegetation management includes not only what traditionally has been considered timber harvesting, but also replanting after harvest and natural disturbances, if necessary; treatments to reduce threats from insects and disease; timber stand improvement to mimic or accelerate stand development (and "natural" succession); treatments to meet specific wildlife objectives; and restoration treatments to restore the Forest to more historic or otherwise desired conditions. Timber harvest is one way to work toward those desired or historic conditions that can also provide an economic benefit for the Forest and the surrounding community. Challenges to timber harvest include a lack of infrastructure and market, thus making timber a byproduct of forest restoration practices and not the driver. Vegetation management, including timber harvest and fuels management, has the most direct effect on restoring and maintaining desired or historic successional patterns on the landscape. However, residual effects of vegetation management including leftover debris may hinder natural succession. Leaving debris on site (e.g., "lop and scatter") without follow-up burning may leave uncharacteristic amounts of coarse woody debris on the ground, impeding the return of native forbs and grasses, while providing fuels for fires. Piling and burning of leftover debris can leave fire scars with sterilized soil, increasing the amount of time needed for succession to later stages.

Treatments that result in soil compaction can also inhibit succession and stall natural regeneration of understory and tree species. Compaction is a concern where mechanical equipment is repeatedly run over a limited area. Compaction results in a change in soil structure and reduction of pore space and rooting depth. This alters the patterns of air and water exchange between the soil and atmosphere, reducing infiltration, soil moisture holding capacity, rooting depth, soil microbial activity and nutrient cycling. Soils with higher clay content are more susceptible to compaction, as are those that are wet at the time the activity occurs. Disturbance from management activities can create opportunities for new or spreading infestations of non-native invasive species, which can delay succession of native plants, or in extreme cases, convert the understory to a different plant community. In contrast, by scarifying seedbeds and promoting forest regeneration, carefully managed ground disturbance can be desirable in some instances. These factors need to be carefully managed during timber production and restoration operations.

The ecosystem classification used in this assessment was developed by Region 3 ecologists using the concept of Ecological Response Units (ERUs) that are classified by similarities in vegetation, soil and fire regime (Terrestrial Vegetation chapter). Each of these ERUs will have a number of seral stages that can be described by dominant vegetation present, and size, age and structure of overstory vegetation. Historically these seral stages would be present on the landscape in characteristic proportions that represent the climatic and disturbance regimes prior to large scale European and American settlement in the late 1880s (Wahlberg et al. 2014). These characteristic proportions are considered reference conditions. Comparison of the current proportions of seral stages of an ERU to its reference condition indicates some level of departure from reference, and can be attributed to the action of one or more stressors. Drivers and stressors influence the successional progression of an ecosystem. With their own historical range of variation, some drivers can serve as key ecosystem characteristics. In many cases, departure of an ecosystem from its characteristic successional patterns can be explained or illustrated by concurrent departure of drivers from their natural range of variation, in which case they are stressors that may influence other ecosystem characteristics to fall outside of their natural range of variation.

Wildland Fire

Wildland fires have been a recurring disturbance in forests, woodlands, shrublands, and grassland ecosystems of the Southwest. Historically, fire played an important role in shaping vegetation structure, composition, and succession. Fire recurrently limited vegetation density, increased structural variability and favored dominance by fire resilient species. Most fires were initiated by lightning, but wildland fires were also initiated by Native Americans for hunting and warfare (Kaufmann et al, 1998). It is often unclear as to what extent Native American ignitions may have influenced fire regimes (particularly fire frequency), but certainly they affected the timing and location of individual fires. This interaction changed dramatically with European settlement. Increased European and American settlement brought logging and railroad building to the area, with an increase in human-caused fires following those activities. Subsequently, concerns over resources and increased settlement resulted in further alterations of the temporal and spatial extent of wildland fire disturbance. Fire suppression and land management actions altered the structure of natural ecosystems, and thus, also moved landscapes out of their natural fire regimes.

Ecosystems throughout the Lincoln NF are fire dependent, and different ecosystems have a characteristic fire regime. Fire frequency on the Forest varies with elevation, aspect, vegetation type, and climate. Landscapes are a diverse mix of grassland, shrubland, piñon-juniper woodland, ponderosa pine, and mixed conifer ecosystems. Fires are historically mixed in severity creating both stand replacement and surface fire patterns on the landscape depending on vegetation condition and fire regime, with mean fire return intervals varying greatly by vegetation type (Terrestrial Vegetation chapter, Fire Regime Condition Class section).

Large fires typically occur April through June. Spring is the windy season and these high winds dry the Forest to the point of extreme fire danger. The fire season usually starts in March or April and continues through mid-July. The rainy season begins in July and continues through September. The first snows fall in late October or early November. Large fire growth is largely determined by wind events. Wind events are frequent in the late winter and spring but also occur in the late fall and early winter.

An analysis of trends in wildland fire and climate in the western United States from 1974 to 2004 shows both the frequency of large wildland fires and fire season length increased substantially after 1985 (Westerling et al. 2006). These changes were closely linked with advances in the timing of spring snowmelt and increases in spring and summer air temperatures. Earlier spring snowmelt probably contributed to greater wildland fire frequency in at least two ways, by extending the period during which ignitions could potentially occur, and by reducing water availability to ecosystems in mid-summer before the arrival of the summer monsoons; thereby enhancing drying of vegetation and surface fuels (Westerling et al. 2006). With drier conditions anticipated as a result of climate change (see Climate Change Vulnerability Assessment section), changes in fire frequency and severity may be exacerbated.

Fire suppression, and other factors forcing the proliferation of woody biomass at the expense of herbaceous biomass, has altered the fire regime that historically maintained much of the structure of

Forest ecosystems, particularly in the ponderosa pine and dry mixed conifer forests and some piñon-juniper woodland types. This has led to wildland fire often being a system stressor, when historically it would be considered a system driver, as ecosystems were adapted to their historic fire regime. As more people live, work and play in the Forest, concerns for resource and human protection have led forest managers to adopt suppression policies to meet those concerns. Those suppression efforts, however, have led to forest conditions that are departed from historic conditions, and have increased the potential for catastrophic wildland fires (although stand replacing fires are a natural occurrence, to an extent, in some of these systems).

Fire suppression, large-scale logging, and even-aged timber management have altered vegetation structure, contributing to increases in fire severity and frequency mentioned above. However, since the late 1900s, recognition of fire's role in maintaining ecosystem integrity has led to changes in Forest Service policy, which has evolved from full suppression to management practices aimed at restoring historic structure to the different ecosystems. Those include fuels reduction treatments, uneven-aged forest management, prescribed burning, and in some cases, management of natural ignitions for beneficial resource objectives. However, beneficial wildland fire use generally allows for only mild to moderate severity burns, and while conditions are improved, not all desired conditions are attained. While current wildland fire regimes are outside the historic range of variation for most ecosystems (Terrestrial Vegetation chapter, Fire Regime Condition Class section), management in place since the late 1900s may help move wildland fire regimes toward historic conditions.

Fuels reduction, along with suppression, helps to diminish the potential for catastrophic wildland fires, particularly in the wildland-urban interface (WUI). WUI is the boundary area where homes and businesses intersect natural vegetation, and fuels reduction is a proactive measure to reduce the spread and severity of wildland fire in those areas. Fuels reduction treatments can be designed to approximate, or move local areas into alternative seral states to help meet landscape desired conditions.

Herbivory

Herbivory disturbance regimes are drivers in nearly all ecological systems. Herbivory was a system driver both before and after the arrival of Europeans. In the current time period it is both a system driver and a substantial stressor in the Plan Area. In pre-European times, native ungulate species such as deer, elk, pronghorn antelope and bighorn sheep grazed portions of the Lincoln NF area, with populations believed to have been kept in check by predators, weather patterns and natural cycles of disease. Grazing and browsing by native species during the reference period differed in degree, location, pattern, diet, slope preference, time spent in a single area and ground disturbance. After the arrival of Europeans, native ungulate populations declined, and in the case of elk and bighorn sheep, were completely eliminated from the Forest. Elk were subsequently reintroduced to the Forest in the 1950s, although some migration from earlier reintroduction efforts on adjacent lands likely occurred. These populations have steadily increased, particularly on the Smokey Bear and Sacramento Ranger Districts, and have contributed negative ecological impacts in some areas, particularly in aspen stands and riparian areas.

The Lincoln NF area has been grazed by domestic livestock, including cattle, sheep, swine, and goats, brought in by Spanish settlers since around 1700. The introduction of high density livestock grazing in the late 1800s is one of the events that marks the end of the reference period (Smith 2006b). Amounts and types of livestock grazing on federally administered lands has changed over time. Currently the Lincoln NF is grazed primarily by domestic cattle, with some incidental grazing by horses and sheep, under a permit system (see Rangeland Resources in Multiple Uses section on Volume II of this Assessment). Currently, nearly 957,000 acres of the Lincoln NF's approximately 1.1 million acres are grazed under permit. The Lincoln NF allows year-long grazing on summer and winter pastures, with approximately 13,000 head of livestock permitted to graze the allotments. Adaptive management of the rangeland resource allows for reduction in grazing numbers when natural conditions such as drought or fire suggest a need. Grazing may be grandfathered in where it existed when the Wilderness Act or other enabling legislation was passed (see Designated Areas chapter of Volume II of this Assessment). Accordingly, livestock grazing is authorized in portions of wilderness areas on the Lincoln NF.

Range management practices and native ungulate herbivory can create long term chronic disturbance of ecosystems. In drier shrub and scrublands, cattle grazing contributes to the proliferation of woody species such as mesquite, with conversion from grasslands to scrubland or woodland in many areas (Brown and Archer 1987; Archer 1989, 1995). Elk herbivory has limited the regeneration of aspen, considered an early seral species, in the mixed conifer and spruce-fir ecosystems.

Herbivory has the potential to impact the composition, structure and function of upland and riparian vegetation, as well as soil hydrologic function, stability and nutrient cycling. Reductions in vegetative canopy cover can reduce the above and below ground vigor of the plant, and reduce the amount of material available to create litter. These reductions can lead to decreased water infiltration, increased runoff and accelerated erosion (Belsky and Blumenthal 1997; Holechek et al. 2010).

Where decreases in herbaceous biomass occur, the ability of frequent fire ecosystems to carry low intensity fire can be reduced (Belsky and Blumenthal 1997; Holechek et al. 2010). It also reduces the risk of moderate and high intensity fire. Additionally, decreases in the herbaceous component reduces competition by grasses with woody species, allowing those woody species to expand or encroach into grasslands and woodland and forest openings. Sustained grazing over time can reduce species diversity as some plants are more palatable than others to specific ungulates (Fleischner et al. 1994).

Hoof action can break up vegetative groundcover and compact soil. In extreme cases, compaction results in a change in soil structure and reduction of pore space. This alters the patterns of air and water exchange between the soil and atmosphere, reducing infiltration, soil moisture holding capacity, rooting depth, soil microbial activity and nutrient cycling.

While there is evidence that heavy grazing can degrade arid rangelands (Fleischner 1994; Todd and Hoffman 1999), some native plants are adapted to ungulate grazing (Pieper 1994; Holecheck et al. 2010) and grazing animals may play a role in nutrient cycling (Pieper 1994). Properly managed grazing, with respect to utilization levels, season of use, and type of animal may minimize impacts to ecosystem function and can be sustainable over the long term (Davies et al. 2011; Holecheck et al. 2006; Pieper 1994). Rest from grazing has been shown to reduce ecosystem degradation, especially in riparian areas (Dalldorf et al. 2013; Schulz and Leininger 1990), but alone, even total cessation of all grazing may not return grass systems to a historic reference state (Pieper 1994). The amount and timing of precipitation also plays a large role in determining rangeland vegetation conditions. Through adaptive management of the timing, intensity and duration of grazing, effects to vegetation productivity and species composition can be managed (Holechek et al. 2010).

Insects and Pathogens

Insects and diseases are important components of forest and woodland ecosystems, greatly influencing structure and species composition over time. They can be both a system driver and stressor. It is only when their effects exceed what is desirable or disrupt ecological integrity that they become a concern. There are some insects that at times cause marked tree dieback that are concerns. For example, widespread tree death in piñon and juniper has occurred in recent decades at rates five to ten times higher than expected in the Western United States, due to the combined effects of drought, insects, and disease (Shaw et al. 2005). Warming temperatures have increased the probability of bark beetle outbreaks in the near future, especially in high elevation, pine-dominated forests (Hicke et al. 2006).

Forested systems have developed under locally specific pathogens at levels that were sustainable historically and may help maintain ecosystem function. An outbreak may have uncharacteristic effects to which the system may or may not be resilient to, either because the outbreak is more severe, or because of factors that amplify damaging effects. In cases of severe infection levels or periodic outbreaks of insects, the effects are more obvious and can be negative (USDA Forest Service 2015a), including increased fuel loading and an elevated risk of wildland fire.

The Insect and Disease Mortality section in the Terraestrial Vegetation chapter provides a summary of impacts on the Forest. Lincoln NF has the same insect and disease associates that occurred 100 years ago, with the exception of a few introduced insects and pathogens, most notably white pine blister rust (WPBR). WPBR is a fungal disease native to Asia. It was introduced to North America on multiple occasions around 1900, through planting stock from Europe (history described in Kinloch 2003). In the Southwestern Region, it was first detected in 1990 on the Lincoln NF. However, it had probably arrived on the Lincoln NF in the early 1970s (Conklin and Hawksworth 1990, Conklin 1994). Non-native WPBR is expected to expand in terms of occurrence and severity. Eventually the disease is expected to impact white pine populations in many areas of the Southwest and may even eradicate white pine from the most susceptible sites (Ryerson 2016).

The incidence of WPBR at monitoring plots has shown a strong correlation with elevation. Higher elevations have the cooler, moist environment that is most favorable for rust development. Moist drainages and higher elevation stands are the most vulnerable, especially where orange gooseberry (*Ribes pinetorum*), the preferred alternate host, is present (though all *Ribes* [gooseberry or currant] species in the Southwest are susceptible). While the presence of the alternate host, *Ribes*, is necessary to complete the rust's life cycle, removal of *Ribes* species is not considered a viable control strategy.

Even where conditions are especially favorable for blister rust, some trees may be resistant, providing a seed source for natural selection and eventual recovery. On drier, low hazard sites, infections and subsequent mortality are expected to be relatively low. These sites will likely serve as important genetic refugia for white pines. Maintaining and promoting the broadest possible genetic diversity present, including adaptive traits important in a changing climate as well as blister rust resistance mechanisms, should help ensure the long-term survival of these unique trees (Ryerson 2016).

Other than WPBR, the primary forest insects and diseases are native, with outbreaks tied primarily to drought or disturbance (USDA Forest Service 2015a). However, climate change is anticipated to substantially change insect and disease dynamics, likely leading to increased tree mortality (USDA Forest Service 2015a).

Invasive Species

Invasive species introductions are a major threat to species biodiversity (Wilcove et al. 1998). Invasive species are the leading cause of avian species extinction and the second leading cause of extinction for North American fish, world fish, and mammals (Clavero and Garcia-Berthou 2005). Invasive species have been widely recognized as contributing to altered states of ecosystem structure and function. Although many of the mechanisms by which invasive species alter the structure and function of ecosystems are interrelated, these mechanisms can be generally categorized into three groups: biotic factors, natural cycles, and other, abiotic factors (Charles and Dukes 2006). Biotic factors consist of changes to species diversity, and community composition and interactions. Abiotic factors influence each of those.

Invasive species can alter natural cycles by changing the way energy, nutrients, and water are exchanged in a system. For example, salt cedar (*Tamarix* spp.) and yellow star-thistle (*Centaurea solstitialis*) are known to alter hydrologic regimes through innate functional traits that increase the rate of evapotranspiration, which gives these invasive species a competitive advantage over native species (Levine et al. 2003). Finally, invasive species are also known to alter other abiotic factors, such as disturbance regimes, climatic and atmospheric composition, and physical habitat.

Invasive species also include disease causing agents such as WPBR. Invasive species are defined (Executive Order 13112) as an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. A species that causes, or is likely to cause, harm and that is exotic to the ecosystem it has infested. Invasive species infest both aquatic and terrestrial areas and can be identified within any of the following four taxonomic categories: Plants, Vertebrates, Invertebrates, and Pathogens (Executive Order 13112).

Terrestrial Invasive Plant Species on the Lincoln NF

In recent decades, invasive plant species progressively increased in abundance on the Lincoln NF and adjacent lands, which led to increased public concern about the effects of invasive plants (principally musk thistle and teasel) and greater demand for treatment. The Forest initiated two extensive invasive plant surveys in the early 1990s, to help assess the extent of the infestation. These surveys revealed the presence of 11 invasive plant species across 4,200 acres. However, most of the surveys were conducted along roads and trails, on the Smokey Bear and Sacramento Ranger Districts. They reflect only major infestations, and only the observed portions of infestations. To date, the Forest has recorded the presence of at least 26 invasive plant species (Table 1); however, no recent surveys have been conducted on the Smokey Bear and Sacramento Ranger Districts and no substantial surveys have been conducted on the Guadalupe District. As a result, the current number of infested acres is unknown at this time.

No significant treatments have been implemented since 2014. Therefore, inventoried, new, and unknown infestations continue to spread on the Forest. In general, invasive plants increase at an estimated rate of 5-30 percent per year, depending on the species, site specific conditions, and success of past treatments efforts (DiTomaso 2000, Frid et al. 2013, and Tu et al. 2001). Of the species listed in Table 1, musk thistle and teasel are the most abundant invasive plant species on the Forest. These species are primarily located along roads, stream corridors, riparian areas, grazed pastures and burned areas. These two species, along with grazing tolerant grasses such as Kentucky blue grass, contribute to the departed condition of riparian areas, meadows and other sensitive areas that contain federally listed species.

Table 1. List of invasive plant species that have been documented on the Lincoln National Forest

Common name	Scientific name	Affected Areas
African rue	*Peganum harmala*	Prefers disturbed environments such as roadsides, fields and rangelands in desert and semi-desert areas. It is often found in soils with high salinity.
black henbane	*Hyoscyamus niger*	Found in disturbed open sites, roadsides, fields, waste places, and abandoned gardens. Grows best in sandy or well-drained loam soils with moderate fertility. Does not tolerate waterlogged soils.

Common name	Scientific name	Affected Areas
bull thistle	*Cirsium vulgare*	Occurs in dry to moist habitats, fields, pastures, grasslands, roadways, forest clearings, rock outcrops, and along waterways. It is not shade tolerant.
Canada thistle	*Cirsium arvense*	Found in prairies and other grasslands and riparian areas with deep, well aerated, mesic soils, but also occurs in almost every upland herbaceous community, especially roadsides, abandoned fields, and pastures.
cheatgrass	*Bromus tectorum*	Found in both disturbed and undisturbed shrub-steppe and grasslands, but the largest infestations are usually found in disturbed shrub-steppe areas, overgrazed rangeland, abandoned fields, eroded areas, sand dunes, road verges, and waste places.
common burdock	*Arctium minus*	Commonly found growing along roadsides, ditch-banks, in pastures and waste areas.
common mullein	*Verbascum thapsus*	Found in natural meadows and forest openings, where it adapts easily to a wide variety of site conditions.
Dalmatian toadflax	*Linaria dalmatica*	An introduced ornamental that is quick to colonize open sites and is capable of adapting growth to a wide variety of environmental conditions.
dandelion	*Taraxacum officinale*	A widespread weed that commonly occurs in disturbed areas such as cut-over or burned forest, overgrazed ranges, and marshy floodplains.
field bindweed	*Convolvulus arvensis*	One of the most persistent and difficult plants to control. It has a climbing habit that allows the plant to grow through mulches and it is very drought tolerant.
hoary cress	*Cardaria spp.*	Prefers non-shaded, disturbed conditions, including roadsides, waste places, fields, gardens, feed lots, watercourses, open grasslands, and along irrigation ditches. It does not do well in highly acidic soils.
houndstongue	*Cynoglossum officinale*	Most abundant in areas with more than 10 percent bare ground.
jointed goatgrass	*Aegilops cylindrica*	A native of southern Europe and western Asia that grows in wheat fields, grasslands, and along roadsides.
leafy spurge	*Euphorbia esula*	Occurs on untilled, non-cropland habitats, including both disturbed and

Common name	Scientific name	Affected Areas
		undisturbed sites, especially abandoned cropland, pastures, rangelands, woodlands, roadsides, and waste places. It tolerates a wide range of soils from rich, moist soils of riparian zones to nutrient-poor, dry soils of western rangelands; however, it is most aggressive in semi-arid situations.
musk thistle	*Carduus nutans*	The most problematic species on the Lincoln National Forest. Grows best in disturbed areas, such as along roadsides, grazed pastures, burned areas, and old fields but also can invade deferred pastures and native grasslands. It can occur in almost all habitats except dense forests, high mountains, deserts, and frequently cultivated farmlands.
perennial pepperweed	*Lepidium latifolium*	Deep-seated rootstocks make this weed difficult to control. It grows in waste places, wet areas, ditches, roadsides, and cropland.
poison hemlock	*Conium maculatum*	Commonly found at lower elevations along roadsides, ditch and stream banks, creek beds, fence lines, waste places, and in or on the edge of cultivated fields where there is sufficient soil moisture.
Russian knapweed	*Acroptilon repens*	Prefers heavy, often saline soils of bottomlands and sub-irrigated slopes and plains. It is commonly found along roadsides, riverbanks, irrigation ditches, pastures, waste places, clear-cuts, croplands, and hayfields. It does not readily establish in healthy native vegetation, it requires disturbance.
Scotch thistle	*Onopordum acanthium*	While this species can occupy dry sites, it typically requires adequate moisture for establishment. It is often associated with waterways in the western United States.
Siberian elm	*Ulmus pumila*	A native of northern Asia that is often grown as a shade tree. This species out-competes native tree species in riparian zones and other sensitive areas. It also establishes along road corridors where its winged seeds are transported by wind and passing vehicles.
spiny cocklebur	*Xanthium spinosum*	Grows in a wide variety of soil types, most frequently found in disturbed areas, but also invades undisturbed rangelands.

Common name	Scientific name	Affected Areas
spotted knapweed	*Centaurea maculosa*	Best adapted to well-drained, light-textured soils in areas that receive some summer rainfall. This includes ponderosa pine and Douglas-fir forests and shrub-steppe habitats with bluebunch wheatgrass, needle-and thread, and Idaho fescue. Spotted knapweed does not do well in irrigated or wetter-than-normal areas.
tamarisk/salt cedar	*Tamarix spp.*	Originally introduced for erosion control and as an ornamental, it invades streambanks, sandbars, lake margins, wetlands, moist rangelands, and saline environments. It is known to crowd out native riparian species, diminish early succession, and reduce water tables, thus interfering with hydrological processes.
teasel	*Dipsacus fullonum*	Favors disturbed sites such as roadsides, ditches, waste places, riparian sites, fields and pastures.
yellow starthistle	*Centaurea solstitialis*	Grows on various soil types and is usually introduced along roadsides and in waste areas; however, it seems to favor sites originally dominated by perennial grasses.
yellow toadflax	*Linaria vulgaris*	An introduced ornamental that is quick to colonize open sites and is capable of adapting growth to a wide variety of environmental conditions.

Exotic Terrestrial Animals

Exotic terrestrial animals of prominent concern on the Lincoln NF are the feral hoofed mammals, pig (*Sus scrofa*), horse (*Equus asinus*), and Barbary sheep (*Ammotragus lervia*).

Feral hog

Feral hog populations in the United States had grown to approximately 5 million animals in at least 38 states by 2012 (USDI Fish and Wildlife Service 2012). Feral hogs cause extensive property damage, negative effects on public domestic animal health, loss of crop production, and numerous impacts to natural resources (Table 2). The total aggregate cost of damage from feral hogs in the United States was estimated to be $1.5 billion annually (USDI Fish and Wildlife Service 2012). Feral hog populations occur in Chaves, Eddy, Lincoln, and Otero counties, including all three Districts on the Forest. While augmented by cases of escaped livestock, the main source of feral hog populations in the Context Area is reported to be from intentional releases for sport hunting opportunities. However, the Pecos River corridor may include dispersal of feral hogs associated with large populations in Texas (USDI Fish and Wildlife Service 2010). New Mexico de-legalized the import, transport within the state, breeding, release, or sale of live feral hog and the operation of commercial feral hog hunting enterprises (New

Mexico HB 594; 2009). The New Mexico office of USDA Wildlife Services noted that "Although the economic consequences of feral hog damage are considerable, the ecological impact to the environment is immeasurable", and… "While feral hogs are notorious for landscape destruction, they are also predators of domestic livestock; including lambs, kids, and calves."

Table 2. Summary of some specific impacts from feral hogs. Based on USDA Wildlife Services (2012)

Impact	Description
Spread of Invasive Weeds	Disturbance of soil by feral hogs while rooting for plant and animal matter and wallowing provides conditions for invasion of exotic weeds, while hog feces provide a seed source in disturbed sites. Fur and hooves serve as additional mechanisms for transport.
Competition with Native Species	Feral hogs exhibit a preference for acorn crops in New Mexico and elsewhere, resulting in widespread regeneration problems and other disturbances in oak communities. Oak crops are critical resources for numerous wildlife species. Hogs may also disturb and consume caches and hoards of acorns and seeds stored by, and critical to the survival of, small mammals and birds. This may result in reduced regeneration of the plants as well. Hogs also compete for forbs and grasses with species such as mule deer and quail at different times of the year.
Predation on Native Species	In the eastern United States, feral hog rooting behavior has greatly reduced local populations of certain salamanders, and the Sacramento Mountain salamander and other Lincoln NF wildlife could potentially be impacted as well. Similarly, small mammal populations have been highly impacted in various areas (e.g., southern red-backed vole [*Clethriomys gapperi*], northern short-tailed shrew [*Blarina brevicauda*]). Additional species that hibernate (e.g., frogs, toads, turtles, snakes and lizards), shelter or otherwise live under the soil surface are also vulnerable to predation by feral hogs. They are also effective at preying on gophers, woodrats, ground squirrels, and mice, and can have major predation impacts on all sorts of ground nesting birds. New Mexico (and Lincoln NF) hosts many endangered, range-restricted and rare springsnails that are highly sensitive to destruction of vegetation along stream margins. Their association with seeps and springs makes them highly vulnerable to feral hogs. Feral hogs are often closely associated with wetlands and riparian areas in New Mexico. On Lincoln NF, these areas are limited, highly sensitive, and relatively stressed due to other factors, and feral hogs further threaten associated species such as the endangered NM meadow jumping mouse.
Disease Concerns	Feral hogs are susceptible to a wide variety of viral and bacteriological diseases, at least 20 of which are zoonotic (may be transmitted to humans). They are also hosts to numerous parasites such as the nematode which causes trichinosis. Feral hogs carry a vast array of diseases that can be transmitted to livestock (e.g., brucellosis, pseudorabies, leptospirosis, classical swine fever and bovine tuberculosis) in which infection may result. In New Mexico, feral hogs have tested positive for both swine brucellosis and pseudorabies. The latter may infect cattle and sheep (typically fatal within days), as well as domestic dogs, raccoons, coyotes, cougar, rodents and deer. Swine brucellosis is a bacterial infection causing abortions and weakened or stillborn piglets, and may infect cattle. Ongoing, illegal relocation of hogs complicates disease surveillance and management.

Impact	Description
Impacts on Domestic Water Supply	Carry and spread waterborne pathogens, including the top five for drinking water (*E. coli*, *Campylobacter*, *Salmonella*, *Cryptosporidium* and *Giardia*). Other important pathogens include *Balantidium coli* and *Entamoeba*. Hogs should be excluded from streams or rivers that empty into municipal reservoirs, as well as from crops (also because of contamination by feral hog feces). Turbidity caused by feral hogs can reduce the effectiveness of chemical disinfection processes.
Impacts on Water Supply	Feral hogs need water, and concentrate at and cause widespread damage to, both natural and developed water sources and supplies. They cause contamination, spillage, and physical damage to stock watering facilities, and increase potential for disease or parasite transmission at the facilities and in wallows derived from spillage. Reduce watering opportunities for livestock and wildlife.
Rangeland and Forest Destruction	Cause long lasting degradation of native ecosystems, including rangelands, forests and plant communities of all sort. Disturbance of soil while rooting for plant and animal matter accelerates erosion. Reduce oak (*Quercus* species) establishment by consuming acorns and destroying seedlings, including older established seedlings. Cause reductions in forest plant diversity, impacting a vast array of upland and wetland plants. Consumption of wetland plant roots often causes plant death and leads to erosion and sedimentation. Damage riparian vegetation, streambanks and shorelines of all sort, including features required by trout. Wetland and riparian damage from wallowing and rooting includes siltation, turbidity, algae blooms, and depletions of oxygen needed by fish and aquatic invertebrates. Spread fungal spores, including root-rot fungus. Hinder restoration projects.
Livestock Predation	Prey extensively on domestic livestock including lambs, kids, and calves, and opportunistically on adult sheep and goats (e.g., adult animals giving birth). They frequently leave no carcasses, and are often overlooked as the source of livestock predation.
Agricultural Damage	Damage to crops is extensive and increasing with the proliferation of feral hogs. Damaged crops including wheat, corn, rice, grapes, barley, oats, rye and potatoes. Also cause extensive damage to pastures, alfalfa fields and forage crops for beef and dairy cows, as well as rangeland forage, and spread noxious weeds in those areas. May travel long distances to forage in croplands. They also break levees, fences, stock tanks, impoundments and irrigation lines and other structures.

Barbary sheep

Barbary sheep are very well adapted to arid, rugged environments like those found on much of the Lincoln NF, particularly the western escarpment of the Sacramento Mountains and in the Guadalupe Mountains. Native to northern Africa, Barbary sheep fit a niche similar to that of desert bighorn sheep, which are presently extirpated from the Lincoln NF. Like bighorn sheep, they navigate extremely precipitous slopes, and can occupy waterless areas. They do use surface water to an extent, depending on need and availability. They graze and browse on a wide variety of grasses, forbs, and shrubs. Mountain mahogany (*Cercocarpus breviflorus*) was the single most important species in a New Mexico study of their diet, and oak species were another important browse. They would likely be direct competitors with bighorn sheep for multiple resources, and there is some evidence indicating direct food competition with mule deer (Davis and Schmidly 2016). They are a game species in New Mexico, with some hunted annually in NMDGF's game management units overlapping the Lincoln NF.

The presence of Barbary sheep on the western escarpment of the Sacramento Mountains is a complicating factor in the potential reintroduction of desert bighorn sheep to that area. Similarly, the presence of Barbary sheep in Carlsbad Caverns National Park complicates prospects for bighorn reintroduction there. Desert bighorn sheep survived on the Sacramento escarpment until the late 1930s or early 1940s (NMDGF 2105), when they were lost from surrounding areas including Carlsbad Caverns National Park. Barbary sheep escaped into the wild in New Mexico by the 1940s, and those were later augmented with released animals, partly to replace hunting opportunities lost along with desert bighorn sheep (Ogren 1965, NMDGF 2015). NMDGF (2015) estimates that the Sacramento escarpment could support approximately 500-1,000 bighorn sheep, but unless Barbary sheep are removed, NMDGF would need to manage some sort of balance between the two species if bighorn sheep were reintroduced to the Sacramento escarpment.

Feral horse

Feral horses are established in the western U.S. and many parts of the world. They can damage natural systems through trampling vegetation, compacting soil, and overgrazing. They graze vegetation very short, close to the soil surface, which damages many plants to the extent that re-growth is precluded. Feral horse impacted areas have lower plant diversity, less plant cover, and more exotic plant species than un-impacted areas. Grazing impacts to the environment are exacerbated, and competition with native grazers and livestock is intensified where feral horses are present.

Feral horses occur on the two northern districts of Lincoln NF. Like feral hogs and other hoofed mammals, they cause impacts to wetlands, wetland restoration projects, and water tanks for wildlife and livestock use. When concentrating at tanks, they leave large concentrations of feces and cause vegetation loss and soil compaction in the local area. Feral horse abundance and distribution on the Smokey Bear RD has been observed to be increasing in recent years.

Climate Change

The purpose of this assessment is to evaluate the best available scientific information (BASI) regarding climate change and to project future conditions on and affecting the Lincoln NF. In this assessment, climate is considered a key ecosystem characteristic since it is relevant to maintaining and/or restoring the ecological integrity of terrestrial, aquatic, and riparian ecosystems in the Plan Area. The assessment provides a basis for the evaluation of ecological influences of climate change to inform any needs for change to current Forest Plan direction. Additionally, this assessment identifies information gaps and uncertainties associated with climate change information pertinent to the Forest.

Ecosystem Services

Climate change may have a major effect on ecosystem services by reducing their capacity (Inkley et al. 2004). As the human population continues to grow in the 21st century, so too will its demand for the goods and services that ecosystems provide. Ecosystem services provided by wildlife (e.g., pollination, natural pest control, seed dispersal, nutrient cycling) are derived from and dependent on their roles within ecosystems. If an ecosystem is vulnerable to changes in climate, so are the services provided. Animal and plant species determine ecosystem stability, health, and productivity. Changes in the structure and function of affected ecosystems can result in a loss of species that can lead to loss of revenue and aesthetics (IPCC 2007b). In addition, animals provide a recreational value (e.g., sport hunting, wildlife viewing). Species reduction due to the loss or significant alteration of habitats could impact the cultural and religious practices of indigenous peoples. Vegetation protects soil against erosion, and forest dieback or uncharacteristic wildland fires in forested ecosystems can greatly increase watershed sediment yield (Allen and Breshears 1998; Miller et al. 2003), potentially reducing water storage capacity in reservoirs.

Best Available Science

The USDA FS Southwestern Regional Office has compiled the best available science (BASI) for climate change relevant to forest planning in the Southwest. The following review is based on that report. Climate scientists agree that the earth is undergoing a warming trend and human-caused elevation of atmospheric concentrations of carbon dioxide (CO2) and other greenhouse gases are chief among the potential causes of global temperature increases. The concentrations of these greenhouse gases are projected to increase into the future. Climate change may intensify the risk of ecosystem change for terrestrial and aquatic systems, affecting ecosystem structure, function, and productivity.

There is broad agreement among climate modelers that the Southwestern US is experiencing a warming and drying trend that will continue well into the latter part of 21st century (IPCC 2007a; Seager et al. 2007). While some models predict increased precipitation for the region, researchers expect the overall balance between precipitation and evaporation would still likely result in an overall decrease in available moisture (Seager et al. 2007). Temperatures are predicted to rise by 5 to 8 degrees Fahrenheit by the end of this century, with the greatest warming occurring during winter months. The number of extremely hot days is projected to rise during the 21st century. By the end of the century, parts of the Southwest are projected to face summer heat waves lasting two weeks longer than those experienced in recent decades. Some climate model downscaling results also suggest a fivefold increase in unusually hot days by the end of the century, compared to temperature data from 1961 to 1985. In effect, high temperatures that formerly occurred on only the hottest 5 percent of days could become the norm for as much as a quarter of the year–100 days or more–in much of the Southwest (IPCC 2007a; USDA FS 2010b).

Climate variability, with both wet periods and droughts, has been a part of southwestern climate for millennia; and droughts of the last 110 years pale in comparison to some of the decades- long “megadroughts” the region has experienced over the last 2,000 years (Seager et al. 2008). Indeed, severe regional floods or droughts have affected both indigenous and modern civilizations on time scales ranging from single growing seasons to multiple years and even decades (Sheppard et al. 2002). However, a warmer, drier, and faster changing climate will increase pressures on the region’s already limited water supplies, including increased energy demand; altered fire regimes and ecosystems; elevated risks for human health; and impacts to agriculture (Sprigg et al. 2000).

Water

Changes in water distribution, timing of precipitation, availability, storage, watershed management, and human water uses, may present some of the most important challenges from climate change to national forest management in the Southwest. Terrestrial and aquatic ecosystems and all human socioeconomic systems in the Southwest are dependent on water. The prospect of future droughts becoming more severe because of global warming is a significant concern, especially because the Southwest continues to lead the nation in population growth. Recent warming in some areas of the Southwest is occurring at a rate that is among the most rapid in the nation (Seager et al. 2007), significantly higher than the global average. This is already driving declines in spring snowpack and Colorado River flow. More water cycle changes are projected, which, when combined with increasing temperatures, signal a serious water supply challenge in the decades and centuries ahead. Water supplies are projected to become increasingly scarce, demanding trade-offs among competing uses, and potentially leading to conflict. Projections for this century point to an increasing probability of drought for the region, made more probable by warming temperatures. The most likely future for the Southwest is a substantially drier one. Combined with the historical record of severe droughts and the current uncertainty regarding the exact causes and drivers of these past events, the Southwest must be prepared for droughts that could potentially result from multiple causes.

The combined effects of natural climate variability and human induced climate change could result in a challenging combination of water shortages for the region (Karl et al. 2009). Additionally, the locations of most snow pack and upland reservoirs in the Southwest are on national forests (NM 2005; Smith et al. 2001). Some studies predict water shortages and lack of storage capabilities to meet seasonally changing river flow, as well as transfers of water from agriculture to urban uses, as critical climate-related impacts to water availability (Barnett et al. 2008). While agriculture remains the greatest user of water in the Southwest, there has been a decreased amount of water used by agriculture, as New Mexico's booming population demands more water for municipal and other uses, and irrigation technologies improve. This has been an ongoing trend and could affect future agricultural uses. Without upland reservoirs and watersheds—many managed by the Forest Service—alternative water sources, water delivery systems, and infrastructure support for agriculture would need to be developed (Lenart 2007). Flash flooding following extended drought may increase the number and severity of floods and accelerate soil erosion rates. The timing and extent of storm-related precipitation will play a key role in determining the degree to which people and the environment are affected (USDA Forest Service 2010).

The potential for flooding is very likely to increase, because of earlier and more rapid melting of the snowpack, with more intense precipitation. Even if total precipitation increases substantially, snowpack is likely to be reduced because of higher overall temperatures. However, it is possible that more precipitation would also create additional water supplies, reduce demand, and ease some of the competition among competing uses (Joyce et al. 2001; Smith et al. 2001). In contrast, a drier climate is very likely to decrease water supplies and increase demand for such uses as agriculture, recreation, aquatic habitat, and power; thus, increasing competition for decreasing supplies (Joyce et al. 2001).

Ecosystems

Long-term and short-term climate variability may cause shifts in the structure, composition, and functioning of ecosystems, particularly within the fragile boundaries of the semiarid regions. These areas contain plants and animals that are highly specialized and adapted to the landscape. A changing climate of wetter, warmer winters, and overall temperature increases would alter species range, type, and number throughout the Southwest. Responding differently to shifts in climate, the somewhat tenuous balance among ecosystem components will also change. As phenology (timing of biological events) is altered, the overall effects among interacting species are difficult to predict, particularly given the rate of climate change and the ability of symbionts to adapt. Because ecosystem health is a function of water availability, temperature, carbon dioxide, and many other factors, it is difficult to accurately predict the extent, type, and magnitude of ecosystem change under future climate scenarios. Yet, should vegetation cover and moisture exchanging properties of the land change, important local and regional climate characteristics such as albedo (amount of radiation reflected by a surface), humidity, wind, and temperature will also change, with potential compounding effects to vegetation (Sprigg et al. 2000).

Climate may influence the distribution and abundance of plant and animal species, through changes in resource availability, fecundity, and survivorship. The potential ecological implications of climate change trends in the Southwest indicate:

- More extreme disturbance events, including wildland fires and intense rain, flash floods, and wind events (Swetnam et al. 1999).
- Greater vulnerability to invasive species, including insects, plants, fungi, and vertebrates (Joyce et al. 2007).
- Long-term shifts in vegetation patterns (Millar et al. 2007; Westerling et al. 2006).
- Cold-tolerant vegetation moving upslope if biologically able, or disappearing in some areas. Migration of some tree species (if able) to the more northern portions of their existing range (Clark 1998).
- Potential decreases in overall forest productivity, due to reduced precipitation (USDA Forest Service 2005).
- Shifts in the timing of snowmelt (already observed) in the American West, which, along with increases in summer temperatures, have serious implications for the survival of fish species, and may challenge efforts to reintroduce species into their historic range (Joyce et al. 2007; Millar et al. 2007).
- Increasing temperatures, water shortages, and changing ecological conditions will effect biodiversity, by putting pressure on wildlife populations, distribution, viability, and migration patterns. Top predators and herbivores are disproportionally at risk in warming environments, which favor autotrophs (e.g., plants, algae) and bacteriovores (NM 2005).

Vegetation

A warmer climate in the Southwest is expected to alter the biotic and abiotic stresses that influence the vigor of ecosystems and increase the extent and severity of disturbances, as a result. Decreasing water availability will accelerate the stresses on forests, which typically involve some combination of multi-year drought, insects, and fire. As has occurred in the past, increases in fire disturbance superimposed on ecosystems, with increased stress from drought and insects, may have significant effects on growth, regeneration, long-term distribution, and abundance of forest species, and carbon sequestration. Many southwestern ecosystems today contain water-limited vegetation. Vegetation productivity in the Southwest may decrease further with warming temperatures, as increasingly negative water balances constrain photosynthesis, although this may be partially offset, if CO2 fertilization significantly increases water-use efficiency in plants (USDA Forest Service 2010b).

In addition to overall increased drought, climatic extremes and variability of precipitation patterns relative to climate change presents greater uncertainties across years. Increased variability and intensity of storms is expected, so there may be more drought in some years, and greatly increased precipitation in others.

Inter-decadal climate variability strongly affects interior dry ecosystems, causing considerable growth during wet periods. This growth increases the evaporative demand, setting the ecosystem up for dieback during the ensuing dry period (Swetnam and Betancourt 1998). Piñon-juniper woodlands, for example, are clearly water-limited systems, and piñon- juniper ecotones are sensitive to feedbacks from environmental fluctuations. Existing canopy structure may provide trees a buffer against drought; however, severe, multiyear droughts may overwhelm local buffering and periodically cause dieback of piñon pines. Piñon dieback during the early 2000s was historically unprecedented in its combination of fire suppression influence (uncharacteristically dense stands), low precipitation, and high temperatures. Increased drought stress via warmer climate was the predisposing factor, and piñon pine mortality and fuel accumulations were inciting factors (USDA Forest Service 2010b). Pinyon ips beetles caused extensive mortality.

Temperature increases are a predisposing factor often causing lethal stresses on forest ecosystems of western North America, acting both directly, through increasingly negative water balances, and indirectly, through increased frequency, severity, and extent of disturbances—chiefly fire and insect outbreaks. Human development of the West has resulted in habitat fragmentation, barriers to migration such as dams, and the introduction of invasive species. The combination of development, presence of invasive species, complex topography, and climate change is likely to lead to a loss of biodiversity in the region. Some species may migrate to higher altitudes in mountainous areas; however, climate change is occurring more quickly than it has during past fluctuations (i.e., beyond the NRV). Some ecosystems, such as alpine tundra, may virtually disappear from the region (Joyce et al. 2008).

Natural disturbances with the greatest impact to forests include insects, diseases, introduced species, fires, drought, inland storms caused by hurricanes, flash flooding, landslides, windstorms, and ice storms. Climate variability and changes can alter the frequency, intensity, timing, and spatial extent of these disturbances. Many potential consequences of future climate change are expected to be buffered by the resilience of forests to natural climatic variation. However, an extensive body of literature suggests that new disturbance regimes under climate change are likely to result in significant perturbations to forests in the United States, with lasting ecological and socioeconomic impacts (Joyce et al. 2001).

Wildland fire

Historically, wildland fires have been a recurring disturbance in conifer forests, piñon-juniper woodlands, shrublands, and grassland ecosystems of the Southwest. An analysis of trends in wildland fire and climate in the western United States from 1974 to 2004 shows both the frequency of large wildland fires and fire season length increased substantially after 1985 (Westerling et al. 2006). These changes were closely linked with advances in the timing of spring snowmelt and increases in spring and summer air temperatures. Earlier spring snowmelt probably contributed to greater wildland fire frequency in at least two ways, by extending the period during which ignitions could potentially occur, and by reducing water availability to ecosystems in mid-summer before the arrival of the summer monsoons; thereby enhancing drying of vegetation and surface fuels (Westerling et al. 2006).

This trend of increased fire size corresponds with an increased cost for fire suppression over the same period. In recent years, areas of western forests have been increasingly impacted by wildland fires, with suppression costs of more than $1 billion per year from Federal land management agencies. Since about the mid-1970s, the total acreage of areas burned and the severity of wildland fires in pine and mixed-conifer forests have increased (USDA Forest Service 2010b). If temperatures increase, precipitation decreases, and overall drought conditions become more common, fire frequency and severity may be further exacerbated. In addition, continued population growth will likely cause greater human-caused fires, as nearly half of the fires in the Southwest are human caused (USDA Forest Service 2010b).

Insects and Diseases

Extensive reviews of the effects of climate change on insects and pathogens have reported many cases where climate change has affected and/or will affect forest insect species range and abundance, as witnessed in the Southwest (USDA Forest Service 2016a). Climate also affects insect populations indirectly through effects on hosts. Drought stress, resulting from decreased precipitation and/or warming, reduces the ability of a tree to mount a defense against insect attack, though this stress may also cause some host species to become more palatable to some types of insects (USDA Forest

Service 2016a). Periods of drought or even average precipitation levels exacerbated by higher temperatures and high stand densities could contribute to future accelerated tree mortality from widespread bark beetle outbreaks and increased incidence of other disease agents, such as *Armillaria* root rot.

Invasive Species

The Southwest suffers from many types of invasive species outbreaks, including plants and animals. Invasive plants can alter landscapes by overtaking native species, facilitating fire outbreaks, and altering the food supply for herbivorous animals and insects. For example, climate may favor the spread of invasive exotic grasses into arid lands, where the native vegetation is too sparse to carry a fire. When these areas burn, they typically convert to non-native monocultures, and native vegetation is lost (Ryan et al. 2008).

Climate Change Vulnerability Assessment

The Forest Service Southwestern Region and Rocky Mountain Research Station developed an all-lands climate change vulnerability assessment (CCVA) for major upland ecosystems of Arizona and New Mexico (USDA Forest Service 2016a). In order to adequately predict vulnerability, the landscape was first stratified into distinct Ecological Response Units (ERU), or plant communities, that repeat across the landscape. “Climate envelopes” were then developed for each major ERU on the Lincoln NF based on historic/contemporary climate data for New Mexico. Based on the anticipated effects of late 21st-century climate change on site potential and projected departure in future climate from the climate envelopes, the vulnerability of individual plant communities was assessed and scored as low, moderate, high, and very high. Departure scores were averaged together across the plan scale, by ERU within the plan scale, and by ERU at the local scale (Figure 2). The CCVA also provides a measure of uncertainty, which represents the degree of disagreement between different Global Circulation Models (GCMs), within a given emission scenario.

The assessment provides three scales of reporting for vulnerability:

Plan Unit Scale – Includes all lands within the administrative boundary of the Lincoln NF

Local Scale – Includes all lands within the six Lincoln local scale units, each made up of clusters of 6th-level watersheds

Sub-Watershed – Includes all lands within 6th-level watersheds that intersect the Lincoln NF.

Reporting at each of the three scales provides useful insights for interpretation of climate change vulnerability results for the Plan Area. In the following tables, vulnerability and uncertainty are reported for each scale and for all ecosystems collectively. In all cases the reporting reflects an all-lands summary, regardless of ownership. For the Plan and Local scales, reporting is also broken out by ERU. The CCVA results for the 6th-level watershed scale are shown as one vulnerability category for each, representing a composite scoring of vulnerability for all lands.

The CCVA does not include the desert ERUs due to issues encountered in the initial interpretation of results. Specifically, desert units are represented by low sample numbers; non-normal distributions were evident for some climate variables; and desert units are represented by samples only from the northern extents of the Sonoran province, suggesting that the resulting climate envelopes may be too conservative, and that vulnerability may be artificially inflated. For those reasons, the vulnerability surface was updated to exclude desert units (MSDS, SDS, CDS, and CSDS). Each is well-adapted to weather extremes and to other forms of variability across temporal scales. However, there is at least some indication that desert systems of the Southwest are already expressing vulnerability (e.g., Guida et al. 2014). Additionally, riparian ERUs were not specifically analyzed for CCVA due to a lack of sufficient data, although some vulnerability for these systems is indicated by the watershed-scale results of the CCVA.

Risk

The CCVA results indicate vulnerability, or ecological risk, based on the projected climate departure from the historic climate envelope for a given ERU and location. In broad terms it may be helpful to think of future climate simply as a potential stressor of significant change (i.e., on ecosystem structure, composition, function), with the vulnerability rating on par with risk or probability of stress—low, moderate, high, or very high. In more specific terms, vulnerability can be considered the “relative probability of type conversion” or ecological departure of the vegetation community. Vulnerability is a consequence of at least three factors: (1) breadth of the climate envelope for a given ERU; (2) current status of a given location relative to its ERU climate envelope; and (3) projected magnitude of climate change for that location. Also, the current resilience and resistance of ecosystems may influence climate change vulnerability and risk. High vulnerability may indicate either that the area is already stressed due to current climate, that climate in the area is predicted to shift far from the current envelope for the ERU, or a combination of both. Results of the CCVA are summarized below.

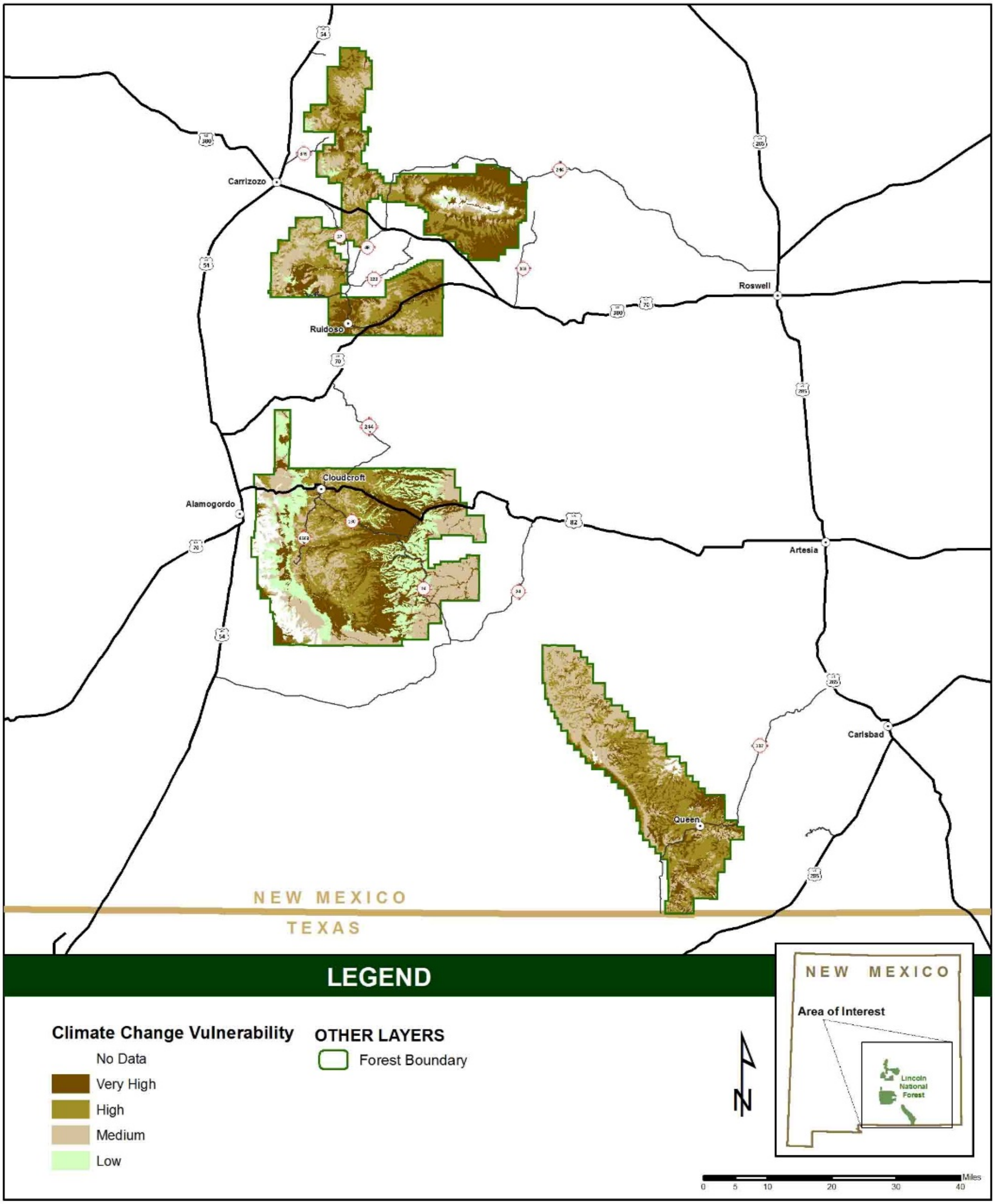

Figure 2. CCVA vulnerability surface for Lincoln NF and surrounding area. Desert ERUs (MSDS, SDS, CDS, and CSDS) are excluded

Plan Unit Scale

Based on the CCVA results, approximately 61 percent of the plan unit (including all ERUs or ecosystems regardless of land ownership) is at high or greater risk (vulnerability) due to climate change. Specifically, of the plan unit, 26 percent is at very high risk; 35 percent is at high risk; 29 percent is at moderate risk; and 10 percent is at low risk (Table 3).

Table 3. Climate change vulnerability at the Plan Unit (Plan Area) scale for all ecosystems combined

Forest	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Lincoln National Forest	Low Vulnerability	3%	7%	0%	10%
	Moderate Vulnerability	8%	18%	4%	29%
	High Vulnerability	7%	28%	0%	35%
	Very High Vulnerability	26%	0%	0%	26%
Grand Total		44%	53%	4%	

Of the major ERUs in the Plan Unit, ponderosa pine-evergreen oak (PPE), piñon-juniper grass (PJG), ponderosa pine forest (PPF), and spruce-fir forest (SFF) are the most vulnerable; and mountain mahogany mixed shrubland (MMS), piñon-juniper evergreen shrub (PJC), and semi-desert grassland (SDG) are the least vulnerable to climate change. Of the Forested ERUs, ponderosa pine forest (PPF), ponderosa pine-evergreen oak (PPE), and spruce-fir forest (SFF) are most vulnerable (Table 4).

Table 4. Climate change vulnerability at the plan scale by ERU

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
JUG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	1%	8%	4%	14%
	High Vulnerability	17%	39%	0%	56%
	Very High Vulnerability	30%	0%	0%	30%
JUG Total		49%	47%	4%	
MCD	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	19%	8%	28%
	High Vulnerability	4%	42%	0%	47%
	Very High Vulnerability	25%	0%	0%	25%
MCD Total		30%	62%	8%	
MCW	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	4%	0%	4%
	High Vulnerability	14%	51%	0%	65%
	Very High Vulnerability	31%	0%	0%	31%
MCW Total		45%	55%	0%	
MMS	Low Vulnerability	11%	10%	0%	22%
	Moderate Vulnerability	1%	28%	10%	39%
	High Vulnerability	2%	27%	0%	28%
	Very High Vulnerability	11%	0%	0%	11%

		Uncertainty Category			
ERU	**Vulnerability Category**	**Low**	**Mod**	**High**	**Total**
MMS Total		25%	65%	10%	
MPO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	10%	0%	10%
	High Vulnerability	16%	59%	0%	75%
	Very High Vulnerability	14%	0%	0%	14%
MPO Total		31%	69%	0%	
MSG	Low Vulnerability	13%	5%	0%	18%
	Moderate Vulnerability	4%	26%	2%	31%
	High Vulnerability	1%	44%	0%	45%
	Very High Vulnerability	6%	0%	0%	6%
MSG Total		23%	75%	2%	
PJC	Low Vulnerability	13%	37%	0%	50%
	Moderate Vulnerability	37%	12%	0%	50%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
PJC Total		50%	49%	1%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	1%	0%	2%
	High Vulnerability	12%	20%	0%	33%
	Very High Vulnerability	66%	0%	0%	66%
PJG Total		78%	22%	0%	
PJO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	7%	26%	2%	34%
	High Vulnerability	8%	45%	0%	53%
	Very High Vulnerability	12%	0%	0%	12%
PJO Total		28%	71%	2%	
PPE	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	5%	5%	0%	10%
	Very High Vulnerability	90%	0%	0%	90%
PPE Total		95%	5%	0%	
PPF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	5%	1%	5%
	High Vulnerability	11%	11%	0%	22%
	Very High Vulnerability	72%	0%	0%	72%
PPF Total		83%	16%	1%	
SDG	Low Vulnerability	2%	7%	0%	9%
	Moderate Vulnerability	0%	29%	29%	57%
	High Vulnerability	1%	22%	8%	31%

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
	Very High Vulnerability	2%	1%	0%	3%
SDG Total		5%	58%	36%	
SFF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	4%	1%	0%	5%
	Very High Vulnerability	95%	0%	0%	95%
SFF Total		99%	1%	0%	

Local Unit Scale

At the local unit scale, the CCVA indicated the following areas to be most vulnerable to climate change: Rio Hondo, Arroyo del Macho, Rio Peñasco, and Salt Basin (Table 5 through Table 16).

Table 5. Climate change vulnerability at the local scale for Arroyo Del Macho (all ecosystems combined)

Local Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Arroyo Del Macho	Low Vulnerability	1%	1%	0%	2%
	Moderate Vulnerability	2%	17%	3%	23%
	High Vulnerability	8%	31%	0%	39%
	Very High Vulnerability	36%	0%	0%	36%
Grand Total		47%	49%	3%	

Table 6. Climate change vulnerability for major ERUs of the Arroyo Del Macho local unit

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
JUG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	2%	13%	13%	29%
	High Vulnerability	14%	57%	0%	70%
	Very High Vulnerability	1%	0%	0%	1%
JUG Total		17%	70%	13%	
MCD	Low Vulnerability	0%	1%	0%	1%
	Moderate Vulnerability	0%	24%	20%	43%
	High Vulnerability	5%	38%	0%	43%
	Very High Vulnerability	13%	0%	0%	13%
MCD Total		18%	63%	20%	
MMS	Low Vulnerability	22%	29%	0%	51%
	Moderate Vulnerability	0%	22%	21%	43%
	High Vulnerability	0%	7%	0%	7%
	Very High Vulnerability	0%	0%	0%	0%
MMS Total		22%	58%	21%	

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
MSG	Low Vulnerability	32%	3%	0%	35%
	Moderate Vulnerability	1%	8%	4%	12%
	High Vulnerability	0%	41%	0%	41%
	Very High Vulnerability	11%	0%	0%	11%
MSG Total		45%	51%	4%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	3%	0%	3%
	High Vulnerability	15%	21%	0%	36%
	Very High Vulnerability	61%	0%	0%	61%
PJG Total		76%	24%	0%	
PJO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	4%	24%	1%	29%
	High Vulnerability	8%	39%	0%	47%
	Very High Vulnerability	24%	0%	0%	24%
PJO Total		37%	62%	1%	
PPF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	5%	1%	7%
	High Vulnerability	9%	16%	0%	25%
	Very High Vulnerability	68%	0%	0%	68%
PPF Total		77%	21%	1%	
SFF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	100%	0%	0%	100%
SFF Total		100%	0%	0%	

Table 7. Climate change vulnerability at the local scale for Rio Hondo (all ecosystems combined)

Local Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Rio Hondo	Low Vulnerability	1%	1%	0%	2%
	Moderate Vulnerability	5%	15%	3%	24%
	High Vulnerability	11%	32%	0%	43%
	Very High Vulnerability	31%	0%	0%	31%
Grand Total		49%	48%	3%	

Table 8. Climate change vulnerability for major ERUs of the Rio Hondo local unit

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	2%	5%	6%	14%

		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
JUG	High Vulnerability	28%	51%	0%	79%
	Very High Vulnerability	8%	0%	0%	8%
JUG Total		37%	56%	6%	
MCD	Low Vulnerability	1%	1%	0%	2%
	Moderate Vulnerability	0%	29%	19%	47%
	High Vulnerability	3%	39%	0%	42%
	Very High Vulnerability	8%	0%	0%	8%
MCD Total		12%	69%	19%	
MCW	Low Vulnerability	5%	32%	0%	37%
	Moderate Vulnerability	0%	12%	43%	55%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	9%	0%	0%	9%
MCW Total		13%	44%	43%	
MMS	Low Vulnerability	22%	29%	0%	51%
	Moderate Vulnerability	0%	22%	21%	43%
	High Vulnerability	0%	7%	0%	7%
	Very High Vulnerability	0%	0%	0%	0%
MMS Total		22%	58%	21%	
MSG	Low Vulnerability	39%	16%	0%	55%
	Moderate Vulnerability	4%	8%	3%	15%
	High Vulnerability	0%	24%	0%	24%
	Very High Vulnerability	5%	0%	0%	5%
MSG Total		48%	49%	3%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	5%	0%	5%
	High Vulnerability	9%	29%	0%	37%
	Very High Vulnerability	58%	0%	0%	58%
PJG Total		67%	33%	0%	
PJO	Low Vulnerability	1%	0%	0%	1%
	Moderate Vulnerability	9%	17%	0%	26%
	High Vulnerability	14%	38%	0%	52%
	Very High Vulnerability	22%	0%	0%	22%
PJO Total		45%	55%	0%	
PPF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	8%	2%	10%
	High Vulnerability	12%	18%	0%	30%
	Very High Vulnerability	59%	0%	0%	59%
PPF Total		72%	27%	2%	
	Low Vulnerability	0%	0%	0%	0%

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
SFF	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	4%	1%	0%	5%
	Very High Vulnerability	95%	0%	0%	95%
SFF Total		98%	2%	0%	

Table 9. Climate change vulnerability at the local scale for Rio Peñasco (all ecosystems combined)

Local Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Rio Peñasco	Low Vulnerability	6%	14%	0%	20%
	Moderate Vulnerability	15%	12%	3%	30%
	High Vulnerability	5%	20%	0%	25%
	Very High Vulnerability	26%	0%	0%	26%
Grand Total		51%	46%	3%	

Table 10. Climate change vulnerability for major ERUs of the Rio Peñasco local unit

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
MCD	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	18%	5%	23%
	High Vulnerability	5%	45%	0%	49%
	Very High Vulnerability	28%	0%	0%	28%
MCD Total		32%	63%	5%	
MCW	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	4%	0%	4%
	High Vulnerability	14%	52%	0%	66%
	Very High Vulnerability	29%	0%	0%	29%
MCW Total		43%	57%	0%	
MMS	Low Vulnerability	23%	19%	0%	42%
	Moderate Vulnerability	2%	33%	22%	57%
	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	0%	0%	0%	0%
MMS Total		25%	53%	22%	
MSG	Low Vulnerability	1%	0%	0%	1%
	Moderate Vulnerability	8%	63%	0%	72%
	High Vulnerability	0%	27%	0%	27%
	Very High Vulnerability	1%	0%	0%	1%
MSG Total		10%	90%	0%	
PJC	Low Vulnerability	13%	37%	0%	49%
	Moderate Vulnerability	42%	8%	0%	51%
	High Vulnerability	0%	0%	0%	0%

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
MCD	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	18%	5%	23%
	High Vulnerability	5%	45%	0%	49%
	Very High Vulnerability	28%	0%	0%	28%
MCD Total		32%	63%	5%	
MCW	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	4%	0%	4%
	High Vulnerability	14%	52%	0%	66%
	Very High Vulnerability	29%	0%	0%	29%
MCW Total		43%	57%	0%	
	Very High Vulnerability	0%	0%	0%	0%
PJC Total		55%	45%	0%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	1%	0%	1%
	High Vulnerability	10%	3%	0%	13%
	Very High Vulnerability	86%	0%	0%	86%
PJG Total		96%	4%	0%	
PPF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	13%	5%	0%	18%
	Very High Vulnerability	81%	0%	0%	81%
PPF Total		94%	6%	0%	
SDG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	15%	54%	69%
	High Vulnerability	0%	15%	15%	30%
	Very High Vulnerability	1%	0%	0%	1%
SDG Total		1%	30%	69%	

Table 11. Climate change vulnerability at the local scale for Salt Basin (all ecosystems combined)

Local Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Salt Basin	Low Vulnerability	2%	6%	0%	9%
	Moderate Vulnerability	7%	24%	5%	36%
	High Vulnerability	5%	29%	0%	34%
	Very High Vulnerability	22%	0%	0%	22%
Grand Total		36%	59%	5%	

Table 12. Climate change vulnerability for major ERUs of the Salt Basin local unit

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
JUG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	25%	1%	26%
	High Vulnerability	0%	74%	0%	74%
	Very High Vulnerability	0%	0%	0%	0%
JUG Total		0%	99%	1%	
MCD	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	18%	4%	22%
	High Vulnerability	5%	40%	0%	44%
	Very High Vulnerability	33%	0%	0%	33%
MCD Total		38%	58%	4%	
MCW	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	3%	0%	3%
	High Vulnerability	12%	46%	0%	59%
	Very High Vulnerability	38%	0%	0%	38%
MCW Total		51%	49%	0%	
MMS	Low Vulnerability	9%	6%	0%	15%
	Moderate Vulnerability	1%	40%	10%	51%
	High Vulnerability	1%	31%	0%	32%
	Very High Vulnerability	1%	0%	0%	1%
MMS Total		13%	77%	10%	
MPO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	9%	1%	9%
	High Vulnerability	13%	70%	0%	83%
	Very High Vulnerability	7%	0%	0%	7%
MPO Total		20%	79%	1%	
MSG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	10%	62%	0%	72%
	High Vulnerability	0%	27%	0%	28%
	Very High Vulnerability	0%	0%	0%	0%
MSG Total		11%	89%	0%	
PJC	Low Vulnerability	10%	35%	0%	45%
	Moderate Vulnerability	43%	10%	1%	55%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
PJC Total		53%	45%	1%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	12%	23%	0%	35%

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
	Very High Vulnerability	65%	0%	0%	65%
PJG Total		77%	23%	0%	
PJO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	46%	5%	51%
	High Vulnerability	0%	48%	0%	49%
	Very High Vulnerability	0%	0%	0%	0%
PJO Total		0%	94%	5%	
PPE	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	6%	5%	0%	11%
	Very High Vulnerability	89%	0%	0%	89%
PPE Total		95%	5%	0%	
PPF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	1%	0%	1%
	High Vulnerability	15%	8%	0%	23%
	Very High Vulnerability	76%	0%	0%	76%
PPF Total		92%	8%	0%	
SDG	Low Vulnerability	0%	1%	0%	1%
	Moderate Vulnerability	0%	37%	2%	39%
	High Vulnerability	11%	30%	1%	42%
	Very High Vulnerability	18%	1%	0%	19%
SDG Total		28%	69%	3%	

Table 13. Climate change vulnerability at the local scale for Tularosa Valley (all ecosystems combined)

Local Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Tularosa Valley	Low Vulnerability	4%	9%	0%	13%
	Moderate Vulnerability	6%	21%	5%	31%
	High Vulnerability	6%	31%	0%	38%
	Very High Vulnerability	18%	0%	0%	18%
Grand Total		34%	61%	5%	

Table 14. Climate change vulnerability for major ERUs of the Tularosa Valley local unit

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
MCD	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	28%	11%	39%
	High Vulnerability	3%	47%	0%	50%
	Very High Vulnerability	10%	0%	0%	10%
MCD Total		13%	75%	11%	

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
MCW	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	5%	0%	5%
	High Vulnerability	14%	57%	0%	71%
	Very High Vulnerability	24%	0%	0%	24%
MCW Total		38%	62%	0%	
MMS	Low Vulnerability	37%	42%	0%	79%
	Moderate Vulnerability	1%	12%	7%	19%
	High Vulnerability	0%	2%	0%	2%
	Very High Vulnerability	0%	0%	0%	0%
MMS Total		38%	55%	7%	
MSG	Low Vulnerability	25%	12%	0%	36%
	Moderate Vulnerability	8%	40%	2%	50%
	High Vulnerability	0%	13%	0%	14%
	Very High Vulnerability	0%	0%	0%	0%
MSG Total		33%	65%	2%	
PJC	Low Vulnerability	14%	55%	0%	69%
	Moderate Vulnerability	20%	11%	0%	31%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
PJC Total		34%	65%	0%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	5%	0%	5%
	High Vulnerability	19%	25%	0%	44%
	Very High Vulnerability	51%	0%	0%	51%
PJG Total		71%	29%	0%	
PJO	Low Vulnerability	2%	0%	0%	2%
	Moderate Vulnerability	16%	36%	1%	53%
	High Vulnerability	4%	42%	0%	45%
	Very High Vulnerability	0%	0%	0%	0%
PJO Total		21%	78%	1%	
PPF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	11%	2%	14%
	High Vulnerability	16%	21%	0%	37%
	Very High Vulnerability	49%	0%	0%	49%
PPF Total		65%	32%	2%	
SDG	Low Vulnerability	3%	14%	0%	17%
	Moderate Vulnerability	0%	15%	40%	55%
	High Vulnerability	0%	14%	11%	25%
	Very High Vulnerability	1%	2%	0%	3%

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
SDG Total		4%	44%	52%	
SFF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	5%	1%	0%	6%
	Very High Vulnerability	93%	0%	0%	93%
SFF Total		98%	2%	0%	

Table 15. Climate change vulnerability at the local scale for Upper Pecos – Black River (all ecosystems combined)

Local Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
Upper Pecos – Black River	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	31%	5%	36%
	High Vulnerability	5%	41%	0%	45%
	Very High Vulnerability	19%	0%	0%	19%
Grand Total		23%	71%	5%	

Table 16. Climate change vulnerability for major ERUs of the Upper Pecos – Black River local unit

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
JUG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	8%	0%	9%
	High Vulnerability	11%	32%	0%	43%
	Very High Vulnerability	48%	0%	0%	48%
JUG Total		59%	40%	0%	
MCD	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	100%	0%	0%	100%
MCD Total		100%	0%	0%	
MMS	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	23%	1%	24%
	High Vulnerability	3%	52%	0%	55%
	Very High Vulnerability	21%	0%	0%	21%
MMS Total		25%	74%	1%	
MPO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	10%	0%	11%
	High Vulnerability	16%	59%	0%	75%
	Very High Vulnerability	15%	0%	0%	15%
MPO Total		31%	69%	0%	
	Low Vulnerability	0%	0%	0%	0%

ERU	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
PJC	Moderate Vulnerability	0%	74%	21%	96%
	High Vulnerability	0%	4%	0%	4%
	Very High Vulnerability	0%	0%	0%	0%
	PJC Total	0%	79%	21%	
PJG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	11%	21%	0%	32%
	Very High Vulnerability	68%	0%	0%	68%
	PJG Total	79%	21%	0%	
PJO	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	38%	4%	42%
	High Vulnerability	1%	58%	0%	58%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	1%	95%	4%	
PPE	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
	High Vulnerability	6%	5%	0%	11%
	Very High Vulnerability	89%	0%	0%	89%
	PPE Total	95%	5%	0%	
SDG	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	60%	1%	61%
	High Vulnerability	4%	30%	0%	34%
	Very High Vulnerability	4%	0%	0%	4%
	SDG Total	8%	90%	2%	

Sub-watershed Scale

Of the 95 sub-watershed scale units analyzed (including all ERUs or ecosystems regardless of land ownership), 13 (14 percent) showed very high vulnerability; 57 (60 percent) showed high vulnerability; and 25 (26 percent) showed moderate vulnerability to climate change (Table 17).

Table 17. Sub-watershed vulnerability. Composite (all ERU) CCVA scores for each 6th-level watershed that intersect the Lincoln NF. As with the previous tables, these results represent all lands regardless of ownership.

6th-Level HUC	HUC Name	Composite Vulnerability Category
130500030301	Big Pine Canyon	High Vulnerability
130500030302	Headwaters Ancho Gulch	High Vulnerability
130500030407	Coyote Canyon	High Vulnerability
130500030408	Headwaters White Oaks Draw	High Vulnerability
130500030409	Outlet White Oaks Draw	Moderate Vulnerability
130500030501	Tortolita Arroyo	Moderate Vulnerability
130500030502	Nogal Creek	Moderate Vulnerability
130500030503	Nogal Draw	High Vulnerability
130500030504	Lemon Draw	High Vulnerability

6th-Level HUC	HUC Name	Composite Vulnerability Category
130500030505	Willow Draw	Moderate Vulnerability
130500030506	Harkey Draw-Nogal Arroyo	Moderate Vulnerability
130500030507	Cottonwood Creek	Moderate Vulnerability
130500031102	Gamble Canyon-Three Rivers	Moderate Vulnerability
130500031103	Golondrina Draw-Three Rivers	High Vulnerability
130500031203	Nogal Canyon	Moderate Vulnerability
130500031205	MiddleTularosa Creek	Moderate Vulnerability
130500031401	Cottonwood Wash	High Vulnerability
130500031403	Sabinata Flat Arroyo	Moderate Vulnerability
130500031404	Domingo Canyon	Moderate Vulnerability
130500031501	Fresnal Canyon	Moderate Vulnerability
130500031502	La Luz Canyon	Moderate Vulnerability
130500031503	Lost River	Moderate Vulnerability
130500031601	Marble Canyon-Dry Canyon	Moderate Vulnerability
130500031602	Dillard Draw	Moderate Vulnerability
130500031701	Alamo Canyon	Moderate Vulnerability
130500031702	Mule Canyon	Moderate Vulnerability
130500031703	Dog Canyon	Moderate Vulnerability
130500031704	Grapevine Canyon	Moderate Vulnerability
130500031705	Bug Scuffle Canyon	Moderate Vulnerability
130500031706	Escondida Well	Very High Vulnerability
130500031806	Pipeline Canyon	Moderate Vulnerability
130500031808	Esoon Peak	Very High Vulnerability
130500040101	Arkansas Canyon-Sacramento River	High Vulnerability
130500040102	Ben WIlliams Canyon-Sacramento River	High Vulnerability
130500040103	Prather Ranch-Sacramento River	Moderate Vulnerability
130500040105	El Paso Canyon	Moderate Vulnerability
130500040401	Lick Canyon-Piñon Creek	High Vulnerability
130500040402	Stevens Draw	Moderate Vulnerability
130500040403	Stevens Draw-Piñon Creek	High Vulnerability
130500040405	Lewis Canyon	Moderate Vulnerability
130500040601	Upper Piñon Wash	Moderate Vulnerability
130500040603	Little Dog Canyon	Moderate Vulnerability
130500040604	Pup Canyon	High Vulnerability
130500040605	Middle Piñon Wash	Moderate Vulnerability
130500040606	Lower Piñon Wash	Very High Vulnerability
130500040701	Outlet Big Dog Canyon	High Vulnerability
130500040702	Upper Dog Canyon	High Vulnerability
130500040704	Box Canyon	High Vulnerability
130600050101	Upper Reventon Draw	High Vulnerability
130600050102	Middle Reventon Draw	High Vulnerability
130600050201	Upper Hasperos Canyon	High Vulnerability
130600050202	Carrabajal Cemetery	Moderate Vulnerability
130600050203	Lavade Draw	Moderate Vulnerability
130600050204	Middle Hasperos Canyon	High Vulnerability
130600050301	Aragon Creek	High Vulnerability
130600050302	Cottonwood Canyon-Arroyo del Macho	High Vulnerability

6th-Level HUC	HUC Name	Composite Vulnerability Category
130600050303	Reventon Draw-Arroyo del Macho	High Vulnerability
130600050501	Copeland Canyon-Seco Arroyo	Very High Vulnerability
130600050502	Red Lick Canyon	Very High Vulnerability
130600050503	Arroyo Serrano	Very High Vulnerability
130600050504	Zeufeldt Arroyo	Very High Vulnerability
130600080101	Carrizo Creek	Very High Vulnerability
130600080102	Cherokee Bill Canyon	High Vulnerability
130600080103	Upper Rio Ruidoso	High Vulnerability
130600080104	Water Hole Canyon	High Vulnerability
130600080105	Devils Canyon	High Vulnerability
130600080106	Middle Rio Ruidoso	High Vulnerability
130600080107	Lower Rio Ruidoso	Very High Vulnerability
130600080201	Upper Rio Bonita	High Vulnerability
130600080202	Magado Canyon	High Vulnerability
130600080203	Headwaters Salado Creek	High Vulnerability
130600080204	Gyp Spring Canyon	High Vulnerability
130600080205	Outlet Salado Creek	High Vulnerability
130600080206	Salazar Canyon	High Vulnerability
130600080207	Middle Rio Bonita	High Vulnerability
130600080208	Lower Rio Bonita	High Vulnerability
130600080301	Maverick Canyon	High Vulnerability
130600080401	Chavez Canyon	Very High Vulnerability
130600080402	Alamo Canyon	High Vulnerability
130600080501	Escondido Canyon	Very High Vulnerability
130600080502	Agua Chiquito Creek-Blackwater Canyon	High Vulnerability
130600100101	Silver Springs Canyon	High Vulnerability
130600100103	Sixteen Springs Canyon	High Vulnerability
130600100104	Outlet Elk Canyon	High Vulnerability
130600100201	Upper Agua Chiquita	High Vulnerability
130600100202	Middle Agua Chiquita	High Vulnerability
130600100203	Mule Canyon	Moderate Vulnerability
130600100204	Lower Agua Chiquita	Moderate Vulnerability
130600100301	Cox Canyon	High Vulnerability
130600100302	Cox Canyon-Rio Peñasco	High Vulnerability
130600100303	James Canyon	High Vulnerability
130600100304	James Canyon-Rio Peñasco	Very High Vulnerability
130600100305	Burnt Canyon	Moderate Vulnerability
130600100306	Burnt Canyon-Rio Peñasco	High Vulnerability
130600100401	Perk Canyon	High Vulnerability
130600100402	Perk Canyon-Cuervo Creek	High Vulnerability
130600100403	Chimney Canyon-Cuervo Creek	Moderate Vulnerability
130600100404	Long Canyon	Moderate Vulnerability
130600100405	Long Canyon-Cuervo Creek	Moderate Vulnerability
130600100502	Big Cherry Canyon	Moderate Vulnerability
130600100503	Big Cherry Canyon-Rio Peñasco	Moderate Vulnerability
130600110404	Bear Canyon	Moderate Vulnerability
130600110405	Bullis Canyon	Moderate Vulnerability

6th-Level HUC	HUC Name	Composite Vulnerability Category
130600110501	Wildhorse Canyon-Box Canyon	High Vulnerability
130600110502	Seco Canyon-Box Canyon	High Vulnerability
130600110601	Antelope Draw-Segrest Draw	Moderate Vulnerability
130600110605	Headwaters Crooked Canyon	Moderate Vulnerability
130600110606	Holt Tank Draw	Moderate Vulnerability
130600110607	Outlet Crooked Canyon	Moderate Vulnerability
130600110701	North Rocky Arroyo	High Vulnerability
130600110702	North Rocky Arroyo-Rocky Arroyo	High Vulnerability
130600110704	Headwaters Dunnaway Draw	High Vulnerability
130600110706	Dunnaway Draw-Rocky Arroyo	Moderate Vulnerability
130600110801	Upper Last Chance Canyon	High Vulnerability
130600110802	Middle Last Chance Canyon	High Vulnerability
130600110803	Wagontire Draw	High Vulnerability
130600110804	Lower Last Chance Canyon	Very High Vulnerability
130600110901	Turkey Canyon	High Vulnerability
130600110902	Turkey Canyon-Dark Canyon	High Vulnerability
130600110903	Last Chance Canyon-Dark Canyon	High Vulnerability
130600111101	Big Canyon	High Vulnerability
130600111102	Big Canyon-McKittrick Canyon	High Vulnerability
130600111104	McKittrick Canyon-Black River	High Vulnerability
130600111105	Rattlesnake Canyon	High Vulnerability

Conclusion

The CCVA results indicate that considerable portions of ecosystems in the Plan Area and characteristic plant communities within and near the Lincoln NF are at risk of ecological departure due to climate change, at present and in the future.

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments relating to drivers and stressors encompassed: forest density, woody encroachment, and loss of open, savannah-like areas and meadows; diseased trees and forest health; altered fire cycles and catastrophic fires; fire and fuels management; limited use, size and effectiveness of controlled burns; decreased precipitation and moisture; resource damage associated with OHV/ATV proliferation; ecosystem services, multiple uses; decline in timber harvest; forest management that is too intensive/not intensive enough; roads and development; weed proliferation; and grazing and degraded range and grasslands.

Expressed values (desires) included: healthy, functioning ecosystems resilient to disturbance; restoration of natural fire and disturbance cycles; and effective communication, collaboration, and decision-making. Additional comment topics related to drivers and stressors are listed in the Stakeholder Input sections of the other chapters in this volume, as pertinent. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for Regional Office approval prior to finalizing it.

Chapter 4 - Terrestrial Vegetation

Introduction

An ecosystem is a spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries (36 CFR 219.19). Ecosystem or ecological integrity is the quality or condition of an ecosystem, when its dominant ecological characteristics (e.g., composition, structure, function, connectivity, and species composition and diversity) act to maintain that quality or condition and maximize its ability to withstand or recover from perturbations imposed by natural environmental dynamics or human influence. Ecosystem sustainability is the capability of an ecosystem to meet the needs of the present generation, without compromising the ability to meet their needs of future generations. Ecosystem sustainability refers to the capability of ecosystems to maintain ecological integrity (36 CFR 219.19). The following chapter briefly discusses ecosystem services provided by the Lincoln NF and its terrestrial vegetation, the system drivers and stressors acting on ecosystems, and lists the ecological characteristics used to gauge the health of terrestrial ecosystems. The scales of analysis are discussed and the classification of ecosystems into Ecological Response Units (ERUs) and how they relate to the analysis are introduced and described.

Ecosystem Services of Terrestrial Vegetation

The diverse upland vegetation across the Lincoln NF provides many supporting, regulating, provisioning and cultural ecosystem services. Vegetative biodiversity supports and reflects the biodiversity in animal life that has co-evolved with various plant forms over time. Habitat for wildlife is an important supporting role of vegetation communities. The genetic variation inherent in vegetative biodiversity provides a regulatory service of system resilience through adaptive vegetation responses to an ever-changing environment, including climate changes. Soil formation and nutrient cycling are supported by vegetation. Vegetation is the most influential biotic driver of soil formation and the unique ability of plants to create food from the energy of the sun through the process of photosynthesis is the foundational support for nutrient cycling services. Regulatory services provided by vegetation include water cycling and filtration, erosion control and climate regulation. Vegetation moderates the passage of water across landscapes to mitigate floods and assists in holding soils in place so they can provide water filtration. Without soil, which is retained in part by the interlocking roots of many plants, clean water would be unattainable in the natural environment. Through evapo-transpiration, plants contribute to water cycling by pulling water up from the ground and releasing it into the air; this moisture contributes significantly to the Southwest’s summer monsoon storms. Vegetation provides shade that can mitigate increases in ambient temperature. Climate regulation is significant in the maintenance of many organisms, especially those that are immobile.

Since plants take in carbon dioxide and release oxygen as a byproduct of their respiratory process, they provide breathable air as a provisioning service. Forage, traditional foods and medicines, fuel and wood products are also provisioning services provided by the vegetation of the Lincoln NF. Cultural ecosystem services are provided by vegetation types and plant species across the forest as they contribute to aesthetics, support cultural values and provide opportunities for education, research, recreation, and tourism.

System Drivers and Stressors for Terrestrial Vegetation

System drivers here refers to the natural disturbance or growth regimes that sustainable functioning ecosystems evolve with and to which they area adapted. System stressors are those disturbance agents that act on ecosystems with the potential to move ecosystems outside their historical range of variation (HRV). System drivers and stressors for upland vegetation include:

- Current climate regime (driver)
- Natural vegetation succession (driver)
- Wildfire (driver/stressor)
- Vegetation manipulation and anthropogenic ground disturbance (driver/stressor)
- Domestic and native ungulate grazing (stressor)
- Insects and diseases (driver/stressor)
- Invasive species (stressor)
- Climate change, uncharacteristic drought (stressor)

System drivers and stressors are discussed individually in more detail in the System Drivers and Stressors chapter. They are also discussed in the following ecological characteristic sections, which serve to measure the effects of the stressors against a reference condition for those characteristics.

Data, Methods and Scales of Analysis for Terrestrial Vegetation

This assessment evaluates terrestrial ecosystems at four spatial scales:

- **Context Scale** = Ecoregion Sections and Subsections
- **Plan Scale** = the Lincoln NF
- **Local Scale** = subdivisions within the Lincoln NF at the sub-basin (HUC 4) level
- **Fire Regime Local Scale** = subdivisions within the Lincoln NF at the watershed (HUC 5) level.

This assessment focuses primarily on the vegetation conditions found within the administrative boundaries of the Lincoln NF (Plan Area). The importance or “contribution to sustainability” of vegetation managed by the Lincoln NF can be quantified by comparing the quantity and spatial extent of vegetation types within and outside of the Forest administrative boundary. The following discussion places the Lincoln NF in the broader context of the surrounding landscape (Context Area) and uses a hierarchical framework of ecological map units including ecoregion provinces, sections, and subsections as described below. Local units help localize where ecosystem sustainability is threatened on the forest. Most ecological characteristics in this chapter use the six Local units described below. For the ecological characteristics of Fire Regime (fire frequency, severity and condition class), Local units were further subdivided to illustrate local differences in fire regime and history.

Context Area

A scale larger than the Forest is desirable to understand the environmental context, opportunities and limitations of NFS lands’ ability to contribute to ecological sustainability. This context scale, or area, is defined by the intersection of the Lincoln and Gila National Forests with Ecological Sections and Subsections from the National Hierarchical Framework of Ecological Units (ECOMAP, 1993; Cleland et al. 1997) to provide an adequate area for comparison of off-forest land with either National Forest. (Figure 3).

With regard to the Context Area, the Lincoln NF is located within the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Ecoregion Province (M313) (McNab and Avers 1994; McNab et al. 2005, 2007); the analysis Context Area for the Lincoln NF is defined as the combined area of the White Mountains-San Francisco Peaks-Mogollon Rim (M313A), Sacramento-Manzano Mountains (M313B) Ecoregion Sections, and the Chihuahuan Semi-Desert Ecoregion Province’s Basin and Range (321A) Ecoregion Section. These ecoregion sections are displayed below in Figure 3. Detailed descriptions of each ecoregion section are provided by McNab and Avers (1994) and McNab and other (2005, 2007).

This broad-scale analysis was done to set the context for the contributions the Lincoln NF makes to ecological sustainability. As described by Bailey (1980, 1983, 1985 and 1998), Ecoregions distinguish areas that share common climatic and vegetation characteristics (Cleland et al. 1997). Ecoregions are subdivided into provinces, which are controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soils. Sections are a subdivision of provinces, described by broad areas of similar sub-regional climate, geomorphic process, geology, geologic origin, topography, and drainage networks. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings such as those mapped by Küchler (1964). Ecological subsections are a further division of sections, and described by areas with similar surface geology, geomorphic process, soil groups, sub-regional climate, and potential natural vegetation communities (McNab and Avers 1994). The Context Area and the Lincoln National Forest share (Table 18) the various climate, sub-climate, geologic, soil and vegetation characteristics of the subsections described above.

Figure 3 shows the relationship (1.1 million acres) of the Lincoln NF to the overall Context Area within the Ecoregion framework. Overall, the three ecoregion sections and the 27 subsections total nearly 46.4 million acres within Arizona and New Mexico. The Lincoln NF occupies 2.4 percent of these total acres. The remaining 97.6 percent of the lands within the ecoregion sections are owned or managed by a diversity of entities; including the Apache-Sitgreaves, Coconino, Coronado, Lincoln, Kaibab, Prescott and Tonto National Forests, the states of Arizona and New Mexico, Bureau of Land Management, Bureau of Reclamation, Department of Defense, National Park Service, Fish and Wildlife Service, White Mountain, San Carlos and Mescalero Apache Nations, and several private organizations and citizens.

Plan Area

The Plan Area is the Lincoln National Forest (NF). The Lincoln NF is located within the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow ecoregion province (M313) (McNab and Avers, 1994; McNab et al. 2005 and 2007); and is located almost entirely (98 percent) within 3 of 5 subsections in the province’s Sacramento-Manzano Mountains ecoregion section M313B. The Lincoln NF is also represented in the Artesia Plains Desert Grass-Shrubland (approximately 2 percent), Jornada Plains Desert Grass-Shrubland (0.2 percent), and the Trans-Pecos Desert Shrubland (less than 0.05 percent).

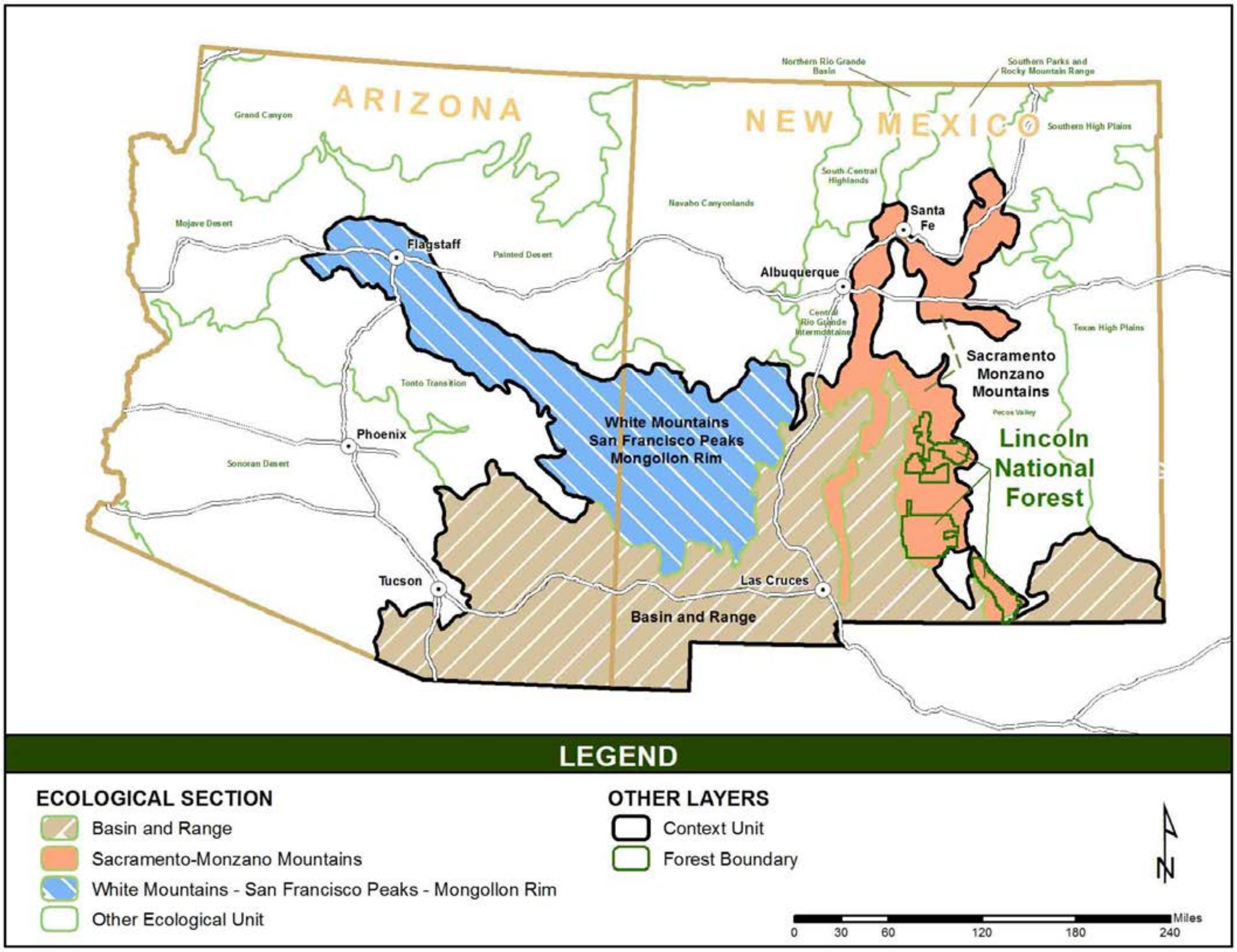

Figure 3. Lincoln NF in relation to the analysis Context Area, of the White Mountains-San Francisco Peaks-Mogollon Rim (M313A), Sacramento-Manzano Mountains (M313B), and Basin and Range (321A) Ecoregion Sections

Local Units

To further help refine the assessment and to capture local variation in ecosystem condition, the Forest was further subdivided into local units, which were developed following two USFS Southwestern Regional Office guidelines: 1) there should be between four and eight units; and 2) there should be representation of as many of the Lincoln NF ecosystems in as many local units as possible. The intent of the local unit scale is to identify any patterns in resource conditions across the Forest that might exist and provide information for consideration in determining future management priorities. Following the guidelines above, the Lincoln NF was subdivided by sub-basin (fourth level HUC) into six local units: Arroyo Del Macho Rio Hondo, Rio Peñasco, Salt Basin, Tularosa Valley, and Upper Pecos-Black River (Figure 4).

When information is available, key ecosystem characteristics are assessed at the local scale. Systems may be at risk in some local units, but not others. For example, large fires have occurred in certain watersheds, significantly altering the structure of some ecosystems and putting the function of those ecosystems at risk. The six local units are designed to distinguish those differences.

Three ecological characteristics relating to fire regimes (fire severity, fire frequency, and fire regime condition class) use a local scale of analysis delineated at the watershed level (fifth level HUC) in order to capture local variation in condition and departure from reference conditions (see Fire Rotation, Fire Severity, Fire Regime Condition Class section). These Fire Regime Local Units are wholly contained within the six sub-basin Local Units described above and shown in Figure 19.

Table 18. Land area, in acres, of the Lincoln NF in relation to the Context Area (CA) of the ecoregion sections and 27 subsections in which it occurs

Province	Section	Section Name	Subsection	Subsection Name	Context Acres	LNF Acres	Non-LNF acres	% Context	% LNF	% Non LNF
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ab	Mangas High Plains Grassland	190,299	0	190,299	0.4	0.0	0.4
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ac	Burro Mountains Oak-Juniper Woodland	128,384	0	128,384	0.3	0.0	0.3
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ad	Mogollon Mountains Woodland	3,586,309	0	3,586,309	7.7	0.0	7.9
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ae	Mogollon Mountains Coniferous Forest	1,786,770	0	1,786,770	3.8	0.0	3.9
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Af	White Mountains Scarp Woodland-Coniferous Forest	321,794	0	321,794	0.7	0.0	0.7
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ag	White Mountains Woodland	1,056,481	0	1,056,481	2.3	0.0	2.3
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ah	White Mountains Coniferous Forest	2,122,316	0	2,122,316	4.6	0.0	4.7
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Ak	Coconino Plateau Woodland	1,610,444	0	1,610,444	3.5	0.0	3.6
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Al	Coconino Plateau Coniferous Forest	1,973,853	0	1,973,853	4.3	0.0	4.4
313	313A	White Mtns-San Francisco Peaks-Mogollon Rim	313Am	San Francisco Peaks Coniferous Forest	681,241	0	681,241	1.5	0.0	1.5
313	313B	Sacramento-Monzano Mtns	313Ba	Guadalupe Mountains Woodland	458,274	260,678	197,596	1.0	23.8	0.4
313	313B	Sacramento-Monzano Mtns	313Bb	San Andres Mountains Woodland	943,446	0	943,446	2.0	0.0	2.1
313	313B	Sacramento-Monzano Mtns	313Bd	Manzano Mountains Woodland	3,705,858	0	3,705,858	8.0	0.0	8.2
313	313B	Sacramento-Monzano Mtns	313Bf	Sacramento Mountains Woodland Forest	1,962,096	294,377	1,667,718	4.2	26.9	3.7
313	313B	Sacramento-Monzano Mtns	313Bg	Sacramento Mountains Coniferous Forest	1,088,300	511,563	576,737	2.3	46.7	1.3

Province	Section	Section Name	Subsection	Subsection Name	Context Acres	LNF Acres	Non-LNF acres	% Context	% LNF	% Non LNF
315	315A	Pecos Valley	315Aa	Artesia Plains Desert Grass-Shrubland	27,851	25,053	2,798	0.1	2.3	0.0
321	321A	Basin and Range	321Ac	Trans-Pecos Desert Shrubland	3,445,015	619	3,444,396	7.4	0.1	7.6
321	321A	Basin and Range	321Ad	Jornada Plains Desert Grass-Shrubland	4,840,450	2,306	4,838,144	10.4	0.2	10.7
321	321A	Basin and Range	321Ae	Sand Hills	854,501	0	854,501	1.8	0.0	1.9
321	321A	Basin and Range	321Af	San Simon Valley Desert Shrubland	524,954	0	524,954	1.1	0.0	1.2
321	321A	Basin and Range	321Ag	Animas Valley Plains Desert Grass-Shrubland	6,380,285	0	6,380,285	13.7	0.0	14.1
321	321A	Basin and Range	321Ah	Animas Mountains Oak-Juniper Woodland	371,242	0	371,242	0.8	0.0	0.8
321	321A	Basin and Range	321Ai	Sulphur Springs Desert Shrubland	509,961	0	509,961	1.1	0.0	1.1
321	321A	Basin and Range	321Aj	Sulphur Springs Plains Desert Grass-Shrubland	5,732,819	0	5,732,819	12.3	0.0	12.6
321	321A	Basin and Range	321Ak	Santa Catalina Mountains Sierra Madre Interior Chaparral	485,912	0	485,912	1.0	0.0	1.1
321	321A	Basin and Range	321Al	San Rafael Sierra Madre High Plains Grassland	55,204	0	55,204	0.1	0.0	0.1
321	321A	Basin and Range	321Am	Santa Catalina Mountains Encinal Woodland	1,580,033	0	1,580,033	3.4	0.0	3.5
Total Acres					46,424,093	1,094,596	45,329,496	100.0	100.0	100.0

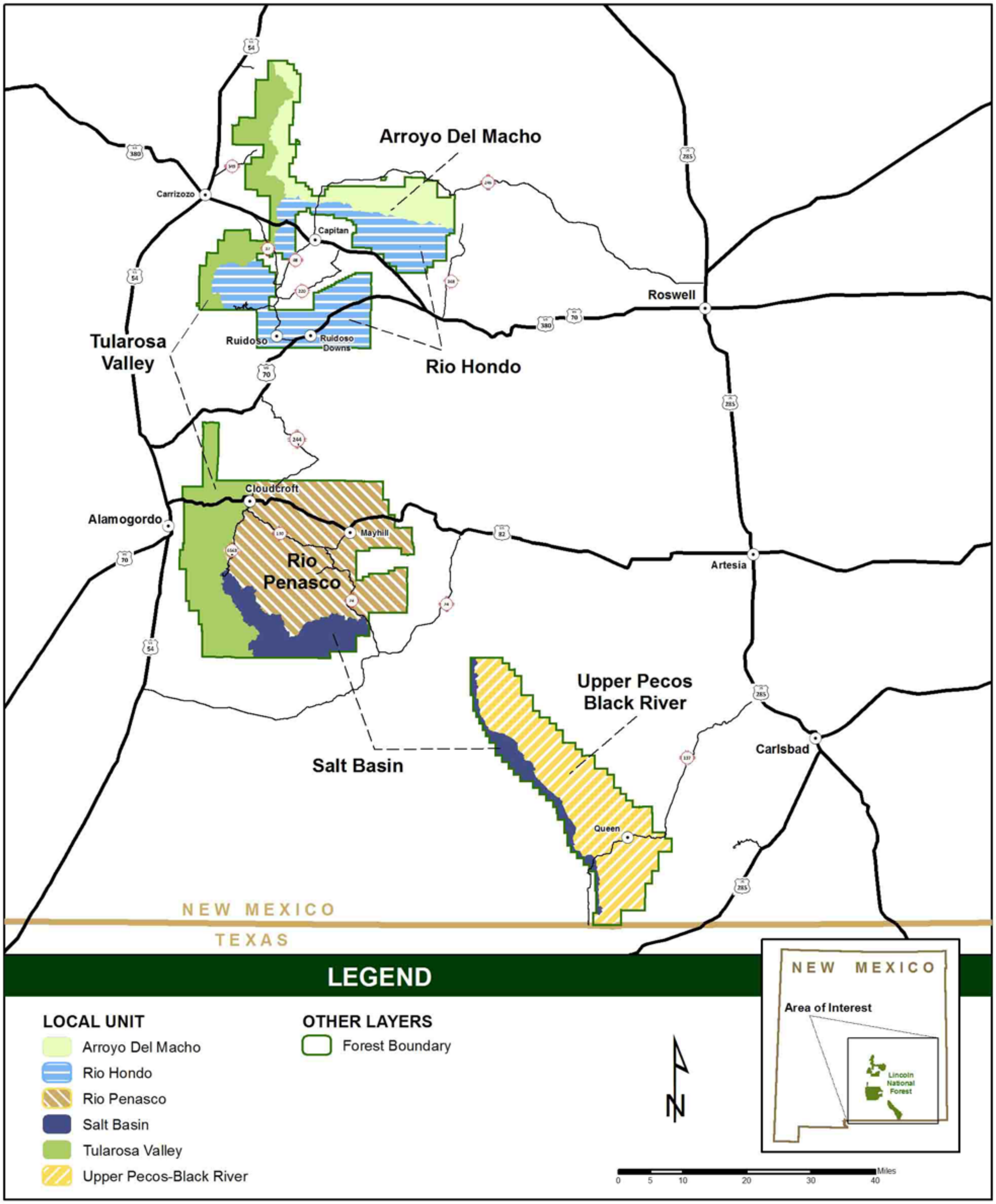

Figure 4. Local unit subdivisions within the framework of the Plan Area (Lincoln NF)

Ecological Response Unit Description

Introduction

The assessment of terrestrial ecosystem condition is stratified using the Ecological Response Unit (ERU) classification system, which is a grouping of sites that are each similar in plant species composition, succession patterns, and disturbance regimes (USDA Forest Service 2015). The ERUs are constructed in concept and resolution, such that they are applicable to management decisions. Because ERUs provide the foundational unit for the analysis of vegetative attributes and associated ecosystem services at the landscape and strategic planning scale (USDA Forest Service 2015), the USFS has employed the ERU concept in the Southwestern Region.

The ERU framework describes all major ecosystem types found in the region based on a coarse stratification of biophysical themes. The ERUs are map unit constructs, technical groupings of finer vegetation classes, with similar site potential and disturbance history. In other words, it is the range of plant associations (USDA Forest Service 1997), along with structure and process characteristics that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006). Similar to LANDFIRE biophysical settings (NIFTT 2010), ERUs combine themes of site potential (plant communities that may become established on an ecological site, they also reflect the current climate and physical environment, as well as the competitive potential of native plant species.) and historic fire regime:

Ecological Response Unit = Site Potential + Historic Disturbance Regime

Each ERU characterizes sites with similar composition, structure, function, and connectivity, and defines their spatial distribution on the landscape.

Stratifying terrestrial ecosystems based on vegetation characteristics and function is appropriate for two reasons. First, vegetation is the primary terrestrial and biological ecosystem component that is manipulated through management and affected by natural processes. Second, it represents habitat for wildlife and provides the required link to species diversity. The At-Risk Species chapter is based on these ERUs, ecosystem characteristics, and ecological integrity.

Method

Upland ERUs on the Lincoln NF are derived from the Terrestrial Ecosystems Survey (TES) of the Smokey Bear Ranger District of the Lincoln NF (USDA Forest Service 1980) and other uncorrelated surveys for the Sacramento and Guadalupe districts. The TES maps the relationships between climate, soil and vegetation communities (USDA Forest Service 1986b) as Terrestrial Ecological Units (TEUs). They are summarized by ERU for some key ecosystem characteristics, particularly those that are soil related. Boundaries are coincident between upland ERUs and TEUs, such that any TEU fits into only one ERU. The ERUs for non-National Forest System lands in Arizona and New Mexico are mapped by the Integrated Landscape Assessment Project (ILAP) and other map sources. For some ecosystem characteristics, LANDFIRE biophysical setting is cross-walked to ERUs, in order to calculate departure (USDA Forest Service 2015). No other data provides analogous TEU soil information for lands outside the Lincoln NF.

The Lincoln NF contains 15 upland ERUs that make up approximately 96 percent of the Forest:

Forest ERUs

- Spruce-Fir (SFF)(Figure 5)
- Mixed Conifer with Aspen (MCW)(Figure 6)
- Mixed Conifer with Frequent Fire (MCD)(Figure 7)
- Ponderosa Pine Forest (PPF)(Figure 8)

- Ponderosa Pine/Evergreen Oak (PPE)(Figure 9)
- Woodland ERUs
  - Piñon-Juniper/Evergreen Shrub (PJC)(Figure 10)
  - Juniper-Grass (JUG)(Figure 11)
  - Piñon-Juniper Woodland (PJO)(Figure 12)
  - Piñon-Juniper-Grass (PJG)(Figure 13)
- Shrubland ERUs
  - Gambel Oak shrublands (GAMB)(Figure 14)
  - Mountain Mahogany Mixed (MMS)(Figure 15)
  - Chihuahuan Desert Scrub (CDS)(Figure 16)
- Grassland ERUs
  - Montane/Subalpine Grasslands (MSG)(Figure 17)
  - Semi-Desert Grasslands (SDG)(Figure 18)
  - Colorado Plateau/Great Basin Grassland (CPGB)

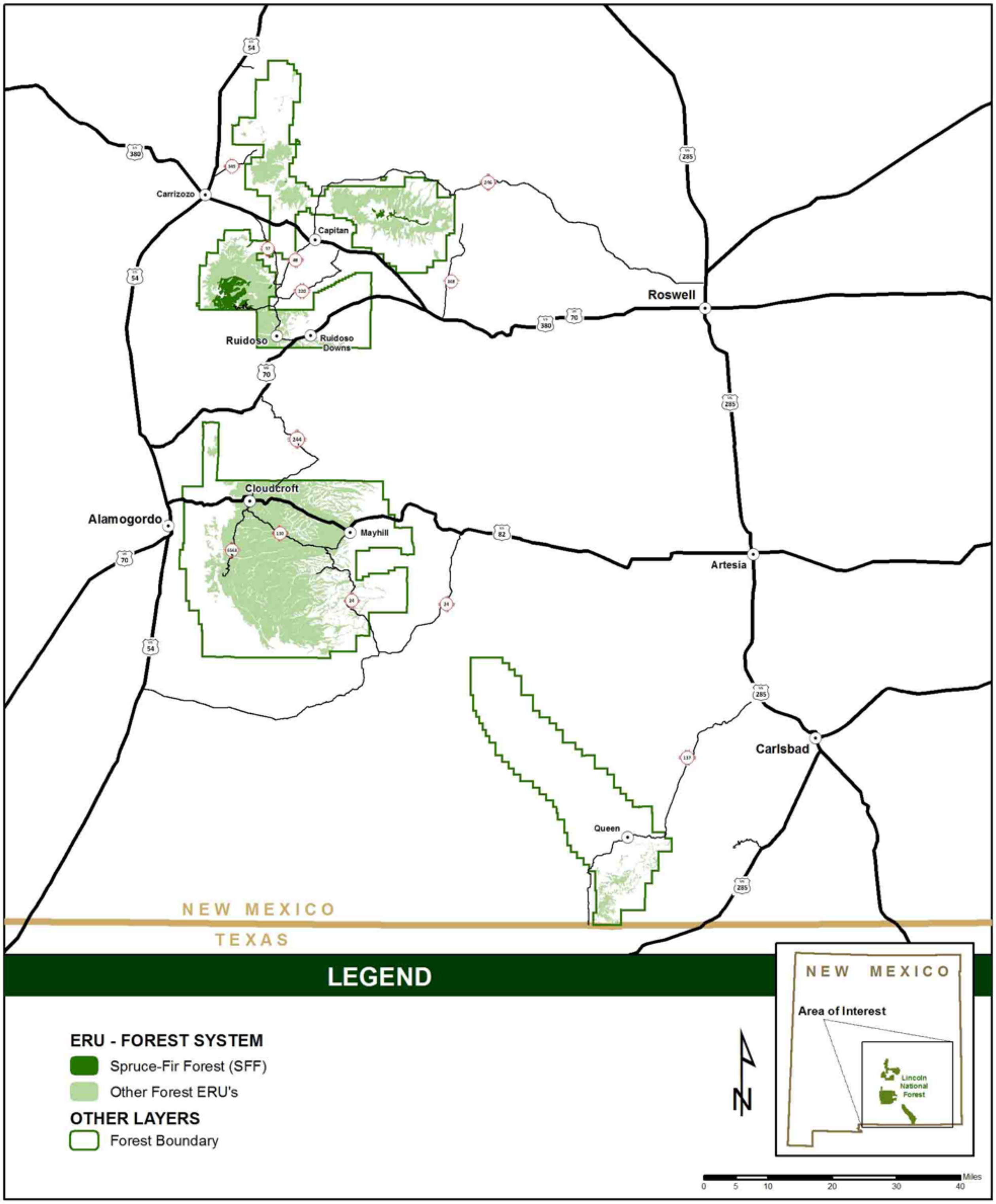

Figure 5. Distribution of Spruce-Fir Forest ERU type on Lincoln NF

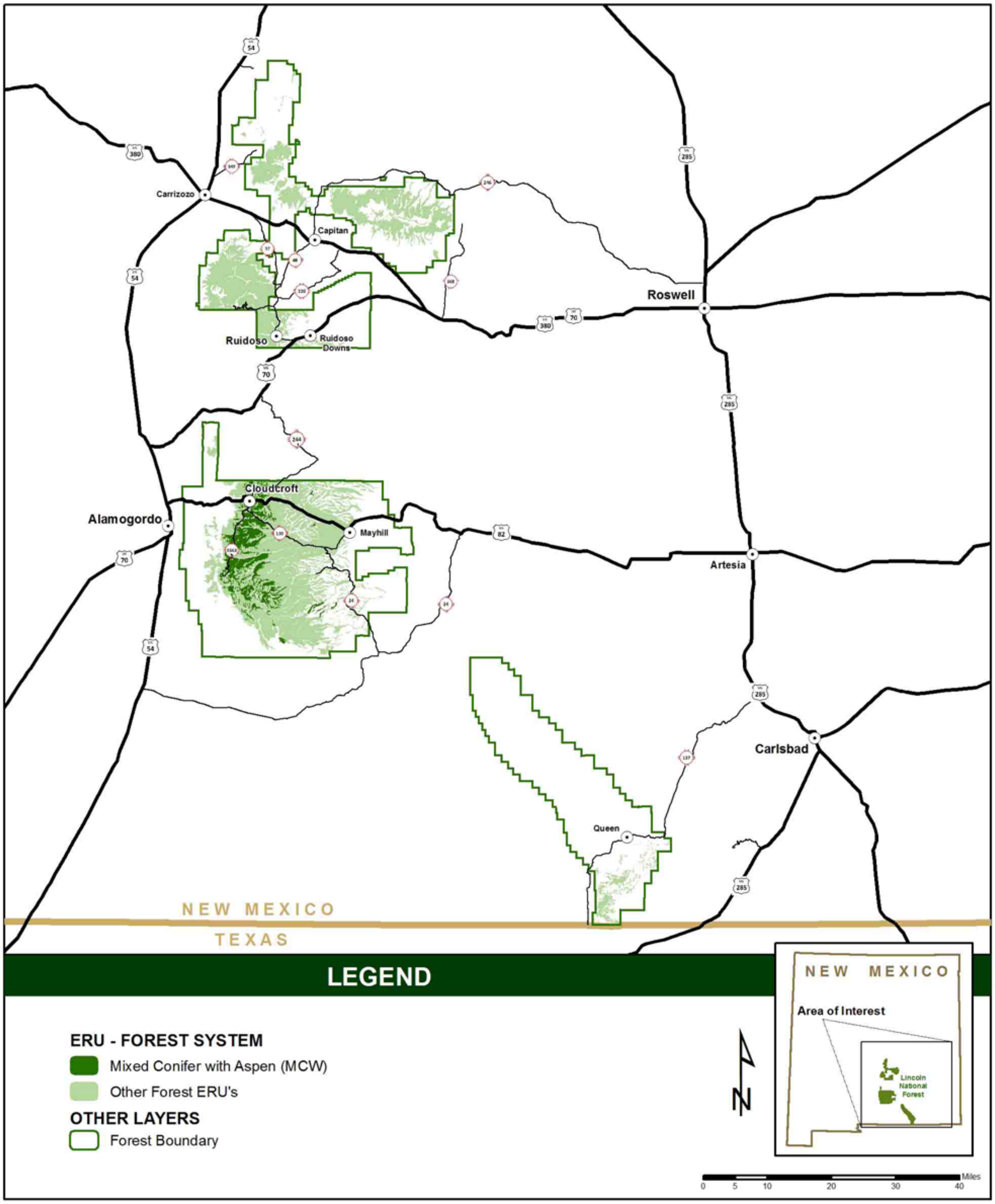

Figure 6. Distribution of Mixed Conifer with Aspen ERU type on Lincoln NF

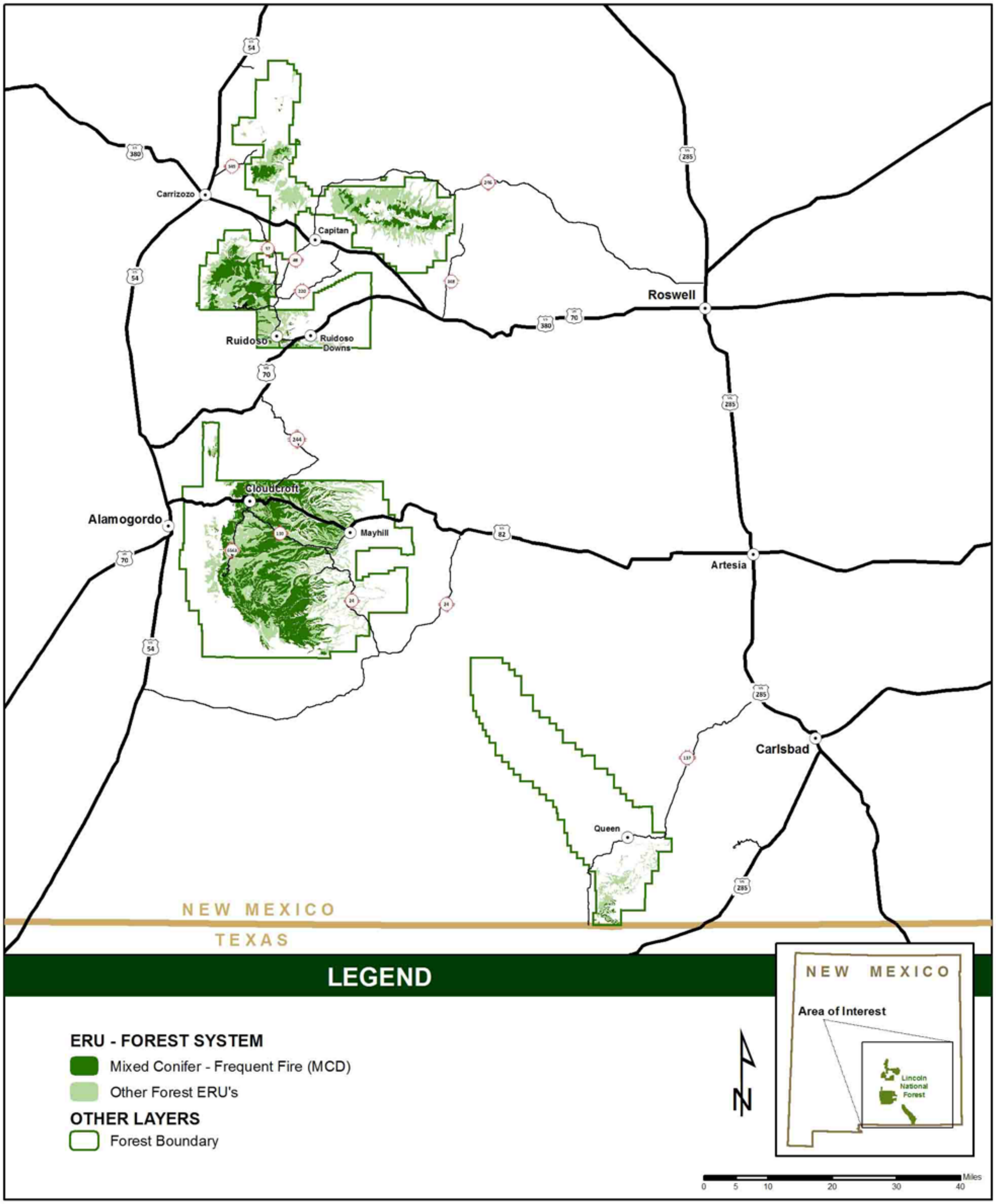

Figure 7. Distribution of Mixed Conifer-Frequent Fire ERU type on Lincoln NF

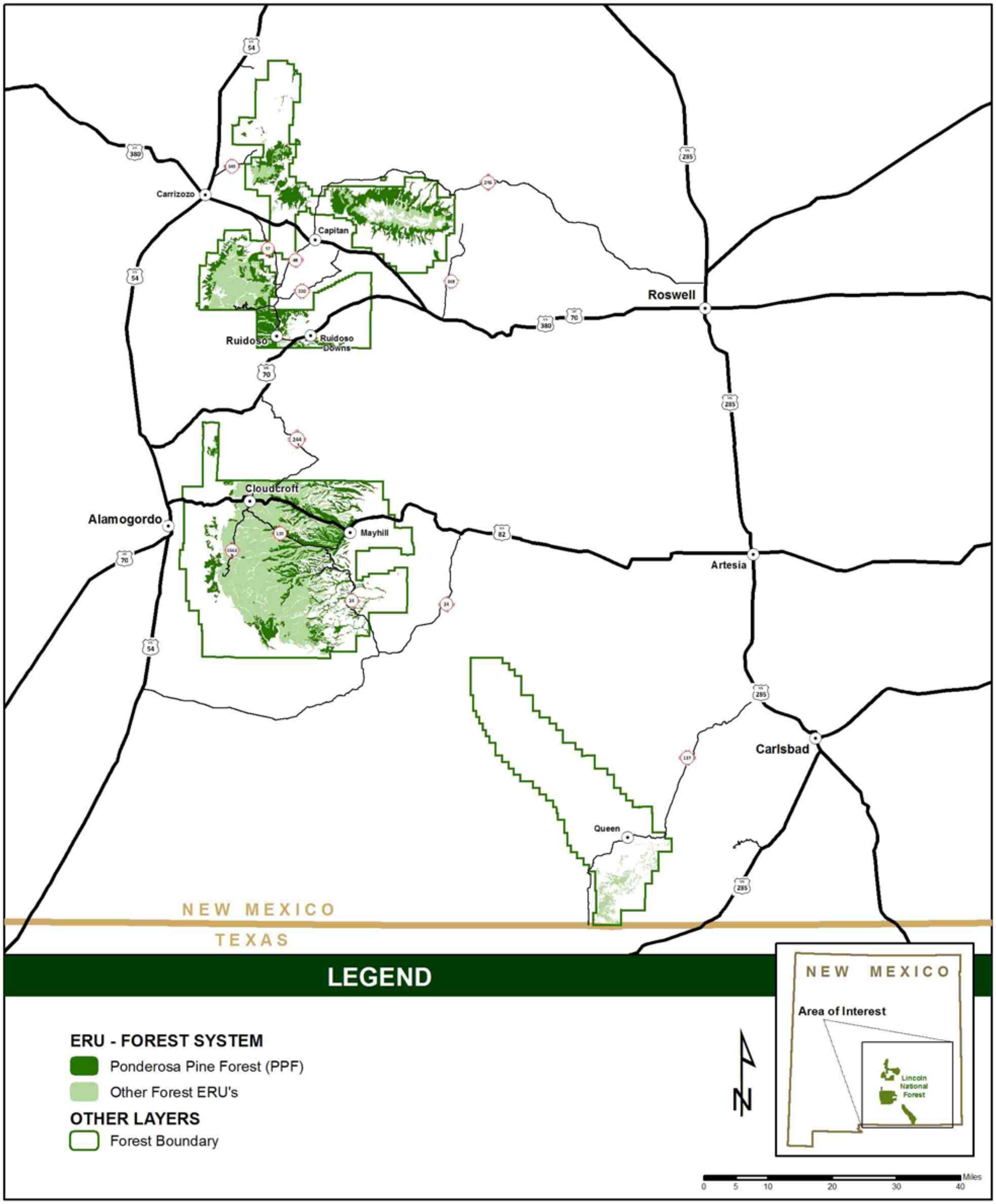

Figure 8. Distribution of Ponderosa Pine Forest ERU type on Lincoln NF

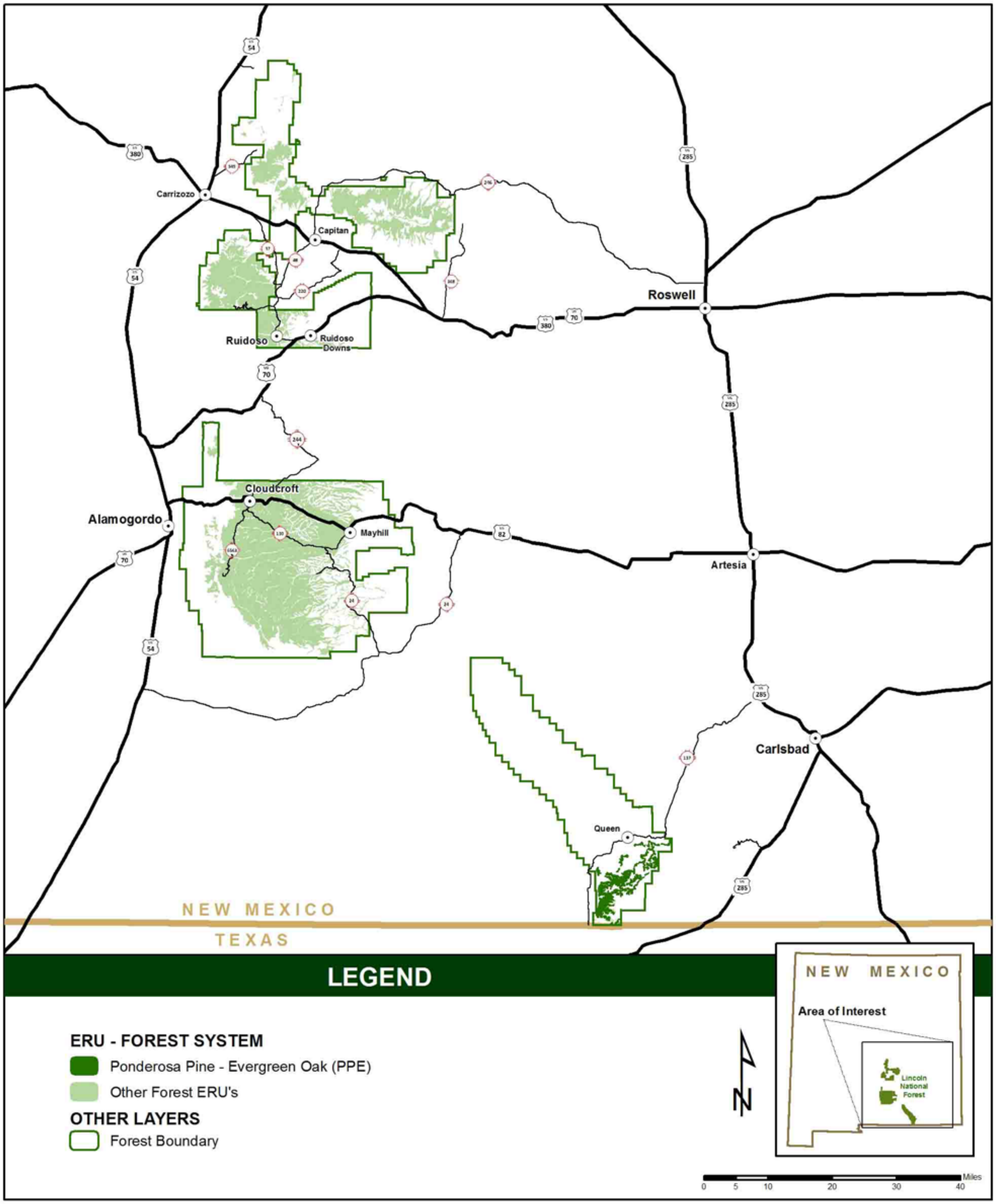

Figure 9. Distribution of Ponderosa Pine/Evergreen Oak Forest ERU type on Lincoln NF

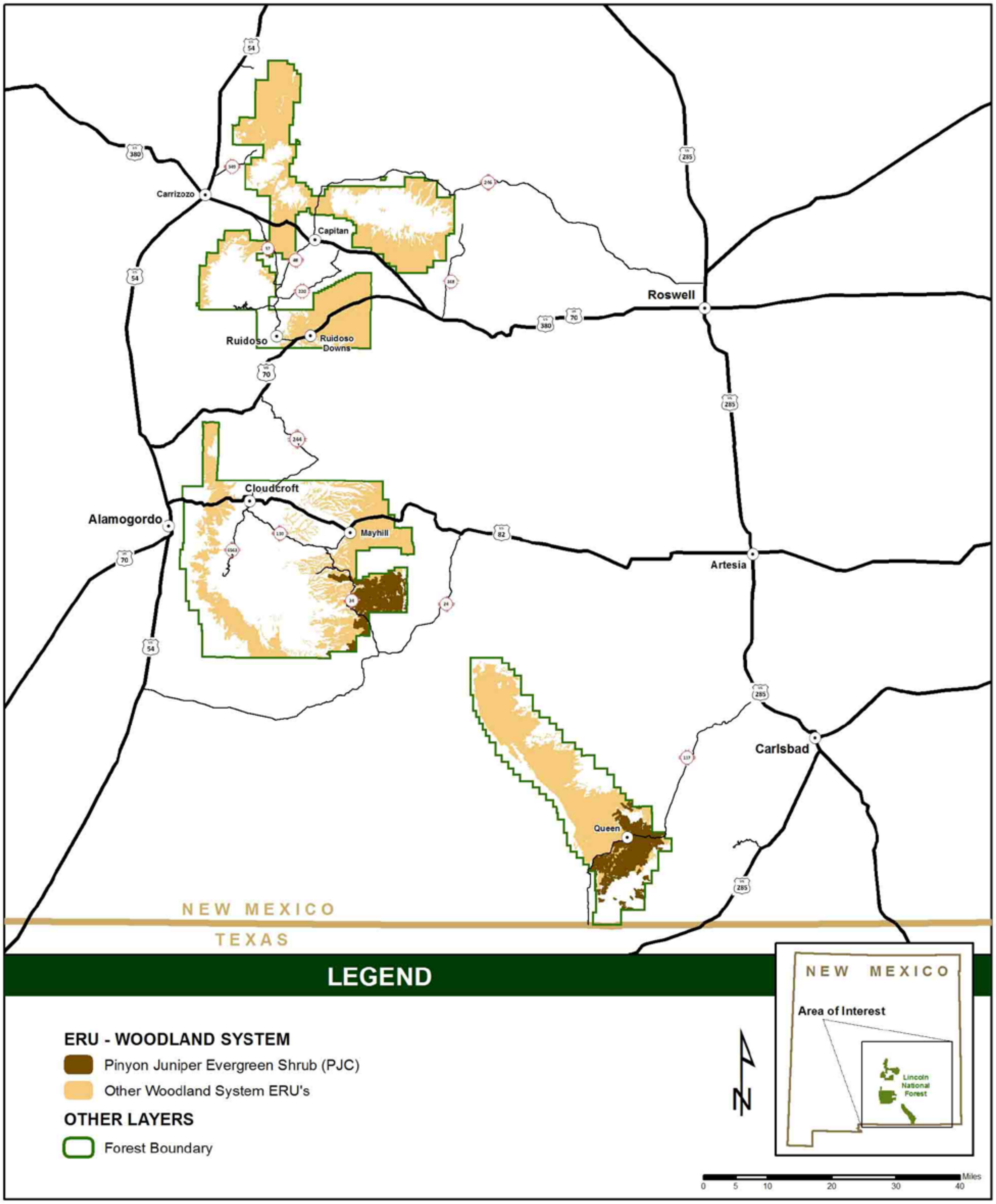

Figure 10. Distribution of Piñon-Juniper/Evergreen Shrub Woodland ERU type on Lincoln NF

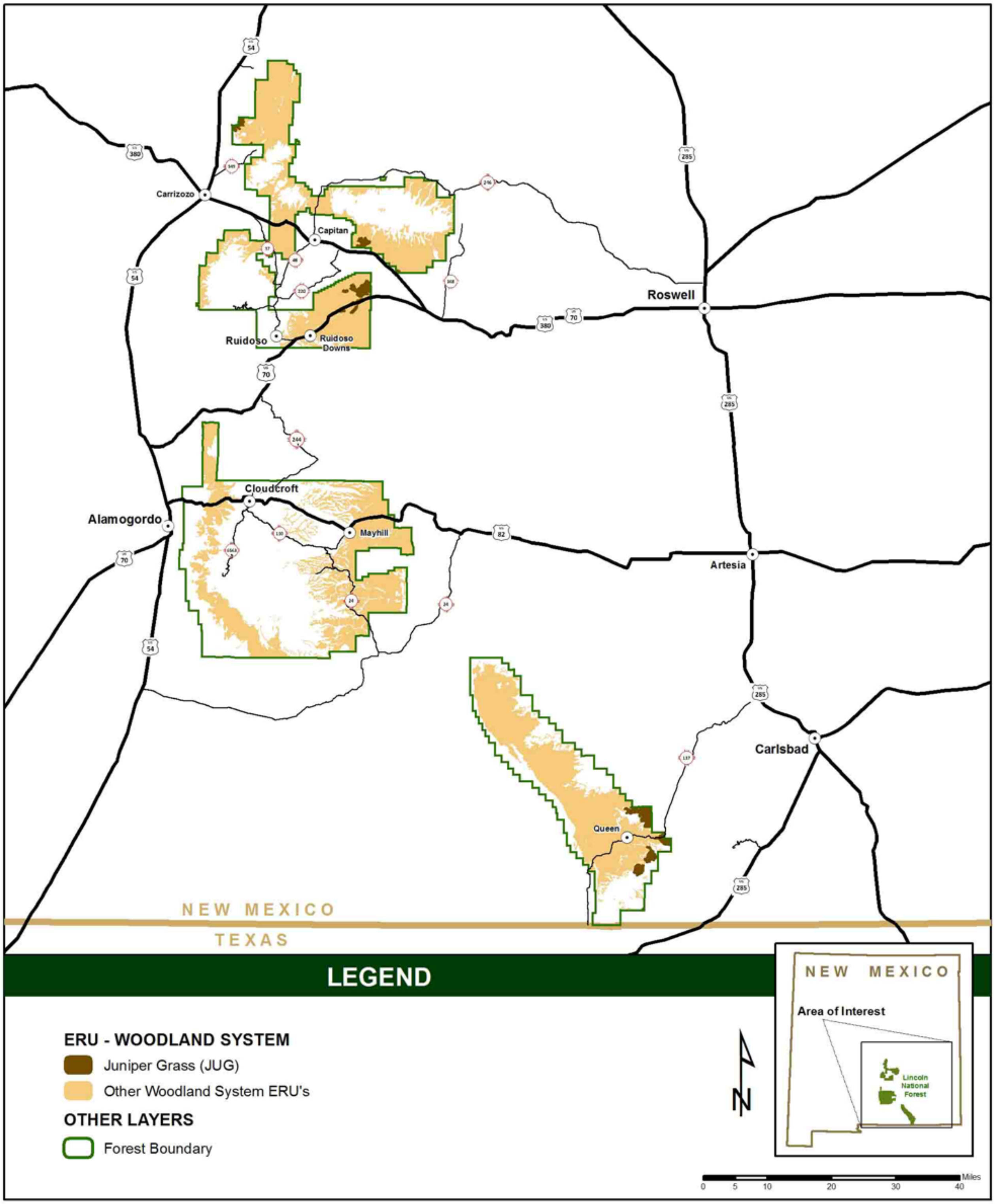

Figure 11. Distribution of Juniper Grass Woodland ERU type on Lincoln NF

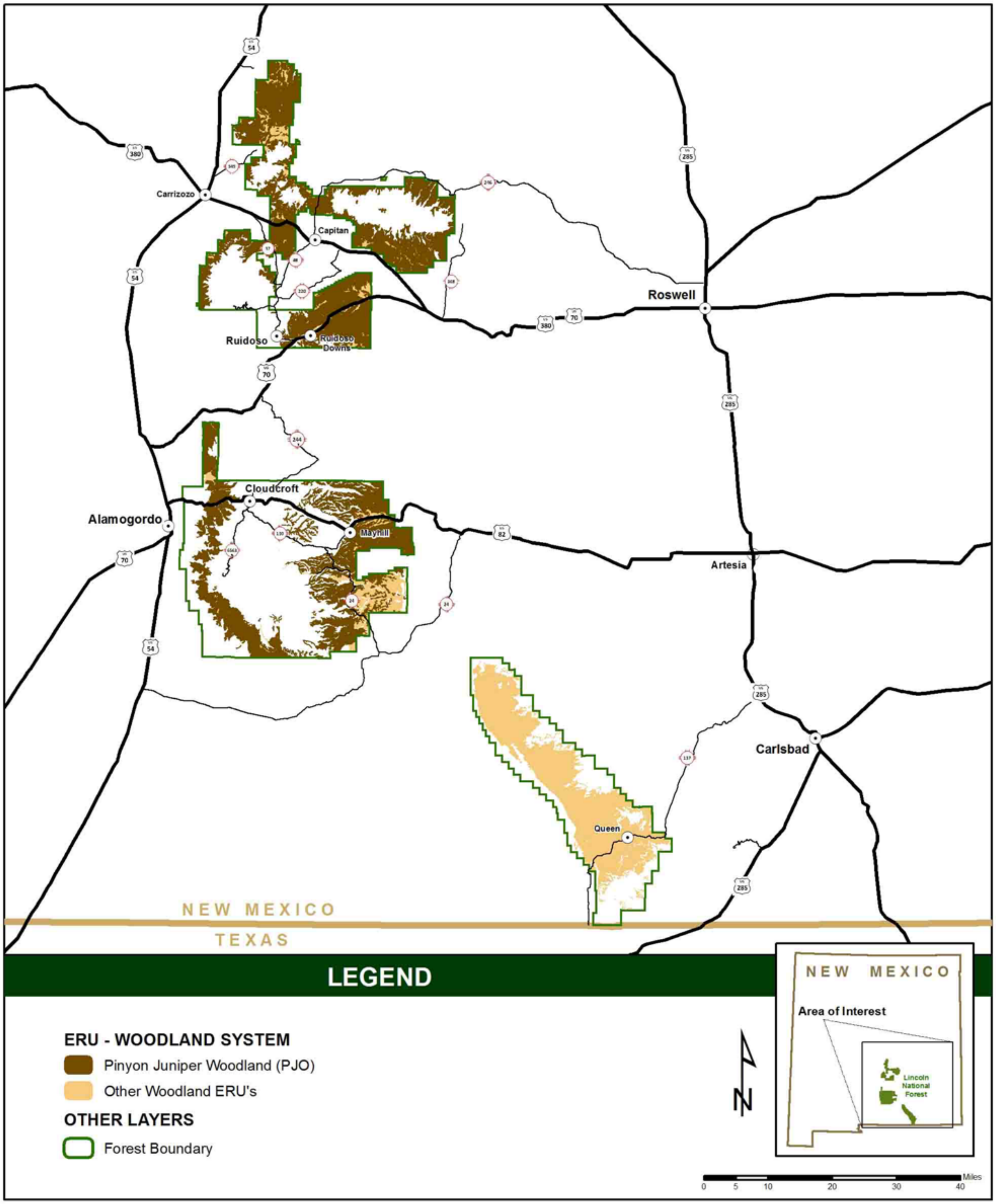

Figure 12. Distribution of Piñon-Juniper Woodland ERU type on Lincoln NF

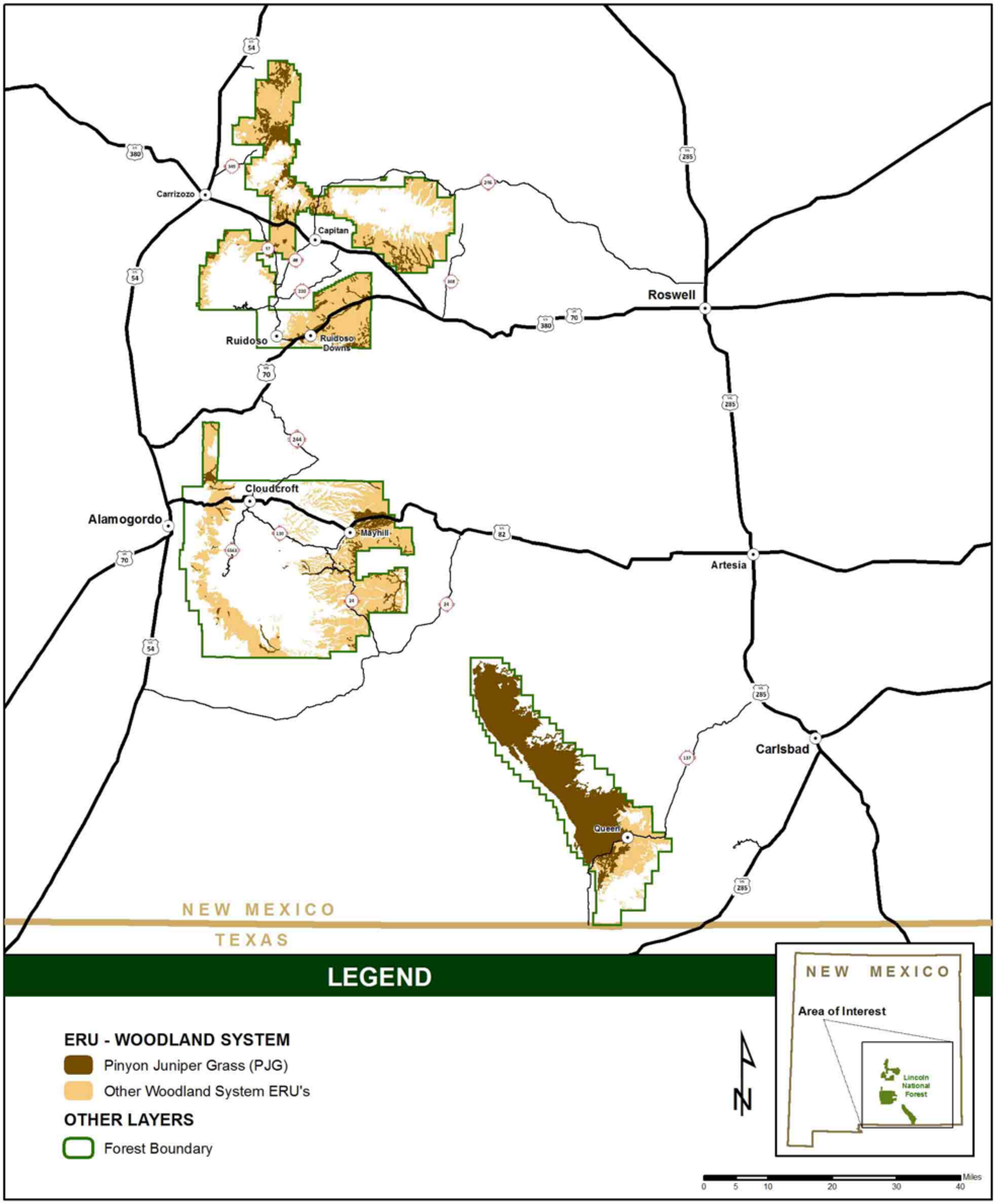

Figure 13. Distribution of Piñon-Juniper-Grass Woodland ERU type on Lincoln NF

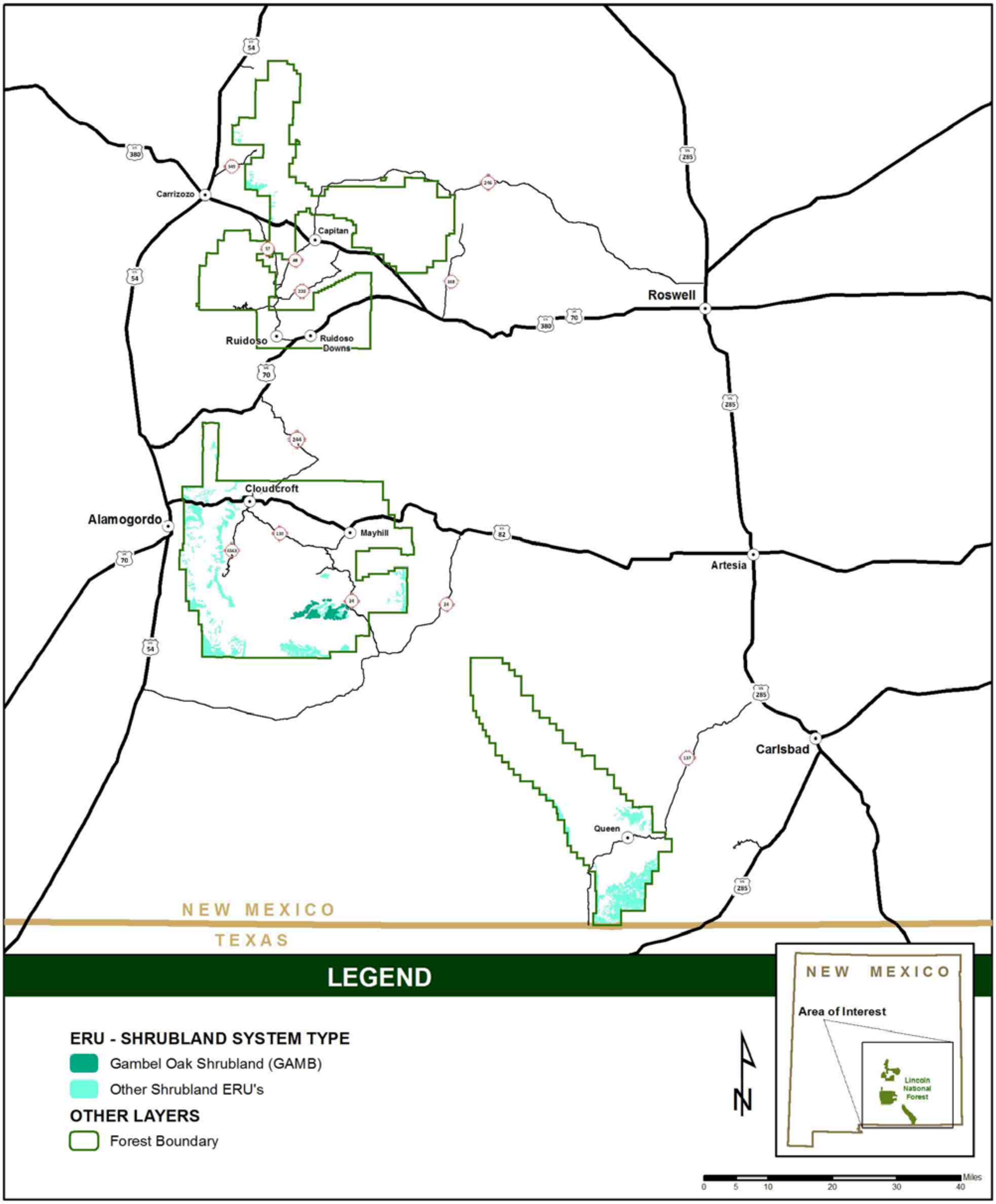

Figure 14. Distribution of Gambel Oak Shrubland ERU type on Lincoln NF

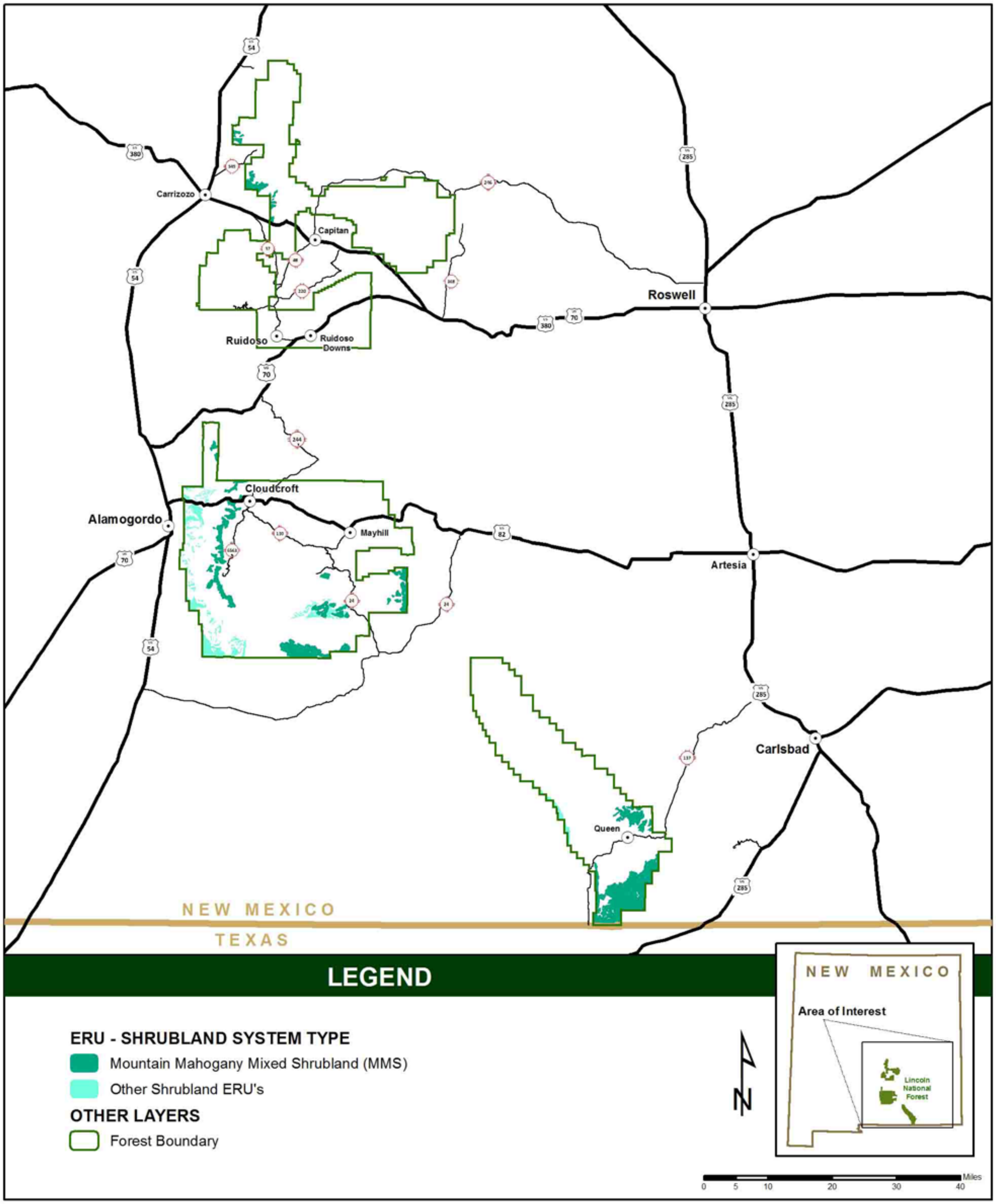

Figure 15. Distribution of Mountain Mahogany Mixed Shrubland ERU type on Lincoln NF

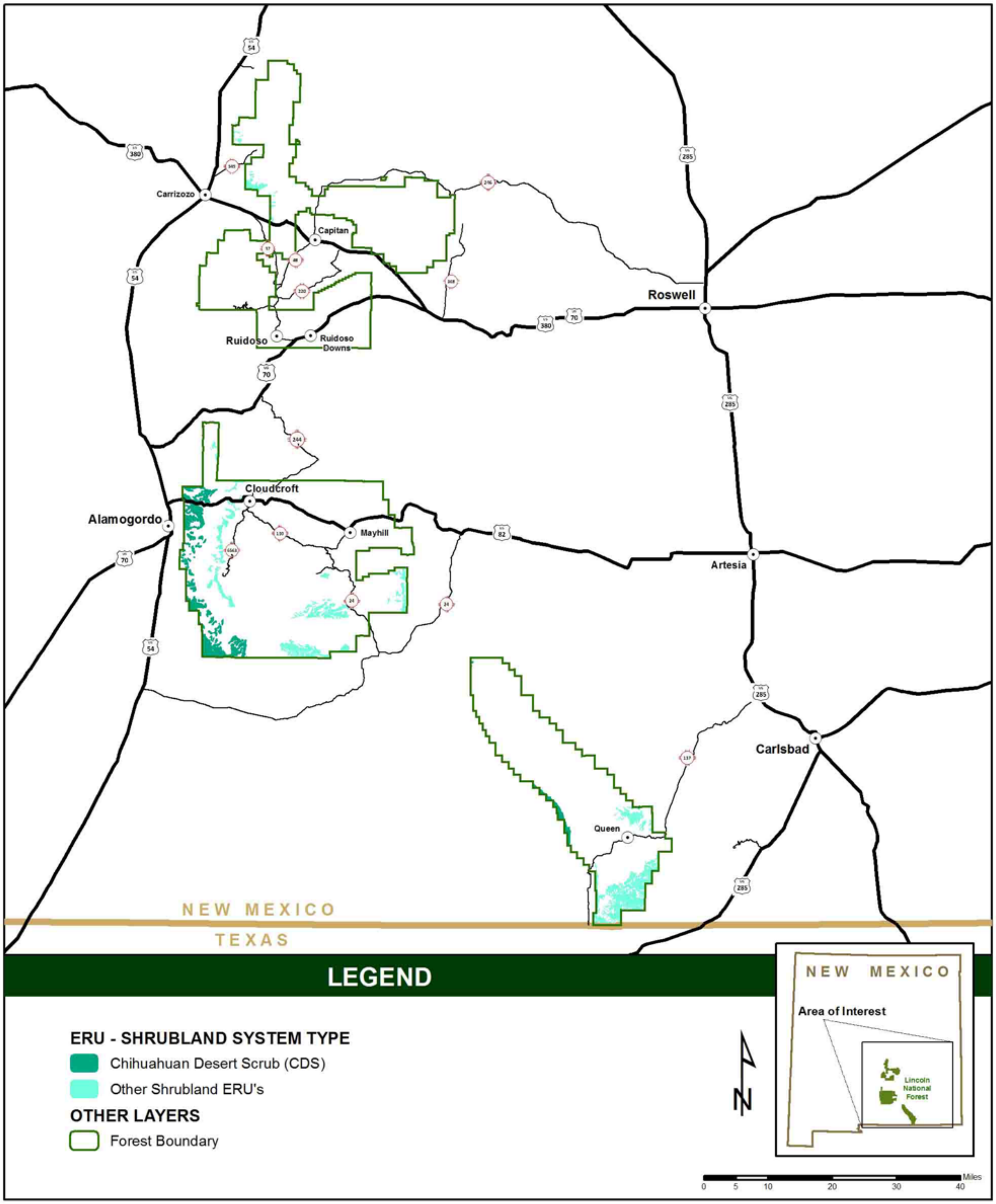

Figure 16. Distribution of Chihuahuan Desert Scrub Shrubland ERU type on Lincoln NF

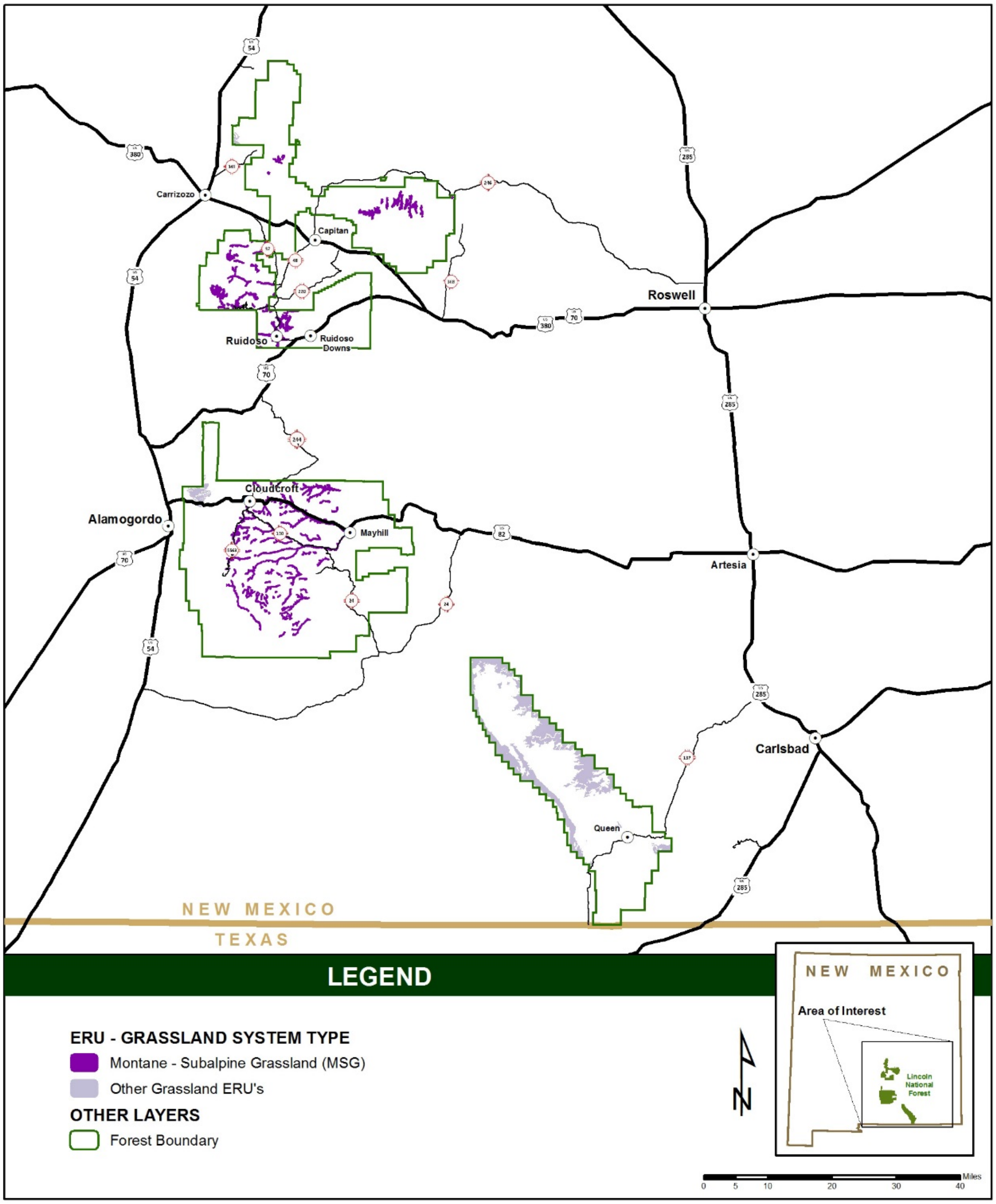

Figure 17. Distribution of Montane/Subalpine Grassland ERU type on Lincoln NF

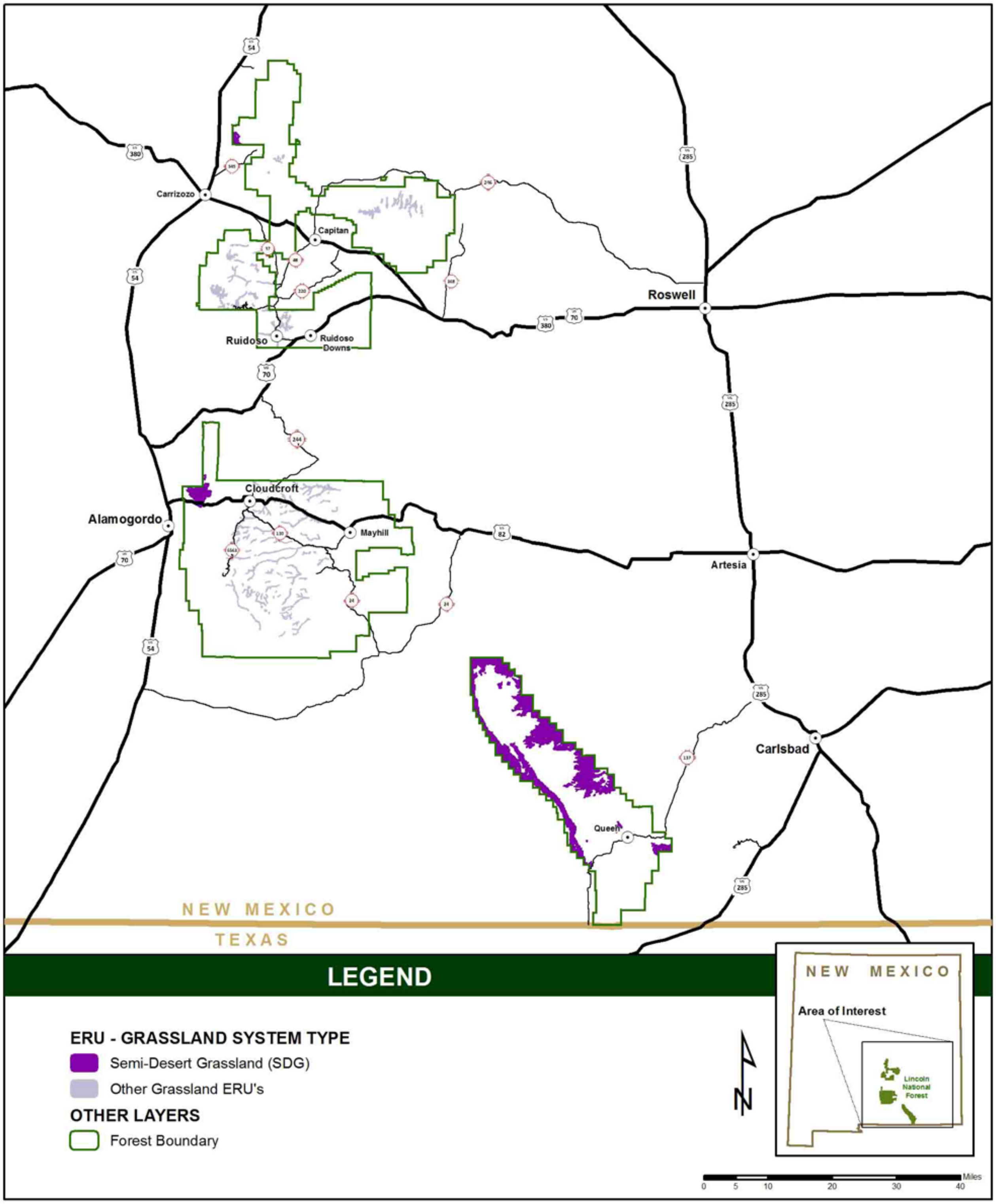

Figure 18. Distribution of Semi-Desert Grassland ERU type on Lincoln NF

Terrestrial Ecosystem Spatial Niche

Spatial Niche Analysis: The spatial niche analysis relates the Lincoln NF to its surroundings, in this case, the Context Area landscape. Spatial niche is dependent on the relative spatial distribution of an ecological response unit (ERU). The contribution of the Lincoln NF to the ecological integrity of an ERU in the context of the surrounding landscape is dependent first on the percent of the Forest occupied by the ERU. There must be enough of the ERU on the Forest that it may serve an important ecological role, and enough that its condition can be accurately assessed. The Lincoln NF's contribution to ecological integrity also depends on the percent of the context landscape occupied by the ERU and the relative amounts of the ERU on-Forest to off-Forest (Table 19). The larger the proportion of an ERU on the Forest relative to the Context Area would indicate a larger role for the Forest in maintaining ecological sustainability for those ERUs. Departure of an ERU from some reference or desired condition suggests those ERUs are at risk of losing ecological integrity, and the distribution of that departure defines the Lincoln NF's role in addressing that risk. Departure is measured for a number of ecological characteristics; their derivation and interpretation will be discussed in later sections (see Ecological Characteristics section), and in the ERU specific sections that follow. Departure of seral state proportion is the primary indicator of overall departure for an ERU. Lincoln NF departure values are similar to those of the Context Area for all ERUs.

Table 19 displays the Ecological Response Units (ERUs; USDA FS 2015 [Walberg]) found within the Lincoln NF and Context Area. The Lincoln NF makes up slightly more than 2.4 percent of the context landscape by area and is almost entirely located in M313B- Sacramento-Manzano Mountains Ecoregion Section (approximately 98 percent). Table 19 also shows Lincoln NF's contribution to the Context Area for each ERU. When an ERU is more common at the plan scale than would be expected based on area alone (which is 2.4 percent for any ERU based on the Lincoln NFs proportion of the context landscape), the Plan Area has a disproportionate influence on ecological sustainability of the system. ERUs that are rare at the context scale, relative to the Forest, will be influenced more by conditions on the Forest, and ERUs that are proportionately more abundant at the Context scale will be influenced more by off-Forest conditions.

Table 19. Proportion of upland ERUs on the Lincoln NF and within the greater Context Area (CA)

Ecological Response Unit	ERU code	Context Acres	% Context	LNF Acres	% Forest	Lincoln % of Context
Spruce - Fir Forest	SFF	16,936	0.1	11,034	1.0	65.2
Mixed Conifer w/Aspen	MCW	75,726	0.2	35,568	3.3	47.0
Mixed Conifer - Frequent Fire	MCD	328,640	1.0	163,674	15.0	49.8
Ponderosa Pine Forest	PPF	594,245	1.8	123,156	11.3	20.7
Ponderosa Pine Evergreen Oak	PPE	40,375	0.1	8,661	0.8	2.2
Piñon Juniper Evergreen Shrub	PJC	85,442	0.3	53,976	4.9	6.3
Juniper Grassland	JUG	2,817,810	8.5	9,755	0.9	0.0
Piñon Juniper Woodland	PJO	1,035,948	3.1	319,105	29.2	30.8
Piñon Juniper Grassland	PJG	571,296	1.7	165,432	15.1	29.0
Gambel Oak Shrubland	GAMB	22,282	0.1	3,589	0.3	16.1
Mountain Mahogany Mixed Shrubland	MMS	173,734	0.5	52,528	4.8	30.2
Chihuahuan Desert Scrub	CDS	6,407,214	19.5	19,526	1.8	0.3
Montane Subalpine Grassland	MSG	41,488	0.1	11,230	1.0	27.1
Semi-Desert Grassland	SDG	15,141,603	45.6	65,888	6.0	0.4

Ecological Response Unit	ERU code	Context Acres	% Context	LNF Acres	% Forest	Lincoln % of Context
Colorado Plateau/Great Basin Grassland	CPGB	959,063	2.90	425	0	4.4

As shown by the size relationship between the upland ERUs found within the Context Area and occurring on the Lincoln NF displayed in Table 19, all of the Forested and woodland ERUs, as well as Gambel Oak Shrubland, Mountain Mahogany-Mixed Shrubland and Montane-Subalpine Grasslands, have greater representation on the Lincoln NF than within the overall Context Area; the Juniper Grassland, Chihuahuan Desert Scrub, and Semi-Desert Grassland ERUs have greater representation within the Context Area than on the Lincoln NF. In terms of acreage, the Lincoln NF has the greatest areal contribution of Spruce-Fir Forest in the Context Area (more than 65 percent). The Forest also contains five other upland ERUs that contribute 30 percent or more to the total respective ERU acreage within the Context Area; they are the Mixed Conifer-Frequent Fire, Mixed Conifer with Aspen, Piñon-Juniper Woodland, Piñon-Juniper Evergreen Shrub, and Mountain Mahogany-Mixed Shrub ERUs.

The Lincoln NF contributes to the overall sustainability of 11 of 15 upland ERUs represented (Table 19). The Lincoln NF contains over 60 percent of the spruce-fir forest and piñon-juniper evergreen woodland ERUs in the Context Area. This would indicate a substantial influence of the Lincoln NF to the ecological condition of these ERUs. Conversely, the Lincoln NF contains less than one percent of the Colorado Plateau/Great Basin, semi-desert and juniper grasslands, and Chihuahuan desert scrub and Gambel oak shrubland ERUs. The Lincoln NF proportion of the remaining ERUs range between 16 and 50 percent.

Three spatial niche scenarios are important to consider:

- The Lincoln NF can have a greater influence on ERUs that are uniquely represented on the Forest, either because they are generally rare or because they are proportionally more common at the plan scale.
- More highly departed ERUs are of greater concern because existing ecological integrity is already low.
- If an ERU is less or equally departed at the plan scale than at the context scale, it may act as an important refuge, and an important contribution to maintaining the ERU as a functioning system.

There are several ERUs that are considered to be rare either on the Forest or within the Context Area based on their relative abundance in those areas. Rarity is defined as contributing one percent or less to the acreage within the Forest and/or within the Context Area. Rare ERUs are shown for both the context and Plan Areas in Table 20, which also shows departure from historic reference conditions for vegetative structure (see Seral State Proportions in Ecological Characteristics section).

Table 20. ERU distribution and structural state departure from reference conditions (RC) in the Context and Plan Area

Upland ERU	Context Area			Lincoln NF		
	Abundance		Departure from Reference Condition	Abundance		Departure from Reference Condition
	%			%		
SFF	0.05	rare	moderate	1.01		moderate
MCW	0.23	rare	moderate	3.25		moderate
MCD	0.99	rare	high	14.96		moderate
PPF	1.80		high	11.26		high
PPE	0.12	rare	moderate	0.79	rare	moderate
PJC	0.26	rare	moderate	4.93		moderate
JUG	8.51		low	0.89	rare	moderate

Upland ERU	Context Area			Lincoln NF		
	Abundance		Departure from Reference Condition	Abundance		Departure from Reference Condition
	%			%		
PJO	3.10		moderate	29.17		moderate
PJG	1.70		moderate	15.12		moderate
GAMB	0.07	rare	moderate	0.33	rare	high
MMS	0.52	rare	moderate	4.80		moderate
CDS	19.50		low	1.79		low
MSG	0.13	rare	moderate	1.03		high
SDG	45.60		high	6.02		high
CPGB	2.90		high	0.04	rare	high

Using these scenarios, the ERUs on the Lincoln NF can be loosely grouped.

Group 1: The SDG, GAMB, PPF, MSG CPGB ERUs are highly departed and the Lincoln NF should have a role in their restoration. However, because the vast majority of SDG and CPGB is off-Forest, the Lincoln NF's role may be limited or would require collaboration with lands outside the Plan Area to have a similar or greater influence on the sustainability of those systems.

Group 2: The Forest may act as a refuge for MCW, SFF, PJC, MMS and MSG. Their distribution on the Lincoln NF may be small, however they are rare in the context landscape, and the Plan Area may play a role by maintaining intact reservoirs. Because four out of the five have moderate, but significant departure. The Forest can have a substantial role in their restoration, maintenance, and overall sustainability of these ERUs.

Group 3: The PJO, PJG, MCD and PPE are moderately departed at the Plan Scale presenting a significant opportunity for the Lincoln NF to have a substantial role in their restoration, maintenance, and overall sustainability of these ERUs. There is also an opportunity for the Lincoln NF to influence JUG's condition, by maintaining its already high ecological integrity on Forest.

Local Unit ERU Distribution

No ERUs occur in all local units, and no local unit has all ERUs (Table 21). For example, the Gambel oak ERU (GAMB) only makes up 1 percent of the Rio Peñasco local unit, but is 84 percent of all the GAMB on the Lincoln NF. Similarly, spruce-fir forest (SFF) takes up less than 5 percent of the area of local unit Rio Hondo, but is 81 percent of the ERU on the Forest. Departure in these local units may have a larger impact on the overall departure of the ERU, but it may not have as much influence in determining overall departure at the local unit scale. Conversely, the smallest local unit, Arroyo del Macho, has 40 percent of its area in PJO, while this makes up only 11 percent of the ERU. Departure of PJO in the Arroyo del Macho local unit will have a large impact on the overall departure of the local unit, it may not have as much influence in determining overall departure for the ERU.

Table 21. Lincoln NF's upland ERU acreage distribution at the local unit scale. Percentages of the ERU within the local units, and percentage of local unit in the ERUs are shown. Blank cells indicate that the ERU does not occur in that local unit.

Local unit>	Arroyo Del Macho			Rio Hondo			Rio Peñasco			Salt Basin			Tularosa Valley			Upper Pecos-Black River		
ERU Code	Acres	% ERU	% LU	Acres	% ERU	% LU	Acres	% ERU	% LU	Acres	% ERU	% LU	Acres	% ERU	% LU	Acres	% ERU	% LU
SFF	845	7.7	1.0	8,880	80.5	4.8							1,309	11.9	0.6			
MCW							27,819	78.2	10.5	5,072	14.3	5.1	2,677	7.5	1.3			
MCD	10,652	6.5	12.4	25,403	15.5	13.7	82,654	50.5	31.3	20,953	12.8	21.2	22,309	13.6	10.5	1,704	1.0	0.7
PPF	25,527	20.7	29.6	30,562	24.8	16.5	39,503	32.1	14.9	5,988	4.9	6.1	21,577	17.5	10.1			
PPE							4	0.0	0.0	412	4.8	0.4				8,245	95.2	3.4
PJC							20,730	38.4	7.8	4,392	8.1	4.4	0			28,854	53.5	11.9
JUG	0	0.0	0.0	3,170	32.5	1.7							573	5.9	0.3	6,012	61.6	2.5
PJO	34,251	10.7	39.8	103,255	32.4	55.8	72,557	22.7	27.4	16,319	5.1	16.5	92,722	29.1	43.4			
PJG	6,525	3.9	7.6	7,141	4.3	3.9	7,841	4.7	3.0	8,369	5.1	8.5	6,347	3.8	3.0	129,209	78.1	53.2
GAMB							3,026	84.3	1.1	563	15.7	0.6						
MMS							5,792	11.0	2.2	8,883	16.9	9.0	11,381	21.7	5.3	26,472	50.4	10.9
CDS										23,081	58.1	23.3	16,395	41.2	7.7	271	0.7	0.1
MSG	2,284	20.3	2.7	3,186	28.4	1.7	4,168	37.1	1.6	480	4.3	0.5	1,112	9.9	0.5			
SDG										3,304	7.2	3.3	3,359	7.4	1.6	39,005	85.4	16.1
CPGB							346	81.3	0.1	80	18.7	0.1						
Local Unit Total Acres (%)	86,126 (8%)			185,107 (17%)			264,440 (24%)			98,920 (9%)			213,429 (20%)			242,982 (22%)		
ERUs/Local Unit	8			8			11			14			13			10		

Key Ecosystem Characteristics of Terrestrial Vegetation

Ecosystem functionality can be gauged by assessing the functionality of key ecosystem characteristics. A key characteristic will be included if the characteristic is available, can be measured, mapped, or otherwise analyzed, and either responds to or informs management activities. Additionally, the characteristic's condition or trend would serve as an indicator of ecological processes and/or show effects of stressors on those processes highlighting sustainability of the ecosystem integrity.

Condition or trend is determined by relating the current values to a reference value for a characteristic. The difference between current and reference values is departure, which indicates some level of risk to the ecosystem. While risk to an individual characteristic is discussed, the real meaning of risk as represented by the characteristic is to the ecosystem. For instance, in the case of coarse woody debris and snags, departure doesn't necessarily mean risk to coarse woody debris and snags themselves, they are the metric. The risk of too much or too little coarse woody debris and snags may have risk to the ecosystem as a whole. Selected key ecosystem characteristics for terrestrial vegetation (ERUs) include:

Seral state proportion
Fire regime- frequency and severity
Fire regime condition class
Coarse woody debris
Snag density
Ecological status (vegetation species composition)
Vegetative groundcover
Patch size
Insect and disease mortality

Ecosystems are classified into Ecological Response Units (ERUs), and the characteristics described above have current data and reference data for comparison related to each ERU. The primary ecological characteristic for ERUs is seral state proportion. That is the relative amounts of an ecological system or type in generalized structure, age and size classes. Fire regime frequency, severity and condition class are related to seral state proportion. Fire frequency and severity (aka fire regime) may be a result of changes in seral state proportions, or cause uncharacteristic changes in seral state proportion. Fire regime condition class (FRCC) combines frequency, severity and seral state proportion into a single metric. Coarse woody debris (CWD) and snag density can arise from changes in fire regime, insect and disease mortality or other reasons. Coarse woody debris and snags can indicate past events leading to current seral states, and serve as wildlife habitat indicators. Ecological status is the state of the current vegetative composition (i.e. the current amounts of the different plant species in an ecosystem relative to what would be expected in a fully functional system at potential). Shifts in species composition can indicate a conversion to another ecosystem type, or be related to seral state transitions. Vegetative groundcover is an indicator of the amount of vegetation at the surface, including litter, versus bare ground. This may be showing the effects of grazing, or changes in fire regime, or alteration in vegetative structure (i.e., grass to shrub dominated landscape). Patch size is an indicator of landscape level changes in continuity of an ecosystem over the landscape. Patch size is determined differently for grasslands, shrublands, woodlands, and forest. Departure could indicate fragmentation of different seral stages within an ERU, or encroachment of woody species into grasslands and savannahs. Insect and disease mortality can be related to changes in fire regime as well as affecting departure for other characteristics such as CWD and snag density, and seral state proportion.

These characteristics will be summarized and briefly discussed across ERUs for the context, plan, and local scales as applicable. Values of characteristics will be presented in tabular and narrative format for each ERU.

Seral State Proportion

Ecological Response Units (ERUs, see ERU Descriptions section) are a vegetation classification based on characteristic vegetation, soil properties, and fire and climatic regime. ERUs are not homogeneous, however, through succession or disturbance, each ERU can manifest a range of potential overstory vegetative conditions, each representing a unique phase in the overall ecology of the system (Weisz et al, 2009). By grouping these phases into seral state classes with unique vegetation characteristics (overstory composition, structure and cover), the current structure of an ecosystem can be described and compared to a reference or desired condition.

Each ecosystem has characteristic seral states, and the proportion of those states in an ecosystem can be indicative of the sustainability or integrity of a system. The proportion of an ecosystem in any particular state is dynamic in time and place, and varies with disturbance, climate and usage. Thus, an ecosystem with characteristic disturbance regimes (e.g. fire, insects and disease) in a characteristic climatic regime, would have characteristic seral state proportions, in the absence of human use. This can be considered the reference condition.

It is assumed that ecosystems maintaining characteristic structure under characteristic disturbance and climate regimes are sustainable. Deviation of any of the above may indicate risk to the stability and sustainability of an ecosystem, and to its ability to provide ecosystem services. Comparisons of current ecosystem structure to its characteristic, or reference, structure would provide a measure of deviation, or departure from the reference condition, and a means to assess risk to the ecological sustainability of the system. In order to do this, both current and reference conditions must be known. Methods described below provide the current structure, while reference conditions have been inferred from historic records and descriptions of ecosystems prior to intensive land use by humans, generally assumed to be the late 1800s (Schussman and Smith 2006), and current landscapes considered free from anthropogenic use.

Seral state departure may indicate changes in the natural disturbance or climate regimes, or result from human land use and management practices. Knowing seral state departure for a system provides a foundation for understanding departure of other related ecosystem characteristics, such as fire severity, coarse woody debris, and others described later. Knowing departure also identifies the trend of effects of human use of the ecosystem, from the reference period until now. Models have been developed that describe the dynamics of disturbance and climate regimes in stable (reference) ecosystems, and have been applied to include the effects of management practices to project how management will affect ecosystem integrity into the future.

Analysis

Method

Seral state proportion is the percent of an ecological response unit (ERU) in each seral state and is assessed at the context, plan, and local scales. Comparing current seral state proportion to reference proportions gives a measure of departure that indicates whether ecosystem integrity is at risk. Departure from the reference distribution is quantified by comparing it to the actual current distribution or to future predicted distributions. The closer composition, structure, cover and process are to their reference conditions, the more the system is maintaining ecological integrity, and the more resilient it will be to stress. For each seral state, similarity to reference percent proportion is compared to the current percent proportion (current landscape or the projected future landscape). The similarity value is the lesser value of the current percent proportion, or the reference proportion. The sum of similarity values for all states of any ERU is 100 percent or less. The similarity value subtracted from 100 equals the departure of the ERU (see example in Table 22). Thus Departure is 100-sum of similarity values. Departure is broken into thirds for descriptive purposes (0 to 33 percent = low departure, 34 to 66 percent = moderate departure, 67 to 100 percent = high departure), but is best viewed as a continuum from low to high, where moderate to high departure is considered significant.

Table 22 provides an example of how vegetation seral states, successional structure, respective compositions and cover, and departure indices from reference condition (RC) on the Lincoln NF and within the greater Context Area (CA) will be displayed for individual ERU descriptions.

Departure from the reference distribution is quantified by comparing it to the actual current distribution or to future predicted distributions. The closer composition, structure, cover and process are to their reference conditions, the more the system is maintaining ecological integrity, and the more resilient it will be to stress. For each seral state, similarity to reference percent proportion is compared to the current percent proportion (current landscape or the projected future landscape). The similarity value is the lesser value of the current percent proportion, or the reference proportion. The sum of similarity values for all states of any ERU is 100 percent or less. The similarity value subtracted from 100 equals the departure of the ERU (see example in Table 22). Thus Departure is 100-sum of similarity values. Departure is broken into thirds for descriptive purposes (0 to 33 percent = low departure, 34 to 66 percent = moderate departure, 67 to 100 percent = high departure), but is best viewed as a continuum from low to high, where moderate to high departure is considered significant.

Table 22. Sample vegetation seral states, successional structure and respective composition, cover, and departure index (DIR) from reference condition (RC) for the mountain mahogany mixed shrubland (MMS) ERU on the Lincoln NF and within the greater Context Area

Seral State	Successional Structure, Composition and Cover Class Description	Percent Proportion			Similarity Values to RC[2]	
		RC[1]	current LNF[4]	current CA[5]	LNF	CA
A	Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover	5	3	96	3	55
B, C	All size shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	65	18	216	18	216
D	All size trees with open or closed woody canopy cover	30	79	679	30	30
Total		100	100	100	51	551
Departure[3] from RC = 100 - ∑ similarity values: Lincoln NF = (100 – 51) = 49 or Moderate; and CA = (100 – 51) = 49 or MODERATE						

[1] Reference Conditions, USFS 2015

[2] Similarity value is the lesser of the two proportions (current Lincoln NF to RC and CA to RC) for a seral state

[3] Lincoln National Forest

[4] Context Area

[5] Departure from RC are; 0 to 33% = low, 34 to 66% = moderate, and 67 to 100% = high

Reference conditions are based on a review of the relevant BASI according to Landfire, The Nature Conservancy, and others by the USFS Southwestern Regional Office (USDA Forest Service 2015). The reference period is best characterized as being prior to the late 1880s, under similar climatic regime, but varies with source.

Current seral state proportion assignment was based on recent existing vegetation mapping derived through remote sensing and interpretation of vegetation size class, canopy cover, dominance type, and storiedness (number of tree canopy levels) at a 1:100,000 scale, with extensive photo interpretation and field data collection (Midscale Vegetation Mapping Project (Mellin et al, 2004)). Existing vegetation is assigned to an ERU and then to the appropriate seral state within that ERU. Thereafter, seral state class descriptions were developed by the Southwestern Regional Office (USDA Forest Service 2015).

Future projections of seral state proportions are produced using the Vegetation Dynamics Development Tool (VDDT) (ESSA, 2006) and models developed by LANDFIRE, The Nature Conservancy, and the Integrated Landscape Assessment Project and refined by the Southwestern Regional Office, with input from Forest specialists. These VDDT state and transition models both define seral states for each ERU and allow comparison among management scenarios. Model results are not precise predictions, but indicate relative trends and are sensitive to changes in management or disturbance. For this analysis, future trend assumes the continuation of management under current plan direction. Most state transition destinations and probabilities are derived from Forest Vegetation Simulator (FVS) modeling (Dixon, 2002). Burn severity information is compiled from Monitoring Trends in Burn Severity (MTBS, 2014) records from 1996 to 2014 (Eidenshink et al, 2007 Wildland Fire Leadership Council, 2014). Other inputs came directly from Forest management actions, such as insect and disease surveys, and wildfire data from the past 15 to 30 years.

By comparing regional Midscale and ILAP current vegetation information to reference seral state proportions, departure is calculated for the context scale, plan scale, and local scale. The Lincoln NF only affects management at the plan scale and only collects management information on the Forest; so VDDT models can only be reliably parameterized at the plan scale. Therefore, future trend is modeled only at the plan scale, though trends at the context scale or local scale may be discussed where information suggests they differ. The trend analysis relies mostly on VDDT modeling results, while trend for other key ecosystem characteristics of vegetation is addressed only when a probable trajectory can be inferred. Seral state proportion trend is discussed in the narrative for each ERU summaries of this chapter.

Results and Interpretation

Seral state proportion current departure is summarized for ERUs at the context, planning and local scales where applicable (Table 23). Similar departure values for an ERU among different local units may mean very different things, for instance a mixed conifer ERU may show departure due to overstocked mature stands dominating one local unit, while another local unit may show departure if it is dominated by early seral and recently burned areas. Results for individual ERUs are discussed in their respective summaries.

Table 23. Departure from Reference condition (%) and class (color) for ERUs at context, Lincoln NF and local unit scales. Blank cells mean ERU does not occur in that unit. Colors represent departure classes: green= Low (0-33%), orange=Moderate (34-66%), and red=High (67-100%). Moderate and High values are considered significantly departed.

Ecological Response Unit	Context Area	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Spruce-Fir Forest	46%	46%	46%	46%			46%	
Mixed Conifer w/Aspen	50%	52%			51%	63%	50%	
Mixed Conifer-Frequent Fire	61%	62%	61%	59%	68%	65%	66%	81%

Ecological Response Unit	Context Area	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Ponderosa Pine Forest	99%	99%	99%	99%	99%	100%	98%	
Ponderosa Pine-Evergreen Oak	66%	66%			95%	64%		66%
Piñon-Juniper Evergreen Shrub	39%	37%			41%	38%	98%	36%
Juniper Grassland	64%	64%	75%	70%			38%	64%
Piñon-Juniper Woodland	64%	65%	69%	68%	68%	68%	59%	
Piñon-Juniper Grassland	58%	58%	65%	62%	65%	60%	61%	56%
Gambel Oak Shrubland	70%	70%			70%	70%		
Mountain Mahogany Mixed Shrubland	49%	49%			66%	67%	65%	35%
Chihuahuan Desert Scrub	0%	5%				4%	5%	
Montane-Subalpine Grassland	85%	94%	99%	83%	100%	100%	92%	
Semi-Desert Grassland	93%	91%				85%	95%	93%

By definition, departure indicates risk to ecosystem integrity. High departure indicates, generally, high risk to ecosystem integrity. For seral state proportion, current departure from reference conditions can be calculated, and future departure can be modeled. While selected ERUs were modeled out to 1,000 years, trend was generally determined from current to the 100 year departure value. According to the Risk Matrix (Table 24), current departure and trend identify the level of risk to ecosystem integrity. For ERUs on the Lincoln NF that were modeled, four were low risk, four were at moderate risk and two are at high risk to ecological integrity (Table 25).

Table 24. Risk matrix for combined departure categories and trend categories

Departure	Trend toward Reference	Trend unknown or static	Trend Away from Reference
High	Low Risk	High Risk	Very High Risk
Moderate	Low Risk	Moderate Risk	High Risk
Low	Low Risk	Low Risk	Moderate Risk

Table 25. Departure (%) and trend from Reference condition of ERUs at the Lincoln NF plan scale currently and projected 10, 100 and 1,000 years into the future. Colors represent departure classes: green= Low (0-33%), orange=Moderate (34-66%), and red=High (67-100%). Moderate and High values are considered significantly departed

ERU	LNF	10 year	100 year	1,000 year	Trend	Risk
MCW	52	50	51	51	Stable	Mod
MCD	62	66	61	59	Stable	Mod
PPF	99	98	88	88	Toward	Low
PJC	37	34	49	46	Away	High
JUG	64	45	44	47	Toward	Low
PJO	65	54	28	31	Toward	Low
PJG	58	48	39	36	Toward	Low
MMS	49	42	37	38	Toward	Low

ERU	LNF	10 year	100 year	1,000 year	Trend	Risk
MSG	94	92	83	75	Toward	Low
SDG	91	94	95	95	Away	Very High

The four low risk ERUs include the juniper woodland and grassland types JUG, PJG, and PJO, and the mountain mahogany mixed shrubland type. Typically, these ERUs have limited vegetation management, as they do not produce timber or other products. However, modeled treatments per recent management efforts to reduce encroaching juniper for fire protection and forage enhancement may have played a role in moving these ERUs toward reference conditions with time. Of the four ERUs showing moderate risk (PPF, MCD, MCW, and MSG), mixed conifer ERUs, MCD and MCW, are moderately departed currently, and remain stable over time. For these ERUs, current forest management has plan direction that are somewhat different from reference conditions to provide protections for wildlife species, particularly the northern goshawk and the Mexican spotted owl. Under that management, trend is stable, and departure is expected to remain moderate in the future. Under a scenario where desired conditions more closely resemble reference conditions, it might be expected that future trends for these types would be toward reference conditions. Two ERUs at moderate risk are the highly departed PPF and MSG types which are moving toward reference conditions. The SDG and PJC ERUs are at high risk as modelled into the future under current management. Allowing wildfire to act as a management tool might mitigate risk for both of these ERUs. Grazing might be the driver for departure in SDG, but it is unclear if removal of grazing would help return the ERU toward reference conditions without active removal of shrubs.

Risk Conclusion

In order to develop a risk conclusion, identification of whether the comparisons between conditions that sustain ecosystem integrity, current conditions, and projected future conditions indicate if one of the following are true for the key ecosystem characteristics being analyzed:

a. The key ecosystem characteristic is functioning in a way that contributes to ecosystem integrity and sustainability over time and is expected to continue to do so under current plan direction;

b. The key ecosystem characteristic is not currently contributing to ecosystem integrity, but with changes to current plan direction, could do so in the future; or

c. The key ecosystem characteristic is not expected to contribute to ecosystem integrity in the future due to threats or stressors that are not within the authority of the Forest Service, or are inconsistent with the inherent capability of the land.

The ecosystem characteristic is applied to individual ERUs, and risk is assessed for the characteristic for individual ERUs according to the risk matrix (Table 24 and Table 25). The four ERUs with low risk (JUG, PJG, MMS, and PJO) meet condition (a) above. The four ERUs with moderate risk (PPF, MCD, MCW, and MSG) meet condition (b), as does the high risk PJC ERU. Semi-desert grassland (SDG) meets condition (c) because so little of the SDG ERU in the Context Area is affected by Lincoln NF management.

Fire Rotation, Fire Severity, Fire Regime Condition Class

Fire regimes are a critical foundation for understanding and describing effects of changing climate on fire patterns and characterizing their combined impacts on vegetation and the carbon cycle (Schoennagel et al, 2004). In general a **fire regime** characterizes the spatial and temporal patterns and ecological influences of fire on the landscape. The two most important factors for determining fire regimes are vegetation type (or ecosystem) and weather and climate patterns. Fire history provides evidence of past relationships between fire and climate. Changing climate may profoundly affect the frequency and severity of fires in many regions and ecosystems in response to factors such as earlier snowmelt and more severe or prolonged droughts. Changing climate will alter the growth and vigor of existing vegetation, with resulting changes in fuel structure and dead fuel loads.

A fire regime is a generalization based on fire histories at individual sites. Fire regimes can be described as cyclic because fire events on the landscape are repeated, and the repetitions can be counted and measured, to provide **fire return interval** (NWCG, 2008). Alternatively, landscapes can have a typical fire rotation (interval), the amount of time for the amount of acres in a landscape to burn, although some acres may not burn and others may burn more than once. Fire regimes are also characterized by typical **fire severities**, depending on vegetation type and conditions. Ponderosa pine forests, for example, historically had a fire regime of high frequency (5-30 years) and low severity, or mortality of overstory. Fire is an integral component in the function and biodiversity of many natural habitats and organisms, and these communities have adapted to withstand and even to exploit natural wildfire. More generally, fire is regarded as a "natural disturbance", similar to flooding, wind-storms, and landslides, that has driven the evolution of species and controls the characteristics of ecosystems. Each vegetation type, or ecological response unit (ERU; see ERU Description) has a characteristic fire regime that contributes to its ecological integrity. If fires are too frequent, plants may be killed before they have matured, or before they have set sufficient seed to ensure population recovery. If fires are too infrequent, plants may not release their seed; species composition may shift toward abnormal combinations; or live and dead biomass may simply accumulate to abnormal levels. Departure from historic fire regimes come from changes in fire rotations and severity or both. Departure for either characteristic indicate a level of risk to ecosystems on the landscape over time. Departure of severity, rotation plus departure of current seral state proportions (see Seral State Proportion section) of an ecosystem provide a fire regime condition class (FRCC) rating that describes the risk to ecosystem integrity from wildfire.

Fire regime condition class (FRCC) is the combination of successional state departure and fire regime departure into a single metric. FRCC is an important tool for measuring the effectiveness of efforts to maintain sustainable landscapes (NIFTT 2010). FRCC ratings describe a level of departure from native ecosystems as they existed prior to Euro-American settlement:

FRCC I: Fire regimes are within the natural or historic range of variation and risk of losing key ecosystem components is low. Vegetation attributes (composition and structure) are intact and functioning (departure < 33 percent).

FRCC II: Fire regimes have been moderately altered. Risk of losing key ecosystem components is moderate. Fire frequencies may have departed by one or more return intervals (either increased or decreased), potentially resulting in moderate changes in fire and vegetation attributes (33-66 percent departed).

FRCC III: Fire regimes have been substantially altered. Risk of losing key ecosystem components is high. Fire frequencies may have departed by multiple return intervals, potentially resulting in dramatic changes in fire size, fire intensity, and fire severity as well as landscape patterns. Vegetation attributes have been substantially altered (greater than 66 percent departed).

Analysis was done at the Plan and Local scale only (Table 26). To capture variation in fire regime condition class, local scales described earlier are further divided into FRCC local units at the sub-watershed (5th code) level.

Fire regime combines mean fire rotation, and the percent of burns that are non-lethal, mixed severity, and stand replacement (fire severity). Departures for fire frequency and severity are determined independently at the plan and local scales. Reference conditions, or the historic range of variation, were determined through a review and synthesis of literature by The Nature Conservancy (2006) and Triepke (2014). While historic reference time periods may vary with literature source, the general reference period is considered to be the late 1800s.

Fire rotation (frequency) at the plan and local scales is based on Lincoln NF fire history data from the 20 year period between 1996 and 2015. Mean fire return interval was calculated for each ERU by dividing ERU area by the average area burned per year for that ERU (Table 27).

Fire severity information was obtained from Monitoring Trends in Burn Severity (MTBS) data for the Lincoln NF from 1996-2014. Burn severity was summarized by ERU at the plan and local scales (Table 27). Forest ecologists define severity by the degree of overstory plant mortality. Although the thresholds are subjective, in general, overstory mortality below *approximately* 30 percent is considered low severity, 30 to 70 percent is considered moderate severity, and greater than 70 percent is considered high severity (Agee 1993). Severity was combined to a single value for each ERU at plan and local scales and compared to reference conditions. Departure was calculated using the formula 1-min/max, where min is the minimum of current or reference values, and max is the maximum of the current or reference values. Fire severity was not analyzed for the Context Area.

The historic distribution of fire severity among low, moderate, and high severity types is ecosystem specific. The current distribution is more departed in some ERUs than in others, and the direction of departure is also ERU specific. The dryer MCD and PPF forested ERUs as well as the PJO woodland ERU were little departed from reference conditions. Severity was moderately departed for the mesic forest SFF and MCW ERUs, as well as for the PJC, JUG, PJO and MMS ERUs. The grassland ERUs MSG and SDG were both highly departed for fire severity. Fire severity departure is discussed in more detail in the individual ERU summaries.

Soil burn severity is a category of fire effects related to the change in soil properties and is one major reason for post-fire assessments of fire severity. It is believed to be an important indicator of the potential for water runoff and erosion, and changes in soil hydrologic function

Forest ecologists define severity by the degree of overstory plant mortality. Although the thresholds are subjective, in general, overstory mortality below *approximately* 30 percent is considered low severity, 30 to 70 percent is considered moderate severity, and greater than 70 percent is considered high severity (Agee 1993). Severity was combined to a single value for each ERU at plan and local scales and compared to reference conditions. Departure was calculated using the formula 1-min/max, where min is the minimum of current or reference values, and max is the maximum of the current or reference values. Fire severity was not analyzed for the Context Area.

The historic distribution of fire severity among low, moderate, and high severity types is ecosystem specific. The current distribution is more departed in some ERUs than in others, and the direction of departure is also ERU specific. The dryer MCD and PPF forested ERUs as well as the PJO woodland ERU were little departed from reference conditions. Severity was moderately departed for the mesic forest SFF and MCW ERUs, as well as for the PJC, JUG, PJO and MMS ERUs. The grassland ERUs MSG and SDG were both highly departed for fire severity. Fire severity departure is discussed in more detail in the individual ERU summaries.

Soil burn severity is a category of fire effects related to the change in soil properties and is one major reason for post-fire assessments of fire severity. It is believed to be an important indicator of the potential for water runoff and erosion, and changes in soil hydrologic function.

FRCC is the combined departure of Fire Rotation and Severity (above) and current seral state proportion.

Average annual current condition values were calculated for rotation and severity for each ERU in the Plan Area and compared to reference conditions. Departure for fire rotation and severity was calculated using the formula 1-min/max, where min is the minimum of current or reference values, and max is the maximum of the current or reference values. Departure is expressed as a percentage, as well as a departure class: 0-33 percent=Low, 34-66 percent=Moderate and 67-100 percent=High.

Fire regime condition class (FRCC) is a summary measure of ecological departure from reference conditions under a natural fire regime. It is calculated by averaging seral state departure and fire regime departure (0-100 scale) and then classified into low (I), moderate (II), high (III) departure classes. The FRCC was calculated for ERUs across the Lincoln NF (Table 27, Table 30).

At the Plan scale, FRCC is reported as a percentage of Plan Area in each class of departure: low (near/within historical range of variation (0-33 percent), moderate (34-66 percent), and high (67-100 percent). At the local scale, a single FRCC value is reported for each ERU to show the variability in condition across the Forest for each ERU and to highlight areas where departure suggests need for change.

Table 26. Breakdown of Forest Local Units by FRCC Local Units, FRCC Code, and Acres per Forest Acres per FRCC Code

Local Unit	FRCC Local Unit	FRCC Code	Acres
Arroyo Del Macho	Reventon Draw	RD	86,215
Rio Hondo	Blackwater Canyon	BC	77,974
	Rio Bonito	RB	28,496
	Rio Ruidoso	RR	78,966
Rio Peñasco	Agua Chiquita - Cuevo Creek	AC	131,917
	Elk Canyon - Rio Peñasco	RP	132,917
Salt Basin	Big Dog Canyon	BD	15,588
	Black River	BR	47
	Piñon Wash	PW	22,995
	Sacramento River	SR	60,431
Tularosa Valley	Tularosa Valley North	TVN	88,834
	Tularosa Valley South	TVS	125,044
Upper Pecos-Black	Black River	BR	20,559
	Dark Canyon	DC	44,054
	Upper Pecos North	UPN	78,123
	Upper Pecos South	UPS	101,668

FRCC was calculated at the local scale by averaging seral state proportion departure and fire regime departure. Characteristic fire regime was defined as the average of HRV reported for each ERU below. Local scale ratings were area weighted for each ERU to determine a percentage by class at the plan scale. ERUs with higher proportions in FRCC II or III are at higher risk of loss of ecosystem integrity as a result of uncharacteristic disturbance. Local units report a single departure value for each ERU and are departed with FRCC values of II or III.

Departure is summarized for 14 ERUs at the Plan Scale. No ERUs were represented in all local units, and no local unit contained all considered ERUs (Table 28) and Forest ecologists define severity by the degree of overstory plant mortality. Although the thresholds are subjective, in general, overstory mortality below *approximately* 30 percent is considered low severity, 30 to 70 percent is considered moderate severity, and greater than 70 percent is considered high severity (Agee 1993). Severity was combined to a single value for each ERU at plan and local scales and compared to reference conditions. Departure was calculated using the formula 1-min/max, where min is the minimum of current or reference values, and max is the maximum of the current or reference values. Fire severity was not analyzed for the Context Area.

The historic distribution of fire severity among low, moderate, and high severity types is ecosystem specific. The current distribution is more departed in some ERUs than in others, and the direction of departure is also ERU specific. The dryer MCD and PPF forested ERUs as well as the PJO woodland ERU were little departed from reference conditions. Severity was moderately departed for the mesic forest SFF and MCW ERUs, as well as for the PJC, JUG, PJO and MMS ERUs. The grassland ERUs MSG and SDG were both highly departed for fire severity. Fire severity departure is discussed in more detail in the individual ERU summaries.

Soil burn severity is a category of fire effects related to the change in soil properties and is one major reason for post-fire assessments of fire severity. It is believed to be an important indicator of the potential for water runoff and erosion, and changes in soil hydrologic function (Table 29).

Results of analysis

Table 27. Summary table of Fire Regime Condition Class (FRCC), Fire Frequency and Fire Severity for the Ecological Response Units of the Lincoln NF at the Plan scale

ERUs	Fire Regime Condition Class			Fire Rotation			Fire Severity		
	I	II	III	interval	ref int	departure	severity	ref sev	departure
SFF	0%	100%	0%	28.9	155.56	81%	0.37	0.58	37%
MCW	0%	84.6%	15.4%	500.9	120.00	76%	0.59	0.65	9%
MCD	0%	30.5%	69.5%	85.9	22.24	74%	0.31	0.18	41%
PPF	0%	0%	100%	70.4	10.50	85%	0.26	0.13	53%
PPE	n/a	n/a	n/a	n/a	12.45	n/a	n/a	0.15	n/a
PJC	0%	100%	0%	335.2	206.30	38%	0.53	0.69	23%
JUG	0%	60.1%	39.9%	40.8	13.00	68%	0.34	0.13	63%
PJO	0%	75%	25%	102.5	254.55	60%	0.22	0.64	66%
PJG	0%	100%	0%	117.5	20.10	83%	0.18	0.13	31%
GAMB	n/a	n/a	n/a	n/a	75.00	n/a	n/a	0.78	n/a
MMS	0%	82%	18%	108.6	75.00	31%	0.37	0.78	53%
CDS	n/a	n/a	n/a	64065.3	250.00	n/a	0.15	0.50	n/a
MSG	0%	4%	96%	73.0	12.00	84%	0.27	0.88	69%
SDG	0%	0%	100%	51.4	6.00	88%	0.15	0.88	83%

FRCC shows percent of ERU in low (FRCC I), moderate (FRCC II) and high (FRCC III) departure from reference condition. Departure from reference conditions for Frequency and Severity is shown by color: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). Departure in the moderate and high ranges is considered significant.

Fire Frequency

Fire frequency is measured in mean fire return interval (MFRI), the number of years it would take for an area equal to the entire ERU to burn. A shorter interval indicates more frequent fire in the system. Reference conditions were provided through a synthesis of literature provided by Region 3 ecologists. Similarity to reference conditions is expressed as the minimum of either the current or reference values, divided by the maximum of either the current or reference values. Departure is calculated as 1- similarity. Table 28 displays fire rotation for each ERU at context, plan and local scales. Not all ERUs or local units had fires in the analysis time frame and are not shown. Fire rotation is longer than reference for all ERUs at the context scale, although departure is moderate for the MCW, PJC and PJO ERUs. All other ERUs are highly departed. At the plan scale, only MMS shows low departure from reference, while PJC and PJG are moderately departed, with remaining ERUs highly departed. More detail is provided in the individual ERU summaries.

Table 28. Fire frequency (rotation) in years and departure class for context, plan and FRCC local unit.

Unit\ERU	Context	LNF	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
SFF	1,568	28.9			19				20	25	32		1,772		
MCW	257	501	70				6,036					205			
MCD	257	86	87	1,927	20	39	139		24	29	42	6,342	3,807		
PPF	295	70	77		30		46		34	26	95		32,645		
PJC	672	335	1,962	6,630		457	637								20
JUG	313	41				28					2,432			0	4
PJO	643	117	192		244		33	0	179	26	55				
PJG	1,214	103	13,799			232,750	37	6,101			15			140	503
MMS	365	109	376	1,192		25									20
MSG	387	73	67		20		97		3	23	40	22,472	206		
SDG	255	51				36								46	38

Colors represent departure: green = low (0-33%), orange = moderate (34-66%), and red = high (67-100%). Departure is considered significant at moderate and high values. Blank cells represent no frequency data for that ERU in that unit.

Fire Severity

Forest ecologists define severity by the degree of overstory plant mortality. Although the thresholds are subjective, in general, overstory mortality below *approximately* 30 percent is considered low severity, 30 to 70 percent is considered moderate severity, and greater than 70 percent is considered high severity (Agee 1993). Severity was combined to a single value for each ERU at plan and local scales and compared to reference conditions. Departure was calculated using the formula 1-min/max, where min is the minimum of current or reference values, and max is the maximum of the current or reference values. Fire severity was not analyzed for the Context Area.

The historic distribution of fire severity among low, moderate, and high severity types is ecosystem specific. The current distribution is more departed in some ERUs than in others, and the direction of departure is also ERU specific (Table 29). The dryer MCD and PPF forested ERUs as well as the PJO woodland ERU were little departed from reference conditions. Severity was moderately departed for the mesic forest SFF and MCW ERUs, as well as for the PJC, JUG, PJO and MMS ERUs. The grassland ERUs MSG and SDG were both highly departed for fire severity. Fire severity departure is discussed in more detail in the individual ERU summaries.

Soil burn severity is a category of fire effects related to the change in soil properties and is one major reason for post-fire assessments of fire severity. It is believed to be an important indicator of the potential for water runoff and erosion, and changes in soil hydrologic function.

Table 29. Fire severity average percent mortality values for each ERU. Colors represent percent departure from reference condition: green= low (0-33%), orange=moderate (34-66%), red=high (67-100%). Blank (gray) cells represent no severity data for that ERU in that unit.

ERU/Unit	LNF	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
SFF	37%			22%				37%	37%	44%		30%		
MCW	59%	60%				33%					18%			
MCD	31%	40%	13%	23%	29%	39%		29%	23%	29%	34%	13%		
PPF	26%	29%		18%		38%		23%	29%	23%		13%		
PJC	53%	15%	13%		15%	29%								51%
JUG	34%				15%					13%			13%	28%

ERU/Unit	LNF	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
PJO	22%	28%		14%		25%	14%	19%	39%	24%				
PJG	18%	13%			13%	15%	15%			26%			14%	22%
MMS	37%	23%	13%		20%									59%
MSG	27%	30%		28%		24%		33%	20%	21%	13%	20%		
SDG	15%				13%								13%	19%

Fire Regime Condition Class

As displayed in Table 30, FRCCs for all of the Forest's ERUs are moderately or highly departed, both at the Forest and local unit scales. FRCC is discussed, along with fire frequency and severity, for individual ERUs in their respective summaries.

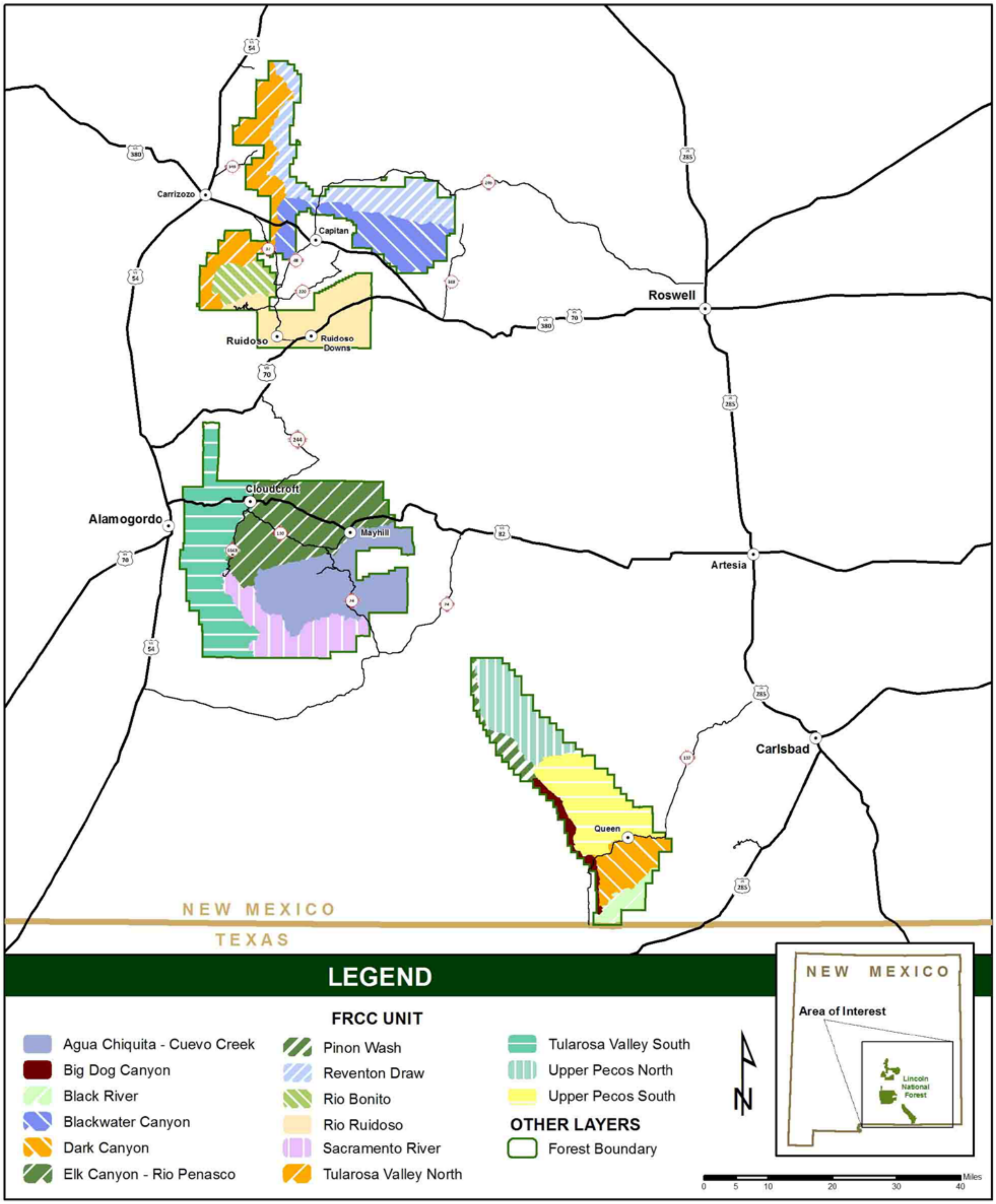

Figure 19. Fire Regime Condition Class unit locations on the Lincoln NF

Table 30. Fire Regime Condition Class by Ecological Response Units (ERUs) for FRCC local units. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Blank (gray) cells indicate no data for that ERU in that unit.

ERU	Agua Chiquita	Big Dog Cyn	Black River	Blackwater Cyn	Dark Cyn	Rio Peñasco	Pinon Wash	Reventon Draw	Rio Bonito	Rio Ruidoso	Sacramento River	Tularosa North	Tularosa South	Upper Pecos North	Upper Pecos South
SFF				II				II	II	II		II			
MCW	II					II					III				
MCD	III		III	II	II	III		II	II	II	III	II			
PPF	III			III		III		III	III	III		III			
PPE															
PJC	II		II		II										II
JUG					II					II					III
PJO	II			II		II		II	II	III					
PJG	II				II	II	II			II				II	II
GAMB															
MMS	III		II		II										II
CDS															
MSG	III			II		III		III	III	III	III	III			
SDG					III									III	III

Trend and Risk

As discussed above, FRCC is a composite of fire severity, fire rotation interval, and vegetation condition, vegetation being discussed in more detail in the Seral State Proportion section. Fire rotation and fire severity each provide a measure of ecological departure and, therefore, are indicators of risk to ecological integrity. FRCC, by design, is an indicator of risk to ecosystem integrity inclusive of fire rotation and severity. For the Lincoln NF Plan Area, FRCC shows the Forest in generally departed conditions for all ERUs. Grasslands (MSG and SDG) are highly departed, due to tree and shrub encroachment, and forested (SFF, MCW, MCD, PPF and PPE) ERUs are departed due to high tree densities and accumulated biomass rising from fire suppression. The woodland types (PJC, JUG, PJO and PJG) have more varied departure among local units, and are generally moderately departed for the Forest. The trend, when measured from reference conditions, is toward more departed. Under current management and disturbance regimes, this trend would likely continue (see modeling results in Seral State Proportion section, where changes in seral state are projected out 10, 100, and 1,000 years under current management and disturbance regimes). Treatments to move the landscape toward reference conditions may alter the seral state proportions, reduce fire severity and fire rotation departure, and thus reduce the FRCC to more moderate levels. However, management activities have not been able to keep up with natural processes and disturbance, and risk to ecological integrity is moderate to high.

Snags and Coarse Wood Analysis

Coarse woody debris (CWD) (downed woody material) serves as an important ecological function. It provides wildlife habitat and contributes to the formation of soil organic matter. Coarse woody debris also help to reduce soil erosion by shielding the soil surface from raindrop impact and interrupting rill and sheet erosion. Like CWD, snags (standing dead trees) serve an important ecological function. Large standing snags provide key habitat for many species, such as woodpeckers that feed on insects dwelling in decomposing wood. Deficient CWD and snags may indicate a lack of appropriate habitat and inadequate nutrient cycling. An overabundance may indicate underlying stress on an ecosystem (such as drought or insect outbreaks), and potentially increases wildfire severity. Reduced disturbance frequency may result in fewer trees dying and becoming available as debris. Also, timber and fuelwood harvesting removes mature and dead trees that would otherwise become coarse woody debris.

Different vegetation types have historically characteristic amounts of CWD and snags. Deviation from those characteristic amounts may be an indication that ecosystem processes are not functioning as historically, and that ecosystem integrity is at risk. For this analysis, vegetation types were stratified as Ecological Response Units. Only forested and woodland ERUs were analyzed.

Analysis

Coarse woody debris (CWD) is defined as tons per acre of dead material greater than three inches in diameter.

Snag density is defined as the number of stems per acre by diameter classes (i.e., 8 to 18 inches, greater than 18 inches).

Current conditions for analysis at the local and plan scale were extracted from FSVEG stand exam survey data collected by the Lincoln NF. No analogous information is available at the context scale.

Reference conditions for the ERUs were synthesized from various sources by Region 3 ecologists (Triepke 2014).

Departure for all three characteristics was calculated using the formula “1-min (ref, current)/max (ref, current)”, that is, if the reference condition was 2 snags per acre, and the current condition is 3 snags per acre, departure would be 1-2/3= 0.33. Departure values are classified as 0-0.33 as low, 0.34-0.66 moderate, and 0.67-1.0 as high. Local unit departure is shown in individual ERU sections. Local Unit values were weighted by their proportion of the Plan Area and summed to provide values for CWD and Snags at the Plan Area scale (Table 31).

Table 31. Lincoln NF departure for coarse woody debris (CWD) and snags. Lincoln column shows current values for each ERU. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Moderate and High departure is considered significant. Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition.

	CWD Tons per acre			Snags per acre 8-18 inches			Snags per acre >18 inches		
ERU	Lincoln	Dep	Trend	Lincoln	Dep	Trend	Lincoln	Dep	Trend
SFF	24.8	0.31	(11.2)	31.0	0.19	6.0	3.0	0.67	(6.0)
MCW	19.3	0.27	(7.0)	21.1	0.34	7.1	12.3	0.67	8.3
MCD	57.0	0.80	45.6	47.2	0.81	38.2	19.7	0.80	15.7
PPF	8.5	0.35	(4.5)	4.3	0.85	3.6	0.5	0.30	(0.2)
PPE	13.9	0.28	3.9	6.8	0.26	1.8	3.4	0.42	1.4
PJO	8.2	0.64	5.2	16.4	0.88	14.4	3.5	0.71	2.5
PJC	11.0	0.73	8.0	6.6	0.54	3.6	2.2	0.54	1.2
PJG	5.0	0.46	2.3	8.7	0.43	3.7	1.5	0.33	0.5

Eight forest and woodland ERUs were analyzed at the Plan Area and Local Unit scales. Departure at the plan scale varied with ERU for all three characteristics (Table 31). Departure generally trended toward more coarse woody debris (CWD) and snags than in reference conditions, although CWD was deficit for both spruce-fir forest (SFF) and wet mixed conifer (MCW), even though departure was low for those ERUs. Snags in the 8-18 inch class were more abundant than reference for all ERUs, with mixed conifer frequent fire (MCD), ponderosa pine forest (PPF) and piñon-juniper woodland (PJO) highly departed. Snags in the greater than 18 inch class mostly exceeded reference conditions, and were highly departed for the MCD, MCW, SFF and PJO ERUs. The SFF ERU was highly departed with a deficit of snags in that size class.

Risk Assessment

For the Plan Area, risk to each of the three characteristics discussed above is moderate, and risk to all ecosystems for the three combined characteristics is also moderate. At moderate or high levels of departure, trend, or whether there is too much or too little of the characteristic, may take on more meaning. Too few snags in the large size class, such as in the SFF, is reflective of the seral state departure for SFF which is under-represented in the larger size class of live trees (see Seral State Proportion section). Wildlife habitat may be compromised if there is not enough of any of these characteristics, depending on species needs. Invertebrates, reptiles, amphibians and small mammals use large coarse woody debris, and cavity nesting birds need snags. Too much of any of these characteristics, however, can indicate a system experiencing effects from stressors, such as fire, insect and disease infestations, or density induced mortality. Departure at the local scale may vary from departure at the plan scale, with trends reflecting local disturbances such as large fires or insect outbreaks. Local unit departure and trend for CWD and snags are shown in Table 31. Snag density and coarse woody debris is discussed in more detail for individual ERUs in their respective summaries.

Departure is primarily a function of natural disturbances and legacy conditions (not current management).

Ecological Status and Ground Cover

Ecological status, or similarity to site potential, is based on vegetation composition (vegetation structure being represented by other characteristics). The similarity to site potential analysis results in an index value that considers the cover value of all plant species collectively, as opposed to evaluating every species or every plant life form. It is a measure of the degree of similarity between the existing plant community and the reference community as described in the Smokey Bear Ranger District Terrestrial Ecosystem Survey (USDA Forest Service 1980). The less similar the species composition at a site is to reference conditions, the more departed that system is (see key ecosystem characteristics). Ecosystem integrity is compromised when species composition is highly departed. Departure may indicate a site is in an early seral state, a shift in species composition for a seral state, loss of native species to encroachment or invasive species, or even conversion of the site to a different habitat type.

Scale of analysis

Ecological status is only analyzed at the plan scale. Insufficient data exists for comparison at local scale, and neither TES nor analogous data is available for reference conditions at the Context Scale.

Data Sources

Reference Conditions

Terrestrial Ecological Unit Inventory (TEUI) data has only been published for the Smokey Bear Ranger District (Terrestrial Ecosystem Survey; USDA Forest Service 1980), and extrapolated to provide reference conditions for Ecological Response Units (ERUs, see Ecological Response Unit section) across the Forest. Reference conditions were developed for TES map units based on vegetation analyses of sites considered to represent stable, diverse and functional ecosystems. Reference units are the estimated cover of species expected in that map unit.

Current Conditions

Integrated Landscape Assessment Project (ILAP) vegetation data was used to provide current conditions for ecological status. Available ILAP data span a period from 1993- 2011. These ILAP plots were clipped to the Lincoln NF boundary with a 200-meter buffer to increase sample size (n=156) and capture underrepresented ERU types. The plots were linked to TEUI map units in ArcGIS using the Identity tool.

Analysis

Method

Species cover values for both current and reference condition were summarized by genus for individual TEUI map units. Departure was calculated for each map unit, area weighted by the proportion of the map unit in an ERU, and summed to provide ERU departure at the plan scale.

Departure from reference conditions is calculated (per LANDFIRE departure for single variables) by the expression Departure = 1- Similarity, where similarity is the minimum of reference or current conditions, divided by the maximum of reference or current conditions, as shown below, and expressed as a percentage.

$$\text{Departure} = 1 - (\text{minimum}(\text{Reference, Current})/(\text{maximum}(\text{Reference, Current})))$$

For example, for PJ woodland, the minimum and maximum was determined for each taxon in a unit and the resulting similarities were summed and the total subtracted from one (Table 32).

Table 32. Example of site, similarity, and departure calculation Departure classes are determined by a percent range with 0-33 percent is low departure (L), 34-66 percent moderate (M) and 67-100 percent high departure.

Genus	Reference	Current	Minimum	Maximum	Similarity	Departure (%)
Agropyron	0.01	0.00	0.00	0.01	0.00	100
Andropogon	2.00	0.00	0.00	2.00	0.00	100
Bouteloua	15.50	0.00	0.00	15.50	0.00	100
Cercocarpus	0.50	0.00	0.00	0.50	0.00	100
Cirsium	0.00	0.50	0.00	0.50	0.00	100
Elymus	0.70	0.00	0.00	0.70	0.00	100
Gutierrezia	0.00	0.50	0.00	0.50	0.00	100
Juniperus	30.00	20.00	20.00	30.00	0.67	33
Lycurus	0.01	0.00	0.00	0.01	0.00	100
Mahonia	0.01	0.50	0.01	0.50	0.02	98
Pinus	25.00	10.00	10.00	25.00	0.40	60
Quercus	0.02	0.50	0.02	0.50	0.04	96
Rhus	0.01	0.50	0.01	0.50	0.02	98
Total			30.04	76.22	0.39	61

Results

Departure is shown in Table 33. Not all ERUs are represented in the departure table for ecological status. Departure could only be calculated where current ILAP data was coincident with TES derived reference data. For some ERUs there may be no ILAP current data or TEUI derived reference data, but it is reasonable to interpolate results from similar ERUs (e.g. PJG and JUG)

Table 33. Ecological Response Unit departure for Ecological Status and Ground Cover at the Plan scale. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%).

Vegetation Type	ERU	Ecological Status Departure	Ground Cover Departure
Forest	SFF	n/a	n/a
	MCW	n/a	n/a
	MCD	76%	39%
	PPF	87%	11%
	PPE	n/a	57%
Woodland	PJC	n/a	n/a
	JUG	n/a	54%
	PJO	73%	35%
	PJG	92%	25%
Shrubland	GAMB	n/a	n/a
	MMS	n/a	56%
	CDS	n/a	55%
Grassland	MSG	69%	40%

Vegetation Type	ERU	Ecological Status Departure	Ground Cover Departure
	SDG	93%	60%

Trend and Risk

All ERUs analyzed were highly departed. High departure could arise from a shift in proportions of species on the landscape. For instance, reference conditions might have 20 percent Douglas-fir and 30 percent ponderosa pine while current conditions may have the percentages reversed. Alternatively, there may be a replacement of a native species with an introduced species such as in the MSG grassland ERU, where the traditional Arizona fescue has lost dominance to the introduced Kentucky bluegrass. The Lincoln NF is at high risk for ecological status.

Vegetative ground cover

Vegetative ground cover is the combined percent cover of basal vegetation and litter. Ground cover provides soil stability, increases water capture, and improves moisture retention. Reduction of ground cover can lead to decreased productivity, changes in runoff timing and quantity, increased erosion, and increased sedimentation. Conversely, increases in ground cover may limit overstory cover of herbaceous vegetation and regeneration of tree or shrub species. Departure from reference conditions can be from an increase or decrease in ground cover. Further, ground cover doesn't discriminate between litter and basal vegetation. A site with proportionately more basal herbaceous vegetation and less litter may have similar departure as a shrubby site with much less basal vegetation and more shrub litter, within the same TEUI map unit or ERU. Regardless, ground cover departure may indicate some risk to the soil resource.

Scale of Analysis

No reference conditions are available for context scale. Current data was insufficient to apply at local scale. Vegetative ground cover was only analyzed at the plan scale.

Data Sources

Reference conditions

Estimates of "natural" vegetative ground cover are available at the plan scale in the Smokey Bear Ranger District Terrestrial Ecosystem Survey (USDA Forest Service 1980), and were extrapolated to the remainder of the Forest. Reference values come from combining "natural" values for basal vegetation and litter in section 3.0, Estimated Soil Properties. Natural values are what might be expected for a site at potential. Similar data is not available for non-National Forest System (NFS) lands in the context landscape, and no departure estimate is made at the context scale.

Current Conditions

Current condition comes from CNVSP (USDA Forest Service 2013) plot data collected by the Forest since 2009. Total percent vegetative cover includes basal area for all plant species, as well as percent cover of litter. The current estimate reflects changes resulting from road construction or other development, concentrated recreation, management related ground disturbance, or legacy impacts from logging, grazing, etc. CNVSP plots were linked to TEUI map units in ArcGIS using the Identity tool.

Analysis

Method

Basal vegetation and litter were combined for both reference and current conditions. Ground cover was averaged across CNVSP plots that occurred within a TEUI map unit, then compared with reference values for that map unit to calculate departure. Departure from reference conditions is calculated (per LANDFIRE departure for single variables) by the expression Departure = 1- Similarity, where similarity is the minimum of reference or current conditions, divided by the maximum of reference or current conditions, as shown below, and expressed as a percentage.

Departure = 1 – (minimum(Reference, Current)/(maximum(Reference, Current)))

TEUI map unit departure was area-weighted by map unit proportion of the ERU, then summed to provide departure values for respective ERUs.

Results

Departure values were mostly in the moderate range for ERUs where departure could be calculated. No ERUs were highly departed while PJG and PPF showed low departure (Table 33). Results for individual ERUs are discussed in their respective summaries.

Patch Size

Patch size is the average size in acres of contiguous area of similar vegetation structure in a vegetation type (ecological response unit or ERU) on the landscape. Patch size plays a significant role in wildfire behavior and wildlife habitat use. Historic timber harvest and fire suppression are largely responsible for decreased fire frequency, increased fire severity, and an increase in closed canopies across Rocky Mountain forests (Schoennagel et al 2004). These changes, where combined with uncharacteristically large patches of contiguous tree canopies, set the stage for uncharacteristically large, severe wildfires. Patch size is also an important element of wildlife habitat. Each wildlife species responds to patch size, and preferences vary by species. For these reasons, and also for reasons of wildfire behavior, current landscape distribution of patches should resemble the distribution under reference conditions—the conditions to which wildlife species adapted—so as to best accommodate the varying preferences of all wildlife species and simultaneously mimic historic fire behavior. Patch size as an ecological characteristic can be used to provide additional interpretation for other characteristics such as seral state proportion or fire severity, as well as to indicate potential wildlife habitat concerns. Changes in current patch size relative to reference patch sizes (departure), and the direction of the change, can mean different things for different ERUs, which will be discussed further below.

Analysis

Method

Patch size is only analyzed at the Plan scale. What makes a ‘patch’ varies with general type of ERU. Patches of shrub, woodland and forest type patches are defined as trees, clumps, or patches. Grasslands, on the other hand, have patches defined as open areas with inclusions of shrubs or trees collectively less than 10 percent. Current conditions come from seral state proportion analysis (see Seral State Proportion section). Patch size is calculated based on the average of all patches of similar vegetation structure of an ERU that intersect the Plan Area. For some ERUs, this means the analysis area may extend significantly into the context landscape. Departure from reference conditions indicate risk to the ecological integrity of the particular ERU. Reference conditions include ranges or individual values for an ERU from a synthesis of information provided in a number of sources. The reference period, though not strictly defined, is considered to be up until the late 1800s. Departure was calculated as 0 if current values fell within the reference condition values, or as 1- (min/max) of current and nearest reference value, if current values fell outside reference values. For example, for CDS, the current value of 89 lies below the reference range of 176 to 326. In this case, the departure calculation would be 1- (89/176) = 0.485, or 49 percent. Departure classes are 0-33 percent = Low, 34-66 percent = Moderate, and 67-100 percent = High (Table 34).

Table 34. Patch size departure. Trend shows whether patch size is smaller or larger than reference. Patch size refers to open grasslands for grassland systems, and contiguous wooded area for shrubland, woodland and forest systems.

SYSTEM TYPE	ERU	REFERENCE CONDITION (acres)		CURRENT CONDITION (acres)	TREND	DEPARTURE (%)
		LWR	UPR			
Forest**	SFF	200	1,000	73	Smaller	63%
Forest**	MCW	100	400	120	Similar	0%
Forest**	MCD	0.02	50	104	Larger	52%
Forest**	PPF	0.02	0.5	41	Larger	99%
Forest**	PPE	0.02	50	7	Similar	0%
Woodland**	PJC	50	200	5	Smaller	90%
Woodland**	PJO	50	400	11	Smaller	79%
Woodland**	PJG	0.07	1.0	12	Larger	92%
Woodland**	JUG	0.07	0.5	19	Larger	97%
Shrubland*	CDS	176	326	89	Smaller	49%
Shrubland*	MMS	300	522	8	Smaller	97%
Grassland*	SDG	265	651	1	Smaller	99%
Grassland*	MSG	87	126	2	Smaller	97%

'* - For grassland and shrubland systems reference condition is based on TEUI polygon geometry, mean patch size plus and minus the standard error to determine lower and upper patch size values.

' - For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.**

Results

Patch size for forest and woodland types are based on contiguous wooded area. The ‘patch’ for woodlands are clumps of trees, and increasing patch size indicates tree encroachment in otherwise more open grassy condition. For grassland ERUs, patch size is related to openings, with smaller current patch sizes reflecting encroachment by woody species. For patch size, most ERUs on the Lincoln NF show high departure from reference conditions (Table 34). Two ERUs, MCW and PPE, showed low (0) departure, although they were near the low end of their respective reference range. Two forested ERUs, SFF and MCD, are moderately departed, as is the shrub type CDS.

Trend

Patch size departure is a result of many causes. Early changes in the post-reference condition landscape may have come from the heavy removal of timber during the early settlement of, and extensive railroad logging in, the Sacramento Mountains of the Lincoln NF. Much of the departure on the Lincoln NF might also be explained in terms of relatively recent large scale disturbances including tree insect infestations and diseases, large wildfires, fire suppression, and increased tree growth in fire adapted forests and woodlands. If climate change projections of warmer and dryer conditions hold true, there would be increased risk from insects and disease and severe large wildfires due to drought. Under current management, including fire suppression and wildlife habitat requirements, and current disturbance regimes, departure would likely increase into the future. For grasslands (MSG, SDG), smaller patches than reference indicate woody encroachment, while in grassy woodlands (JUG, PJG), larger patch size implies increased growth. In the absence of mechanisms to check encroachment, openings could be expected to become smaller. For woodlands and dry forested systems, larger patches than reference indicate more contiguous canopy, with associated elevated risks from uncharacteristic wildfire and insect/disease mortality. For both these conditions, which represent the bulk of the ERUs, departure would likely remain the same or increase into the future.

Insect and Disease Mortality Summary

Infestations of insects and plant diseases are both disturbance agents and indicators of forest ecological condition. Mortality and loss of forest resources can arise from infestations which may become extreme after large wildfires or periods of drought.

Insect and disease damage and mortality to forest resources has been monitored through aerial detection surveys (ADS) on the Lincoln National Forest since 1996. The effects of insect and pathogenic infestations may not always result in mortality, but may limit forest growth and disrupt natural succession, as well as alter fire regime and increase the chances of mortality from other agents. The primary agents of mortality are bark beetles and engravers. Defoliators and other disease agents may cause damage that looks like mortality, and to a small extent create mortality, but more often increase vulnerability to primary mortality agents and fire events. Vulnerability to infestation is also enhanced by disturbance events such as wildfire or extended drought.

In this section of the assessment, mortality patterns are discussed for the Lincoln National Forest for the last 20 years. Acres of mortality are reported for the individual Ecological Response Units (ERUs) at the Plan (Lincoln National Forest) scale (Table 19), as well as the local scale to illustrate distribution of insect mortality (Table 36). A more complete report on all types of insect and disease damage on the Lincoln National Forest, including historical and regional context, is contained in the Insect and Disease Report included in the project record (USDA Forest Service 2016a). For the purpose of this chapter, low levels of mortality are not included (prior to 2012, mortality was not classified; since 2012, mortality is reported in classes, and those with greater than 10 percent mortality are included).

Mortality over the 20-year period was reported only for the Smokey Bear and Sacramento Ranger Districts. Aerial detection surveys are not generally flown over the Guadalupe Ranger District (USDA Forest Service, 2016b). Twenty-year mortality in local units varied from just over 16,000 acres in Rio Peñasco, to over 37,200 acres in Rio Hondo (Table 35, Figure 20). There was no reported mortality in the Upper Pecos which is totally on the Guadalupe Ranger District.

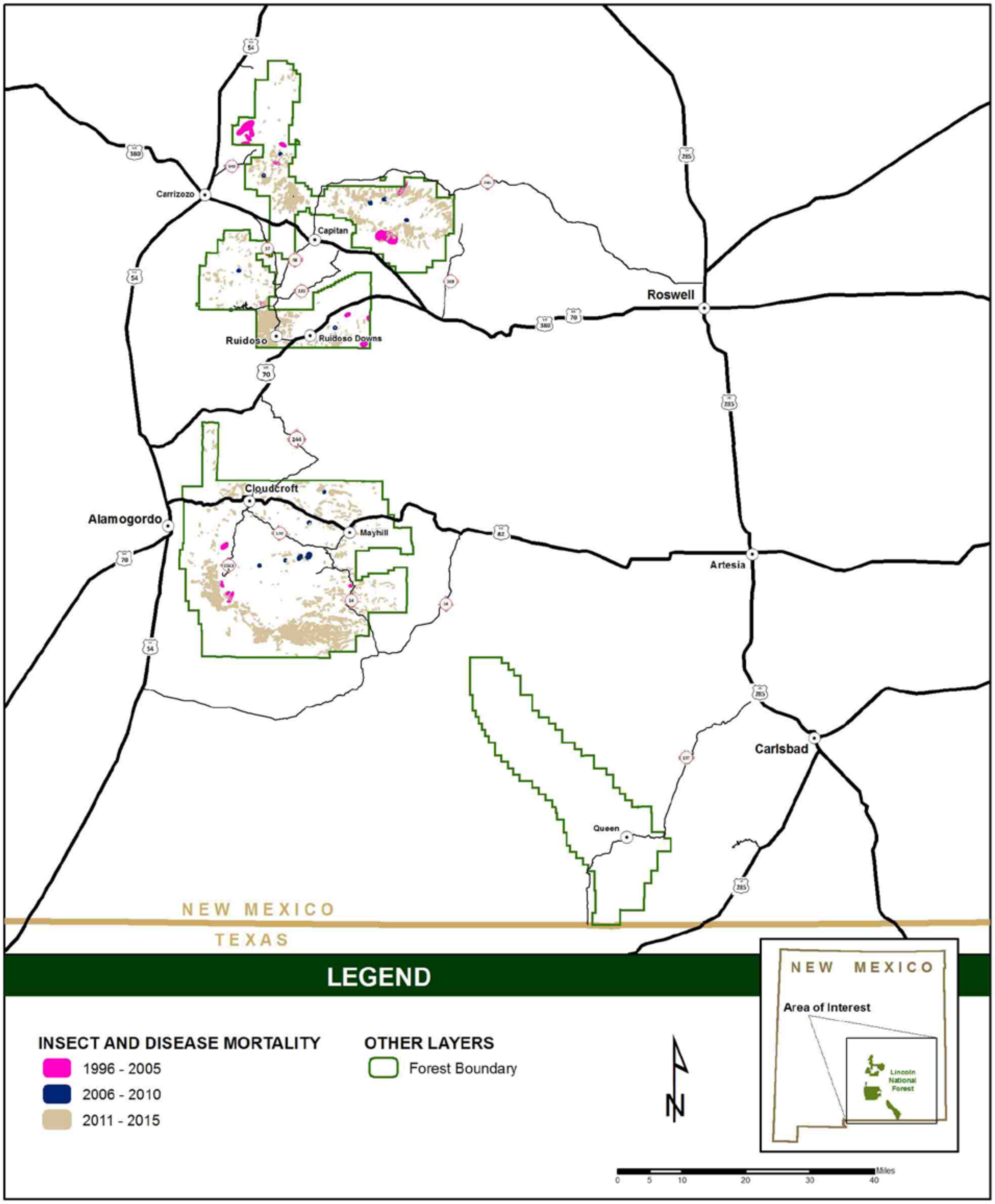

Figure 20. Insect mortality on the Lincoln National Forest at the Local Unit Scale, 1996-2015

Table 35. Local units insect and disease total mortality acres for 20 year period 1996-2015

Local Unit	20 Year Acres Mortality
Rio Peñasco	16,048
Arroyo Del Macho	16,527
Tularosa Valley	21,074
Salt Basin	27,204
Rio Hondo	37,247
Grand Total	118,101

Mortality across the Forest was low (less than 400 acres/year) for most of the period from 1996-2010, with a small spike of just over 6000 acres in 2003 (Figure 21, Table 36). A marked increase in mortality occurred in 2011, continuing through 2013, then dropping in 2014 and 2015. A recently released report (USDA Forest Service 2016b) shows 2016 mortality decreasing for the third straight year.

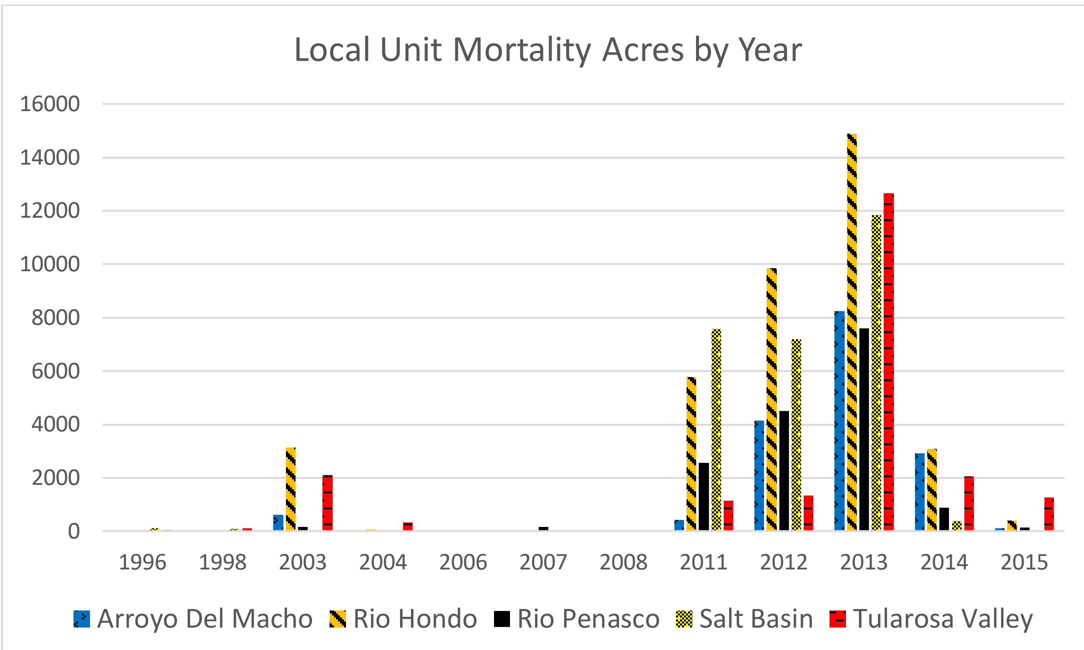

Figure 21. Lincoln NF and local unit mortality by year

Most of the mortality is caused by Ips beetles in Piñon-Juniper Woodlands and Ponderosa Pine Forests (Figure 21). The 2003 spike in mortality mostly occurred in piñon-juniper woodlands by the piñon ips beetle, while later infestations in the years 2011-2013 were mostly in ponderosa pine forests by the ips engraver beetle. In both cases, the infestations were preceded by periods of drought (USDA Forest Service 2016a). Localized outbreaks of beetles will continue to be a part of woodland and forest ecology and should be expected in dense stands, especially in low elevation sites along ecotones, older stands, and those under stress from other factors, such as dwarf mistletoe, defoliators or drought. During drought periods, widespread outbreaks of ips and mortality from other various beetles and borers are probable and not likely to be limited to the most susceptible sites. There is a substantial amount of pine on these types of sites on the Lincoln NF that could be affected by future outbreaks.

Douglas-fir and Fir-engraver beetles were responsible for most of the remaining mortality on the Lincoln in the years 2011-2014 in mixed conifer and spruce-fir vegetation types, although much fewer acres were affected. Mortality was preceded by drought conditions, and increased stand densities from fire exclusion and management activities that included higher ratios of white fir and Douglas-fir than historically probably increased the potential for infestations (USDA Forest Service 2016a).

Defoliators can cause significant damage, and occasionally mortality in severe cases. In the piñon woodlands and ponderosa pine forests, defoliation comes from a number of species of insects and fungi and is usually minor, although a 1945 infestation of needle scale in piñon on Capitan Mountain was notable because of the mortality it caused (USDA Forest Service 2016a). Defoliation in the mixed conifer is due primarily to western spruce budworm, Douglas-fir tussock moth and loopers. Extreme defoliation can cause mortality as was observed on the Lincoln in 2007 and 2008, although that mortality does not show up in our analysis. Looper populations crashed in 2008, but outbreaks are likely to occur periodically as long as host tree species are present.

Mistletoes, both true and dwarf, are common on the Lincoln NF. Parasitic plants do not cause mortality directly. In piñon and juniper woodlands, juniper mistletoe, a true mistletoe, can increase host mortality during drought periods. Piñon dwarf and southern dwarf mistletoes are common, and it is likely that distribution of those is similar to the late 1800s, although the intensity has likely increased due to increased density of host species. The Lincoln NF has the highest level of infestation of all forests in the region, hypothesized to be due to the climatic regime of the Sacramento Mountains and the amount and timing of monsoonal rains. Douglas-fir mistletoe in the mixed conifer responds similarly to those described above.

Root diseases caused by fungi reduce tree growth and longevity and can create pockets of mortality. They often appear to proliferate on stressed trees, so their significance increases following drought, which may become more common with projected climate change (USDA Forest Service 2016a). Root diseases also promote susceptibility to bark beetle infestations.

White pine blister rust (WPBR) was first detected in the Southwestern Region in 1990 on the Lincoln NF, although it had probably been here since the 1970s. White pine blister rust is a fungus found primarily in the mixed conifer forest that affects five needle pines (southwestern white pine in our forest) and has alternate hosts in Ribes species, and occasionally in some Indian paintbrush and snapdragon species. While the time for disease development from twig to mainstem is relatively long, mortality is possible in susceptible trees, and much has been observed on the Lincoln NF. Climatic conditions on the Lincoln favor development of the rust during the monsoonal storms in the Sacramento and Capitan mountains. Eradication of alternate host species is considered unfeasible, and maintaining populations of southwestern white pine in the mixed conifer forest will probably rely on supplemental planting of genetically resistant trees in the future. The Lincoln is not only where WPBR was first found in the southwest, it apparently also has white pines with either full or partial resistance to the disease. Work being done by Dr. Waring of Northern Arizona University and others has looked at finding and cultivating resistant white pine cones, and replanting in areas affected by the disease. Collection has been occurring since the 1980s, including a 2012 collection by Dr. Waring for the Genetic Conservation Program, with resistance testing being carried out at a US Forest Service nursery in Cottage Grove, Oregon.

There are other insects and diseases that cause damage and some mortality in forest types on the Lincoln, but are relatively minor compared to the mortality agents discussed above. They can be reviewed in the complete Insect and Disease Report in the project record (Ryerson 2016).

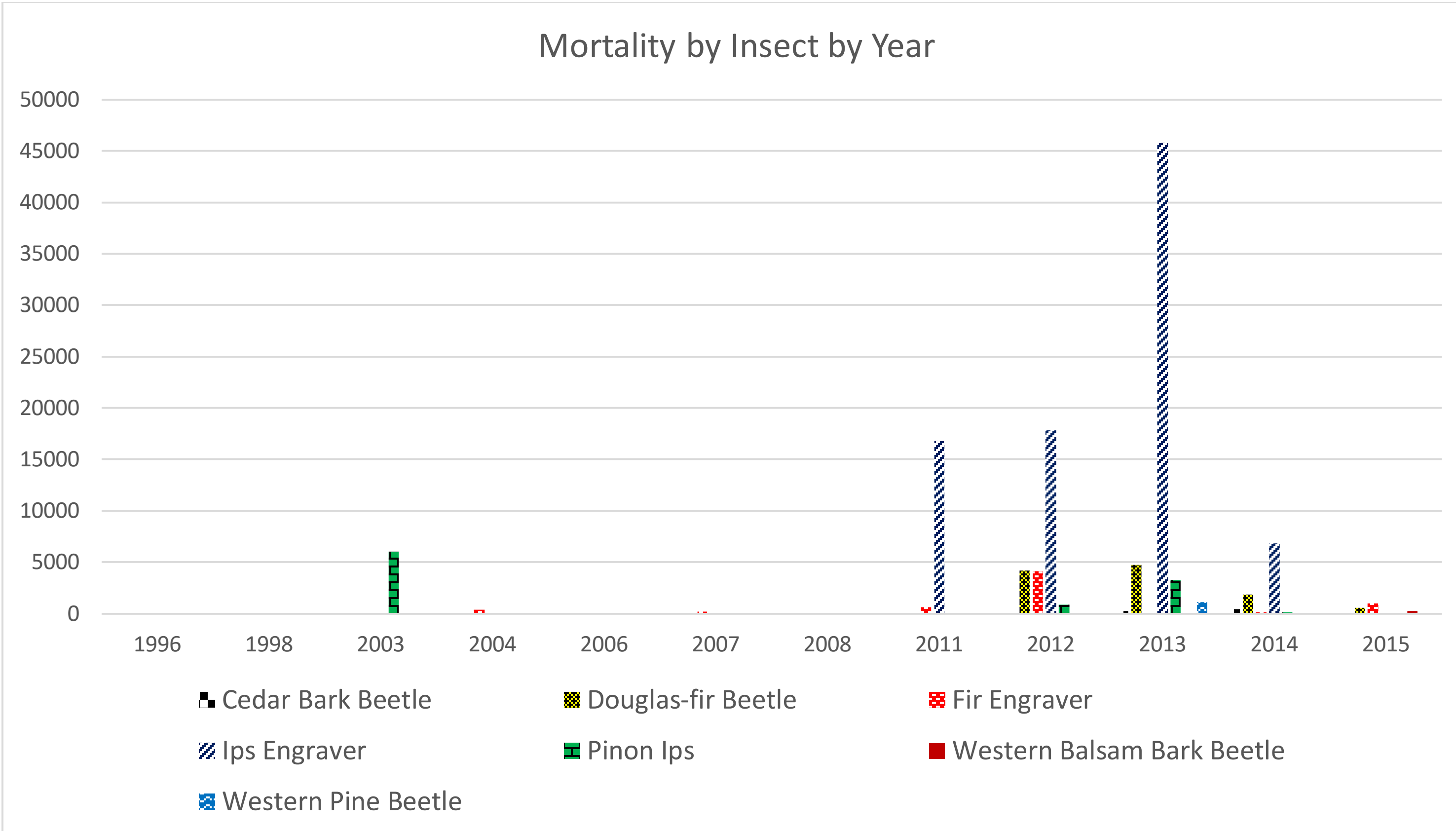

Figure 22. Mortality by insect by year

Table 36. Annual acres experiencing greater than 10 percent tree mortality for ERUs on the Lincoln NF.

Ecological Response Units (ERUs)	1996	1998	2003	2004	2006	2007	2008	2011	2012	2013	2014	2015	Total
Spruce-Fir Forest						0		0		27	149	309	484
Mixed Conifer w/ Aspen		35				1		126	222	178	2	39	604
Mixed Conifer - Frequent Fire	156	48	6	282	2	168		6,595	6,524	7,862	1,728	875	24,245
Ponderosa Pine Forest			1,123	72	1	4	19	6,896	11,431	24,295	4,908	391	49,139
PJ Evergreen Shrub								119	225	1,267			1,611
PJ Woodland		13	4,682				6	3,220	7,438	18,191	2,179	118	35,849

Ecological Response Units (ERUs)	1996	1998	2003	2004	2006	2007	2008	2011	2012	2013	2014	2015	Total
PJ Grass			141					1	218	535	13		908
Gambel Oak Shrubland								131	386	461			978
Mountain Mahogany Mixed Shrubland	1	93	51	39				235	222	1,689	218	136	2,684
Montane / Subalpine Grassland			39					117	265	487	158	50	1,114

Ecological Response Unit Summaries

Ecological Response Unit (ERUs) summaries are provided as an interpretation across ecological characteristics and scales. Interpretation may not be available for some characteristics for a given ERU, or at all scales. Interpretation will inform an assessment of risk for each ERU of maintaining its ecological integrity or converting to another vegetation type, and whether or not the risk is due to or regardless of current management activities. The final paragraph of each ERU summary is a narrative risk assessment of the ecological sustainability of that ERU on the Lincoln National Forest.

Spruce-Fir Forest (SFF):

General Description

Also known as sub-alpine conifer forests, the Spruce-Fir forest (SFF) ERU ranges in elevation from 9,000 to 10,500 ft. along a variety of gradients including gentle to very steep mountain slopes. Generally, annual precipitation ranges from 27 to 36 inches, with 50 percent coming between October 1st and March 31st. The Spruce-fir forest is widespread in the Southwestern region, occurring on the Apache-Sitgreaves, Carson, Cibola, Coconino, Gila, Kaibab, Lincoln, and Santa Fe National Forests. This ERU is comprised almost entirely of Engelmann spruce (Picea engelmannii Parry ex Engelm.) and subalpine fir (Abies lasiocarpa (Hook.) Nutt.) and/or corkbark fir (A. lasiocarpa (Hook.) Nutt. var. arizonica (Merriam) Lemmon) associations. Common understory species may include but are not limited to red baneberry (Actaea rubra Aiton) Willd.), sprucefir fleabane (Erigeron eximius Greene), strawberryleaf raspberry (Rubus pedatus Sm.), whortleberry (Vaccinium myrtillus L.), and twinflower (Linnaea borealis L.). Spruce-fir forests are disturbance forests, with climax seral states being less common than early seral communities (Peet, 1988). Natural system drivers and stressors in this ERU include blow-down, insect outbreaks, climate change, and stand replacing fires.

Ecological Characteristics

Spatial Niche

The Lincoln NF contains just over 11,000 acres of SFF, with over 6700 acres in wilderness, with all occurring only on the Smokey Bear Ranger District. This comprises only 1 percent of the Forest. The Context Area has even less SFF, with only 0.05 percent in this ERU. Thus, the Lincoln NF has 65 percent of the SFF within the Context Area, and a substantial contribution to the ecological integrity of the ERU. However, more than 60 percent of SFF on the Lincoln NF is in wilderness, which not only limits man-made disturbances, but also constrains management activities.

Seral State Proportion

Total seral state departure is moderate for this ERU for the Context Area, Lincoln NF and all local units, with similar departure values (43-46%) among all units (Table 37). Departure from reference conditions is primarily due to over-representation of early seral herbaceous, shrub and small tree states (A, B, C, G) and forested states dominated by larger trees 10 to 20 inches (D, H), and under-representation of late seral large closed forest (greater than 20 inches, greater than 30 percent canopy) (Figure 23). The Lincoln NF had 39 percent in combined early seral states A, B, C, G, compared to 57 percent for the Context Area, and 21 percent for reference. Overrepresentation of the early seral states likely reflect multiple recent past disturbances such as stand replacement fires, part of the natural fire regime. The mid seral states D and H make up 60 percent of the ERU, and are likely from earlier stand replacement events (Dyer and Moffett 1999). Fires can provide opportunity for resetting succession on the landscape, often by replanting in high severity burned areas. No post fire planting has occurred in the SFF ERU. Currently there is less than two acres of early seral (graminoid/forb/shrub) in the

Capitan and White Mountain wildernesses where the Peppin Fire (2004) and Little Bear Fire (2012) burned with high severity. There are 76 acres in those same areas in trees under 10 inches, although trees larger than 5 inches were probably established before the fires. Seedlings and saplings established since the fires are naturally regenerated. Outside of the wilderness, there are 7.4 acres early seral in the Little Bear Fire area of the Rio Hondo local unit, and 32.4 acres of small (less than 10 inches) trees for both the Little Bear and Peppin fires in Rio Hondo. The Lincoln NF had 61 percent in 10-to-20-inch forest compared to 40 percent for the Context Area, with a reference condition of 33 percent. The Lincoln NF has virtually no forest in the late seral large closed forest, and the Context Area only 3 percent, compared to a reference condition of 46 percent. This ERU was not modelled into the future. However, it is likely that future growth and succession of mid-seral closed forest to late-seral closed will trend SFF toward reference condition.

Table 37. Spruce-fir forest ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Hondo	Arroyo Del Macho	Tularosa Valley
A, B, C, G	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover, and seedling/sapling (< 5” dbh/drc), small (≥ 5” & < 10” dbh/drc) tree sizes with open (≥ 10% & < 30%) or closed woody canopy cover, all storiedness	0.21	0.57	0.39	0.38	0.41	0.41
D, H	MID-SERAL: Medium to large size (≥ 10” & < 30” dbh/drc) trees, all storiedness with open or closed woody canopy cover	0.33	0.40	0.61	0.62	0.59	0.59
E, F	LATE SERAL: Very large size (≥ 30” dbh/drc) trees, single or multi-storied with closed woody canopy cover	0.46	0.03	0.00	0.00	0.00	0.00
I, J	LATE SERAL: Very large size trees, single or multi-storied with open woody canopy cover (occurs on contemporary landscapes only…)	0.00	0.00	0.00	0.00	0.00	0.00
Departure			43%	46%	46%	46%	46%

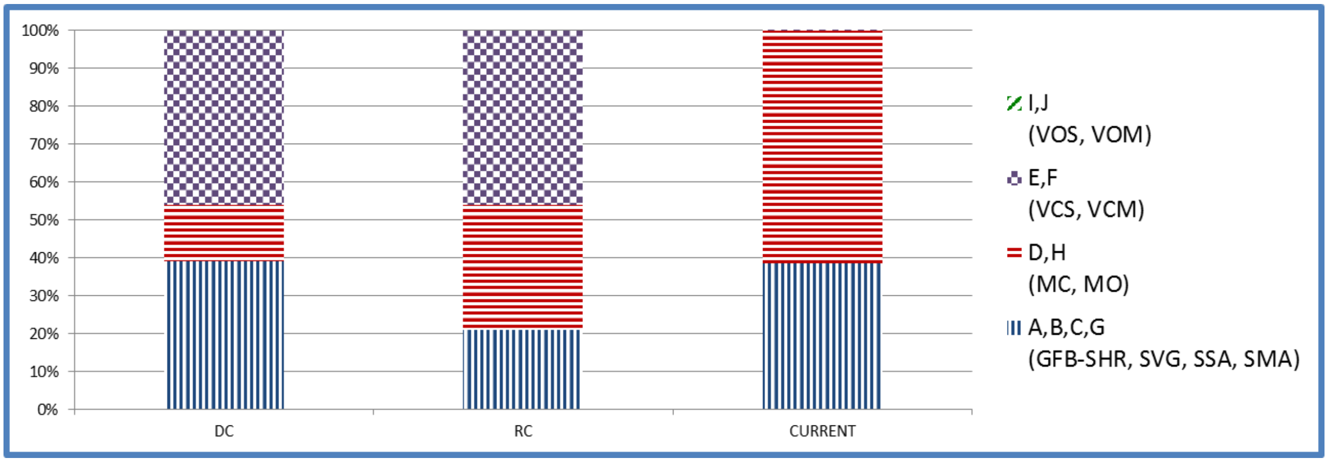

Figure 23. Seral state percentages for Spruce-Fir Forest ERU at the plan scale. DC is desired condition, RC is reference condition, Current is current condition.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The SFF ERU fire regime historically consists of stand replacement fires with long fire return intervals (Fire Regime V) or less often, mixed severity fires with fire return intervals of 35-200 years (Fire Regime III). Fire regime (FRCC) for this ERU was 100 percent in the moderately departed condition class (Table 38). Fire rotation is highly departed (81 percent) with three local units having much shorter fire return interval compared to the reference of 156 years, and one with a longer fire return interval than reference (Table 39). Recent fires in the twenty years that data is available may mask longer fire free periods, and resulting departure may be overstated, with fire return intervals much shorter than reference an artifact of the limited data. Fire severity is moderately departed (37 percent), with all local units having less severity than reference (58 percent).

Table 38. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	100%	0%	28.9	155.56	81%	37%	58%	37%

Table 39. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval			19				20	25	32		1,772			
Fire Severity			22%				37%	37%	44%		30%			
FRCC			II				II	II	II		II			

Coarse Woody Debris and Snags

Table 40. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition. Blank cells mean data was unavailable for those local units.

SFF		Coarse Woody Debris (tons per acre)					
Local Unit	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	31%		31%				
Reference	36.00		36.00				
Current	24.80		24.80				
Trend	(11.20)		(11.20)				
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	19%		19%				
Reference	25.00		25.00				
Current	31.00		31.00				
Trend	6.00		6.00				
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	67%		67%				
Reference	9.00		9.00				
Current	3.00		3.00				
Trend	(6.00)		(6.00)				

Coarse woody debris and snags were analyzed at the Plan Area and local unit scales only. Departure for coarse woody debris (CWD) and snags are shown in Table 40. Data was only collected for one local unit for this ERU, although it occurs in three. CWD and snags 8 to 18 inches both showed low departure (31 percent and 19 percent, respectively) while snags greater than 18 inches were highly departed (67 percent)(Table 40). This conforms to seral state departure where spruce-fir forest on the Lincoln NF has no acreage mapped in the very large (greater than 20 inches) states. It is likely with time, and barring catastrophic disturbance, that departure will be reduced as snags in the over abundant 8-18 inch size class fall creating more CWD, causing both characteristics to trend toward reference. Larger snags may take more time to recruit as it will take time to grow the medium size seral states to larger trees.

Ecological Status and Ground Cover

No data was available for ecological status or ground cover departure analysis. Dominant potential vegetation of TEUI map unit components in the late 1980s show measurable cover for overstory tree species only, with all other shrub and herbaceous species being expected at trace values. There may be some departure from that with the larger proportion of early seral states possibly having more forb and shrub cover. There may be some additional departure from potential in relative percentages of overstory trees, as mid-seral stands may have more Douglas-fir, aspen or white fir, compared to late seral stands with relatively more spruce or subalpine fir. Understory species composition is not expected to vary much in species presence or abundance from potential.

Table 41. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
n/a	n/a		200	1,000	73	Smaller	63%

Patch Size

Patch size was only analyzed at the Patch size was moderately departed at 63 percent, with mean patch size of 73 acres, compared to a reference range of 200-1,000 acres (Table 41). This may be related to the large proportion of SFF in early seral states, recent large disturbances (fire) and how the different seral states are distributed on the landscape. Fire severity has been less than historically, which may create a mosaic of mortality rather than large areas of stand replacement.

Insect and Disease

Total insect and disease mortality over 20 years was 484 acres, with an average annual mortality of 24 acres. However, most of that mortality was in the period from 2013 (27 acres) to 2015 (over 300 acres). More recently mortality has been reduced, although 200 acres of spruce beetle activity was noted in 2017.

Summary

Departure is moderate for seral state, fire severity, FRCC (derived from seral state, fire frequency, and fire severity), and patch size (Table 21), and low for CWD and smaller snags, while large snags are highly departed (Table 40). Seral state, FRCC and large snag departure may be reduced in the future with growth, succession, and absence of large disturbance. Generally, management is limited to recreation and fire management in this ERU, and much of this type is in designated wilderness. Grazing is generally limited to vegetation types at lower elevations. Thinning treatments have primarily been limited to safety concerns in recreational areas. Thus, management is only lightly implicated in the future of this type, primarily from fire suppression. However, climate change may put the spruce-fir ERU at risk of type conversion. The spruce-fir forest type currently is at moderate risk of losing ecological sustainability, but in the future is probably at high risk of losing ecological sustainability, for reasons that are beyond the Lincoln NF's ability to control.

Mixed Conifer w/Aspen Forest (MCW):

General Description

The Mixed conifer with aspen, or wet mixed conifer (MCW) ERU hosts a variety of dominant and co-dominant species spanning mesic environments in the Rocky Mountain and Madrean Provinces. Wet mixed conifer forests range in elevation from approximately 9,000 to 10,500 feet along a variety of gradients including gentle to very steep mountain slopes, situated between ponderosa pine and dry mixed conifer forests below and Spruce-Fir Forest ERU above. Generally, annual precipitation ranges from 23 to 32 inches, with 50 percent coming between October 1st and March 31st. Dominant and co-dominant vegetation varies in elevation and moisture availability. Ponderosa pine occurs incidentally or is absent, while Douglas-fir, southwestern white pine, white fir, and

Colorado blue spruce occur as dominant and or codominant conifer species. Other species that may be present in sub-dominant proportions include limber pine (*Pinus flexilis* James). Understory vegetation is comprised of a wide variety of shrubs, graminoids, and forbs depending on soil type, aspect, elevation, disturbance history, and other factors. Historically this ERU had over 10 percent tree canopy cover, with the exception of early, post-fire plant communities. At the moment, two subclasses exist for this ERU, with and without elk, differentiated by the presence of a quaking aspen (*Populus tremuloides* Michx.) state in the case of the latter ecosystem. The current situation on the Lincoln NF is with elk. Elk impacts are considered because according to (Bailey and Whitham, 2002; Rolf, 2001), if elk are present, they may browse aspen until it does not produce ramets within 2 to 5 years.

Aspen stands are a component of the Mixed Conifer with Aspen ERU. This component is dominated by quaking aspen and may or may not have a significant conifer component, depending upon successional status. The understory structure may have shrubs and an herbaceous layer, or just an herbaceous layer. Common shrubs include oceanspray (*Holodiscus dumosus* (Nutt. ex Hook.) A. Heller), thimbleberry (*Rubus parviflorus* Nutt.), fivepetal cliffbush (*Jamesia americana* Torr. & A. Gray), and mountain ninebark (*Physocarpus monogynus* (Torr.) J.M. Coult.). The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. Some of the species typically found associated with aspen include Nevada peavine (*Lathyrus lanszwertii* Kellogg var. *leucanthus* (Rydb.) Dorn), Fendler's meadow-rue (*Thalictrum fendleri* Engelm. ex A. Gray), elkweed (*Frasera speciose* Douglas ex Griseb.), common yarrow (*Achillea millefolium* L.), Canadian white violet (*Viola canadensis* L.), Indian paintbrush (*Castilleja* spp. Mutis ex L. f.), and several grasses and sedges (*Poa* spp. L. and sedges). Distribution of aspen within this ERU is limited by several factors including adequate soil moisture required to meet its high evapotranspiration demand, the length of the growing season or low temperatures, and major disturbances that clear areas of vegetation and stimulate root sprouting and colonization.

Ecological Characteristics

Spatial Niche

Wet Mixed Conifer makes up 3.3 percent of the Lincoln NF at 35,568 acres, and only 0.23 percent of the Context Area. The Lincoln NF contains 46 percent of the MCW in the Context Area, which implies a substantial contribution to the ecological integrity of the ERU. MCW is located entirely on the Sacramento Ranger District, and nearly entirely on the Rio Peñasco local unit.

Seral State Proportion

Seral or structural state departure from reference conditions is moderate for the Lincoln NF, Context Area, and all local units (Table 42 and Figure 24). The Context Area is least departed (45 percent) while the Salt Basin is most departed (63 percent). For all units, departure arises in part from an over-representation of early to mid-seral tree dominated sites in under 20-inch size classes (states C, D, G, H), and under-representation of very large, closed late-seral forest (greater than 20 inches, greater than 30 percent canopy, states E, F; Table 42, Figure 24). This may be attributable to logging in the early to mid-20th century. Clearcutting in that period would lead to current stands in the 60-110 age range. Many of those stands can grow to late-successional states in the absence of disturbance. Departure also is attributable to the Lincoln NF lacking in the mixed deciduous/aspen state B. The Lincoln NF only has 18 percent of this ERU in state B, while reference conditions call for 21 percent. Aspen is an early to mid-successional species, and successful regeneration of aspen stands may reduce departure in the future. This is illustrated to a small degree in Table 21, where the Tularosa local unit has slightly more aspen and less of the early-mid seral conifer states compared to the other local units, and the Lincoln NF in general. However, aspen is not considered to be reproducing successfully on the Sacramento Ranger District due to excessive foraging by elk (personal communications, Jack Williams, Rhonda Stewart, Lincoln NF wildlife biologists, 2016). However, fire suppression may also play a role in that few stand replacement fires have occurred to provide opportunities for aspen regeneration. No post-fire planting has occurred in this ERU, although 582 acres of seedlings, saplings and small trees under 10 inches diameter are growing where the Scott Able fire (2000) burned in the Rio Peñasco local unit. Trees larger than 5 inches diameter were probably established before the fire; trees established since the fire were naturally regenerated. Modelling management activities, wildfire, insect and disease mortality and other disturbances, and natural succession out 10, 100 and 1,000 years show the aspen state B dropping to 13 percent after 10 years, and to only 1 percent after 100 years. There is a very slight decrease in overall departure (Figure 24); an increase in very large closed forest toward reference conditions comes at the expense of a decrease in state B, a mixed deciduous/aspen state.

Table 42. Mixed Conifer with Aspen ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Peñasco	Salt Basin	Tularosa Valley
A	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.01	0.05	0.00	0.00	0.01	0.00
B	EARLY TO LATE SERAL: Aspen/mixed deciduous trees of all sizes with open or closed woody canopy cover	0.21	0.22	0.18	0.19	0.08	0.27
C, D, G, H	EARLY TO MID-SERAL: Seedling/sapling (< 5” dbh/drc), small (≥ 5” & < 10” dbh/drc), medium (≥ 10” & < 20” dbh/drc) and large (≥ 20” & < 30” dbh/drc) tree sizes, all storiedness with open or closed woody canopy cover	0.29	0.69	0.81	0.80	0.91	0.72
E, F	LATE-SERAL: Very large size (≥ 30” dbh/drc) trees, all storiedness with closed woody canopy cover	0.49	0.04	0.01	0.01	0.00	0.00
I, J	LATE-SERAL: Very large size trees, all storiedness with open woody canopy cover (occurs on contemporary landscapes only…)	0.00	0.00	0.00	0.00	0.00	0.00
Departure			45%	52%	51%	63%	50%

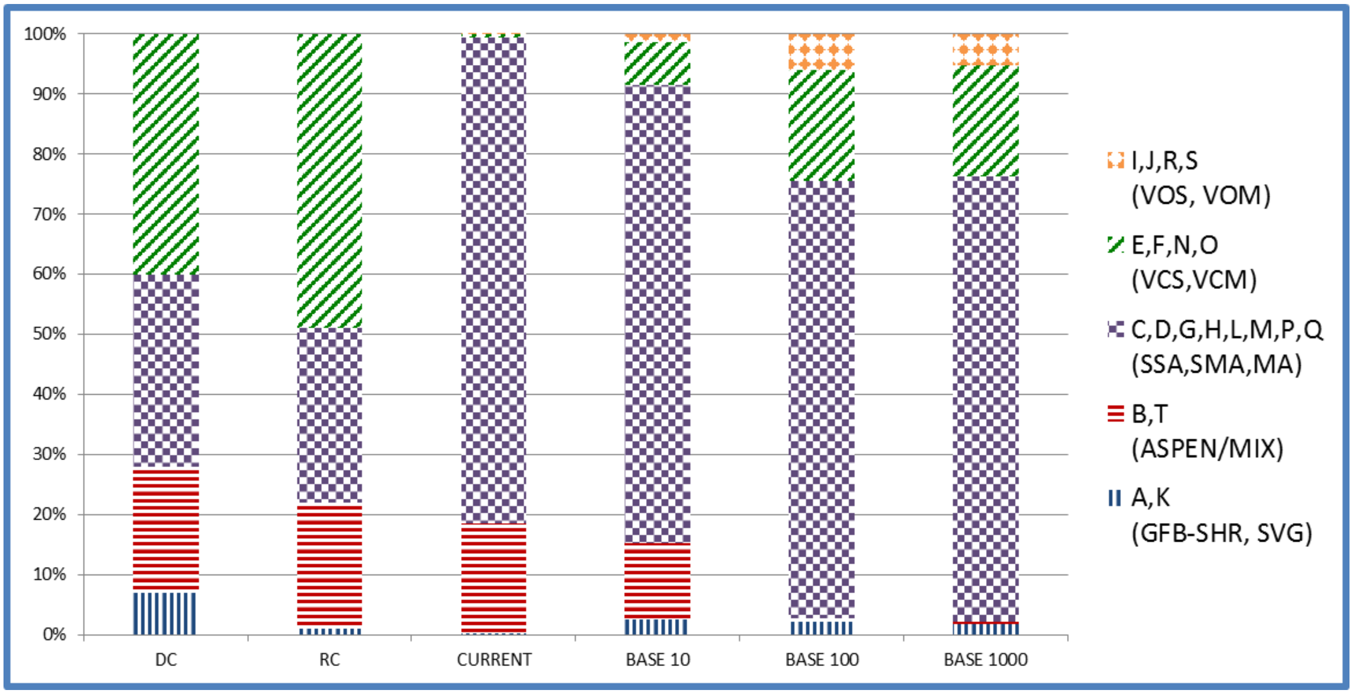

Figure 24. Seral state percentages for Mixed Conifer with Aspen Forest at the plan scale modelled out to 1,000 years. DC is desired condition, RC is reference condition, Current is current condition, Base 10, 100 and 1,000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units. FRCC was not calculated for the Context Area.

The MCW ERU is associated with Fire Regimes III (mixed severity with 35 to 200 year mean fire return interval) and V (stand replacing fires with greater than 200 year fire return interval). Fire regime (FRCC) for the Plan Area shows the MCW ERU as 85 percent in moderately departed condition class, and 15 percent highly departed. (Table 43). The Agua Chiquita and Rio Peñasco local units were both moderately departed in condition class II, while the Sacramento River unit is highly departed. Fire rotation is highly departed at the plan scale (76 percent), with longer rotations than the reference of 120 years. In this moist conifer type, fire rotation interval was highly departed and longer for the Lincoln NF (501 years), and the Rio Peñasco and Sacramento local units than the 120 year reference period, while the Agua Chiquita local unit was moderately departed with a 70 year fire rotation interval (Table 43 and Table 44). Fire frequency departure for the infrequent stand replacing or mixed severity fire regimes (III, IV) may not be accurate as the data used to calculate frequency reflects only the last 20 years, and fire history since Euro-American expansion and settlement (approximately 1880), which are both much less than the top of the rotation period range of 200 years for Regime III and IV. Fire severity is the mean value of canopy mortality per acre burned per year over the 20-year period covered by the data. MCW typically had years of small, creeping fires, or larger areas of mixed severity fire, with occasional infrequent large stand replacing (high severity) fires. Fire severity shows low departure for the Plan Area (Table 43) with a mean severity of 59 percent compared to a reference of 65 percent. The Agua Chiquita local unit had low departure with mean severity of 60 percent, Rio Peñasco was moderately departed with mean severity of 33 percent, and the Sacramento River unit was highly departed with mean severity of 18 percent. Fire severity has probably been reduced due to fire suppression reducing the size and number of medium size mixed severity and small low severity fires.

Table 43. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	84.6%	15.4%	500.9	120.00	76%	59%	65%	9%

Table 44. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	70				6,036					205				
Fire Severity	60%				33%					18%				
FRCC	II				II					III				

Coarse Woody Debris and Snags

Coarse woody debris (CWD) and snags data is not available for the Context Area. Data is available for the Lincoln NF Plan Area and the three local units where MCW occurs. CWD showed low departure at the Plan scale with current tons per acre approximately 70 percent of reference condition (Table 45). At the local unit scale, Rio Peñasco had low departure from reference, while Salt Basin and Tularosa Valley units were moderately departed. In all cases, current CWD is less than reference. Snags in the 8-18 inch size class was moderately departed at the Plan scale with about 50 percent more snags/acre than reference, and snags in the larger than 18 inch size class was highly departed with more than three times the snags/acre than reference. At the local scale, Rio Peñasco had low departure for snags 8-18 inches while Salt Basin and Tularosa Valley were moderately departed. Rio Peñasco and Tularosa Valley were moderately departed for snags larger than 18 inch while Salt Basin was highly departed. Eventually, falling of snags may help reduce departure in all three measures. The ERU in general is moderately departed for structural state, with acres in the medium closed structural state (canopy greater than 30 percent, dominant size class of trees 10 to 20 inches diameter) more than twice the reference acres for all seedling/sapling, small and medium size tree structural states combined. That departure implies future recruitment into both snag size classes, and continued departure from reference for snags. Fire is generally less a player in this ERU, although suppression and lack of management may lead to conditions promoting stand replacing fire. Other factors that may be contributing to the higher departure of snags include insects and disease and drought induced mortality.

Table 45. Plan Area and Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition,

and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition. Blank cells mean data was unavailable for those local units.

MCW Local Unit	Coarse Woody Debris (tons per acre) LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	27%			18%	57%	48%	
Reference	26.33			26.33	26.33	26.33	
Current	19.3			21.65	11.21	13.63	
Trend	(7.0)			(4.68)	(15.12)	(12.70)	
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	34%			25%	12%	3%	
Reference	14.00			14.00	14.00	14.00	
Current	21.1			19.79	23.20	25.64	
Trend	7.1			(6.54)	(3.13)	11.64	
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	67%			60%	83%	65%	
Reference	4.00			4.00	4.00	4.00	
Current	12.3			10.07	23.38	11.58	
Trend	8.3			6.07	19.38	7.58	

Ecological Status and Ground Cover

No data was available for ecological status or ground cover departure analysis at the context, plan or local scales. In general, current composition of overstory tree species is probably departed from potential as described in the TEUI map units due to relative cover proportion differences among species in different seral states and not to a loss of species. It is likely that aspen and spruce are under-represented as species, while seral Douglas-fir is abundant. Understory shrub and herbaceous species are probably somewhat departed although departure is measured as difference from potential as described in the TEUI, not an historical species cover range. This is particularly important for this ERU, as the TEUI includes potential for Kentucky bluegrass, a naturalized but non-native grass that is common and is often the dominant grass in the understory.

Table 46. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres) LWR	REFERENCE (acres) UPR	CURRENT (acres)	TREND	DEPARTURE (%)
n/a	n/a		100	400	120	Similar	0%

Patch Size

Patch size showed little or no departure from reference (Table 46).

Insect and Disease

Total insect and disease mortality over 20 years was 604 acres, with an annual average of 30 acres per year. Most of that mortality was recorded between 2011 and 2013, with substantial reductions since then, although over 200 acres of mortality attributable to spruce beetle may have affected some of this ERU.

Summary

The moist mixed conifer ERU (MCW) is moderately departed for seral state and fire regime, although fire frequency is highly departed, likely a result of fire suppression. Modeling of current management and disturbance regimes 10 and 100 years into the future doesn't alter departure much, but it is notable that a desired component of the ecosystem, the aspen state B, declines with increasing open and closed canopy forest of very large trees (greater than 20 inch trees) (Figure 24). While decline is generally considered due to elk predation, fire suppression may also play a causal role in reducing the stand-replacing opportunities for aspen regeneration. The current overabundance of trees in the 0-20 inch classes continues through the modeling period. Deficiencies in CWD will eventually be replaced by recruitment by excess in large snags and recruitment from mortality in medium trees, and future recruitment to large snags as medium sized stands get older and larger. Under current management and in the absence of potential climate change effects, this ERU is considered to be at moderate risk to ecological sustainability, perhaps due equally to management and natural factors beyond Forest control. Future ecosystem integrity may be maintained or improved through Forest mitigation and management. Intensive management could provide openings for aspen regeneration but would likely require protection from elk foraging. Protections for wildlife that restricted management activities in the past have provided more flexibility for future management with recent changes to the Mexican Spotted Owl Recovery Plan (2012). Resource protection measures such as limiting management due to soil erosion concerns may be less restrictive with technological advances allowing ground based mechanical treatments on steep slopes. Climate change modeling, however, places 96 percent of the moist mixed conifer in the high and very high vulnerability category by the end of the century for vegetation type conversion as predicted conditions become warmer and drier. Considering the climate change effects, the risk to the integrity of this ecosystem would be high, and due to factors uncontrolled by management.

Mixed Conifer/ Frequent Fire Forest (MCD):

General Description

The Mixed conifer/frequent fire (MCD) ERU spans a variety of semi-mesic environments in the Rocky Mountain and Madrean Provinces. Generally, annual precipitation ranges from 16 to 32 inches, with 45-55 percent coming between October 1st and March 31st. In the Southwestern US, mixed conifer forests may be found at elevations between 6,000 and 10,000 ft., situated between ponderosa pine, pine-oak, or piñon-juniper woodlands below and spruce-fir forests above. Typically these types were dominated by ponderosa pine in an open forest structure (< 30 percent tree canopy cover), with minor occurrence of aspen (*Populus tremuloides* Michx.), Rocky Mountain Douglas-fir, white fir (*Abies concolor* (Gord. & Glend. Lindl. ex Hildebr.), and southwestern white pine (*Pinus strobiformis* Engelm.). On contemporary landscapes, more shade tolerant conifers, such as Douglas-fir, white fir ((Gord. & Glend.) Lindl. ex Hildebr.), and blue spruce (*Picea pungens* Engelm.), tend to increase in cover in late succession, contrary to conditions under the characteristic fire regime. However, historically, these species could have achieved dominance in localized settings where aspect, soils, and other factors limited the spread of surface fire. Currently, much of this type is dominated by closed structure (greater than 30 percent tree canopy cover) and climax species as a result of fire suppression.

Ecological Characteristics

Spatial Niche

The MCD ERU at 163,674 acres makes up nearly 15 percent of the Lincoln NF, compared to just under 1 percent for the Context Area (328,640 acres). All six local units (and three Ranger Districts) have some MCD. Most occurs on the Sacramento RD (nearly 115,000 acres) in the Rio Peñasco, Salt Basin and Tularosa local units, while just over 36,000 acres occurs in the Rio Hondo, Arroyo del Macho and Tularosa units of the Smokey Bear RD. Of those 36,000 acres, 27,000 are located in wilderness. Only 1,700 acres of MCD occurs in the Upper Pecos unit of the Guadalupe RD at the extreme south of the district. The Lincoln NF contains nearly 50 percent of the MCD occurring in the Context Area, so has a large contribution to the ecological sustainability of the ERU.

Seral State Proportion

Seral state departure for the Lincoln NF is moderate at 62 percent, and also moderate for four of the six local units in which it occurs (59-66 percent) (Table 47 and Figure 25). The Context Area is highly departed at 69 percent as is the Rio Peñasco local unit at 68 percent, just over the threshold, while the Upper Pecos local unit is highly departed at 91 percent. Seral state proportions are similar among the context, plan and most local units (Table 47), although the Arroyo del Macho local unit (in Smokey Bear RD) has relatively more area in mid to late-seral open, single story forest, and less area in late seral large closed forest. Current conditions differ from reference primarily in the late seral large tree dominated size classes, with closed canopy currently about 60 percent compared to a reference condition of 5 percent, and open multi-storied canopy only 2 percent currently compared to a reference condition of 60 percent. Early seral states were similar to reference conditions for the Plan Area and all local units, but underrepresented in the Context Area. Recent fires have left approximately 130 acres of graminoid/forb/shrub state A and 2030 acres of seedlings and saplings less than five inches in the Rio Peñasco local unit, mostly from the Peñasco (2002) and Scott Able (2000) fires. Trees were naturally regenerated. No post fire planting was done. An additional 1212 acres of seedling/sapling sized trees are growing in high severity scars of unnamed fires in the Salt Basin local unit, also naturally regenerated. Management activities, wildfire, insect and disease mortality and other disturbances, and natural succession were modelled out for the Lincoln NF for 10, 100, and 1,000 years. Early seral herbaceous states A, B, F, N combined and closed canopy small tree state G increased through 100 years with little additional change through 1,000 years, while desired states J, K increased through all age intervals from 2 to 9 percent, although far below reference conditions of 60 percent. Early seral states are currently near reference condition, but more than double when modelled out 10 years. A history of wildfire, insect infestations and past management practices of clearcutting contributed to current departure, while management requirements for wildlife habitat, and fire suppression, keep the ERU in departure. Recent wildfire effects and insect mortality contribute to the current high percentage in the early seral state. With time, under current management, it may be expected that some mid/late seral large sized closed forest.

Table 47. Mixed Conifer with Frequent Fire ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
A, B, F, N	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs, seedling/sapling size (< 5" dbh/drc) trees with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.20	0.12	0.19	0.17	0.21	0.18	0.20	0.18	0.40
C	MID-SERAL: Small size (≥ 5" & < 10" dbh/drc) trees with open canopy cover	0.10	0.05	0.09	0.32	0.12	0.06	0.07	0.06	0.45
D, E	LATE-SERAL: Medium to very large size (≥ 10" dbh/drc) trees, single storied with open canopy cover (occurs on contemporary landscapes, historically rare/localized)	0.00	0.06	0.06	0.22	0.08	0.04	0.04	0.05	0.02
G	MID-SERAL: Small size trees with closed canopy cover	0.05	0.14	0.03	0.06	0.06	0.01	0.02	0.03	0.48
H, I, L, M	LATE-SERAL: Medium to very large size trees, single or uneven-aged (multi-storied) with closed canopy cover	0.05	0.59	0.62	0.21	0.52	0.69	0.65	0.66	0.00
J, K	LATE-SERAL: Medium to very large size trees, uneven-aged (multi-storied) with open canopy cover	0.60	0.03	0.02	0.02	0.01	0.02	0.01	0.02	0.00
Departure			69%	62%	61%	59%	68%	64%	66%	91%

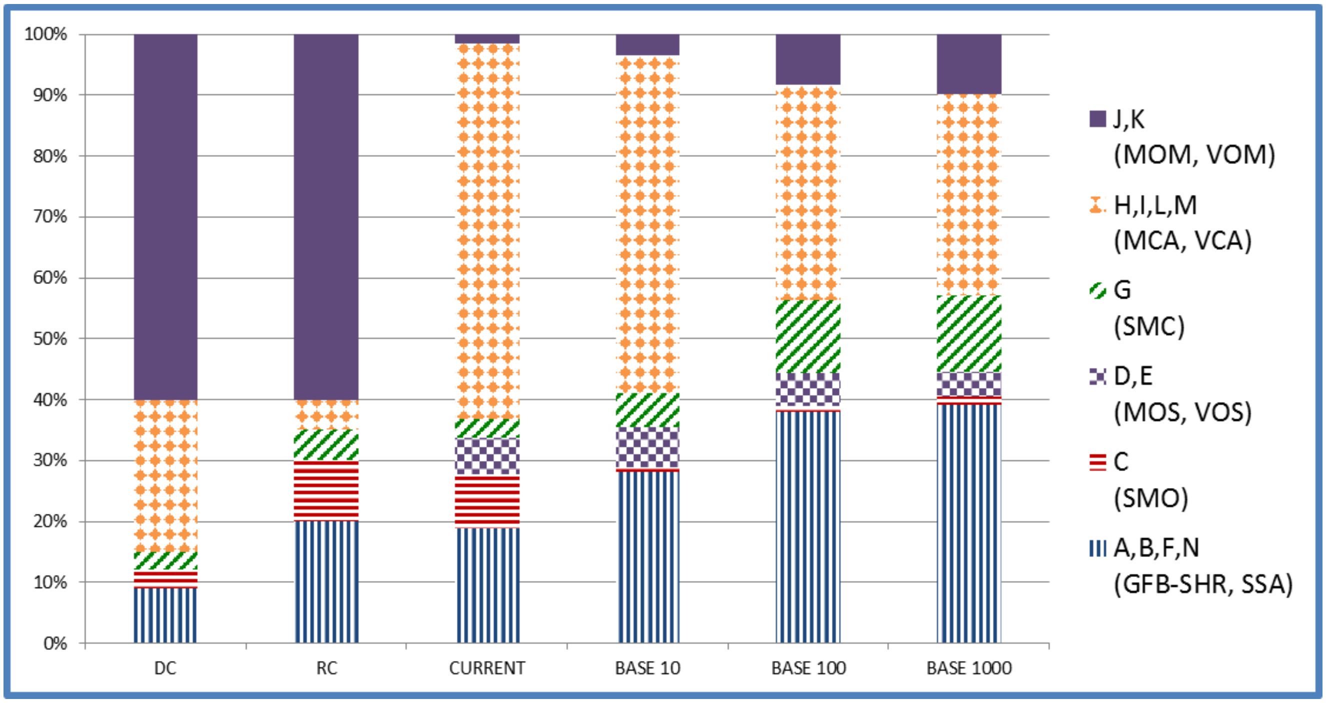

Figure 25. Seral state percentages for Mixed Conifer/Frequent Fire Forest ERU at the plan scale modelled out to 1,000 years. DC is desired condition, RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime (I-V) is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units. FRCC was not calculated for the Context Area.

The MCD ERU is primarily classified as Fire Regime I, with non-lethal fires occurring frequently (0-35 year mean fire interval), or less often as Fire Regime III, with a 35-200 year fire interval of mixed severity. Fire regime (FRCC) shows 31 percent of the ERU moderately departed and 69 percent highly departed from reference (Table 48). Locally, six units are moderately departed (FRCC II) and four units are highly departed (FRCC III). The local units in condition class III (AC, BR, RP and SR) are also highly departed for fire rotation (Table 49, see Fire Regime section for acronym names). Fire rotation at the plan scale is highly departed at 74 percent, with a mean interval of 86 years compared to reference of 22 years, while fire severity at the plan scale is moderately departed at 41 percent, with a severity of 31 percent, compared to reference of 18 percent. Increased severity concurrent with increased rotation intervals reflect years of fire suppression. Other factors that increase severity are overstocked conditions in the larger size classes that increase the risk of crown mortality. Dominant species in overstocked conditions often have shifted from shade intolerant fire resistant species such as ponderosa pine and Douglas-fir to less fire resistant shade tolerant species such as white fir. Overstocking is the result of fire suppression, management direction arising from conservation needs of wildlife species, as well as economic, infrastructure, and capacity constraints. The 2012 recovery plan for the Mexican spotted owl may be less restrictive of timber management practices in the future, which coupled with technological advances in mechanical ground-based harvest could counter those constraints and foster restorative treatments. This would help reduce seral state departure, and perhaps reduce potential fire severity as well, which would reduce FRCC departure. However, climate change is expected to bring warmer, drier conditions to the southwest (see the Stressors and Drivers chapter for more detail); if so, MCD is likely to experience more drought stress and longer fires seasons, which may increase fire severity and frequency.

Table 48. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0.0%	30.5%	69.5%	85.9	22.24	74%	31%	18%	41%

Table 49. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	87		1,927	20	39	139		24	29	42	6,342	3,807			
Fire Severity	40%		13%	23%	29%	39%		29%	23%	29%	34%	13%			
FRCC	III		III	II	II	III		II	II	II	III	II			

Coarse Woody Debris and Snags

Departure for coarse woody debris (CWD) and snags are shown in Table 50. No data is available for the context scale. Data was available for all local units where MCD occurs. Coarse woody debris (CWD), snags 8 to 18 inches and snags greater than 18 inches are all highly departed from reference at the Plan scale at 80 percent, 81 percent and 80 percent, respectively (Table 50). For all three measures at the plan scale, there is more currently than in reference condition. Currently, MCD contains about 57 tons per acre (TPA) of coarse woody debris compared to reference condition of 11.3 TPA. At the local scale, departure was low for the Arroyo del Macho and Rio Peñasco units, the Rio Hondo and Tularosa Valley units were moderately departed, while the Salt Basin and Upper Pecos units were highly departed. In the 8 to 18 inch snag size class, there are more than 47 snags per acre at the plan scale compared to nine per acre in reference condition for a departure of 81 percent. The Arroyo del Macho, Rio Peñasco, Tularosa Valley and Upper Pecos local units are moderately departed for the 8-18 inch snag class, while Rio Hondo and Salt Basin are highly departed. In the larger than 18 inch snag size class, current condition is about 20 snags per acre compared to 4 snags per acre in reference. Departure is low for the larger than 18 inch snag class in the Arroyo del Macho and Tularosa Valley units, moderate in the Rio Hondo and Rio Peñasco units, and highly departed in the Salt Basin and Upper Pecos units. These higher than reference values reflect mortality and retention of dead trees/CWD due to ongoing insect mortality, recent large fires and overstocking. Falling snags, in the absence of further recruitment by fire or insects and disease, will continue to provide CWD into the future, and reduce the number of snags per acre in both size classes. . At the local scale, departure was low for the Arroyo del Macho, Rio Peñasco and Upper Pecos units, Rio Hondo and Tularosa Valley were moderately departed, while the Salt Basin unit was highly departed. However, fire and insect/disease mortality are highly likely at some point in the future and will continue to recruit new snags.

Table 50. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and

by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition. Blank cells mean data was unavailable for those local units.

MCD		Coarse Woody Debris (tons per acre)					
Local Unit	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	80%	33%	51%	22%	83%	60%	83%
Reference	11.33	11.33	11.33	11.33	11.33	11.33	11.33
Current	57.0	16.84	23.18	14.57	65.12	4.53	1.88
Trend	45.6	5.51	11.85	3.24	53.79	(6.80)	(9.45)
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	81%	42%	68%	61%	70%	35%	41%
Reference	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Current	47.2	15.63	28.27	23.14	29.72	5.85	5.35
Trend	38.2	6.63	19.27	14.14	20.72	(3.15)	(3.65)
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	80%	32%	34%	54%	84%	30%	80%
Reference	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Current	19.7	5.85	2.62	8.76	25.78	5.73	0.79
Trend	15.7	1.85	(1.38)	4.76	21.78	1.73	(3.21)

Ecological Status and Ground Cover

Ecological status and ground cover were only analyzed at the plan scale. Ecological status is highly departed at 76 percent, primarily due to differences in tree and shrub cover between current and reference conditions (Table 51). In the MCD, conifers are less abundant in current condition (ranging from 6-68 percent in TEUI map units making up the ERU) than in reference (67-70 percent), while oak and locust (10-85 percent, current; 10 percent reference) are relatively more abundant. As mentioned above in the FRCC discussion, the shift from open mid to late seral to overstocked closed canopy forest also implies a shift from shade intolerant ponderosa pine and Douglas-fir to the more shade tolerant white fir, particularly in understory regeneration. Under current management including constraints mentioned above and for other forest types as well as fire suppression, that trend is likely to continue. Mixed conifer was only moderately departed (39 percent) for ground cover but the measure doesn't tell whether there is currently more or less ground cover than in reference condition. It is likely that under conditions where mortality from fire or insect and disease is predominant, that ground cover departure comes from more litter than in reference conditions, and in overstocked dense stands, departure is due to less basal vegetation and litter under dense canopies.

Table 51. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
76%	39%		0.02	50	104	Larger	52%

Patch Size

Patch size was calculated for the Plan Area only. Patch size is moderately departed (52 percent). Currently, average patch size is 104 acres, compared to a reference range of 0.02- 50 acres (Table 51). Larger patch sizes can be the result of past management that makes groups of stands more structurally homogenous, such as clearcutting. The larger patch sizes currently may also reflect fire effects from fire suppression causing larger fires with increased severity over more of the mixed conifer landscape, also making larger areas structurally more homogeneous. Future management may continue to promote fire suppression because of social and economic concerns, resulting in continued departure for patch size. Departure may also be an artifact of desired silviculture treatments constrained by wildlife habitat requirements, or soil erosion concerns. New recovery plans for the Mexican spotted owl, as well as technological improvements in logging practices may provide flexibility to improve structural proportion and distribution, including patch size. Current and near future management using the regionally consistent Desired Conditions guidance and thoughtful use of fire, may mitigate structural departure in the absence of extreme disturbance (such as fire or insect mortality). Patch size is expected to remain departed in the short term. Effective management can push patch size toward reference conditions; extreme disturbance can increase departure in patch size.

Insect and Disease

Total insect and disease mortality for 20 year data is 33,767 acres, with an average annual mortality of 1688 acres for all disease agents. The period from 2011 through 2014 showed the most mortality, with reduced acres since then. Defoliation is also down from past years. While insects and disease have always been present to some extent, data show a trend for more synchronous and widespread outbreaks (see Insect and Disease section). This suggests that fire suppression and past logging practices that have led to denser, spatially contiguous stands have contributed to increased area and intensity of infestation. Under current management, insects and disease will continue to have a presence in the mixed conifer forests with occasional widespread outbreaks.

Summary

The MCD ERU is mostly departed for all ecological characteristics. Seral state is moderately departed, but near the threshold of high departure, and as modeled under current management and disturbance regimes, departure changes little over one hundred years although there is some increase in the large and very large open canopied stands with a decrease in those same sized closed canopied stands. Small sized closed canopy stands and herbaceous and shrub states also increase with time. Fire regime is highly departed, not only due to seral state departure as noted but also an increase in fire rotation times, likely a result of suppression. Coarse wood and snags are overabundant and highly departed; this will likely continue into the future from density induced and insect and disease mortality. Ecological status is highly departed, probably the result of persistent shrub states created by large wildfires. While only moderately departed for patch size with more contiguous and larger patches of forest, the current overabundance in closed canopy (greater than 30 percent) may lead to further insect mortality as well as density dependent mortality. These conditions may be the result of past management as well as large scale disturbances resulting in overstocked even aged forest that are susceptible to future disturbance. Climate change modeling places 72 percent of this ERU in the high or very high vulnerability category to vegetation type change by the end of the century, although what that would look like is unclear. The mixed conifer- frequent fire ERU is considered to be at moderate risk to ecological sustainability, without taking into account the effects of climate change. The Lincoln NF can play a large role in maintaining or improving the ecological integrity of the mixed conifer forest through vegetation and fire management (not necessarily suppression). Including potential climate change effects, the mixed conifer- frequent fire forest is at high risk to ecological sustainability, which may be largely out of the control of the Forest.

Ponderosa Pine Forest (PPF):

General Description

The Ponderosa pine forest (PPF) ERU generally occurs on loose, well-drained soils derived from igneous, metamorphic, and sedimentary parent material at elevation ranging from 6,000 to 10,000 feet. Ponderosa pine forest is typically bounded at the upper elevation by mixed conifer forest, and at the lower elevation by grasslands or piñon-juniper woodlands, although extensive intergrading of species may occur at ecotone boundaries along gradients of slope, elevation, aspect, and moisture (Moir, 1993). Generally, annual precipitation ranges from 17 to 28 inches, with 45 to 55 percent coming between October 1st and March 31st. The dominant species in this system is ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson var. *scopulorum* Engelm.[1]). Other trees, such as Gambel oak (*Quercus gambelii* Nutt.), Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco), twoneedle piñon pine (*Pinus edulis* Engelm.), and junipers (*Juniperus* spp. L.) may be present. There is typically a shrubby understory; such as currants/gooseberries (*Ribes* spp. L.), and buckbrush (*Ceanothus* spp. L.), mixed with a variety of grasses and forbs, such as Arizona fescue (*Festuca arizonica* Vasey), mountain muhly (*Muhlenbergia montana* (Nutt.) Hitchc.), pine dropseed (*Blepharoneuron tricholepis* (Torr.) Nash), blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths), fleabanes (*Erigeron* spp. L.), pussytoes (*Antennaria* spp. Gaertn.), and others. This ERU sometimes occurs as savannah with extensive grasslands interspersed between widely spaced clumps or individual trees. This system is adapted to drought during the growing season, and has evolved several mechanisms to tolerate frequent, low intensity surface fires.

Ecological Characteristics

Spatial Niche

The Lincoln NF is made up of approximately 11.3 percent of PPF (123,156 acres), while the Context Area contains approximately 1.8 percent. The Lincoln NF contains about 21 percent of the PPF in the Context Area, and so makes a fairly substantial contribution to ecological sustainability.

Seral State Proportion

Seral state percentages for calculating departure are shown in Table 52 and Figure 26. The Lincoln NF and its local units (five of six) are all highly departed for seral state (98-100 percent). The Context Area is also highly departed (95 percent). This is primarily due to a reference condition where 100 percent of the PPF landscape

[1] All common names and scientific nomenclature follow USDA, NRCS, 2016. The PLANTS Database (http://plants.usda.gov, 2016). National Plant Data Team, Greensboro, NC 27401-4901 USA.

was in an open canopied, multi-storied state (J, K combined) dominated by large trees (greater than 10 inches). Regeneration was limited to dispersed groups or individuals of smaller trees in various size classes maintained by the frequent fire regime. With fire suppression and grazing regimes that limited the ability of understories to carry fire, the open canopied mature state shared the landscape with open and closed stands of smaller trees. Where mature trees were still dominant, with time they became closed stands containing various sized trees in the understory. The Lincoln NF and its local units currently range from 0-2 percent in that open reference state, compared to five percent for the Context Area. The Lincoln NF has 17 percent in early seral herbaceous/shrub combined states A, B, F, N, and ranges from 10 percent in the Rio Hondo unit to 26 percent in the Rio Peñasco unit. The Context Area has only 10 percent in these early seral states. Previous disturbances, such as fire or overgrazing, could lead to conditions favoring extensive shrub, seedling and sapling growth with subsequent fire suppression allowing the growth of dense stands of small trees. These can grow into more dense stands of mid and late seral trees, including favoring a shift to more shade tolerant and/or fire intolerant tree species. Evidence for this may be seen in the mid seral states C and G (5-10 inches, open and closed canopies, respectively). The Lincoln NF has 28 percent in small tree open canopy state C with local units ranging from 16 to 40 percent. The Context Area, on the other hand, only has five percent in that state. For the closed mid seral state G, the Lincoln NF has only about five percent (local unit range 5-13 percent) compared to the Context Area's fifteen percent. These states are management opportunities to reduce departure through thinning and enhanced use of fire. Late seral states (D, E) of single storied open canopy large trees were similarly abundant for the Lincoln NF, and the Context Area at nine percent (Local Unit range seven to twelve percent). Late seral states (H, I L, M) of large tree stands with closed canopies (greater than 30 percent canopy) were much different than reference. The Lincoln NF had 39 percent in late seral closed canopy states (Local Unit range 26 to 51 percent) compared to the Context Area's 57 percent. These states may provide a more immediate opportunity to reverse departure by opening the canopy and restoring the open understory structure to allow low severity fire as a maintenance tool. Modelling of management activities, wildfire, insect, disease and other disturbance and natural successional dynamics of the ERU into the future show departure drops slightly but remains high at 10 years (98 percent), 100 years (88 percent) and 1,000 years (88 percent). These changes come primarily from a shift from larger closed canopy and open single-storied states (H, I, L, M, and D, E, Figure 8). While trend is marginally toward less departure, the system is still at risk.

Table 52. Ponderosa Pine Forest ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley
A, B, F, N	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs, seedling/sapling size (< 5" dbh/drc9) trees with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover (occurs on contemporary landscapes, historically rare/localized)	0.00	0.10	0.17	0.18	0.10	0.26	0.13	0.14
C	MID-SERAL: Small size (≥ 5" & < 10" dbh/drc) trees with open woody canopy cover (occurs on contemporary landscapes, historically rare/localized)	0.00	0.05	0.28	0.40	0.27	0.26	0.36	0.16
D, E	LATE-SERAL: Medium to very large size (≥ 10" dbh/drc) trees, single storied with open woody canopy cover (occurs on contemporary landscapes, historically rare/localized)	0.00	0.09	0.09	0.09	0.12	0.07	0.07	0.11
G	MID-SERAL: Small size trees with closed woody canopy cover (occurs on contemporary landscapes, historically rare/localized)	0.00	0.15	0.05	0.06	0.06	0.04	0.13	0.05
H, I, L, M	LATE-SERAL: Medium to very large size trees, single storied or uneven-aged stands (multi-storied) with closed woody canopy cover (occurs on contemporary landscapes, historically rare/localized)	0.00	0.57	0.39	0.26	0.44	0.37	0.30	0.51

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley
J, K	LATE-SERAL: Medium to very large size trees, uneven-aged stands (multi-storied) with open woody canopy cover	1.00	0.05	0.01	0.01	0.01	0.01	0.00	0.02
Departure			96%	99%	99%	99%	99%	100%	98%

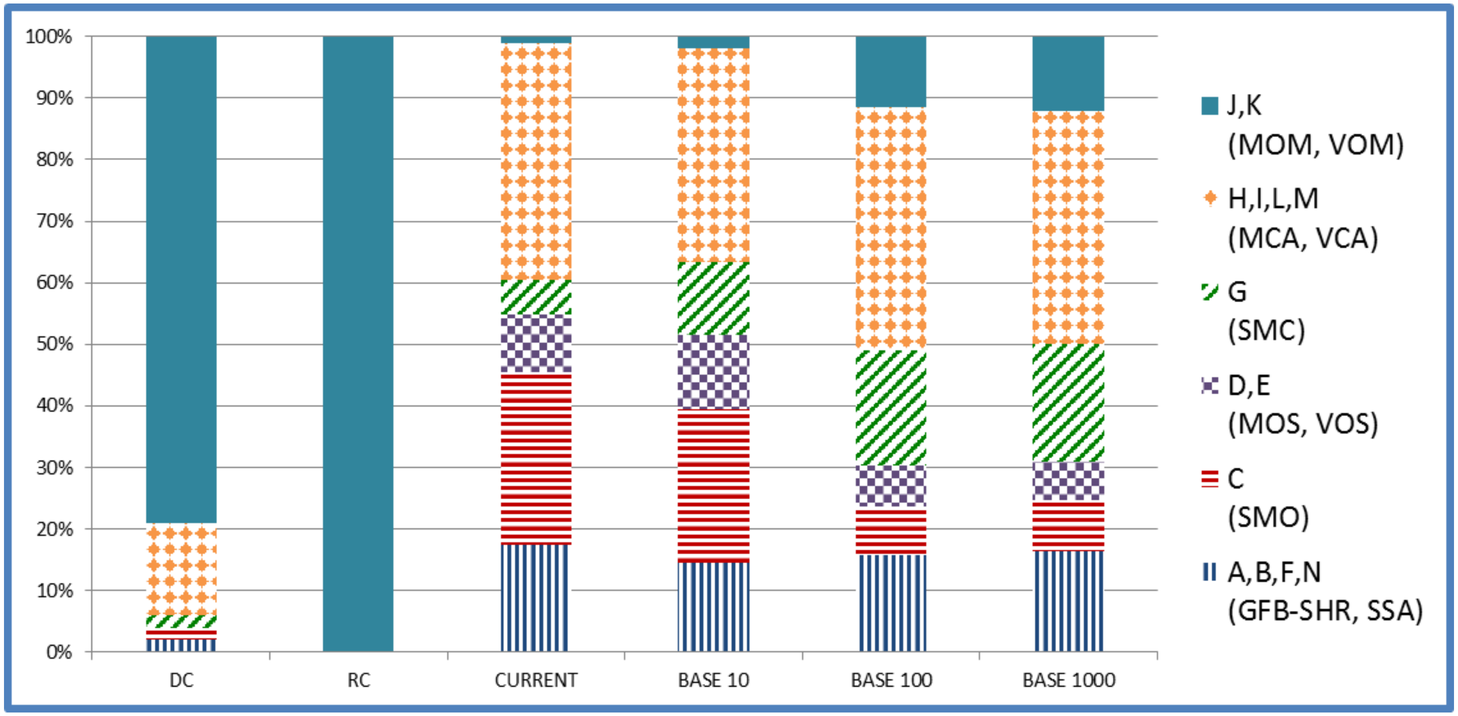

Figure 26. Seral state percentages for Ponderosa Pine Forest ERU at the plan scale modelled out to 1,000 years. DC is desired condition, RC is reference condition, Current is current condition, Base 10, 100 and 1,000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units. FRCC was not calculated for the Context Area.

The historic fire regime for the PPF ERU was one of frequent, low severity fires (Fire Regime I). Fire regime (FRCC) for the ponderosa pine ERU in the Plan Area is 100 percent in the highly departed condition class III (Table 53). FRCC reflects the seral state departure discussed above, combined with fire rotation interval and severity. Seral state is departed nearly 100 percent. Fire rotation is highly departed at 85 percent, with a mean interval of 70.4 years compared to reference of 10.5 years, while fire severity is moderately departed at 53 percent, with severe mortality currently 26 percent, compared to a reference of 13 percent. Local units were generally highly departed, with all units having longer rotations than reference, while severity ranged from 13 percent to 38 percent, equal or greater than reference (Table 54). FRCC was highly departed for all local units. Increased severity concurrent with increased rotation intervals reflect years of fire suppression and departure of structural states. Factors that increase severity are overstocked conditions and ladder fuels in the larger size classes that increase the risk of crown mortality, as well as social and economic constraints that limit management options. In the overstocked condition, pine and Douglas-fir can persist in the overstory, but regeneration can include shade tolerant species such as white fir which is less resistant to fire damage. However, climate change is expected to bring warmer, drier conditions to the southwest (see Systems Drivers and Stressors chapter for more detail); if so, PPF is likely to experience more drought stress and longer fires seasons, which can increase fire severity, fire frequency and the possibility of type conversion to drier vegetation types, most likely pinon pine-juniper woodland types.

Table 53. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	0%	100%	70.4	10.50	85%	26%	13%	53%

Table 54. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	77		30		46		34	26	95		32,645			
Fire Severity	29%		18%		38%		23%	29%	23%		13%			
FRCC	III		III		III		III	III	III		III			

Coarse Woody Debris and Snags

Departure for coarse woody debris (CWD) and snags are shown in Table 55. Data was analyzed only for the Plan Area and for local units where data was available.

The ponderosa pine forest ERU occurs in four Local Units. Departure is moderate at the Plan scale for CWD, with current tons/acre approximately 70 percent of reference condition. Departure was low for the Rio Peñasco and Tularosa Valley local units, while the Arroyo del Macho and Rio Hondo units were moderately departed. In all cases, CWD is less than the reference range. Snags in the 8-18 inches size class were highly departed at the plan scale with more than six times the number of snags currently than in reference conditions. All local units were also highly departed, with similarly larger current than reference abundances. Past fire, insect infestation, and density influenced mortality have probably contributed to the overabundance of snags in this size class. Deficits in CWD may be reduced by recruitment from the overabundant small size class snags. Departure was low for snags in the larger than 18 inches size class at the plan scale, with current values approximately 70 percent of reference condition. At the local scale, departure was low for the Arroyo del Macho and Rio Hondo units, while the Rio Peñasco and Tularosa Valley units are moderately departed (Table 55). Increased density as shown in seral state departure may have contributed to insect outbreaks and mortality creating an excess of snags in the smaller (8-18 inch) size class.

Table 55. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition. Blank cells mean data was unavailable for those local units.

PPF		Coarse Woody Debris (tons per acre)					
Local Unit	**LNF Plan Area**	**Arroyo Del Macho**	**Rio Hondo**	**Rio Peñasco**	**Salt Basin**	**Tularosa Valley**	**Upper Pecos**
Departure	35%	59%	44%	6%		28%	
Reference	13.00	13.00	13.00	13.00		13.00	
Current	8.5	5.32	7.28	12.21		9.36	
Trend	(4.5)	(7.68)	(5.72)	(0.79)		(3.64)	
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	85%	82%	88%	85%		77%	
Reference	0.65	0.65	0.65	0.65		0.65	
Current	4.3	3.66	5.41	4.48		2.77	
Trend	3.6	3.01	4.76	3.83		2.12	
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	3%	12%	15%	65%		35%	
Reference	0.65	0.65	0.65	0.65		0.65	
Current	0.5	0.57	0.55	0.23		0.42	
Trend	(0.2)	(0.08)	(0.10)	(0.42)		(0.23)	

Ecological Status and Ground Cover

Ecological status is species composition and cover, and is highly departed (87 percent) from reference conditions (Table 56). Departure is derived not only from a change in the species present, but also from differences between current and reference values for species' cover. Higher conifer/lower graminoid cover values in current condition compared to lower conifer/higher graminoid cover in reference are indicative of a system that may be overstocked or encroached. Overstory species also show change in relative cover, with more Douglas-fir and white fir now than historically. Ground cover shows only low departure from reference values (11 percent). This suggests that although a shift in species composition has occurred, the functions that ground cover provide have not been compromised

Table 56. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status Departure	Ground Cover Departure	Patch Size	REFERENCE (acres)** LWR	REFERENCE (acres)** UPR	CURRENT (acres)	TREND	DEPARTURE (%)
87%	11%		0.02	0.5	41	Larger	99%

Patch Size

Patch size in the ponderosa pine forest is highly departed (99 percent), with a patch size larger than reference range (0.2-0.5 acre)(Table 56). For this type, as well as PPE and MCD, a 'patch' is a clump of trees, and larger patch size would indicate more contiguous tree canopy. Departure for patch size is consistent with PPF's high departure for seral state with 45 percent in closed canopy (greater than 30 percent) conditions. Reference seral state for PPF is 100 percent in very open forest of small clumps of trees. In the case of MCD and PPF, larger patch sizes may lead to increased risk of stand replacement wildfires or insect mortality over larger areas.

Insect and Disease

Total acres of insect and disease mortality over 20 years was 49,139 acres, for an average annual mortality of 2457 acres. Most of the mortality occurred between 2011 and 2014, with a peak of 24,300 acres in 2014. Since then, annual mortality has fallen every year. Localized activity of bark beetles in single trees and small groups will continue to be a part of the ponderosa pine forest ecology and should be expected in dense stands, especially those under stress from dwarf mistletoe, other diseases, or abiotic factors. Throughout the Southwest, the greater abundance of dense, crowded stands due to fire exclusion and past management activities has increased the potential for bark beetle activity over pre-settlement stand conditions and contributes to higher mortality levels when drought-related outbreaks develop. The Lincoln NF has particularly had a history of large, widespread, and regular bark beetle outbreaks in the ponderosa pine forests. This pattern is expected to continue as long as suitable host stands are present. Defoliating agents and root disease are present and can cause some mortality, but usually at low levels. These can stress trees and make them more vulnerable to bark beetle attack. Dwarf mistletoe is common in ponderosa pine, and amounts change little from year to year. The Lincoln NF has the highest infestation rate of all forests in the region. Approximately 70 percent of the ponderosa pine ERU is infested with mistletoe, compared with 36 percent for the rest of the region. This high level of infestation has been attributed to past selective cutting and uneven aged management that was in some instances intended to reduce dwarf mistletoe. Dwarf mistletoe has increased throughout the southwest due to high density uneven-aged conditions that have allowed young trees to become established under infected overstory trees. Under current overstocked and structurally departed conditions, the ponderosa pine ERU remains at risk for mistletoe infestations, as well as mortality due to bark beetles.

Summary

Seral state, fire regime condition class and fire frequency, ecological status and patch size are all highly departed for the ponderosa pine forest ERU (Table 52). Ponderosa pine makes up a fair (11.3 percent) of the Lincoln NF and is about 21 percent of ponderosa pine forest in the Context Area. This makes the Lincoln NF a fairly large contributor to the ecological integrity of the ERU. The Forest and Context Area are similarly departed for seral state, with the Lincoln slightly more departed. This plays into FRCC departure, which is strongly affected by seral state, as well as ecological status and patch size. While fire severity is generally moderately departed, it is still more severe than historically and fires are happening less often, or across less of the landscape. Modeling current disturbance and management regime 10 and 100 years into the future shows departure reduced by a small amount but still high (88 percent). It is considered that under current management, the ponderosa pine forest ERU is at high risk to ecological integrity, primarily from disturbances such as fire and insect mortality. Climate change models indicate that the PPF ERU has a 94 percent of vegetation type change in the next 100 years. In the absence of climate change effects, the Lincoln NF can play a large role in maintaining or increasing the ecological sustainability of the ponderosa pine ERU through density management and reintroduction of fire into the landscape.

Ponderosa Pine-Evergreen Oak Forest (PPE):

General Description

The Ponderosa pine- Evergreen Oak (PPE) ERU occurs in the mild climate gradients of central and southern Arizona and in southern New Mexico, particularly below the Mogollon Rim, where warm summer seasons and bi-modal (winter-summer) precipitation regimes are characteristic. Generally, annual precipitation ranges from 13 to 25 inches, with 40-45 percent coming between October 1st and March 31st. This ecological type occurs at elevations ranging from 5,500 to 7,200 feet, on sites slightly cooler-moister than the Madrean Piñon-Oak ERU, and with a much greater plurality of ponderosa pine. This system is dominated by ponderosa pine and can be distinguished from the PPF ERU by well-represented evergreen oaks (e.g., Emory oak (*Quercus emoryi* Torr.), Arizona white oak, silverleaf oak, gray oak (*Quercus grisea* Liebm.)), alligator juniper, and piñon pine. Though not an indicator in the ponderosa pine life zone, border piñon (*Pinus discolor* D.K. Bailey & Hawksw.), along oneseed juniper (*Juniperus monosperma* (Engelm.) Sarg.) can occur as a dominant or codominant component of the PPE ERU. In terms of disturbance, the PPE averaged greater fire severity than the PPF above the Mogollon Rim, and greater patchiness with less horizontal uniformity and more even-aged conditions. Site potential, fire history, and the importance of perennial grasses versus shrubs in the understory vary on a gradient between two provisional subclasses (described below). Understory shrubs include manzanita (*Arctostaphylos* spp. Adans.), Sonoran scrub oak (*Quercus turbinella* Greene), skunkbush sumac (*Rhus trilobata* Nutt.), and mountain mahogany (*Cercocarpus montanus* Raf.).

Ecological Characteristics

Spatial Niche

PPE, with 8,661 acres, occupies less than 1 percent of the Lincoln NF and only 0.12 percent of the Context Area. PPE on the Lincoln is 21 percent of the Context Area PPE. This ERU occurs in only 3 of 6 local units: four acres in Rio Peñasco on the Sacramento RD, and the remainder in the Salt Basin (412 acres) and Upper Pecos (8245 acres) local units on the Guadalupe RD. On the Guadalupe District, the ERU is limited to the steep canyons south of Queen Highway. While the PPE type is a low percentage of both the Lincoln NF and the Context Area, the Lincoln NF contains 21 percent of the ERU in the Context Area, and thus has a role in maintaining the ecological integrity of the type.

Seral State Proportion

Both the Lincoln NF and the Context Area are moderately and similarly departed for seral state distribution at 66 and 63 percent, respectively (Table 57 and Figure 27). Two local units are moderately departed similar to Lincoln NF (64-66 percent), while the Rio Peñasco unit was highly departed at 95 percent (there are very few acres in the Rio Peñasco local unit so it has little effect on the Lincoln NF departure). Departure is most related to under-representation of open canopied large (greater than 10 inches) tree dominated state D, and over-representation of small tree (5 to 10 inches) open state C, for the Lincoln NF, and Salt Basin and Upper Pecos local units (because of the acre distribution, the Lincoln NF and Upper Pecos local unit seral state proportions are nearly identical). The Rio Peñasco is 100 percent (all four acres) in the seedling/sapling state F, likely a result of relatively recent fire disturbance. The Context Area has 56 percent of its PPE area in large, closed canopy tree-dominated state E, relative to a reference amount of four percent. No acres on the Lincoln NF are mapped in state E. The Lincoln NF has a combined 92 percent in small tree (5 to 10 inches diameter class) open and closed states, while the Context Area has 22 percent in those states, compared to a reference condition of 27 percent. Because PPE occupies less than 1 percent on the Forest, it was not modelled into the future.

Table 57. Ponderosa Pine/Evergreen shrub ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Peñasco	Salt Basin	Upper Pecos-Black
A	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.04	0.03	0.02	0.00	0.01	0.02
B	MID-SERAL: Small size (≥ 5" & < 10" dbh/drc) trees with closed woody canopy cover	0.03	0.14	0.27	0.00	0.07	0.28
C	MID-SERAL: Small size trees with open woody canopy cover	0.24	0.08	0.65	0.00	0.84	0.65
D	LATE-SERAL: Medium to very large size (≥ 10" dbh/drc) trees, single-storied or uneven-aged (multi-storied) with open woody canopy cover	0.60	0.16	0.02	0.00	0.05	0.02
E	LATE-SERAL: Medium to very large size trees, single-storied or uneven-aged (multi-storied) with closed woody canopy cover	0.04	0.56	0.00	0.00	0.00	0.00
F	EARLY-SERAL: Seedling/sapling size (< 5" dbh/drc) trees with open or closed woody canopy cover	0.05	0.03	0.03	1.00	0.03	0.03
Departure			63%	66%	95%	64%	66%

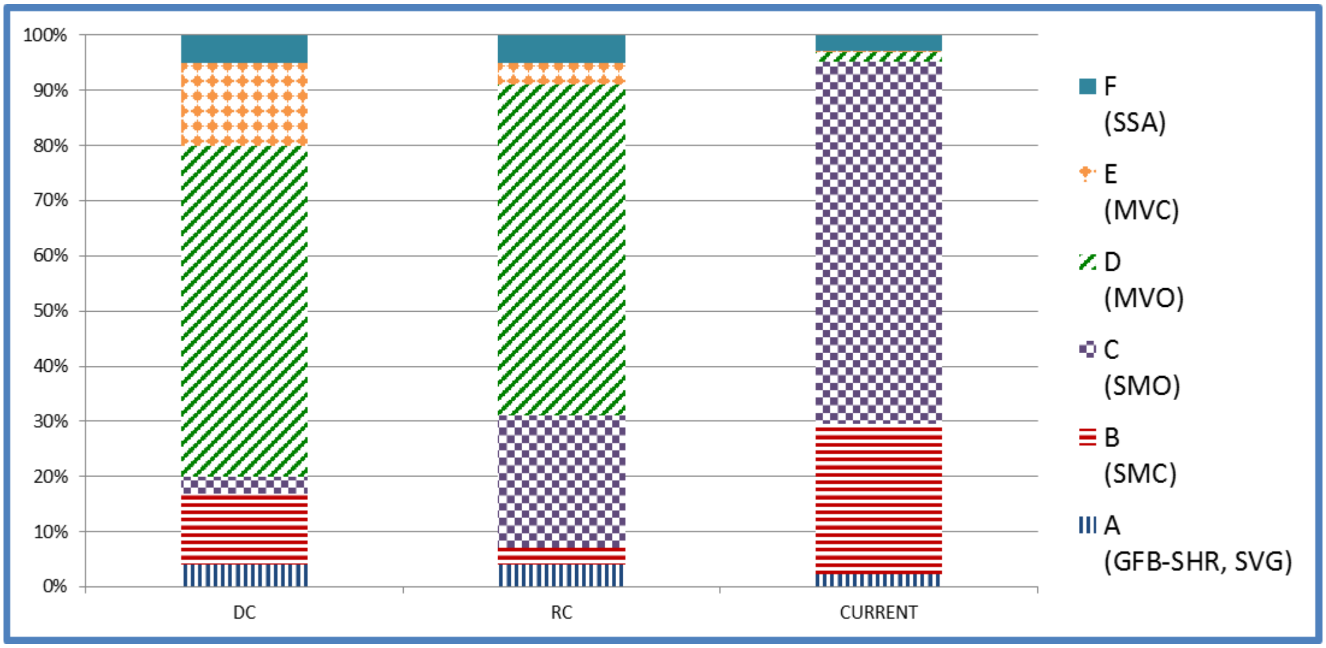

Figure 27. Seral state percentages for Ponderosa Pine-Evergreen Oak Forest ERU at the plan scale. DC is desired condition, RC is reference condition, Current is current condition.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units. FRCC was not calculated for the Context Area.

The PPE ERU has a typical fire regime of frequent, non-lethal (Fire Regime I) or less frequent, mixed severity (Fire Regime III) fires. There were no fires in the 20 year data for fire rotation and severity, so departure could not be calculated for those characteristics, or fire regime condition class (Table 58 and Table 59). As a primary factor in determining FRCC, seral state departure is at the high end of moderate, so it may be expected that FRCC is also moderately to highly departed.

Table 58. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
n/a	n/a	n/a	n/a	12.45	n/a	n/a	0.15	n/a

Table 59. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
Fire Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
Fire Severity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FRCC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Coarse Woody Debris and Snags

Departure for coarse woody debris (CWD) and snags are shown in Table 60. Data was analyzed only for the Plan Area and for local units where data was available. The Plan Area is moderately disturbed for CWD with current abundance about 60 percent of reference value. The ponderosa pine evergreen shrub ERU is found mostly in the Salt Basin and Upper Pecos local units. Coarse wood and snag data was only available for those two units. Departure is low for Salt Basin and moderate for Upper Pecos local units. Plan Area departure is low in both the 8-18 inches, and larger than 18 inch snag size classes with current snags per acre being approximately 70 percent the amount in reference condition in both classes. Departure was low for both local units for the 8- 18 inch size class, while both were moderately departed in the larger than 18-inch size class. In the 8-18 inch class, both local units had less snags per acre than reference, while in the larger size class, Salt Basin currently has nearly twice the snags as reference, while the Upper Pecos has only 65 percent the snags as in reference condition. The ERU as a whole is moderately departed for structural state, with current percentage in the small tree size class (5-10 inches) more than three times the reference condition (92 percent compared to 27 percent), and current acres in the medium to very large size class (greater than 10 inches) just a fraction of that expected in reference condition (2 percent compared to 64 percent). Eventually, mortality (succession, insect/disease, or fire) should provide recruitment in CWD and the 8-18 inches snag size class. Low numbers of acres in the medium-very large structural state may extend the time needed to recruit snags in the larger than 18 inches size class. (Table 60).

Table 60. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition. Blank cells mean data was unavailable for those local units.

PPE	Coarse Woody Debris (tons per acre)						
Local Unit	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	28%				20%		31%
Reference	10.00				10.00		10.00
Current	13.9				12.54		6.92
Trend	3.9				2.54		(3.08)
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	26%				14%		28%
Reference	5.00				5.00		5.00
Current	6.8				5.79		3.59
Trend	1.8				0.79		(1.41)

PPE Local Unit	Coarse Woody Debris (tons per acre) LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	42%				48%		37%
Reference	2.00				2.00		2.00
Current	3.4				3.83		1.26
Trend	1.4				1.83		(0.74)

Ecological Status and Ground Cover

No data was available for ecological status. Ground cover was moderately departed at 57 percent (Table 61).

Table 61. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres) LWR	REFERENCE (acres) UPR	CURRENT (acres)	TREND	DEPARTURE (%)
n/a	57%		0.02	50	7	Similar	0%

Patch Size

Patch size showed low departure with virtually no difference from reference (Table 61).

Insect and Disease

No Insect and disease mortality was noted (but see limits to analysis in the Insect and Disease section).

Summary

Departure of most characteristics of the ponderosa pine/evergreen shrub ERU is moderate, or low. Fire regime characteristics could not be analyzed for departure. While the PPE type is a low percentage of both the Lincoln NF and the Context Area, the Lincoln NF contains 21 percent of the ERU in the Context Area, and thus has a role in maintaining the ecological integrity of the type. While modeling into the future was not done, it might be expected with time that the surplus in small tree states B and C will grow into desired state D, larger trees with open canopy. Given no change in climate, disturbance or management, the risk to ecological sustainability is considered moderate; however, climate change modeling places 90 percent of the ERU at high and very high vulnerability to vegetation type conversion toward the end of the century, although it is unclear what that might look like. In the absence of climate change effects, the Forest could use management practices such as density management and re-introduction of fire into the landscape to maintain or improve ecological integrity of this ERU.

Piñon-Juniper/Evergreen Shrub Woodland (PJC):

General Description

The piñon-juniper/evergreen shrub woodland (PJC) ERU is typically found on lower slopes in transition zones, often between interior chaparral and montane forests, and is most extensive in geographic areas dominated by mild climate gradients and bi-modal precipitation regimes. The PJC ERU is a broad grouping of different plant associations for descriptive purposes, with tree and shrub species composition varying throughout the Region. Historically this ERU had greater than 10 percent tree canopy cover in later successional stages, expressed by twoneedle piñon, single leaf piñon, Utah juniper, oneseed juniper, or alligator juniper. Piñon is occasionally absent, but one or more juniper species are always present. Oak trees (i.e., Arizona white oak, gray oak, Emory oak) are subordinate, but have high constancy in mild climate zones between central Arizona and southwestern New Mexico. Trees occur as individuals or in smaller groups and range from young to old, but typically small stands or clumps are even-aged in structure as a consequence of mixed severity fire (at least historically). The understory is dominated by low to moderate density shrubs, with herbaceous plants in the interspaces. Shrub species include species of manzanita, mountain mahogany, antelope bitterbrush (*Purshia tridentata* (Pursh) DC.), silktassles *(Garrya* spp. Douglas ex Lindl.), Stansbury cliffrose (*Purshia stansburiana* (Torr.) Henrickson), Sonoran scrub oak, and sumacs (*Rhus* spp. L.).

Typical drivers and stressors (fire, insects, disease) are mixed severity and moderate, although some evergreen shrub woodland types exhibit infrequent fire/high severity effects (FR IV, 35-200 years, replacement severity; e.g., piñon-juniper/manzanita). These disturbance patterns create and maintain tree-age diversity and low to moderately-closed canopy typical of this type. Understory plants consisting of perennial native grasses and both annuals and perennial forbs comprise the remainder of the inter-canopy interspaces. Climate generally consists of mild winters and wet summers with mean annual precipitation ranging from about 10 to 25 inches with 55-60 percent coming between April 1st and September 31st. The PJC ERU is found on well-drained soils, frequently with coarse-textured or gravelly (stony) soil characteristics. Aside from disparities in structure and composition, PJC can also be differentiated from interior chaparral by longer fire intervals and less severe fire events. Due to the effects of long-term fire suppression, in many locations the current condition is severely departed from historic conditions. Typically these changes include in-filling of the canopy gaps, increased density of tree groups, and reduced composition, density and vigor of the herbaceous understory plants. Many of these sites currently are closed-canopy woodlands, with insufficient understory vegetation to support surface fires.

Ecological Characteristics

Spatial Niche

The Lincoln NF contains just under 5 percent PJC (53,976 acres), compared to the Context Area's 0.26 percent. However, this represents 63 percent of the PJC in the Context Area, so the Lincoln NF has a large contribution to the ecological sustainability of the PJC ERU.

Seral State Proportion

Seral state departure of PJC is moderate for the Context Area, Plan Area and all local units where it is found (Table 62 and Figure 28). Departure is less for the Lincoln NF than the Context Area at 37 percent and 52 percent respectively. PJC is found in three of six local units; all are moderately departed, with individual state proportions similar to the Plan Area. The Context Area is more abundant by proportion than the Lincoln NF in the early seral state A, and late seral large tree states D and G, while the Plan Area has a much larger proportion of the early/mid seral combined states B, C, and E than the Context Area (79 percent and 20 percent, respectively). Some of that abundance may be explained by recent fires, primarily the Last Chance and Dinner fires in the Upper Pecos and Salt Basin local units in the Guadalupe district.

Modelling out into the future management activities, wildfire, insect and disease and other disturbances, and natural successional dynamics show reduced departure at 10 years compared to currently, but increasing departure at 100 years, and only a slight reduction 1,000 years out. This appears to be movement from the small and open size classes into the closed tree dominated states (F and G). At 100 and 1,000 years, state D is similar to reference conditions, but state G is far greater than reference conditions (34 percent and 33 percent, vs. 0 percent reference)

Table 62. Piñon-Juniper/Evergreen Shrub Woodland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Peñasco	Salt Basin	Upper Pecos-Black
A	EARLY SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.05	0.18	0.07	0.03	0.08	0.10
B, C, E	MID-SERAL: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover	0.55	0.20	0.79	0.82	0.85	0.75
D	LATE-SERAL: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover	0.40	0.23	0.03	0.01	0.02	0.04
F	MID-SERAL: Small size trees with closed woody canopy cover	0.00	0.12	0.11	0.14	0.05	0.10
G	LATE-SERAL: Medium to very large size trees with closed woody canopy cover	0.00	0.27	0.00	0.00	0.00	0.01
Departure			52%	37%	41%	38%	36%

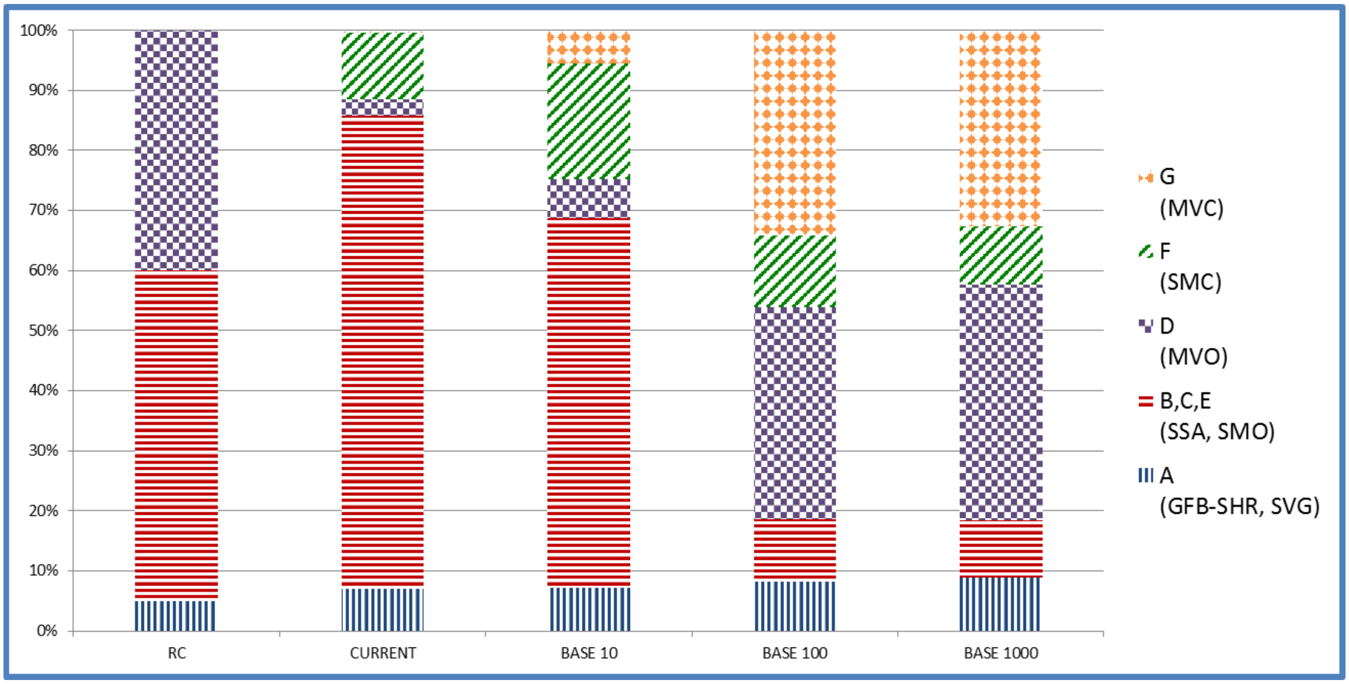

Figure 28. Seral state percentages for Piñon-Juniper/Evergreen Shrub Woodland ERU at the plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The PJC ERU has a fire regime that includes Fire Regime III (mixed severity) and IV (high severity), with mean fire return intervals of 35-200 years. Fire regime (FRCC) is 100 percent in the moderately departed condition class at the plan scale (Table 63) and for all local units. At the plan scale fire rotation is moderately departed at 38 percent with a mean rotation of 335 years compared to a reference of 206 years. Three local units were highly departed for rotation with much longer rotations than reference, while the UPS local unit was highly departed with much shorter rotation period. The DC local unit was moderately departed for rotation, although still much longer than reference (Table 64). Plan scale fire severity shows low departure of 23 percent, with a current severity of 53 percent lower than the reference of 69 percent. Three of five local units were highly departed for severity with much lower severity values than reference, while the RP unit was moderately departed. The UPS local unit was not significantly departed, with severity of 51 percent compared to the reference of 69 percent. The moderate departure in FRCC is probably a reflection of seral state departure described above, and increased fire rotation interval due to fire suppression.

Table 63. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure

0%	100%	0%	335.2	206.30	38%	53%	69%	23%

Table 64. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	1,962		6,630		457	637									20
Fire Severity	15%		13%		15%	29%									51%
FRCC	II		II		II	II									II

Coarse Woody Debris and Snags

The Piñon-Juniper evergreen shrub woodland ERU is mostly found in the Upper Pecos, Salt Basin and Rio Peñasco local units. CWD was moderately departed with more than twice the tons per acre currently than in reference condition. Departure is low for the Rio Peñasco unit, moderate for the Upper Pecos which contains most of the type, and high for the Salt Basin Unit, all current values larger than reference. Snags in the 8-18 inch class were moderately departed at the plan scale with 67 percent more currently than in reference condition. Departure is low for Salt Basin, and moderate for the Rio Peñasco and Upper Pecos units with current values equal or greater than reference condition. At the plan scale, snags in the larger than 18 inches size class have low departure with approximately 10 percent more snags now than historically. Departure is low for the Rio Peñasco and Upper Pecos units and moderate for the Salt Basin unit. The Rio Peñasco has slightly fewer snags than in reference, while the Salt Basin and Upper Pecos units have more snags than in reference condition (Table 65).

Table 65. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition.

PJC		Coarse Woody Debris (tons per acre)					
Local Unit	**LNF Plan Area**	**Arroyo Del Macho**	**Rio Hondo**	**Rio Peñasco**	**Salt Basin**	**Tularosa Valley**	**Upper Pecos**
Departure	73%			27%	69%		58%
Reference	3.00			3.00	3.00		3.00
Current	11.0			4.13	9.70		7.14
Trend				1.13	6.70		4.14
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	54%			56%	0%		38%
Reference	3.00			3.00	3.00		3.00
Current	6.6			6.80	3.00		4.86
Trend	3.6			3.80	0.00		1.86

PJC		Coarse Woody Debris (tons per acre)					
Local Unit	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	54%			19%	50%		3%
Reference	1.00			1.00	1.00		1.00
Current	2.2			0.87	2.00		1.34
Trend	1.2			(0.19)	1.00		0.03

Ecological Status and Ground Cover

There was no data available for ecological status or ground cover.

Table 66. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
n/a	n/a		50	200	5	Smaller	90%

Patch Size

Patch size departure is high at 90 percent, with current average patch size of five acres much less than the reference range of 50-200 acres (Table 66).

Insect and Disease

Total insect and disease mortality over 20 years was 1611 acres, with an average annual mortality of 81 acres. Most mortality occurred from 2011 to 2013, peaking in 2013. Little insect activity has been recorded since then with only 10 acres of pinyon ips mortality in 2017. These numbers may be low as the PJC ERU is mostly in the Guadalupe Ranger District, which does not get surveyed annually.

Summary

The piñon-juniper evergreen shrub (PJC) ERU is moderately departed at the plan scale for seral state, FRCC, fire frequency and snags in both size classes. This is seen on the ground as much greater abundance (90 percent) of area in mid seral small trees (less than 10 inches, open or closed canopies) than in reference condition (55 percent), and more than late seral large trees (three percent, compared to the reference of 40 percent. Fire severity departure, however, is low. Coarse woody debris and patch size are highly departed. Modelling seral state out to 10 years reduces departure somewhat, but out to 100 years, departure increases with closed canopy states (greater than 30 percent canopy cover) for trees greater than five inches the main source of departure. This could lead to increased fire risk and severity, as well as increase the abundance of CWD and snags. The PJC type is considered to have moderate risk to ecological sustainability, and with 63 percent of the ERU occurring on the Lincoln NF, the Forest has a large contribution to make toward maintaining or increasing ecological sustainability. Given that the greatest departure comes from substantial increases in closed tree dominated states, active vegetation density management by the Forest may have a large role in determining future ecological sustainability.

Juniper Grassland (JUG):

General Description

The Juniper grasslands (JUG) ERU is typically found on warmer and drier settings beyond the environmental limits of piñon, and just below and often intergrading with the piñon-juniper zone. The juniper-grass ecosystem is generally uneven-aged and very open in appearance (savanna-like), primarily on mollisol soils. Trees occur as individuals or in smaller groups and range from young to old. A dense herbaceous matrix of native grasses and forbs characterize this type. Typical drivers and stressors (i.e., fire, insects, disease) are low severity and high frequency. These disturbance patterns create and maintain the uneven-aged, open-canopy nature of this type. The tree and grass species composition varies throughout the region, consisting of a mix of one or more juniper species. Typically, native understory grasses are perennial species, while forbs consist of both annuals and perennials. Shrubs are characteristically absent or scattered. This type is typically found on sites with well-developed, loamy soil characteristics, generally at the drier edge of the woodland climatic zone. Generally these types are most extensive in geographic areas dominated by warm (summer) season or bi-modal precipitation regimes. Generally, annual precipitation ranges from 11 to 22 inches, with 55-60 percent coming between April 1st and September 31st. It is mostly found on lower slopes of mountains and in rolling hills at approximately 4,500 to 7,500 feet in elevation. Common grass species found in JUG include blue grama and other species of grama grass (*sideoats, hairy, black (Bouteloua eriopoda (Torr.) Torr.*), New Mexico muhly (*Muhlenbergia pauciflora Buckley*), curlyleaf muhly (*Muhlenbergia setifolia Vasey*), western wheatgrass (*Pascopyrum smithii* (Rydb.) Á. Löve), and needle and thread grasses (*Hesperostipa* spp. (Elias) Barkworth). It is hypothesized that a regime of frequent, low-intensity surface fires is responsible for maintaining the open stand structure and dense herbaceous growth of piñon-juniper savanna (USDI NPS 2016). Overall these sites are less productive for tree growth than the piñon-juniper woodland type.

Ecological Characteristics

Spatial Niche

The JUG ERU represents 8.5 percent of the Context Area but less than 1 percent of the Lincoln NF. The Lincoln’s 9,755 acres in JUG are only 0.35 percent of JUG in the Context Area. The Lincoln NF has a relatively low contribution to ecological sustainability for this ERU. Thus, while structural state of the Lincoln NF is moderately departed at 64 percent, it has little effect on the Context Area, which has low departure of 16 percent.

Seral State Proportion

Seral state departure of the JUG ERU is moderate at the plan scale, but low for the context scale. Of the local units, two show moderate departure and one shows high departure from reference conditions. Current conditions show much more early seral herbaceous and small tree dominated states A, B, C, and E, than reference conditions, and much less late seral open woodlands (state D: trees greater than 10 inches, greater than 10 percent canopy cover). All local units are below reference in large tree states (D and G); the Rio Hondo unit is nearly all in seedling/sapling and small, open states (B, C, E), which have a combined abundance of 95 percent compared to a reference of 25 percent. The Upper Pecos, on the other hand, is near reference in those small tree states, but has 67 percent in herbaceous/shrub/sparsely vegetated state A, far above the reference value of 5 percent. This is likely due to so much JUG located in the fire scars of the Last Chance (2011), Horse Canyon (2011) and Dinner Fires (2012), in the Guadalupe Ranger District. Modelling natural succession, current management, wildfire, and insect and disease mortality show a trend toward reference conditions with movement from small tree dominated states to larger tree dominated states, with both open (10-29 percent) and closed (greater than 30 percent) canopy (Table 67, Figure 29). The closed canopy state G becomes over-represented through time, below reference currently and ten years out (0 and 5 percent respectively), but increasing to uncharacteristic levels at the 100 and 1,000 year intervals (41 and 47 percent, respectively).

Table 67. Juniper Grassland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Hondo	Tularosa Valley	Upper Pecos-Black
A	EARLY SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.05	0.08	0.43	0.02	0.19	0.67
B,C,E	MID-SERAL: Seedling/sapling size (< 5" dbh/drc) trees with open or closed woody canopy cover, and small size (≥ 5" & < 10" dbh/drc) trees with open woody canopy cover	0.25	0.15	0.50	0.95	0.50	0.27
D	LATE-SERAL: Medium to very large size (≥ 10" dbh/drc) trees with open woody canopy cover	0.50	0.45	0.02	0.00	0.31	0.01
F	MID-SERAL: Small size trees with closed woody canopy cover	0.10	0.08	0.04	0.03	0.00	0.05
G	LATE-SERAL: Medium to very large size trees with closed woody canopy cover	0.10	0.23	0.00	0.00	0.00	0.00
Departure			16%	64%	70%	38%	64%

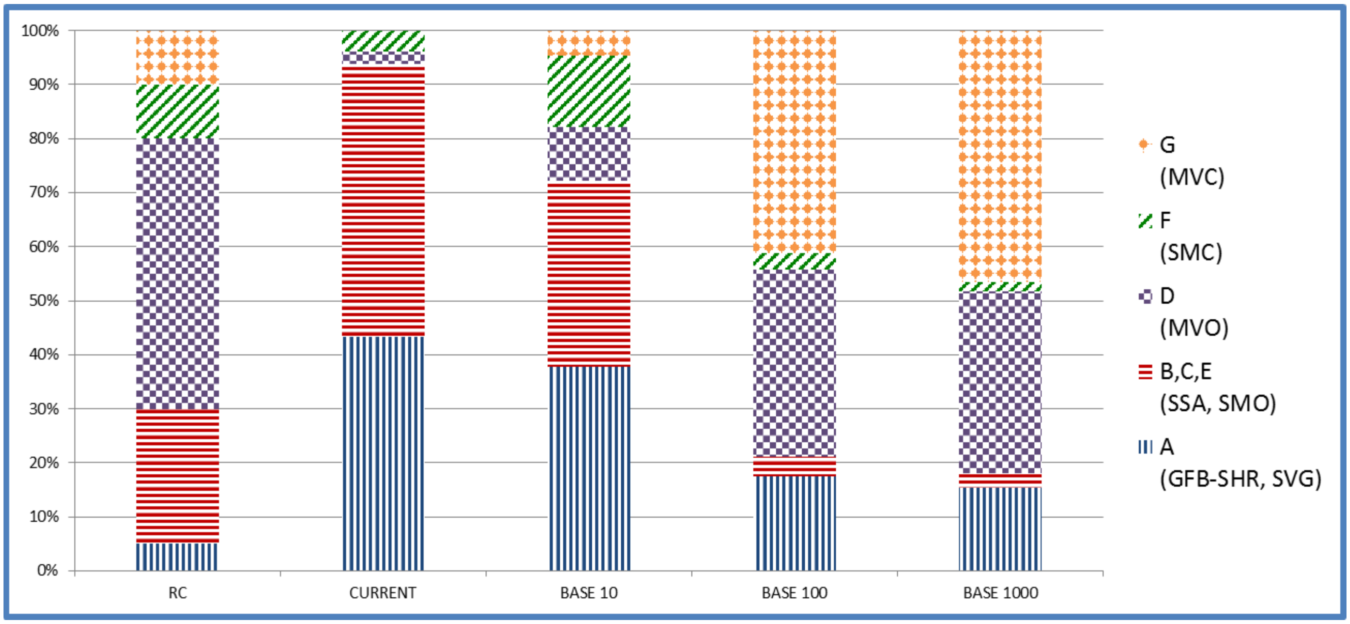

Figure 29. Seral state percentages for Juniper Grassland ERU at the plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The JUG ERU has an historic fire regime of frequent (0-35 year rotation), non-lethal fires, Fire Regime I. At the plan scale, FRCC is 60 percent moderately departed and 40 percent highly departed from reference conditions. Fire rotation is highly departed at 68 percent, while fire severity is 63 percent (Table 68). Two of three local units are in moderate FRCC, with insignificant departure for severity. Of those, the DC local unit is moderately departed for fire rotation, while the RR local unit is highly departed, with a rotation of 2,432 years compared to reference of 13 years (Table 69). The UPS local unit is in highly departed FRCC, highly departed for fire rotation, and moderately departed for fire severity. FRCC departure is strongly dependent on seral state departure; in this case seral state departure, particularly in the early seral state A, and the seedling/sapling states B, C and E, may be attributable to recent fires (Dinner and Last Chance fires, 2011, and Horse Canyon Fire, 2012). These were all in the southern Guadalupe Mountains.

Table 68. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0.0%	60.1%	39.9%	40.8	13.00	68%	34%	13%	63%

Table 69. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
Fire Interval				28					2,432				4
Fire Severity				15%					13%				28%
FRCC				II					II				III

Coarse Woody Debris and Snags

No data was available for CWD and snags.

Ecological Status and Ground Cover

No data was available for ecological status. Ground cover was moderately departed from reference at 54 percent (Table 70).

Table 70. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). **-For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
n/a	54%		0.07	0.5	19	Larger	97%

Patch Size

Patch size was highly departed at 97 percent, with patches much larger currently than reference condition (Table 70). For this woodland type, that indicates increased connectivity and filling in of wooded 'clumps'.

Insect and Disease

Insect and disease mortality was not available for JUG in the Plan Area.

Summary

Departure for seral state of the JUG ERA on the Lincoln NF is due primarily to an overabundance in the small tree states B, C, and E, and the early seral/shrub state A, relative to reference condition. Locally the Upper Pecos and Tularosa Valley local units most closely resemble the Lincoln NF for seral state proportion, while the Rio Hondo unit, having similar departure, has much more in states B, C, and E than in state A. Fire regime is departed at the plan scale, with fire rotations longer than reference, and fire severity greater than reference. This may be due to fire suppression or lack of continuous grassy understory to support non-lethal frequent fires. Evidence for this is in the moderate departure for ground cover as well as highly departed patch size with much larger contiguous groups of trees in the grassland matrix, or larger areas of early seral in areas burned in recent fires. Future modelling shows reduced departure over time under current management and disturbance conditions, although it appears there may be room for the Forest to mitigate that departure through thinning or other density management. Juniper grassland is generally moderate in departure across characteristics, but climate change models indicate an 86 percent high and very high vulnerability of vegetation type change through the end of this century, although what that may look like is unclear. While it appears that departure will be reduced over time under current climate and management, climate change may put the juniper grassland at high risk of losing ecological sustainability. Not considering climate change, risk to ecological sustainability is probably moderate to high, with the Forest potentially able to mitigate that risk if resources are available.

Piñon-Juniper Woodland (PJO):

General Description

Also called the "piñon-juniper persistent woodland," the PJO ERU serves as a broad grouping of different plant associations for descriptive purposes. Trees may occur as individuals or in smaller groups and range from young to old, but more typically as large even-aged structured patches. The site is characteristically dominated by moderate to high density tree canopy, and understory herbaceous plants/shrubs are limited or scarce. It is mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation. Generally, annual precipitation ranges from 11 to 22 inches, with 40-45 percent coming between October 1st and March 31st. Typical stressors and drivers (fire, insects, disease, etc.) are high severity and occur infrequently. These disturbance patterns create and maintain the even-aged nature of this vegetation type. Woodland development occurs in distinctive phases; ranging from open grass-forbs, to mid-aged open canopy to mature closed canopy woodland. Where fire is very infrequent, the fire regime is usually attributed to local edaphically-influenced fire affects such as rocky scarps, etc. On these sites, factors such as insect and disease may be the only disturbance agents that affect woodland development. Tree and shrub species composition varies throughout the Southwest and common trees include twoneedle piñon (*Pinus edulis*), singleleaf piñon (*Pinus monophylla* Torr. & Frém.), Utah juniper (*Juniperus osteosperma* (Torr.) Little), oneseed juniper, and alligator juniper. Typically, sparse native understory grasses are perennial species, such as several species of grama (*Bouteloua* spp. Lag.), common wolftail (*Lycurus phleoides* Kunth), and threeawns (*Aristida* spp. L), while forbs consist of both annuals and perennials. Shrubs are characteristically sparse to moderately distributed. This type is typically found on sites with rocky soil characteristics. Fire suppression has not exhibited the far-reaching effects on this ERU, as has been the case in other woodland types, since the fire frequency may or may not have been altered during the period since Euro-American settlement. Vegetation maturation, decadence and overall readiness for ignition are some of the key characteristics that influence fire disturbances in this type.

Ecological Characteristics

Spatial Niche

The PJO ERU makes up nearly 30 percent of the Lincoln NF at 319,105 acres, comprising just over 3 percent of the total Context Area. Departure is higher for the Lincoln NF than the Context Area (see Seral State Proportion, below), and the Lincoln PJO is 30 percent of all the PJO in the Context Area, making the Lincoln NF a substantial contributor to the ecological sustainability of this ERU.

Seral State Proportion

Both the Lincoln NF and Context Area are moderately departed for seral state distribution (65 and 37 percent respectively, Table 71) although the Lincoln NF is at the high end of the range, and the Context Area at the low end (moderate ranges from 34-67 percent). Five of six local units contain PJO; four of the five are highly departed from reference (68-69 percent), while the Tularosa unit is moderately departed (59 percent). Departure class notwithstanding, the Lincoln NF and its local units didn't differ much among seral states. Departure for the Lincoln NF and local units arises from high percentages (63-75 percent) in early seral seedling/sapling and small diameter open canopies (<10-inch trees, <30 percent canopy, states B, C, E) and low percentages (4-11 percent) in larger late seral closed canopy tree dominated state G. Reference conditions, in contrast, are 5 percent for the early seral state and 60 percent for state G. The Context Area, while also over-represented in the early seral states B, C, E, and under-represented in the late seral state G, is less departed from reference with values of 26 percent for both states B, C, E combined, and state G. The large values for the mid seral states B, C, and E on the Lincoln NF may be attributable to the Peppin Fire (2004) in the Arroyo del Macho local unit, the Cree (2000), White (2011) and Donaldson (2011) fires in the Rio Hondo local unit, and the Scott Able (2000) and Mayhill (2011) fires in the Rio Peñasco local unit. Management activities, wildfire, insect, disease and other disturbances, and natural succession modelled out 10, 100 and 1,000 years for the Lincoln NF show departure dropping to Low by 100 years (28 percent) then slightly increasing over the next 900 years (Table 71, Figure 30).

Table 71. Piñon-Juniper Woodland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley
A	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.10	0.10	0.04	0.07	0.05	0.02	0.01	0.02
B, C, E	MID SERAL: Seedling/sapling size (< 5” dbh/drc) trees with open (≥ 10% & < 30%) or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover	0.05	0.26	0.70	0.74	0.73	0.73	0.69	0.62
D	LATE-SERAL: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover	0.10	0.25	0.08	0.04	0.08	0.05	0.03	0.11
F	MID-SERAL: Small size trees with closed woody canopy cover	0.15	0.12	0.10	0.08	0.09	0.09	0.19	0.12
G	LATE-SERAL: Medium to very large size trees with closed woody canopy cove	0.60	0.26	0.09	0.06	0.06	0.12	0.08	0.12
Departure			37%	65%	69%	68%	68%	68%	59%

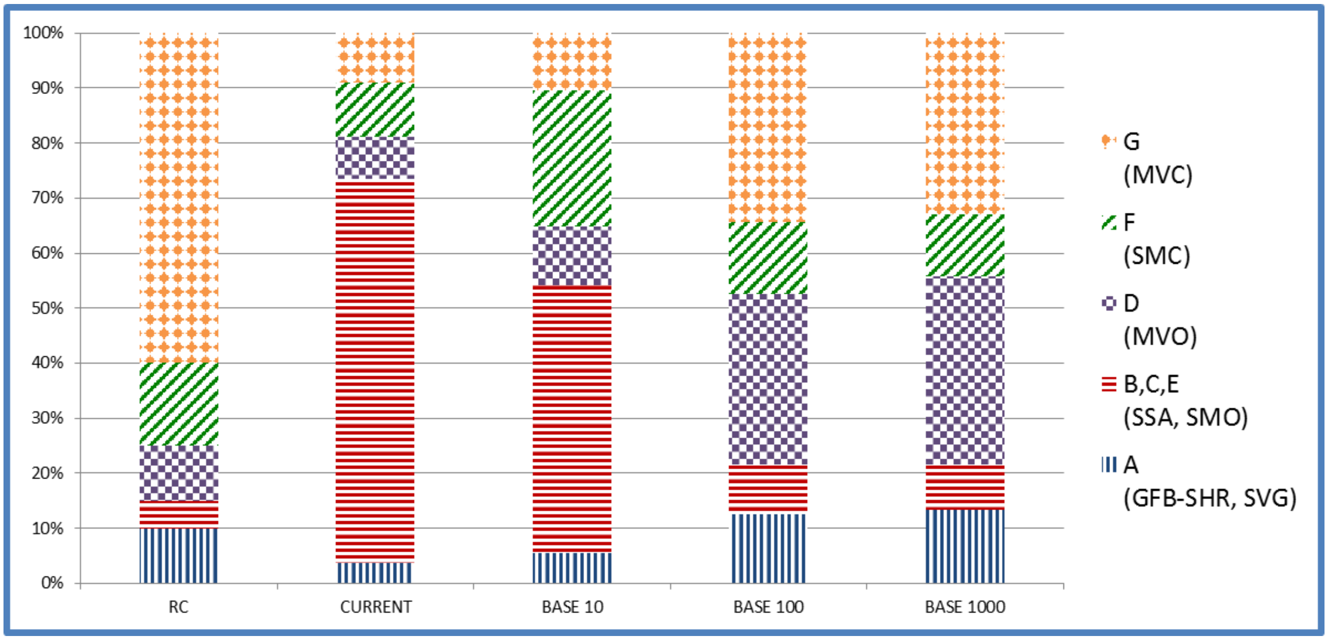

Figure 30. Seral state percentages for Piñon-Juniper Woodland ERU at the plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The PJO historic fire regime is one of long rotations and high severity (Fire Regime V, stand replacement and rotations greater than 200 years) or somewhat shorter rotations of mixed severity (Fire Regime III, 35-200 year mean fire interval) similar to mixed and high severity stand replacement forested ERUs. PJO is moderately departed at the plan scale for both fire rotation and severity, and has 75 percent of the ERU in the moderately departed condition class and 25 percent highly departed, reflecting the departure in structural state described above, and changes in fire rotation and severity (Table 72). Fire rotation is moderately departed at 60 percent, with current fire rotation intervals calculated to be 102.5 years, compared to a reference condition of 255 years. Fire severity has a moderate departure value of 66 percent, with current severity of 22 percent compared to the reference condition of 64 percent. Fire rotation of 102 years is still fairly long, but the severity is low, and may be a result of fire suppression not allowing the fires that occur to create the mortality they did historically. Most local units were in moderate FRCC, except for RR, which is in highly departed FRCC. Fire rotation was not significantly departed for the AC, BC and RD local units, but highly departed for the RP, RB and RR units; all showed shorter rotations than reference (Table 73). Fire severity was moderately to highly departed for local units, with current severity less than the reference of 64 percent.

Table 72. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	75%	25%	102.5	254.6	60%	22%	64%	66%

Table 73. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	192		244		33		179	26	55					
Fire Severity	28%		14%		25%		19%	39%	24%					
FRCC	II		II		II		II	II	III					

Coarse Woody Debris and Snags

The piñon-juniper woodland ERU data come from five local units. CWD is moderately departed at the plan scale, with nearly twice the tons/acre currently than in reference condition. The Arroyo del Macho, Rio Hondo, Rio Peñasco and Tularosa local units are moderately departed for CWD while departure was high for the Salt Basin unit (Table 74). All local units have more snags per acre than reference. Snags in the 8-18 inches class were highly departed from reference conditions at the plan scale with more than eight times the number of snags/acre than reference. The Arroyo del Macho, Rio Hondo, Rio Peñasco and Salt Basin units are highly departed while the Tularosa Valley unit is moderately departed, all with more snags currently than in reference condition. Snags in the larger than 18 inches size class are highly departed at the plan scale with current abundance 60 percent of reference condition. Local unit departure is high for the Rio Peñasco, Salt Basin and Tularosa Valley units, moderate for the Arroyo del Macho unit, and low for the Rio Hondo unit. Overabundance of snags and CWD relative to the reference condition are likely due to the dead or dying trees from recent disturbances.

Table 74. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition.

PJO		Coarse Woody Debris (tons per acre)					
Local Unit	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	64%	40%	48%	44%	74%	50%	
Reference	3.00	3.00	3.00	3.00	3.00	3.00	
Current	8.2	5.01	5.75	5.33	11.70	5.95	
Trend	5.2	2.01	2.75	2.33	8.70	2.95	
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	88%	86%	88%	83%	88%	62%	
Reference	2.00	2.00	2.00	2.00	2.00	2.00	

PJO		Coarse Woody Debris (tons per acre)					
Local Unit	**LNF Plan Area**	**Arroyo Del Macho**	**Rio Hondo**	**Rio Peñasco**	**Salt Basin**	**Tularosa Valley**	**Upper Pecos**
Current	16.4	14.75	16.24	11.72	17.00	5.29	
Trend	14.4	12.75	14.24	9.72	15.00	3.29	
		Snags per acre, greater than 18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	71%	49%	17%	100%	100%	93%	
Reference	1.00	1.00	1.00	1.00	1.00	1.00	
Current	3.5	0.51	1.20	0.00	0.00	13.34	
Trend	2.5	(0.49)	0.20	(1.00)	(1.00)	12.34	

Ecological Status and Ground Cover

Ecological status at the plan scale is highly departed (73 percent), indicating either a change in species occurring in the type, or a shift in the abundance of species, relative to reference conditions (Table 75). This may differ among the subunits representing the PJ woodland. Overall, both conifer and oak cover are higher currently than in reference conditions. Ground cover is moderately departed (35 percent). A relative overabundance of conifers and oak may reduce ground cover and increase bare ground. While early seral condition acres may increase over time (Figure 30), so does the late seral state of larger trees (greater than ten inch) in closed (greater than 30 percent cover) canopy. The early seral state includes sparsely vegetated land and it is unclear how much of the modelled increase would be sparsely vegetated, which would suggest more bare ground (less ground cover). It is also unclear how an increase in larger woody vegetation would affect ground cover. Live vegetation such as bunch grasses would probably decrease from being shaded out, but litter from increased woody species may increase. It is likely that ground cover would decrease, and departure for that characteristic would increase.

Table 75. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
73%	35%		50	400	11	Smaller	79%

Patch Size

Patch size for the piñon-juniper woodland ERU is highly departed (79 percent). Current patch sizes are approximately 11 acres compared to a reference range of 50-400 acres (Table 75). This may be due to a change in fire regime that has more frequent but less severe fires, creating a mosaic landscape of seral states.

Insect and Disease

Insect and disease mortality for PJO has been reported at nearly 35,849 acres over a twenty year period, averaging 1792 acres per year. The primary agents have been bark beetles, particularly the native piñon ips beetle (see Insect and Disease section for more detail). While always present at some background levels, drought and density increase the probability of a severe infestation, as does stress due to mistletoe infections. Ironically, density reducing activities such as thinning, chipping and mastication that release volatile compounds may draw ips to a site, and slash can provide breeding ground for the beetles which can then infest adjacent trees. Warmer, drier conditions in the southwest predicted by some climate change models could further stress trees, increasing the potential size, extent and severity of future infestations. Continued density reduction treatments and reintroduction of fire to the PJ landscape might mitigate the effects of infestations, but it is likely that insect and disease remains a large risk factor for the woodlands, driven primarily by climate.

Summary

The PJO ERU is moderately departed for seral state departure at the plan scale, while all but one local units are highly departed. Departure reflects a much greater abundance in area of mid seral small trees than in late seral larger trees, especially with closed canopies. Fire regime is also moderately departed for both fire rotation and fire severity, with relatively more frequent and less severe fires than historically. Ecological status and patch size are highly departed, and ground cover is moderately departed. While modeling seral state out ten and one hundred years reduces departure significantly, it is expected that under current management, ecological status, patch size and coarse wood and snags will remain highly departed. Climate change modeling places 65 percent of the ERU at high and very high vulnerability to vegetation type change by the end of the century, although it is unclear what that will look like. As the Lincoln NF has 30 percent of the PJO in the Context Area, the Forest can play a major role in maintaining the ecological integrity of the ERU, particularly in density management of woodland trees and use or reintroduction of fire into the landscape. The piñon-juniper woodland ERU is considered to have low risk to ecological sustainability, except when climate change is considered. The Lincoln NF may be able to mitigate much of that risk, although effects of climate change may dampen the effects of mitigation.

Piñon-Juniper Grassland (PJG):

General Description

The piñon-juniper grassland (PJG) ERU occurs across the states of Arizona and New Mexico, in what were historically more open woodlands with grassy understories. It is mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation. Tree species include one seed juniper, Utah juniper Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), and alligator juniper. Piñon trees include two needle piñon. Native understories were made up of perennial grasses, with both annual and perennial forbs, and shrubs that were absent or scattered. Contemporary understories often include invasive grasses and uncharacteristically high shrub cover. The PJG ERU including its various vegetation states, occurs on deep, fine-textured soils (usually mollisol) in valley bottoms and on gentle plains with few barriers to fire spread; within areas of warm summer seasons and a bi-modal precipitation regime. Generally, annual precipitation ranges from 11 to 22 inches, with 40 to 45 percent coming between October 1st and March 31st. According to Wahlberg et al. (2014), empirical information on the historic condition of this type is lacking; however, site productivity provides inference for the development of a grass/fine fuels layer, in turn, providing inference of frequent fire and open, uneven-aged forest dynamics. At least one study, substantiating multiple tree cohorts in similar plant communities, corroborates these assumptions (Gottfried 2003). There is photo documentation of various pinon and juniper landscapes of this and similar ERUs that show historically more open canopies and grasslands (Fuchs 2002). As such, trees would have occurred as individuals or in smaller clumps and range from young to old. Scattered shrubs and a dense herbaceous understory of native grasses and forbs characterize this type. Typical drivers and stressors (fire, insects, disease, etc.) are low severity and high frequency. These disturbance patterns would have created and maintained uneven-aged and open-canopied conditions. The tree and grass species composition varies throughout the Region, consisting a mix of one species of piñon (ranges are typically distinct) and one or more juniper species. Typically, native understory grasses are perennial species, while forbs consist of both annuals and perennials. Shrubs are characteristically absent or scattered. Due to the effects of long-term fire suppression and grazing in this type, in many locations the current condition is severely departed from historic conditions. Typically these changes include in-filling of the canopy gaps, increased density of tree groups; and reduced composition, density and vigor of the herbaceous understory plants. Many of these sites currently are closed-canopy woodlands, with insufficient understory vegetation to support surface fires.

Ecological Characteristics

Spatial Niche

The PJG ERU makes up less than 2 percent of the Context Area, but more than 15 percent of the Lincoln NF at 165,432 acres. It represents nearly 30 percent of PJG in the Context Area. This ERU occurs in all six local units. Overall departure from reference condition for seral states is moderate and similar for the Lincoln NF and all individual local units. The Context Area is also moderately departed from reference conditions, although not as departed as the Lincoln NF (Table 76). Modelling of management activities, wildfire, insect and disease and other disturbances, and natural succession dynamics show a reduction in departure over time (10, 100, 1,000 years) but still in the moderate range (Figure 31) units, 50 percent reference). In contrast, the Context Area has only 22 percent in the small states but 27 percent in larger sized closed canopy late seral state G, compared to the Lincoln NF’s two percent and a reference of 10 percent.

Seral State Proportion

The PJG ERU was moderately departed for seral state proportion at both the Lincoln NF and the Context Area, although the Context Area was less departed (58 and 35 percent, respectively). For the local units, all were moderately departed, ranging from 56 to 65 percent, with much greater percentages in small tree dominated states B, C, and E, than reference (greater than 63 percent for all local units except Arroyo del Macho vs. 25 percent reference). In contrast, the Context Area has only 22 percent in those small states. Small mid-seral trees in closed canopy (state F) were less than reference for the Lincoln NF and all local units, but the Context Area had 15 percent compared to the reference of 10 percent. All units had much less percentage in the late seral medium/large tree, open canopy state D (0-3 percent for local units, 50 percent reference). The Lincoln NF and all local units (two percent or less) were less than reference (10 percent) for late seral closed canopy state G, while the Context Area had much more (27 percent) than reference. This indicates that all areas are departed, with more closed canopy than occurred in reference times, although the closed canopy in the Context Area seems to have larger trees than the Lincoln NF. This ERU should typically have larger trees in an open canopy, but due to legacy grazing and fire suppression, vegetation structure has shifted to more closed states. The difference in tree sizes may be a reflection of time since last large disturbance.

Table 76. Pinon-Juniper Grassland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos-Black
A	EARLY-SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover	0.05	0.18	0.13	0.50	0.23	0.08	0.15	0.28	0.11
B, C, E	MID-SERAL: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover	0.25	0.22	0.74	0.45	0.69	0.87	0.75	0.63	0.76
D	LATE-SERAL: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover	0.50	0.18	0.02	0.01	0.02	0.00	0.03	0.02	0.02
F	MID-SERAL: Small size trees with closed woody canopy cover	0.10	0.15	0.08	0.03	0.05	0.03	0.07	0.06	0.09
G	LATE-SERAL: Medium to very large size trees with closed woody canopy cover	0.10	0.27	0.02	0.02	0.02	0.01	0.00	0.01	0.02
Departure			35%	58%	65%	62%	65%	60%	61%	56%

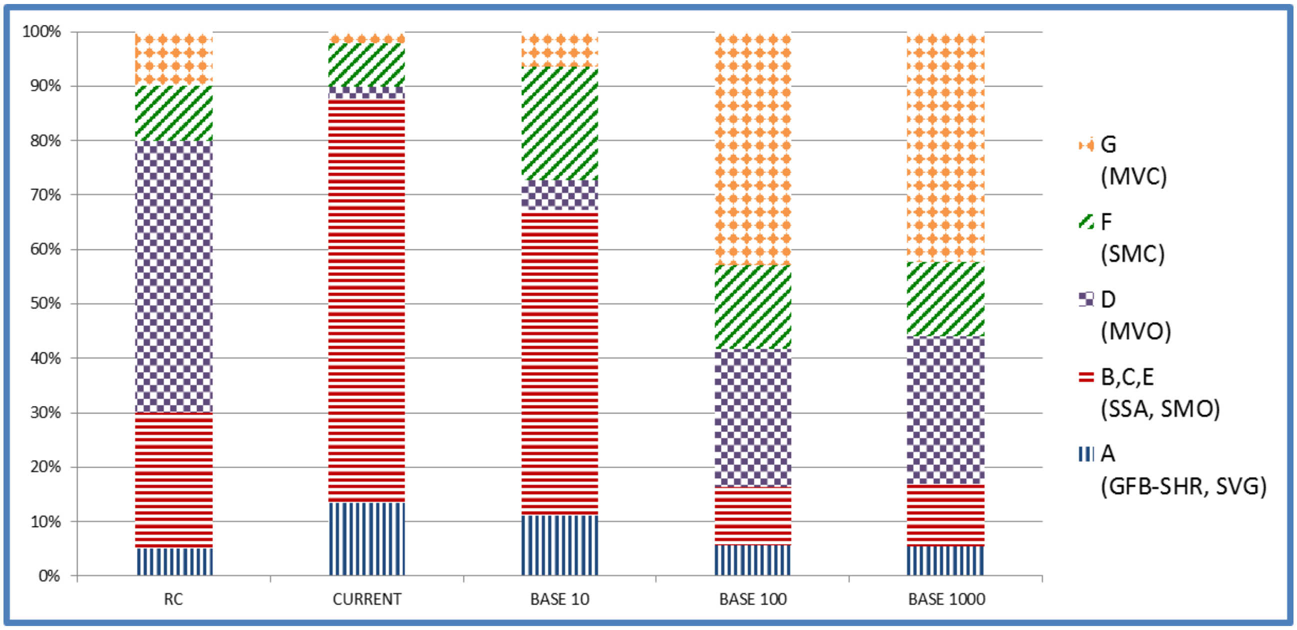

Figure 31. Seral state percentages for Piñon-Juniper Grassland ERU at the plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The referenc fire regime for the PJG ERU is Fire Regime I of high frequency (0-35 year fire return interval) and low severity non-lethal fires. Fire regime condition for PJG at the plan scale was 100 percent in the moderate condition class. Fire rotation and severity were both moderately departed (Table 77), with current fire rotation at 118 years compared to a reference of 20 years. Local units were all moderately condition class except for PW, which was highly departed (Table 78). Fire rotation departure is likely due to effects of grazing and woody encroachnmment reducing the understory fuels needed to carry fires, and fire suppression keeping fires small when they do occur. Historically low severity was because frequent fires consumed the fuels that could carry into the overstory, and the woody vegetation was usually old and large enough to resist fire. Low severity now may be a result of understory fuels being inadequate to sustain fire across the landscape and into the overstory, regardless of tree resistance to fire, and fire suppression limiting mortality when fires do occur.

Table 77. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	100%	0%	117.5	20.10	83%	18%	13%	31%

Table 78. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	13,799				232,750	37	6,101			15				140	503
Fire Severity	13%				13%	15%	14%			26%				14%	22%
FRCC	II				II	II	III			II				II	II

Coarse Woody Debris and Snags

Four local units contain the piñon-juniper grassland ERU. Departure of CWD at the plan scale is moderate, with current value approximately half that of reference condition. Departure is low for the Rio Hondo, Salt Basin and Tularosa Valley local units, with more tons per acre than reference. The Upper Pecos unit is moderately departed, with fewer tons per acre than reference. Snags in the 8-18 inch size class is moderately departed at the plan scale, with current abundance only 40 percent of reference condition. Locally, the Rio Hondo, Salt Basin and Tularosa Valley are moderately departed, while the Upper Pecos unit is highly departed. Departure is low for snags in the larger than 18 inch size class for the Plan Area, with slightly less currently than historically. The Rio Hondo and Tularosa Valley units are moderately departed, while the Salt Basin and Upper Pecos units have nearly reference condition values. The relationship between snags/CWD departure and structural state departure is similar to the woodland types described above, but also moderated. However, the ERU in general is moderately departed for seral state proportion with too many acres currently in the seedling/sapling open (<5”, 10-30 percent cover) state and too few in larger and more closed seral/structural states, relative to reference conditions (see Seral State Proportion section). Many of these acres occur in the Guadalupe RD, where topography and soil types may limit those under-represented seral states. (Table 79).

Table 79. Local Unit departure for coarse woody debris (CWD) and snags. CWD is measured in tons per acre while snag density represents individuals per acre. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%). Trend shows whether current values of CWD and snags are greater or lesser than reference condition, and by how much. Red parenthetical trend values mean Lincoln NF's current values are less than reference condition, while black trend values are greater than reference condition. Blank cells mean data was unavailable for those local units.

PJG	Coarse Woody Debris (tons per acre)						
Local Unit	**LNF Plan Area**	**Arroyo Del Macho**	**Rio Hondo**	**Rio Peñasco**	**Salt Basin**	**Tularosa Valley**	**Upper Pecos**
Departure	46%		20%		25%	21%	48%
Reference	2.70		2.70		2.70	2.70	2.70
Current	5.0		3.39		3.62	3.42	1.40
Trend	2.3		0.69		0.92	0.72	(1.30)
		Snags per acre, 8-18 inches DBH					
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	43%		39%		60%	39%	71%
Reference	5.00		5.00		5.00	5.00	5.00
Current	8.7		8.22		2.00	8.16	1.44
Trend	3.7		3.22		(3.00)	3.16	(3.56)
		Snags per acre, greater than 18 inches DBH					

PJG	Coarse Woody Debris (tons per acre)						
Local Unit	LNF Plan Area	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Local Unit		Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos
Departure	33%		51%		0%	51%	7%
Reference	1.00		1.00		1.00	1.00	1.00
Current	1.5		0.49		1.00	0.49	0.93
Trend	0.5		(0.51)		0.00	(0.51)	(0.07)

Ecological Status and Ground Cover

The ERU was highly departed for ecological status (species composition) at 92 percent. Ecological status can be departed by either a shift to non-historic species, or a change in relative abundance of species that historically occurred in the ERU. This could be occur among understory species, or by increases in tree cover relative to understory species such as grasses. Given the seral state departure discussed above, it is likely that much of the Ecological Status departure is due to an increase in tree cover and decrease in grasses. As ground cover departure was low (25 percent), the ratio of bare ground to basal vegetative cover has not changed nearly as much (Table 80). However, as ground cover is the combined cover of litter and live basal vegetation, it is suspected that there is more litter and less basal vegetation in this ERU.

Table 80. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** -For woodland and forest system reference conditions are based on interpolation, fire regime inferences, and the range of available literature values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
92%	25%		0.07	1.0	12	Larger	92%

Patch Size

Patch size is highly departed at 92 percent, with woodland patch sizes more than 12 times the reference range (0.07-1.0 acres)(Table 80). This is likely due to woody vegetation encroachment as described in the seral state proportion section above, or closing in of the grassland matrix where smaller clumps of trees grow together to form larger aggregates. This can also help explain departure in ecological status, where departure can be a function of a shift from more open woodland with abundant grasses to more closed woodland with more juniper and fewer grasses and forbs.

Insect and Disease

Insect and disease mortality has affected 908 acres in the PJG over 20 years, averaging about 45 acres per year. This may have the potential to increase as a continued shift from grass dominated to tree dominated landscape may promote more frequent and severe insect infestations.

Summary

The piñon-juniper grassland is moderately departed for most characteristics with the exception of ecological status, and patch size, which are highly departed. Seral state proportion departure is probably a result of over-represented seedling/sapling and small tree state B, C, E. Modeling into the future shows a trend toward reference under current management and disturbance regimes, although in the areas of large sized trees there is more closed canopy and less open canopy than in reference conditions. Departure currently may be attributable to removal of fire as a system driver. Fire regime is moderately departed, with much longer fire return intervals than historically, although severity is low and similar to reference. Departure is high for ecological status and patch size, likely due to encroachment filling in areas between groups of trees and more woody vegetation now relative to herbaceous species than historically. Risk to the ecological sustainability of the piñon-juniper grassland ERU may be considered to be moderate, in part due to fire suppression, although modeling indicates reduced future risk. However, the Lincoln NF can have a role in maintaining or reducing departure, and thus risk, in the future through density management and/or re-introduction of fire in the ecosystem. Climate change models projecting toward the end of the century indicate the ERU has a high vulnerability to vegetation type change. Including climate change in a risk analysis substantially increases risk into the future, beyond the control of the Lincoln NF.

Gambel Oak Shrubland (GAMB):

General Description

The following description is adapted from the LANDFIRE draft model description for Rocky Mountain Gambel Oak-Mixed Montane Shrubland (LANDFIRE 2010):

> Gambel Oak Shrubland is dominated by long-lived Gambel oak clones that form largely mono-typic overstories (Simonin 2000). It occurs between [6,500-9,500 ft.] on all aspects, and at higher elevations occurs more predominantly on southern exposures. Gambel oak occurs as the dominant species ranging from dense thickets to clumps associated with other shrub species such as serviceberry or sagebrush. Older, more developed Gambel oak can have a well-developed understory comprised of snowberry, elk sedge, letterman's needlegrass, Poa ampla, yarrow, lupine, and goldenrod. Depending on site potential, ponderosa pine, juniper, and pinyon can encroach older plant communities. The primary disturbance mechanism is mixed-severity to stand replacement fire resulting in top-kill and rare mortality. Gambel oak responds to fire with vigorous sprouting from the root crown. Larger forms may survive low- intensity surface fire.
>
> The Gambel Oak Shrubland (GAMB) ERU is classified as an edaphic-fire disclimax by the Southwestern Region Terrestrial Ecological Unit Inventory. On contemporary landscapes, in the absence of recurring mixed to stand replacing fire, coniferous tree species may be co-dominant to dominant.

Ecological Characteristics

Spatial Niche

A first look at much of the Lincoln NF’s landscape, particularly in burned areas on the Smokey Bear and Sacramento districts, would lead one to think there is a great deal of the GAMB) ERU on the Lincoln NF, but much of that is really a persistent shrub phase of the Mixed Conifer/Frequent Fire (MCD) or Ponderosa Pine (PPF) ERUS. The GAMB ERU makes up only 0.33 percent of the Lincoln NF, occurring in only two local units. The

GAMB ERU occurring on the Lincoln makes up only 0.067 percent of the Context Area, but is 16 percent of all that occurs in the Context Area, so the Lincoln has a small role in the sustainability of the ERU.

Seral State Proportion

This relatively small proportion of the ERU is more departed than the Context Area as a whole, having little if any area in early seral herbaceous and shrub state (Table 81). Historically the GAMB ERU would have only 30 percent of the tree dominated state D, but current condition for the Context Area has 86 percent in state D, while the Lincoln NF and each local unit in which it occurs have 100 percent in state D (Table 81 and Figure 32). State D includes all size classes of trees, so it is unclear what the distribution of sizes or ages is, but as trees become dominant in this state as a result of succession without disturbance, it is likely that the absence of fire is the largest contributor to departure, whether through suppression or lack of ignition. This ERU is often intermixed with the MCD or PPF ERUs, and may be managed similarly, especially in interrupted fire regimes where trees can gain dominance over shrubs.

Table 81. Gambel Oak Shrubland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Peñasco	Salt Basin
A	EARLY SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover	0.05	0.04	0	0	0
B	MID-SERAL: All size shrubs with open (≥ 10% & < 30%) canopy cover	0.5	0.04	0	0	0
C	LATE-SERAL: All size shrubs with closed (≥30%) canopy cover	0.15	0.06	0	0	0
D	LATE-SERAL: All size trees with open or closed canopy cover	0.3	0.86	1	1	1
Departure			56%	70%	70%	70%

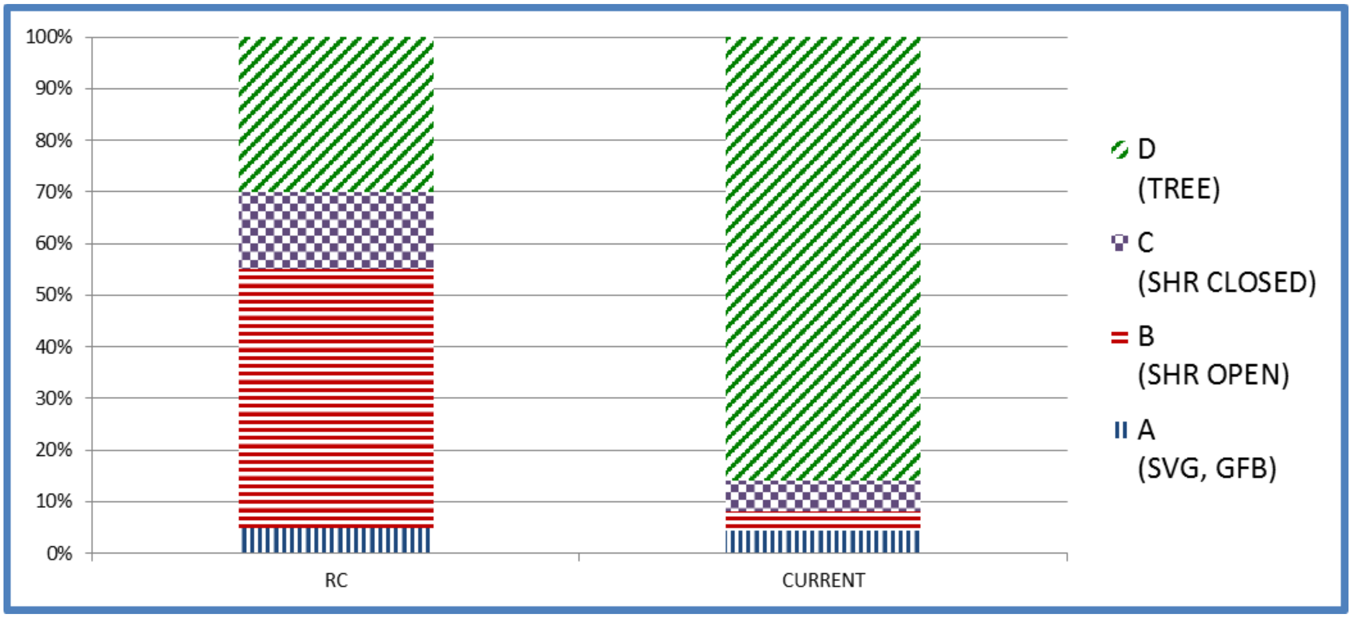

Figure 32. Seral state percentages for Gambel Oak Shrubland ERU at the Plan scale. RC is reference condition, Current is current condition.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section).

The historic fire regimes for the GAMB ERU are II and IV, both stand replacement but with differing fire return intervals of 0-35 years and 35-200 years, respectively. FRCC was not calculated for the Context Area.There were no fires located in the GAMB ERUin the 20 year data for fire rotation and severity, so departure could not be calculated for those characteristics, or fire regime condition class (Table 82 and Table 83). Seral state departure, a primary component of FRCC, shows more of the ERU in later seral state D, dominated by trees, suggesting missed fire rotations and FRCC departure in condition class III.

Table 82. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
n/a	n/a	n/a	n/a	75.00	n/a	n/a	78%	n/a

Table 83. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
Fire Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	UPN	UPS
Fire Severity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FRCC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Coarse Woody Debris and Snags

No reference conditions are available for CWD and snags.

Ecological Status and Ground Cover

No data was available for either ecological status or ground cover.

Table 84. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** - For grassland and shrubland systems reference condition is based on TEUI polygon geometry, mean patch size plus and minus the standard error to determine lower and upper patch size values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
n/a	n/a		n/a	n/a	n/a	n/a	n/a

Patch Size

No data was available for patch size.

Insect and Disease

Total insect and disease mortality over 20 years was 978 acres, averaging 49 acres of mortality annually.

Summary

The Gambel oak ERU is small and relatively localized on the Lincoln NF, and intermixed with the mixed conifer-frequent fire type. The high seral state departure is likely the result of nearly the total area burning in large fires a number of years ago resulting in nearly all acres undergoing succession from the same starting point in time, and subsequent suppression or lack of fire contributing to the current overabundance in tree state D, and under-representation in the early seral and open and closed shrub states. While it appears that risk to ecological sustainability is high, departure could change dramatically if a disturbance such as fire or insect and disease mortality were to occur, or if management resources were applied to remove tree cover. The GAMB ERU was not modelled into the future, so it is unclear how management affects future departure. However, to the extent that the Lincoln NF suppresses or takes advantage of fires when they occur in this ERU, or otherwise promotes vegetation treatments to restore desired structure, The Lincoln NF has an opportunity to contribute to the ecological sustainability of the Gambel Oak Shrubland ERU.

Mountain Mahogany Mixed Shrubland (MMS):

General Description

The Mountain Mahogany Mixed Shrubland ERU (MMS) occurs in the foothills, canyon slopes, and lower slopes of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico extending north into Colorado. These shrublands are often associated with exposed sites, rocky substrates, dry conditions, and recurrent historic fire that limited tree growth. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs including mountain mahogany and skunkbush sumac. Historically this ERU had less than 30 percent tree canopy cover. The mountain mahogany mixed shrubland ERU is characterized by historic fire regime group IV, with an average fire return interval of 35 to 200 years from stand replacing fire.

Ecological Characteristics

Spatial Niche

The MMS ERU makes up only 0.52 percent of the Context Area, but five percent of the Lincoln NF (52,528 acres). The MMS ERU on the Lincoln NF contains 30 percent of the ERU occurring in the Context Area, and thus contributes substantially to the ecological sustainability to the ERU.

Seral State Proportion

This ERU is equally moderately departed for both the Lincoln NF and the Context Area at 49 percent. Three of the four local units are moderately departed, while Salt Basin barely exceeds the threshold for high departure. As noted in GAMB above, tree encroachment is the primary indicator of departure. For Lincoln NF, Context Area and local units, the tree dominated state D far exceeds the reference conditions (Table 85), while the open shrub state B is far less in the Lincoln NF, Context Area or local units. Modelling under current management, wildfire, other disturbance and successional factors, the trend is toward less departure, but remaining in the moderate range. While there is some increase in closed shrub state C, and some decrease in tree state D through 100 years, there is still only half as much open shrub state B, and twice as much of tree state D than reference. Current management as modelled means vegetation treatment, either through mechanical means or by prescribed fire. Typically, there is little active management in this ERU, and this is reflected in the relatively small changes in seral state proportion in the future. Increasing vegetation treatment, including the use of prescribed fires (either intentionally or naturally ignited) may accelerate the trend toward reference conditions.

Table 85. Mountain Mahogany Mixed Shrubland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Rio Peñasco	Salt Basin	Tularosa Valley	Upper Pecos-Black
A	EARLY SERAL: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover	0.05	0.06	0.03	0.04	0.02	0.09	0.01
B	MID-SERAL: All size shrubs with open (≥ 10% & < 30%) canopy cover	0.5	0.12	0.18	0.00	0.01	0.00	0.35
C	LATE-SERAL: All size shrubs with closed (≥30%) canopy cover	0.15	0.04	0.00	0.00	0.00	0.00	0.00
D	LATE-SERAL: All size trees with open or closed canopy cover	0.3	0.79	0.79	0.96	0.97	0.91	0.65
Departure			49%	49%	66%	67%	65%	35%

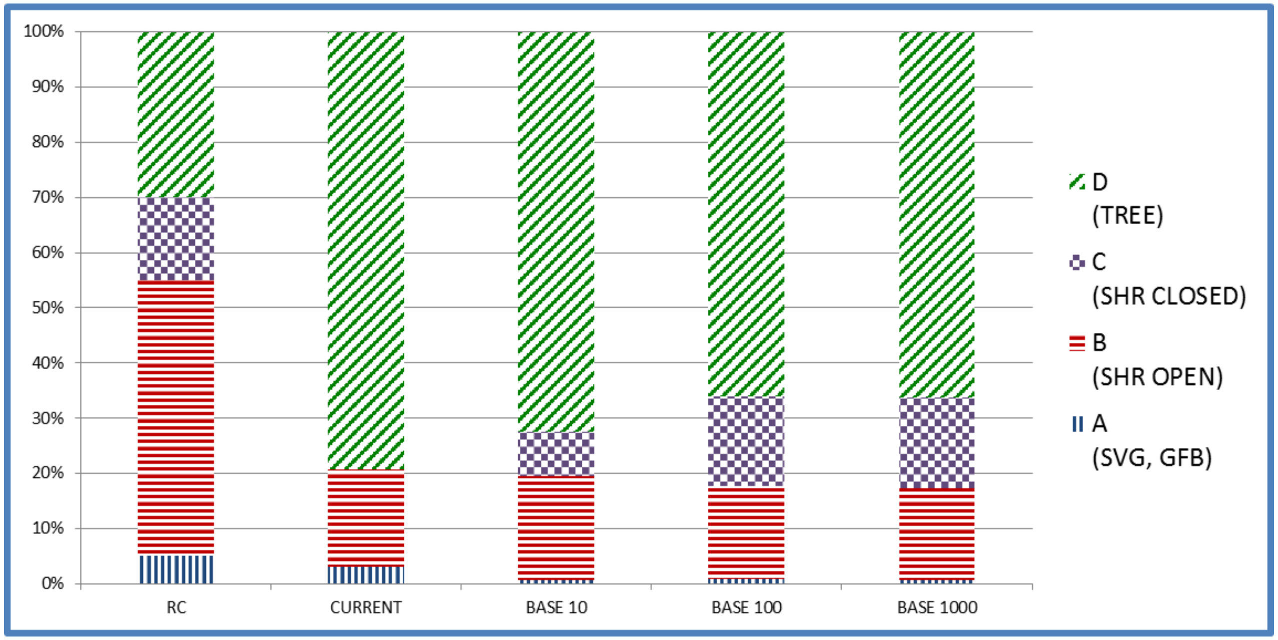

Figure 33. Seral state percentages for Mountain Mahogany Mixed Shrubland ERU at the plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The MMS ERU is characterized by historic fire regime group IV, with an average fire return interval of 35 to 200 years from stand replacing fire. Fire regime condition class at the plan scale was 89 percent moderately departed and 11 percent highly departed (Table 86). Fire rotation departure was low at 31 percent, while fire severity was moderately departed at 53 percent. At the local scale, three of four local units are in moderately departed FRCC II, while the Aqua Chiquita (AC) local unit is in FRCC III. Fire severity is universally lower than reference except for the UPS local unit.

Table 86. Fire interval (years), severity (% mortality) and condition class (FRCC) at the Plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	82%	18%	108.6	75.00	31%	37%	78%	53%

Table 87. Fire interval (years), severity (% mortality) and condition class (FRCC) at the Local Unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	376		1,192		25										20
Fire Severity	23%		13%		20%										59%
FRCC	III		II		II										II

Coarse Woody Debris and Snags

No data were available for CWD, or snags.

Ecological Status and Ground Cover

No data was available for ecological status. Ground cover was moderately departed at 56 percent (Table 88).

Table 88. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** - For grassland and shrubland systems reference condition is based on TEUI polygon geometry, mean patch size plus and minus the standard error to determine lower and upper patch size values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
n/a	56%		300	522	8	Smaller	97%

Patch Size

Patch size was highly departed at 97 percent, with smaller patches (currently 8 acres compared to a reference range of 300 to 522 acres, Table 88). This may be a result of fire suppression and a reduction in fire severity, and stand replacement over the landscape where the ERU occurs.

Insect and Disease

Twenty year total insect and disease mortality was 2,684 acres, for an annual average of 134 acres.

Summary

The mountain mahogany-mixed shrub ERU is moderately departed for seral state for the Lincoln NF and three of the four local units it occurs in. The Salt Basin local unit is highly departed, but only marginally so, and the Upper Pecos-Black River is just over the threshold for moderate departure. Moderate departure for seral state and fire severity combined with low departure for fire frequency put most of the ERU in the moderate fire regime condition class, with the remainder in high FRCC. Departure may be attributable to fire suppression not allowing natural processes to keep the tree layer in check. Shrub states are under-represented currently in both open and closed states, although modelling out to ten and one hundred years reduce departure somewhat. Patch size departure is likely an effect of increased tree cover. The vegetation in this ERU is typically managed lightly except for grazing or incidental vegetation treatments if adjacent ERUs such as juniper or piñon woodlands are being treated, and fires are generally suppressed as they occur. This ERU is considered to have moderate risk to ecological sustainability, perhaps a result of past management (i.e., fire suppression). This risk may be mitigated by future management that controls the amount of trees in this type. Climate change models indicate a 39 percent high and very high vulnerability to type conversion by the end of the century, although it is unclear exactly what that would look like. Climate change might include warmer and drier conditions that may also reduce tree cover in the future, without type conversion, thus reducing departure into the future.

Chihuahuan Desert Scrub (CDS):

General Description:

The following description is excerpted from the ILAP Arid Lands Model Documentation (2012):

> [The Chihuahuan Desert Scrub ERU] ranges from the edges of basin floors, up alluvial fan piedmonts to foothills of desert mountains and mesas. The major dominant is creosotebush (*Larrea tridentata*), often mixed with tarbush (*Flourensia cernua*). Other sites may be dominated by whitethorn acacia (*Acacia constricta*), viscid acacia (*Acacia neovernicosa*), Rio Grande saddlebush (*Mortonia scabrella*), and ocotillo (*Fouquieria splendens*). Sub-shrubs are also abundant and often codominants. These include lechugiulla (*Agave lechuguilla*), cactus apple (*Opuntia engelmannii*), Wright's beebrush (*Aloysia wrightii*), and mariola (*Parthenium incanum*). Other typical sub-shrub associates are broom snakeweed (*Gutierrezia sarothrae*), pricklyleaf dogweed (*Thymophylla acerosa*), plumed crinklemat (*Tiquilia greggii*), and mat rockspirea (*Petrophyton caespitosum*). Herbaceous cover can by sparse or grassy with fluffgrass (*Dasyochloa pulchela*) and bush muhly (*Muhlenbergia porter*) key indicators. Black grama (*Bouteloua eripoda*), tobosagrass (*Pleuraphis mutica*), and burrograss (*Scleropogon brevifolius*) may also occur.

Ecological Characteristics

Spatial Niche

There are 19,256 (<2 percent) acres of CDS on the Lincoln NF, while that ERU makes up 19 percent of the Context Area. This ERU is found at the lower elevations of the western scarp of the Sacramento Mountains on the Sacramento Ranger District, and around the base of the Guadalupe Mountains on the Guadalupe Ranger District.

Seral State Proportion

Seral state departure is low for CDS at all scales. Departure is due to sparsely vegetated ground being under-represented (Table 89, Figure 34), which implies a lack of disturbance. However, grazing has indirectly increased the amount of shrubs, with mesquite qrowth following cattle trails (Dick-Peddie 1993), and although fire seldom occurs, in generally small patches of mixed severity, suppression and lack of continuous fuels to carry fire into shrubs may also keep state A in lower than reference abundance. Some sources say that fire had little to do historically, or currently. This ERU was not modelled into the future.

Table 89. Chihuahuan Desert Scrub ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Salt Basin	Tularosa Valley
A	Sparsely vegetated, recently burned, less than 10% shrub or tree cover	0.05	0.01	0.00	0.01	0.00
B, C, D, G	Native herb, shrub or tree dominance types	0.95	0.99	1.00	0.99	1.00
E, F	Exotic annual or perennial herbaceous, with or without tree and shrub cover	0.00	0.00	0.00	0.00	0.00
Departure			4%	5%	4%	5%

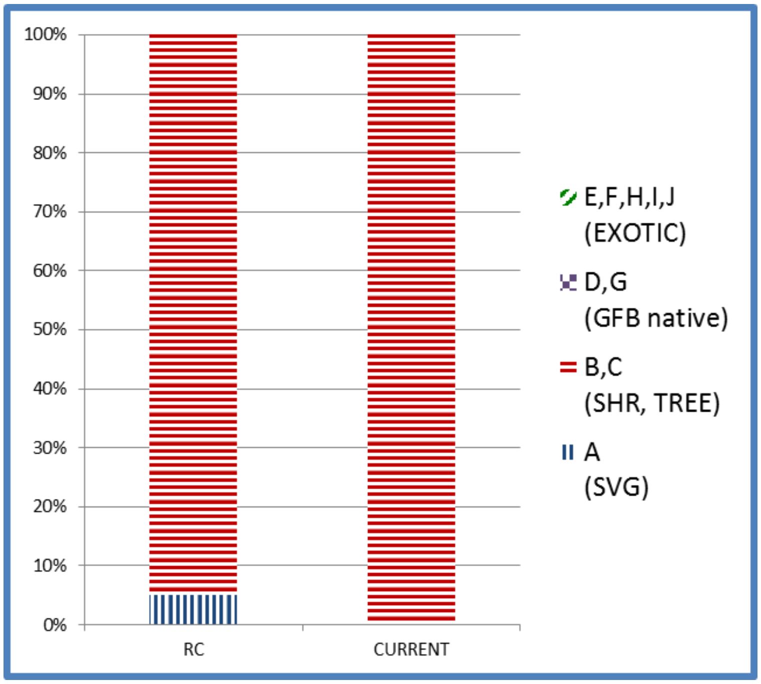

Figure 34. Seral state percentages for Chihuahuan Desert Scrub ERU at the Plan scale. RC is reference condition, Current is current condition.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area.

The Chihuahuan Desert Scrub ERU is characterized by historic fire regime group III, with an average fire return interval of 200 years or more from mixed severity fire. The sparse nature of this ERU indicates that fires likely would have been limited in size to small areas of continuous fuels. There were no fires in CHD in the 20 year data for fire rotation and severity, so departure could not be calculated for those characteristics, or fire regime condition class (Table 90).

Table 90. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
n/a	n/a	n/a	n/a	250.00	n/a	n/a	50%	n/a

Table 91. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fire Severity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FRCC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Coarse Woody Debris and Snags

There is no data for coarse wood or snags.

Ecological Status and Ground Cover

There is no data for ecological status. Ground cover is moderately departed at 55 percent (Table 92).

Table 92. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). **- For grassland and shrubland systems reference condition is based on TEUI polygon geometry, mean patch size plus and minus the standard error to determine lower and upper patch size values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
n/a	55%		176	326	89	Smaller	49%

Patch Size

Patch size is moderately departed at 49 percent, with patches currently smaller than the reference condition (Table 92). Little vegetation management is done in the CDS except for grazing and incidental vegetation treatment intended primarily for adjacent woodlands.

Summary

The Chihuahuan Desert Scrub ERU on the Lincoln NF is highly departed for seral state, and fire regime condition class. Fire frequency and severity could not be calculated because of the lack of fire data for this ERU on the Lincoln, which for may be a real reflection fire activity. Seral state departure is very low but not zero, due to a lack of sparsely vegetated ground. It was assumed for both the Context Area and the Lincoln NF that vegetation was primarily native and not exotic. Ground cover is moderately departed, while patch size is highly departed and smaller than reference. These are perhaps related, as decreased shrub patch size may also indicate more bare ground. As stated above, little active vegetation management occurs in the Chihuahuan desert scrub outside of grazing and incidental vegetation removal treatment at the ecotones with other vegetation types. This ERU is not considered to have much risk to ecological sustainability, although better data on species composition could change that assessment if it was found that this ERU was dominated by exotic species. That risk, if increased, might be mitigated by Lincoln NF intervention in the spread of exotic plants, but is unlikely to make a difference to the ERU within the Context Area.

Montane Subalpine Grassland (MSG):

General Description

Also referred to as montane grasslands, this system occurs at elevations ranging from 8,000 to 10,900 feet. Size of montane/subalpine grasslands range from small park-like openings to extensive landscapes covering several thousand acres. This ERU contains a mix of dominant and co-dominant species in both dry and moister environments and often harbors several plant associations with varying prominent grasses and herbaceous species. Such dominant species may include Parry's oatgrass (*Danthonia parryi* Scribn.), Arizona fescue, Thurber's fescue (*Festuca thurberi* Vasey), pine dropseed, non-native bluegrasses (*Poa pratensis* L. and *P. compressa* L.), mountain muhly, various sedges, shooting star (*Dodecatheon jeffreyi* Van Houtte), fowl mannagrass (*Glyceria striata* (Lam.) Hitchc.), Sierra rush (*Juncus nevadensis* S. Watson), Rocky Mountain iris (*Iris missouriensis* Nutt.), Parry's bellflower (*Campanula parryi* A. Gray), California false hellebore (*Veratrum californicum* Durand), and species of bulrush (*Scirpus* spp. L. and/or *Schoenoplectus* spp. (Rchb.) Palla). Historically this ERU had less than 10 percent tree canopy cover and less than 10 percent shrub cover. However, tree encroachment may occur along the periphery of the grasslands, trees may include Engelmann and blue spruce, Rocky Mountain Douglas-fir, white and subalpine fir, ponderosa and limber pine, depending on elevation and adjacent forest ERUs. Some shrubs may also be present. Some portions of the MSG are seasonally wet, which is closely tied to snowmelt, though they typically do not experience flooding events. The montane/subalpine grasslands are often interspersed with the herbaceous riparian (RU190) ERU. Soils in swales and on riparian benches are usually moist throughout the year, and often harbor several plant associations with varying dominant grasses and herbaceous species. Upland and swale vegetation composition are characterized by different dominant species. Generally, annual precipitation ranges from 20 to 31 inches, with 50-55% coming between October 1st and March 31st. Because of the broad nature of this ERU, future work may develop subclasses splitting out montane grassland from the subalpine grassland.

Ecological Characteristics

Spatial Niche

The LNF contains 11,230 acres of the MSG ERU, for 1% of the forest, while it makes up just 0.12% of the Context Area. This means the LNF has a higher relative proportion of this ERU than the Context Area. LNF contains 27 percent of the MSG in the Context Area, thus the LNF has a substantial role in the ecological sustainability of this ERU.

Seral State Proportion

Seral state distribution for this ERU is highly departed at Plan and Local scales, (Table 93) and only moderately departed for the Context Area. Departure for the Plan Area and local units is due to tree encroachment and the dominance of ruderal species such as Kentucky bluegrass (*Poa pratensis*). No information on understory species composition was available for the Context Area, so its departure may be higher than shown here. Modeling MSG out 10, 100 and 1,000 years show departure decreasing at each interval, but remaining high, primarily due to tree encroachment and ruderal understory species, although encroachment is reduced with time (Figure 35). Departure will remain high into the future because it is unlikely that native or late seral herbaceous species will replace naturalized species like bluegrass.

Table 93. Montane Subalpine Grassland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Arroyo Del Macho	Rio Hondo	Rio Peñasco	Salt Basin	Tularosa Valley
A, C	EARLY-SERAL: Short-term recently burned, sparsely vegetated, high species diversity and high condition < 10% tree cover & < 10% shrub cover; and EARLY- TO MID-SERAL: Short-term recently burned, sparsely vegetated, low to moderate species diversity and < 10% tree cover & < 10% shrub cover	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	LATE-SERAL: All herb dominance types with high species diversity and condition < 10% tree cover & < 10% shrub cover	0.45	0.66	0.00	0.00	0.00	0.00	0.00	0.00
D	EARLY- TO MID-SERAL: All herb dominance types of low-moderate diversity and condition and < 10% tree cover & < 10% shrub cover	0.35	0.00	0.06	0.01	0.17	0.00	0.00	0.08
E, F, G	EARLY- TO MID-SERAL; WOODY ENCROACHMENT: All shrub dominance types of low-moderate seral condition, low to moderate species diversity and condition, and ≥ 10% shrub cover and < 10% tree cover; and all tree dominance types of early to mid-seral condition, low to moderate species diversity and condition, and < 10% shrub cover and ≥ 10% tree cover (occurs on contemporary landscapes only…)	0.00	0.33	0.94	0.98	0.82	1.00	1.00	0.91
Departure			55%	94%	99%	83%	100%	99%	92%

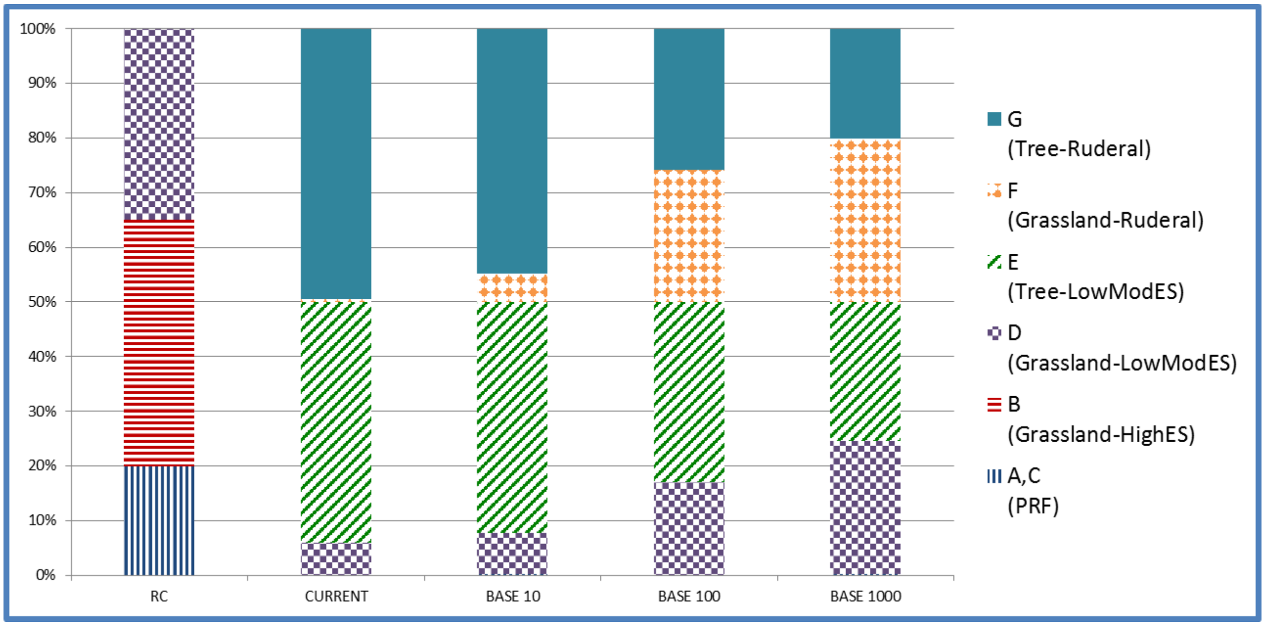

Figure 35. Seral state percentages for Montane Subalpine Grassland ERU at the Plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area (Table 94 and Table 95).

The MSG ERU has a characteristic fire regime of frequent stand replacing fires (Fire Regime II). At the plan scale, the MSG ERU is almost entirely in FRCC III, with only four percent in FRCC II, and none in FRCC I. Both fire rotation and severity are highly departed, with longer return intervals and lower severity than historically. Nearly all local units are highly departed for fire rotation, severity and FRCC. Fire suppression may be responsible for departure in fire rotation and severity, as well as seral state proportion as meadows are encroached by woody species.

Table 94. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	4%	96%	73.0	12.00	84%	27%	88%	69%

Table 95. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval	67		20		97		3	23	40	22,472	206			
Fire Severity	30%		28%		24%		33%	20%	21%	13%	20%			
FRCC	III		II		III		III	III	III	III	III			

Coarse Woody Debris and Snags

There is no data for coarse woody debris or snags.

Ecological Status and Ground Cover

Ecological status is highly departed for the MSG ERU, while ground cover is moderately departed (Table 96). Species composition has changed through the increased cover of encroaching conifers into the grasslands, as well as a shift in dominant grass species in some local areas. Grasslands in the Sierra Blanca and Capitan mountains of the Smokey Bear Ranger District are mostly located in the respective Sierra Blanca and Capitan wildernesses, and retain dominance of native grasses such as Arizona fescue, while grasslands in the Sacramento Ranger District have shifted dominance to ruderal non-native grasses such as *Poa pratensis* (Kentucky bluegrass). It is unlikely those areas will return to native grass dominance, but if fire can be re-introduced into the grasslands, tree encroachment may be reduced over time.

Table 96. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). **- For grassland and shrubland systems reference condition is based on TEUI polygon geometry, mean patch size plus and minus the standard error to determine lower and upper patch size values.

Ecological Status Departure	Ground Cover Departure	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
69%	40%		87	126	2	Smaller	97%

Patch Size

Patch size is highly departed for this grassland ERU, with a mean patch size of two acres compared to a reference range of 87 to 126 acres (Table 96), likely due to fire suppression allowing the encroachment of conifers to break up the continuity of grassland.

Insect and Disease

Generally, grasslands are not surveyed for insect and disease mortality, but our grasslands show a total of 1,114 acres that had more than ten percent mortality of trees, on acres with more than 10 trees per acre, reflecting the encroachment of trees into the grasslands.

Summary

The MSG ERU was highly departed for seral state proportion at the plan scale and all local units where it occurs, compared to moderate departure for the Context Area. Departure is almost entirely due to woody encroachment into the grasslands, and the replacement of late seral native herbaceous vegetation with non-native grasses. Woody encroachment is largely the result of fire suppression, and a shift in fire regime from a frequent high severity fires to less frequent less severe fires allowing regeneration of trees. Ecological statu departure is high due both to shifts in relative abundance of trees and herbaceous vegetation, as well as shifts from native to non-native grasses, particularly in the Sacramento Ranger District. Patch size is highly departed and smaller, likely a result of encroachment breaking up contiguous grassland. Current management consists mostly of grazing and recreation, with vegetation treatments similar to adjacent forest types where encroachment is advanced. Under current management, disturbance and succession, this ERU modelled out to 1,000 years shows a reduction in encroached tree seral states and an increase in grasslands with both native and non-native grasses. Increased management activities can accelerate recovery from departure with regard to tree encroachment, but departure due to non-native grasses may not be reversed.

Semi-Desert Grassland (SDG):

General Description

The semi-desert grassland (SDG) ERU occurs throughout southeastern Arizona and southern New Mexico at elevations ranging from 3,000 to 4,500 feet. These grasslands are bounded by Sonoran or Chihuahuan desert at the lowest elevations and woodlands or chaparral at the higher elevations. Species composition and dominance varies across the broad range of soils and topography that occur within the two states. Generally, annual precipitation ranges from 13 to 21 inches, with 40 percent coming between October 1st and March 31st. Dominant grassland associations/types are black grama grassland, blue grama grassland, curly mesquite (*Hilaria belangeri* (Steud.) Nash) grassland, tobosagrass (*Pleuraphis mutica* Buckley) grassland, big sacaton (*Sporobolus wrightii* Munro ex Scribn.) grassland, mixed native perennial grassland, and non-native perennial grassland. Shrubs (mesquite (Prosopis spp. L.), catclaw acacia (*Senegalia greggii* (A. Gray) Britton & Rose), catclaw mimosa (*Mimosa aculeaticarpa* Ortega), etc.) also occupy these grasslands and their abundance and species composition also varies. As described, this ERU may have had over 10 percent shrub cover historically, but had less than 10 percent tree cover. Semi-desert grassland tends to occur adjacent to and above desert communities, and below interior chaparral and woodlands. The boundary between semi-desert grassland and desert communities is sometimes hard to distinguish as desert shrub species can be common in this ERU (Girard et al, 2008) as they share similar overarching ecosystem properties (USDA Forest Service 2015a).

Ecological Characteristics

Spatial Niche

The Lincoln National Forest (Lincoln NF) contains about 65,888 acres of SDG, comprising 6 percent of the Forest, mostly around the edges of the Forest, while SDG makes up 45 percent of the Context Area. Thus the Lincoln NF has a relatively smaller proportion of SDG, and a relatively smaller role in the ecological sustainability of the ERU.

Seral State Proportion

Seral state composition of SDG on the Lincoln NF is slightly more departed than in the Context Area (91 percent to 78 percent) although both are considered highly departed. In the three local units where SDG occurs, departure ranges from 85-95 percent (Table 97 and Figure 36). This is primarily due to the shift from grassland state B, with high ecological status plants, to state C-D, grassland with low/moderate ecological status, and encroachment of woody species. When natural succession, stressors, disturbance factors, and current management actions are modeled into the future(10, 100 and 1,000 years), departure increases to 95 percent., with no mechanism in place to reverse that trend, with state C-D decreasing and state E, wood encroachment, increasing. In the case of SDG, encroachment includes greater than 10 percent tree, shrub and cacti species, with no discrimination among taxa. Reference conditions include a fair amount of shrubs, sometimes locally abundant, although trees were fairly scarce. SDG is transitional between more xeric desert communities and piñon or juniper woodlands at the upper elevation range, so could include species from those communities as well.

Table 97. Semi-Desert Grassland ERU current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Seral State Structure, Composition and Cover Class Description	Reference	Context	Lincoln	Salt Basin	Tularosa Valley	Upper Pecos-Black
A	EARLY- TO MID-SERAL: Sparsely vegetated or recently burned with very open (< 10%) woody canopy cover	0.20	0.17	0.04	0.10	0.00	0.02
B	LATE-SERAL: Herbaceous layer dominated by late successional perennial grasses with very open woody canopy cover	0.75	0.00	0.00	0.00	0.00	0.00
C, D	EARLY- TO MID-SERAL, WOODY ENCROACHMENT: Shrub and tree dominated (encroached) with open (≥ 10 & > 29%) woody canopy cover, low species diversity, herbaceous layer dominated by early-mid successional vegetation	0.05	0.40	0.94	0.89	0.91	0.98
E, F, G, H	EARLY- TO MID-SERAL, WOODY ENCROACHMENT: Shrub and tree dominated (encroached) with closed (≥ 30%) woody canopy cover, low species diversity herbaceous layer dominated by low species diversity and exotic dominated herbaceous layer (occurs on contemporary landscapes only…)	0.00	0.43	0.01	0.01	0.09	0.01
Departure			78%	92%	85%	95%	93%

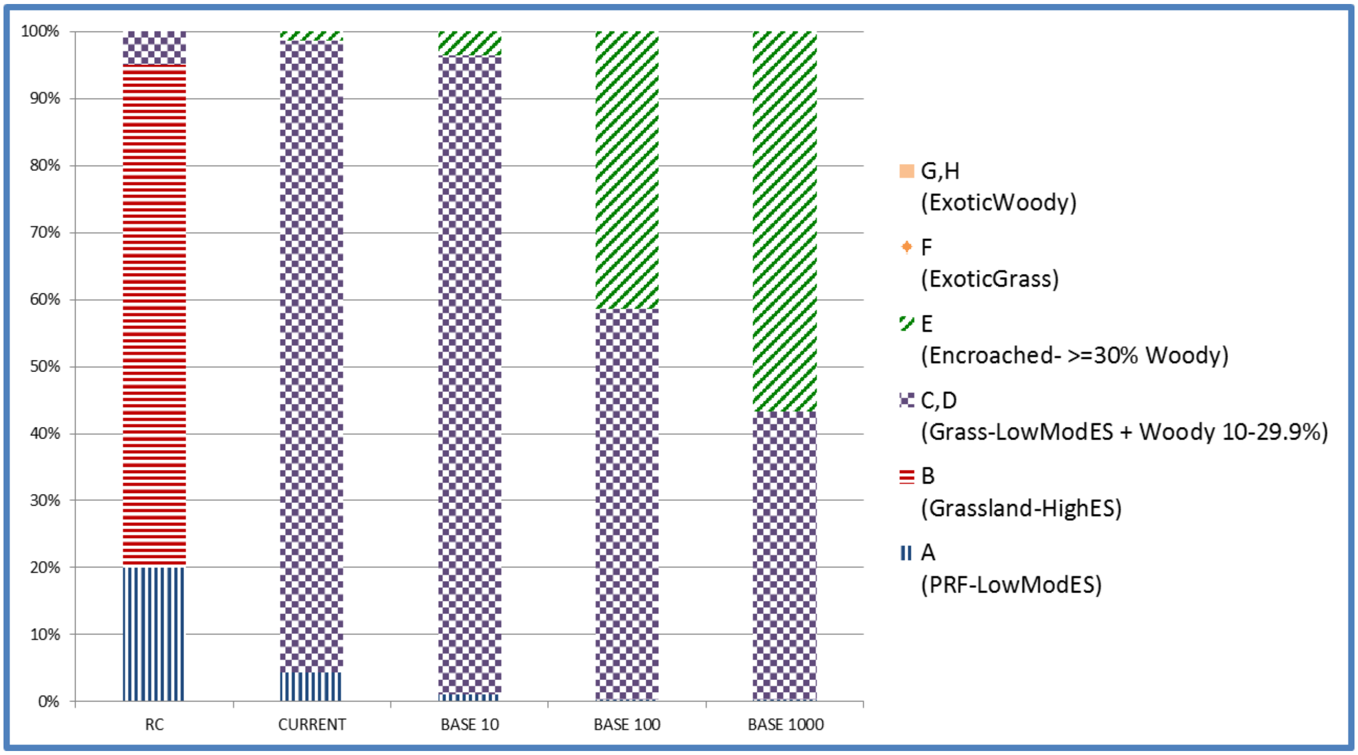

Figure 36. Seral state percentages for semi-desert grassland ERU at the Plan scale modelled out to 1,000 years. RC is reference condition, Current is current condition, Base 10, 100 and 1000 are modelled outcomes at 10, 100 and 1,000 years.

Fire Regime and Condition Class

Fire regime is an ecosystem property composed of fire frequency and severity. Fire regime condition class (FRCC) is a measurable characteristic that categorizes the combined current departure from reference conditions of seral state proportion, fire frequency and fire severity. FRCC is reported as a percentage of the three condition classes (I-III) for the Plan Area, and as a single class for local units (See Fire Frequency, Severity and Condition Class section). FRCC was not calculated for the Context Area (Table 98 and Table 99).

The characteristic fire regime for the SDG ERU is frequent stand replacement (Fire Regime II, 0-35 year mean fire return interval). Fire Regime Condition Class was 41 percent moderately departed and 59 percent highly departed (II and III, respectively) with none at reference condition (I) (Table 98). As FRCC is related to structural state, this reflects the departure shown in Table 97. Fire rotation and severity are both highly departed at 88 and 8 percent, respectively. Current fire rotation is estimated at 51 years, compared to a reference of six years, while severity is 15 percent, compared to a reference of 88 percent. Encroachment of woody species (primarily shrubby species) at the expense of grasses and forbs, as well as fire suppression has reduced the ability of fire to carry across the landscape and through the ‘crown’ of the stand, resulting in lower severity of canopy mortality and higher rotation ages as each acre is less likely to burn in any year.

Table 98. Fire interval (years), severity (% mortality) and condition class (FRCC) at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Fire Regime Condition Class			Fire Rotation			Fire Severity		
I	II	III	interval	ref int	departure	severity	ref sev	departure
0%	0%	100%	51.4	6.00	88%	15%	88%	83%

Table 99. Fire interval (years), severity (% mortality) and condition class (FRCC) at the local unit scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Local Unit	AC	BD	BR	BC	DC	RP	PW	RD	RB	RR	SR	TVN	TVS	UPN	UPS
Fire Interval					36									46	38
Fire Severity					13%									13%	19%
FRCC					III									III	III

Coarse Woody Debris and Snags

No data are available for coarse woody debris (CWD) or snags, so departure could not be calculated.

Ecological Status and Ground Cover

Ecological status was not calculated due to lack of current or reference data. Ground cover was moderately departed at 60 percent (Table 100). Departure for this characteristic is likely due to the shift from grassland to shrub dominated scrubland or woodland, as described above. Presumably, ground cover was higher for both litter and basal vegetation in reference conditions; scrublands and woodlands developing from woody encroachment of grasslands may be expected to have more bare ground and less litter and basal vegetation.

Table 100. Ecological status, ground cover and patch size at the plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). ** - For grassland and shrubland systems reference condition is based on TEUI polygon geometry, mean patch size plus and minus the standard error to determine lower and upper patch size values.

Ecological Status	Ground Cover	Patch Size	REFERENCE (acres)		CURRENT (acres)	TREND	DEPARTURE (%)
			LWR	UPR			
93%	60%		265	651	1	Smaller	99%

Patch Size

Patch size was highly departed at 99 percent (Table 100). Current patch size for SDG was one acre, while reference patch size ranged from 225 to 447 acres. Patches for grassland types refer to open space dominated by herbaceous vegetation. Decrease in patch size reflects encroaching woody vegetation, which could be piñon-juniper or desert scrub species, depending on adjacent vegetation types. Little active management is performed in this type except for grazing, which may or may not have an effect on patch size. Overuse could decrease herbaceous growth, leading to more open ground which may allow an increase in woody or scrubby vegetation but there is not data to support that. In the absence of active management, it is unlikely that patch size departure will decrease with time.

Insect and Disease

Mortality due to insect and disease infestations are generally mapped only for woodland and forested vegetation; mortality in this type would be restricted to piñon-juniper woodlands. Typically, the primary agents would be bark beetles, with some mortality by mistletoe infestations. Encroaching woody vegetation, particularly of piñon and juniper, and decreasing patch size increase vulnerability to future infestations. Climate change that creates more droughty conditions may increase stress on woody vegetation, which could increase both the extent and severity of future infestations.

Summary

The SDG ERU is highly departed for most ecological characteristics at the plan and local scale. Seral state, fire rotation, severity and condition class, as well as patch size, are all highly departed, with future projections likely to remain or become increasingly departed. This is likely due to an increase in woody vegetation. It is assumed in the analysis that the semi-desert grassland type on the Lincoln NF consists of low to moderate ecological status vegetation with a larger than reference component of woody vegetation (state C, D). While the Context Area is also highly departed (78 percent), it is less departed than the Lincoln NF, primarily because it has less of state C, D. Modelled increases in woody vegetation will drive departure further from reference conditions, particularly in closed condition (greater than 30 percent canopy cover). That departure is likely to account for the current 13 percent increase from reference for biomass carbon, which continues to increase into the next 100 years (see Carbon Stocks chapter). Climate change models indicate a 34 percent high and very high vulnerability of vegetation type change, although what that change might be is unclear. The Lincoln makes only a small contribution to semi-desert grassland in the Context Area, current management is unlikely to be the driver or stressor contributing to departure in this ERU, but is also unlikely to reverse the trend. Risk to ecological sustainability for the semi-desert grassland is high, due to past and future factors outside of Lincoln NF control.

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments relating mostly to terrestrial ecosystems and their conditions, trends, and issues included these topics: overgrown, dense forests and canopies; stunted, diseased and unhealthy trees; loss of open, grass-dominated areas (savannah-like) and meadows on the landscape impacting forest health, forage, wildlife, scenic, and other values; woody encroachment, including piñon-juniper; decreased regeneration; decreased precipitation and moisture; increase in resource damage associated with OHV/ATV proliferation, and by 300 foot travel allowance for motor vehicle use off forest routes as allowed by travel rules; ecosystem services, multiple uses; substantial decline in timber harvest/logging and, consequently, forest management and health; forest management that is too intensive; loss of natural character due to roads and human development; catastrophic fires and weed proliferation in wilderness due to limited management; ponderosa pine is being treated/managed as mixed-conifer type; no harvest or removal of dead aspen; loss of vegetation treatments from the past due to forest overgrowth; visual, watershed, vegetation, and other impacts from firebreaks; heavy fuels increasing the risk of uncharacteristic fire and altered fire cycles; standing, dead and burned trees; no use of controlled burns to address fire risk; prescribed fires by the Forest Service are limited in size and effectiveness; recent focus on fuel reduction efforts by the agency in some areas of the Forest; using old data and limited field verification to manage forests; vegetation treatments are not designed for the species present; overgrazing and concentrated use by livestock; and degraded range and grasslands associated with livestock use and poor management practices. Expressed values (desires, for terrestrial, riparian and aquatic systems) included healthy, intact forests and ecosystems; forest products and multiple uses; human safety and livelihoods; and effective communication, collaboration, and decision-making. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for regional office approval prior to finalizing it.

Summary

Risk, for the purposes of this assessment, can be generalized as a function of current departure and the expected future departure based on the best estimates of management, disturbance and natural process effects. A task of this assessment was to determine the departure from reference of each ERU and the risk to future sustainability of the ERU based on expected departure in the future. This assessment has calculated departure for a number of ecological characteristics for each ERU, and modelled natural succession, disturbance regimes, and current management for some of those ERUs to determine the trend, or direction and extent, of future departure. Risk is not assigned to a characteristic per se, but given a value as an indicator of risk to the ERU.

Seral state proportion is the only characteristic modelled into the future, based on existing data for management activities, succession, and historic disturbance regimes such as wildfire and insect and disease mortality. Thus seral state proportion and its derivatives (FRCC, patch size) are the only characteristics for which a trend can be determined. The following discussion on risk summarizes departure for each ERU in the context of how that may affect sustainability of the ERU into the future. Table 101 shows how departure and trend function to create a risk. Any level of departure, if trending toward less departure in the future, is assigned low risk. For non-modelled characteristics, or for ERUs not modelled (less than 1 percent of forest area), risk is equal to departure. For characteristics trending toward increased departure in the future, risk is one step higher, that is, for moderate departure trending toward more departed, risk to sustainability is high. If current departure is high, and trending toward more departure, risk to sustainability is very high. Thus, even though current departure for a number of characteristics of an ERU may be high, the anticipated risk to sustainability of that ERU may be low.

Table 101. Risk matrix for combined departure categories and trend categories

Departure	Trend toward Reference	Trend unknown or static	Trend Away from Reference
High	Low Risk	High Risk	Very High Risk
Moderate	Low Risk	Moderate Risk	High Risk
Low	Low Risk	Low Risk	Moderate Risk

Risk as shown in Table 102. Is not necessarily additive across characteristics, because some characteristics are derived from seral state proportion, such as Fire Regime Condition Class and patch size.

Table 102. Departure summmary for all ERUs across ecological characteristics at the plan scale. Colors represent departure from reference condition: Green= low (0-33%), Orange=moderate (34-66%), Red=high (67-100%), Pink=very high. Moderate and High values are considered significantly departed. Blank cells mean departure was not calculated. Cells with "N/D" have no data. Reporting units where an ERU does not occur are labelled with "none".

ERU Code	Reporting Unit	Key Ecosystem Characteristics: Seral State Proportion	Fire Frequency	Fire Severity	FRCC	Coarse Woody Debris	Snags 8-18 inches	Snags >18 inches	Ecological Status	Ground Cover	Patch Size
SFF	Lincoln NF	M	H	M	M	L	L	H	N/D	N/D	M
SFF	Arroyo del Macho	M	H	M	M	N/D	N/D	N/D	N/D	N/D	N/D
SFF	Rio Hondo	M	H	M	M	L	L	H	N/D	N/D	N/D
SFF	Rio Peñasco	None									
SFF	Salt Basin	None									
SFF	Tularosa Valley	M	H	M	M	N/D	N/D	N/D	N/D	N/D	N/D
SFF	Upper Pecos	None									

ERU Code	Reporting Unit	Seral State Proportion	Fire Frequency	Fire Severity	FRCC	Coarse Woody Debris	Snags 8-18 inches	Snags >18 inches	Ecological Status	Ground Cover	Patch Size
		Key Ecosystem Characteristics									
MCW	Lincoln NF	M	H	L	M	L	M	H	N/D	N/D	L
	Arroyo del Macho	None									
	Rio Hondo	None									
	Rio Peñasco	M	H	M	M	L	L	M	N/D	N/D	N/D
	Salt Basin	M	H	M	H	M	L	H	N/D	N/D	N/D
	Tularosa Valley	M	N/D	N/D	N/D	M	L	M	N/D	N/D	N/D
	Upper Pecos	None									
MCD	Lincoln NF	M	H	M	M	H	H	H	H	M	M
	Arroyo del Macho	M	L	M	M	L	M	L	N/D	N/D	N/D
	Rio Hondo	M	L	L	M	M	H	M	N/D	N/D	N/D
	Rio Peñasco	H	H	M	H	L	M	M	N/D	N/D	N/D
	Salt Basin	M	H	M	H	H	H	H	N/D	N/D	N/D
	Tularosa Valley	M	H	L	M	M	M	L	N/D	N/D	N/D
	Upper Pecos	H	H	M	M	H	M	H	N/D	N/D	N/D
PPF	Lincoln NF	L	H	M	L	M	H	L	H	L	H
	Arroyo del Macho	L	H	M	L	M	H	L	N/D	N/D	N/D
	Rio Hondo	L	H	M	L	M	H	L	N/D	N/D	N/D
	Rio Peñasco	L	H	H	L	L	H	M	N/D	N/D	N/D
	Salt Basin	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	Tularosa Valley	L	H	L	L	L	H	M	N/D	N/D	N/D
	Upper Pecos	None									
PPE	Lincoln NF	M	N/D	N/D	N/D	L	L	M	N/D	M	L
	Arroyo del Macho	None									
	Rio Hondo	None									
	Rio Peñasco	H	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	Salt Basin	M	N/D	N/D	N/D	L	L	M	N/D	N/D	N/D
	Tularosa Valley	None									

ERU Code	Reporting Unit	Key Ecosystem Characteristics									
		Seral State Proportion	Fire Frequency	Fire Severity	FRCC	Coarse Woody Debris	Snags 8-18 inches	Snags >18 inches	Ecological Status	Ground Cover	Patch Size
	Upper Pecos	M	N/D	N/D	N/D	L	L	M	N/D	N/D	N/D
PJC	Lincoln NF	H	M	L	H	H	M	M	N/D	N/D	H
	Arroyo del Macho	None									
	Rio Hondo	None									
	Rio Peñasco	H	H	H	H	L	M	L	N/D	N/D	N/D
	Salt Basin	H	N/D	N/D	N/D	H	L	M	N/D	N/D	N/D
	Tularosa Valley	VH	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	Upper Pecos	H	H	L	H	M	M	L	N/D	N/D	N/D
JUG	Lincoln NF	L	H	M	L	N/D	N/D	N/D	N/D	M	H
	Arroyo del Macho	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	Rio Hondo	L	H	L	L	N/D	N/D	N/D	N/D	N/D	N/D
	Rio Peñasco	None									
	Salt Basin	None									
	Tularosa Valley	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	Upper Pecos	L	H	L	L	N/D	N/D	N/D	N/D	N/D	N/D
PJO	Lincoln NF	L	M	M	L	M	H	H	H	M	H
	Arroyo del Macho	L	L	H	L	M	H	M	N/D	N/D	N/D
	Rio Hondo	L	H	M	L	M	H	L	N/D	N/D	N/D
	Rio Peñasco	L	M	M	L	M	H	H	N/D	N/D	N/D
	Salt Basin	L	N/D	N/D	N/D	M	H	L	N/D	N/D	N/D
	Tularosa Valley	L	N/D	N/D	N/D	M	M	H	N/D	N/D	N/D
	Upper Pecos	None									
PJG	Lincoln NF	L	H	L	L	M	M	L	H	L	H
	Arroyo del Macho	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	Rio Hondo	L	L	M	L	L	M	M	N/D	N/D	N/D
	Rio Peñasco	L	M	L	L	N/D	N/D	N/D	N/D	N/D	N/D
	Salt Basin	L	H	L	L	L	M	L	N/D	N/D	N/D

ERU Code	Reporting Unit	Key Ecosystem Characteristics: Seral State Proportion	Fire Frequency	Fire Severity	FRCC	Coarse Woody Debris	Snags 8-18 inches	Snags >18 inches	Ecological Status	Ground Cover	Patch Size
	Tularosa Valley	L	N/D	N/D	N/D	L	M	M	N/D	N/D	N/D
	Upper Pecos	L	H	M	L	L	H	M	N/D	N/D	N/D
GAMB	Lincoln NF	H	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
GAMB	Arroyo del Macho	None									
GAMB	Rio Hondo	None									
GAMB	Rio Peñasco	H	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
GAMB	Salt Basin	H	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
GAMB	Tularosa Valley	None									
GAMB	Upper Pecos	None									
MMS	Lincoln NF	L	L	M	L	N/D	N/D	N/D	N/D	M	H
MMS	Arroyo del Macho	None									
MMS	Rio Hondo	None									
MMS	Rio Peñasco	L	H	H	L	N/D	N/D	N/D	N/D	N/D	N/D
MMS	Salt Basin	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
MMS	Tularosa Valley	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
MMS	Upper Pecos	L	H	H	L	N/D	N/D	N/D	N/D	N/D	N/D
CDS	Lincoln NF	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	M	H
CDS	Arroyo del Macho	None									
CDS	Rio Hondo	None									
CDS	Rio Peñasco	None									
CDS	Salt Basin	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
CDS	Tularosa Valley	L	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
CDS	Upper Pecos	None									
MSG	Lincoln NF	L	H	H	L	N/D	N/D	N/D	H	M	H
MSG	Arroyo del Macho	L	H	M	L	N/D	N/D	N/D	N/D	N/D	N/D

ERU Code	Reporting Unit	Seral State Proportion	Fire Frequency	Fire Severity	FRCC	Coarse Woody Debris	Snags 8-18 inches	Snags >18 inches	Ecological Status	Ground Cover	Patch Size
		Key Ecosystem Characteristics									
	Rio Hondo	L	M	H	L	N/D	N/D	N/D	N/D	N/D	N/D
	Rio Peñasco	L	H	H	L	N/D	N/D	N/D	N/D	N/D	N/D
	Salt Basin	L	H	H	L	N/D	N/D	N/D	N/D	N/D	N/D
	Tularosa Valley	L	H	H	L	N/D	N/D	N/D	N/D	N/D	N/D
	Upper Pecos	None									
SDG	Lincoln NF	VH	H	H	VH	N/D	N/D	N/D	H	M	H
SDG	Arroyo del Macho	None									
SDG	Rio Hondo	None									
SDG	Rio Peñasco	None									
SDG	Salt Basin	VH	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
SDG	Tularosa Valley	VH	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
SDG	Upper Pecos	VH	H	H	VH	N/D	N/D	N/D	N/D	N/D	N/D

Forested ERUs

The Lincoln NF has five forested ERUs. The SFF and PPE ERUs were not modelled because their individual areas were less than 1 percent of the forest, so risk is equal to departure for all characteristics. The MCW, MCD and PPF ERUs were modelled for seral state proportion and that trend was applied to FRCC as well. All forested ERUs have moderate risk to sustainability except PPF which has low risk.

SFF was not modelled, so risk to sustainability is considered the same as departure, which is moderate. However, departure is due in part to a lack of large old trees, and in the absence of large scale disturbance, it is expected that natural succession will trend toward reference conditions with enough time. Fire severity and FRCC were also considered to provide moderate risk to sustainability, while fire rotation was highly departed so is considered a high risk. However, as mentioned earlier, fire rotation in historically infrequent fire regimes may not be as departed as calculated due to the short time period of available data for calculating departure. Snags in the smaller size class and coarse wood are not departed significantly, and indicate low risk, while the lack of large snags indicate high risk, but that should be mitigated as trees grow into the larger size classes and eventually die. Current management is limited in this ERU and is not likely to lead to increased departure. Risk to sustainability of this ERU may be expected from potential climate change, insect or disease mortality, or large scale severe fires. However, stand replacing fires are part of the natural fire regime in this ERU and it appears that the SFF ERU on the Lincoln NF is somewhere in the middle of the natural fire cycle.

The MCW and MCD ERUs are moderately departed for seral state proportion now, and under current management as modelled, will remain moderately departed in the future. Risk is considered moderate for seral state proportion and FRCC for both ERUs, although the Rio Peñasco and Upper Pecos local units show MCD at high risk from seral state proportion departure. Fire severity risk is low for MCW and moderate for MCD, likely due to overstocking in smaller size classes, but fire frequency is highly departed for both, and indicate high level of risk.

The MCW ERU is not significantly departed for coarse woody debris (CWD), moderately departed for smaller snags, and highly departed for large snags (more abundant than reference in both cases), indicating those same levels of risk. Patch size is similar to reference and indicates low risk to sustainability. Aspen in this ERU is not considered to be regenerating successfully, due in part to elk predation, and also to fire suppression reducing the openings for aspen regeneration. Management has a role to play in reducing departure as wildlife constraints have been reduced with the 2012 MSO Recovery Plan, and techniques for ground based harvesting on steep slopes have been developed. Additionally, changes in how wildfires are managed for resource beneficit may mitigate the negative impacts from fire suppression.

The MCD ERU highly departed for CWD and snags in both size classes, more abundant at the plan scale for all three characteristics than reference, indicating a high level of risk. This is likely due to recent fires or insect and disease mortality. Ecological status is highly departed, and indicates a high level of risk. Departure is due both to more deciduous trees and shrubs such as oak and locust than historically, as well as a shift from shade intolerant species such as ponderosa pine and Douglas-fir to white fir dominating the overstory. Similar to MCW, management has opportunities to mitigate future risk as new wildlife policies and harvesting techniques overcome past limitations and wildfire management is used for resource benefit as appropriate.

The PPF ERU is highly departed for seral state proportion, but because as modelled it improves with time, is considered at low risk in the future. FRCC, also highly departed currently, indicates low risk in the future, a result of improvement in seral state proportion. Fire frequency is highly departed, with longer rotations than historically as a result of fire suppression, and indicating high risk in the future under current management. Small snags are highly departed and overabundant, indicating high risk, while CWD is moderately departed and underabundant, indicating moderate risk. It might be expected that snags will fall and become CWD, reducing departure for both characteristics. However, insect and disease mortality in overstocked stands may continue to create an overabundance of snags. Ecological status is highly departed and indicates a high level of risk. This comes in part from a reduction in understory grasses and increase in tree cover, as well as a shift from ponderosa pine dominance to mixed stands including Douglas-fir and white fir. Although the PPF ERU was traditionally open woodlands with scattered individuals and groups of pine, on the Lincoln NF the PPF ERU may have been more closed, with more Douglas-fir, than the reference conditions would suggest. Management has a large role in mitigating departure in the future, for similar reasons as discussed in the ERUs above.

The PPE ERU is less than 1 percent of the Lincoln NF, so seral state proportion was not modelled, and risk is assigned as current departure. Seral state proportion is moderate for the forest and the local units in the Guadalupe Ranger District. The PPE in the Rio Peñasco local unit is highly disturbed, but such a small area that it contributes little risk to sustainability of the ERU as a whole. Risk to sustainability from seral state proportion is considered moderate. Fire data was not available for this ERU, but considering FRCC is highly dependent on seral state departure, moderate risk is likely probable, but not indicated in the table. Departure of CWD and smaller snags was insignificant, indicating low risk, while larger snags were moderately departed, with moderate risk indicated. Little vegetation management outside of prescribed fire is done in this ERU, mostly due to topography and access, and eventually trees will grow out of the smaller size classes, reducing departure. Management has a limited role in the sustainability of this ERU, but use of wildfire for resource benefit may help reduce departure, and subsequent future risk.

Woodland ERUs

The Lincoln NF has four woodland ERUs, all of which were modelled for management and disturbance effects into the future. The PJC ERU trended toward more departure in the future, a result of more closed canopy than in reference, but the JUG, PJO and PJG ERUs all trended towards less departed with time.

The PJC ERU is at high risk to future sustainability, due to more closed canopy conditions. Fire risk (FRCC) is also high due to seral state departure, although fire severity departure is not significant, and fire rotation is only moderately departed with longer rotations than reference, indicating moderate risk. Snags and coarse wood were highly and moderately departed, respectively, with associated levels of risk indicated. Patch size is highly departed with much smaller patches than historically, and indicates a high level of risk. Management in this ERU is largely grazing and fuels treatments. Management has a significant role to play in the sustainability of this ERU, particularly through fuel treatment, although that may be limited by funding and workforce capacity.

The JUG ERU while generally moderately departed is at low risk to sustainability due to improvements in seral state proportion as modelled into the future. For that reason, FRCC is also indicating low risk, in spite of fire rotation and severity both departed from frequent low severity to infrequent higher severity fires. Patch size indicates a high risk to ecological sustainability, a result of tree encroachment creating larger patches than historically. Management activities are primarily grazing and fuels reduction treatments, and even though there is low risk to the ERU, management can continue to play a role in maintaining sustainability with continued fuels treatments and wildfire management for resource benefit when appropriate.

The PJO ERU is currently moderately departed for seral state proportion at the plan scale, but improves with time as management, disturbance and succession is modeled into the future, so risk to sustainability is low. Fire frequency and severity are both moderately departed with more frequent and less severe fires than historically, indicating moderate risk to the ERU but FRCC is considered low risk as seral state departure improves. Other characteristics such as ecological status, snags and patch size are highly departed with high risk indications, but those may improve as seral state departure improves. Management activities are primarily grazing and fuels treatments in this ERU, and the Lincoln NF plays a large role in mitigating risk through increased treatments to reduce tree cover, improve grass cover, and by wildfire management for resource benefit when and where appropriate.

The PJG ERU is currently moderately departed at the plan scale and while it remains moderately departed as modeled into the future, the trend is toward less departed, so the indicated risk to ecological sustainability is low. FRCC risk indication is also low due to seral state trend, although fire frequency indicates high risk, while fire severity indicates low risk. Coarse wood and small snags are moderately departed, with moderate level of risk indicated, while departure for large snags was insignificant. Ecological status and patch size were highly departed with high level of risk indicated, but as seral state departure improves, that risk may be reduced. Management activities in the PJG ERU are primarily grazing and fuels treatments. The Lincoln NF plays a large role in mitigating risk through increased treatments to reduce tree cover, improve grass cover, and by wildfire management for resource benefit when and where appropriate.

Shrubland ERUs: The Lincoln NF has three shrubland ERUs. The GAMB and CDS ERUs were not modelled into the future as neither met the 1 percent area criterion. The only modeled ERU was MMS, which although highly departed currently, shows a trend toward reference in the future, with reduced associated risk.

The GAMB ERU is similar structurally to MMS with equivalent reference conditions, although currently more departed. Risk may be similar as well, but because it is highly departed and trend was not modeled, high risk to ecological sustainability is indicated. No other characteristics were analyzed, thus no associated risk is indicated. This ERU can have significant tree cover, and may be managed with MCD or PPF, with which it is intermingled on the landscape. Management activities include grazing and fuels treatments, as well as commercial and non-commercial thinnings where appropriate. This ERU can be confused with persistent shrub states in the MCD, so there appears to be much more of this ERU than is actually mapped. Continued thinning and fuels treatments, including wildfire management for resource benefit, may reduce departure in the future with associated reduction in risk to ecological sustainability.

The MMS ERU is moderately departed at the plan scale for seral state proportion, but trends toward reference as modelled into the future, resulting in low risk to ecological sustainability indicated by this characteristic. Fire frequency was only slightly departed and severity was moderately departed, with low and moderate risk indicated, respectively. FRCC also indicates low risk. No CWD or Snags data was available for this ERU so no departure or risk was calculated. Patch size is highly departed with associated high risk, but that risk is subordinate to seral state. Management activities in the MMS ERU include grazing and fuels treatments, with some commercial or non-commercial thinning as tree cover warrants. Although risk to sustainability appears low, the Lincoln NF can still have a role in maintaining the ERU through continued fuels treatments and wildfire management for resource benefit when appropriate.

The CDS ERU seral state departure is insignificant, with low risk to ecological sustainability indicated, and as FRCC is dependent on seral state departure, it may also be assumed to indicate low risk, although lack of fire data in the CDS ERU meant fire severity and frequency, and subsequent FRCC could not be calculated. Coarse wood, snags and ecological status were not analyzed, and no associated risk determined. Patch size is highly departed, although seral state structure is not, so while patch size indicates a high level of risk, overall risk to this ERU on the Lincoln should remain low.

Grassland ERUs

The Lincoln NF has two grassland ERUs at opposite ends of the elevation gradient. Both ERUs were modeled into the future.

The MSG ERU is highly departed at the plan scale currently but trends toward reference over time, so risk to sustainability is considered low for seral state proportion and FRCC. Departure is high for both fire frequency and severity, with associated risk indication also high. Departure is primarily due to two factors, tree encroachment and a shift in grass species from native bunchgrasses to non-native grasses such as Kentucky bluegrass. Encroachment is likely due to fire suppression, and through active management such as treating fuels, thinning where encroachment has created cohorts of harvestable trees, and more wildfire management for resource benefit future departure and associated risk could be mitigated. Departure and risk due to species shifts are more likely beyond the capability of the Lincoln NF to mitigate, so while overall risk is low to the MSG ERU, there is high risk to historic species composition, particularly on the Sacramento Ranger District.

The SDG ERU is highly departed for seral state proportion, with modeling showing a trend toward increased departure from reference over time. Risk to the sustainability of this ERU is determined to be very high, a result of encroachment of woody vegetation into the grasslands. FRCC is also considered to indicate very high risk, while fire frequency and severity are highly departed, with associated high risk to ecological sustainability. Ecological status and ground cover were highly and moderately departed, respectively, with high and moderate risk indicated. Patch size was also highly departed, indicating high risk, likely due to encroachment reducing the size of open continuous grassland. Management activities in the SDG ERU are mainly grazing and fuels treatments. The Lincoln NF can play a role in sustaining the SDG ERU through continued fuels treatments and wildfire management for resource benefit.

Conclusion

Overall, the Lincoln NF is at moderate risk to sustainability of its forested ERUs, although the highly departed PPF ERU as modelled indicates low future risk. The woodland ERUs are at low risk with the exception of the PJC ERU, which although not modeled, appears to be at high risk. Two shrub ERUs exhibit low risk, but the GAMB ERU, although not modeled, appears to be at high risk to sustainability. Grasslands are very departed from historic conditions, but while the MSG ERU trends toward reference in the future, and projected risk is low, the SDG Grassland continues toward further departure, and projected risk is very high.

Chapter 5 - Riparian Vegetation

Introduction

Riparian areas are where ecosystems develop from the influence of water, along streams, lakes, springs and other waterbodies. Riparian ecosystems are transitional between aquatic and adjacent upland ecosystems. These riparian ecosystems also vary depending on the geology, topography, climate and weather patterns, and level of disturbance. Riparian areas offer their own ecosystem services distinct from the adjacent upland ecosystems, as well as serve as indicators of overall ecosystem health. Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies. Riparian areas have distinctively different vegetative species than adjacent areas; specifically, riparian mapping is conducted where riparian/wetland plant species are common. Where indicator plants may not be present, riparian areas are identified by signs of fluvial processes and/or fluvial features created under the current flow and climatic regimes. (RMAP Regional Riparian Mapping Project, Triepke et al. 2014).

Riparian ecosystems and their associated vegetation contribute to water quality and storage, wildlife habitat, and recreational opportunities. Riparian ecosystems can have a disproportionate influence on perspective of overall ecosystem sustainability because of their small size relative to the more broadly distributed upland ecosystems (see Terrestrial Vegetation chapter). Human habitation, roads and use are often centered around or along riparian areas, and riparian ecosystems can be dramatically affected in a short time by human activity as well as natural disturbances. On the Lincoln NF, riparian areas are generally very small with little transition to upland ecosystems. Disturbance or use, such as flooding, fire or grazing can appear to have different effects for adjacent upland and riparian areas. However, while changes in condition may be a function of normal processes following disturbance, such as seasonal flooding, other changes leading to vegetation type conversion may indicate management concerns or shifting climate, and thus a threat to the sustainability of the riparian ecosystem, as well as to the sustainability of the ecological structure of the Lincoln NF as a whole.

Ecosystem Services of Riparian Vegetation

Much of the riparian vegetation within the Lincoln NF boundary is in headwater systems and many of the main watercourses are on private land. Primary ecosystem services of riparian vegetation include riparian habitat for aquatic and terrestrial wildlife, groundwater storage and filtration for local water use and municipal watersheds, surface water for livestock use, and aesthetic values for outdoor recreationalists.

Riparian habitats are among the most critical elements of biodiversity within the landscape. In Arizona and New Mexico, 80 percent of all vertebrate species use riparian areas for at least half their life cycles, and more than half of these are totally dependent on riparian areas (Chaney et al. 1990). According to the Arizona Riparian Council 60 to 70 percent of the state's wildlife species depend on riparian areas to sustain their populations, even though riparian habitats occupy less than half a percent of the land area (Arizona Riparian Council 1995). Likewise, aquatic habitats and fish productivity are directly related to properly functioning riparian systems (Washington Dept. Fish and Wildlife 1995) from RMAP Regional Riparian Mapping Project, Triepke et al. 2014).

Key Ecosystem Characteristics of Riparian Vegetation

Key ecosystem characteristics were chosen for riparian ecosystems based on their relevance to ecosystem condition and sustainability, their ability to be measured and compared to desired or reference condition, and if that information is readily available. Characteristics were analyzed at the Plan scale, and at the Context scale when data was available. Ecological characteristics were analyzed at the local scale when possible, qualitatively or quantitatively, as data was available. Selected key ecosystem characteristics for riparian vegetation (ERUs) include:

- Seral state proportion
- Fire regime- frequency
- Fire regime- severity
- Fire regime- condition class
- Proper functioning condition

System Drivers and Stressors for Riparian Vegetation

System drivers and stressors for hydrological and riparian systems are discussed in the Water Resources chapter.

Data, Methods and Scales of Analysis for Riparian Vegetation

Data, methods, scales of analysis, uncertainties, and data gaps are provided below, as pertinent to the subtopics.

Riparian Ecological Response Units

Riparian ERU delineations on the Forest were based on the Regional Riparian Mapping Project (RMAP; Triepke et al. 2014). Riparian ERUs for other lands in the Context Area were based on LANDFIRE Biophysical Setting. The Biophysical Setting units from LANDFIRE were cross-walked to riparian ERUs on the Lincoln NF.

The Lincoln NF contains 15 riparian ERUs in five groups that make-up approximately 0.3 percent of the Forest (Table 103). Figure 37 shows all five groups mapped as one overall riparian category. Figure 38 through Figure 42 show the distribution of the groups across the three Ranger Districts of the Lincoln NF.

Table 103. Riparian ERU groups and individual ERU Local Units acreage by ownership and total acreage

Riparian ERU Group	ERUs with Local Unit (4th Level Watershed)	FS	Private	Total
Cottonwood Group (CWG)	Cottonwood / Hackberry	40.8		40.8
	Upper Pecos-Black River	40.8		40.8
	Fremont Cottonwood / Shrub	200.6	6.9	207.5
	Rio Hondo	31	2.9	33.8
	Tularosa Valley	169.7	4	173.7
	Narrowleaf Cottonwood / Shrub	61.8	2.2	64
	Rio Hondo	61.8	2.2	64
	Rio Grande Cottonwood / Shrub	44.6	1.4	46
	Rio Peñasco	13.8	1.4	15.2
	Upper Pecos-Black River	30.8		30.8
Desert Willow Group (DWG)	Desert Willow	62.6		62.6
	Salt Basin	13.5		13.5
	Tularosa Valley	27		27

Riparian ERU Group	ERUs with Local Unit (4th Level Watershed)	FS	Private	Total
	Upper Pecos-Black River	22		22
	Little Walnut / Desert Willow	324.5		324.5
	Upper Pecos-Black River	324.5		324.5
Montane Conifer/Willow Group (MCWG)	Arizona Alder - Willow	35.9	9.9	45.8
	Rio Peñasco		0	0
	Tularosa Valley	35.9	9.9	45.8
	Ponderosa Pine / Willow	292.9	0.2	293.2
	Arroyo Del Macho	7.3	0	7.3
	Rio Hondo	123.4	0.1	123.4
	Salt Basin	30.7	0	30.7
	Tularosa Valley	111.5	0.1	111.7
	Upper Pecos-Black River	20.1		20.1
	Upper Montane Conifer / Willow	201.3	0.6	201.9
	Arroyo Del Macho	71.8		71.8
	Rio Hondo	98.2	0.6	98.8
	Salt Basin	31.3		31.3
	Willow - Thinleaf Alder	47.9	0.3	48.2
	Rio Hondo	7.6	0.3	8
	Tularosa Valley	40.2		40.2
Walnut-Evergreen Tree Group (WEG)	Arizona Walnut	15.5		15.5
	Tularosa Valley	15.5		15.5
	Little Walnut - Chinkapin Oak	301		301
	Upper Pecos-Black River	301		301
	Little Walnut - Ponderosa Pine	684.3	1	685.3
	Salt Basin	12.5		12.5
	Upper Pecos-Black River	671.7	1	672.7
Herbaceous Wetland (WET)	Herbaceous Wetland	431.7	3.1	434.8
	Rio Hondo	1.1	0.1	1.2
	Rio Peñasco	368.4	2.7	371.1
	Salt Basin	53		53
	Tularosa Valley	9.2	0.3	9.5
N/A	Historic Riparian - Agriculture	7.7	0.4	8.1
	Rio Peñasco	7.7	0.4	8.1
Grand Total		2,753.2	26.1	2,779.3

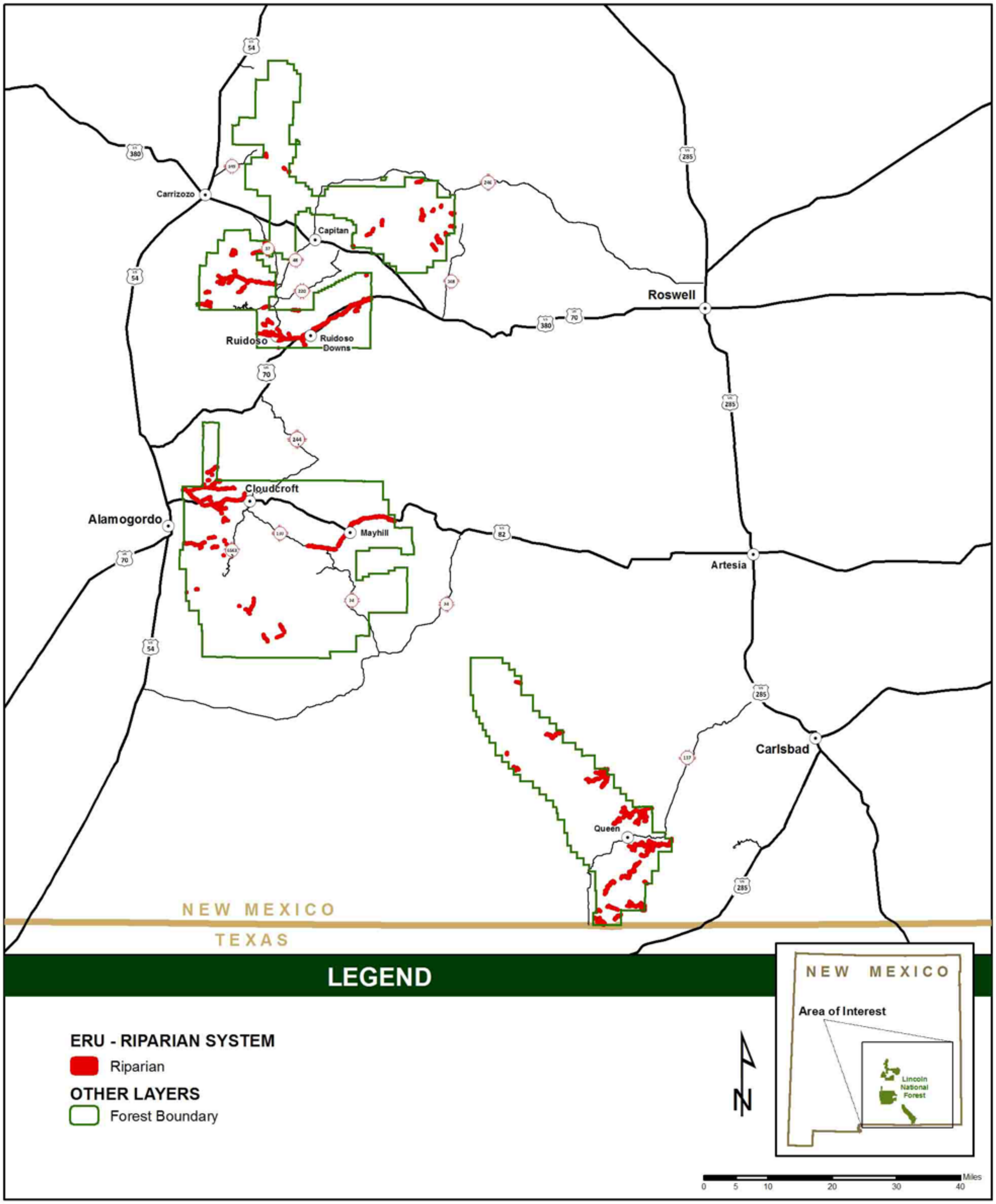

Figure 37. Riparian Ecological Response Units (ERU) for the Plan Area

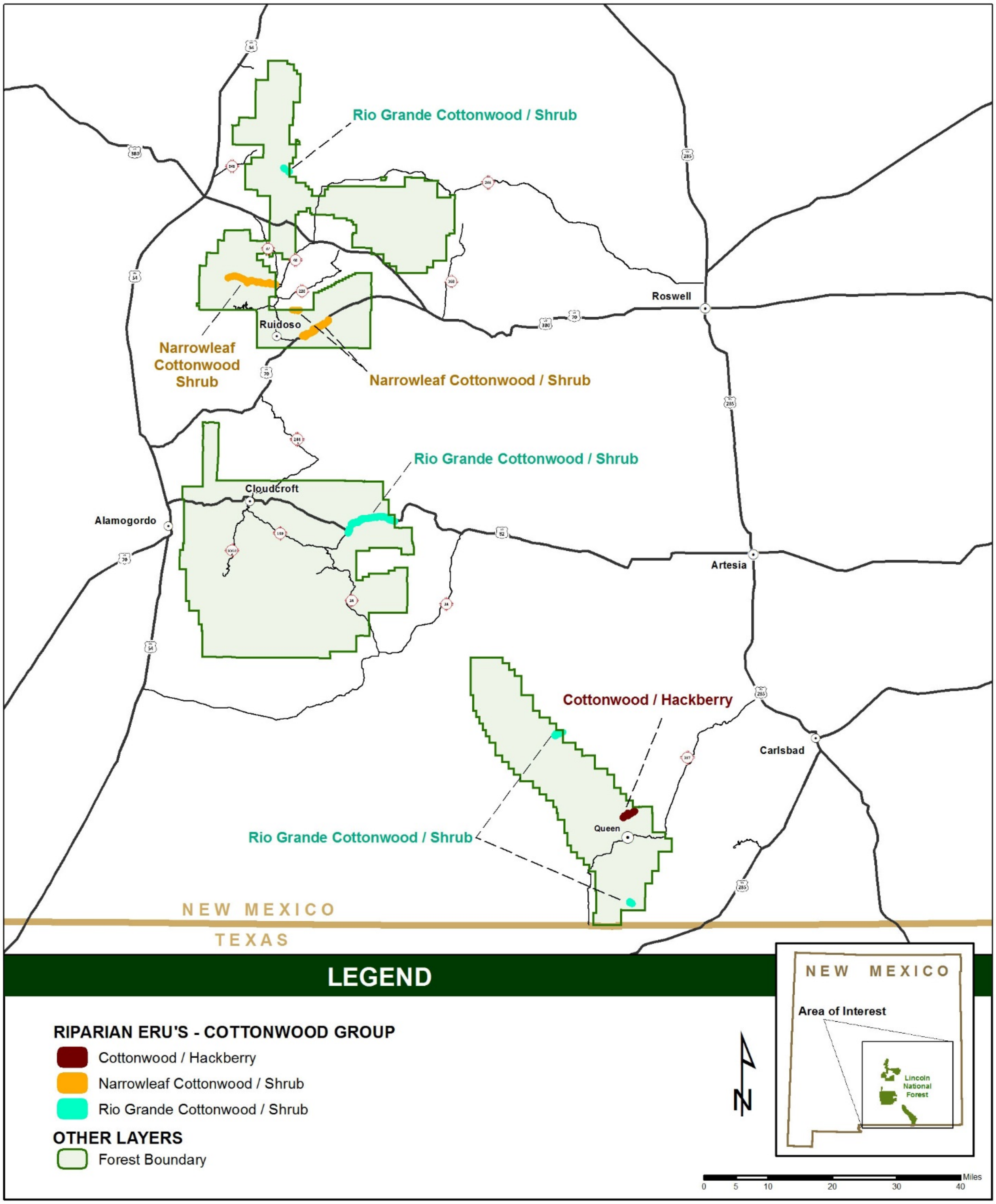

Figure 38. Cottonwood Group distribution within the Plan Area

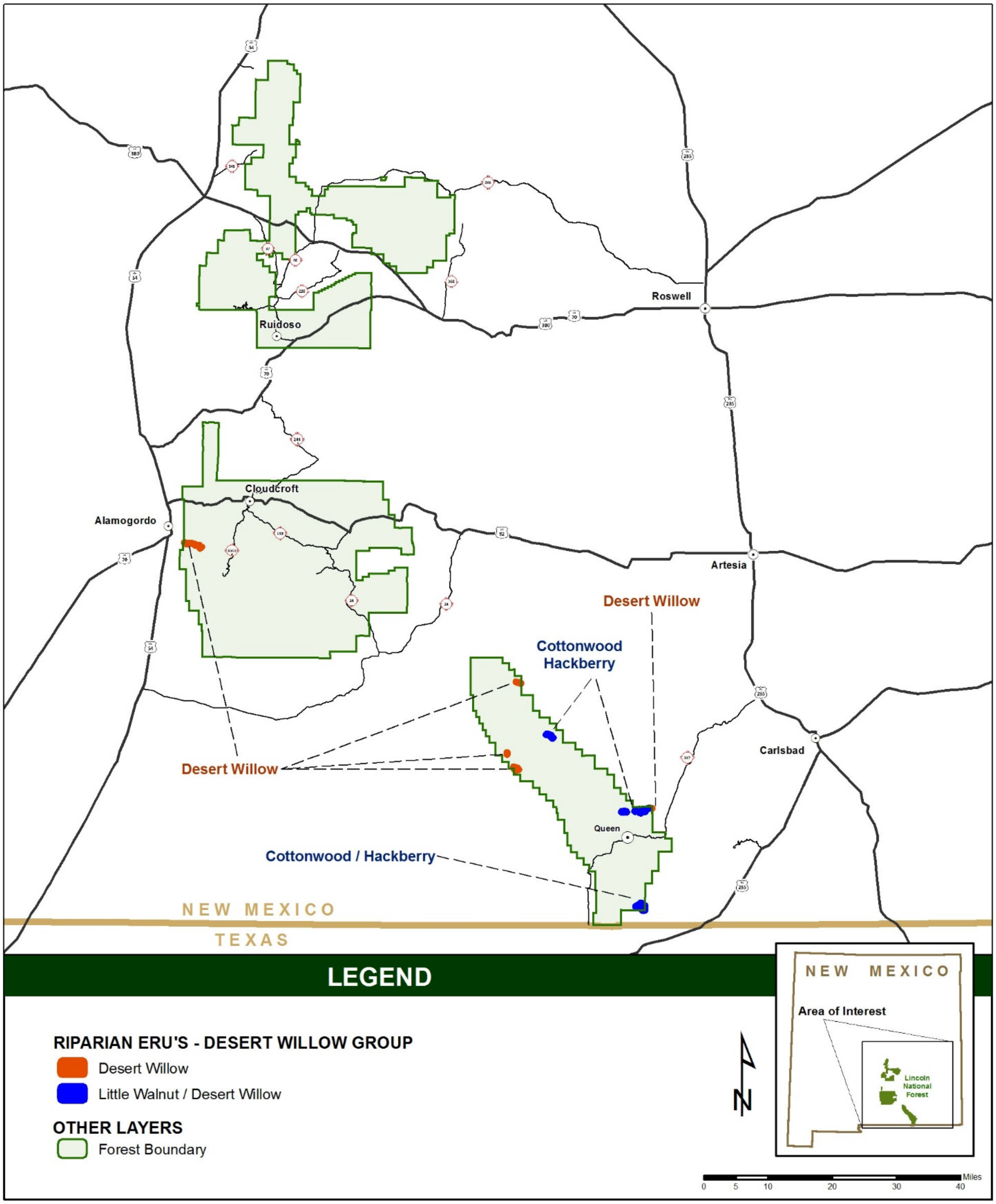

Figure 39. Desert Willow Group distribution within the Plan Area

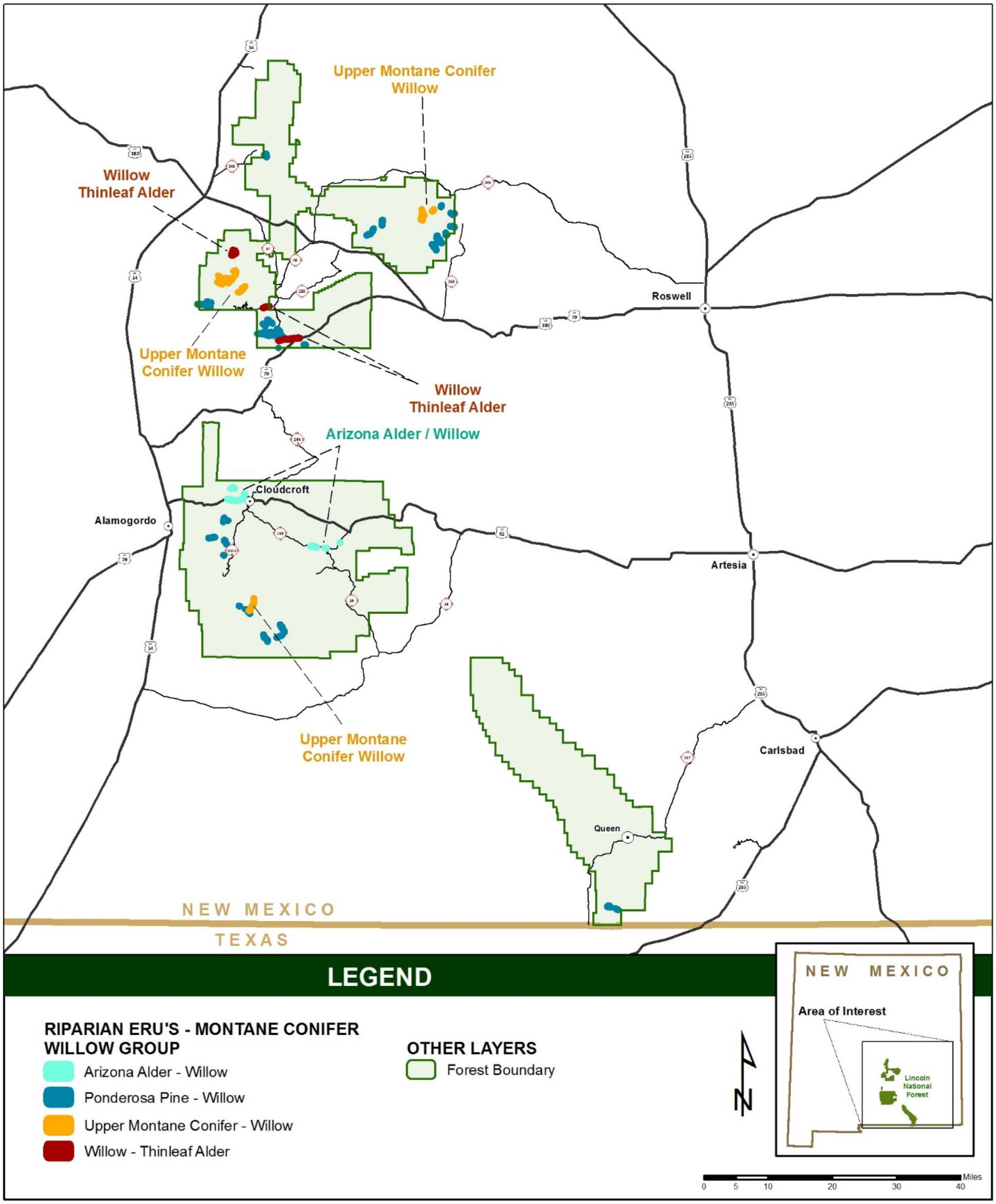

Figure 40. Montane Conifer Willow Group distribution within the Plan Area

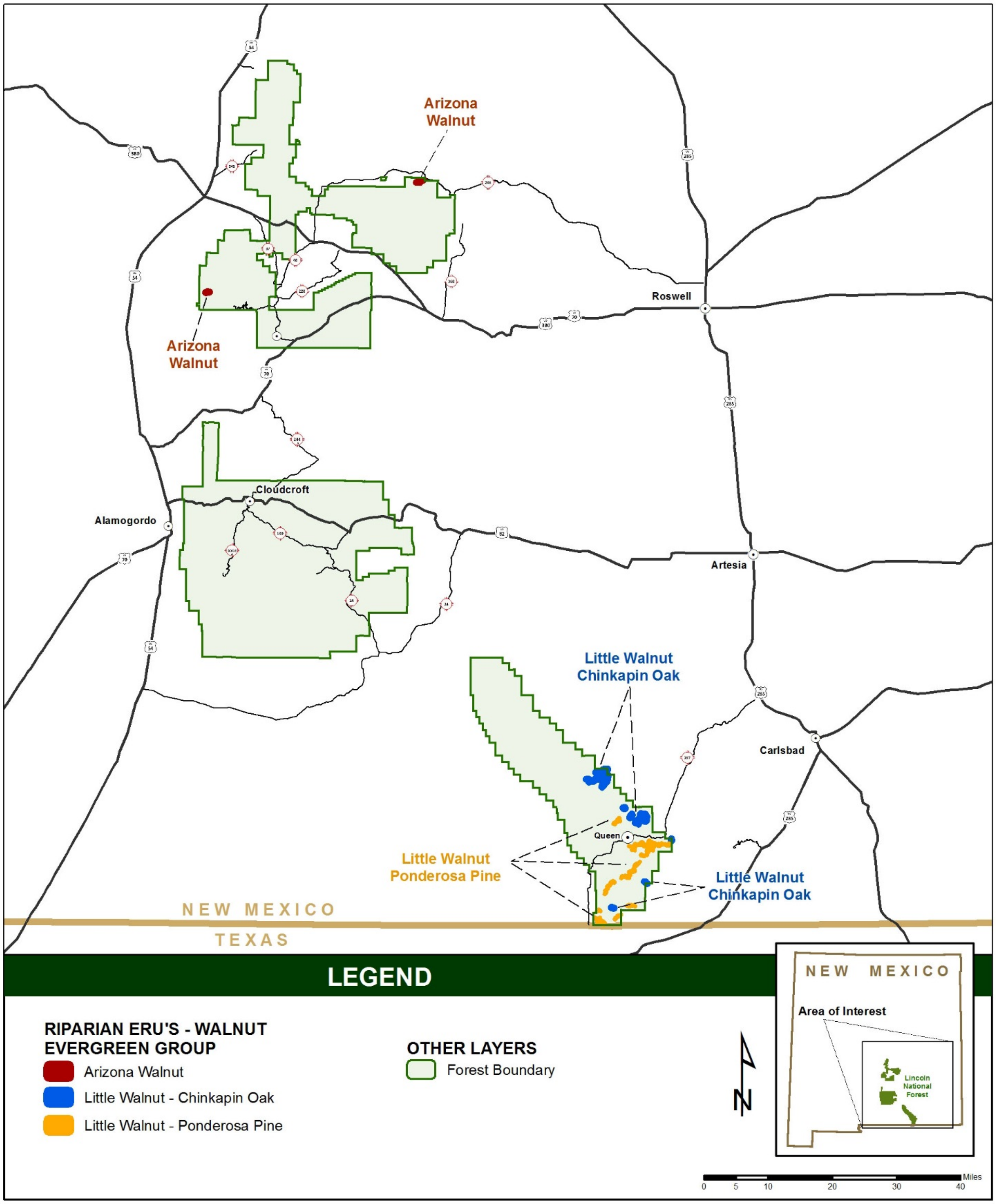

Figure 41. Walnut-Evergreen Tree Group distribution within the Plan Area

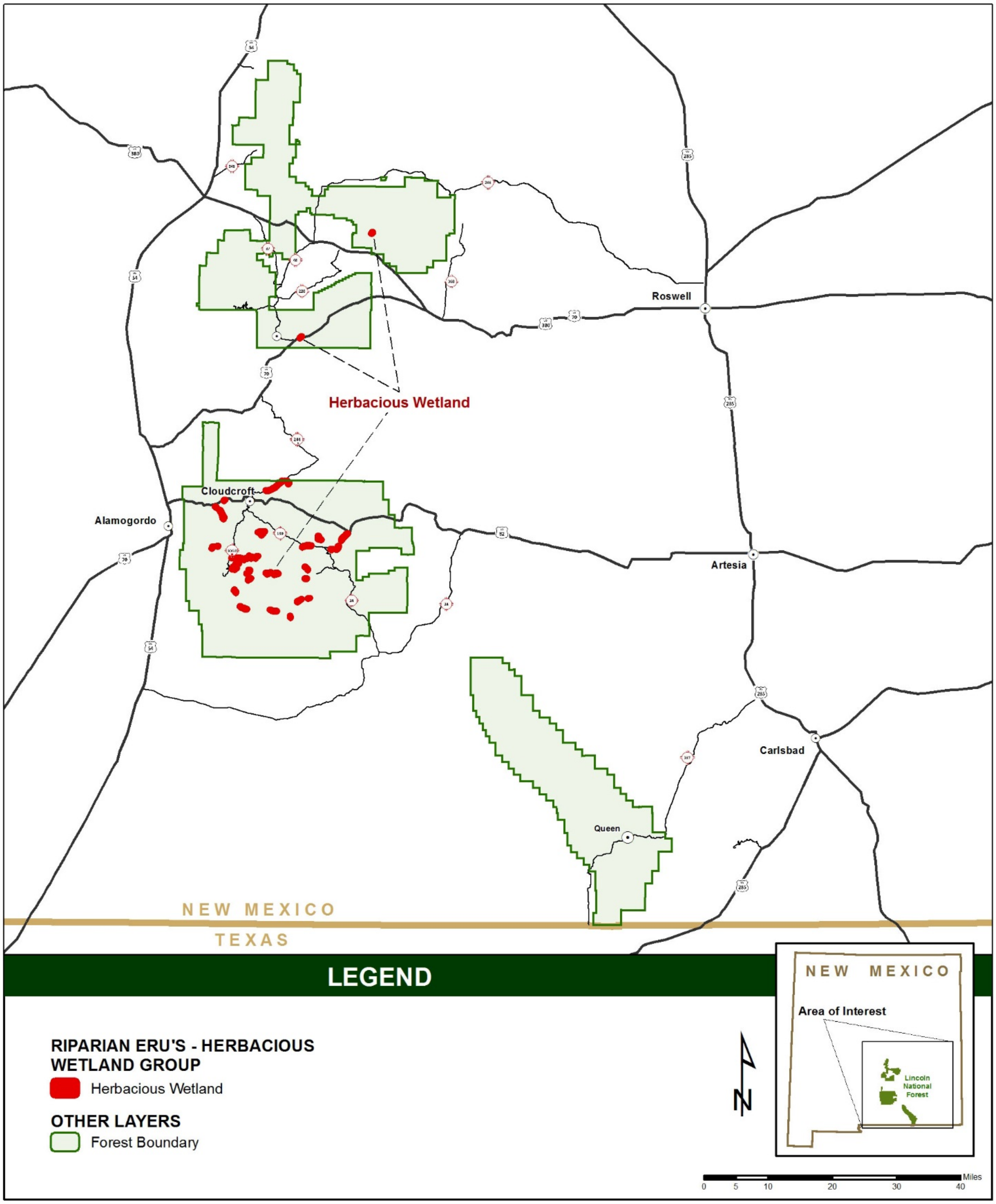

Figure 42. Herbaceous Wetland Group distribution within the Plan Area

Riparian ERU Distribution

Riparian Ecological Response Units (ERUs) on Lincoln NF comprise a small portion of the landscape, about 0.3 percent, the rest being in upland ERUs (Terrestrial Vegetation chapter). In the relatively arid landscapes on Lincoln NF, the riparian interface can be very abrupt. Additionally, many perennial streams on the Forest may have subsurface stretches where the 'riparian area' may look similar to, and respond to disturbances similarly to, the adjacent upland types. The Riparian ERU distribution for the Context Area and Plan Area (Lincoln NF) is shown in Table 104. The acres and percentages of each ERU are shown for both Context and Plan Areas. For each ERU in the Context, the portion falling within Lincoln NF is also shown.

Table 104. Riparian ERU acres for Lincoln NF and the Context Area

Riparian ERU Group	Riparian ERU	Context Area Acres	Context Acres %	Lincoln NF Acres	Lincoln NF Acres %	Lincoln % Context Area
CWG	Cottonwood / Hackberry	62	0.000	41	0.004	66%
CWG	Fremont Cottonwood / Shrub	102,179	0.309	218	0.020	0%
CWG	Narrowleaf Cottonwood / Shrub	2,105	0.006	64	0.006	3%
CWG	Rio Grande Cottonwood / Shrub	29,791	0.090	47	0.004	0%
DWG	Desert Willow	11,296	0.034	71	0.007	1%
DWG	Little Walnut / Desert Willow	364	0.001	325	0.030	89%
MCWG	Arizona Alder - Willow	511	0.002	46	0.004	9%
MCWG	Ponderosa Pine / Willow	1,076	0.003	298	0.027	28%
MCWG	Upper Montane Conifer / Willow	407	0.001	202	0.018	50%
MCWG	Willow - Thinleaf Alder	1,586	0.005	48	0.004	3%
WEG	Arizona Walnut	750	0.002	24	0.002	3%
WEG	Little Walnut - Chinkapin Oak	325	0.001	301	0.028	93%
WEG	Little Walnut - Ponderosa Pine	888	0.003	695	0.064	78%
WET	Herbaceous Wetland	115,294	0.348	435	0.040	0%
n/a	Historic Riparian - Agriculture	32,398	0.098	8	0.001	0%

Percentages of land area in riparian ERUs are low at both context and plan scales, as expected in an arid region. Five ERUs show high (50% or greater) percentages on the Lincoln NF relative to the Context Area: cottonwood/hackberry, little walnut-chinkapin oak, upper montane conifer/willow, (little walnut/desert willow, and little walnut-ponderosa pine. The little walnut-chinkapin oak, little walnut/desert willow and little walnut-ponderosa pine ERUs are found only in the Guadalupe Ranger District and adjacent lands. The LNF has roughly half the upper montane conifer/willow in the Context Area. Ponderosa pine/willow on the Lincoln NF makes up 28 percent of that ERU in the Context Area.

Riparian ERUs were also assigned to Local Units (Table 105), in order to assess the distribution of ecological characteristics among different parts of the Forest. This allows for highlighting areas in need, as an aid to development of future forest plan components where there is need for change. The local scale units are the same as for terrestrial ecosystem characteristics (Terrestrial Vegetation chapter). Fourth-level watersheds provide the local units for seral state proportion and fifth-level watersheds make up the local units for fire characteristics.

Table 105. Riparian ERU distribution at the local unit scale in acres and percent of occurrence on the Lincoln NF. Gray cells mean the ERU doesn't occur in that local unit.

Riparian ERU Group	Local Units	Arroyo del Macho		Rio Hondo		Rio Peñasco		Salt Basin		Tularosa Valley		Upper Pecos	
	Riparian ERUs	**Acres**	**% ERU**	**Acres**	**% ERU**	**Acres**	**% ERU**	**Acres**	**% ERU**	**Acres**	**% ERU**	**Acres**	**% ERU**
CWG	Cottonwood / Hackberry											40.8	100%
CWG	Fremont Cottonwood / Shrub			33.8	15%					184.4	85%		
CWG	Narrowleaf Cottonwood / Shrub			64	100%								
CWG	Rio Grande Cottonwood / Shrub	0.7	1%			15.2	33%					30.8	66%
DWG	Desert Willow							13.5	19%	35.9	50%	22	31%
DWG	Little Walnut / Desert Willow											324.5	100%
MCWG	Arizona Alder - Willow					0	0%			45.8	100%		
MCWG	Ponderosa Pine / Willow	7.3	2%	123.4	41%			30.7	10%	116.4	39%	20.1	7%
MCWG	Upper Montane Conifer / Willow	71.8	36%	98.8	49%			31.3	16%				
MCWG	Willow - Thinleaf Alder			8	17%					40.2	83%		
WEG	Arizona Walnut	8.6	36%							15.5	64%		
WEG	Little Walnut - Chinkapin Oak											301	100%
WEG	Little Walnut - Ponderosa Pine							12.5	2%			682.9	98%
WET	Herbaceous Wetland			1.2	0%	371.1	85%	53	12%	9.5	2%		
n/a	Historic Riparian - Agriculture					8.1	98%					0.1	2%
	Total Riparian	88.4		329.2		386.3		128.6		447.9		414.7	

Analysis and Findings-Riparian ERUs

Seral State Proportion

Departure of seral state proportions from reference seral state proportions was calculated for riparian ERUs in the same manner as for terrestrial vegetation seral state proportion. Individual ERUs were grouped for analysis and their grouping are shown in Table 103.

Methods and Results for Assessing Seral State Proportion

For each riparian ERU group, the reference and current Lincoln NF seral state proportions, and the overall departure of current seral state proportions from the reference proportions are shown in tables 85 though 89. Departure was moderate for the WET, DWG and MCWG groups, and low for the CWG and WEG groups, relative to reference conditions. The desert willow group (DWG) has more in early seral and closed shrub/small to medium tree states, and lacking in open forest and shrub states and late seral closed large tree states. The montane conifer willow (MCWG) group lacks early seral, and is over represented in shrub and tree (all size classes) state. Herbaceous wetland (WET) is lacking in early seral proportion. Results are discussed further by ERU groups in the following sections.

Fire Rotation, Severity and FRCC Analysis

Methods for Assessing Fire Rotation, Fire Severity and FRCC

Analysis of the fire characteristics (Fire Rotation, Severity and Fire Regime Condition Class [FRCC]) for riparian areas was done in a similar manner to the analysis for terrestrial vegetation (Terrestrial Vegetation chapter, FRCC section) at the Plan (Lincoln NF) and Local scales.

Fire Regime Condition Class is a measure of the combined vegetative and fire regime departure for an ERU. Vegetation departure (see seral state proportion departure, above) was calculated for the ERU groups, and applied to each ERU member of the group. Fire rotation and severity reference conditions for many upland ERUs were synthesized from various literature sources by Region 3 ecologists. Reference conditions were not developed for specific riparian ERUs. Recent work has suggested four scenarios of fire behavior for riparian areas (Dwire et al. 2016). In our part of the southwestern United States, two scenarios are likely: riparian areas burn like adjacent uplands, and riparian areas burn more frequently or more severely (or both) than adjacent Uplands. The first scenario is most likely to occur along stream reaches where the riparian vegetation, terrain, and general topography are similar to uplands. Stream reaches that drain shrub-dominated portions of drainage networks—such as shrub-steppe ecosystems throughout portions of the Great Basin or stream segments that drain the lower parts of stream networks in shallowly dissected terrain with low local relief—are likely to burn as frequently and severely as adjacent uplands. Other examples occur in the upper portions of drainages at high-to-moderate elevations in fairly steep terrain with steep stream valleys. This scenario could also occur when a large fire carries across the entire landscape and overwhelms both the influence of local topography and vegetation differences between riparian and upland areas.

The second scenario can occur where steep, narrow stream valleys funnel hot updrafts, fostering convective heating of the fire, thus causing it to carry up the canyon rapidly and with high intensity. This fire behavior is most likely to occur in the middle or upper portions of drainage networks with south-facing aspects, along small perennial or intermittent stream channels. This scenario is locally dependent on fuel characteristics, physical context, and the characteristics of a given fire event. This fire behavior likely occurs where riparian vegetation is either (1) similar to upland vegetation in stand- and understory-species composition, or (2) contains higher levels or denser fuel loads (particularly ladder fuels) than adjacent uplands. Although not well documented, riparian areas can also burn more severely in arid landscapes where frequent, low-intensity fires limit fuel buildup in uplands, while fuel accumulates in streamside areas. During periods of drought, differences in the riparian versus upland microclimate and fuel moisture might not be high enough to protect riparian vegetation from fire. This scenario is of particular concern for resource managers and fuels specialists in southwestern United States where woody encroachment into riparian areas has increased streamside fuel loads. For this analysis, the fire regime, particularly fire rotation, for riparian ERUs is assumed to be similar to the adjacent upland vegetation types, so reference conditions of the predominant adjacent ERUs were applied to Riparian ERUs at the local scale. Where multiple adjacent upland ERUs occurred, reference condition of the dominant upland ERU by area was used. Where dominance was questionable, the upland ERU reference condition that showed longer fire rotation periods was used.

Results for Fire Rotation, Fire Severity and FRCC

Summary results for fire rotation, severity and FRCC departure are shown at the Plan scale for all riparian ERU groups in Table 106, and for the separate groups and their member ERUs in the summaries for the ERU groups. Fire rotation departure, fire severity departure, and FRCC for local units are shown in the analysis and findings section for each ERU group in their respective sections. The CWG ERUs were nearly all highly departed for fire rotation and severity with the exception of Rio Grande Cottonwood/Shrub only moderately departed for rotation. FRCC was predominately moderate for the CWG as a group and for the individual ERUs. The DWG ERUs were also mostly moderately departed for FRCC, with the Desert Willow ERU highly departed for both rotation and severity, while the Little Walnut/Desert Willow ERU was not significantly departed (0-33 percent departure) for fire rotation and moderately departed for fire severity. ERUs in the MCWG group except Ponderosa Pine/Willow were highly departed for fire rotation. The Ponderosa Pine/Willow and Upper Montane Conifer/Willow ERUs were highly departed for fire severity, while departure for the Arizona Alder/Willow and Willow-Thinleaf Alder ERUs was not significant. FRCC was mostly in moderate for the MCWG group, although the Upper Montane Conifer/Willow ERU had more than half in the highly departed FRCC. In the WEG group, Little Walnut-Chinkapin Oak was not significantly departed for Fire Rotation, Severity or FRCC, while the Little Walnut-Ponderosa Pine ERU is moderately departed for rotation and FRCC, an highly departed for fire severity. Herbaceous wetland was moderately departed for all three measures.

Table 106. Summary table of Fire Regime Condition Class (FRCC), Fire Frequency and Fire Severity for the Ecological Response Units of the Lincoln NF at the Plan scale. Departure from reference conditions for Frequency and Severity is shown by color: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%). Departure in the moderate and high ranges is considered significant.

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (Years)	Severity % Mortality	I	II	III
CWG	Cottonwood / Hackberry	20	26%		100%	
CWG	Narrowleaf Cottonwood / Shrub	744	14%		100%	
CWG	Rio Grande Cottonwood / Shrub	1104	13%	56%	494%	
DWG	Desert Willow	1198	51%		100%	
DWG	Little Walnut / Desert Willow	555	49%	22%	78%	
MCWG	Arizona Alder / Willow	6168	13%		100%	
MCWG	Ponderosa Pine / Willow	7251	17%		100%	
MCWG	Upper Montane Conifer / Willow	26	18%		41%	59%
MCWG	Willow - Thinleaf Alder	2891	13%		100%	
WEG	Little Walnut - Chinkapin Oak	56	66%	100%		
WEG	Little Walnut - Ponderosa Pine	9112	13%		100%	

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (Years)	Severity % Mortality	I	II	III
WET	Herbaceous Wetland	7139	23%		100%	
n/a	Historic Riparian - Agriculture	173	15%		100%	

Riparian Ecological Response Unit Summaries

Cottonwood Group (CWG)

This group combines cottonwood-hackberry, Fremont cottonwood-shrub, narrowleaf cottonwood-shrub, and Rio Grande cottonwood-shrub riparian ERUs. Only about 370 acres occur on the Forest. The cottonwood-hackberry ERU occurs on the eastern slopes above the plains in the Upper Pecos local unit of Lincoln NF.

Typically found at elevations of 4,000 to 6,000 feet, the streamside vegetation includes cottonwood and willow species, while the floodplain terraces have higher concentrations of common hackberry (*Celtis occidentalis*). The invasive exotic, tamarisk, can be common.

Fremont Cottonwood/Shrub is found throughout the region (except Carson and Santa Fe NFs) at elevations ranging from 1,000 to 7,600 feet. This ERU contains Fremont cottonwood, willow species, boxelder and desert willow. Some areas in this type are an ash-willow community that supports cottonwood regeneration. Lanceleaf cottonwood, a hybrid between Fremont and narrowleaf cottonwoods, may occur in areas transitional to narrowleaf cottonwood type.

Narrowleaf Cottonwood/Shrub is found throughout the region (except the Prescott and Kaibab NFs). It is typically found at elevations ranging from 1,900 to 10,000 feet. Vegetation includes narrowleaf cottonwood, boxelder, willow species, Arizona alder, and Arizona walnut. Lanceleaf cottonwood may occur in areas transitional to Fremont cottonwood type.

Rio Grande Cottonwood/Shrub occurs on the Carson, Cibola and Santa Fe NFs as well as the Lincoln, at elevations ranging from 3,300 to 8,500 feet. It is similar to the Fremont cottonwood/shrub ERU, the main distinguishing difference is Rio Grande cottonwood instead of Fremont. Multiple willow species occur, the most common being narrowleaf willow.

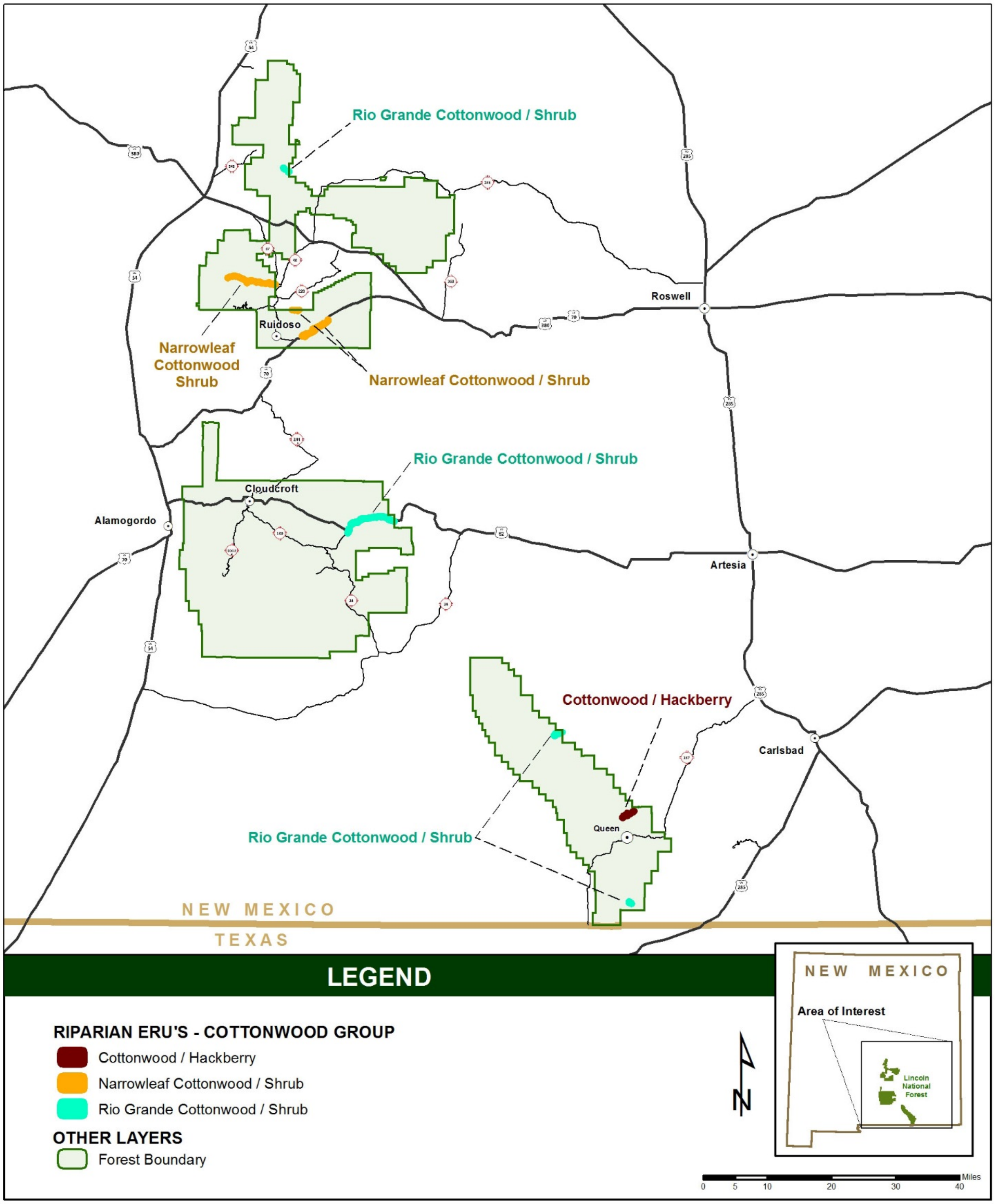

Figure 43. Distribution of Cottonwood Group ERUs on the Lincoln NF.

Seral State Proportion

The Cottonwood group of riparian ERUs shows low departure for seral state proportion (28 percent, Table 107, Figure 44) at the plan scale. Currently, upland dominance types and exotic vegetation (state D) differ little from reference condition, and late seral stage (state C) with native trees having more than 25 percent cover is only slightly less than reference. Currently the early developmental stage of sparsely vegetated, recently burned, or otherwise low shrub or tree cover, is nearly twice as abundant on the landscape as in reference condition, while the mid-developmental state B of native trees (less than 25 percent cover) and shrubs (greater than 25 percent cover) is only half that of reference values. Grazing and recreation are the only managed activites occurring in this ERU. While overgrazing could have impacted recruitment of trees or shrubs post disturbance, it is more likely that the recent fire and flood events are the source of departure of this group.

Table 107. Cottonwood ERU group current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Cottonwood Group	Reference	Current
A	Early development, open: recently burned, sparsely vegetated, shrub cover less than 25%, trees less than 5 in. dbh all cover,	0.25	0.46
B	Mid development, open: native shrub and tree dominance types, shrub cover greater than 25%, trees greater than 5 inches dbh, less than 25% cover	0.50	0.28
C	Late development, closed: native tree dominance types, greater than 5 inches dbh, greater than 25% cover.	0.25	0.20
D	Upland dominance types and exotic vegetation	0.00	0.07
Departure		28%	

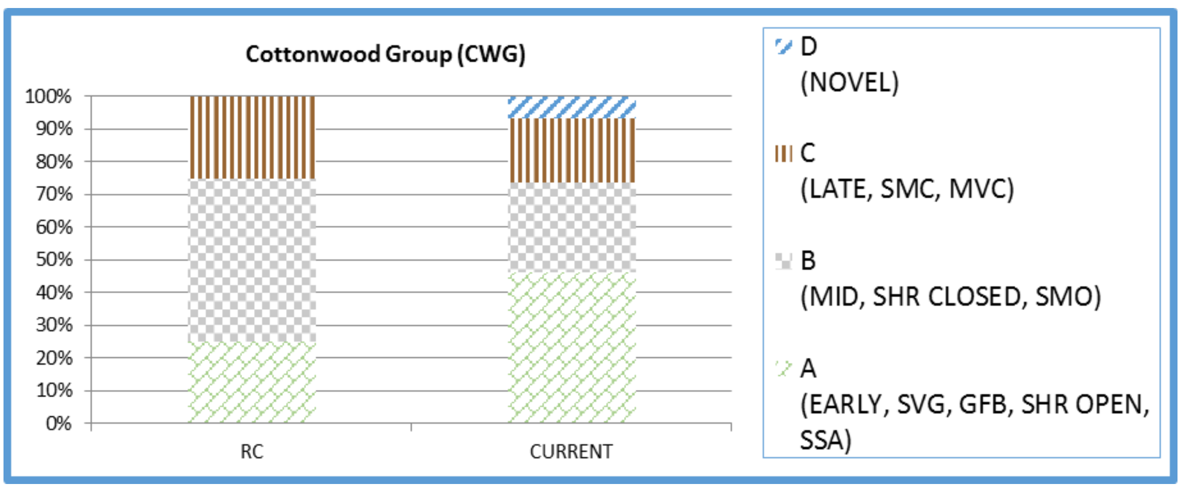

Figure 44. Seral state percentages for Cottonwood Group

Fire frequency, severity and FRCC

At the Plan scale, The CWG ERUs were nearly all highly departed for fire rotation and severity with the exception of Rio Grande Cottonwood/Shrub only moderately departed for rotation. FRCC was predominately moderate for the CWG as a group and for the individual ERUs. At the local scale individual ERUs in the CWG group had fire rotations ranging from 11 to 442 years, and fire severity from 13 to 78 percent (Table 86). Fire appears to return relatively frequently, but with high severity. This may relate to CWG being somewhat departed for seral state, with the early seral state dominating. Fire regime condition class is moderately departed in general for the group, more due to fire rotation and severity departure than seral state which is not significantly departed. High severity fires in the recent past may account for the current amount of early seral state A nearly double the reference value. Fire suppression and higher fuel accumulations may have contributed to high severity fire in the CWG, as has been noted elsewhere in the Southwest (Dwire et al. 2011).

Table 108. Fire interval (years), severity (% mortality) and condition class (FRCC) at the Plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (years)	**Severity (%)**	I	II	III
CWG	Cottonwood / Hackberry	20	26%		100%	
CWG	Narrowleaf Cottonwood / Shrub	44	14%		100%	
CWG	Rio Grande Cottonwood / Shrub	104	13%	6%	94%	

Table 109. Fire frequency, severity and FRCC for Cottonwood Group. Fire frequency is years for number of acres in ERU to burn; severity is average percent canopy mortality and FRCC is mean condition class for the ERU. Blank Cells mean no data for those local units.

CWG ERU Group	**Riparian ERU \ Local Unit >>**	Agua Chiquita	Blackwater Cyn	Dark Cyn	Rio Peñasco	Reventon Draw	Rio Bonito	Rio Ruidoso	Upper Pecos North	Upper Pecos South
Fire Rotation (years)	Cottonwood / Hackberry									20
	Narrowleaf Cottonwood / Shrub						24	442		
	Rio Grande Cottonwood / Shrub				182				11	
Fire Severity	Cottonwood / Hackberry									78%
	Narrowleaf Cottonwood / Shrub						58%	64%		
	Rio Grande Cottonwood / Shrub				64%				13%	
FRCC	Cottonwood / Hackberry									II
	Narrowleaf Cottonwood / Shrub						II	II		
	Rio Grande Cottonwood / Shrub				II				I	

Desert Willow Group (DWG)

This group includes desert willow and little walnut/desert willow riparian ERUs. Approximately 396 acres occur on the Forest.

Desert willow is found throughout the region on the Cibola, Coconino, Coronado, Gila, Prescott, Tonto and Lincoln NFs. Found at elevations ranging from 1,300 to 6,900 feet, often along ephemeral and drier reaches of interrupted alluvial channels, the vegetation is comprised of desert willow, along with netleaf hackberry and velvet mesquite.

Little walnut/desert willow only occurs on the Guadalupe RD of Lincoln NF and surrounding areas. It is typically found at elevations ranging from 4,500 to 5,600 feet. Velvet mesquite is also found in this ERU.

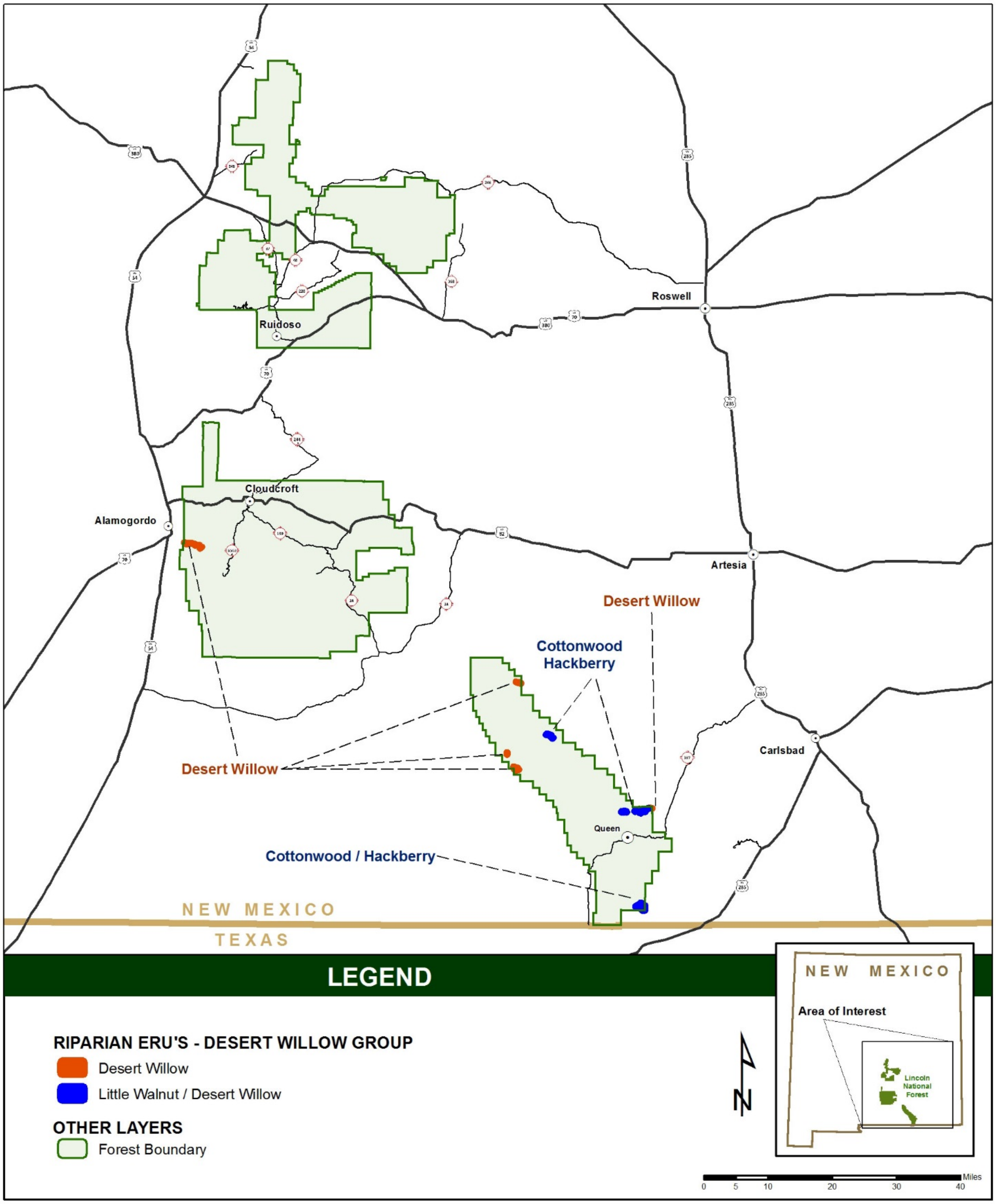

Figure 45. Distribution of Desert Willow group ERUs on the Lincoln NF

Seral State Proportion

The Desert Willow group is moderately departed at the plan scale for seral state proportion (53 percent, Table 110, Figure 46). Upland dominance types and exotic vegetation (state F) differ little from reference condition, and late seral stage (state E) of native trees with greater than 25 percent cover is only slightly less than reference. Mid- and late-seral open states (C and D) are much less abundant than reference conditions while early seral (state A) and mid-seral closed states (B) are much more abundant than reference. Grazing and recreation are the only managed activites occurring in this ERU.

Table 110. Desert Willow ERU Group current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Desert Willow Group	Reference	Current
A	Early development, open: recently burned, sparsely vegetated, herbaceous dominance types, less than 10% shrubs, 10% trees.	0.20	0.32
B	Mid-development, closed: native tree and shrub dominance types, shrubs all sizes, 25-60% cover; trees less than 5 inches dbh, cover greater than 25%	0.15	0.56
C	Mid-development, open: native tree and shrub dominance types, all size shrubs less than 25% cover, trees less than 5 inches dbh less than 5% cover	0.40	0.10
D	Late development, open: native tree dominance types, size greater than 5 inches dbh, less than 50% cover	0.20	0.01
E	Late development, closed: native tree and shrub dominance types, shrub and trees (>5 inches) cover greater than 50%	0.05	0.00
F	Upland dominance types and exotic vegetation	0.00	0.01
Departure		53%	

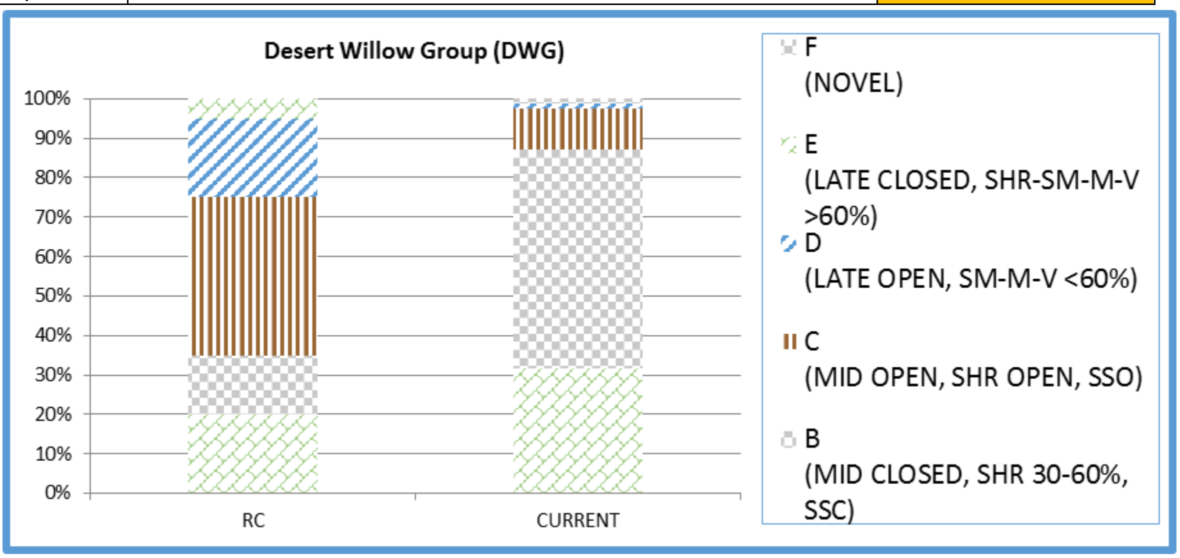

Figure 46. Seral state percentages for Desert Willow Group

Fire frequency, severity and FRCC

Fire regime is moderately departed for the Desert Willow group of riparian ERUs (Table 111 and Table 112) at the Plan scale. The DWG ERUs were mostly moderately departed for FRCC, with the Desert Willow ERU highly departed for both rotation and severity, while the Little Walnut/Desert Willow ERU was not significantly departed (0-33 percent departure) for fire rotation and moderately departed for fire severity. Fire severity and rotation is highly departed for the Desert Willow ERU, while fire regime condition class is moderate. The Little Walnut/Desert Willow ERU has low departure in the Upper Pecos North local unit but is highly departed in the Upper Pecos South unit, even though they show the same mean rotation. This is a function of assuming the adjacent upland ERU fire regime for determining local departure.Fire severity departure is low for the Little Walnut/Desert Willow ERU in both local units, although severity differs greatly, again from assuming local upland fire regimes. Fire regime condition class is moderately departed in general for the group, a function of seral state departure. The DWG group was moderately departed for seral state departure, with the shrubby-small tree closed state B over-represented. Depending on the adjacent upland ERUs, fire may not occur often or carry from the upland into riparian, but seral state departure (increased woody vegetation) in DWG may provide the potential for higher severity fires.

Table 111. Fire interval (years), severity (% mortality) and condition class (FRCC) at the Plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (years)	Severity (%)	I	II	III
DWG	Desert Willow	198	51%		100%	
DWG	Little Walnut / Desert Willow	55	49%	22%	78%	

Table 112. Fire frequency, severity and FRCC for Desert Willow Group. Fire frequency is years for number of acres in ERU to burn; severity is average percent canopy mortality and FRCC is mean condition class for the ERU. Blank Cells mean no data for those local units.

DWG ERU Group	Riparian ERU \ Local Unit >>	Agua Chiquita	Blackwater Cyn	Dark Cyn	Rio Peñasco	Reventon Draw	Rio Bonito	Rio Ruidoso	Upper Pecos North	Upper Pecos South
Fire Rotation (years)	Desert Willow									20
	Little Walnut / Desert Willow								19	20
Fire Severity	Desert Willow									51%
	Little Walnut / Desert Willow								13%	760%
FRCC	Desert Willow									II
	Little Walnut / Desert Willow								I	II

Montane Conifer Willow Group (MCWG)

This group includes Arizona alder-willow, upper montane conifer/willow, willow-thinleaf alder, and ponderosa pine/willow riparian ERUs. Approximately 296 acres occur on the Forest.

Arizona alder- willow is found throughout the region (except Carson and Santa Fe NFs) at elevations ranging from 3,330 – 9,900 feet. While both Arizona alder and willow species are indicative of this unit, some areas of may contain only one species or the other. Common willow species include red willow (*Salix laevigata*) and arroyo willow (*S. lasiolepsis*). Other riparian species commonly found include Arizona walnut, velvet ash, and Rocky Mountain maple (*Acer glabrum*).

Upper montane conifer/willow is found throughout the Region except on the Prescott and Tonto NFs. Typically found at elevations ranging from 6,100–11,400 feet, common conifer species include spruce, subalpine fir, white fir and Douglas-fir. Quaking aspen (*Populus tremuloides*) can be present to codominant. Other riparian species commonly found include thinleaf alder and boxelder.

Willow-thinleaf alder occurs on the Apache-Sitgreaves, Carson, Cibola, Coconino, Gila, and Santa Fe NFs, as well as the Lincoln, at elevations ranging from 5,400–11,900 feet. While both thinleaf alder and willow species are indicative of this unit, some locations may contain only one species or the other. This ERU frequently occurs in wet drainages associated with ponderosa pine and mixed conifer forests. Common willow species include dewystem willow (*Salix irrorata*), Drummond's willow (*S. drummondiana*), park willow (*S. monticola*) and grayleaf willow (*S. glauca*).

Ponderosa pine/willow occurs throughout the Region. Found at elevations ranging from 4,500-9,700 feet, it is typified by an overstory of ponderosa pine with an understory of shrub-form willow species. Other riparian species commonly found include Arizona walnut (*Juglans major*), boxelder (*Acer negundo*) and velvet ash (*Fraxinus velutina*).

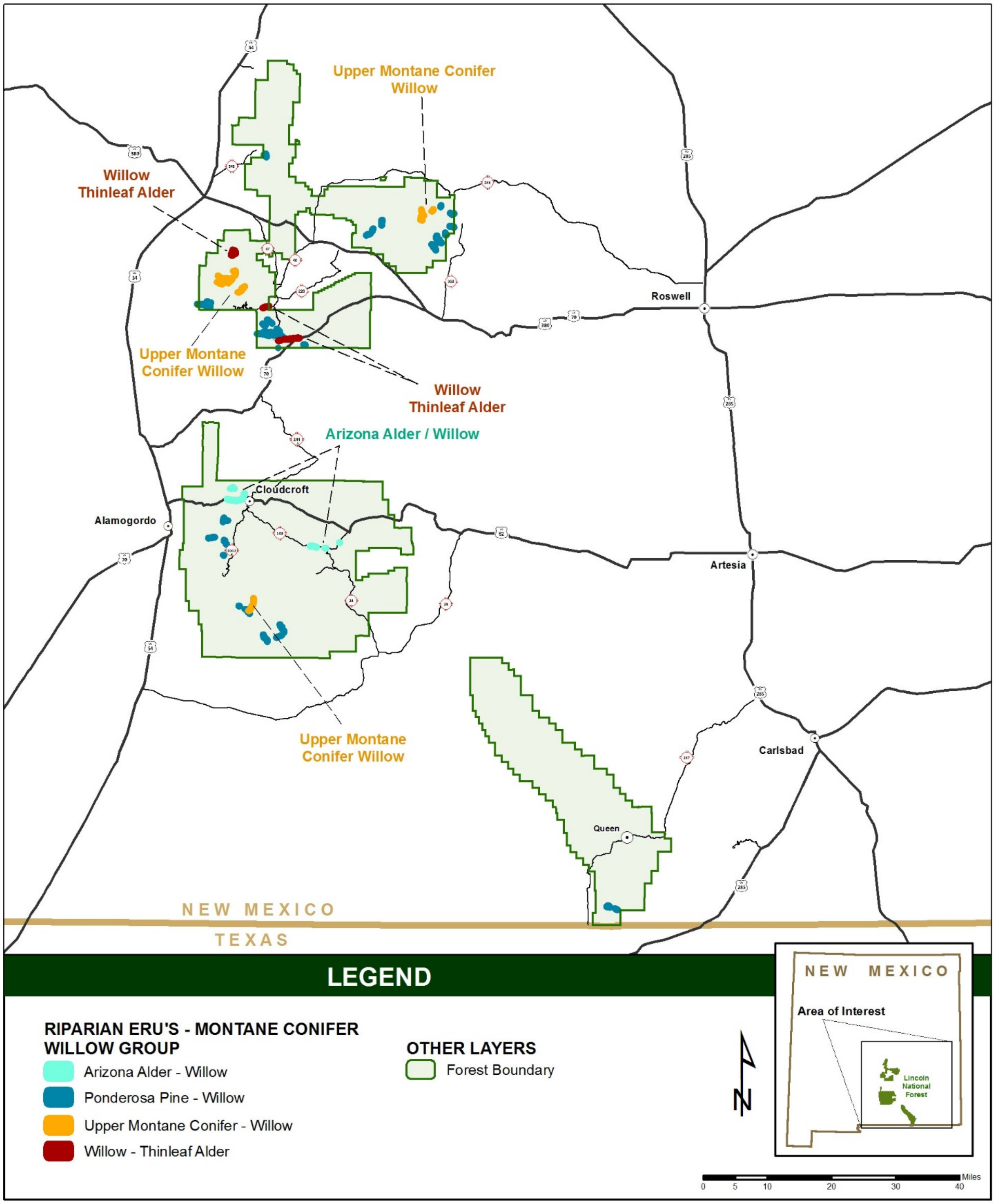

Figure 47. Distribution of Montane Conifer Willow group ERUs on the Lincoln NF

Seral State Proportion

The Montane-Conifer Willow group is moderately departed at the plan scale for seral state proportion (54 percent, Table 113). Upland dominance types and exotic vegetation (state C) is more abundant than reference although still low, but the mid-development stage B is much more abundant than reference (75 percent versus 35 percent, respectively). Conversely, the early seral state A is much less abundant than reference. The ERUs that make up this type span much of the elevational gradient within a number of upland ERUs of the forest, so it is possible that fire suppression may have the effect of maintaining closed tree and shrub states without resetting to early seral states. Grazing and recreation are the only managed activites occurring in this ERU.

Table 113. Montane-Conifer Willow ERU group current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Montane-Conifer Willow Group	Reference	Current
A	Early development: recently burned, all herbaceous, shrub and tree dominance types, shrubs less than 25% cover, trees (all cover, less than 5 inches dbh.	0.65	0.11
B	Mid-closed: all tree, shrub dominance types; shrub cover greater than 25%, tree size greater than 5 inches dbh, all cover.	0.35	0.75
C	Upland dominance types and exotic vegetation	0.00	0.14
Departure		54%	

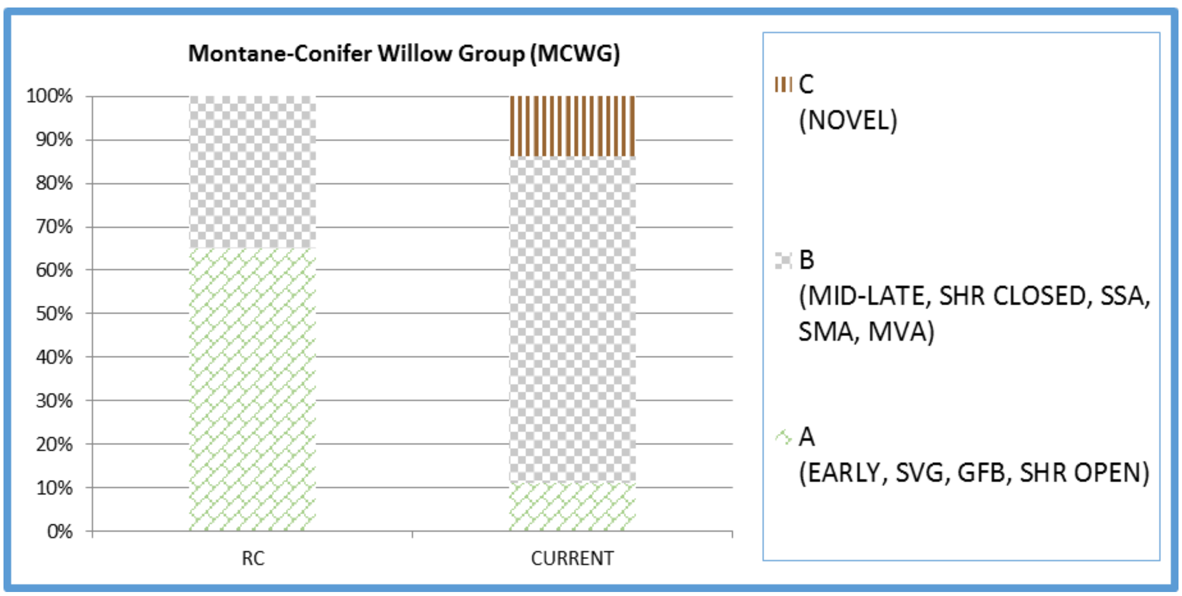

Figure 48. Seral state percentages for Montane-Conifer Willow Group

Fire frequency, severity and FRCC

All ERUs in the MCWG group except Ponderosa Pine/Willow were highly departed for fire rotation except Ponderosa Pine/Willow, which was not significantly departed. The Ponderosa Pine/Willow and Upper Montane Conifer/Willow ERUs are highly departed for fire severity, while departure for the Arizona Alder/Willow and Willow-Thinleaf Alder ERUs is not significant. FRCC is mostly in moderate for the MCWG group, although more than half the Upper Montane Conifer/Willow ERU is in the highly departed FRCC. The four individual ERUs that make up the group range from 20 to 682 years for fire rotation and from 13-21 percent fire severity. These are generally more mesic, higher elevation types that may have characteristically had higher rotations and lower severity depending on adjacent upland ERUs and structural (seral state) departure. None of the individual ERUs have high departure values for fire severity (values were 0 to 30 percent, conventionally considered low). At the Local scale, the Willow-Thinleaf Alder ERU in Rio Ruidoso has the highest fire rotation of 682 years, while the Upper Montane Conifer/Willow in Reventon Draw has the shortest at 20 years. This may be reflective of the fire regimes in the adjacent upland ERUs, and recent fire history on the Forest. For example, upper montane conifer/willow appears to be more often associated with the frequent fire mixed conifer ERU (MCD), and the Willow-Thinleaf Alder more often associated with the wetter mixed conifer-aspen ERU (MCW), although those associations are not documented. It is reasonable to expect these types to have a relatively high value for fire rotation and low value for fire severity, as found for MCWG overall.

Table 114. Fire interval (years), severity (% mortality) and condition class (FRCC) for riparian ERUs at the Plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (years)	Severity (%)	I	II	III
MCWG	Arizona Alder / Willow	168	13%		100%	
MCWG	Ponderosa Pine / Willow	251	17%		100%	
MCWG	Upper Montane Conifer / Willow	26	18%		42%	58%
MCWG	Willow - Thinleaf Alder	891	13%		100%	

Table 115. Fire frequency, severity and FRCC for Montane Conifer Willow Group. Fire frequency is years for number of acres in ERU to burn; severity is average percent canopy mortality and FRCC is mean condition class for the ERU. Blank Cells mean no data for those local units.

MCWG ERU Group	Riparian ERU \ Local Unit >>	Agua Chiquita	Blackwater Cyn	Dark Cyn	Rio Peñasco	Revento n Draw	Rio Bonito	Rio Ruidoso	Upper Pecos North	Upper Pecos South
Fire Rotation (years)	Arizona Alder / Willow				30					
	Ponderosa Pine / Willow		91			55				
	Upper Montane Conifer / Willow					20	24			
	Willow - Thinleaf Alder							682		
Fire Severity	Arizona Alder / Willow				13%					
	Ponderosa Pine / Willow		14%			113%				
	Upper Montane Conifer / Willow					121%	515%			
	Willow - Thinleaf Alder							13%		
FRCC	Arizona Alder / Willow				II					
	Ponderosa Pine / Willow		II			II				
	Upper Montane Conifer / Willow					II	III			
	Willow - Thinleaf Alder							II		

Walnut-Evergreen Tree Group (WEG)

This group includes Arizona walnut, little walnut/chinkapin oak, and little walnut/ponderosa pine riparian ERUs. Approximately 1,319 acres occur on the Forest.

Arizona walnut is found throughout the region (except Carson and Santa Fe NFs) at elevations ranging from 4,000 to 8,300 feet, typically within mild climate gradients of central Arizona, southeastern Arizona, and southwestern New Mexico. This highly diverse unit tends to occur in dryer drainages than other riparian types and often also includes species such as willows, boxelder (*Acer negundo*), ponderosa pine (*Pinus ponderosa var.* scopulorum), piñon pines, juniper, and various species of oak.

Little walnut/chinkapin oak occurs only on the Guadalupe Ranger District of the Lincoln NF and surrounding areas. This ERU is typically found at elevations ranging from 4,600 to 5,500 feet and commonly includes willow species.

Little walnut/ponderosa pine is only found in the Guadalupe Ranger District of the Lincoln NF. It is typically found at elevations ranging from 5,000 - 6,800 feet. Boxelder (*Acer negundo*) and bigtooth maple (*Acer grandidentatum*) are also commonly found.

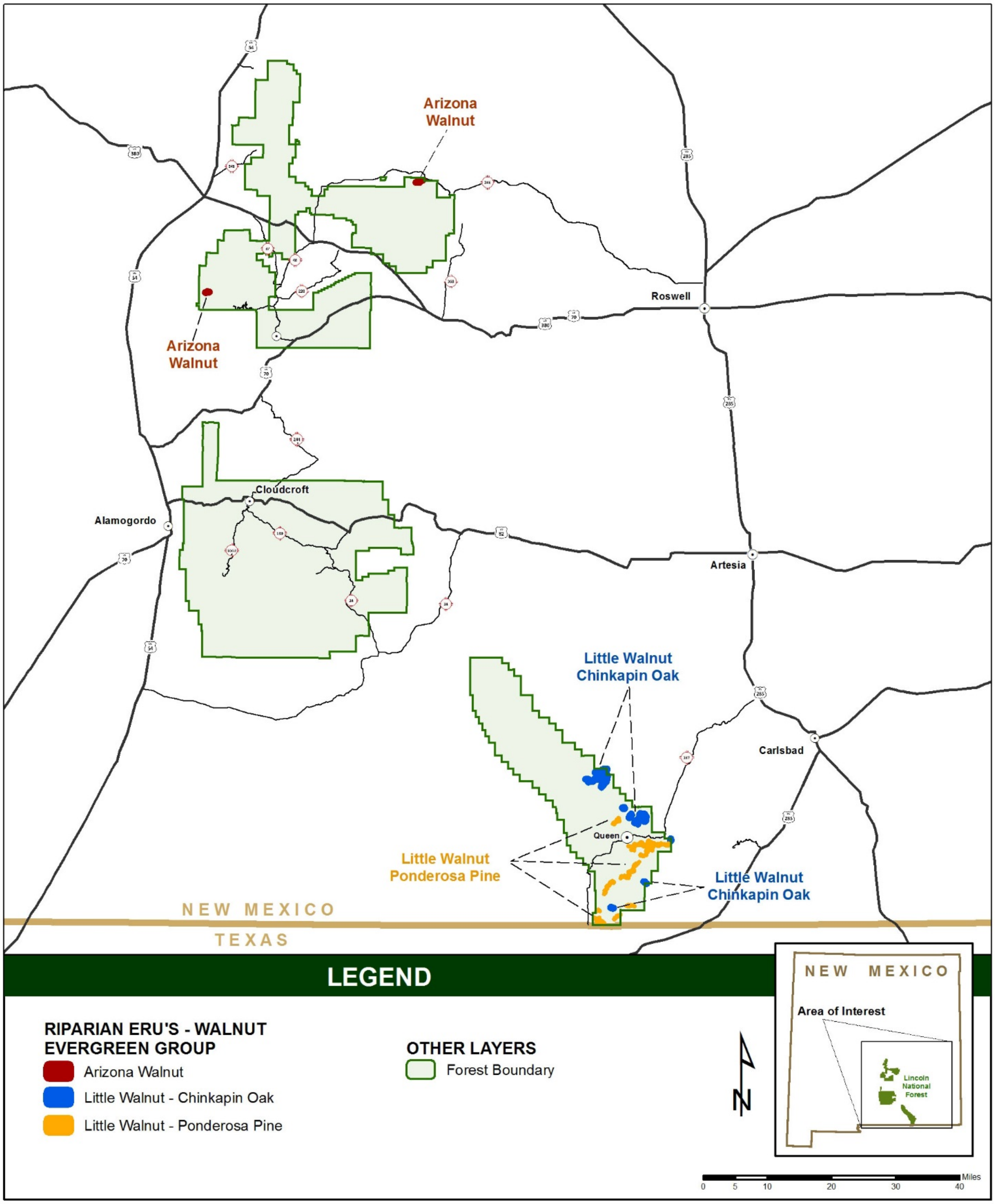

Figure 49. Distribution of Walnut Evergreen group ERUs on the Lincoln NF

Seral State Proportion

The Walnut-Evergreen Tree group shows low departure of 27 percent from reference condition (Upland dominance types and exotic vegetation differ little from reference condition (state D), and late seral stage (state C) of native trees with greater than 25 percent cover is only slightly more than reference. Currently the early developmental stage of sparsely vegetated, recently burned, or otherwise low shrub or tree cover (state A), is nearly twice as abundant on the landscape as in reference condition, while the mid-developmental state (state B), of native trees (less than 25 percent cover) and shrubs (greater than 25 percent cover) is only half that of reference values. Grazing and recreation are the only managed activites occurring in this ERU. While overgrazing could have impacted recruitment of trees or shrubs post disturbance, it is more likely that fire and flood events are the source of departure of this group.

Table 116 and Figure 50). Upland dominance types and exotic vegetation differ little from reference condition (state D), and late seral stage (state C) of native trees with greater than 25 percent cover is only slightly more than reference. Currently the early developmental stage of sparsely vegetated, recently burned, or otherwise low shrub or tree cover (state A), is nearly twice as abundant on the landscape as in reference condition, while the mid-developmental state (state B), of native trees (less than 25 percent cover) and shrubs (greater than 25 percent cover) is only half that of reference values. Grazing and recreation are the only managed activites occurring in this ERU. While overgrazing could have impacted recruitment of trees or shrubs post disturbance, it is more likely that fire and flood events are the source of departure of this group.

Table 116. Walnut-Evergreen Tree Group ERU group current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Walnut-Evergreen Tree Group	Reference	Current
A	Early development: recently burned, all herbaceous, shrub and tree dominance types, shrubs less than 25% cover, trees (all cover, less than 5 inches dbh.	0.25	0.47
B	Mid development, open: native shrub and tree dominance types, shrub cover greater than 25%, trees greater than 5 inches dbh, less than 25% cover	0.50	0.23
C	Late development, closed: native tree dominance types, greater than 5 inches dbh, greater than 25% cover.	0.25	0.27
D	Upland dominance types and exotic vegetation	0.00	0.03
Departure		27%	

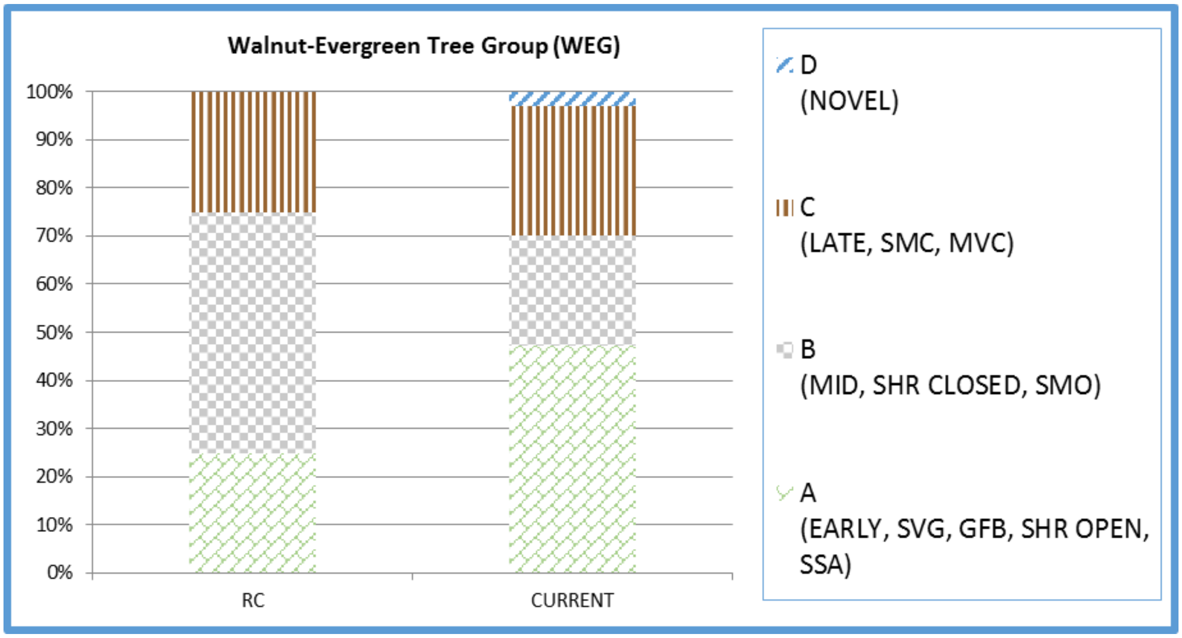

Figure 50. Seral state percentages for Walnut Evergreen Tree Group

Fire frequency, severity and FRCC

In the WEG group, Little Walnut-Chinkapin Oak is not significantly departed for Fire Rotation, Severity or FRCC, while the Little Walnut-Ponderosa Pine ERU is moderately departed for rotation and FRCC, and highly departed for fire severity. Of the three individual ERUs in the group, two occur only in the Guadalupe Mountains. The third, Arizona Walnut, had no acres burned in the time period 1996-2015, and is not shown in the table. Fire rotation is probably reflective of adjacent upland ERU fire behavior, as severity may also be. For example, at the plan scale the Little Walnut- Chinkapin Oak ERU has a fire severity of 66 percent while Little Walnut-Ponderosa Pine has a severity of only 13 percent, even though rotation is 56 and 112 years for the respective ERUs. The expectation could be that longer rotations would encourage higher severity through accumulation of fuels, but that does not appear to be the case here.

Table 117. Fire interval (years), severity (% mortality) and condition class (FRCC) at the Plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (years)	Severity (%)	I	II	III
WEG	Little Walnut - Chinkapin Oak	56	66%	100%		
WEG	Little Walnut - Ponderosa Pine	112	13%		100%	

Table 118. Fire frequency, severity and FRCC for Walnut Evergreen Tree Group. Fire frequency is years for number of acres in ERU to burn; severity is average percent canopy mortality and FRCC is mean condition class for the ERU. Blank Cells mean no data for those local units.

WEG ERU Group	Riparian ERU \ Local Unit >>	Agua Chiquita	Blackwater Cyn	Dark Cyn	Rio Peñasco	Revento n Draw	Rio Bonito	Rio Ruidoso	Upper Pecos North	Upper Pecos South
Fire Rotation (years)	Little Walnut - Chinkapin Oak									50
	Little Walnut - Ponderosa Pine			116						21
Fire Severity	Little Walnut - Chinkapin Oak									66%
	Little Walnut - Ponderosa Pine			13%						15%
FRCC	Little Walnut - Chinkapin Oak									I
	Little Walnut - Ponderosa Pine			II						II

Herbaceous Wetland (WET)

The herbaceous wetland ERU occurs throughout the Region, at elevations ranging from 2,100 to 12,000 feet. This ERU supports a whole host of riparian and wetland herbaceous species that vary greatly with elevation and climate. Approximately 435 acres occur on the Forest.

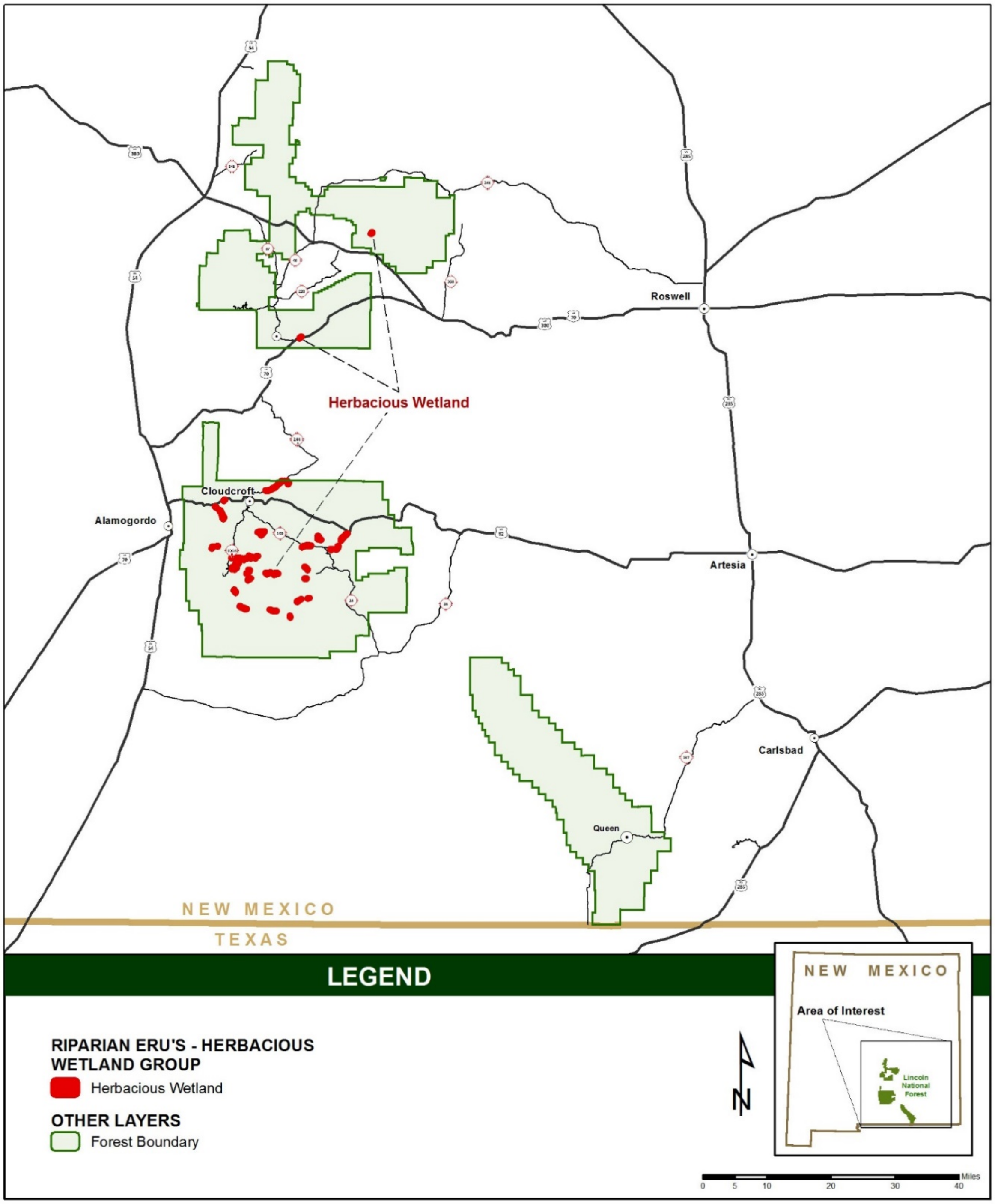

Figure 51. Distribution of Herbacious Wetland group ERUs on the Lincoln NF

Seral State Proportion

The Wetland ERU is moderately departed (61 percent) at the plan scale for seral state proportion (Table 119 and Figure 52). A large proportion (61 percent) of the ERU is in the Upland Dominance type/exotic vegetation (state D), implying either a shift in vegetation to either upland or non-native grasses, or perhaps encroachment from adjacent upland vegetation types, perhaps due to falling water tables. There have been no inventories of riparian wetland vegetation, but anecdotal evidence suggests that native wet sedges and grasses have been replaced with non-native forage grasses (Ralph Fink, personal communication). Relatively no early seral or post disturbance vegetation (state A) exists currently compared to a reference of 15 percent, and mid development herbaceous and shrub states (B, C) is much less currently than in reference condition (38 percent compared to 85 percent, respectively). Grazing is the only managed activity occurring in this ERU.

Table 119. Wetland ERU group current and reference seral state proportions, and percent departure from reference condition for context, plan and local scales. Green = low departure (0-33%), orange = moderate (34-66%) and red= high (67-100%) departure.

Seral State	Wetland (cienega)	Reference	Current
A	Post replacement: recently burned, sparsely vegetated	0.15	0.00
B, C	Mid-development, closed: all herbaceous and shrub types, shrub cover greater than 10%.	0.85	0.38
D	Upland dominance types and exotic vegetation	0.00	0.61
Departure		61%	

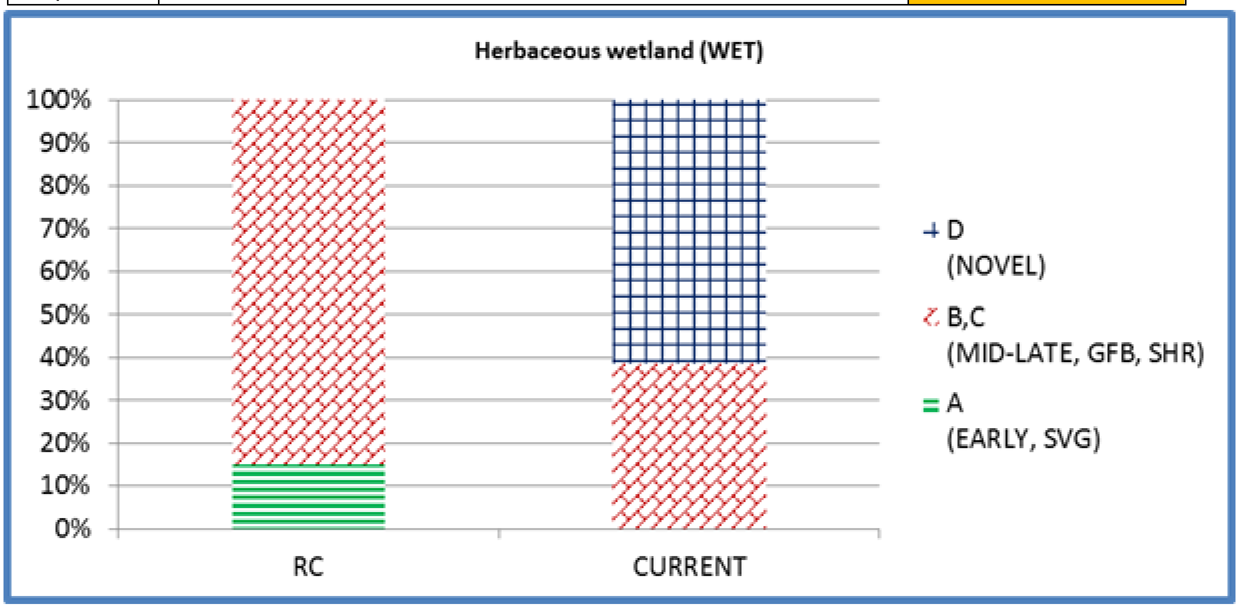

Figure 52. Seral state percentages for Herbaceous Wetland

Fire frequency, severity and FRCC

The Wetland ERU is moderately departed for Fire rotation interval, severity and FRCC (Table 120). Fire rotation intervals appear to be much less than in reference (although reference conditions here mean the adjacent uplands, which were probably infrequent fire mixed conifer), while severity was greater. Fire regime condition class was 100 percent in condition class II for the Plan Area, as well as for the two local units where the ERU occurs.

Table 120. Fire interval (years), severity (% mortality) and condition class (FRCC) at the Plan scale. Colors represent departure from reference condition: green=low (0-33%), orange= moderate (34-66%) and red= high (67-100%).

Riparian ERU Group	Riparian ERU	Plan Scale Departure		Fire Regime Condition Class		
		Rotation (years)	Severity (%)	I	II	III
WET	Herbaceous Wetland	73	23%		100%	
n/a	Historic Riparian - Agriculture	139	15%		100%	

Table 121. Fire frequency, severity and FRCC for Herbaceous Wetland. Fire frequency is years for number of acres in ERU to burn; severity is average percent canopy mortality and FRCC is mean condition class for the ERU. Blank Cells mean no data for those local units.

WET ERU Group	Riparian ERU \ Local Unit >>	Agua Chiquita	Blackwater Cyn	Dark Cyn	Rio Peñasco	Reventon Draw	Rio Bonito	Rio Ruidoso	Upper Pecos North	Upper Pecos South
Fire Rotation (years)	Herbaceous Wetland	175			103					
	Historic Riparian - Agriculture				57					
Fire Severity	Herbaceous Wetland	13%			624%					
	Historic Riparian - Agriculture				115%					
FRCC	Herbaceous Wetland	II			II					
	Historic Riparian - Agriculture				II					

Proper Functioning Condition

Riparian-wetland areas are some of the most productive resources on the landscape. They are highly prized for their recreation, livestock production, fish and wildlife, water supply, cultural, and historic values, and accordingly, have great economic value. Maintaining these values requires assurance that riparian areas and wetlands are functioning properly (USDI BLM 1998). Definitions of Proper Functioning Condition (PFC) have been developed to assess whether a given area is functioning properly, functioning at risk, or nonfunctional. USDI BLM (1998) defines PFC as "…a qualitative method for assessing the condition of riparian-wetland areas. The term PFC is used to describe both the assessment process, and a defined, on the-ground condition of a riparian-wetland area".

Proper Functioning Condition (PFC) Categories:

Proper Functioning Condition (PFC): adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high water flows.

Functional- At Risk (FAR): in functional condition but an existing soil, water, or vegetation attribute makes them susceptible to degradation.

Nonfunctional (NON): not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows.

Methods for Assessing Riparian Conditions on Lincoln NF

The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soil) attributes and processes to assess the condition of riparian-wetland areas. The on-the-ground condition termed PFC refers to how well the physical processes are functioning. PFC is a state of resiliency that will allow a riparian-wetland area to hold together during high-flow events with a high degree of reliability. This resiliency allows an area to sustain production of desired values, such as fish and wildlife habitat and forage, over time. Riparian-wetland areas that are not functioning properly cannot sustain these values (USDI BLM 1998).

The functioning condition of riparian-wetland areas is a result of interaction among geology, soil, water, and vegetation. Riparian-wetland areas are functioning properly (PFC) when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high water flows. This functions to reduce erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity. Riparian-wetland areas that are Functional—At Risk (FAR) are in functional condition but an existing soil, water, or vegetation attribute makes them susceptible to degradation. Nonfunctional (NON) riparian-wetland areas are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus not reducing erosion, improving water quality, and so on, as listed above. The absence of certain physical attributes such as a floodplain where one should be are indicators of nonfunctioning conditions (USDI BLM 1998).

A number of factors identified as contributing to PFC are attributed as either yes or no in a checklist process that guides the determination of PFC. Although the formal checklist was not used for specific reaches in this assessment, the same hydrological, vegetation, and erosion/deposition (soil) factors guide the general determination of functionality of the riverine systems assessed. Factors for consideration in the determination of PFC (USDI BLM 1998) are:

Hydrology

Floodplain above bankfull is inundated in "relatively frequent" events where beaver dams are present they are active and stable sinuosity, width/depth ratio, and gradient are in balance. Riparian-wetland area is widening or has achieved potential extent upland watershed is not contributing to riparian-wetland degradation

Vegetation

There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery. There is diverse composition of riparian-wetland vegetation (for maintenance/recovery). Species present indicate maintenance of riparian-wetland soil moisture characteristics. Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events. Riparian-wetland plants exhibit high vigor. Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows. Plant communities are an adequate source of coarse and/or large woody material (for maintenance and recovery)

Erosion/Deposition

Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or woody material) are adequate to dissipate energy. Point bars are revegetating with riparian-wetland vegetation. Lateral stream movement is associated with lateral sinuosity. The system is vertically stable. Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition).
Riparian-wetland condition (PFC) is a key ecological characteristic. Considering definitions and guidelines developed by USDI BLM (1998a, b)(TR 1787-9, 1998; TR 1787-15, 1998), PFC categories were subjectively approximated for the main watercourses and tributaries of the Lincoln NF. Formal PFC assessment has been conducted in few areas (Sacramento Allotment PFC Assessment, 1999; Sacramento Allotment: Alamo and Caballero Canyons, 2012), therefore estimates of PFC are based on professional opinion of Forest hydrology and range experts.

Results for Stream Conditions on Lincoln NF

There are approximately 193 miles of perennial streams on the three Ranger Districts (RD) of the Lincoln NF. Rio Ruidoso and Cedar Creek, Rio Bonito and its tributaries, and Eagle Creek make up the main perennial systems on the Smokey Bear RD. Smokey Bear RD also includes a number of stream systems in the Capitan Mountains, including Michalles Canyon, Pine Lodge, Copeland Creek, Seven Cabins, West Lucero Canyon and Peppin Creek. On the Sacramento RD perennial stream systems include the Rio Peñasco, Wills Canyon and Hubble Canyon system, Agua Chiquita River, Sacramento and Scott Able system, Alamo and Caballero canyons system, and La Luz, Fresnal and Dry canyons systems. The Sitting Bull Creek system is the main perennial system on the Guadalupe RD. Following is a general description of the conditions of these streams and associated riparian areas and wetlands, and an estimation of the amount of those systems in PFC or otherwise. PFC assessments for the Sacramento Grazing Allotment are included for Upper Rio Peñasco, Water Canyon, Wills Canyon, Hubbell Canyon, and Caballero Canyon (1999) and Alamo and Caballero Canyon (2012)

Rio Ruidoso (HUC 6: 130600080101-130600080107)

Rio Ruidoso is a perennial system primarily located on private land, but its main tributaries start on Forest land and the adjacent Mescalero Apache Indian Reservation. Cedar Creek, heavily used by recreationists, has the most flow. Flume, Perk and Brady Canyons contain similarly low gradient streams that exhibit good riparian plant diversity and generally flow above ground most of the year, but often go underground 2 to 3 months out of the year. These canyons make up a relatively small area southeast of the village of Ruidoso and cross private land on their way to Rio Ruidoso. They are subject to recreation pressures (hiking, biking and horseback riding).

PFC rating: NON: 20 percent; FAR: 60 percent; PFC: 20 percent

Rio Bonito (HUC 6:130600080201, 130600080207)

The Rio Bonito drains to the east side of the White Mountain Wilderness and the slopes of Sierra Blanca. Main tributaries of the main stem include Big Bear, Turkey and Argentina canyons, plus the South Fork Rio Bonito which provides the most volume of water to the system. Most of the Lincoln NF portion of the Rio Bonito system is in the wilderness, with Rio Bonito entering private land about two miles above the confluence of the South Fork and main stem Rio Bonito. The upper reaches are in steep V-shaped valleys, while on lower slopes the valley broadens and both the valley and side slopes are less steep. Past fires and subsequent flooding along the South Fork have altered the upper stretches and filled them with rubble, essentially burying the stream channel. Approximately five miles of formerly fish-bearing stream was lost in the fire events and associated deposition.

As with other streams, natural disturbances affecting Rio Bonito include fire, flooding, and a degree of erosion. While fire followed by flooding was a periodic disturbance in the past which varied in extent and severity with climatic conditions, extreme fire events have contributed to extreme flooding events in recent years. Grazing, mining and logging were past influences that do not continue today in the White Mountain Wilderness. In the lower reaches, recreational use occurs, including camping, hiking, biking, and horseback riding on streamside trails. Access roads also follow and influence the lower reaches.

The Rio Bonito has a boulder and cobble substrate (Figure 53) and is not as prone to downcutting and channelizing as the Rio Peñasco and Agua Chiquita. The Little Bear Fire of 2012 has caused excess sedimentation in the stream. Much of this sedimentation has occurred in the way of excess cobbles and boulders being conveyed into the stream from the steep sideslopes and subsequently being transported downstream. The 107C bridge area, near the confluence of the Rio Bonito and South Fork Rio Bonito, has extensively filled with sediment, and the bottom of the channel is presently within a couple or few feet below the bottom of the bridge. Before the Little Bear Fire, the stream channel was at least 8 feet below the bottom of the bridge (Figure 54).

Figure 53. Rio Bonito substrate of mostly cobbles and boulders

Figure 54. Bridge 107C in 2009 (left) and in 2013, one year after the Little Bear Fire

Beavers *(Castor canadensis)* inhabited the northern Sacramento Mountains in the past. They were still inhabiting Ruidoso Creek, for example, as of 1902. By then, however, many of the dams had been destroyed (Bailey 1931:215). They were extirpated some time subsequently.

PFC rating: NON: 30 percent; FAR: 40 percent; PFC: 30 percent

Eagle Creek (HUC 6: 130600080105)

Eagle Creek drains to the east side of Sierra Blanca, with the North Fork on the Lincoln NF, and the South Fork mostly on Mescalero Apache land, joining the main stem on the Lincoln NF. The river goes back and forth across Forest and private land until its confluence with the Rio Ruidoso near the eastern border of the forest. The upper reaches are functioning better than lower reaches. Upper reaches are relatively intact, while lower reaches are prone to flash floods. Much of the lower portion is dry, and subject primarily to natural disturbances of fire and flood.

PFC rating: NON: 40 percent; FAR: 40 percent; PFC: 20 percent

Capitan Mountains (HUC 6: 130600050501, 130600050503,

Riparian systems in the Capitan Mountains in the eastern portion of the Smokey Bear RD arise in the Capitan Wilderness, and are nearly dry or running underground by the time they reach the edge of the wilderness. Most drainages are on the north side of the range, and have historically been heavily grazed, as well as subjected to extreme fires. Much of the upper range consists of large boulder fields that moderated fire behavior to some extent, leaving large intact patches of forest mixed with large patches of severely burned forest. This has contributed to patchiness in the riparian areas with varying levels of disturbance and recovery. The riparian areas discussed below (from east to west) are associated with either extant fish-bearing streams, or where native fish recently inhabited.

The Michalles Canyon system has substantial water, and historically had native fish. The upper reaches are fast flowing in a steep V-shaped incised canyon with little sinuosity over a boulder substrate. Generally, this type of stream has little riparian development in isolated patches of sediment deposition. Areas that don’t appear to have many riparian characteristics may be functioning properly for this kind of system. However, disturbances such as fire that can affect adjacent uplands can be extended into the riparian area, either through deposition from upland erosion, or alteration in peak flows from precipitation events causing flooding.

The Pine Lodge system is perennial and though it lost its native fishery, has experienced some success with reintroduction of Rio Grande cutthroat trout. This canyon is similar to Michalles Canyon, although it does contain approximately two miles of a broader, low gradient valley with a developed floodplain. Fires, particularly the Peppin fire of 2004, burned hot in portions of the riparian area and burned the shrub and tree overstory, but recovery in the form of willows and other shrub recruitment has been observed.

Copeland Creek starts as a steep gradient narrow canyon. After about two miles the gradient becomes shallower and the stream meanders through its valley. Copeland is a perennial system with an extant native fishery. The canyon was heavily burned in the Peppin fire, yet the native fish population survived. Large amounts of coarse woody debris (CWD) in the channel probably helped provide refugia for fish populations. The canyon gets steeper and more defined as it enters the piñon-juniper woodlands, and goes underground, a common occurrence of stream systems on the Lincoln NF. The system as a whole is in good shape, although there is a good deal of livestock use both in and out of the Capitan Wilderness. This influences lower gradient sections more than steeper sections, as cattle are unlikely to settle in the steeper canyons.

Similar to other systems in the Capitans, Seven Cabins Canyon starts as a steep sided, steep gradient canyon, but moderates quickly to a more level, less steep-sided canyon that contains about a three-mile stretch of pools, glides and riffles over a boulder substrate. High intensity fire severely damaged the riparian vegetation, but recovery has already been substantial. While there is some grazing pressure, the riparian areas appear not at risk because it is difficult for cattle to access and settle in those areas.

West Lucero Canyon starts in broad flat basins at the top of the Capitans, with its upper reaches comprised of many tributaries flowing through mixed conifer forest. Fires have not had the extreme effect as in drainages further east, and the upper reaches are relatively intact and functioning.

The Peppin drainage is similar to West Lucero Canyon. Historically it had good flow, the fishery is extant, and the upper reaches remain relatively intact. Fire (particularly the Peppin fire) did not move downslope as much in Peppin and West Lucero canyons as in drainages further east.

In general, for all the Capitan drainages discussed above, flows are perennial at higher elevations in mixed conifer and ponderosa pine zones. At lower elevations, generally once the streams reach piñon-juniper zones, the streams become intermittent, or flow underground. In these areas, upland vegetation generally starts right at the stream edge with little riparian development. For the Capitans as well as many other areas on the forest, large amounts of insect mortality in the ponderosa pine has impacted adjacent uplands, contributing to reduced interception of precipitation and increased peak flows, which can lead to sedimentation and flooding. While livestock grazing occurs in the lower reaches, the main disturbances are fire and flooding, and will continue at some level into the future.

PFC rating: NON: 20 percent; FAR: 40 percent; PFC: 40 percent

Upper Rio Peñasco, Wills Canyon, Hubble Canyon (HUC 6: 130600100302, 030600100304)

The Rio Peñasco is located in the middle of the Sacramento RD and runs west to east from NM Hwy 6563 to the Pecos River. The Rio Peñasco drainage, Wills Canyon and Hubble Canyon consist of broad U-shaped canyon bottoms with deep soils and gradual slopes. This system currently provides domestic and agricultural water for agricultural lands and residences along the drainages. Perennial flow is segmented throughout this system, with a stretch of continuous flow from Posey Spring to the junction of Highways 82 and 24 that supports fish. Most of the perennial stretches of the Rio Peñasco are associated with private lands, with the upper portions of the canyon and its tributaries located on the Forest. Currently these canyons have segments that are perennial, fed by springs and seeps. These systems are dependent on annual moisture and the perennial stretches expand and contract greatly based on climatic shifts. These canyons frequently receive monsoonal flash floods that exceed the flood plain.

A majority of the uppermost portion of the Rio Peñasco and Wills Canyon consists of stream channels that are severely degraded and greatly incised in relation to historic floodplains (Figure 55). The original floodplain, where waters of the stream flowed during high flows or flood events, is now an abandoned floodplain, or terrace. Accelerated channel downcutting, the lowering of the stream channel in relation to the adjacent valley floor, has occurred. The resultant concentrated flow causes more downcutting, creating an incised channel, where water in the stream is unable to overflow its banks and spill onto the floodplain. Connectivity to the floodplain is lost and the water table is lowered. In many places along the upper part of the Rio Peñasco, the channel is downcut at least ten feet.

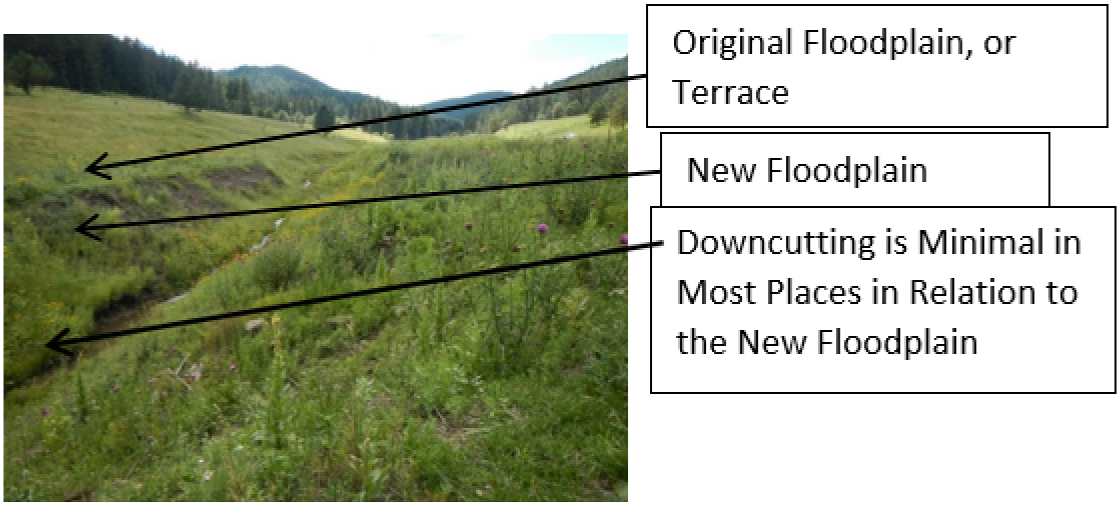

Figure 55. Upper Rio Peñasco showing stream channel, adjacent new floodplain, and the original floodplain, or terrace

These areas were historically areas where sediment would deposit and create productive wet meadows. Due to the current conditions with downcut channels these areas now transport sediment, bank erosion continues, and vast quantities of productive soil can be lost. Stream banks lose their capacity to store water, the water tables continue to lower, and amount of water available for streamflow decreases. When streams have access to their floodplains, the floodplains are dominated by sedges and other riparian/wetland types of vegetation. This type of vegetation allows water to infiltrate the soil, thus acting as a natural "sponge" keeping water flowing more reliably during dry periods. As degradation and downcutting continue, riparian plants are replaced by upland species as necessary access to moist areas at or near the water table are lost. When the soils dry and convert to upland vegetation, evaporation increases and water availability is diminished, compared to soils high in organic matter that retain large quantities of water. Wetland and riparian plant communities have a greater capacity to retain organic matter than upland types of vegetation. The riparian vegetation in Rio Peñasco, Wills and Hubble, where soils are still saturated for at least a portion of the year, is characterized by wet meadows and cienegas with deep soils dominated by wetland sedges, rushes, and other herbaceous vegetation. This system supports much of the Sacramento Mountain thistle population (Federally listed as threatened). In some places willows and other woody riparian vegetation are present. Those areas that are functioning properly have access to the original floodplain and are abundant in *riparian* vegetation.

Most of this system has become channelized. Channeling and head-cutting have lowered the water table as much as 20 feet in some areas. This channeling includes stream stretches between wet meadows, and many of the wet meadows have likely been extirpated. Many stream channels throughout New Mexico and the western United States have experienced degradation as a result of major disturbances to the landscape following the arrival of European settlers in the late 1800s. These disturbances included building of roads and railroads, construction of recreational trails with accompanying increased use, livestock grazing, changes in the behavior of wild ungulates as a result of elimination of natural predators, logging, altered fire regimes, water diversions, and agriculture.

Many sections of perennial streams have dried up due to degradation and now only flow in response to rain events. As this occurs, a new floodplain develops next to the stream channel but is much smaller and does not have the capacity to store the larger amounts of water of the original floodplain. A lowered water table also contributes to diminished water availability. In the Upper Rio Peñasco drainage, much of the water in the stream is able to overflow its banks and spread out onto the new, diminished floodplain, but the original floodplain is inaccessible even during high flows.

Along much of the upper part of the Rio Peñasco, the stream channel is only slightly incised in relation to the new floodplain. There are numerous headcuts along this section of stream. Headcuts are areas where there is a sudden drop in the elevation of the stream in relation to the adjacent valley floor (new floodplain). Most headcuts along the Upper Rio Peñasco and Wills Canyon are small, being only 1-2 feet high, but a few are extremely large, such as 6 to 8 feet high (Figure 56 and Figure 57). As headcuts develop, they migrate upstream, resulting in channel downcutting. Large headcuts may move upstream through a wetland and confine the flow to one incised channel instead of dispersed flow across the wetland. Over time, the channel may experience continuous downcutting, resulting in the drying out of all or a portion of the wetland as the adjacent water table lowers. The remaining wetland may then convert to a wet or even dry meadow, with different plant species, less organic matter in the subsoil, and diminished water-holding capacity.

Figure 56. Small headcut about 1 to 2 feet high

Figure 57. Large headcut, about 6 to 8 feet high

In 1999, a PFC assessment was conducted for a number of reaches on the Sacramento Allotment, in the upper Rio Peñasco and Water, Wills and Hubbell canyons. Seven of nine reaches in the Upper Rio Peñasco were in PFC, according to PFC monitoring protocol, while two were FAR. One of the FAR reaches showed a downward trend, the other no trend. In Water Canyon, one reach was non-functional, four reaches were FAR, with three of those showing a downward trend. Wills Canyon had seven FAR reaches, with two exhibiting a downward trend and trend apparent for the remainder. Hubbell Canyon showed one PFC reach and two FAR reaches, with no trend apparent. The PFC reach is in a grazing exclosure. Summary rating for 1999 Sacramento allotment PFC: NON: 4 percent; FAR: 63 percent; PFC: 33 percent.

PFC rating: NON: 20 percent FAR: 56 percent; PFC: 24 percent

Agua Chiquita (HUC 6: 130600100302)

The Agua Chiquita drainage is located in the middle of the Sacramento RD and runs west to east from approximately the junction of FS Roads 480 and 64 to the Rio Peñasco east of the district boundary. Perennial flow is segmented throughout this system. During wet years there is flowing water throughout much of this system. During drought years flow has been greatly reduced to short segments associated with springs. This system has supported fish in the past. The Agua Chiquita drainage consists of broad U-shaped canyon bottoms with deep soils and gradual slopes. This system currently provides domestic and agricultural water for agricultural lands and residences along the drainage, including the communities of Sacramento and Weed. Currently these canyons have segments that are perennial, fed by springs and seeps. These systems are dependent on annual moisture and the perennial stretches expand and contract greatly based on climatic shifts. These canyons frequently receive monsoonal flash flood events that exceed the flood plain. The riparian vegetation in Agua Chiquita is characterized by wet meadows or cienegas with deep soils dominated by sedges, rushes, and wetland obligate herbaceous vegetation with willows occurring infrequently. Stretches between wet meadows have experienced channeling. In some areas channeling and head-cutting have lowered the water table as much as 20 feet. Most of this system has become channelized and many of the wet meadows have likely been extirpated due to channelization. Agua Chiquita is similar to the Upper Rio Peñasco and Wills Canyon in that headcutting and channelizing is extensive. The channel has been lowered dramatically since European settlement starting in the late 1800s. Some sections of stream have adjacent banks that are lacking in vegetation or only have sparse vegetation immediately adjacent to the channel. These areas are sources of large quantities of sediment during high flows (Figure 58).

Associated lowering of ground water tables and lack of access to the original floodplain has resulted in diminished stream flow. Stream flows are still influenced by yearly precipitation patterns. Several small springs and wetland stringers adjacent to the stream are also found in this area. Based upon knowledge of this stream system, it is estimated that 53 percent of this system is functioning at risk. Those areas that are in proper functioning condition are connected to the original floodplain and have abundant riparian vegetation.

PFC rating: NON: 27 percent; FAR: 53 percent; PFC: 20 percent

Figure 58. Lowered stream channel along Agua Chiquita Creek, leaving bare banks

Figure 59. Stretch of Agua Chiquita below Barrel Spring during a dry spring (May 15, 2014)

Figure 60. Stretch of location below Barrel Spring location on a rainy day during a wet spring (May 15, 2015)

Sacramento River (HUC 6: 130500040101, 130500040102)

The Sacramento River and Scott Able Canyon are located in the southwest corner of the Sacramento Mountains. The Sacramento River drainage consists of broad U-shaped canyon bottoms with deep soils and gradual slopes in its upper reaches, but the flood plain narrows and becomes rocky with shallower soils below the confluence of Scott Able Canyon. Scott Able Canyon consists primarily of steep canyons and rocky narrow channels. This system currently provides domestic and agricultural water for Orogrande and the surrounding area. Currently these canyons have segments that are perennial, fed by springs and seeps. The riparian vegetation in the Sacramento River above the confluence of Scott Able Canyon is characterized by wet meadows or cienegas with deep soils dominated by sedges, rushes, and wetland obligate herbaceous vegetation. The riparian vegetation in Scott Able Canyon and continuing down the Sacramento River drainage are dominated by woody vegetation with rocky or gravely soils. Mountain maple is dominant in Scott Able Canyon and the Sacramento River Drainage, transitioning to willow in the lower elevations near Timberon, NM. These systems are dependent on annual moisture and the perennial stretches expand and contract greatly based on climatic shifts. These canyons frequently receive monsoonal flash floods that exceed the flood plain. One such event occurred in Scott Able

Canyon in 2005. "Most of the obligate riparian species of these montane habitats are well adapted to catastrophic flooding events and respond with rapid reproduction and colonization" (Dick-Peddie, 2000).

The Sacramento River has experienced degradation similar to Rio Peñasco and Agua Chiquita. Some sections are in better condition with a well-established secondary floodplain and an original floodplain that is not as vertically removed from the present channel as are the original floodplains along the Rio Peñasco and Agua Chiquita (Figure 61). Other portions of the Sacramento River are in a more degraded condition. Those areas that are functioning properly have access to the original floodplain and abundant riparian vegetation.

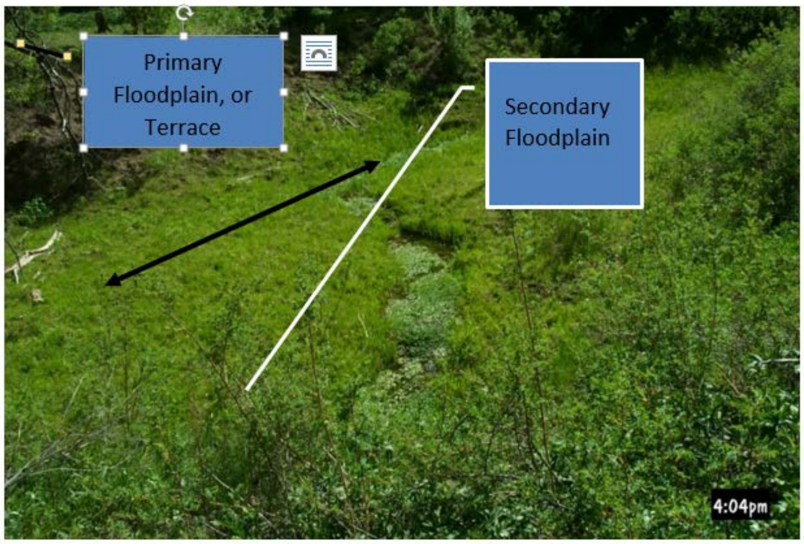

Figure 61. Area of the Sacramento River where the main channel has access to the secondary floodplain

PFC rating: NON: 20 percent; FAR: 43 percent; PFC: 37 percent

Alamo and Caballero Canyons (HUC 6: 130500031701, 130500031702)

Alamo and Caballero canyons are located on the west escarpment of the Sacramento Mountains. This system consists primarily of steep canyons and rocky narrow channels. Historically this system likely produced perennial flow out to the Tularosa Basin. This system currently provides domestic and agricultural water for Alamogordo and the surrounding area. Currently these canyons have segments that are perennial, fed by springs and seeps. These systems are dependent on annual moisture and the perennial stretches expand and contract greatly based on climatic shifts. These canyons frequently receive monsoonal flash flood events that exceed the flood plain. The riparian vegetation in these canyons is dominated by woody species primarily cottonwood and Arizona ash. The Sacramento prickly poppy is also associated with these canyon systems as this species is somewhat facultative and prefers the dry riparian systems.

In 1999, a PFC assessment of three reaches in Caballero Canyon showed all three in PFC. This condition is probably due to adequate riparian vegetation characteristics to support function, although valley landform seems to control functionality. In 2012, two of the above reaches were re-assessed and found to be in PFC. Two other reaches adjacent to Alamo Canyon were assessed and also found to be in PFC.

PFC Rating: NON: 2 percent; FAR: 8 percent; PFC: 90 percent

La Luz, Salado, Fresnal Canyons (HUC 6: 130500031501-130500031503)

La Luz, Salado, and Fresnal Canyons are located on the west escarpment of the Sacramento Mountains. This system consists primarily of steep canyons and rocky narrow channels. Historically this system likely produced perennial flow out to the Tularosa Basin. This system currently provides domestic and agricultural water for the surrounding communities and private lands (High Rolls, Mountain Park, La Luz and Alamogordo). Currently these canyons have segments that are perennial, fed by springs and seeps. Fresnal Canyon maintains persistent flow that supports recreational activities in plunge pools within the Fresnal Box. This stretch also supports some fish. These systems are dependent on annual moisture and the perennial stretches expand and contract greatly based on climatic shifts. These canyons frequently receive monsoonal flash floods that exceed the flood plain. The riparian vegetation in these canyons is dominated by woody species primarily cottonwood and Arizona ash. Wright’s Marsh thistle is found in La Luz and Fresnal canyons on private land. The Sacramento prickly poppy is also associated with these canyon systems. This species prefers the dry arroyos.

PFC Rating: NON: 5 percent; FAR: 25 percent; PFC: 70 percent

Last Chance Riparian Pasture and Sitting Bull Creek (HUC 6: 130600110801, 130600110802, 130600110804)

These areas constitute the main courses of perennial water in the Guadalupe RD. Last Chance Riparian Pasture has seen some improvements over the last 25 years as willows and other riparian vegetation have reestablished along the riparian corridor (Figure 62 and Figure 63). Increases in riparian vegetation have captured more sediment, resulting in a greater water holding capacity. Sections of the stream channel that did not run perennially now have permanently flowing water. Although improvements have been realized, this area is still functioning at risk.

Sitting Bull Creek is in a degraded condition relative to its potential. Many native riparian plants that should exist along this section are not present, and non-native invasive species are present. Disturbances including trespass livestock grazing and wildfire have contributed to degraded conditions (Figure 64). This area is occasionally flooded when heavy rains occur, and without the proper riparian vegetation and soils to attenuate the effects of high flows, accelerated streambank erosion and increased conveyance of sediment through the channel occurs. Streams and associated riparian areas that are functioning properly are resilient, having the necessary vegetation and water holding capacity in the soils to mitigate potential adverse effects.

PFC Rating: Non: 25 percent; FAR: 25 percent; PFC: 50 percent

Figure 62. Last Chance Trail in 1997

Figure 63. Last Chance Trail in 2002, showing a greater amount of riparian vegetation

Figure 64. Sitting Bull Creek above Sitting Bull Falls showing disturbance from trespass livestock grazing and presence of non-riparian vegetation

PFC Summary for the Lincoln NF

Estimated PFC values for the watersheds are summarized in Table 122. Values for each watershed are composite estimates from resource specialists and, in the case of Upper Rio Peñasco, and Wills, Hubble, Alamo and Caballero canyons, PFC assessments done by private contractors. PFC for the Lincoln NF was calculated as the mean of the watershed values reported in Table 122. No weighting by area was done. As an estimate of PFC, the Lincoln NF is approximately 48 percent in proper functioning condition, 34 percent functioning at risk, and 18 percent non-functioning.

Data needs include more PFC assessments on the Forest. Currently, assessments appear to be done in response to some specific management need, such as reviewing a grazing allotment management plan. PFC assessments at key locations that are representative of a watershed or sub-watershed and conducted on a systematic and repeatable basis would allow for more accurate monitoring of trends.

Table 122. PFC values for watersheds in Lincoln NF

Watershed(s)	NON	FAR	PFC
Upper Rio Peñasco, Wills Canyon, Hubble Canyon	20	56	24
Aqua Chiquita River	27	53	20
Sacramento River	20	43	37
Alamo and Caballero Canyons	2	8	90
La Luz, Soldano and Fresnal Canyons	5	25	70
Rio Bonito	25	25	50
Last Chance Riparian, Sitting Bull Creek	25	25	50
Mean Values for Forest, no areal weighting	**18**	**34**	**48**

PFC values for the Lincoln are estimated using the mean of the watershed values, with no weighting for watershed area.

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments relating to riparian area conditions, trends, and issues included these topics: overgrown, dense forests and canopies; stunted, diseased and unhealthy trees; loss of open, grass-dominated areas (savannah-like) and meadows on the landscape impacting forest health, forage, wildlife, scenic, and other values; woody encroachment; decreased regeneration; decreased precipitation and moisture; increase in resource damage associated with OHV/ATV proliferation and travel rules; impacts to vegetation and hydrology due to 300 foot travel allowance for motor vehicles use off of forest routes; overgrazing and concentrated use by livestock; reduced/limited fisheries and suitable waters; reduced focus on fisheries and stream-based recreation management; riparian area damage, vegetation trampling, and invasive species infestation due to livestock grazing; riparian areas in general; loss of riparian areas that, decades ago, flowed regularly and supported many riparian species that are now gone; and disappearance of riparian vegetation due likely to overgrazing and timber removal (plus climate change), and subsequent loss of biodiversity. Expressed values (desires, for terrestrial, riparian and aquatic systems) included healthy, intact forests and ecosystems; forest products and multiple uses; human safety and livelihoods; and effective communication, collaboration, and decision-making. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for regional office approval prior to finalizing it.

Summary of Findings for Riparian Vegetation

Riparian ecosystems (ERUs) are relatively uncommon on the Lincoln National Forest, comprising less than three tenths of one percent of the forest. There are 15 riparian ERUs represented on the Lincoln NF, ranging from eight acres for Historic Riparian, to 695 acres for the Little Walnut – Ponderosa Pine. Eight of those ERUs, more than half of the approximately 2800 acres of Lincoln NF riparian ERUs, are in wilderness or wilderness study areas. Of that nearly 1500 acres, almost 1100 acres are in the Guadalupe Wilderness Study Area, with nearly 400 acres in the White Mountain and Capitan wildernesses. Three riparian ERUs, the Little Walnut/ Desert Willow, Little Walnut - Ponderosa Pine and Little Walnut – Chinkapin Oak, are located almost entirely in the Guadalupe Wilderness Study Area.

Riparian areas make up similarly small percentages of the Context Area, but for the three ERUs mentioned above, the Lincoln has nearly all of those ERUs in the Context Area (Table 82). Additionally, the Lincoln NF contains 66 percent of the Cottonwood/Hackberry ERU, 50 percent of the Upper Montane Conifer/Willow ERU, and 28 percent of the Ponderosa Pine/Willow ERU. The LNF contains less than 10 percent individually of the remaining nine ERUs within the Context Area.

Ecological characteristics for the riparian vegetation are limited compared to those of terrestrial vegetation. Lack of current data and reference conditions only allowed for analysis of seral state proportion and limited analysis of fire regime.

For seral state proportion, the ERUs were stratified into five groups with similar characteristics and reference conditions. These were the cottonwood group (CWG), desert willow group (DWG), montane conifer/willow group (MCWG), walnut-evergreen tree group (WEG), and herbaceous wetland group (WET). Departure was moderate for the WET, DWG and MCWG groups, and low for the CWG and WEG groups, relative to reference conditions. The desert willow group (DWG) has more in early seral and closed shrub/small to medium tree states, and lacking in open forest and shrub states and late seral closed large tree states. The montane conifer willow (MCWG) group lacks early seral, and is over represented in shrub and tree (all size classes) state. Herbaceous wetland (WET) is lacking in early seral proportion.

Fire severity and rotation is reported for the riparian groups and individual ERUs. Reference conditions are lacking for riparian ERUs and in general, given the small size of riparian areas on the forest, fire behavior is assumed to be similar to the adjacent upland vegetation. Departure was calculated at both plan and local scales. Fire regime condition class (FRCC) was calculated using the seral state departure of the group for individual ERU members, and fire regime departure as described above. In general, nearly half the riparian ERUs at the plan scale were highly departed for either fire rotation or severity. Nearly all ERUs were predominantly in FRCC II (moderate). The Upper Montane-Willow ERU is 41 percent moderately departed and 59 percent highly departed while the Little Walnut-Chinkapin Oak ERU was not significantly departed. The CWG ranged from 20 to 104 years for rotation, and 13 to 26 percent severity. The DWG ranged from 55 to 198 years for rotation and around 50 percent severity. In the MCWG, the four individual ERUs that make up the group range from 26 to 891 years for fire rotation and from 13 to 18 percent fire severity. These are generally more mesic, higher elevation types that may have characteristically had longer rotations and lower severity depending on adjacent upland ERUs. The willow–thinleaf alder ERU had the highest fire rotation of 891 years, while the upper montane conifer/willow had the shortest at 26 years. This may be reflective of the fire regimes in the adjacent upland ERUs, and recent fire history on the Forest. For example, upper montane conifer/willow appears to be more often associated with the frequent fire mixed conifer ERU (MCD), and the willow-thinleaf alder more often associated with the wetter mixed conifer-aspen ERU (MCW), although those associations are not documented. It is reasonable to expect these types to have a relatively high value for fire rotation and low value for fire severity, as found for MCWG overall. The WEG fire rotation ranged from 56 to 112 years and severity ranged from 13 to 66 percent. Fire rotation is probably reflective of adjacent upland ERU fire behavior, as severity may also be. WET ERUs ranged from 73 to 139 years for fire rotation and 15 to 23 percent for severity.

Estimated PFC values for the watersheds are summarized in Table 122. As an estimate of PFC, the Lincoln NF is approximately 48 percent in proper functioning condition, 34 percent functioning at risk, and 18 percent non-functioning. Where systems are functioning at risk or non-functioning, it is likely due to lack of connection to, or reduction of, the floodplain and shift in vegetation to more upland affiliated species.

Data needs include more PFC assessments on the Forest. Currently, assessments appear to be done in response to some specific management need, such as reviewing a grazing allotment management plan. PFC assessments at key locations that are representative of a watershed or sub-watershed and conducted on a systematic and repeatable basis would allow for more accurate monitoring of trends.

Chapter 6 - Soils

Introduction

Soil is a complex and dynamic system that consists of a mineral component, organic matter, air, water, and living soil organisms. It is formed over time by interactions between climate, parent material, topography, and organisms, both above and below ground. Soil yields *supporting* ecosystem services by providing a substrate and nutrients for plants. Soil provides *regulating* ecosystem services through thermoregulation (daytime heat absorption, nighttime heat release), nutrient cycling, and water purification and storage. Soil contributes to *provisioning* ecosystem services by providing wildlife habitat (burrows, dens), plant-growth media (nurseries), and fill (construction). Especially important to humans are the *cultural* ecosystem services that soil provides to society (recreation, relaxation) (Comerford et al. 2013). Due to the slow rate of formation in the arid Southwestern climate, soils are essentially a non-renewable resource (USDA Forest Service 1986b).

The diverse and productive soils of the Lincoln National Forest are described, characterized, and classified in Terrestrial Ecosystem Survey (TES)/Terrestrial Ecological Unit Inventory (Winthers et al. 2005). The information regarding the kind of soils on the Lincoln NF is intricately linked to the climate, vegetation, geology, and landforms of the Forest. This survey was completed at the Forest scale (1:24,000), within the administrative boundaries of the Lincoln NF (Plan Area) Refer to Data, Methods and Scales of Analysis section in the Terrestrial Vegetation chapter.

Climate and Vegetation

The climate and vegetation surrounding the Lincoln National Forest is typical of many areas throughout the Southwestern United States. In general, the climate ranges from semiarid at the lower elevation to subhumid/humid at the higher elevations. The climate is variable as a consequence of the uneven topography and wide range in elevation. Plant communities follow an elevational-climatic gradient from low-elevation desert scrub and steppe grassland upward to piñon and juniper woodlands, mid-elevation montane ponderosa pine forest, upper montane mixed conifer forest, and up to high-elevation subalpine spruce fir forests including montane and subalpine grasslands. For a description of each ERU's precipitation ranges and plant communities, see Ecological Response Unit Summaries in the Terrestrial Vegetation chapter.

Ecosystem Services of Soils

Soil provides many ecosystem services but is often overlooked and undervalued (Bridges and Van Baren 1997; Comerford et al. 2013). It provides provisioning services in the form of construction, landscaping and industrial materials. Many important medicines, such as penicillin and other antibiotics, are produced by soil microorganisms. The activities of soil microorganisms are also the primary means by which nitrogen, a necessary nutrient, is made available to plants. Soil provides supporting ecosystem services as it is the primary medium for plant growth and provides habitat for micro and macro soil organisms. A single handful of soil can contain more biodiversity than an entire forest.

Regulating services provided by the soil resource include cycling of nutrients, water and energy. It contributes to global regulation of greenhouse gases including carbon dioxide which is stored as soil organic carbon. It regulates water storage and release, water filtration and purification, and provides for erosion control and sediment retention. Soil also provides thermal regulation, absorbing heat energy when temperatures are high, and releasing it when temperatures are cool. Soil microorganism provide for biological control of crop pests and bioremediation of contaminants. Soil is the land that provides economic, recreation, education, research and personal enrichment opportunities and as such, provides many cultural ecosystem services.

Data

Terrestrial Ecological Unit Inventory The Terrestrial Ecological Unit Inventory (TEUI), previously referred to as the Terrestrial Ecosystem Survey, maps relationships between climate, geographic location, geology, geomorphology, aspect, slope, soil and vegetation at the scale of a standard United States Geological Survery (USGS) map. The TEUI classifies ecological types and maps ecological units to interpret both site potential and current ecosystem characteristics. The conditions under site potential are those that exist at the latest successional stage, or steady-stable-state as reflected by stable, diverse and functioning climate-soil-vegetation systems.

The Lincoln NF’s TEUI, which includes data from several surveys completed at the project level, is the primary dataset for this analysis. Completed surveys provide statistical summaries of survey data and management interpretations, including those equivalent to key characteristics analyzed for the assessment.

Analysis Methods

The TEUI mapping process includes three general types of documentation: observations, transects, and ecological site descriptions. Observations and transects are the least intensive form of documentation and are used to develop quantitative descriptions of characteristics defining site potential for a given map unit. In the process of gathering data, conditions that represent site potential, and those that represent other successional states are documented. Ecological site descriptions are the most intensive form of sampling and are used to document site potential, once it has been defined through observations and transects. In this analysis, representative observations and transects are used to describe current conditions and ecological site descriptions are used as a contemporary reference condition.

There is multiple TEUI units in each ERU. Departure is assessed at the TEUI level using a similarity analysis (Czekanowski 1913 as cited in kent and Coker 1992) to describe variability in conditions within each ERU. Departure is simply the inverse of similarity. The TEUI unit departure rating that represents the largest percentage of the ERU area is used as a single departure rating each ERU. Not all TEUI units contain the same number of observations, transects and ecological site descriptions. There is less uncertainty associated with larger datasets and greater uncertainty associated with smaller datasets.

Soil Diversity and Distribution

In the Southwest the US Forest Service uses a system of ecosystem types, “ecological response units” (ERUs, see Ecological Response Unit section), to facilitate landscape analysis and strategic planning. ERUs have been built from plant associations and ecosystem units that have been identified through Terrestrial Ecological Unit Inventory (Wahlberg, et. al. 2013). On National Forest System lands, TEUI units provide the primary source for building Ecological Response Units, and ERUs can be thought of as functional aggregates of TEUI units at a slightly broader scale. Thus, TEUI provides the primary biophysical and geographic boundary delineations of ERUs on National Forest System lands, facilitating geospatial analysis.

One hundred eighty nine terrestrial ecosystem maps units were identified and aggregated into 14 ERUs. Table 19 displays the Ecological Response Units (ERUs; USDA FS 2015 [Walberg]) found within the

Lincoln NF and Context Area, within these 14 ERUs, 5 of the 12 soil orders are represented; *Alfisols, Aridisols, Entisols, Inceptisols, and Mollisols* (Figure 65).

Alfisols are inherently fertile with soil horizon development and are normally formed under forested vegetation. These soils form in a wide range of parent materials and occur under a large range of environmental conditions (Staff 2014). In general, Alfisols are productive soils high in native fertility. Globally, Alfisols occupy about 10 percent of the total ice-free land area (Brady and Weil 2008). They primarily form on rhyolite and tuff, but have been documented on alluvium, granite and basalt. They occur in ERUs of MCW, MCD, PPF, PPE, SDG, and MMS. They account for 12 percent of the Lincoln NF.

Aridisols are characterized by an ochric epipedon that is generally light in color and low in organic matter. Water deficiency is a major limiting characteristic of these soils. The soil moisture level is sufficiently high enough to support plant growth for no longer than 90 consecutive days. These soils mainly consist of scattered desert shrubs and short bunchgrasses. These soils may have a horizon of accumulation of calcium carbonate, gypsum, soluble salts or exchangeable sodium (Brady and Weil, 2008). They occur in ERUs of PJG, and SDG areas. They account for 6 percent of the Lincoln NF.

Entisols are very young soils with little to no subsurface soil development. These soils formed in landscape positions where the soil material has not been in place long enough for soil-forming processes to create distinctive soil horizons; areas with recent deposition such as floodplains, alluvial fans, or stream terraces are examples. In general, these soils exist in settings where erosion or deposition is happening at rates faster than those needed for soil formation (Staff, 2014). Globally, Entisols occupy 16 percent of the total ice-free land area. Soil productivity ranges from very high for certain Entisols formed in recent alluvium (where topography is nearly level, close proximity to water, and periodic nutrient replenishment occurs from floodwater sediments) to very low for those forming in shifting sand or on steep rocky slopes (Brady and Weil 2008). Entisols on the Lincoln NF mostly occur on active steep scarp, mountain, and hill slopes although some of these soils occur on flat valley plains formed in alluvium. They occur in ERUs of MCD, SDG, and CDS. They account for 2 percent of the Lincoln NF.

Inceptisols have moderate degrees of soil weathering and soil horizon development, but typically lack significant clay accumulation in the subsoil. These soils generally occur on relatively young geomorphic surfaces (landforms) that are stable enough to allow some profile development. Globally, Inceptisols occupy 17 percent of the total ice-free land area (Staff 2014). The natural productivity of Inceptisols varies widely and is dependent upon clay and organic matter content, and other plant-related factors (USDA Forest Service 2015a). They occur in ERUs of JUG, PJO, PJG and SDG, CDS They account for 2 percent of the Lincoln NF.

Mollisols have a dark-colored surface horizon, are relatively high in organic matter, and are highly fertile. These soils formed as a result of deep inputs of organic matter and nutrients from decaying roots and litter. Microbes, earthworms, ants and other organisms contributed to the inputs and nutrient cycling of these soils (Staff 2014). Mollisols cover a larger land area in the United States than any other soil order and globally occupy 7 percent of the total ice-free land area. Mollisols are among the world's most productive soils because of high native fertility (Brady and Weil 2008). This soil order is probably the most economically important soil order because of its high use in agriculture. Mollisols are the dominate soils found on the Lincoln NF accounting for approximately 78 percent. These soils are distributed widely, mostly occurring on relatively flat to moderately sloping landform and can be found in all 14 ERUs on the Lincoln NF. See Ecological Response Units in the Terrestrial Vegetation chapter (ERUs; USDA FS 2015 [Walberg]) found within the Lincoln NF and Context Area.

Soils on the Lincoln NF have predominantly dry moisture regimes and mild temperature regimes at the lower elevations and humid to sub-humid moisture regimes and cold temperature regimes at the higher elevations. Soils range from fine (< 35 percent clay) to loamy, and skeletal (>35 percent rock fragments) to non-skeletal in nature. They occur on slopes ranging from 0-80 percent, with flat and vertical rock outcrops present in some areas. Soil texture varies with parent material.

Soil productivity is highly variable across the Forest depending on many factors including, but not limited to; soil climate, soil depth, stability, hydrologic function, nutrient cycling, soil biology, soil-water holding capacity, filtering and buffering capacities and the nature of the parent material.

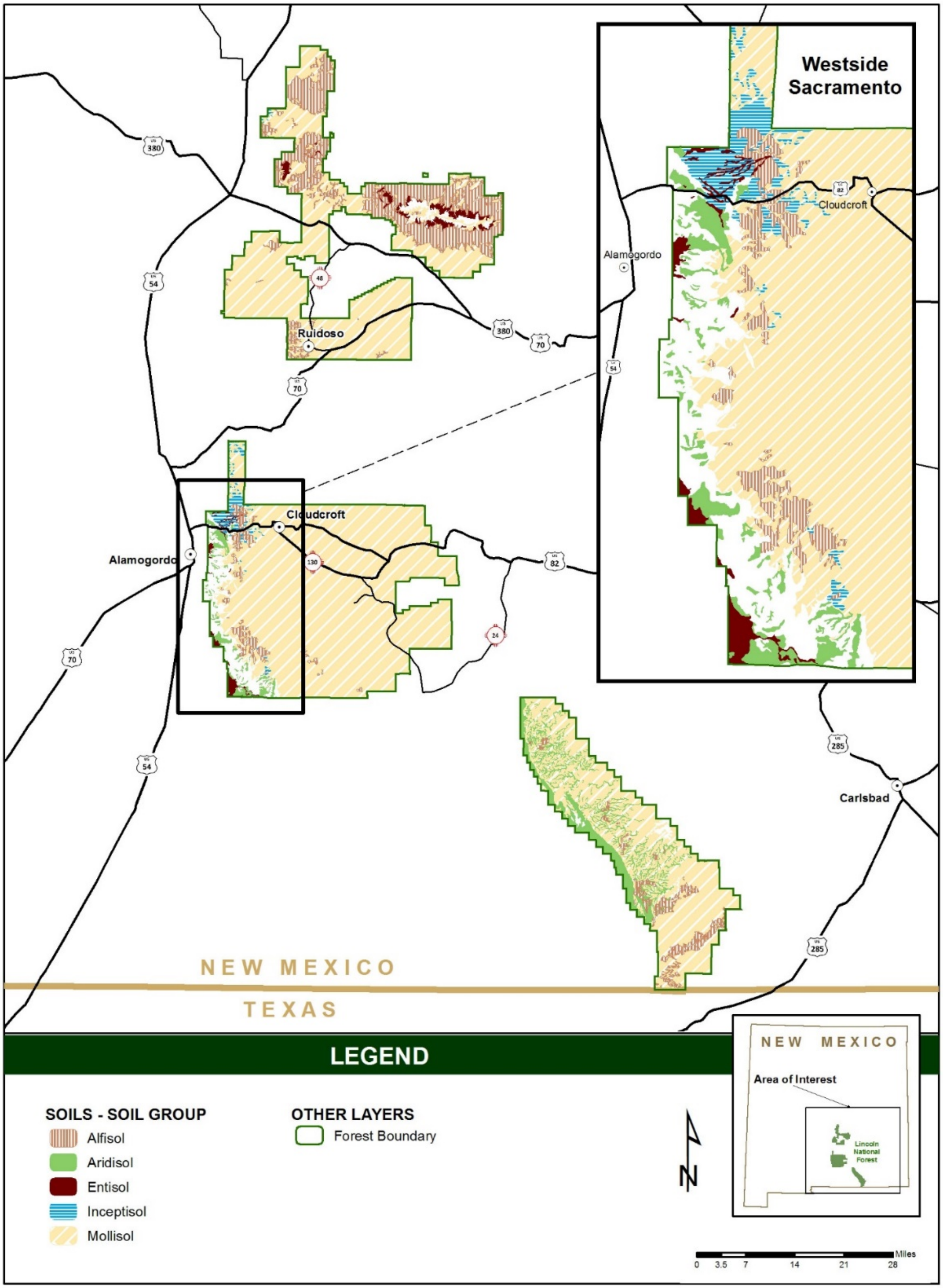

Figure 65. Soil distribution on the Lincoln National Forest

Key Ecosystem Characteristics of Soils

The primary ecosystem characteristics, soil condition and soil erosion hazard, are directly linked to the ability of the soil to withstand disturbances from management activities and natural events while maintaining site productivity and sustainability of the soil resource. Soil loss rates are predicted from soil loss models and are important factors when classifying soil erosion hazard and soil condition ratings. Soil organic carbon (SOC) is an integral part of the soil resource and ultimately the ecosystem. SOC provides the main source of energy for microorganisms which are vital to the soil resource. These characteristics are used to analyze the reference and current conditions and future trends of the soil resource.

Key ecosystem characteristics of the soil resource include those that determine the capacity of soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Doran and Parkin 1994). This analysis describes soil diversity and distribution on the Lincoln National Forest and evaluates three key characteristics:

- Soil Condition
- Soil Loss
- Erosion Hazard

System Drivers and Stressors for Soils

Primary system drivers for all soil characteristics are climate, topography, parent material, biota (living organisms), and time. These are known as the five soil forming factors. Patterns in precipitation, temperature and wind influence the potential natural vegetation community, natural rates of soil formation and soil loss. The canopy and ground cover provided by the vegetation community and the timing, duration and intensity of precipitation and wind events greatly influence the ability of the soil to resist erosion. The vegetation community, including its composition and structure, determine the types and rates of organic matter contribution to the soil. Water availability and temperature largely determine the types and rates of physical and chemical weathering processes and the biological reactions involved in decomposition and nutrient cycling. Both of these factors are important determiners in the natural fertility and productive capacity of the soil. Climate change, including increased frequency and severity of drought conditions (IPCC 2007; Seager et al. 2007) is a stressor that is expected to have cascading effects. The predominant climate regime and climate change are characterized and discussed in the Systems Drivers and Stressors chapter.

Topography is a system driver in its influence on climate, vegetation, and natural soil stability. Erosional and depositional areas are defined by the position they occupy on the landscape and the steepness of slope. The steepness of the slope also influences the lateral movement and redistribution of soil water. Regardless of the elevation, differences in solar radiation between north and south facing slopes influence the temperature and moisture regimes that control the rate of weathering and soil formation, and influence vegetative composition, productivity, and the accumulation of soil organic matter. North facing slopes tend to be cooler and wetter than south facing slopes, which is reflected in both the degree of soil development and vegetation patterns across the Forest. At the lower elevational ranges of a given vegetation community, that community may only be found on north facing slopes, where at the upper end of its elevational range it may only occur on south facing slopes.

The term “parent material” describes both the primary original of the matter from which soil is formed, either geologic or organic, and its last mode of transport. Parent materials on the Lincoln NF are geologic in nature and are dominated by volcanic and sedimentary rock. Modes of transportation include flowing water, wind, and gravity. Those materials are referred to as alluvium, eolian, colluvium and residuum, respectively. Parent material is a system driver in that the physical structure and chemical composition of the rock are largely responsible for the physical and chemical properties of the resulting soil. It is the combination of climate and these soil properties that ultimately determine the potential natural vegetation community.

In general, soils across the Forest are interbedded limestone, shale, gypsum, and minor sandstone. Soils formed from the Abo, Yeso and San Andres formations.

The Abo formation overlies a marked angular unconformity in all but the northwestern part of the Sacramento Escarpment. In the northern part of the Sacramento Mountains, the Abo consists of terrestrial red mudstone and course arkose, a facies that thickens rapidly toward the northwest. Towards the south, the middle part of the Abo formation grades from brackish to marine limestone and shalle of the Pendejo tongue of the Hueco limestone.

The Yeso Formation consists of red beds, yellow and gray shale, limestone, siltstone, sandstone and gypsum. Halite and anhydrite occur in the subsurfaces. The deposits record the fluctuating conditions of a show marine back-reef or lagoonal area of the regional extent. Carbonate rocks are more abundant and evaporites are more prevalent toward the presumed shoreward area.

The San Andres formation consists of resistant carbonate rocks mostly along the crest and high eastern slopes of the Sacramento Mountains. Marine limestone and dolomitic limestone form most of the rock units, whereas other areas have quartz sandstone. The only known Mesozoic strata of the Sacramento Mountains escarpment occurs as a small outlier along the crest of this formation.

Forest activities (management actions) that remove soil surface cover, create soil compaction, or increase accelerated erosion have the potential to result in unsatisfactory soil conditions. Activities include timber harvesting, road construction and use, recreation facility construction and use, prescribed burning, fuelwood harvesting, and herbivory. For example, poorly placed roads or roads constructed with poor drainage contribute to increased erosion and unsatisfactory soil conditions.

Noxious and invasive plants may result in a decrease or loss of ground cover or change the dynamics of a native vegetative community because of their ability to out-compete native species for solar energy, soil nutrients, and water. This can lead to a departure of surface organic matter. The departure of the surface organic matter can result in a departure of soil organic matter because there is a lack of recruitment of organics. Departure of organic matter can also result in the departure of soil loss because the loss of the protective organic matter cover and its ability to promote aggregate stability and infiltration while reducing runoff has departed from reference condition. The risk of soil loss resulting in a departure of soil productivity is associated with erosion hazard classes. All of these soil characteristics interact and result in how a soil functions which impacts soil condition. This ultimately impacts the soil productivity potential.

The Forest has experienced several recent years of drought with occasional normal levels of seasonal moisture. Reduced precipitation results in reduced vegetative growth, reduced surface organic matter and nutrient cycling and lower site productivity. Ineffective vegetative ground cover puts the soil at risk of accelerated erosion during peak storm events and subsequent erosion and loss of soil productivity. As the potential for vegetation mortality increases, there is an increased risk of wild fire spread and subsequent accelerated erosion and overall watershed degradation.

Prescribed fire or wildfire can cause flooding post fire which may result in localized sediment production in the stream channel, stream banks and floodplains if not well protected with vegetative ground cover. Frequent flooding is a natural process and disturbance or flash flooding can occur in perennial, intermittent and ephemeral streams in all ERUs, especially in large watersheds where short duration, high intensity storms occur. It is important to maintain native vegetation described in the Potential Plant Community of the TES to provide channel stability, functional riparian areas, and good water quality for wildlife and aquatic species. With the exclusion of wildfire throughout some of the ERUs during the 20th century fuel loading has increased in woodland and forest ERUs resulting in the risk of high burn severity and resulting accelerated erosion, loss of soil and vegetative productivity, and sediment transport to connected streams following wildfires in areas with moderate and high erosion hazard on the Forest.

Methodology

The Terrestrial Ecological Unit Inventory (TEUI), previously referred to as the Terrestrial Ecosystem Survey, maps relationships between climate, geographic location, geology, geomorphology, aspect, slope, soil and vegetation at the scale of a standard United States Geological Survey (USGS) map. The TEUI mapping process includes three general types of documentation: observations, transects, and ecological site descriptions. Observations and transects are the least intensive form of documentation. Ecological site descriptions are used to develop quantitative descriptions of characteristics defining site potential for a given map unit. In the process of gathering data, conditions that represent site potential, and those that represent other successional states are documented. Ecological site descriptions are the most intensive form of sampling and are used to document site potential, once it has been sampled through observations and transects. In this analysis, representative observations and transects are used to describe current conditions and ecological site descriptions are used as a reference condition, where available.

Analysis and Findings- Conditions, Trends and Sustainability of Soils

Soil Condition

Soil condition is an evaluation of soil quality based on an interpretation of factors which affect vital soil functions. Soil quality is the capacity of the soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Doran and Parkin 1994).

Soil condition is based on three soil functions including 1) the ability of the soil to resist erosion, 2) the ability of the soil to infiltrate water and 3) the ability of the soil to recycle nutrients. Soil condition provides an overall picture of soil health vital in sustaining ecosystems. Soil condition rates soils as they exist currently and reflects the effects of management and disturbance history—soils were generally assumed to be in satisfactory soil condition under reference conditions.

The soil condition rating procedure evaluates soil quality based on an interpretation of factors that affect three primary soil functions. The primary soil functions evaluated are soil stability, soil hydrology, and nutrient cycling.

Definitions of soil functions are as follows:

- **Soil Stability**: The ability of the soil to resist erosion. Soil erosion is the detachment, transport, and deposition of soil particles by water, wind, or gravity. Vascular plants, soil biotic crusts, and vegetation ground cover (VGC) are the greatest deterrent to surface soil erosion. Visual evidence of surface erosion includes sheets, rills, and gullies; pedestalling, soil deposition, erosion pavement, and loss of the surface "A" horizon. Erosion models may also be used to predict on-site soil loss.
- **Soil Hydrologic Function**: The ability of the soil to absorb, store, and transmit water, both vertically and horizontally. This function is assessed by evaluating or observing changes in surface structure, surface pore space, consistence, bulk density, infiltration, or penetration resistance. Increases in bulk density or decreases in porosity results in reduced water infiltration, permeability, and plant available moisture.

- **Nutrient Cycling**: The ability of the soil to accept, hold and release nutrients. This function is assessed by evaluating vegetative community composition, litter, coarse woody material, root distribution, and soil biotic crusts. These indicators are considered an important source of soil organic matter, which is essential in sustaining long-term soil productivity. It provides a carbon and energy source for soil microbes, stores and provides nutrients which are needed for the growth of plants and soil organisms and by providing for cation and anion exchange capacities.

Soil Condition Categories

Ecological Response Units are assigned a soil condition category which is an indication of the status of soil functions. Soil condition categories reflect soil disturbances resulting from both planned and unplanned events. Current management activities provide opportunities to maintain or improve soil functions that are critical in sustaining soil productivity. The following is a brief description of each soil condition category:

- **Satisfactory**: Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high.
- **Impaired:** Indicators signify a reduction in soil function. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation. An impaired category indicates there is a need to investigate the ecosystem to determine the cause and degree of decline in soil functions. Changes in land management practices or other preventative measures may be appropriate.
- **Unsatisfactory**: Indicators signify that a loss of soil function has occurred. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs, or recover from impacts. Unsatisfactory soils are candidates for improved management practices or restoration designed to recover soil functions.

Existing management activities need to be evaluated to determine if the current management activity is contributing to the loss of soil function. In some cases, current management activities may not have caused the loss of soil function but may be preventing recovery. Management activities that slow or prevent recovery of soil function should be evaluated for best management practices.

Satisfactory soil condition (soil quality) is important in maintaining long-term soil productivity—key to sustaining ecological diversity. Unsatisfactory and impaired soil conditions have resulted in the reduced ability of the soil to grow plants and sustain productive, diverse vegetation.

Reference Condition, Current Conditions and Trends

The Terrestrial Ecosystem Survey of the Lincoln National Forest was used as the basis for determining current soil condition. The TES identifies soil condition by ecological map unit and predicted soil loss. Soil condition is influenced by management. Current soil condition in this assessment reflects conditions that were assessed from the early 1970s to early 1990s when the TES data was collected and published. Additional soil condition data has been collected for site specific projects.

Also current soil condition information was taken from more recent Forest project assessments. Since then significant changes have occurred across the landscape from management and natural disturbances such as fire, drought, and grazing. Satisfactory soil conditions have likely decreased and impaired or unsatisfactory conditions have likely increased in areas where disturbances have occurred.

Soil condition ratings were summarized by TEUI within each ERU.

Reference Condition

Very little quantitative data exist to measure historical soil condition. However, some qualitative and quantitative inferences can be made, providing insight into historical soil condition by using knowledge about present disturbances and their effect on soil stability, soil compaction, and nutrient cycling. Reference conditions generally estimate Pre-European settlement conditions (Winthers et al. 2005).

Historically (without anthropogenic disturbance), soil loss, soil compaction, and nutrient cycling would probably have been within functional limits to sustain soil function and maintain soil productivity for most soils that are not inherently unstable—the exception being during cyclic periods of drought and possibly local areas impacted through native populations and non-domestic herbivory. Natural flood disturbance would have had a limited effect on the extent of soil loss, only causing accelerated erosion adjacent to stream channels or floodplains. Natural fire disturbance would have had a limited effect on the extent of soil loss, only causing accelerated erosion in localized areas where total consumption of the litter layer and/or canopy occurred. Drought may have reduced the amount of protective vegetative ground cover resulting in accelerated erosion during prolonged rainstorms.

Most areas that are currently unsatisfactory for soil condition would probably have been historically satisfactory for soil condition. The reference condition is “satisfactory” and is represented by the ecological site description documentation with current conditions described by observations and transects. Since then significant changes have occurred across the landscape from management and natural disturbances creating less satisfactory soil conditions across the Lincoln NF. Table 123 estimates the change in historic and current soil conditions.

Table 123. Estimated historic versus current soil condition percentages on Lincoln NF

Soil Condition Class	Historic Percent	Current Percent	Difference between Historic and Current
Satisfactory	95%	70%	25%
Unsatisfactory	Low	30%	30%

Current Soil Condition

Approximately 67 percent of the Lincoln NF is in satisfactory soil condition. More than half of the upland ERUs have satisfactory soil conditions (11 out of 14). These include SFF, MCW, MCD, PPF, PPE, PJC, PJO, GAMB, MSG, SDG, and CDS (Figure 66). The most productive soils (satisfactory soil condition) are within ERUs that produce high amounts of organic matter to ensure stability of the soil and support nutrient cycling. The satisfactory rating indicates that soil function is being sustained within ecosystem boundaries and the ability of the soil to main resource values and sustain outputs is high. Soil condition is shown in Figure 67.

An impaired rating indicates a reduction of soil function, a reduced capacity to maintain resource values and sustain outputs, and an increased vulnerability to degradation. Approximately 33 percent of the Lincoln NF is in unsatisfactory and impaired soil condition. The Pinyon-Juniper ERUs have portions of the ERU that are impaired and unsatisfactory soil condition due to high amounts of bare soil from drought, grazing, and dense overstory due to lack of fire. These individual ERU percentages include JUG (62 percent), PJG (75 percent) and MMS (76 percent). The loss of soil productivity (unsatisfactory soil condition) through a reduction in soil function is due to a lack of effective vegetative ground cover and organic matter. A reduction in vegetative ground cover also decreases the sites ability to buffer the soil surface again rain drop impact, and excessive animal or mechanical traffic, which compacts the soil surface.

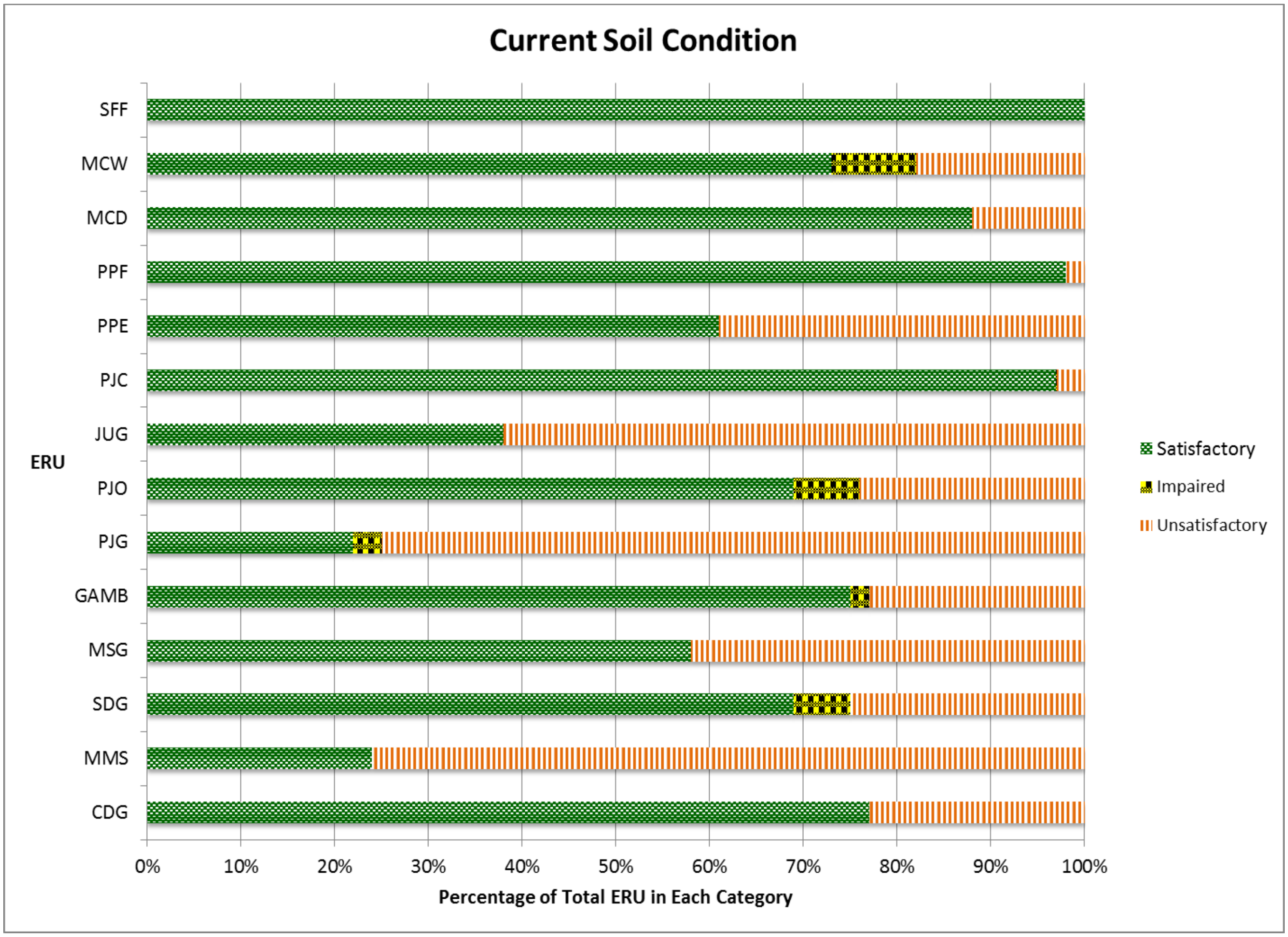

Figure 66. Current soil condition across Lincoln NF

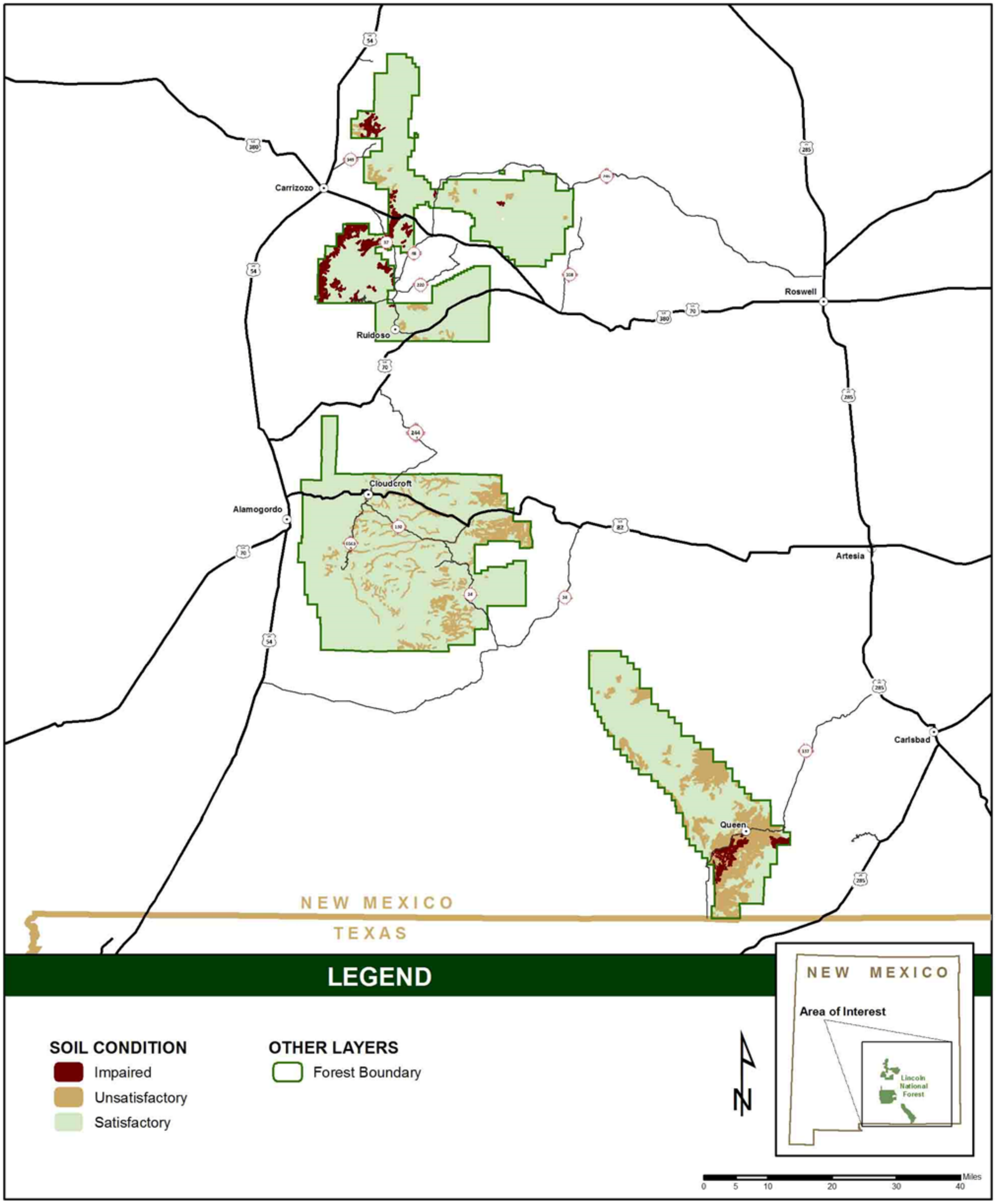

Figure 67. Soil condition on the Lincoln NF (Plan Area)

Soil Condition Departure and Trend

Soil Condition Departure

The reference condition for this characteristic is all soils are function properly and retain their inherent productivity. Departure ratings were summarized by TEUI unit for each ERU. Departure ratings for the ERU were assigned using the parameters below.

- 0 to 24 percent Unsatisfactory Soil Condition = Low Departure
- 25 to 49 percent Unsatisfactory Soil Condition = Moderate Departure
- greater than or equal to 50 percent Unsatisfactory Soil Condition = High Departure

Soil condition classes correlated to departure ratings are as follows:

- Satisfactory = Low
- Impaired = Moderate
- Unsatisfactory = High

Table 124 summarizes the departure ratings across the Lincoln NF. JUG and PJC have high departure. Visible erosion is in these ERUs are evident in the way of gully erosion, deposition, pedestalling of grasses, bare soil and compaction. The grasslands (MSG and SDG) and PPE ERUs have a moderate departure. These areas are experiencing the same visible erosion indicators but with a lesser degree of departure. The remaining ERUs have low departure overall, however there are areas within those ERUs that are experiencing moderate to high departure on a more site specific bases.

Table 124. Soil condition departure on the Lincoln NF

ERU	Satisfactory	Impaired	Unsatisfactory	Departure from Reference Condition
SFF	100%	0%	0%	Low
MCW	73%	9%	18%	Low
MCD	88%	0%	12%	Low
PPF	98%	0%	2%	Low
PPE	61%	0%	39%	Moderate
PJC	97%	0%	3%	Low
JUG	38%	0%	62%	High
PJO	69%	7%	24%	Low
PJG	22%	3%	75%	High
GAMB	75%	2%	23%	Low
MSG	58%	0%	42%	Moderate
SDG	69%	6%	25%	Moderate
MMS	24%	0%	76%	High
CDG	77%	0%	23%	Low

Soil Condition Trend

Trends of soil condition on the Lincoln NF will be a product of a variety of factors and interactions. Among those factors are current and future management objectives, management practices, climate change, and natural disturbances. Table 125 estimates of current soil condition trend were analyzed using two criteria: (1) when 25 percent or more of an ERU was rated in unsatisfactory soil condition the ERU was considered to be trending away from reference condition and (2) when 24 percent or less of an ERU was rated in unsatisfactory soil condition the ERU was considered to be in stable condition.

Eight out of the 14 ERUs have a stable trend. These ERUs include SFF, MCW, MCD, PPF, PJC, PJO, GAMB, and CDG. These ERUs have less than 24 percent of unsatisfactory soil conditions. The remaining seven ERUs have 25 percent or more unsatisfactory soil conditions thus are trending away from reference conditions.

Stressors such as altered fire regimes, nonnative species, and drought—coupled with historical unmanaged grazing and fuelwood gathering—have produced unnaturally dense overstories and sparse vegetative ground cover. These stressors (past, current, and future) will affect soil condition trends by either moving away from reference conditions or remaining stable. Soil erosion may be occurring beyond its threshold due to high amounts of bare soil and larger, more intense wildfires; and many soils may be trending toward conditions of accelerated erosion and declining site productivity. Current management practices strive to restore ecosystem health and improve soil condition.

Table 125. Soil condition ratings trend summary

ERU	Satisfactory	Impaired	Unsatisfactory	Trend from Reference Condition
SFF	100%	0%	0%	Stable
MCW	73%	9%	18%	Stable
MCD	88%	0%	12%	Stable
PPF	98%	0%	2%	Stable
PPE	61%	0%	39%	Away
PJC	97%	0%	3%	Stable
JUG	38%	0%	62%	Away
PJO	69%	7%	24%	Stable
PJG	22%	3%	75%	Away
GAMB	75%	2%	23%	Stable
MSG	58%	0%	42%	Away
SDG	69%	6%	25%	Away
MMS	24%	0%	76%	Away
CDG	77%	0%	23%	Stable

Soil Condition Risk Rating

Once trend and departure ratings were assessed for each ERU. The results were run through a risk matrix to identify risk by ERU. A weighted average for risk was then calculated by ERU for each zone. The weighted average was calculated for Soil Condition. Risk is a function of Departure and Trend as either a Low, Moderate or High Risk. The purpose of the risk assessment is to identify systems at risk due to specific management activities.

Risk has been generalized into three vulnerability categories of low, moderate and high and is summarized in Table 126 for the Lincoln NF.

Stressors are not incorporated into the matrix below, but do intensify risk and therefore are assumed to increase the level of risk by one level (e.g., moderate to high) if considered significant and influence by that stressor. High insect and disease and climate change rating are considered significant stressors. See the Stressors and Drivers section for a more detailed discussion. Parameters were identified and are described below to identify one risk rating for each ERU.

Table 126. Soil Characteristic Risk Matrix for Risk Rating by ERU

Departure	Trend towards (Reference Condition)	Risk
Low	Stable	Low
Low	Away	Moderate
Moderate	Stable	Low
Moderate	Away	High
High	Stable	Moderate
High	Away	High
Departure and Trend = Risk (towards or away from reference conditions)		

Soil Condition Risk Results

Soil conditions are influenced by management and are the criteria used in this risk assessment. Four out of the 14 ERUs analyzed on the Lincoln NF are considered to be at High Risk for soil condition. They are PPE, JUG, PJG and MSG (Table 127). A High risk rating indicates that these ERUs are high risk and moving away from reference conditions. Ecological need for change should address the site-specific characteristics (plant basal cover, canopy cover, litter, coarse woody material, etc.) for these ERUs that are a high risk for soil condition.

Lower elevation ERUs, such as SDG, and MMS received a moderate risk rating. These areas have effects from historical grazing and management. The herbaceous cover and increasing bare soil has contributed to this moderate risk rating. Reference the System drivers and stressors of soils for a more detailed discussion. Table 127 displays all 14 ERU's risk rating results for Soil Condition.

Table 127. ERU risk ratings for Lincoln NF ERUs

ERU Name	ERU Soil Condition Departure from Reference Condition	ERU Soil Condition Trend from Reference Condition	ERU RISK
SFF	Low	Stable	Low
MCW	Moderate	Stable	Low
MCD	Low	Stable	Low
PPF	Low	Stable	Low
PPE	Moderate	Away	High
PJC	Low	Stable	Low
JUG	Moderate	Away	High
PJO	Low	Stable	Low
PJG	Moderate	Away	High
GAMB	Low	Stable	Low
MSG	Moderate	Away	High
SDG	Low	Away	Moderate
MMS	Low	Away	Moderate
CDG	Low	Stable	Low

Soil condition risk is associated with both historic and current fire and livestock grazing management. All management activities that impact vegetation, impact the soil resource and vice versa. Competition between the restoration of fire adapted ecosystems and current livestock grazing is a factor contributing to risk since the herbaceous understory vegetation needed to fuel fire also provides forage for livestock. The organic material contributes to soil stability, hydrologic and nutrient cycling functions. While current livestock grazing management has allowed for improvements over historic management and resource conditions, it slows the rate of natural recovery that might be expected in the absence of this stressor.

Soil Loss Departure and Trend

Data, Methods and Scales of Analysis

A certain amount of soil loss occurs as a natural geologic process, even under reference conditions. This is referred to as the baseline, minimum, or natural rate of soil loss (NSL). Some amount of soil loss greater than the minimum rate can occur without impairing natural soil productivity. This rate varies by soil and ecological system. The reference condition for soil loss is based on the assumption that soil loss rates would have been below some threshold in most places on the Lincoln National Forest.

Vegetative groundcover includes basal area, litter, microbiotic, lichens and mosses. Basal aera is the area covered by tree trunks and stems of shrubs, forbs and graminoid species where they meet the ground. Effective litter includes all coarse woody and finer plant debris, a half inch or more in depth (UDA FS 1986a). Litter less than this depth is not considered effefctive in supporting soil stability. The distribution of litter is also important. Where litte is unevenly distributed and /or only associated with all vegetative layers (USFS FS 2013b). Microbiotic crusts can be a key component in helping hold soils in place and these crusts exist all across the Forest to varying degrees, those with thickness great enough to contribute to overall soil stability are not extensive. The same can be said for lichens and mosses, except at high elevation where mosses can play a large role in soil stability after fire.

Vegetative groundcover plays a critical role in soil stability and site productivity as it also reduces the raindrop impact energy responsible for detachment of soil particles, limits and the movement of detached particles and reduces the potential for concentration of surface runoff water that contributes to rill and gully erosion. Vegetative groundcover is also an indicator of nutrient cycling status.

Annual soil loss rates are predicted from the Rangeland Hydrology and Erosion Model (RHEM) v2.3, developed by the Agricultural Research Station. This model is in the public domain and available at http://apps.tucson.ars.ag.gov/rhem. In the past, the only available soil loss models were based on cropland data. The RHEM model is based on rangeland data and is the most current, accepted model for use in rangeland and forest systems by the Southwest Region. Instead of a TSL rate, a threshold rate is determined using the RHEM (v2.3) risk function. Departure is categorized as low, moderate, or high. The Regional soil condition guidance discussed in the next subsection differentiates the modeled soil loss indicator of soil stability function between condition categories based on whether or not Current Soil Loss (CSL) exceeds TSL. As applied to departure, this means departure either exists or it does not. Where they are below the threshold rate, departure is low for that TEUI unit. Where CSL rates exceed the threshold rate, departure from the reference is categorized as significant for that TEUI unit.

CSL rates are those occurring under vegetative canopy and groundcover conditions as documented by TEUI observation, transect data, and NSL by the ecological site descriptions. ERU acres burned at high and moderate severities are not represented by modeled data. It is assumed that CSL rates exceed the NSL and threshold rates on these acreages for five years post-fire. This assumption is based on soil loss modeling for BAER assessments, Forest monitoring data, and professional observation and judgement.

The RHEM model is only capable of modeling sheet and rill erosion. Therefore, gully and wind erosion are not considered. The processes involved in gully erosion are more like stream channel processes, and while there may be some capable watershed models, it is beyond the scope of this assessment to do so. Gully erosion is considered qualitatively based on notes that accompany the TEUI documentation and on the ground knowledge but is not used to assess soil loss, rather it is accounted for in the soil condition assessment.

Currently, no wind erosion models developed for forest or rangeland data are available. Although the Air Resources chapter does include quantitative data on particulate matter, it cannot be used to estimate wind erosion on the Forest as the origins of that particulate matter cannot be traced to a specific area of land. Wind erosion is generally considered a larger issue in cropland systems than in forest and rangeland systems.

The value in modeling soil loss, or anything for that matter, is not to arrive at an absolute value, rather it is the relative difference between management scenarios that is important, such as the reduction in the vegetative canopy and/or groundcover. Figure 68 displays the results of the soil loss modeling. Where departure is low, current soli loss rates are below the threshold rate. Significant departure indicates soil loss exceeds the threshold rate. When an ERU has more than 33 percent of their area represented by TEUI units that are in significant departure, the ERU is considered significantly departed as a whole (see Departure and Risk sections of this chapter).

Reference Condition

Reference conditions generally estimate Pre-European settlement conditions (Winthers et al. 2005). The extent and magnitude of natural disturbances (e.g., fire, floods) under reference conditions was smaller than under current conditions, and the subsequent loss of vegetation cover and litter for a given site—and the likelihood of erosion—would have been smaller as well. However, it is probable that when soils were burned and farmed, accelerated erosion occurred after. There is substantial evidence that the Native American landscape of the early sixteenth century was a humanized landscape, populations were large and forest composition had been modified, grasslands had been created, wildlife disrupted, and erosion was severe in places (Denevan 1992). Soil loss, historically, would have been within natural soil loss rates in most places on the Lincoln NF.

Current Condition

As described in the Analysis methods, all ERUs with more than 33 percent of their area represented by TEUI units in significant departure are considered significantly departed as a whole. PPE, PJC and PJG are the ERUs that are significantly departed and has unsustainable levels to sustain inherent site productivity. The remaining (11 out of 14) of the ERUs analyzed on the Lincoln NF have current soil loss rates that do not exceed threshold soil loss rates, thus are considered low in departure. These ERUs are SFF, MCW, MCD, PPF, JUG, PJO, GAMB, MSG, SDG, MMS, and CDS. These ERUs are currently sustaining inherent site productivity. All (14 out of 14) of the ERUs analyzed on the Lincoln NF have current soil loss rates that exceed natural soil loss rates.

In some ERUs, a small percentage of what is interpreted as exceeding a threshold in this analysis, is actually a reflection of natural instability. Natural instability is defined by soils where NSL rate is greater than the tolerance, or threshold soil loss rate. In other words, the geologic rate of soil loss is greater than the rate of soil formation. The RHEM model automatically identifies the lowest soil loss rate as the NSL (RHEM calls it “baseline”), which means that all other scenarios (current or otherwise) will be represented by a soil loss rate greater than NSL. Soil loss modeling with RHEM cannot serve as the basis on which to identify naturally unstable soils. Natural instability is due to interrelationships between bedrock composition and structure, parent material, soil texture, rock content, landform, and slope.

While slope is only one of many factors, slopes over 40 percent have been excluded from mechanical vegetation treatments on the Forest because of stability considerations. As a general rule, these slopes are also infrequently utilized by livestock. The most important disturbance regimes on these slopes are drought and fire. Slopes over 40 percent are considered inherently unstable. Approximately 68 percent of the Forest occurs on slopes 40 percent or greater. All ERUs contain some areas with slopes of over 40 percent, but the SFF ERU has the largest area. Larger drainageways that consist of sandstone and shales from the Yeso Formation have been exposed by erosion and are considered highly erodible.

As described in the Data, Methods and Scales of Analysis section in this chapter, all ERUs with more than 33 percent of their area represented by TEUI units in significant departure are considered significantly departed as a whole. Where departure is low, current soil loss rates are below the threshold rate. Significant departure indicates current soil loss exceeds the threshold rate. Figure 68 displays the results of the soil loss modeling.

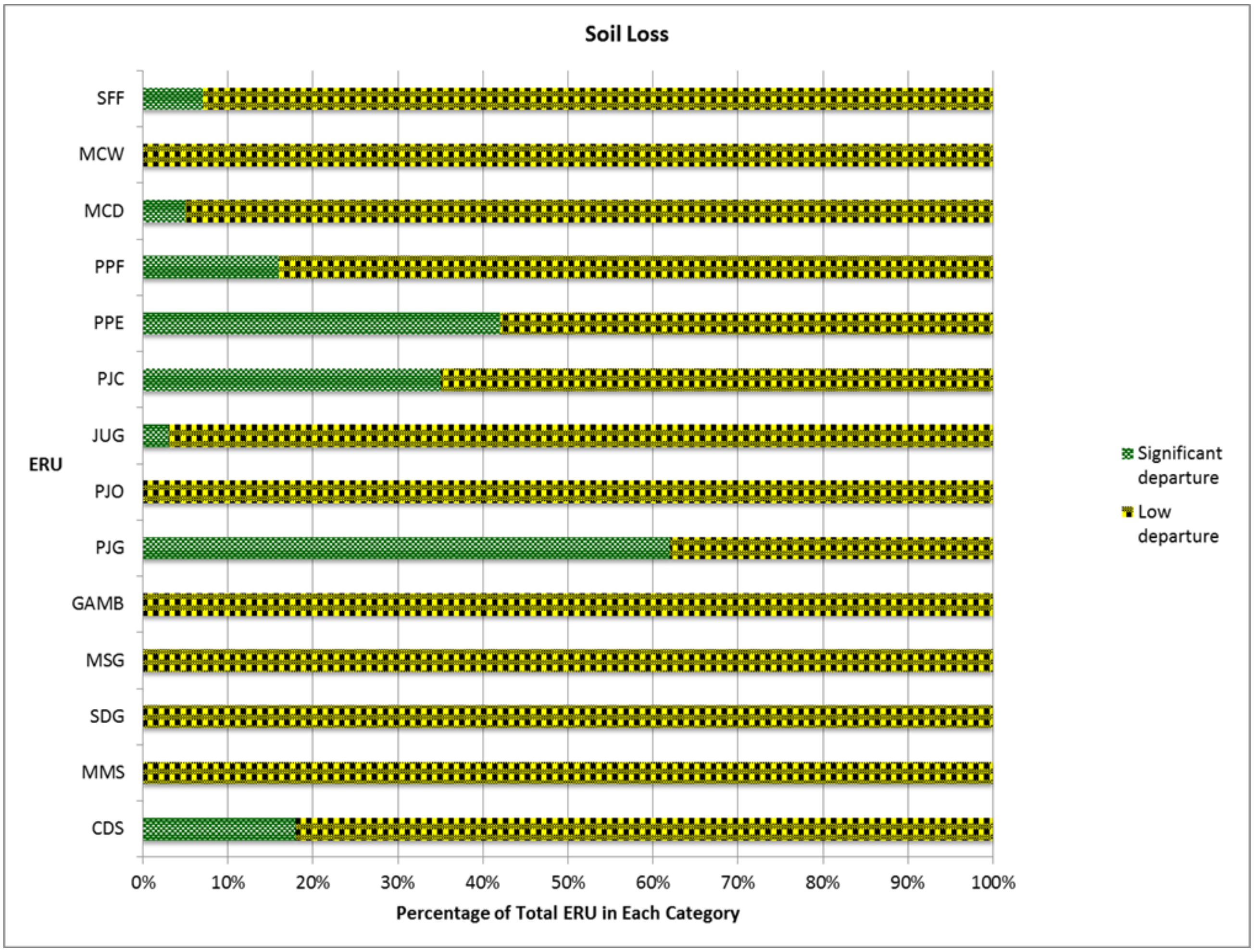

Figure 68. Soil loss across ERUs on the Lincoln NF

The PPE ERU has a significant departure due to high and moderate burn severities they have experienced. These areas have experienced slow recovery of vegetative ground cover and as a result have experienced loss of soil site productivity. Drought, thinning, livestock grazing management, historic and current fires as described below have contributed to the departure away from reference conditions.

There is significant departure in two of the four woodland ERUs. PJC and PJG have areas of distribution where vegetative groundcover is uneven in the current condition as indicated by generally higher percentages of bare ground. The difference in canopy grasses has resulted in a shift from reference conditions (more grass and litter) to current conditions (less grass and litter).

Gully erosion has been documented by the TEUI in all grassland ERUs, PJ Woodland, PJ Grass, and Juniper Grass. Most of these processes were initiated as a result of historic grazing practices that are no longer practiced due to improved management. However, gullies remain active to the current day as it takes long periods of time for natural processes to stabilize themselves. Just because the TEUI has not documented gully erosion in other ERUs does not necessarily mean they do not exist. In fact, gully erosion (as well as hillslope failure) is known to occur in recent high and moderate burn severity areas within the mixed conifer forests. Gully erosion is not used to modify the results of the modeling analysis, but is considered in the analysis of soil condition that follows.

As previously described in Systems Drivers and Stressors of soils section, thinning activities, historic and current fire, and livestock grazing management have contributed to the shirt in reference conditions to current conditions. In areas where slopes are steeper, smaller differences in vegetative canopy and groundcover contribute to accelerate erosion. In areas that are relatively flat, larger differences in vegetative canopy and groundcover could accelerate erosion. Drought also plays a large role in both vegetative canopy and groundcover departures, particularly with regard to grass species. During periods of drought, vegetation may not be as vigorous, able to withstand disturbance, and may die, impacting both vegetative canopy cover and groundcover. The death of some grass plants has been observed in some places on the Forest over the last several years of drought.

Departure

ERU departure for soil loss is determined by applying the same 33 percent threshold as was used in the assessment of vegetation related to the Ecocological Characteristics section. If more than 33 percent of the ERU area is represented by TEUI units is exceeding soil loss threshold, then departure is significant for that ERU (Table 128).

The soil loss departure rating is as follows:

- When current soil loss rates are below threshold soil loss rates the ERU was considered to be at low departure.
- When current soil loss rates exceed threshold soil loss rates by 0-49 percent the ERU was considered to be at moderate departure.
- When current soil loss rates exceed threshold soil loss rates by greater than 50 percent the ERU was considered to be at high departure.

If soil Loss rates exceed this threshold, it is considered a threat to the sustainability of the productivity of the land.

The Rangeland Hydrology an Erosion model (RHEM) v.2.3 was used to model soil loss rates for departure. As with any modeled values, these soil loss rates should not be considered absolute values and are considered valuable only as a means of comparing the relative relationships in terms of Risk as it relates to Reference Conditions.

Table 128. ERU departure for soil loss

ERU Name	Percent of ERU that exceeded Soil Loss Theshold rates	ERU Soil Loss Departure rating
SFF	7%	Low
MCW	0%	Low
MCD	5%	Low
PPF	16%	Low
PPE	42%	Moderate
PJC	35%	Moderate
JUG	3%	Low
PJO	0%	Low
PJG	62%	High
GAMB	0%	Low
MSG	0%	Low

ERU Name	Percent of ERU that exceeded Soil Loss Theshold rates	ERU Soil Loss Departure rating
SDG	0%	Low
MMS	0%	Low
CDG	18%	Low

Soil Loss Trend

Current soil loss trends were analyzed on the basis of current soil loss rates as compared to threshold soil loss rates. When current soil loss rates exceeded threshold soil loss rates the ERU was considered to be trending away from reference condition. If current soil loss rates were less than threshold soil loss rates the ERU was considered to be in stable condition. Approximately (3 out of 14) ERUs on the Lincoln NF are trending away from reference soil loss conditions based the analysis. These ERUs include PPE, PJC and JUG. As previously notes, soil loss in PJ Woodlands includes a relatively large difference in canopy cover of grasses, between reference (more grass and litter) vs. current conditions (less grass and litter). The vegetative groundcover is uneven in the current conditions as indicated by higher precentages of bare soils. See System drives and stressors of soils for further discussion.

Table 129. Soil loss trend on Lincoln NF

ERU Name	ERU Soil Loss (exceeds/below) Thresold	ERU Soil Loss Trend from Reference Condition
SFF	Below	Stable
MCW	Below	Stable
MCD	Below	Stable
PPF	Below	Stable
PPE	Exceeded	Away
PJC	Exceeded	Away
JUG	Below	Stable
PJO	Below	Stable
PJG	Exceeded	Away
GAMB	Below	Stable
MSG	Below	Stable
SDG	Below	Stable
MMS	Below	Stable
CDG	Below	Stable

Soil Loss Risk Rating

Once trend and departure ratings were assessed for each ERU. The results were run through a risk matrix to identify risk by ERU. A weighted average for risk was then calculated by ERU for each zone. The weighted average was calculated for Soil Loss. Risk is a function of Departure and Trend as either a Low, Moderate or High Risk. Each of these ratings describe what the relationship is in terms of moving away from the reference condition. The purpose of the risk assessment is to identify systems at risk due to specific management activities. Parameters were identified and are described below to identify one risk rating for each ERU. Table 130 shows the overall risk results for the ERUs on the Lincoln NF.

Table 130. Soil Characteristic Risk Matrix for Risk Rating by ERU

Departure	Trend towards (Reference Condition)	Risk
Low	Stable	Low
Low	Away	Moderate
Moderate	Stable	Low
Moderate	Away	High
High	Stable	Moderate
High	Away	High
Departure and Trend = Risk (towards or away from reference conditions)		

Soil Loss Risk Results

PPE is in high departure due to the large extent of high and moderate burn severities. These areas have a slow natural recovery and soil loss is occurring at an accelerated rate. The reasons for significant departure in PJC and PJG are relatively large difference between the canopy cover of grasses, and bare soil between reference (more grass and litter) and current conditions (less grass and litter).

Although the remaining ERUs are not significantly departed overall, there are areas that are experiencing accelerated soil loss. Recall that the RHEM model inputs include both vegetative canopy cover by life form and vegetative groundcover. Of those areas, there are 5 percent that has exceeded the threshold soil loss rate. Where departure within this ERU is significant, there tends to be less canopy cover of trees and less litter associated with current conditions as opposed to the reference. For the most part, the difference is not offset by higher canopy cover of grasses. Past thinning activities explain both the lower tree canopy cover and litter. After removing trees, coarse woody debris is typically piled and burned. Coarse woody debris is also important for long-term nutrient cycling and soil productivity. The finer material can be displaced or redistributed during these activities.

Table 131. Risk rating for all 14 ERUs

ERU Name	ERU Soil Loss Departure	ERU Soil Loss Trend from Reference Condition	RISK
SFF	Low	Stable	Low
MCW	Low	Stable	Low

ERU Name	ERU Soil Loss Departure	ERU Soil Loss Trend from Reference Condition	RISK
MCD	Low	Stable	Low
PPF	Low	Stable	Low
PPE	Moderate	Away	High
PJC	Moderate	Away	High
JUG	Low	Stable	Low
PJO	Low	Stable	Low
PJG	High	Away	High
GAMB	Low	Stable	Low
MSG	Low	Stable	Low
SDG	Low	Stable	Low
MMS	Low	Stable	Low
CDG	Low	Stable	Low

There is always some degree of risk as a result of management action or inaction. High soil loss and degradation of soil condition risk occurs in different ERUs across the Forest. Climate change is a major stressor that elevates risk to all characteristics analyzed for the soil resource.

Negative impacts to the soil stability and hydrologic function occur across the Forest, high and moderate burn severities from past wildfire may accelerate soil nutrient availability short-term. Some of these areas have experienced complete or nearly complete consumption of biomass which releases nutrients that were previously unavailable. Long term nutrient availability is not necessarily enhanced in these burned areas but potentially have negatively impacted sites, given the large extent of these burns. Biomass consumed is no longer available to support nutrient cycling and long-term productivity.

Some of this high risk is likely associated with areas where vegetative ground cover is uneven and soil instability. Parent material also plays a strong role in soil stability, on flat or steep terrain. Soils formed from volcanic sediment, granite, tuff, many rhyolites and conglomerates, as well as sandstone and shale can be highly erodible if vegetative groundcover is not maintained.

While soil loss risk is generally low across the entire Forest, departure is characterized as low based on the higher percentage of soil loss rates that do not exceed threshold rates. The majority of the current rates are within 25 percent of the threshold. The closer soil loss rates are to the threshold, the greater the risk current and future management activities that reduce vegetative canopy and ground cover might have (Table 130).

Non-fire vegetation treatments (e.g. fuelwood or timber harvest) have been conducted in most ERUS to restore both vegetation structure and composition (ecological status). These activities have been fairly limited due to budget, staffing levels and regional priorities, but could foreseeably increase with landscape scale restoration. Mechanical treatments such as these can have a large impact on soil hydrologic, stability, and nutrient cycling status, depending on a variety of factors including but not limited to: soil clay and moisture content, temperatures during treatment and time between entries (for maintenance). Slope restrictions or methods designed to reduce impacts to the soil resource and protect water quality are recommended and implemented at the project level. However, without restoring ecological processes, like fire, these treatments require maintenance. Re-entry increases the risk to soil functions and could potentially decrease soil productivity long term.

Soil Erosion Hazard

Data, Methods and Scales of Analysis

Soil Erosion Hazard is the probability of soil loss resulting from complete removal of vegetation and litter—an inherent soil property (not influenced by management). Slope, soil texture, and vegetation type greatly influence soil erosion hazard rating. The soil erosion hazard rating reflects inherent site and soil characteristics which are determined from modeled soil loss rates. It is an interpretation based on the relationship between the maximum soil loss (potential) and the tolerable (threshold) soil loss of a site. Soils are given a slight, moderate, or severe erosion hazard rating.

- A rating of **slight** indicates the maximum soil loss does not exceed the threshold, and therefore, the loss of the soil production potential is of low probability.
- A **moderate** erosion hazard indicates that the loss in soil production potential from erosion is probable and significant if unchecked.
- A **severe** erosion hazard rating indicates that the loss of soil production potential from erosion is inevitable and irreversible if unchecked.

These ratings provide land managers with an index for identifying three classes of land stability. Slopes less than 15 percent are considered stable; slopes from 15 to 40 percent are normally metastable and slopes over 40 percent are unstable. Erosion hazard is useful in determining where erosion control measures should be evaluated when (or before) the soil surface has been exposed by logging, grazing, prescribed burning, or other disturbances. These ratings are also useful in identifying areas that should receive minimum exposure of mineral soil. Severe ratings mean that accelerated erosion is likely to occur in most years and that erosion control measures should be evaluated.

The range in erosion hazard classes within an ERU often reflect the various slope gradients, landforms, and associated canopy and ground cover for which they occur.

Reference Condition, Current Conditions and Trends

Reference Condition

Erosion hazard is an estimate of risk. Therefore, there is no reference condition or trend.

Current Condition

Approximately 42 percent of the Lincoln NF has a Slight erosion hazard rating. Six out of 14 ERUs have 50 percent or greater. These ERUs are JUG, PJG, GAMB, MSG, MMS, and CDG. In the grassland, shrubland, and woodland ERUs, the slight erosion hazard rating is typically associated with lower slope gradients and more level landforms.

ERUs that have 50 percent or greater combined of moderate and severe erosion hazard class are found in 8 of the 14 ERUs. These include SFF, MCW, MCD, PPF, PPE, PJC, PJO, and SDG. The moderate and severe erosion hazard class has a high probability that accelerated erosion would occur if erosion control measures are not addressed or when natural or management induced disturbances occur. With increasing canopy densities and a decreasing understory herbaceous component in the the potential for accelerated erosion to occur is high, if left unchecked.

PPE is 1 out of the 14 upland ERUs that have 50 percent or greater for severe erosion hazard. Systems with severe erosion hazard ratings occur within watersheds that have uncharacteristic disturbance regimes and fuel loadings, the potential risk for accelerated erosion exceeding thresholds, and subsequent runoff is high. Excessive fuel loadings combined with uncharacteristic fire regimes have the potential to create large swaths of land that lack canopy cover (overstory plants) and effective ground cover. This will increase the risk of accelerated soil erosion and debris flows on the landscape.

System stressors that create major disturbances include natural events such as wildfires, mass movements, and human-induced disturbances such as road construction and timber harvesting. Soil erosion, combined with other impacts from forest disturbance, such as soil compaction, can reduce forest sustainability and soil productivity (Elliot et al., 1999). When accelerated erosion occurs soil productivity is decreased thus decreasing ecosystem productivity. Erosion generally decreases productivity of forests by decreasing the available soil water for forest growth and through loss of nutrients in eroded sediment (Elliot et al., 1999).

While slope is only one of many factors of determining erosion hazard, slopes over 40 percent in the past have been excluded from mechanical vegetation treatments on the Forest because of stability considerations. As a general rule, these slopes are also infrequently utilized by livestock. The most important disturbance regimes on these slopes are drought and fire. Roads and trails are also an important disturbance regime in some cases (USDA Forest Service 2013).

Figure 69 displays current erosion hazard for the Lincoln NF upland ERUs. A weighted average was calculated for each ERU.

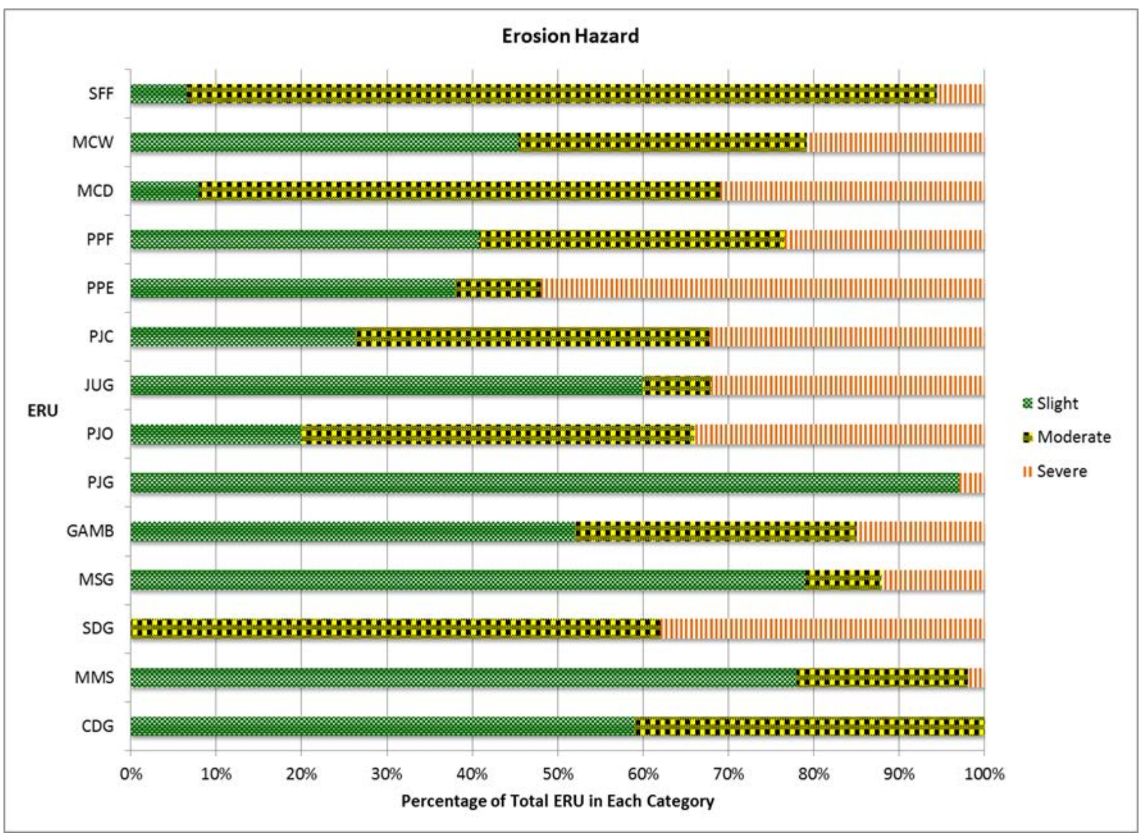

Figure 69. Erosion hazard for Lincoln NF upland ERUs

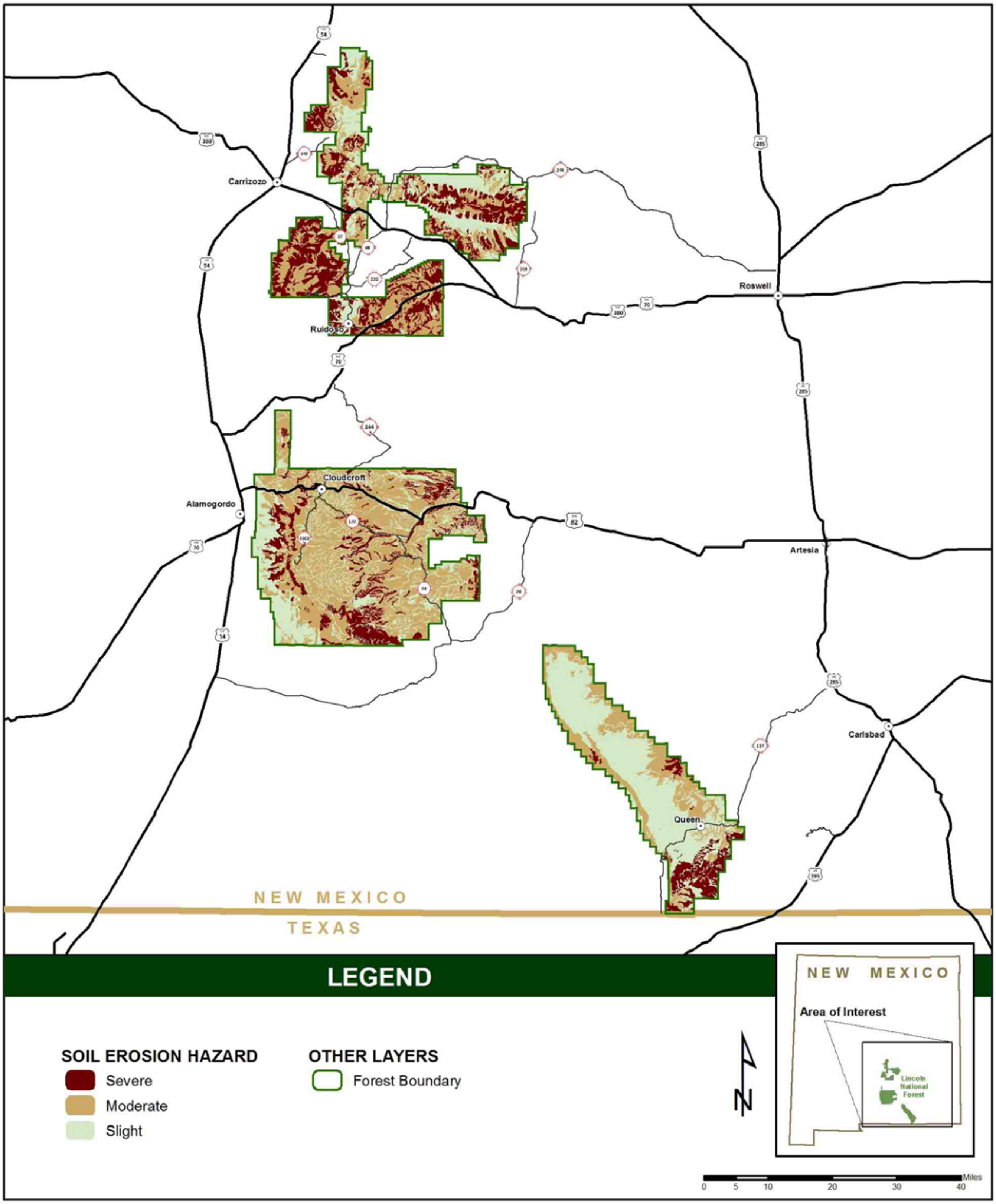

Figure 70. Soil erosion hazard on the Lincoln NF

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments relating to soils and their conditions, trends, and issues included these topics: impaired watershed function with impacts to all other resource values; increased stream turbidity; decreased precipitation, available water and moisture; decreased moisture; poor or limited recovery of watersheds following fire; sedimentation of streams following catastrophic fire; increased soil erosion, compaction, head cutting, and down cutting associated with livestock grazing; ecosystem services, multiple uses; lack of emphasis on watershed restoration/improvement; woody encroachment; decreased regeneration; increase in resource damage associated with OHV/ATV proliferation and travel rules; and various riparian area topics. Additional comment topics related to soils are listed in the stakeholder input sections of the other chapters, as pertinent. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for regional office approval prior to finalizing it.

Summary of Findings for Soils

This assessment reviews the best available soils information at the Ecological Response Unit (ERU), Forest and local unit scales. These ecosystem services are the product of soil hydrologic, stability and nutrient cycling functions reflected by key characteristics that include: Soil Condition, Erosion hazard and soil loss.

Soil hydrologic, stability and nutrient cycling can be defined and assessed individually, but are interrelated and inseparable on the ground. Soil condition represents the summation of these functions and relationships, while the other characteristics indicate specific issues. Departure and risk under current climate and management varies from low to high across the Forest's ERUs, but is generally low at the Forest scale. However risk is elevated by climate change (e.g., low to moderate or high to very high).

The relationships between climate, soil, and vegetation influences soil condition. Every management activity that is implemented, or not has an overall affect. Historic and current fire along with livestock grazing management are the primary themes for departure. The causal factors of departure from the reference condition, contribute to risk. Future risks due to non-fire vegetation treatments are expected to increase with the increasing emphasis on landscape scale restoration. This risk can be mitigated by Forest management, both at the Forest plan and project level.

While climate change is beyond the control of Lincoln NF management, opportunities exist for the Forest to manage ecological outcomes and risk with regard to the soil resource. These opportunities can be defined through better understanding and integration of watershed, ecological, and fire management strategies and objectives, as well as consistent, efficient, and effective monitoring designed to document outcomes and assess the effectiveness of management actions relative to key soil characteristic.

Chapter 7 - Water Resources

Introduction

This assessment of water resources characterizes and evaluates the status of watersheds and water resources (surface water, ground water, and water quality) and their role in sustaining the structure and function of terrestrial, riparian, and aquatic ecosystems within the Plan Area and the larger Context Area, assuming management is consistent with current Forest plan direction (see Ecological Assessment Introduction chapter). The Plan Area (1,260,821 acres) for water resources includes the Lincoln NF (Forest) and consists of all the land area where any portion of a 4th level hydrologic unit, or sub-basin, lies within the Forest boundary. The Context Area (11,556,613 acres) includes a larger area extending beyond the Lincoln NF and consist of six sub-basins that lie partially within the Forest. Any sub-basin that touches the Forest is part of the Context Area. This area covers much of South Central New Mexico, but does not include any area in Texas, even though a portion of some of these sub-basins lie partially in Texas (Figure 71).

The Context Area is needed to put the Forest condition in context with the status and distribution of resources on lands beyond the Forest boundary. An understanding of the environmental context extending beyond the plan area is useful in determining opportunities or limitations for Forest lands to contribute to the sustainability of broader ecological systems, as well as the impacts of the broader landscape on the sustainability of resources within the plan area. In some instances, a unique role of Forest lands may become apparent at this larger scale (FSH 1909.12, Chap. 10, Sec. 12.13b).

Lands administered by the Forest are at higher elevations than in the surrounding basins making these lands more conducive to greater amounts of precipitation and cooler climates. These factors allow water to be held on the landscape for longer amounts of time. Therefore, headwaters for many perennial streams lie within the boundaries of the Forest and much of the recharge to the surrounding groundwater basins comes from lands administered by the Forest.

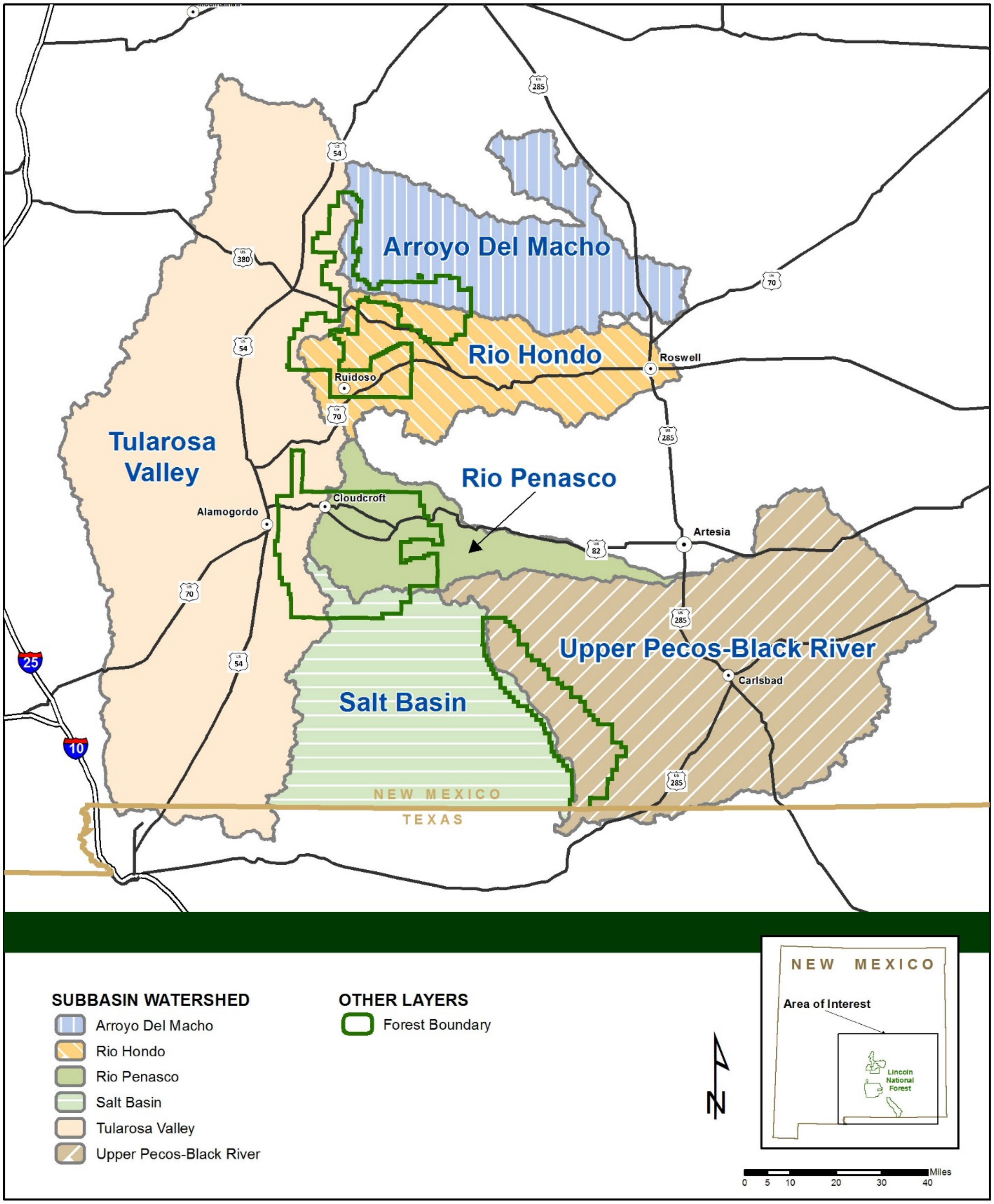

Figure 71. Context Area above the plan area showing the six sub-basins that intersect the Forest boundary

Scales of Analysis

To the extent practicable, water resources are assessed on a Context Area, Forest and watershed spatial basis. A watershed is a "region or land area drained by a single stream, river, or drainage network; a drainage basin" (36 CFR 219.19). These drainage areas are defined by the highest elevations surrounding a selected location on a stream so that a drop of water falling inside the boundary will drain to that stream while a drop of rain falling outside of the boundary will drain to another watershed and stream system. Watersheds encompass all of the ecosystem elements – water, soils, vegetation, and animals. Watersheds also span the landscape at many different scales. Watershed boundaries cross ownership boundaries since they are based on topography. A systematic method of delineating watershed boundaries and giving them a number code was developed by the USGS (Seaber, Kapinos, and Knapp 1987). This number code is called the hydrologic unit code (HUC).

To facilitate a consistent and understandable process for identifying and numbering watersheds, USGS has divided and subdivided hierarchical drainage basin levels into smaller and smaller hydrologic units, which are classified at six different levels. These hydrologic units are hierarchically nested within each other from the smallest (sub-watershed) to the largest (region). Each hydrologic unit is identified by a unique HUC consisting of two to 12 digits based on the six levels of classification in the hydrologic unit system. As they are successively subdivided, the numbering scheme of the units increases by two digits per level. The first level of classification divides the nation into 21 major geographic areas, or regions. This is represented by the first two hydrologic unit digits. The plan and Context Area, as well as the majority of the land area in New Mexico, is in the Rio Grande Region and has a hydrologic unit code of "13". The second level divides these 21 regions into 222 sub-regions, represented by four-digit HUCs. The third level divides these sub-regions into accounting units (basins) within the sub-regions and are represented by six digit HUCs. The fourth level is referred to as sub-basins, which have eight digit HUCs. The fifth levels are referred to as watersheds (10 digit HUCs). The smallest, or sixth level, is the sub-watershed (12 digit HUCs). Sub-watershed's on the Lincoln NF range from about 7,500 acres to 73,500 acres.

Each hydrologic unit is identified by a unique HUC consisting of two to twelve digits based on the six levels of classification:

- First-level (region): 2-digit HUC
- Second-level (sub-region): 4-digit HUC
- Third-level (basin): 6-digit HUC
- Fourth-level (sub-basin): 8-digit HUC
- Fifth-level (watershed): 10-digit HUC
- Sixth-level (sub-watershed): 12-digit HUC

The plan area is located entirely within the Rio Grande Region (HUC 13), which is on the eastern side of the Continental Divide. Within this region, the plan area is located in three sub-regions, which include the Rio Grande Closed Basins (HUC 1305), the Upper Pecos River Basin (HUC 1306), and the Lower Pecos River Basin (HUC 1307).

For the purposes of this chapter, fourth-level (8-digit) hydrological units will be referred to as "sub-basins", fifth-level (10 digit HUCs) units will be referred to as "watersheds", and sixth level (12 digit HUCs) units will be referred to as "sub-watersheds". This analysis assesses sub-basins (fourth level; eight digit HUCs) at the context scale. There are six sub-basins in the Context Area, ranging from 685,882 acres (Rio Peñasco sub-basin) to 4,293,040 acres (Tularosa sub-basin). The six sub-basins that overlap the Lincoln NF include the Tularosa Valley, Arroyo Del Macho, Rio Hondo, Rio Peñasco, Upper Pecos-Black, and the Salt Basin. Within this boundary there are seventy-five watersheds and 451 sub-watersheds. The watersheds (fifth level; ten digit HUCs) range from approximately 60,000 to 250,000 acres and were used to assess stressors and risk of impaired watershed condition. The sub-watersheds (sixth level; twelve digit HUCs) range from approximately 7,500 to 73,500 acres and were used to assess the watershed condition and the factors that contribute to watershed condition.

The area encompassing the six sub-basins that overlap Lincoln NF provide information about the regional context and extend well beyond the boundaries of the plan area. On the Forest, the plan area is located within portions of 34 watersheds and 122 sub-watersheds. Figure 72 through Figure 77 show each of the 6 sub-basins, watersheds, and sub-watersheds contained within each.

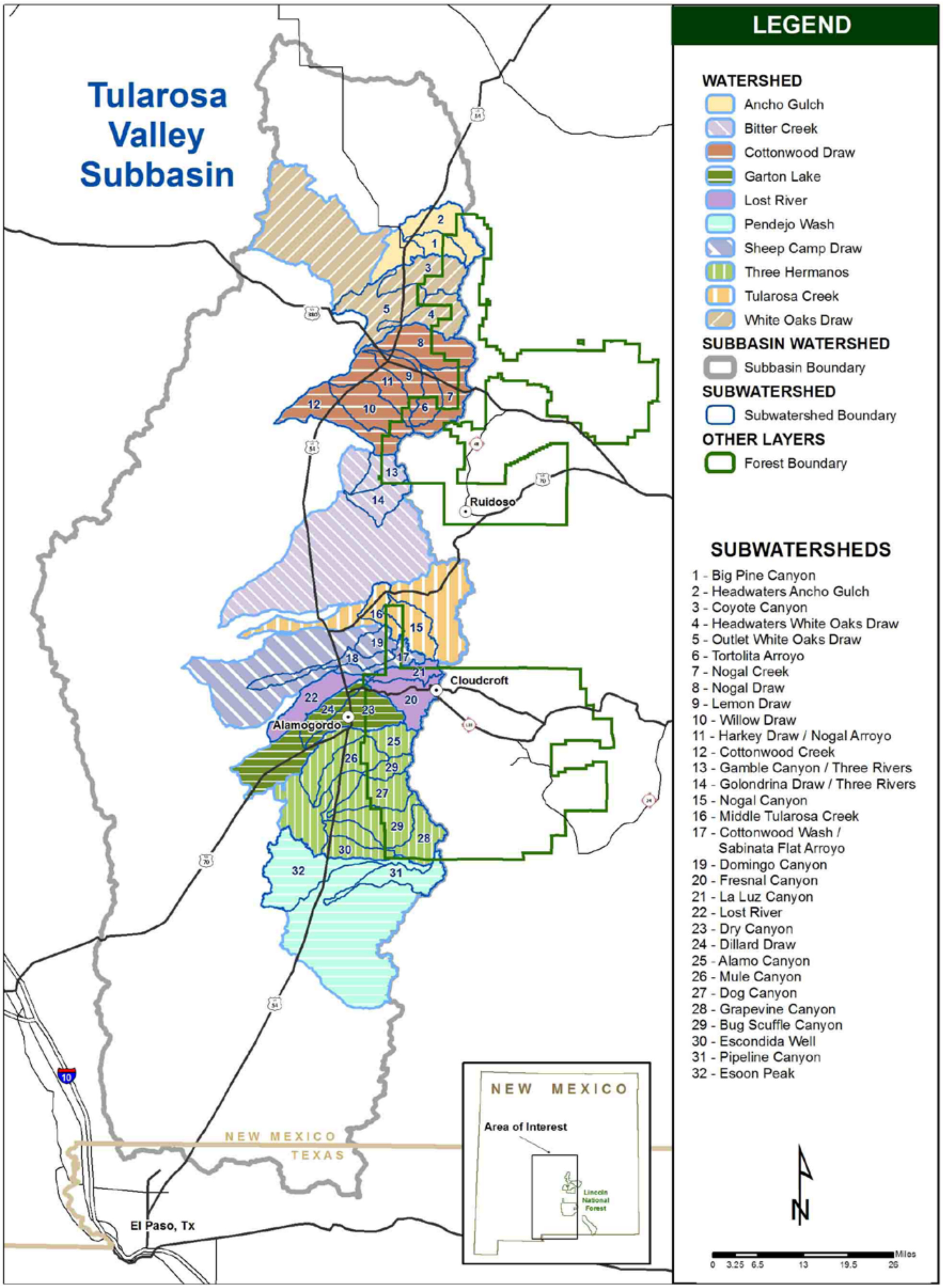

Figure 72. Tularosa Valley sub-basin showing all watersheds and sub-watersheds contained within the Lincoln National Forest

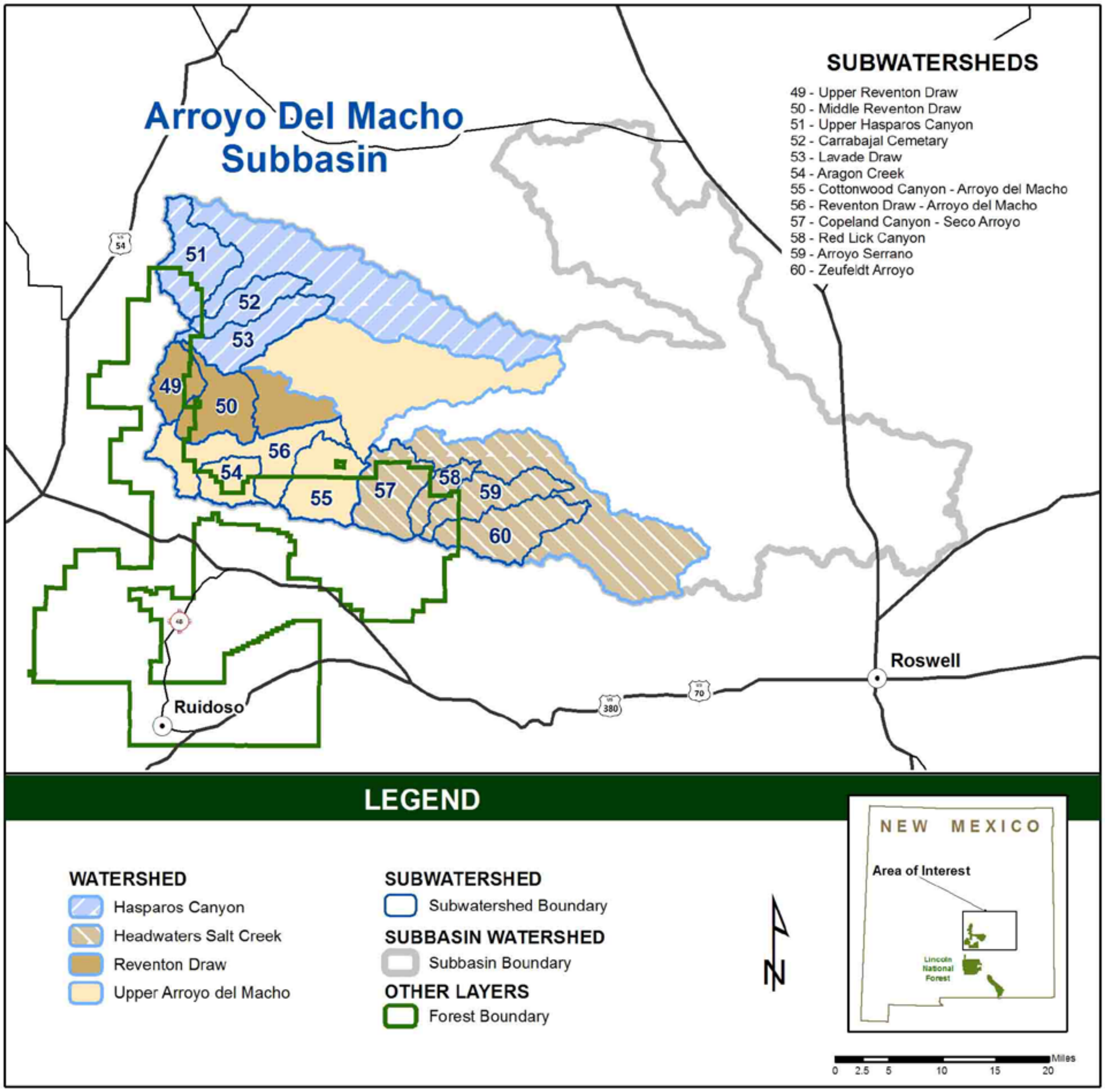

Figure 73. Arroyo Del Macho sub-basin showing all watersheds and sub-watersheds contained within the Lincoln National Forest

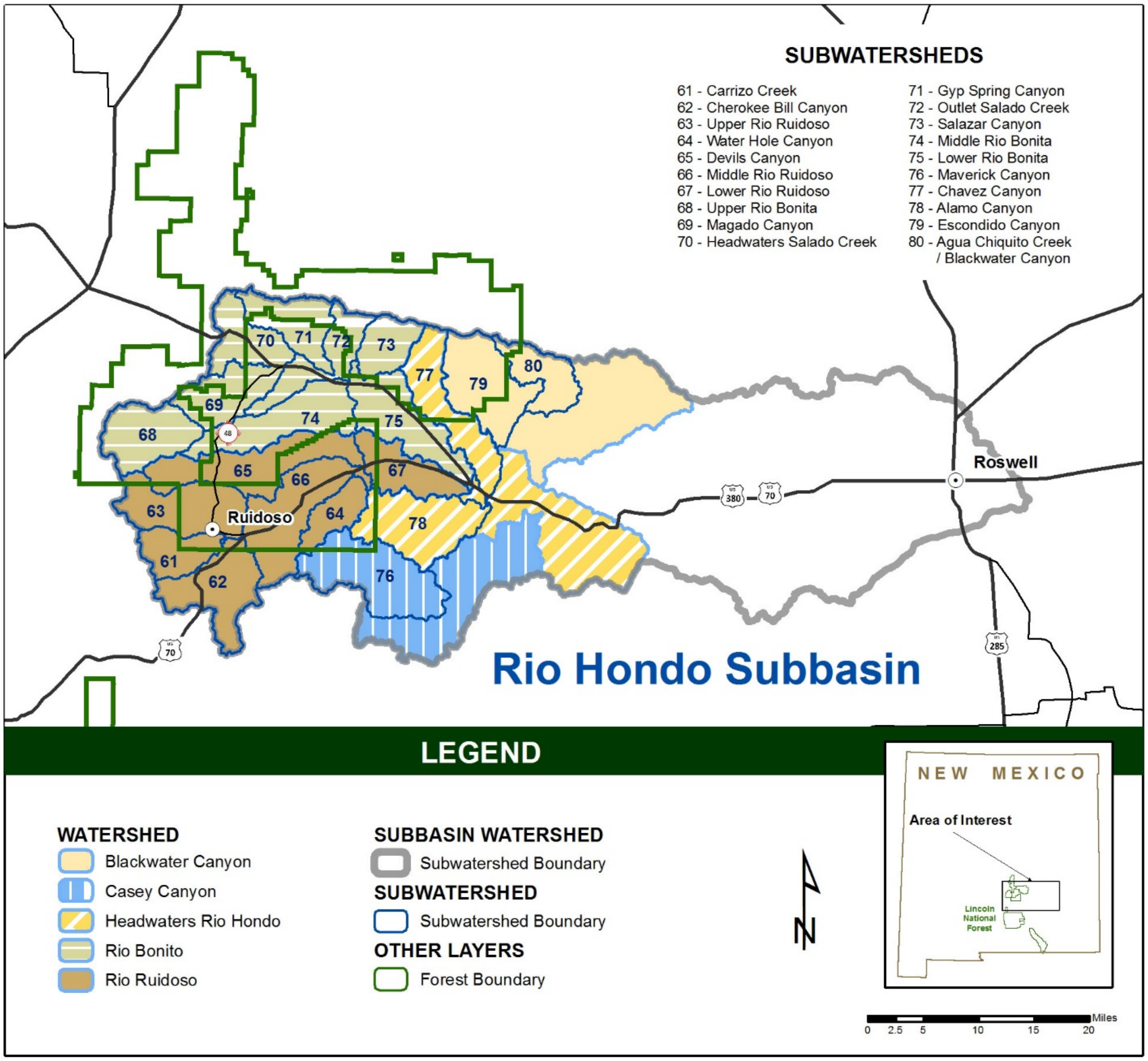

Figure 74. Rio Hondo sub-basin showing all watersheds and sub-watersheds contained within the Lincoln National Forest

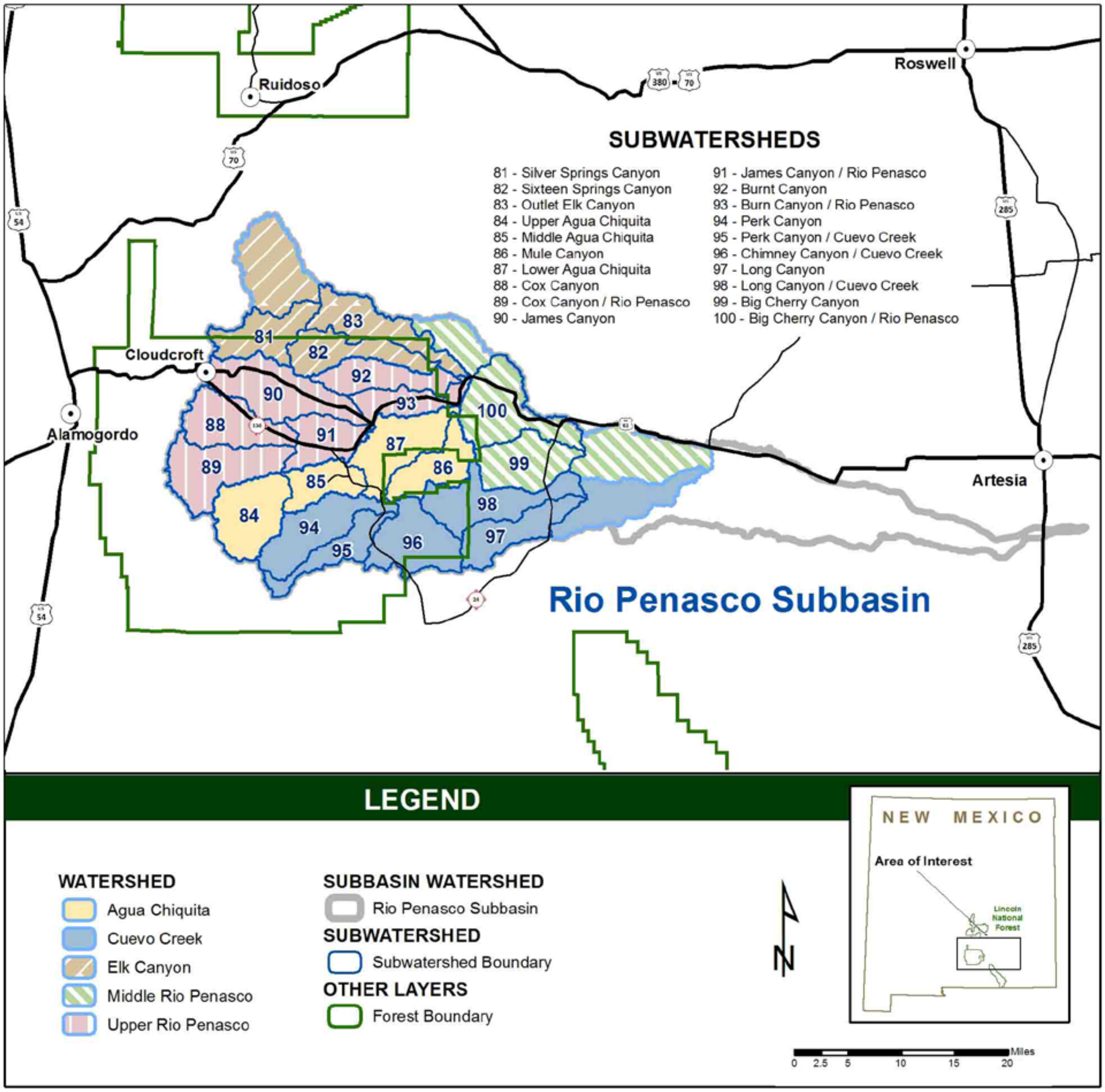

Figure 75. Rio Peñasco sub-basin showing all watersheds and sub-watersheds contained within the Lincoln Forest

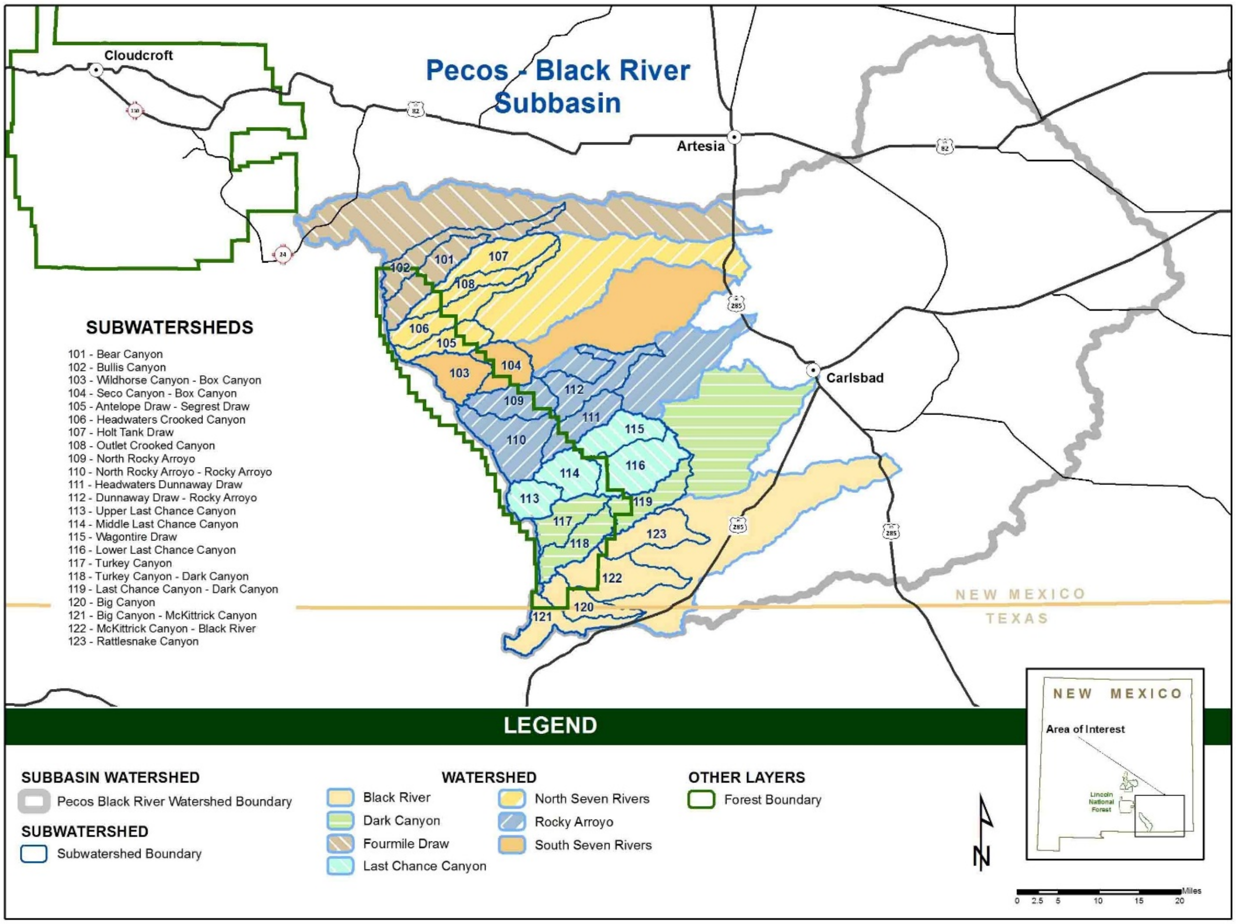

Figure 76. Pecos River-Black River sub-basin showing all watersheds and sub-watersheds contained within the Lincoln NF

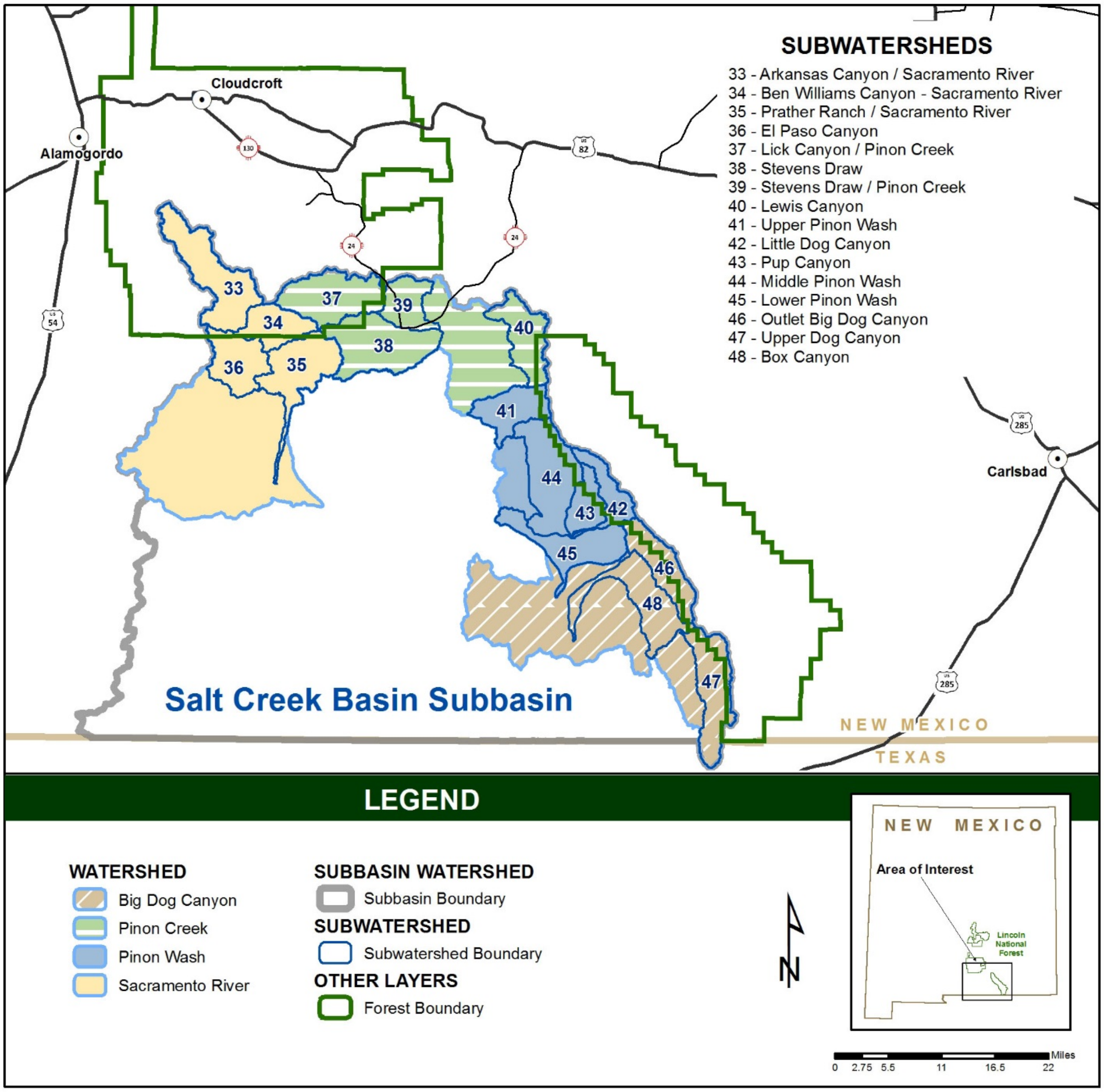

Figure 77. Salt Creek sub-basin showing all watersheds and sub-watersheds contained within the Lincoln National Forest

Ecosystem Services of Water Resources

During the assessment portion of the Forest plan revision, the planning team considers benefits the Forest provides to surrounding communities and its role in the greater landscape. To help understand the contributions and impacts of water resources on the Forest, this chapter will utilize the concept of "ecosystem services." Four ecosystem services and their application to water resources include the following:

- **Provisioning** ecosystem services of water is critical in providing for domestic and municipal water supplies, production of agricultural products, and forage for livestock and game animals. The wood production industry as well as the mining, oil and gas, and other related industries related to fuel and energy extraction also depend on water as a provisioning service for their operations.

Streams, springs, seeps, and groundwater resources provide fresh water for humans as well as all life forms, sustaining life at all levels.

- **Supporting** ecosystem services of water in streams, springs, and seeps support society by contributing to nutrient cycling and primary production, as well as acting as a catalyst in soil formation.
- **Regulating** ecosystem services of water contribute to storage and diversions for current and future use of domestic and agriculture needs, erosion control, flood regulation, drought control, recharging aquifers, and water purification, *and*
- **Cultural** ecosystem services of water provides multiple societal benefits, such as research opportunities, educational study areas, and public entertainment opportunities. Other forms of cultural services include recreation (e.g., fishing, wildlife viewing, boating, and swimming) or providing for places of quiet solitude and personal enrichment next to a stream or spring. All of these opportunities depend on clean and available water.

These are services that provide “public goods” but have benefits that often exist outside of formal markets. The goal of this holistic approach during the assessment is to capture the economic, ecological, social, and cultural benefits that water on the Forest provides and identify a sustainable approach to managing this resource for present and future generations. All of these ecosystem services related to water are becoming more valuable in the context of the larger landscape, where much of the Context Area is facing increased development pressure and influences that may degrade water quality and quantity. At the same time, the capacity of the Forest to contribute to these same ecosystem services may be declining in the face of drier and hotter climatic conditions and increased demand for water. The status of watersheds and water resources across the larger landscape influences conditions on the Forest, and in turn the Forest contributes to the overall sustainability of areas far removed from Forest management.

Chapter Organization

This chapter is divided among different aspects of water resources, and will assess each within the Context and Plan Areas. The sections are as follows:

- Watersheds
- Perennial Streams
- Springs and Seeps
- Groundwater
- Water Quality
- Water Rights and Uses, and
- Aquatics

Key Ecosystem Characteristics of Water Resources

Ecosystem characteristics are specific components of ecological conditions that sustain ecological integrity. A key ecosystem characteristic is a prominent aspect of ecosystem composition, structure, connectivity, and or function. Table 132 lists key ecosystem characteristics of water features pertinent to the Forest and in the contextual landscape.

Table 132. Water features and key ecosystem characteristics

Water Resource Feature	Ecosystem characteristic
• Streams	• Water quantity • Water quality • Geomorphological condition • Representativeness and redundancy at the plan scale
• Springs/seeps	• Water quality (not addressed in this chapter) • Water quantity • Condition/development • Representativeness and redundancy at the plan scale
• Aquatics	• Fish • Macro-invertebrate
• Groundwater	• Recharge, discharge, withdrawals
• Water rights/uses	• Location • Surface and ground-water conditions • Withdrawals
• Riparian areas, wetlands	• Geomorphological Condition
• Watershed	• HUCs/scales • Condition/"watershed condition classification
• Water quality	• Miles of impaired stream

Risk summarizes threats to ecological integrity from unsustainable levels of stressors, either current or predicted. The risk of losing integrity for each key ecosystem characteristic is summarized by Hydrologic Unit Code (HUCs), in order to quantify overall risk to the system. Risk is assessed on Forest lands as it relates to systems and processes that are under agency control and/or authority. However, to fully understand risk to these lands, systems, and processes, they are assessed at the context scale to the extent possible.

System Drivers and Stressors for Water Resources

A number of natural and man-made factors drive the hydrologic system. Two of the major natural factors include climate and geology. The main climatic influences include the amounts and patterns of seasonal variations in precipitation. Long term climatic changes will have an effect on hydrologic systems. Human-caused impacts such as mining and oil exploration and development can cause changes in the local geologic strata such that surface and ground water behavior may be affected. Table 133 lists disturbances that affect components of the hydrologic system within the Plan and Context Areas.

Table 133. Stressors that influence the hydrologic system within the Plan and Context Areas

Stressor	Potential Effects
Legacy Stressors of Upland Areas	• Compacted soils and loss of natural vegetative communities resulting in changes in the timing, duration, frequency, and magnitude of overland flow in the uplands and degradation of a riparian system. • Reduction in groundwater recharge and perennial stream extent due to increased runoff and decreased infiltration. • Downward trends in upland vegetation or soil conditions leading to increased erosion and sediment delivery rates and degradation of a riparian system. • Decreases in distribution/occurrence of riparian vegetation and encroachment of upland vegetation. • Reduction in sediment and nutrient filtration cycling and storage from uplands and increased delivery of nutrients to riparian and aquatic systems.
Groundwater Pumping and Streamflow Diversion	• Decreased water availability for baseflow, loss of riparian vegetation, and decrease in natural geomorphic processes (i.e., channel maintenance, floodplain formation, and recruitment of woody/herbaceous riparian species). • Decreases in vegetative composition, distribution, structure, vigor, and recruitment. • Increases in riparian vegetation mortality and establishment of invasive plant species in riparian corridors that lead to uncharacteristic fire.
Dams and Impoundments	• Interception of run-off and sediment supply, resulting in lower peak flows, higher base flows, increased channel and bank erosion downstream, and excess sedimentation upstream. All this results in disruption of natural channel morphology and/or floodplain function. • Decreased water and sediment availability for maintenance/recruitment of riparian vegetation downstream. • Change in streamflow characteristics from lotic to lentic function. • Increase in dispersed recreation impacts.

Stressor	Potential Effects
Livestock Grazing (past and current)	• Removal of vegetation by grazing and browsing or trampling vegetation and changes of plant and animal structure, composition, productivity, and resiliency of the riparian area. • Altered hydrograph, soil compaction, stream bank alteration, increased sedimentation, loss of geomorphic integrity of stream channel and susceptibility to degradation during flood events. • Reduction of nutrient and sediment filtration, altering chemical composition and biological processes (shift in macroinvertebrate communities and/or algae growth).
Roads, Trails, and Infrastructure	• Valley bottom roads can result in stream/floodplain confinement and geomorphic adjustments such as channel incision. • Interception/concentration of overland flows resulting in higher intensity watershed response to precipitation and runoff events. • Increases in erosion and sediment delivery to riparian and aquatic systems. • All of these can result in accelerated geomorphic adjustment, loss of riparian vegetation, loss of stream/floodplain function, and water quality degradation.
Dispersed Recreation	• Result in removal/damage of vegetation (fuelwood collection, trampling, etc.), soil compaction, reduced streambank stability, increased runoff and stream sedimentation from riparian and uplands, vector for noxious/invasive species.
Unauthorized OHV	• Result in removal/damage of vegetation, soil compaction, interception/concentration of overland flows, increased runoff and stream sedimentation, reduced streambank stability, and alteration of stream channel morphology, act as a vector for noxious/invasive species.
Mining/Dredging	• Change in vegetative composition, distribution, structure, vigor, and recruitment. • Leads to lateral/vertical instability and streambank alteration, and altered channel morphology/floodplain function. • Dredging of stream channels and banks reduces the system’s ability to withstand flood events. • Drainage or discharge from mines can result in degradation of water quality and exceedance of water quality standards.

Stressor	Potential Effects
Drought	• Downward trends in vegetative composition, distribution, structure, vigor, and recruitment. • Increase susceptibility to wildfire and/or insect/disease. • Decreased baseflow in perennial streams and reduced flow in intermittent streams. • Decrease streambank, floodplain, and soil surface stability from plant mortality and increase woody debris availability.
Invasive Species / Upland Species Encroachment	• Contribute to a downward trend in riparian vegetative composition, distribution, structure, vigor, and recruitment. • Increased water consumption (i.e. tamarisk) and decrease water availability for baseflow and for maintenance/recruitment of riparian vegetation. • Increase in the fire return interval. • Decrease in root densities which can affect soil stabilization.
Uncharacteristic Fire	• Reduce riparian vegetative community, floodplain, and stream channel ability to withstand flood events. • Occur more frequent than reference condition. • Downward trend in vegetative composition, distribution, structure, vigor, and recruitment. • Decreased streambank, floodplain, and soil surface stability from plant mortality, and increase woody debris availability.
Aquatic Invasive Species	• May harm native ecosystems or commercial, agricultural, or recreational activities dependent on these ecosystems. • Degrade water quality affecting aquatic systems and human health.

Dams and Impoundments

The majority of the watersheds on the Lincoln NF contain streams that eventually drain to the Pecos River east of the Forest. The influence of these watersheds on the ecological sustainability of the Pecos River system are diminished as a result of the presence of dams and reservoirs within or adjacent to the Forest, which control water discharge off the Forest. The dams that do exist are relatively small. Dams holding water that eventually flows to the Pecos River include Bonita Lake, Mescalero Lake, Alto Lake, Grindstone Canyon, Upper Rio Hondo Site 1, Cooley Canyon No. 2, Silver Lake, Parker Dam, Graveyard Canyon, Curtis Canyon, and Bear Creek. Some of these dams were constructed as holding basins for post-fire mitigation. Watersheds that drain to the Tularosa Basin contribute substantially to the ecological sustainability downstream from the Forest but the presence of the few dams and reservoirs on or adjacent to the Forest have little impact on the ecological sustainability of the waters in this basin. Nogal Dam No. 2 and two small La Luz-Fresnal Reservoirs, all off the Forest, contains water that ultimately flow into the Tularosa Basin.

Groundwater Pumping and Streamflow Diversion

Water originating from the Forest is used both on and off Forest for many uses. Groundwater and surface water uses include, but are not limited to: drinking water, waste disposal, livestock and agricultural uses, industry, recreation, and wildlife. Lower streamflow and groundwater recharge leads to higher water temperatures and concentration of pollutants.

Ground water and surface water form an interconnected hydrologic system. Recharge to ground water supplies originates from precipitation and surface waters. Conversely, ground water discharge is the reason that perennial streams, springs and seeps flow throughout the year. Under natural conditions, a ground water system exists in a state of dynamic equilibrium, and a long-term balance between natural recharge and discharge processes maintains this equilibrium. Ground water pumping from wells can disturb this system, resulting in lower water tables and reduced stream flows. As surface water and shallow ground water sustain riparian and aquatic ecosystems, ground water removal can negatively impact these resources. Effects on riparian vegetation occur when water table drawdown limits available moisture to riparian vegetation and creates sustained water tables below the minimum rooting depths for facultative wetland species. This can cause poor growth, reduced seed production, and in severe enough cases, the death of individual plants, loss of species, and vegetation change (USDA Forest Service 2015a). In addition, excessive groundwater extraction can lead to a lowered water table, increased pumping cost, less available water for discharge to streams and lakes, and land subsidence.

In the plan and Context Areas, municipal wells owned by the Village of Ruidoso pump groundwater along the North Fork of Eagle Creek. This has resulted in changes in streamflow and stress to the adjacent riparian area. The U.S. Geological Survey’s base flow analyses of the North Fork Eagle Creek found that during the pre-groundwater-pumping period (1969-1980) the mean annual discharge, direct runoff, and base flow in North Fork Eagle Creek was 2,260, 1,440, and 819 acre feet per year respectively compared to data from the ground-water pumping period (1989-2008) of 1,290, 871, and 417 acre-feet per year respectively. The study also concluded that although annual discharges were not significantly different between the two study periods, median monthly discharges were significantly less for 7 of the 12 months from 1989 to 2008 as compared to 1979-1980 (Matherne et al 2011).

Extensive groundwater pumping and surface water diversion has also occurred in the Rio Hondo sub-basin over the last few decades as the municipality of Ruidoso and surrounding areas has experienced substantial growth (see the water rights and uses section of Volume II of this assessment for more information). East of the Forest, in the Roswell Artesian Basin, extensive groundwater pumping and diversions for irrigation has occurred due to farming and oil industry needs. On the west side of the Forest, adjacent to the Sacramento Mountains, the City of Alamogordo diverts very large quantities of water from Bonita Lake for municipal purposes. The Upper Bonita sub-watershed, which supplies all water for this reservoir, lies on the Lincoln NF. There is also a large concentration of points of diversion (PODs) along the western edge of the Sacramento Mountains, north and south of Alamogordo. The Sacramento Mountains also host many PODs where water is either being pumped from a groundwater source or is diverted from springs or streams. The area surrounding Carlsbad also has a high concentration of PODs.

No water withdrawals occurred previous to European settlement. As a result, the groundwater system likely maintained a long-term equilibrium based on climatic conditions (Wirt and others 2005). Currently, withdrawals from both surface water streams and connected groundwater aquifers may affect streamflow. In the Upper Pecos-Black Sub-basin, water diversions for irrigation use have been present since the 1870s and sometimes reduce portions of the smaller rivers to a trickle during irrigation season. Increasing urban and subdivision development with wells is also impacting the streamflow. Local segments of perennial streams which are downstream from wells (used for irrigation and for residential, commercial, or recreational development) and within their cones of depression are subject to impact and loss or diminution of perennial flow.

Livestock Grazing

Domestic livestock grazing was not limited prior to European settlement and thus had very minimal disturbance effect. Livestock grazing has occurred throughout the Lincoln NF since the late 1800s. Cattle, horses, and sheep have grazed portions of the Forest. At this time, most of livestock grazing is from cattle with some horses and sheep permitted for use. Because of the limited distribution of water and the adjacent lush herbaceous vegetation, cattle commonly concentrate grazing along perennial and intermittent streams, and in riparian areas and wetlands around seeps and springs. Unmanaged herbivory has been observed to reduce effective vegetative ground cover and riparian vegetation, contribute to accelerated erosion, soil compaction and sedimentation to connected perennial waters, and to reduce or impair water quality.

Cattle were introduced to New Mexico in the late 1870s following the Civil War and the subjugation of the Apaches. Very large numbers of cattle, sheep, and goats were grazed throughout the Southwest in the last two decades of the 19th century, and the Sacramento Mountains were no exception. A report proposing the creation of the Sacramento NF estimated that 17,000 head of cattle and horses, 10,000 sheep and 40,000 goats were grazing in the proposed Forest at the turn of the century. As the land became more and more overgrazed, the animals had to travel farther for food and water and became concentrated around water sources, increasing damage to ecological systems (Spoerl 1981b). During this time, there was no regulation of grazing. There have been many accounts of the overgrazing and subsequent drought (1889-1892, 1902-1904) and flood events that occurred throughout this area. In 1907, the Sacramento NF was created and in 1908 the Alamo NF was created in an effort to regulate livestock grazing. The Alamo NF, in the first effort to regulate grazing in the Sacramento Mountains, made a list of grazing permittees on the Forest and how many cattle and horses they were allowed, a total of 15,454 cattle and 2,093 horses. The present allotment arrangement was established by 1957, when the Forest acquired much of the State-owned land in the Sacramento Mountains, which had been leased for timber cutting and grazing with little or no control over the exploitation. Efforts to reduce stocking rates and recover the grazing resource have depended not only on reducing the number of stock on the range, but on simultaneously rotating available range, so that the animals do not continue to concentrate near the same water sources and canyon bottoms (US Forest Service 1978).

Overgrazing in the late 1800s and early 1900s, combined with other stressors, resulted in extreme erosion and gullying along the Upper Rio Peñasco, Aqua Chiquita, and the Sacramento River. Effects of these legacy stressors are still obvious today (Kaufman et al, 1998). Feral cows have impacted Sitting Bull Creek and Last Chance Creek in the Guadalupe Mountains (personal communication with Larry Paul 2016).

Native Herbivores

Pronghorn antelope, mule deer and desert bighorn sheep were present on the Lincoln NF at least as early as the 1700s (Kaufman et al, 1998). . Reference condition prior to European settlement likely included effective populations of ungulate predators. Anthropogenic manipulation of ungulate and predator populations is a significant stressor on watershed, riparian, and stream channel function. Ungulates without effective predators are known to excessively graze riparian vegetation, resulting in the removal or degradation of riparian vegetation necessary to provide bank stabilization and a food source for beavers. Willows (Salix spp.), alders (Alnus spp.), quaking aspen (Populus tremuloides) are often browsed to an extent that recruitment levels fail to sustain a resilient system. Deciduous components are preferentially consumed allowing for conifer encroachment (Roger and Mittanck 2014). This results in a cascading effect that reduces soil organic carbon, which has less available water holding capacity (Shepperd et al. 2006; Woldeselassiea et al. 2012) and promotes warm season bunchgrasses over cool season bunchgrasses. Eventually overgrazing removes bank stabilizing vegetation, creating channel downcutting and a dysfunctional floodplain (Beschta and Ripple 2006). Elk and feral hogs are known to occur along streams and riparian areas in the Sacramento Mountains.

Recreation

Dispersed camping and other recreational uses may result in soil compaction resulting in accelerated overland flow and increased hillslope erosion. This can result in increased sediment loads in streams, decreasing water quality, and impacts to aquatic life and sometimes human health. Oil and gas leaks from vehicles also impact water quality. Water quality may also be impacted by human and animal waste that makes its way into the stream and also may impact ground water.

Along the Rio Bonita, impacts due to overcrowding and dispersed camping along the stream causes sanitation issues. In the Sacramento Mountains, Agua Chiquita, Rio Peñasco, Wills Canyon, and Water Canyon are impacted by dispersed camping, especially during the hunting season. Much of Agua Chiquita is frequently traversed by OHVs and ATVs in portions where it is dry during some parts of the year. In the Guadalupe Mountains, Sitting Bull Creek below Sitting Bull Falls is impacted directly by human use as people spend time directly in fragile areas such as the pool below the falls.

NFS and Non-NFS roads, trails, and stream crossings

Roads, trails, and stream crossings are known to cause sediment detachment and transport. High road densities, and especially roads located in riparian areas, can create conditions that degrade floodplain and/or channel function. User-created routes and poorly-stabilized old logging skid trails exist in various densities throughout the Lincoln NF. Motorized and non-motorized trails may have similar effects on sedimentation and overland flow concentration. Best management practices (BMPs) that are planned, implemented, and/or maintained greatly decrease detachment and transport of sediment.

Roads and off-highway vehicle trails are causes of channelization, contributing to habitat fragmentation of streams, especially in the cases of unhardened low water crossings and raised road beds crossing the streams, creating physical barriers to movement upstream. This reduced connectivity limits a species' ability to move into adjacent areas, to colonize suitable habitat or utilize habitat that fulfills its life cycle needs, including gene flow. In addition, the roads and trails that run parallel to the streams and sometimes directly adjacent to the stream, channelize the water flow, and block water from reaching down-slope habitat, which results in fragmentation of the habitat and decreased survival of individuals. Timber management, with temporary roads, landings and logging decks, also contribute to channelization resulting in habitat fragmentation and decreased survival of individuals within a species. In addition, soil compaction resulting from these management activities has the potential to alter hydrological regimes and could contribute to habitat fragmentation. Entrenchment of upland vegetation, poorly vegetated floodplains, and terracing of older floodplains contribute to this as well. Table 134 shows road densities in sub watersheds where perennial streams exist. The sub watersheds having the highest impacts from roads and trails are the Cottonwood Wash, Fresnal Canyon, La Luz Canyon, Lost River, Arkansas Canyon-Sacramento River, Carizzo Creek, and Upper Rio Ruidoso.

Table 134. Road Densities in sub-watersheds with perennial streams

HUC 4	HUC 5	Rd Density HUC 5 (per sq. mile)	HUC 6	Rd Density HUC 6 (per sq. mile)
Tularosa Valley	Cottonwood Draw	0.58	Nogal Creek	1.28
	Bitter Creek	0.02	Gamble Canyon Three Rivers	0.02
			Golondrina Draw-Three Rivers	0
	Tularosa Creek	1.46	Nogal Canyon	1.08
			Middle Tularosa Creek	1.92
	Sheep Camp Draw	2.1	Cottonwood Wash	3.68
			Sabinata Flat Arroyo	1.12
	Lost River	3.33	Fresnal Canyon	3.59
			La Luz Canyon	2.63
			Lost River	3.24
Salt Basin	Sacramento River	2.89	Arkansas Canyon-Sacramento River	3.75
Rio Hondo	Rio Ruidoso	2.78	Carizzo Creek	4.68
			Upper Rio Ruidoso	6.6
			Devils Canyon	2.1
			Middle Rio Ruidoso	1.67
			Lower Rio Ruidoso	0.69
	Rio Bonito	1.06	Upper Rio Bonita	0.76
			Magado Canyon	0.76
			Headwaters Salado Creek	1.9
			Outlet Salado Creek	1.5
			Middle Rio Bonita	0.83
			Lower Rio Bonita	0.79
Rio Peñasco	Elk Canyon		Silver Springs Canyon	2.73
			Outlet Elk Canyon	1.12
	Agua Chiquita	1.42	Upper Agua Chiquita	1.86
	Upper Rio Peñasco	2.55	Cox Canyon-Rio Peñasco	2.15

HUC 4	HUC 5	Rd Density HUC 5 (per sq. mile)	HUC 6	Rd Density HUC 6 (per sq. mile)
			James Canyon - Rio Peñasco	2.2
			Burnt Canyon	1.66
			Burnt Canyon-Rio Peñasco	0.9
	Middle Rio Peñasco	0.12	Big Cherry Canyon-Rio Peñasco	0.14
	Last Chance Canyon	1.12	Middle Last Chance Canyon	0.11
	Dark Canyon	1.49	Last Chance Canyon-Dark Canyon	1.12

Off-Highway Vehicles

The primary effects of OHV activity on soils and overall watershed function include altered soil structure (soil compaction in particular), destruction of soil crusts (biotic and abiotic), and erosion pavements (gravel surfaces) that would otherwise stabilize soils and soil erosion. As soil compaction increases, the soil's ability to support vegetation diminishes, because resulting increases in soil strength and changes in soil structure (loss of porosity). This inhibits growth of root systems and reduces infiltration of water. As vegetative cover, water infiltration, and soil stabilizing crusts are diminished or disrupted, precipitation runoff rates increase, and soil erosion accelerates, leading to formation of rills, gullies, and other surface changes (Ouren *et al*., 2007). Pollutants associated with deposition of OHV emissions and spills of petroleum products may be adsorbed into sediments, absorbed by plant material, or dissolved in runoff; once mobilized, these contaminants may enter aquatic systems (Ouren *et al*., 2007). Where slope is a factor, extensive networks of off-highway vehicle (OHV) routes can proliferate across landscapes and serve as conduits that intercept and alter direction of natural surface flow pathways. These conduits may be eroded to form gullies that channel dislodged sediments and contaminants into stream systems. Where OHV activity occurs, networks of OHV routes often proliferate. The general impervious nature of soils compacted by OHV traffic enhances gully formation in these conduits, thus promoting additional flows of sediments and suspended solids into stream systems, effectively extending the drainage network of a given watershed, and potentially changing the timing of peak runoff flows (Ouren *et al*., 2007).

OHV impacts exist in a number of areas on the Forest that have direct and indirect impacts to the hydrologic system. OHV use on administratively closed roads that are still physically open contribute to these impacts in the Sacramento Mountains. Use occurs along the Agua Chiquita and Rio Peñasco stream channels. There is some unauthorized OHV use in Wills Canyon on closed roads. There are also user-created routes in these areas that contribute to unauthorized use. Baily and Pumphouse Canyons, both having ephemeral streams, contain a number of user-created routes.

Mining and Dredging

A number of past and present gold mines exist in Lincoln County, a majority of them on the Lincoln NF. Many of them are small and exist on the steep slopes of the Rio Bonita Sub watershed. This has been a known source of sediment into the Rio Bonita, especially during times of intense summer monsoonal rain events. There are also a few mines in the Nogal Creek Drainage that could affect this perennial stream. The greatest concentration of mine sites is in the Jicarilla Mountains on the northern tip of the Forest. This is a dry section with no perennial water and few springs.

Drought

Drought patterns are known to have occurred throughout at least the last millennium, as evidenced through tree ring studies. Recent studies report that the drought of the 1950s was equaled or exceeded in duration and severity several times. Major droughts of prolonged duration have been reported in the 13th, 16th, and 18th centuries (Swetnam and Betancourt 1998). Some studies suggest periods of drought are believed to have contributed to higher levels of soil loss and sediment delivery than periods of normal or above moisture due to reduced effective vegetative ground cover soil protection.

Periodic droughts have been reported since European settlement. Severe drought in the 1890s resulted in large scale mortality of livestock (Kaufman et al 1998). An extended drought occurred from about 1942-56 (U.S. Geological Survey 1963)). Recently the Lincoln NF has experienced a number of years of drought (roughly since about 1996) with occasional levels of seasonal moisture at or above the long-term mean. Reduced precipitation results in reduced upland vegetative growth, reduced surface organic matter and ineffective vegetative ground cover, putting the soil at risk of accelerated erosion and sediment delivery to connected streams during storm events. As vegetation dries out, there is increased risk of wildfire spread and subsequent accelerated erosion and watershed degradation. Perennial stream riparian vegetation is very resilient to drought and has not been shown to be drastically altered during periods of drought. Riparian vegetation in wetland sites at springs and seeps has been observed to dramatically decrease during periods of drought, resulting in less-ponded and available water for those species that rely on it for their survival.

Flooding

Flooding affects riparian habitat as well as ephemeral drainages throughout the plan area. Flooding may cause localized soil loss, increased sediment delivery, and reduced water quality in the stream channel, streambanks, and floodplains if not well protected with vegetative ground cover. Frequent flash flooding is a natural process and disturbance. Flash flooding can occur in perennial, intermittent and ephemeral streams, especially in large watersheds where high intensity rains occur. Along the Rio Peñasco, flooding, gullying, and erosion have been a problem along the river during the 20th century. Floodwater damage occurs almost annually, but destructive floods were recorded in 1941, 1951, 1954, and 1955 (Otero Soil Conservation District 1957). Floods become a stressor when they exceed the NRV in terms of averages, extremes, or variability.

Climate

The climate, and any associated changes in climate dictates timing, amount, and type of precipitation and controls the evapotranspiration rate through temperature and vegetation assemblages. Aquatic ecosystems have evolved to be resilient in the face of a certain level of variability in climatic regime. Climate becomes a stressor when it exceeds the NRV in terms of averages, extremes, or variability. For a more detailed discussion on climate change, see the System Drivers and Stressors chapter.

Terrestrial Vegetation

Vegetation and soil condition influence water quality, runoff timing, and groundwater recharge through the combination of precipitation interception, evapotranspiration rate, soil and stream bank stability, and shading. For example, frequent fire ponderosa pine and mixed conifer forests are more dense and even-aged as a result of fire suppression. They are more susceptible to uncharacteristic, severe wildfire that removes cover and degrades soil stability, raising the potential for flooding, erosion, and sedimentation. In addition, overstocked uplands have been observed to exhibit higher evapotranspiration, lowering the water table and reducing desirable understory vegetation due to closed canopy conditions (USDA Forest Service 2015)(see the Terrestrial Vegetation chapter).

Fire

Frequent fire ERUs adjacent to riparian areas and throughout watersheds, shifts in the fire regimes have increased the potential for catastrophic impacts associated with wildfire. Altered fire regimes have increased the susceptibility of uplands to large scale stand-replacing fires or fire-related catastrophic changes to the stability of the watershed, and have increased the potential for uncharacteristic fire effects in adjacent riparian ERUs (see the Riparian Vegetation chapter). Uncharacteristic fire raises the possibility of increased sedimentation, higher water temperatures, and shifts in flood severity or frequency, essentially destabilizing the watershed. FRCC III refers to fire regimes that have been substantially altered. Risk of losing key ecosystem components is high. Fire frequencies may have departed by multiple return intervals, resulting in dramatic changes in fire size, fire intensity, and fire severity as well as landscape patterns. Vegetation attributes have been substantially altered (see the Terrestrial Vegetation chapter for more information on Fire Regime Condition Classes.

Fifth code watersheds having high risk and showing a substantial amount of land area in FRCC #3 include the following watersheds:

- Rio Bonita--a majority of the departure is in the 6th code Upper Rio Bonita sub watershed; 6th code Rio Bonita is all in departure but just a small amount of this sub-watershed is on the Forest.
- Rio Ruidoso--Devils Canyon 6th code is high departure at headwaters but just a small amount of this sub watershed is on forest; Upper Rio Ruidoso and Carrizo Creek sub watersheds are high departure.
- Cottonwood Draw--there is considerable risk from wildfire in the Cottonwood Creek, Willow Draw, Harkey Draw-Nogal Arroyo, and Tortolita Arroyo; Nogal Creek sub-watershed is the only sub-watershed with perennial water; where perennial water exists is also where the high risk for wildfire exists.
- Lost River--contains substantial areas of high fire risk in the higher elevation areas; Fresnal Canyon and La Luz sub-watersheds have most of the high fire risk in this watershed.
- Elk Canyon--sub-watershed has substantial high fire risk.
- Upper Rio Peñasco--a checkerboard pattern of wild fire risk; amount of high risk, coupled with the larger amount of perennial stream, makes this an area that should be considered high risk.
- Sacramento River--a large area of high fire risk in the area where perennial streams are present.
- Dark Canyon--high fire risk in the area where the small amount of perennial streams exist.
- Black River--high fire risk in areas where perennial streams exist.

Invasive and Upland Species Encroachment

Invasive species have the capacity to utilize excess water, leaving less water for base flow. They also have the capacity to alter the habitat for fish and other aquatic life. They may alter natural cycles by changing the way energy, nutrients, and water are exchanged within a system. Some species alter hydrologic regimes by increasing evapotranspiration rates, giving these species a competitive advantage over native species. Invasive species may also alter other abiotic factors, such as disturbance regimes, microclimates, and physical habitat.

The number of infested acres on the Lincoln NF is presently unknown. Of the invasive plant species known to occur on the Forest, musk thistle and teasel are the most abundant. Watersheds (5th code) where these and other noxious weeds are abundant include the following, Rio Bonito, Rio Ruidoso, Elk Canyon, Upper Rio Peñasco, Agua Chiquita, Cuevo Creek, Lost River, Tularosa Creek, Dark Canyon, and Last chance Canyon.

Data, Methods and Scales of Analysis for Water Resources

Data Sources

Data used for analysis of water features such as streams and springs are derived from Lincoln NF GIS datasets and the National Hydrography Data (NHD; USGS 2016). Additional data, such as sources from the State of New Mexico, were used as indicated by references throughout this chapter. Stream flow attributes for perennial, intermittent, and ephemeral streams are not complete. As a result, many smaller perennial portions of streams, as well as intermittent streams, are not well represented. There is little quantitative data regarding the existing condition of streams, riparian areas, and wetlands in the analysis area. However, qualitative data does exist and is used in this assessment to the degree that it is useful in this analyses. An ongoing inventory conducted by the New Mexico Environment Department is currently occurring for wetlands but has not been completed. Water quality data from the State of New Mexico Environment Department's Surface Water Bureau provides information on impaired streams. Water quantity data is provided by the United States Geological Survey on streams where gaging stations provide stream flow data. Limited flow data is available for selected springs in the Sacramento Mountains and the Rio Hondo Basin. These data come from scientific reports and are referenced in their respective sections.

Methods

Methods of analyses for the various water resources are provided in the pertinent subsections that follow.

Analysis and Findings- Conditions, Trends and Sustainability of Water Resources

Watershed Condition Classification

This section describes the Watershed Condition Classification (WCC) and how it is used to rate the condition of watersheds in the Plan Area. Then, analyses of the watersheds in the Plan Area are provided.

Description of the Watershed Condition Classification

The term "watershed" as used in the following explanation refers to the sixth level, 12-digit HUCs, which are referred to as "sub-watersheds" described above and throughout this chapter. For the purposes of describing the WCC, the term "watershed" will be used because that is how it is described in the WCC literature. Outside of this description of WCC, these will be referred to as "sub-watersheds" to maintain consistency throughout this chapter.

As part of the Watershed Condition Classification, there are twelve indicators of watershed condition, grouped according to four major process categories: (1) aquatic physical, (2) aquatic biological, (3) terrestrial physical, and (4) terrestrial biological. These categories represent terrestrial, riparian, and aquatic ecosystem processes or mechanisms by which management actions can affect the condition of watersheds and associated resources. Each of the four process categories is represented by a set of indicators (Table 135 and Figure 78) (Potyondy and Geier 2011).

Table 135. Description of the 12 national core watershed condition indicators

Aquatic Physical Indicators	
Water Quality	This indicator addresses the expresses alteration of physical, chemical, and biological components of water quality.
Water Quantity	This indicator addresses the natural flow regime with respect to the magnitude, duration, or timing of the natural streamflow hydrograph.
Aquatic Habitat	This indicator addresses aquatic habitat condition with respect to habitat fragmentation, large woody debris, and channel shape and function.
Aquatic Biological Indicators	
Aquatic Biota	This indicator addresses the distribution, structure, and density of native and introduced aquatic fauna.
Riparian/Wetland Vegetation	This indicator addresses the function and condition of riparian vegetation along streams, water bodies, and wetlands.
Terrestrial Physical Indicators	
Roads and Trails	This indicator addresses the hydrologic and sediment regimes because of density, location, distribution, and maintenance of the road and trail network.
Soils	This indicator addresses the alteration to natural soil condition, including productivity, erosion, and chemical contamination.
Terrestrial Biological Indicators	
Fire Regime or Wildfire	This indicator addresses the potential for altered hydrologic or sediment regimes because of departures from historical ranges of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern.
Forest Cover	This indicator addresses the potential for altered hydrologic and sediment regimes because of the loss of forest cover on forest lands
Rangeland Vegetation	This indicator addresses effects on soil and water because of the vegetative health of rangelands.
Terrestrial Invasive Species	This indicator addresses potential effects on soil, vegetation, and water resources because of terrestrial invasive species (including vertebrates, invertebrates, and plants).
Forest Health	This indicator addresses forest mortality effects on hydrologic and soil function because of major invasive and native forest insect and disease outbreaks and air pollution.

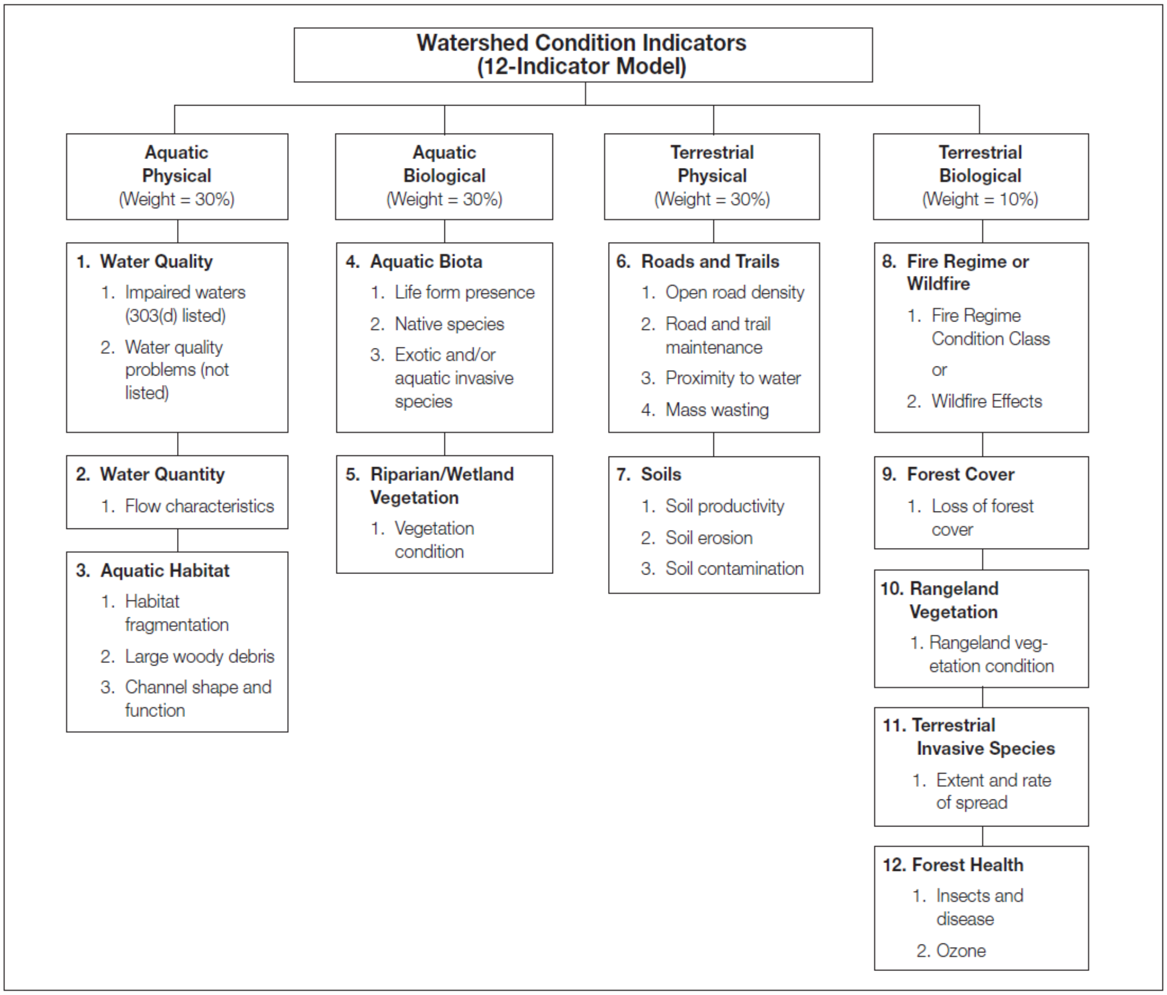

Figure 78. Core national watershed condition indicators

For each of the 12 indicators, the WCC provides a rating for corresponding indicators related to watershed processes. The WCC uses three watershed condition scores that are directly related to the degree or level of watershed functionality or integrity. The scores are reported as watershed condition classes 1, 2, or 3. Class 1 watersheds exhibit high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. Class 2 watersheds exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition, and Class 3 watersheds exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition (USDA Forest Service 2004, FSM 2521.1). The overall watershed condition score is computed as a weighted average of the four process category scores (aquatic physical, aquatic biological, and terrestrial physical each get a 30 percent weight and terrestrial biological gets only 10 percent of the weight) (Figure 79) . Scores from 1.0 to 1.6 are rated as Class 1—"Functioning Properly," scores from 1.7 to 2.2 are rated as class 2—"Functioning at Risk," and scores from 2.3 to 3.0 are rated as Class 3—"Impaired Function."

Table 136. WCC ratings for watersheds within each sub-basin

Sub-basin	Functioning Properly	Functioning at Risk	Impaired Function
Tularosa Valley	2	19	4

Sub-basin	Functioning Properly	Functioning at Risk	Impaired Function
Arroyo Del Macho	0	9	1
Rio Hondo	0	11	8
Rio Peñasco	0	13	5
Pecos River-Black River	4	16	0
Salt Basin	1	10	0
TOTAL	7	78	18

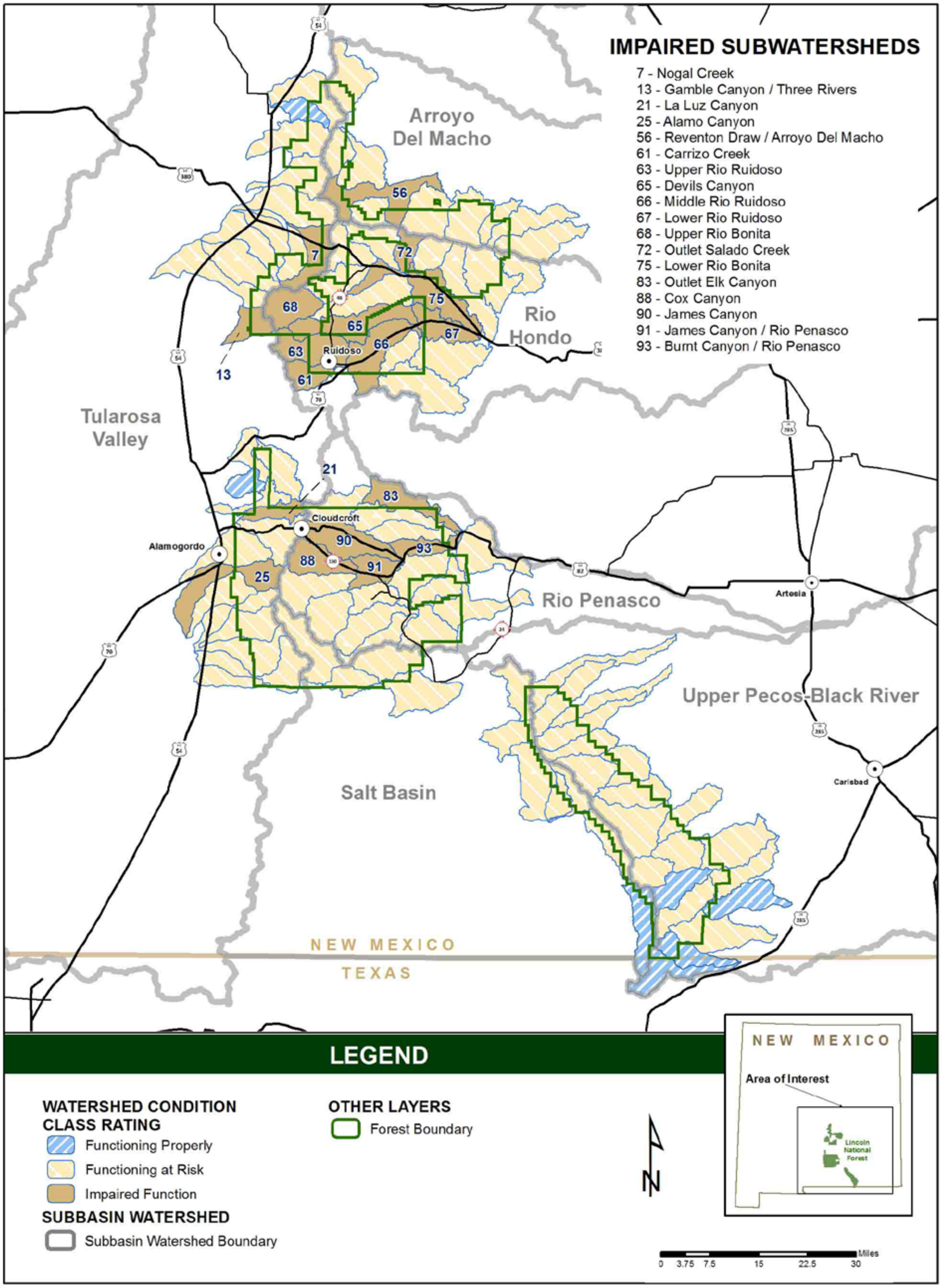

Figure 79 Watershed condition ratings in the Plan Area

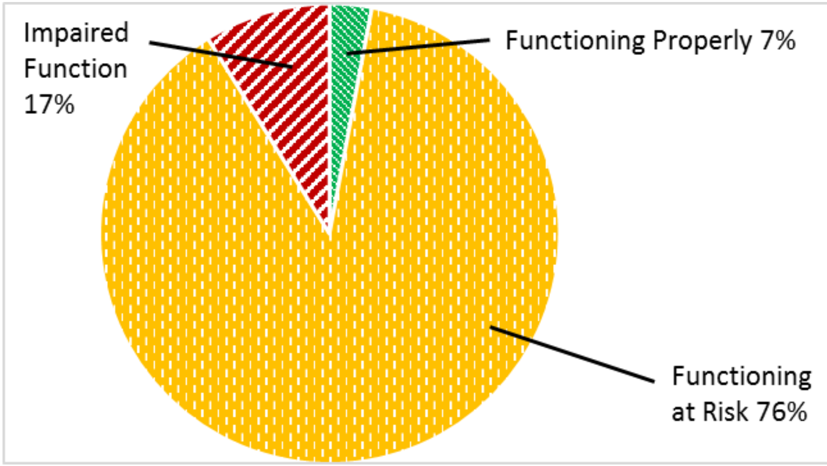

Figure 80. Percent of sub-watershed within each condition class

Analyses of Sub-watershed Conditions

Figure 80 illustrates the results of the WCC for 103 sub-watersheds within the Plan Area that were rated. 19 sub-watersheds that touch the Plan Area were not rated because less than 10 percent of the sub-watershed is within the Plan Area. In the Plan Area, 7 sub-watersheds are functioning properly, 78 sub-watersheds are functioning at risk, and 18 are impaired. Percent of sub-watersheds in each condition class is displayed in Figure 80.

Of the 12 indicators used in the WCC, 8 contributed substantially to impairment of the 16 sub-watersheds that were rated as “impaired function”. These indicators are summarized below with a brief explanation of the conditions that result in an impaired rating:

Water Quality--Water bodies are water quality limited and are not fully supporting beneficial uses as identified by the State water quality agency. The watershed has extensive water quality problems such as consumption advisories, excessive sediment, nutrients, nutrients, chemicals; extensive contamination from mines; or frequent contamination of public drinking water supplies. Strong evidence of acidification, eutrophication, or toxicity due to atmospheric deposition.

Water Quantity--The magnitude, duration, and/or timing of annual extreme flows (low and/or high) significantly depart from the natural hydrograph. Dams and diversion facilities are operated so that they fail to mimic the natural hydrographs. The magnitude, duration, and/or timing of annual extreme flows (low or high) significantly depart from the natural hydrograph. The timing and rate of change in flows often do not correlate with expected seasonal changes.

Aquatic Biota--The watershed may support small, wildly scattered populations of native aquatic species. Exotic and/or aquatic invasive species are pervasive. Less than 70 percent of expected aquatic life forms and communities are present based on the potential natural communities present. Exotic and/or aquatic invasive species are present and have mostly replaced native species. Aquatic habitat is lacking connectivity. Exotic and/or aquatic invasive species are present and have greatly lowered the condition of native aquatic species. More than 50 percent of the historic native-fish-bearing streams have exotic and/or aquatic invasive species present and/or there has been an expansion of nonnative exotic and/or aquatic invasive species over the past decade.

Riparian Wetland Vegetation--A large percent of native vegetation attributes along stream corridors, wetlands, and water bodies is not functioning properly (see Riparian Vegetation chapter for more information). A large percent of native vegetation attributes along stream corridors, wetlands, and water bodies is not functioning properly. Native vegetation is vigorous, healthy, and diverse in age on less than 25 percent of the riparian wetland areas. Native vegetation is less than the site's potential communities. In these areas, cover and composition are strongly reflective of early seral species dominance. Mesic-dependent herbaceous vegetation is limited in extent with many lower terraces dominated by xeric species most commonly associated with uplands. Reproduction of mid and late seral species is very limited. For much of the area, the water table is disconnected from the riparian area and the vegetation reflects this loss of available soil water.

Road and Trail Network--The density and distribution of roads and trails indicates a high probability that the hydrologic regime and spatial distribution of runoff is altered. A high road density is present in the watershed. BMPs for the maintenance of designed drainage features are applied to less than 50 percent of the roads, trails, and water crossings in the watershed. More than 25 percent of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them. Most roads are on unstable landforms or rock types subject to mass wasting with extensive evidence of active movement or road damage. Mass wasting that could deliver large quantities of debris to the stream channel is a primary concern in this watershed.

Fire Regime or Wildfire--High likelihood of losing defining ecosystem components because of the presence or absence of fire (see Terrestrial Vegetation chapter for more information). FRCC 3—A predominate percentage of the watershed has a high departure from the reference fire regime. The vegetative species and cover types are affected by the fire regime resulting in infrequent intense fires with high severity leading to vegetation mortality, loss of soil organic matter, and poor protection to soil and water resources.

Forest Cove -- The amount of forest land that is not supporting forest cover is high. More than 15 percent of the NFS land in the watershed contains cut-over, denuded, or deforested forest land

Terrestrial Invasive Species -- Populations of terrestrial invasive species infest significant portions (greater than 25 percent) of the watershed, may be expanding their range, and widespread impacts to soil, native vegetation, or other water resources have been documented. Management adjustments or treatments must be ongoing just to keep the invasive species in check. Management intervention is necessary to alleviate significant resource damage and increased degradation of watershed condition.

The Rio Hondo Sub-basin has the highest number of watersheds classified as impaired function (7). The greatest impairments are due to water quantity and riparian vegetation. Other indicators greatly contributing to impaired conditions are water quality, aquatic biota, road and trail network, aquatic habitat, fire regime or wildfire, and rangeland.

In the Rio Peñasco Sub-basin, there are five impaired watersheds. The greatest impairment is due to riparian vegetation. Other indicators contributing to impairments are water quality, aquatic habitat, aquatic biota, roads and trails, fire regime or wildfire, and terrestrial invasive species.

In the Tularosa sub-basin, there are three impaired watersheds. Water quantity was the indicator with the greatest impairment. Aquatic biota and road and trail network were also strong contributors to the impaired conditions.

Watersheds change as a result of disturbance from human-related activities and can diverge from properly functioning conditions when disturbances fall substantially outside the range of natural variability. For example, fluvial changes occur naturally in undisturbed areas but occur more rapidly on disturbed lands. This is because disturbance often results in reduced ground cover, changes to runoff patterns, and/or soil changes. Arid lands are more susceptible to change due to their natural condition of less cover (USDA Forest Service 1999). Therefore, thresholds for change vary within individual watersheds, depending on local characteristics. Of particular interest is how this threshold for change is altered due to the influence of management activities.

On the Lincoln National Forest, the function of many watersheds and their streams was altered during the mid- to late-1800s during a period of overgrazing by cattle and sheep (USDA Forest Service 1999). Huge numbers of cattle, sheep, and goats grazed all over the Southwest in the last two decades of the 19th century, and the Sacramento Mountains were no exception (Fig. 9). A report proposing the creation of the Sacramento National Forest estimated that 17,000 head of cattle and horses, 10,000 sheep and 40,000 goats were grazing in the proposed Forest at the turn of the century (Spoerl 1981b). Many stream channels started downcutting during this time. Channel downcutting, or channelizing, is a term referring to the vertical erosion of the stream channel where the elevation of the channel is lowered relative to the elevation of the surrounding valley. Widening of stream channels frequently occurs concurrently. Channel downcutting and widening result in lower water tables and loss of riparian habitat. Excess energy from the flow of water from upland areas and into and through the stream channel exacerbate such channel conditions. Subsequent logging exacerbated the problem by removing bank cover and woody material from the ground and streams. These effects caused departures from the range of natural variability in how much water ran off into streams during floods and how much infiltrated the ground to support groundwater and springs (USDA Forest Service 1999, Scurlock 1998). Perennial streams in the Sacramento Mountains have been affected in this manner, resulting in a loss of hydrologic functions such as the capacity to store, transmit, and filter water. This has contributed substantially to the majority of the watersheds having perennial streams being classified as “functioning at risk” and contributes to other watersheds classified as “impaired function”. The Riparian Vegetation chapter of this assessment describes the riparian ERUs on the Lincoln National Forest.

By using a watershed approach, all of the 12 indicators which contribute to watershed condition are considered. This process includes: identifying priority watersheds for restoration, developing watershed action plans, and implementing essential projects to improve watershed condition. **Priority watersheds** are the designated watersheds where restoration activities will concentrate on the explicit goal of maintaining or improving watershed condition. For priority watersheds, forests will develop a **Watershed**

Restoration Action Plan that identifies specific projects necessary to improve watershed condition class. The field-based watershed condition assessment will be documented in a Watershed Restoration Action Plan that synthesizes problems, actions, and timelines. Identifying essential projects is a primary goal. **Essential projects** are a discreet group of conservation actions and treatments that are implemented as an integrated suite of on-the-ground management activities focused primarily on restoring watershed health and thereby improving watershed condition class. Within the assessment area for the Forest, Perk Canyon (130600100401) and Perk Canyon Cuevo (130600100402) in the Sacramento Mountains were chosen in 2012 as priority watersheds with essential projects identified to improve watershed condition. As essential projects in these watersheds are completed, priority watersheds will be removed from the list and replaced by new priority watersheds that need restoration. By using this methodology, watersheds can move to properly functioning condition in a systematic way. Implementing this strategy is expected to eventually begin moving all watersheds towards a trend of properly functioning condition within the assessment area. Reference conditions for watersheds using the WCC would be for watersheds to be functioning properly. These conditions existed before the structure and function of the landscape was altered by Euro-American settlers. Although these dynamic conditions were constantly changing, they sustained themselves.

Risks are assigned as follows: Impaired function is high risk; functioning at risk is moderate risk, and functioning properly is low risk.

Table 137. Condition ratings for sub-watersheds in the Plan Area with their respective watersheds and sub-basins

Sub-watershed	Risk Rating	Sub-watershed Risk
Tularosa Valley Sub-basin		
Ancho Gulch Watershed		
Big Pine Canyon	Functioning Properly	Low
Headwaters Ancho Gulch	Functioning at Risk	Moderate
White Oaks Draw Watershed		
Coyote Canyon	Functioning at Risk	Moderate
Headwaters White Oaks Draw	Functioning at Risk	Moderate
Cottonwood Draw Watershed		
Tortolita Arroyo	Functioning at Risk	Moderate
Nogal Creek	Impaired Function	High
Nogal Draw	Functioning at Risk	Moderate
Lemon Draw	Functioning at Risk	Moderate
Willow Draw	Functioning at Risk	Moderate
Harkey Draw-Nogal Arroyo	Functioning at Risk	Moderate
Cottonwood Creek	Functioning at Risk	Moderate
Bitter Creek Watershed		
Gamble Canyon-Three Rivers	Impaired Function	High
Tularosa Creek Watershed		
Nogal Canyon	Functioning at Risk	Moderate
Middle Tularosa Creek	Functioning at Risk	Moderate
Sheep Camp Draw Watershed		
Cottonwood Wash	Functioning at Risk	Moderate
Domingo Canyon	Functioning Properly	Low
Lost River Watershed		
Fresnal Canyon	Functioning at Risk	Moderate
La Luz Canyon	Impaired Function	High
Garton Lake Watershed		
Dry Canyon 06	Functioning at Risk	Moderate
Three Hermanos Watershed		
Alamo Canyon 01	Impaired Function	High
Mule Canyon (east Sacramento)	Functioning at Risk	Moderate
Dog Canyon	Functioning at Risk	Moderate
Grapevine Canyon	Functioning at Risk	Moderate
Bug Scuffle Canyon	Functioning at Risk	Moderate
Escondida Well	Functioning at Risk	Moderate
Salt Basin Sub-basin		

Sub-watershed	Risk Rating	Sub-watershed Risk
Sacramento River Watershed		
Arkansas Canyon-Sacramento River	Functioning at Risk	Moderate
Ben WIlliams Canyon-Sacramento River	Functioning at Risk	Moderate
Piñon Creek Watershed		
Lick Canyon - Piñon Creek	Functioning at Risk	Moderate
Stevens Draw	Functioning at Risk	Moderate
Lewis Canyon	Functioning at Risk	Moderate
Piñon Wash Watershed		
Upper Piñon Wash	Functioning at Risk	Moderate
Little Dog Canyon	Functioning at Risk	Moderate
Pup Canyon	Functioning at Risk	Moderate
Middle Piñon Wash	Functioning at Risk	Moderate
Big Dog Canyon Watershed		
Outlet Big Dog Canyon	Functioning at Risk	Moderate
Upper Dog Canyon	Functioning Properly	Low
Arroyo Del Macho Sub-basin		
Reventon Draw Watershed		
Upper Reventon Draw	Functioning at Risk	Moderate
Middle Reventon Draw	Functioning at Risk	Moderate
Hasparos Canyon Watershed		
Upper Hasparos Canyon	Functioning at Risk	Moderate
Upper Arroyo del Macho Watershed		
Aragon Creek	Functioning at Risk	Moderate
Cottonwood Canyon-Arroyo del Macho	Functioning at Risk	Moderate
Reventon Draw-Arroyo del Macho	Impaired Function	High
Headwaters Salt Creek Watershed		
Copeland Canyon-Seco Arroyo	Functioning at Risk	Moderate
Red Lick Canyon	Functioning at Risk	Moderate
Arroyo Serrano	Functioning at Risk	Moderate
Zeufeldt Arroyo	Functioning at Risk	Moderate
Rio Hondo Sub-basin		
Rio Ruidoso Watershed		
Carrizo Creek	Impaired Function	High
Upper Rio Ruidoso	Impaired Function	High
Water Hole Canyon	Functioning at Risk	Moderate
Devils Canyon	Impaired Function	High
Middle Rio Ruidoso	Impaired Function	High
Lower Rio Ruidoso	Impaired Function	High
Rio Bonito Watershed		

Sub-watershed	Risk Rating	Sub-watershed Risk
Upper Rio Bonita	Impaired Function	High
Magado Canyon	Functioning at Risk	Moderate
Headwaters Salado Creek	Functioning at Risk	Moderate
Gyp Spring Canyon	Functioning at Risk	Moderate
Outlet Salado Creek	Impaired Function	High
Salazar Canyon	Functioning at Risk	Moderate
Middle Rio Bonita	Functioning at Risk	Moderate
Lower Rio Bonita	Impaired Function	High
Casey Canyon Watershed		
Maverick Canyon	Functioning at Risk	Moderate
Headwaters Rio Hondo Watershed		
Chavez Canyon	Functioning at Risk	Moderate
Alamo Canyon 02	Functioning at Risk	Moderate
Black Water Canyon Watershed		
Escondido Canyon	Functioning at Risk	Moderate
Agua Chiquito Creek - Blackwater Canyon	Functioning at Risk	Moderate
Rio Peñasco Sub-basin		
Elk Canyon Watershed		
Silver Springs Canyon	Functioning at Risk	Moderate
Sixteen Springs Canyon	Functioning at Risk	Moderate
Outlet Elk Canyon	Impaired Function	High
Agua Chiquita Watershed		
Upper Agua Chiquita	Functioning at Risk	Moderate
Middle Agua Chiquita	Functioning at Risk	Moderate
Mule Canyon 02	Functioning at Risk	Moderate
Lower Agua Chiquita	Functioning at Risk	Moderate
Upper Rio Peñasco Watershed		
Cox Canyon	Impaired Function	High
Cox Canyon-Rio Peñasco	Functioning at Risk	Moderate
James Canyon	Impaired Function	High
James Canyon-Rio Peñasco	Impaired Function	High
Burnt Canyon	Functioning at Risk	Moderate
Burnt Canyon-Rio Peñasco	Impaired Function	High
Cuevo Creek Watershed		
Perk Canyon	Functioning at Risk	Moderate
Perk Canyon-Cuervo Creek	Functioning at Risk	Moderate
Chimney Canyon-Cuervo Creek	Functioning at Risk	Moderate
Long Canyon-Cuervo Creek	Functioning at Risk	Moderate
Middle Rio Peñasco Watershed		

Sub-watershed	Risk Rating	Sub-watershed Risk
Big Cherry Canyon-Rio Peñasco	Functioning at Risk	Moderate
Upper Pecos-Black Sub-basin		
Fourmile Draw Watershed		
Bear Canyon	Functioning at Risk	Moderate
Bullis Canyon	Functioning at Risk	Moderate
South Seven Rivers		
Wildhorse Canyon-Box Canyon	Functioning at Risk	Moderate
Seco Canyon - Box Canyon	Functioning at Risk	Moderate
North Seven Rivers Watershed		
Antelope Draw-Segrest Draw	Functioning at Risk	Moderate
Headwaters Crooked Canyon	Functioning at Risk	Moderate
Outlet Crooked Canyon	Functioning at Risk	Moderate
Rocky Arroyo Watershed		
North Rocky Arroyo	Functioning at Risk	Moderate
North Rocky Arroyo - Rocky Arroyo	Functioning at Risk	Moderate
Headwaters Dunnaway Draw	Functioning at Risk	Moderate
Last Chance Canyon Watershed		
Upper Last Chance Canyon	Functioning at Risk	Moderate
Middle Last Chance Canyon	Functioning at Risk	Moderate
Lower Last Chance Canyon	Functioning at Risk	Moderate
Dark Canyon Watershed		
Turkey Canyon	Functioning Properly	Low
Turkey Canyon-Dark Canyon	Functioning at Risk	Moderate
Last Chance Canyon-Dark Canyon	Functioning at Risk	Moderate
Black River Watershed		
Big Canyon	Functioning Properly	Low
Big Canyon-McKittrick Canyon	Functioning Properly	Low
McKittrick Canyon-Black River	Functioning at Risk	Moderate
Rattlesnake Canyon	Functioning Properly	Low

Perennial Streams

Streams are classified by their flow characteristics into perennial, intermittent, and ephemeral types. These flow types provide information about the timing and duration of water flow within the streams.

- **Perennial system** – A stream system that flows continuously in all or most years. It is generally fed in part by springs, and the streambed is often located below the water table for most of the year. Ground water supplies the baseflow for perennial streams during dry periods, but flow is also supplemented by stormwater runoff and snowmelt (Meizner 1923; Nadeau 2011). A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water (Nadeau 2011).

- **Intermittent system** – A stream system that flows only at certain times when it receives water from springs or gradual and long, continued snowmelt. The intermittent character of streams of this type is generally due to fluctuations of the water table whereby part of the time the streambed is below the water table and part of the time it is above the water table. The term intermittent may be arbitrarily restricted to streams or stretches of streams that flow continuously during periods of at least 1 month (Meizner 1923). An intermittent stream may lack the biological and hydrological characteristics commonly associated with the continuous conveyance of water (Nadeau 2011). The channel may or may not be well defined.
- **Ephemeral system** – A stream system that flows only in direct response to precipitation. It receives no water from springs and no long-continued supply from melting snow or other surface sources. Its stream channel is at all times above the water table. The term ephemeral may be arbitrarily restricted to streams or stretches of streams that do not flow continuously during periods of as much as 1 month (Meizner 1923). An ephemeral stream does not exhibit the typical biological, hydrological, and in some cases, physical characteristics associated with the continuous or intermittent availability of water (Nadeau 2011).

Perennial and intermittent streams support riparian vegetation. Intermittent and ephemeral streams provide many of the same ecosystem services as perennial streams (Levick et al. 2008). All streams are pathways for the movement of water, nutrients, and sediment throughout the watershed. Intermittent and ephemeral streams comprise a large portion of the stream network within watersheds. These features have greater relative moisture than the surrounding area, often stored in the ground. When these features erode and downcut, gullies can form. This leads to soil loss and lowering of water tables surfaces (Schumm, Harvey, and Watson 1984). Figure 81 shows the location of perennial streams in the Context Area.

The Forest is a major contributor to the ecological sustainability of the entire Context Area even though the Forest comprises a small portion of this area. Table 138 shows that 41 percent of the perennial streams within the Context Area are on the Lincoln NF, while only about 11 percent of the Context Area is within the Lincoln NF boundaries. All of the sub-basins with the exception of the Rio Hondo have less than 10 percent of the land area within the Plan Area, with the Rio Hondo Sub-basin having 21.4 percent of its land within the Plan Area.

Table 138. Miles of perennial stream in each of the sub-basins in the Context and Plan Area

Sub-basin	Sub-basin Number	Total Perennial Stream Miles Context Area	Total Perennial Stream Miles Plan Area	Percent Perennial Stream Miles Plan Area	Total Acres Context Area	Total Acres Plan Area	Percent Acres Plan Area
Tularosa	13050003	104	29	27.9%	4,293,041	248,230	5.8%
Salt Basin	13050004	5	5	100%	1,513,628	116,420	7.7%
Arroyo Del Macho	13060005	0	0	0%	1,196,971	99,242	8.3%
Rio Peñasco	13060010	104	53	51%	6,858,822	319,730	4.7%

Sub-basin	Sub-basin Number	Total Perennial Stream Miles Context Area	Total Perennial Stream Miles Plan Area	Percent Perennial Stream Miles Plan Area	Total Acres Context Area	Total Acres Plan Area	Percent Acres Plan Area
Rio Hondo	13060008	180	82	45.6%	1,063,595	227,511	21.4%
Upper Pecos-Black	13060011	28	5	17.9%	2,803,496	249,689	8.9%
Total		**421**	**174**	**41.3%**	**11,556,613**	**1,260,822**	**10.9%**

The density of the perennial streams on the Forest is about 4 ½ times that of all the streams within the Context Area. This is due to lower average precipitation throughout most of the Context Area outside the Forest as well as higher evaporation rates due to higher temperatures outside the Forest. A good portion of the Lincoln National Forest is in the higher elevation mountainous areas where temperatures are cooler and precipitation is greater. The few perennial streams on the Forest either dry up before reaching the alluvial valley floors or sink into the desert alluvium and cease to flow perennially. A vast majority of the perennial stream miles on the Forest are in the Rio Peñasco and Rio Hondo Sub-basins. The Rio Peñasco and its perennial tributaries constitute a majority of the perennial stream miles within this sub-basin. In the Rio Hondo Sub-basin, the Rio Bonita and Rio Ruidoso and their tributaries contains a majority of the perennial stream miles. The streams in both of these sub-basins flow east and eventually flow into the Pecos River. In the Tularosa Valley Sub-basin, a majority of the perennial streams flow west from the crest of the Sacramento Mountains. A few perennial streams flow off the San Andres Mountains east of the Forest. In the Upper Pecos-Black Sub-basin, there are a few perennial streams south of Artesia and a few south of Carlsbad, with just a few miles of stream flowing off the Guadalupe Mountains.

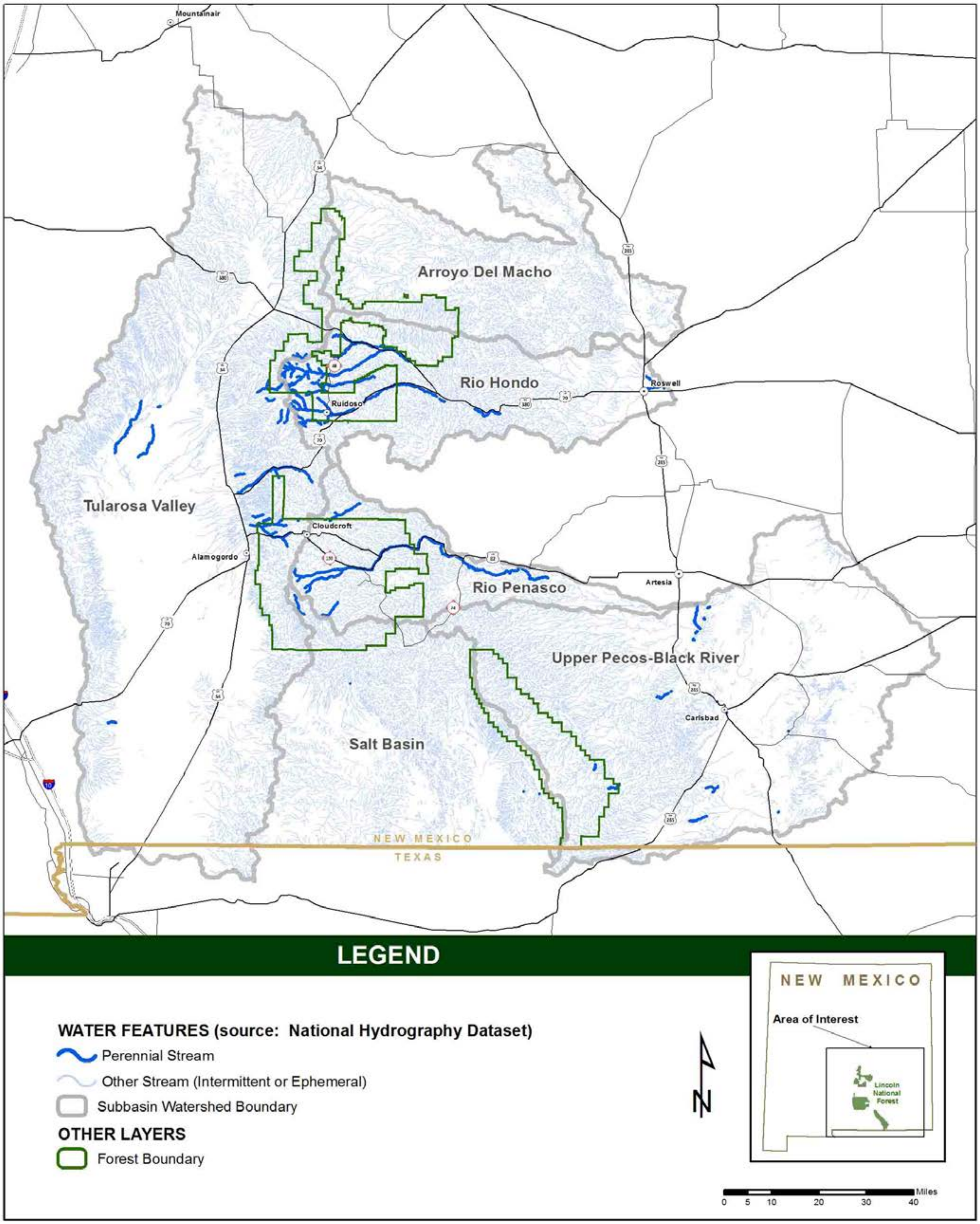

Figure 81. Map of perennial streams and sub-basins in the Context Area

Representativeness as a Tool for Analyses

Representativeness is a measure of the distribution of a resource (e.g., stream miles, number of springs, etc.) within the Plan Area compared to the total of all of these features within the Plan and Context Areas. The result is a determination of where features are over or under-represented. Features that are underrepresented within the Plan Area may necessitate more attention to ensure adequate function. Similarly, features that are largely represented within the Plan Area but are rare outside the Plan Area may impose a greater responsibility on the Forest to maintain integrity of those features. The risks to ecological features can be managed if features are located within the Plan Area, while features outside of the Plan Area are outside the purview of management direction of a forest plan.

Table 139 below provides an example of how to determine whether perennial streams within a sub-watershed are “underrepresented”, “representative”, or “overrepresented”. To determine this, the proportion of perennial streams in the sub-watershed that lie within the Plan Area (“N”, the numerator, in column 7) is divided by the proportion of sub-watershed acreage that lie within the Forest (“D”, the denominator, in column 4). If the ratio “N/D” (column 8) is 0.8 to 1.2, then the perennial streams in that sub-watershed (sixth level twelve digit HUC) are “representative” of what lies within that watershed (fifth level ten digit HUC). If N/D is less than 0.8, then perennial streams within that sub-watershed are “underrepresented” for what is in that watershed. If N/D is greater than 1.2, the perennial streams are “overrepresented” for what is in that watershed.

Table 139. Examples showing calculations of representative, underrepresented, and overrepresented perennial streams in sub-watersheds

Sub-watershed	Total Area (Acres)	Forest Area within HUC 6 (Acres)	% Forest in HUC 6 (D)	Total Perennial Stream Miles in HUC 6	Total Perennial Stream Miles in HUC 6 (Forest)	% Stream Miles on Forest (N)	Ratio (N/D)	Representative: 0.8-1.2 Overrepresented: >1.2 Underrepresented: <0.8
Cox Canyon-Rio Peñasco	30,434	30,434	100	26	26	100	100/100= 1.0	Representative
La Luz Canyon	13067	9568	73.2	7	7	100	100/73.2=1.37	Over
Lower Rio Ruidoso	20794	4075	19.6	12	1	8.3	8.3/19.6= 0.42	Under

Redundancy as a Tool for Analyses

Redundancy of water resources is determined by looking at the degree of repeated occurrences of water resource features within the watersheds. It calculates the distribution and extent of repetitiveness of perennial streams in the watershed. Perennial streams that are rare on the landscape or clustered in one area have low redundancy. These low redundancy features are more vulnerable to catastrophic events or management actions as compared to features which occur repeatedly and are widely distributed. Redundancy for water features within a watershed is determined to be either “yes” or “no.” Table 140 gives an example of how redundancy for perennial streams in two watersheds is determined. It is important to keep in mind the difference between “watershed” and “sub-watershed” as described above to understand how redundancy is determined. Redundancy in the Rio Peñasco Watershed is determined to be “no” because perennial steams exist in only four of the six sub-watersheds and are not considered to be repetitive or recurring within the watershed. In the Tularosa Valley Watershed redundancy is determined to be “yes” because perennial streams exist in all three sub-watersheds and are determined to be repetitive and recurring within the watershed.

Table 140. Example of redundancy determination in two watersheds

Sub-watershed (sixth level 12 digit HUC)	Perennial Streams Exist in Sub-watershed	Redundancy of Streams within Watershed
Rio Peñasco Sub-basin		
Upper Rio Peñasco Watershed		
Cox Canyon	No	
Cox Canyon-Rio Peñasco	Yes	
James Canyon	No	No
James Canyon-Rio Peñasco	Yes	
Burnt Canyon	Yes	
Burnt Canyon-Rio Peñasco	Yes	
Tularosa Valley Sub-basin		
Lost River Watershed		
Fresnal Canyon	Yes	
La Luz Canyon	Yes	
Lost River	Yes	Yes

Representativeness and redundancy are combined to determine the overall risk to ecological integrity. Table 141 illustrates how risk is determined utilizing the representativeness-redundancy matrix. Moderate/high or high risk ratings trigger a closer examination of the water resource feature in question to determine if system integrity is satisfactory or not. To assess risk of perennial streams on the Forest, representativeness and redundancy are used to calculated risk to perennial streams. If an event such as a flood or wildfire were to occur that caused extreme degradation to the perennial streams in a sub-watershed having a high or moderate/high risk rating, this could be catastrophic in terms of the ecological, social, and economic services provided by that watershed.

Table 141. Risk matrix for representativeness and redundancy method

		Redundancy	
Representativeness		**Yes (Low Risk)**	**No (High Risk)**
	Over (Low)	Low Low = **Low Risk**	Low High = **Moderate Risk**
	Representative (Moderate)	Moderate Low = **Moderate Low Risk**	Moderate High = **Moderate High Risk**

	Redundancy		
	Under (High)	High Low = **Moderate Risk**	High High = **High Risk**

There are approximately 174 miles of perennial streams on the Lincoln National Forest and they are contained within 32 sub-watersheds within the Plan Area. Of these sub-watersheds, only three have low to moderate/low risk and seven are assigned a moderate risk rating. Twenty-two of these sub-watersheds are assigned moderate/high to high risk ratings.

Table 142 shows the risk categories for each of the sub-watersheds and Figure 82 shows the locations of the sub-watersheds in the Plan Area with their respective risk ratings. A majority of the sub-watersheds in the Plan Area do not have any perennial streams.

Table 142. Risk ratings for sub-watersheds in Plan Area having perennial streams using the representativeness-redundancy model

Sub-watershed	Representativeness	Redundancy	Risk
Tularosa Basin Sub-basin			
Cottonwood Draw Watershed			
Nogal Creek	Over	No	Moderate
Bitter Creek Watershed			
Gamble Canyon-Three Rivers	Representative	Yes	Moderate/Low
Golondrina Draw-Three Rivers	Under	Yes	Moderate
Tularosa Cree Watershed			
Nogal Canyon	Under	Yes	Moderate
Middle Tularosa Creek	Under	Yes	Moderate
Sheep Camp Draw Watershed			
Cottonwood Wash	Under	No	High
Sabinata Flat Arroyo	Under	No	High
Lost River Watershed			
Fresnal Canyon	Representative	Yes	Moderate/Low
La Luz Canyon	Over	Yes	Low
Lost River	Over	Yes	Low
Salt Basin Sub-basin			
Sacramento River Watershed			
Arkansas Canyon-Sacramento River	Representative	No	Moderate/High
Rio Hondo Sub-Basin			
Rio Ruidoso Watershed			
Carrizo Creek	Representative	No	Moderate/High

Sub-watershed	Representativeness	Redundancy	Risk
Upper Rio Ruidoso	Representative	No	Moderate/High
Devils Canyon	Representative	No	Moderate/High
Middle Rio Ruidoso	Over	No	Moderate
Lower Rio Ruidoso	Under	No	High
Rio Bonito Watershed			
Upper Rio Bonita	Representative	No	Moderate/High
Magado Canyon	Under	No	High
Headwaters Salado Creek	Under	No	High
Outlet Salado Creek	Under	No	High
Middle Rio Bonita	Representative	No	Moderate/High
Lower Rio Bonita	Under	No	High
Rio Peñasco Sub-basin			
Elk Canyon Watershed			
Silver Springs Canyon	Under	No	High
Outlet Elk Canyon	Under	No	High
Agua Chiquita Watershed			
Upper Agua Chiquita	Representative	No	Moderate/High
Upper Rio Peñasco Watershed			
Cox Canyon-Rio Peñasco	Representative	No	Moderate/High
James Canyon - Rio Peñasco	Representative	No	Moderate/High
Burnt Canyon	Under	No	High
Burnt Canyon-Rio Peñasco	Representative	No	Moderate/High
Middle Rio Peñasco Watershed			
Big Cherry Canyon-Rio Peñasco	Under	No	High
Upper Pecos-Black Sub-basin			
Last Chance Canyon Watershed			
Middle Last Chance Canyon	Representative	No	Moderate/High
Dark Canyon Watershed			
Last Chance Canyon-Dark Canyon	Over	No	Moderate

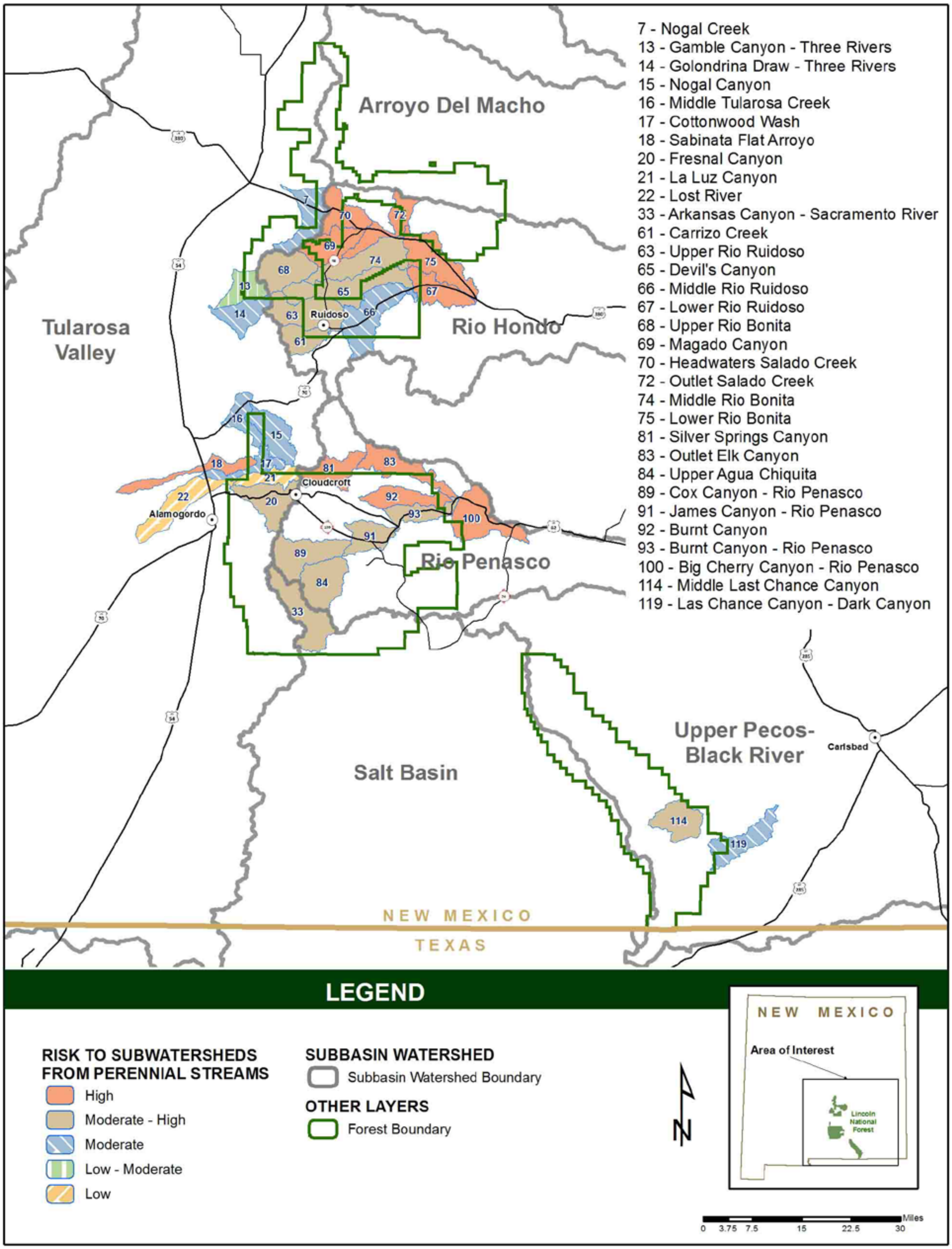

Figure 82. Risk to sub-watersheds in the Plan Area

The perennial streams in the Plan Area occur largely along the Rio Bonita and its tributaries, the Rio Peñasco, Agua Chiquita, the Sacramento River, and along Sitting Bull Creek. Other areas of perennial flowing water are scattered throughout the forest. All of these perennial streams lie within sub-watersheds that have been identified by the previous matrix as being at high risk or high/moderate risk. The Rio Hondo and Rio Peñasco Sub-basins have the greatest number of high and moderate/high risk ratings. They also contain the majority of the sub-watersheds in the Plan Area having perennial streams. Reference conditions would be to have the sub-watersheds rated as low or moderate/low risk.

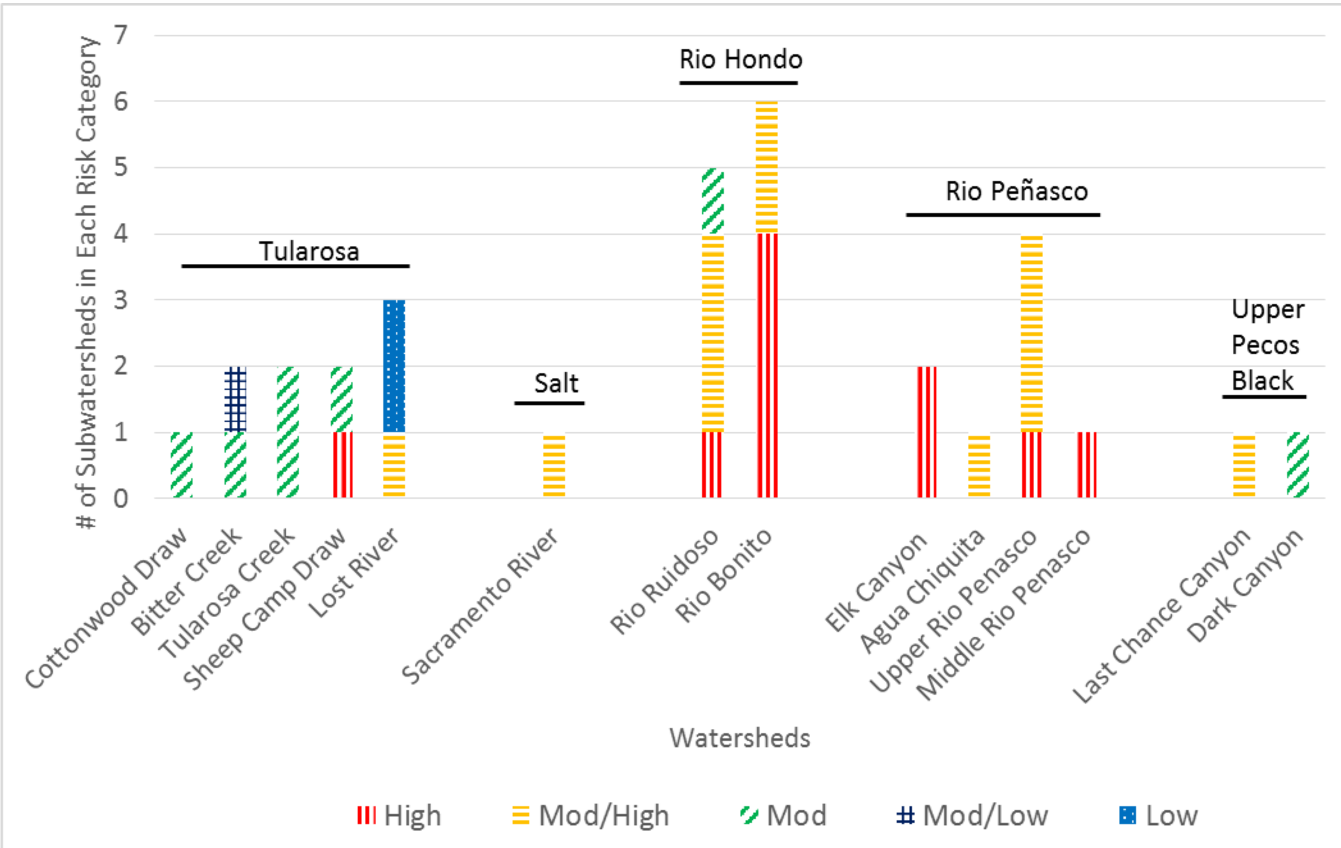

Figure 83. Perennial stream risk values for watersheds

Figure 83 shows the Rio Ruidoso and Rio Bonito Watersheds as having the highest risk. This is due to the lack of distribution of perennial streams and the low representativeness of perennial streams within the respective sub-watersheds compared to the amount of land managed by the Lincoln National Forest within the sub-watershed. All watersheds within the Rio Peñasco Sub-basin are at either high or moderate/high risk.

Water Quantity as Streamflow

The sections below describe the natural climatic variations over the last 11,000 years as well as manmade changes that have occurred over the last 140 years since European settlement. Streamflow trends from two stream gaging stations and precipitation trends from two weather records illustrate the variability of yearly changes as well as trends over the last 70 to 80 years.

Climatic Variations over Time

Throughout time, changes in natural climatic variations have occurred. The following paragraph provides a brief summary of these changes, starting with the culmination of the most recent ice age about 11,000 years ago. About 10,000 years ago, the Ponderosa Pine range expanded. During the period from about 9,000 to 5,000 years ago, a warming trend ensued. Desert scrub-grass communities were in place at the lower elevations by the end of this period. About 4,000 years ago, the Monsoon climate begins, bringing cooler temperatures. Modern vegetation types were in place. Rocky Mountain juniper becomes more restricted in range and alligator juniper increases. From about 2,500 to 800 years ago (1200 AD), gradual warming occurred. The Medieval Warm Period (1000 AD to 1350 AD) saw temperatures warmer than the present, including prolonged summer drought from 1130 to 1180 AD. Drought also occurred from 1217 to 1226 AD. From about 1450 until 1850; this area experienced what is referred to as the Little Ice Age. This was a period that was generally cooler and wetter than the present. Wet periods ensued from 1429 to 1440 and again from 1487 to 1498. Severe drought occurred from 1577 to 1598, followed by a wet period from 1609 to 1623. Drought again occurs from 1778 to 1787. From 1835 to 1849, a wet period occurs. In 1850, the “Little Ice Age” ends. A period of high rainfall, which started around 1880, abruptly ended around 1889. Drought years occur in 1889-1893, 1902, 1904, 1934-1937, and 1951-1957 (Kaufmann et al, 1998).

Streamflow

In general, streamflow has two primary components: base flow and surface runoff. Base flow comes from groundwater that flows from springs or directly from the bed and banks of stream channels. Base flow maintains streamflow in perennial streams throughout the year and is particularly important during dry periods. Surface runoff is the result of rainfall and snowmelt. Surface runoff varies with the total amount of rainfall and the intensity, duration and extent of rainfall events. The influence of temperature, watershed condition, evapotranspiration rates, as well as soil depth, texture, structure and moisture content before the rainfall event are also important factors in determining runoff responses.

Factors That Have Influenced Streamflow

Natural and anthropogenic factors have influenced streamflow, and thus water availability, since settlement of this area by the Europeans in the late 19th century. The paragraph above summarizes long-term climatic changes that have occurred. Additionally, annual variations in temperature and precipitation impact water quantity and streamflow. Even seasonal weather changes have an impact. The paragraph above mentions several periods of drought since European settlement. These drought periods have been interspersed with wet cycles. As an example of how changes can occur over a period of decades, Dark Canyon is not presently a perennial stream but as late as the 1940s, during a much wetter period than we are experiencing at present, people who lived in this area observed perennial flow and permanent riparian vegetation. Additionally, local residence who live along the upper part of the Rio Peñasco have stated that perennial flow along sections of this stream were much more common even as late as the 1990’s than exists at present. Sections of former wetland areas that are now dry have been reported to have been perennially wet in the past.

Anthropogenic activities have also contributed to changes in the characteristics of streamflow, including the timing, magnitude, frequency, duration, and the variability associated with each of these characteristics. Previous to the advent of European settlement, the forests were more open than they are at present. Starting in the late 1800’s and early 1900’s, logging, wildfire suppression, and livestock grazing began in the Sacramento Mountains and adjacent areas. Originally, logging opened up more areas as clearcutting was a common practice at this time. Wildfire suppression and removal of ground fuels by livestock inhibited the smaller fires from occurring that previously had kept the forests thinned. As a result, larger fires occurred. Burning of slash was also common and resulted in large fires. During this time, there was much less vegetation on the hillsides to hold the soil and water in place and as a result, accelerated overland flow occurred. Considerable erosion occurred, especially in canyons, gullying on steep slopes was common, especially where logging occurred (Kaufman et al, 1998). Additionally, unmanaged livestock grazing not only removed ground fuels in the uplands but also in the riparian areas, where livestock had a tendency to spend more time. This resulted in removal of vegetation and compaction of riparian soils, which inhibited the natural infiltration of water into the soil surface and down to the water table. All this resulted in accelerated overland flow and high energy flood flows in the perennial stream channels. Subsequently, channel downcutting occurred which further degraded the functionality of the riparian areas and lowered the water table, decreasing base flows. As a result of these man-caused activities, the natural flow regime of the streams changed and less water became available for downstream use. Irrigation and diversions also contributed to less water being naturally conveyed through the stream channels. It is likely that sections of stream channel previously exhibiting perennial flow ceased to flow perennially due to loss of water storage capacity. Concurrently, these same channels likely experienced higher than normal flows and excess sedimentation during times of flooding.

During September, 1941, three or four days of continuous torrential rain resulted in record high flows along the Rio Peñasco (United States Geological Survey, Water Data Reports and personal communication with local residence). Local residence report that extreme degradation of channel conditions occurred during this time and a part of the deep channels we observe today are a result of this event. By this time, a half century of channel degradation resulted in hillside gullies and deep stream channels. Energy from overland flow as well as flow down the main channels was concentrated in narrow channels rather than dispersed over the hillsides and floodplains. This resulted in extreme gully formation and channel cutting along the Rio Peñasco and its tributaries that is beyond what was present previous to European settlement.

Today the mixed conifer and Ponderosa Pine forest have regenerated and have a higher basal area than before European settlement occurred. The gullies and deep channels that were created during the late 1800s and early 1900s are still present. As a result, there is less water that is available for streamflow contributions as a result of more mixed conifer vegetation and lower water tables and poorly functioning riparian areas.

Data from Stream Gaging Stations and Weather Records

The United States Geological Survey (USGS) has measured and compiled stream discharge data for several sites in the plan and context area. They have also done studies that have provided valuable information on streamflow. New Mexico Bureau of Geology and Mineral Resources and others have also provided valuable data. The following sections summarizes streamflow and precipitation data for the Tularosa, Rio Hondo, and Peñasco Sub-basins.

Tularosa Valley

There are three main streams that drain the northern, central, and southern portions along the western mountain front of the Sierra Blanca and Sacramento Mountains, approximately from Carrizozo to northern Alamogordo. These include Nogal Creek, Three Rivers, and the Tularosa River. Nogal Creek is an ephemeral stream whose headwaters are located on the eastern flank of Nogal Peak in the northern high mountains. There is no stream gauge to measure flow, though total flow is estimated to be approximately 4,300 acre-feet per year (Mamer et al. 2014).

Three Rivers is an ephemeral stream that flows southwest from the western slopes of the Sierra Blanca. The only streamflow data collected here was from 1956 to 1977 by the USGS and recorded only peak flow. Measured peak flows ranged from 260 cubic feet per second in 1958 to 15,000 cubic feet per second on August 5, 1967. Average estimated total streamflow is 8,300 acre-feet per year (Waltemeyer 2001).

The largest perennially flowing stream in the area is the Tularosa River, which flows southwest down the mountain front and through the town of Tularosa before infiltrating into the valley alluvium. Discharge measurements have been recorded since 1932, although continuous recordings have occurred since 1949, with an average year-round flow of 13.5 cubic feet per second (Figure 84). Streamflow is historically lowest in June, averaging 11 cubic feet per second and spikes to 15.1 cubic feet per second in August as a result of heavy monsoon rains. A second, and more sustained peak occurs in January and February as snowmelt and springs feed the river averaging 14.6 cubic feet per second (Figure 85).

Average discharge has fluctuated significantly through its period of record. From 1932 to 1947, the average flow was around 10,000 acre-feet per year. Between 1948 and 1977, the average flow lowered to around 7,000 acre-feet per year. From 1978 to 1995, average flow increased dramatically to approximately 16,000 acre feet per year. From 1996 to the present, the average flow has been around 10,000 acre-feet per year (Mamer et al. 2014). These flow patterns correspond to the precipitation patterns at the Cloudcroft Weather Station (Figure 85)

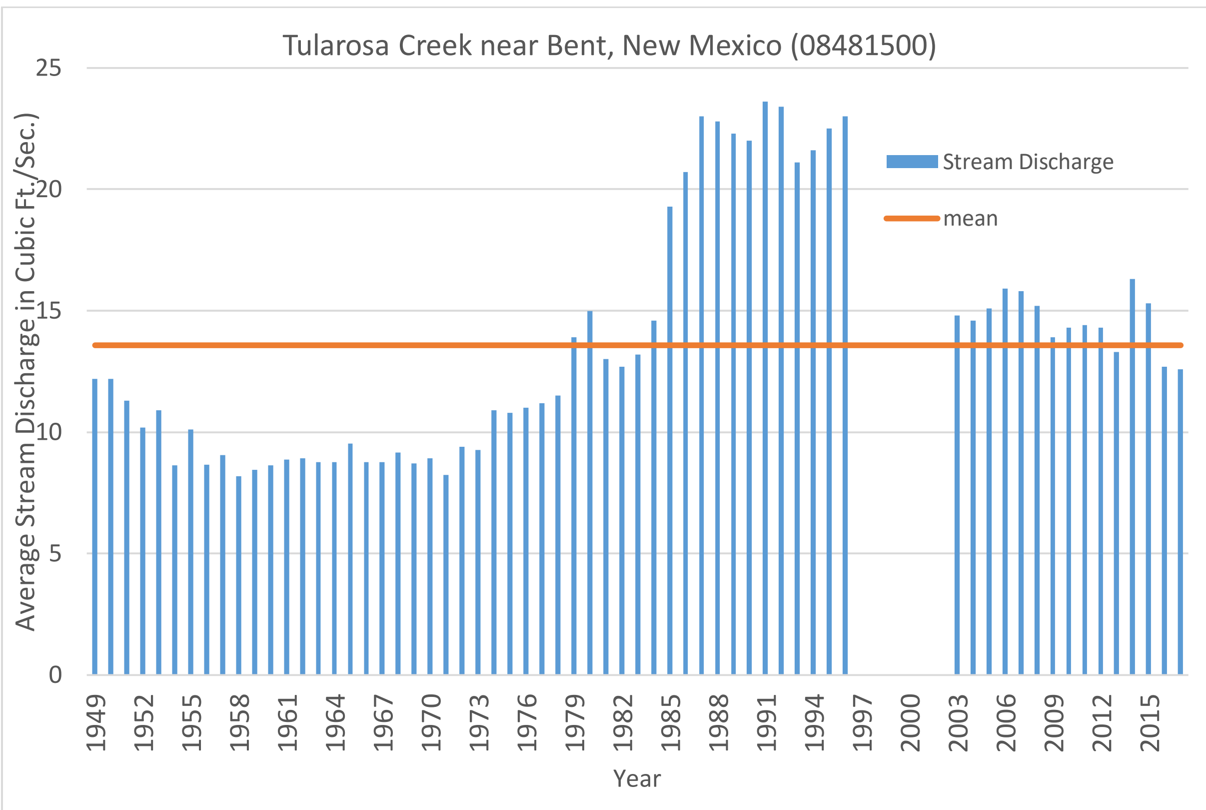

Figure 84. Average Annual Streamflow at USGS Gaging Station Tularosa Creek, New Mexico (08481500) from 1949 to 2017

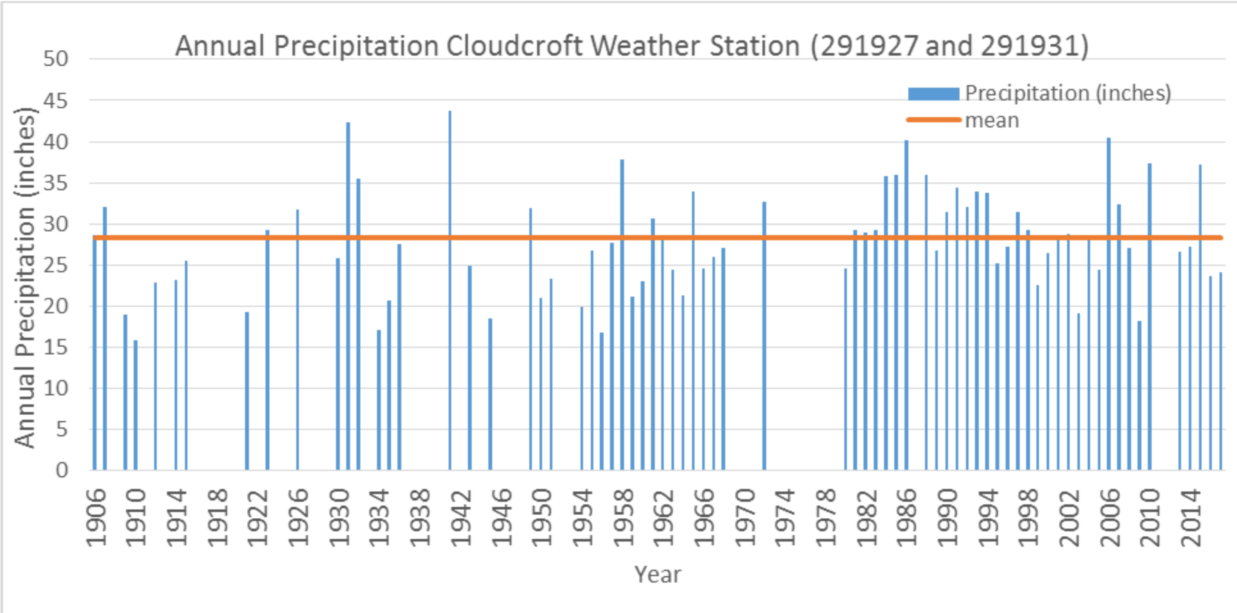

Figure 85. Annual Precipitation at NOAA Weather Station Cloudcroft, New Mexico (291931) from 1906 to 2017 (some years have incomplete data and the annual data is not included in this graph)

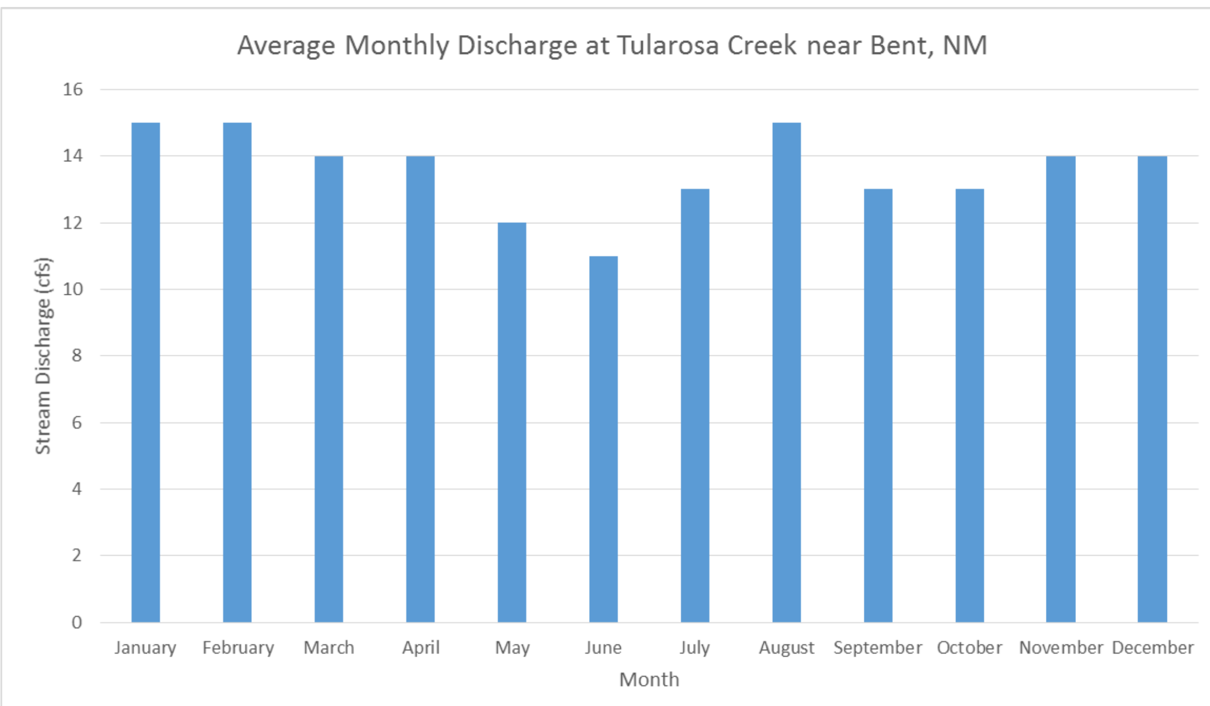

Figure 86. Mean of monthly discharge at Tularosa Creek near Bent, New Mexico (USGS Gage # 08481500)

Table 143 shows the instantaneous peak flows for each year from 1948 to 1996. These range from 154 cubic feet per second in 1953 to 4,610 cubic feet per second in 1991. These peak flows are orders of magnitude greater than even the highest average daily flows. It also shows most peak flows occurring during the height of the monsoon season in July or August.

Table 143. Dates of Instantaneous Peak Flows at Tularosa Creek near Bent, New Mexico USGS Stream Gauging Station (08481500)

Year	Date	Streamflow (cubic ft/sec)
1948	Oct. 13, 1947	448
1949	Sep. 21, 1949	948
1950	Jul. 12, 1950	2,360
1951	Jul. 31, 1951	183
1952	Oct. 31, 1951	154
1953	Jul. 02, 1953	195
1954	Jul. 23, 1954	180
1955	Aug. 19, 1955	286
1956	Aug. 02, 1956	246
1957	Aug. 31, 1957	344
1958	Sep. 23, 1958	185
1959	Jul. 08, 1959	173
1960	Aug. 29, 1960	543
1961	Jul. 04, 1961	1,820
1962	Aug. 01, 1962	1,860
1963	Sep. 08, 1963	2,020
1964	May 26, 1964	873
1965	Jun. 18, 1965	4,280
1966	Aug. 24, 1966	1,580
1967	Aug. 04, 1967	3,160
1968	Aug. 02, 1968	435
1969	Aug. 29, 1969	174
1970	Jul. 02, 1970	1,700
1971	Aug. 29, 1971	1,400
1972	Aug. 27, 1972	2,090
1973	Aug. 30, 1973	2,140
1974	Jul. 09, 1974	3,210
1975	Jul. 26, 1975	197
1976	Jul. 15, 1976	449
1977	Jul. 23, 1977	1,060
1978	Jul. 23, 1978	1,160
1979	Aug. 17, 1979	624
1980	Aug. 14, 1980	2,080
1981	Jul. 12, 1981	1,880
1982	Sep. 10, 1982	211
1983	Sep. 30, 1983	463
1984	Aug. 04, 1984	892
1985	Mar. 26, 1985	131
1986	Jul. 16, 1986	2,210

Year	Date	Streamflow (cubic ft/sec)
1987	Oct. 10, 1986	2,830
1988	Aug. 02, 1988	3,980
1989	Jul. 21, 1989	3,730
1990	Sep. 10, 1990	2,910
1991	Aug. 14, 1991	4,610
1992	Aug. 14, 1992	501
1993	Jul. 11, 1993	989
1994	Sep. 01, 1994	2,660
1995	Jul. 31, 1995	3,840
1996	Aug. 03, 1996	1,650

Two other ephemeral streams in the area, which Waltemeyer (2001) identified as providing significant streamflow to the Tularosa Basin are Temporal Creek and La Luz Creek. Temporal Creek, which flows from Rinconada Canyon is located between Three Rivers and the Tularosa River, is estimated to discharge 9,200 acre-feet per year. La Luz Creek, located just south of the Tularosa River, is estimated to discharge at 5,300 acre-feet per year.

Rio Hondo Sub-basin

In this sub-basin, several stream gaging stations are used in this analyses. The gage at Eagle Creek below South Fork near Alto, New Mexico has data from 1970 to 1980 and then from 1988 to the present. The gage at Rio Ruidoso at Hollywood, New Mexico (08387000), has data from 1954 to the present.

At Eagle Creek, below South Fork near Alto New Mexico, from 1970 to 1980, the average mean daily discharge was 3.1 cubic feet per second while from 1989 to 2016 the average mean daily discharge was 1.8 cubic feet per second. This gage was not operational from 1981 to 1988. In the Eagle Creek Basin, climate data have been collected at the Sierra Blanca, New Mexico, climate station from 2003 to the present (2009). This station is part of the SNOwpack TELemetry (SNOTEL) automated network that collects snowpack and other related climate information and is located at about 10,280 feet above sea level and is near the western boundary of the Eagle Creek Basin. The Ruidoso climate station has collected long term precipitation records and is about 4 miles southeast of the Eagle Creek gage. Data from this station indicate a below-normal precipitation from 1946 to 1975, above normal from 1976 to 1998, and below-normal conditions again from 2000 to 2006, and a return to above-normal again from 2007 to 2009 (Matherne et al. 2011). Precipitation data from the Ruidoso and Sierra Blanca Climate stations indicate that about 65 and 58 percent, respectively, of annual precipitation falls from June through October, and that about 39 and 35 percent, respectively, falls during July and August. Mean monthly precipitation is lowest in March, April, May, and November.

An analyses of base flow at the Eagle Creek gaging station indicates that the 1970 to 1980 mean annual discharge, direct runoff, and base flow were 2,260, 1,440, and 819 acre-feet per year, respectively (Table 144). Mean annual discharge, direct runoff, and base flow for 1989 to 2008 were 1,290, 871, and 417 acre-feet per year, respectively. These results indicate that mean annual discharge, direct runoff, and base flow were less during the 1989 to 2008 period than during the 1970 to 1980 period but that the amount of direct runoff and base flow as a percent of measured discharge was similar for the two periods Table 145.

Table 144. Results of base flow analyses of discharge data from Eagle Creek gaging station (08387600), August 27, 1969, to December 31, 1980. "-" indicates no data.

Mean Annual Discharge, in Acre-Feet				
Year	Measured Discharge	Estimated Direct Runoff	Estimated Base Flow	Comment
1969	847	563	284	Streamflow record Begins on August 27, 1969
1970	836	525	311	
1971	527	346	181	
1972	2,540	1,630	903	
1973	3,350	2,080	1,260	N/A
1974	2,460	1,600	862	N/A
1975	2,850	1,780	1,070	N/A
1976	1,350	864	486	N/A
1977	1,500	984	516	N/A
1978	3,850	2,810	1,040	N/A
1979	4,000	2,220	1,780	N/A
1980	1,620	1,020	599	Streamflow record ends on December 31, 1980
1981	-	-	-	N/A
1982	-	-	-	N/A
1983	-	-	-	N/A
1984	-	-	-	N/A
1985	-	-	-	N/A
1986	-	-	-	N/A

Mean Annual Discharge, in Acre-Feet				
Year	Measured Discharge	Estimated Direct Runoff	Estimated Base Flow	Comment
1987	-	-	-	N/A
1988	-	-	-	Streamflow record resumes on April 27, 1988
1989	1,180	775	409	N/A
1990	1,880	1,320	556	N/A
1991	3,300	2,120	1,180	N/A
1992	2,830	1,830	994	N/A
1993	2,130	1,350	780	N/A
1994	943	707	236	N/A
1995	775	451	324	N/A
1996	458	328	131	N/A
1997	2,110	1,440	671	N/A
1998	2,360	1,650	708	N/A
1999	410	269	142	N/A
2000	411	300	111	N/A
2001	401	272	129	N/A
2002	113	95	18	N/A
2003	152	110	42	N/A
2004	396	306	90	N/A

Year	Mean Annual Discharge, in Acre-Feet: Measured Discharge	Estimated Direct Runoff	Estimated Base Flow	Comment
2005	1,360	916	444	N/A
2006	1,960	1,400	566	N/A
2007	1,310	830	479	N/A
2008	1,290	954	333	N/A

Table 145. Mean annual measured discharge, direct runoff, and base flow for the Eagle Creek gaging station (08387600), 1970 to 1980, and 1989 to 2008

Years	Mean Annual Measured Discharge, in Acre-Feet/Year	Mean Annual Direct Runoff, in Acre-Feet/Year	Direct Runoff as a Percentage of Mean Annual Measured Discharge	Mean Annual Base Flow, in Acre-Feet/Year	Base Flow as a Percentage of Mean Annual Measured Discharge	Comment
1970 to 1980	2,260	1,140	64%	819	36	Means do not include incomplete years (1969 and 1988)
1989 to 2008	1,290	871	68%	417	32	

Over the period of record of the Eagle Creek gaging station, mean daily discharge increased in response to precipitation. However, the pattern of the flow response differed between the early (1969 to 1980) and the late (1989 to 2009) time periods. No days of zero flow were recorded for the 11 year period from 1970 to 1980. Beginning in 1989, however, no-flow days were recorded in 11 of 20 years, with 8 of the last 10 years of the late time period having no-flow days. A total of 789 no-flow days were recorded from 1989 to March 2009. The number of no-flow days during the dry period 1999 to 2004 correlates with a time of decreased precipitation, but no-flow days also occurred during times of above-average precipitation and did not occur during periods of below average precipitation during the early period (Darr et al. 2010).

Alto Reservoir is located on Eagle Creek about 3 miles downstream from the Main Stem Eagle Creek gage. Four miles downstream from the lake, USGS streamflow-gaging station 08387800 (Eagle Creek near Alto, measured a mean annual streamflow of 1,253 acre-feet per year (1.7 cubic feet per second) over the period of record (1969 to 1980)(Figure 86). The record at this gage shows zero streamflow (the creek bed was dry) for about 5 months of the year, usually in the winter months.

In the spring of 2010, record snowfall on Sierra Blanca created abundant snowmelt conditions, and seepage investigations were conducted to better understand streamflow losses below Alto Reservoir. An estimated 220 acre-feet were released to Eagle Creek from Alto Reservoir over the course of about 1 month, and the streamflow was measured at fixed locations downstream from the reservoir on several different occasions. All available streamflow (about 2 to 9 cubic feet per second) infiltrated into the streambed within 2 to 4 miles. The loss of streamflow along this 2 to 4 mile stretch of Eagle Creek below Alto Reservoir is associated with a paleosinkhole mapped by Rawling (2009).

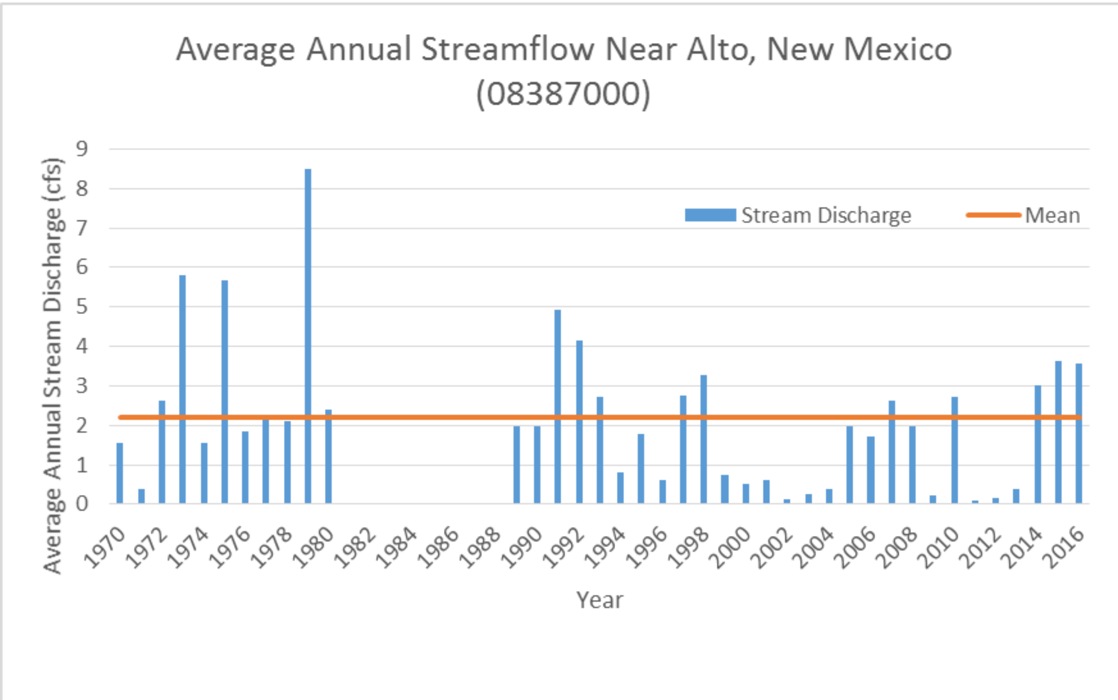

Figure 87. Average Annual Streamflow at USGS Gaging Station Eagle Creek below South Fork, Near Alto, New Mexico (08387000) from 1970 to 2016

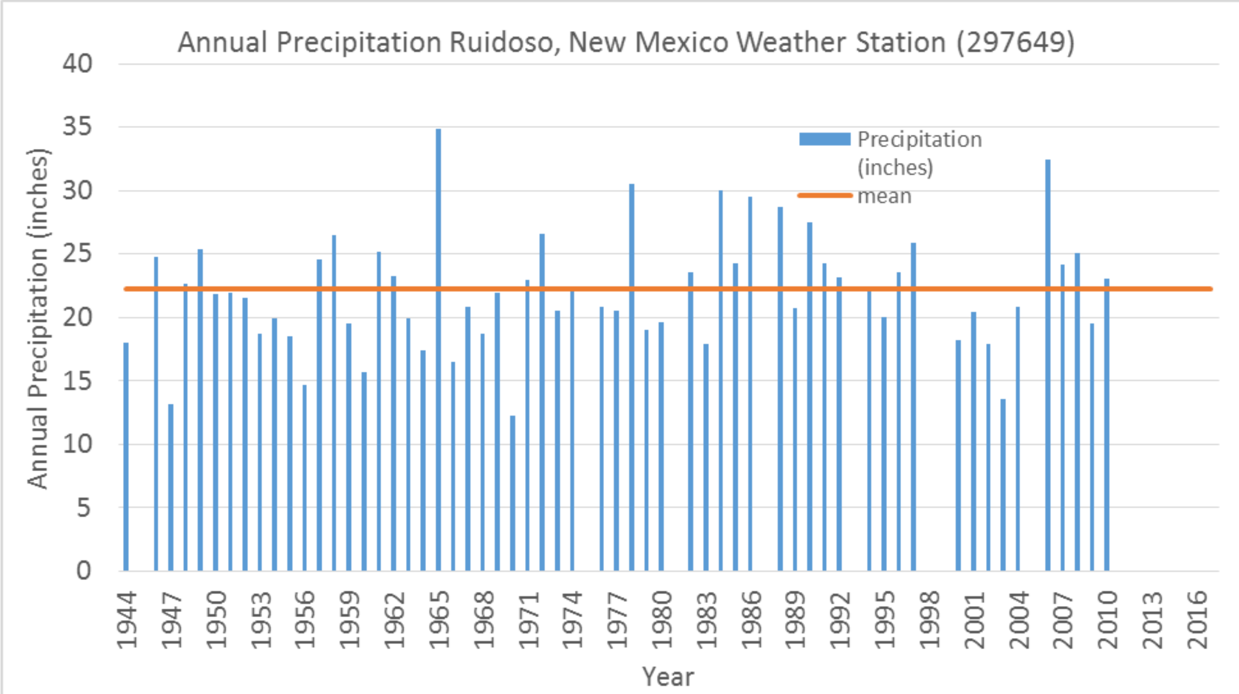

Figure 88. Annual Precipitation at NOAA Weather Station Ruidoso, New Mexico (297649) from 1944 to 2010 (some years have incomplete data and the annual data is not included in this graph)

The stream gage at Rio Ruidoso at Hollywood (USGS gage # 08387000) (Figure 88) shows a mean annual streamflow of 18.1 cubic feet per second, which is roughly double the streamflow measured from the upstream gage at Rio Ruidoso at Ruidoso (USGS gage # 08386505). Seepage studies have shown an increase in streamflow from upstream to downstream and have attributed this to groundwater inflow. Streamflow for the period of record at the gage at Rio Ruidoso at Hollywood shows an increase from the 1950s drought period to the late 1980s wet period and then a subsequent decrease over the next 20 years. This variation in flow parallels trends in precipitation, which have also been decreasing since the mid-1980s (Figure 87). Downstream from this gage the increasing number of diversions causes a decrease in streamflow (New Mexico Office of the State Engineer, unpublished data 2010).

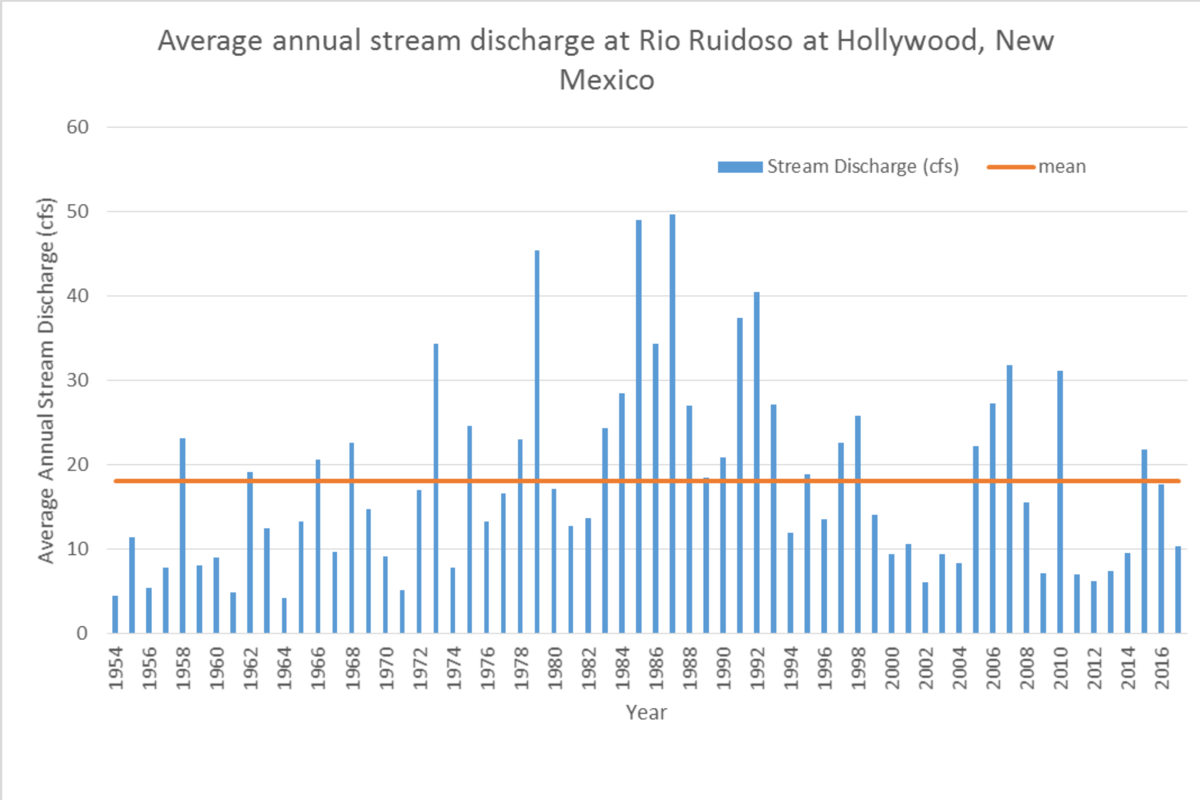

Figure 89. Average annual stream discharge at Rio Ruidoso at Hollywood, New Mexico (USGS gage # 08387000)

The Rio Bonito is one of the major streams in this sub-basin. In 1931, a dam was constructed to form Bonito Lake, from which water has been diverted to the Bonito pipeline (Powell 1954). Prior to construction of the dam, a seepage investigation was conducted in the streambed about 2 miles southwest (upstream) from the Bonito Lake dam site, releasing 2.9 cubic feet per second from the pipeline diversion into the previously dry creek bed for the month of August 1908. After the first 6 days of the investigation, flow extended for the first half-mile of streambed below the dam before completely infiltrating into the stream alluvium; after 8 days flow extended to three-quarters of a mile below the dam (New Mexico Territorial Engineer, 1909).

Powell (1954) reported that from 1931 to 1940 the mean annual streamflow above the Bonito Lake dam site was 6,800 acre-feet per year (9.4 cubic feet per second). During the drought years of 1934, 1947, and 1953, flow at the dam site averaged 20 percent less than average for the period 1931 to 1940, but the Rio Bonito was perennial to the town of Angus (Powell 1954). A hydrographic survey made at the turn of the 20th century (New Mexico Territorial Engineer 1909) stated that the maximum flow in the Rio Bonito occurred near the town of Angus at an estimated 3,000 acre-feet for a partial year (November 1908 to August 1909), and it appears likely that the Rio Bonito below the dam site to Angus has historically been a perennial stream reach.

The Rio Bonito is perennial from Government Spring for about 10 miles downstream to Lincoln, with flow augmented by additional groundwater discharge in this area (Daniel B. Stephens and Associates, Inc. 2000). The USGS maintained a streamflow-gaging station just downstream from Government Spring (08389055, Rio Bonito near Lincoln) from 1999 to 2002, with a mean annual streamflow of 580 acre-feet per year (0.8 cubic feet per second) for the 3-year period of record.

Near the mouth of the Rio Bonito, the USGS maintained a streamflow-gaging station from 1930 to 1955 (08389500, Rio Bonito at Hondo). The mean annual streamflow was 7,485 acre-feet per year (10.4 cubic feet per second) for the period of record, with the lowest flow occurring during the winter months (December to March). Some zero-flow months occurred during most years (Darr et al. 2014).

The confluence of the Rio Bonito and Rio Ruidoso forms the Rio Hondo about 25 miles east of Ruidoso near Hondo. The Rio Hondo is perennial about 7 miles downstream from the confluence of the Rio Bonito and Rio Ruidoso, where the San Andres Formation intersects the stream and the river begins to lose water to the permeable limestone bed. The loss of streamflow on the Rio Hondo has been estimated at about 19,400 acre-feet per year in an average year (Mourant 1963).

The USGS operated a streamflow-gaging station on the Rio Hondo from 1956 to 1962 (08390100, Rio Hondo at Picacho), during which time the mean annual flow was 15,413 acre-feet per year (21.2 cubic feet per second). There was only a single month of no-flow conditions during the period of record; during this time, the flows declined consistently from 32,100 acre-feet per year (44.3 cubic feet per second) in 1957 to 6,700 acre-feet per year (9.3 cubic feet per second) in 1960. Precipitation during this 4-year period also declined about 50 percent from 1958 to 1960 at the Capitan and Ruidoso stations, providing an explanation for the anomalously low-flow conditions during this time. Direct-flow measurements on the Rio Hondo by the USGS were resumed in July 2008. Streamflow-gaging station 08390020 was installed on the Rio Hondo above Chavez Canyon near Hondo. The mean annual flow at this location is 19,725 acre-feet per year (28.9 cubic feet per second) for water years 2008 to 2010 (Darr et al. 2014).

Rio Peñasco Sub-basin

The USGS gaging station at Rio Peñasco near Dunken, New Mexico, has continuous flow data from March 2000 through 2016 (Figure 90). Instantaneous peak flow data has been measured since 1941. For this analyses, high flow days are those at or above the 90th percentile, or those flows whose daily mean discharge are equaled or exceeded only 10 percent of the time. This mean daily discharge is 49 cubic feet per second. Low flow days are those that are at or below the 10th percentile, or flows in which are exceeded 90 percent of the time. This mean daily discharge is 6.4 cubic feet per second. For water years 2002 through 2016, there have been 498 low flow days and 548 high low days. A majority of the low flow days occurred during 2005 and 2006 and included a number of days in which there was no flow. It is not known whether this occurred due to diversions or some other man-caused phenomenon. Almost all the high flow days occurred from 2009 through 2012. Of note is the fact that the highest peak flow for the period of record (2000 to 2016) is 4,900 cubic feet per second while the highest daily mean flow is 600 cubic feet per second During each water year the instantaneous peak flow is much higher than the highest mean daily flow, which is an indicator of extremely high and temporary flows that occur during extreme climatic events during the summer monsoons. These events are usually of short duration as is shown by the vast difference between the daily mean flow and the instantaneous peak flow.

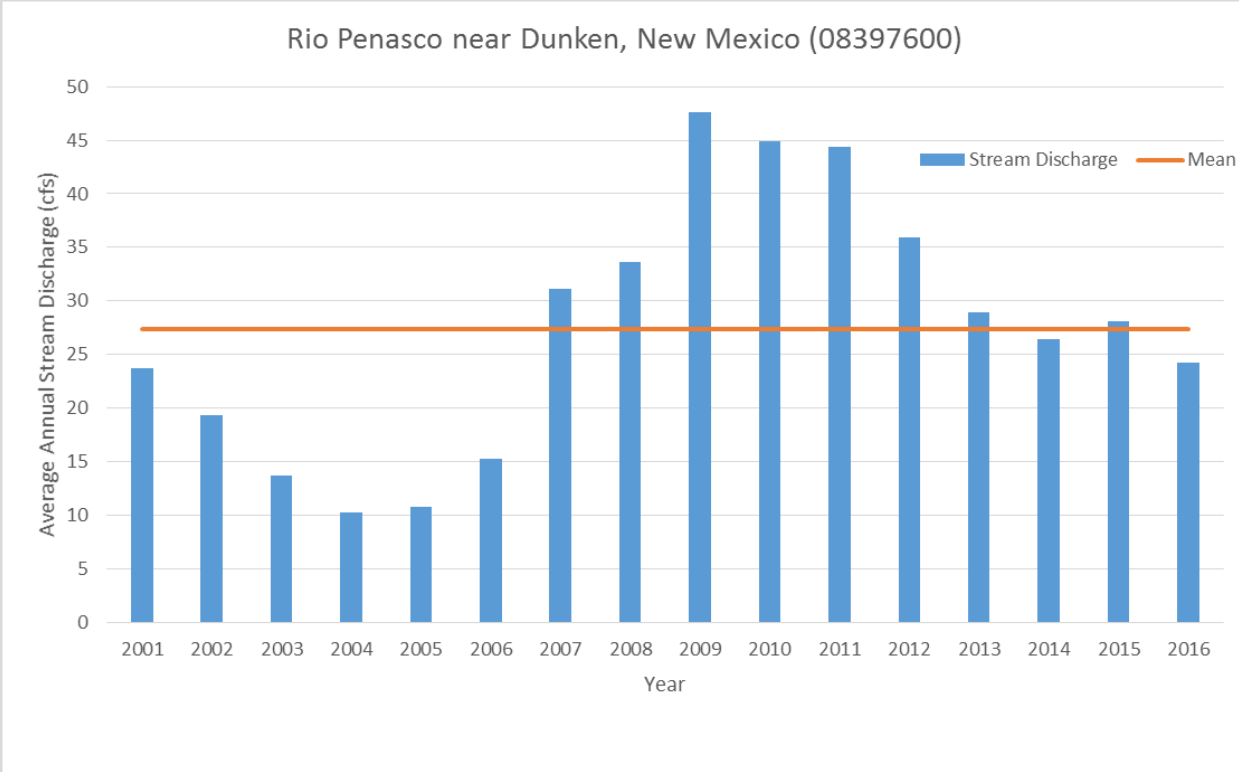

Figure 90. Average Annual Streamflow at USGS Gaging Station Rio Peñasco near Dunken, New Mexico (08397600) from 1970 to 2016

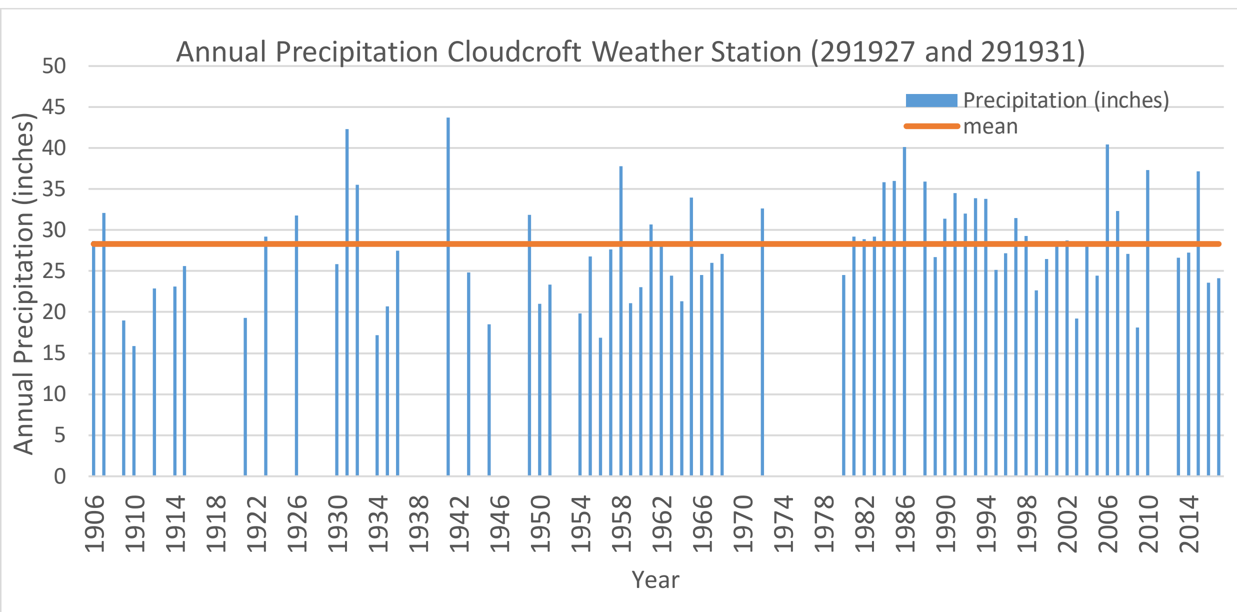

Figure 91. Annual Precipitation at NOAA Weather Station Cloudcroft, New Mexico (291931) from 1906 to 2017 (some years have incomplete data and the annual data is not included in this graph)

Table 146 shows the dates and magnitudes of instantaneous peak flows at the gaging station at Rio Peñasco near Dunken, New Mexico. Most peak flows occur during July or August. In September, 1941 a peak flow of 70,000 cubic feet per second occurred due to heavy rains. This data correlates with precipitation data recorded from a number of weather stations in the area and from peak flows at other gages (Figure 90). This peak flow represents a flow that exceeds the 200 year event.

Table 146. Dates of instantaneous peak flows at Rio Penasco near Dunken, New Mexico USGS Stream Gauging Station (08397600) for the years 1941 to 2015 (no data for years 1942 to 1952, 1970, 1995, and 1996)

Water Year	Date	Streamflow (cubic ft/sec)
1941	Sep. 22, 1941	70,000
1953	Aug. 22, 1953	6,600
1954	Aug. 09, 1954	2,400
1955	Oct. 06, 1954	36,300
1956	Jul. 1956	1,050
1957	Aug. 30, 1957	2,990
1958	Jul. 06, 1958	10,200
1959	Oct. 11, 1958	832
1960	Aug. 11, 1960	3,870
1961	Aug. 26, 1961	980
1962	Jul. 29, 1962	7,070
1963	Jul. 08, 1963	314
1964	Jul. 11, 1964	500
1965	Sep. 01, 1965	880
1966	Aug. 23, 1966	1,050
1967	Aug. 10, 1967	1,100
1968	Jul. 06, 1968	1,850
1969	Sep. 30, 1969	3,650
1971	1971	100
1972	1972	1,200
1973	Jul. 29, 1973	3,400
1974	1974	100
1975	Jun. 24, 1975	4,990
1976	Jul. 16, 1976	210
1977	Aug. 12, 1977	1,170
1978	Jun. 06, 1978	400
1979	Aug. 15, 1979	270
1980	Sep. 09, 1980	6,800
1981	Jun. 03, 1981	215
1982	Sep. 30, 1982	670
1983	1983	140
1984	Aug. 10, 1984	6,000
1985	1985	25
1986	Jun. 24, 1986	4,750
1987	Aug. 23, 1987	2,250
1988	Sep. 20, 1988	4,150
1989	Aug. 27, 1989	440
1990	Sep. 16, 1990	1,760

Water Year	Date	Streamflow (cubic ft/sec)
1991	Aug. 17, 1991	2,600
1992	May 23, 1992	118
1993	Oct. 01, 1992	2,150
1994	Aug. 20, 1994	410
1997	1997	62
1998	Jul. 03, 1998	98
1999	Sep. 02, 1999	1,000
2000	Jun. 30, 2000	4,900
2001	Sep. 16, 2001	504
2002	Sep. 12, 2002	3,140
2003	Aug. 17, 2003	2,930
2004	Aug. 17, 2004	604
2005	Aug. 28, 2005	4,440
2006	Aug. 22, 2006	3,950
2007	Jul. 12, 2007	313
2008	Sep. 09, 2008	3,160
2009	Aug. 18, 2009	2,560
2010	Aug. 19, 2010	1,760
2011	Jun. 29, 2011	156
2012	Jul. 06, 2012	92
2013	Sep. 15, 2013	3,760
2014	Sep. 21, 2014	1,560
2015	Jul. 15, 2015	530

In 2012, New Mexico Bureau of Geology and Mineral Resources published the Final Technical Report of the Sacramento Mountains Hydrogeology Study (Newton et al. 2012). As a part of this study, repeat stream flow measurements and reductions in flow length were taken on three perennial streams between November 2007 and April 2008. This was an extremely dry winter and streamflow rates and the extent of perennial stream reaches decreased throughout the Sacramento Mountains. Stream discharge measurements are presented inTable 147.

Table 147. Streamflow rates on perennial streams between November 2007 and April 2008

Stream	Flow Rate (cubic ft/sec) November 2007	Flow Rate (cubic ft/sec) April 2008	Reduction in stream length between Nov. and April (miles)
Wills Canyon	0.6	0.4	2
Agua Chiquita	4.1	2.0	>2
Sacramento River	2.17	0	3

Extreme Events

In any given year, even during times of severe drought, climatic events may result in high flows that have the potential to impact the stream channel and adjacent riparian area and result in accelerated sediment delivery to the stream system. According to USGS records, the highest flows on record occurred during September 1941 at both the Rio Ruidoso at Hollywood and Rio Peñasco near Duncan gaging stations. USGS water data reports for Rio Ruidoso at Hollywood state that extremely high flooding occurred in 1904. USGS annual water data reports frequently report all-time high flow events for each respective gaging station.

Current Condition and Trend for Streamflow

Reference conditions are considered those that existed immediately prior to European settlement. During this time, the cycles of drought and high precipitation would have resulted in periods of more streamflow and less streamflow, but the extreme events would not have resulted in the extreme high and low flows that exist at present and are considered to be within the natural range of variation. Presently, more extreme flood flows occur because of degraded riparian conditions, loss of floodplain connectivity, more gullies in the uplands that concentrate flow, and a fire regime that results in more extreme wildfires and a higher loss of vegetation that impedes soil water holding capacity. During the dry times of the year streamflow is presently lower and in many areas perennial flow ceases due to loss of water holding capacity in the degraded riparian areas. Higher density of mixed conifer forest contributes to greater amounts of precipitation that do not contribute to streamflow. All these conditions described above are common throughout the entire Lincoln National Forest. Additionally, precipitation has been below average for the last 15 to 18 years, contributing to lower stream flows.

In addition to the representativeness/redundancy method that is used to assign risk to the ecological integrity of perennial streams, qualitative assessments are made for several perennial streams within the Plan Area. These assessments are based on personal observations documented by many photographs as well as by professional judgements and a knowledge of how these systems work. Literature references and professional scientific articles written on other stream systems have aided in this assessment. The hydrology specialist report has a more detailed description of these areas along with photographs that show the conditions of these streams.

Tularosa Basin Sub-basin

Tularosa Creek Watershed

Middle Tularosa Creek Sub-watershed

Upstream of the Forest boundary, a short section of La Luz Creek, at its headwaters, flows through the Lincoln National Forest and the remainder flows through private land (inholdings within the Forest boundary) before flowing into Fresnal Creek. The stream channel is extremely incised and widened throughout its entire length. Much of the riparian area has been degraded and riparian species have been replaced with upland species. Currently, livestock grazing and recreation occur in this area. This stream channel as being extremely incised and widened throughout its entire length. Much of the riparian area has been degraded and riparian species have been replaced with upland species.

Risk and Trends

Risk is high due to extensive incision and accompanying lowering of water tables and loss of riparian function. Trends are stable because present activities are not likely to cause further degradation.

Salt Basin

Sacramento River Watershed

Arkansas Canyon-Sacramento River Sub-Watershed

The Sacramento River has experienced downcutting and channelizing. Some sections are in better condition with a well established secondary floodplain and an original floodplain not far above the present channel. Other portions of the Sacramento River has more incised channels. Riparian vegetation is present along much of the stream corridor. Areas where livestock utilize the riparian areas more frequently have more sectons of stream bank void of riparian vegetation.

Risk and Trends

Based upon knowledge of this stream system and the definition of a properly functioning riparian/wetland area, including the perennial stream system, it is estimated that half of this system is functioning at risk. Close to ¼ is non-functional and ¼ is functioning properly. This is based upon the loss of floodplain connectivity and associated change in the natural hydrologic flow regime, increased road density, loss of stream, riparian, and wetland connectivity, and the large amount of anthropogenic disturbances which have occurred since large scale settlement began in the 1880s. Trends are stable due to activities causing these conditions will not increase into the future.

Rio Hondo Sub-Basin

Rio Bonito Watershed

Upper Rio Bonita Sub-Watershed

The Rio Bonita has a boulder and cobble substrate and is not as prone to downcutting and channelizing as the Rio Peñasco and Agua Chiquita. The increased amount of sediment coming in from the steep side slopes that were affected by the Little Bear Fire of 2012 has caused excess sedimentation in the stream. Much of this sedimentation has occurred in the way of excess cobbles and boulders being conveyed into the stream from the steep side slopes and subsequently being transported downstream. The 107C Bridge, near the confluence of the Rio Bonita and South Fork Rio Bonita has filled up with sediment and the bottom of the channel is presently only one to two feet below the bottom of the bridge. Before the Little Bear Fire occurred, the stream channel was about 8 to 10 feet below the bottom of the bridge. USGS stream gauges located downstream (Rio Ruidoso at Hondo and Rio Bonita at Hondo) show major annual flows occurring in 1941 and 1942 (Figure 91). Nearby weather stations show that record precipitation occurred during these years.

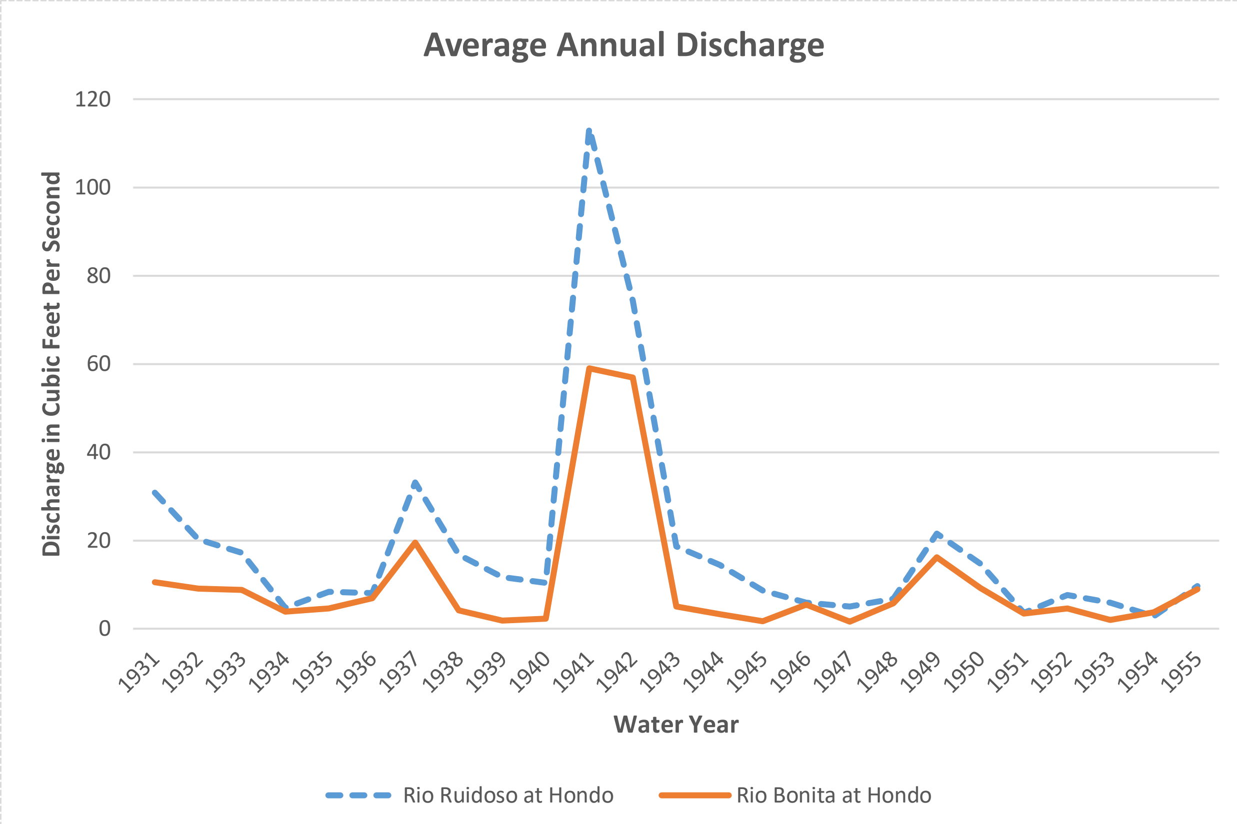

Figure 92. Annual average discharge at two USGS gaging stations (1931-1955)

Risk and Trends

Based upon knowledge of this stream system, it is estimated that ¼ of this system is functioning at risk and ¼ is non-functional. Close to ½ is in proper functioning condition. Trend is upward as the watershed conditions resulting from the Little Bear Fire will continue to improve as vegetation returns. Future projects and management activities are focused on improving watershed conditions.

Rio Peñasco Sub-Basin

Upper Rio Peñasco Watershed

Cox Canyon-Rio Peñasco Sub-Watershed

Perennial streams in this sub watershed include the upper part of the Rio Peñasco. A majority of this system consists of deeply incised channels and access to the adjacent floodplain has been lost. In many places along the upper part of the Rio Peñasco, the channel is downcut at least ten feet or more. There are numerous headcuts, or sudden drops in elevation of the stream channel in relation to the adjacent valley floor. Most headcuts are small, being only 1 to 2 feet high. A few are extremely large, being 6 to 8 feet high. There are some wetland areas adjacent to the stream channel as well as some former wetlands adjacent to the streams, many of which have dried up or are continuing to dry up due to incised channels running through them and draining them. Some of these wetlands have converted to wet meadows due to having different plant species, less organic matter in the subsoil, and diminished water-holding capacity.

Further downstream, the Rio Peñasco flows about 20 miles where it is all on private lands but is surrounded by the Lincoln National Forest. Much of this area is also extremely deeply incised and connectivity with the adjacent floodplain has been lost. This area had been observed to have stream channel incision 15 to 20 feet deep.

High Flow Events

Flooding, gullying, and erosion have been a problem along the river during the 20th century. Floodwater damage occurs almost annually. United States Geological Survey Gaging Station at Rio Peñasco near Dunken, NM shows peak flow events for most years beginning in 1941 (Figure 92). This gaging station is located downstream from this sub-watershed indicates peak flows that would likely result in damage to the stream channels. By far the largest and most destructive event occurred in 1941. Local residents who lived along the upper part of the Rio Peñasco during that time remember it as being a time of extreme channel downcutting and damage to the stream channel and surrounding riparian areas. Figure 92 below shows this would be greater than a 200 year event. In 1955, a peak flow event occurred that approaches the 100 year event. Over the last 20 years, this site has not recorded any extreme flood events, even though high precipitation events occurred during the summers of 2006 and 2008. Local residents who live along the Rio Peñasco have stated that flow events occur annually and deposit debris onto their property.

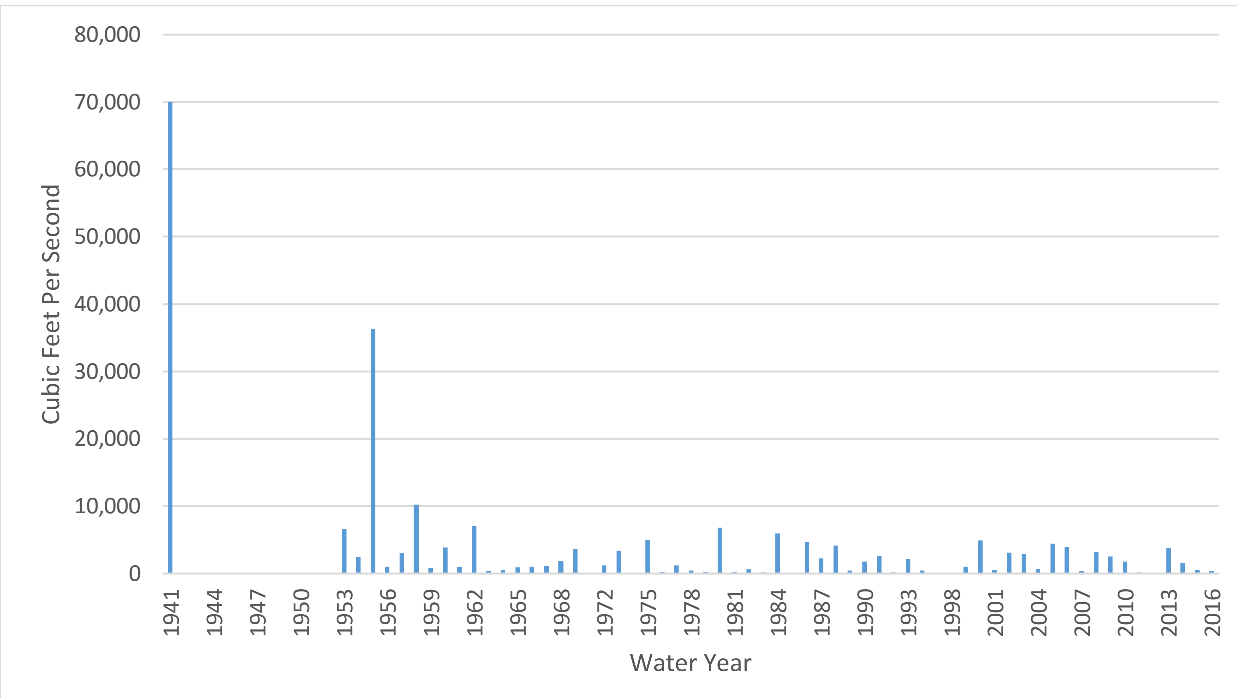

Figure 93. Rio Peñasco high flow events

Table 148. Return Periods and Associated Stream Discharges for the Rio Peñasco near Dunkin, NM (USGS Gaging Station 08397600)

Return Period	Discharge (Cubic Feet Per Second)
2	1,199
5	4,395
10	8,511
25	17,021

Return Period	Discharge (Cubic Feet Per Second)
50	26,363
100	38,944
200	55,590

Risk and Trends

Based upon knowledge of this stream system and the definition of a properly functioning riparian/wetland area, it is estimated that 2/3 of this system is functioning at risk. Close to 1/3 may be non-functional and only a small portion (< 5%) is functioning properly. This is based upon the key ecosystem characteristics described above and their departure from the natural range of variation (NRV). These include the loss of floodplain connectivity and associated change in the natural hydrologic flow regime, increased road density, loss of stream, riparian, and wetland connectivity, and the large amount of anthropogenic disturbances which have occurred since large scale settlement began in the 1880s. Trends are stable as activities causing these disturbances are not expected to increase or decrease.

Rio Peñasco Sub-Basin

Agua Chiquita Watershed

Upper Agua Chiquita Sub-Watershed

Agua Chiquita is similar to the Upper Rio Peñasco in that headcutting and channelizing is extensive. The channel has been lowered dramatically since settlement started in the late 1800s. Some sections of stream have adjacent banks that are lacking in vegetation or only have sparse vegetation immediately adjacent to the channel. These areas are sources of large quantities of sediment during high flows. Associated lowering of ground water tables and lack of access to the original floodplain has resulted in diminished base flow. **Base flow** is the water that sustains streamflow during dry periods. It’s two basic sources are groundwater flow and drainage from unsaturated zones. Stream flows are still influenced by yearly precipitation patterns. Several small springs and wetland stringers adjacent to the stream are found in this area.

Risk and Trends

Based upon knowledge of this stream system and the definition of a properly functioning riparian/wetland area, including the perennial stream system, it is estimated that 2/3 of this system is functioning at risk. Close to 1/3 is non-functional and only a small portion (< 5%) is functioning properly. This is based upon the loss of floodplain connectivity and associated change in the natural hydrologic flow regime, increased road density, loss of stream, riparian, and wetland connectivity, and the large amount of anthropogenic disturbances which have occurred since large scale settlement began in the 1880s. Trends are stable as activities causing these disturbances are not expected to increase or decrease.

Upper Pecos-Black

Last Chance Canyon Watershed

Last Chance Riparian Pasture and Sitting Bull Creek (Middle Last Chance Canyon)

These areas constitute the main courses of perennial water in the Guadalupe Ranger District. Last Chance Riparian Pasture has seen some improvements over the last 25 years as willows and other riparian vegetation has reestablished along the riparian corridor. Increases in riparian vegetation have captured more sediment, resulting in a greater water holding capacity. Sections of the stream channel that did not run perennially now have permanently flowing water. Although improvements have been observed, this area is still functioning at risk.

Sitting Bull Creek is in a degraded condition in relation to its potential. Many of the riparian plants that should exist along this section do not exist. Some invasive species are present and are proliferating. Disturbances due to trespass livestock grazing and wildfires has contributed to degraded conditions. This area is occasionally flooded when heavy rains occur and without the proper riparian vegetation and soils to attenuate the effects of high flows, accelerated streambank erosion and increased conveyance of sediment through the channel occurs.

Risk and Trends

Based upon knowledge of this stream system, it is estimated that ½ of this system is functioning at risk while ¼ is in proper functioning condition and ¼ is non-functional. There are upward trends in some areas, such as along Last Chance Riparian Pasture, and downward trends in other areas where management changes need to occur.

Summary of Current Conditions, Trends, and Desired Conditions

Many of the stream systems described have become deeply incised and some have widened. This has resulted in preventing water during high flows from accessing the adjacent floodplain and loss of riparian/wetland obligate species. When this occurs, considerable wildlife habitat is lost as well as palatable forage for domestic and wild ungulates. As riparian vegetation is lost along the streambanks, accelerated erosion occurs and streams convey higher sediment loads. Sediment has been deposited downstream onto private property along the Rio Peñasco. Channel incision has also resulted in demised baseflow because of the riparian areas diminished capacity to store water and because of lowering of the adjacent water table. Most of the stream systems described above have experienced this and are trending downward. Desired conditions would be for the water in the stream channels to access their adjacent floodplains, streambank and channel erosion would be such that the stream channels would not aggrade or degrade and at the same time transport stream flow and sediment through the watershed without adverse impacts to the stream morphology and physical and biological function of the system is maintained. Streams and associated riparian areas that are functioning properly have the necessary vegetation and water holding capacity in the soils to mitigate these adverse effects.

Reference Conditions

Reference conditions are those conditions that existed prior to large scale European settlement during the 1880s. Stream channels had access to their floodplains. Headcuts were absent or minimal and wetlands were more pervasive adjacent to the stream channels. In some areas there were no channels through the wetlands. Riparian/wetland vegetation along stream bands were abundant.

Springs

A **spring** is a place where water flows naturally from the earth into a body of surface water or onto the land surface whereas a seep is a discharge of water that oozes out of the soil or rock over a certain area without distinct trickles or rivulets (USDA Forest Service 2012). Springs provided an important role in the human occupation of the western United States as they were frequently developed to provide water for livestock, mining, domestic purposes, and other uses. They also provide critical habitat for wildlife and plants. They frequently have been altered due to trampling, diversion, channelization, impoundment, groundwater pumping, and invasion and establishment of exotic species.

Springs are a valuable but limited resource on the Lincoln NF. Water discharged from springs supports riparian habitat and provides important water sources for wildlife, livestock, and human needs. Springs also serve as an important source of base flows for perennial streams and can maintain stream flows during the drier times of the year. The condition of springs and seeps on the Lincoln NF is varied, with some springs being in a degraded condition and some being in good condition. Table 149 below shows conditions of springs as part of the Sacramento Mountain Hydrogeology Study conducted by New Mexico Institute of Mining and Technology. These assessments were conducted on a one-time bases over a small section of the Plan Area but are likely representative of spring conditions throughout the Plan Area. An assessment of spring developments was also conducted to help determine spring conditions and risks. Additionally, photo documentation as part of the hydrology specialist report also verifies the variety of spring conditions over parts of the Plan Area. More data on spring conditions will be needed for proper management into the future. Figure 93 illustrates the location of springs throughout the Context Area.

Springs below the Context Area

Throughout the Context Area, springs are clustered in some regions and in other regions are sparsely located. The Tularosa Valley Sub-basin is the largest sub-basin in aerial extent and has the largest number of springs of all the sub-basins in the Context Area. The Forest encompasses only 5.8 percent of the sub-basin but contains 16.2 percent of the sub-basin's springs. A large number of springs in this sub-basin are concentrated near and to the southeast of the town of Tularosa, not far from the western boundary of the Forest. This basin's eastern edges encompass the western flanks of the Sacramento Mountains and the Sierra Blanca highlands on the Forest. The Rio Peñasco Sub-basin also has a large concentration of springs on the Forest. Many of these springs are adjacent to or near the headwaters of the Rio Peñasco. The Forest contains about 83 percent of this sub-basin's springs, while 46.6 percent of the sub-basin's land area is on the Forest. This is by far the smallest sub-basin in the Context Area, contributing only 6 percent of the total land area. A large number of springs also occur in the Upper Pecos-Black River Sub-basin. Many of these springs are concentrated south of the town of Carlsbad, east of the Forest. The Arroyo Del Macho Sub-basin on the north side of the Context Area and the Salt Basin on the south side have very few springs (Figure 93). These two sub-basins also have the lowest percentage of springs in the Plan Area.

Table 149 lists watershed area and the number of springs in each sub-basin in the context and Plan Area. Spring data is derived from the USGS National Hydrography Dataset (NHD). Spring data from this source is not complete, as the number of springs in the NHD may be 25-50 percent less than what is actually on the ground. This dataset, however, allows for comparisons of springs between Plan and Context Areas. NHD data identify 1,762 springs within the Context Area and 501 springs within the Plan Area. The Plan Area occupies about 11 percent of the entire Context Area but contains about 28 percent of the springs. The greater proportion of springs on the Forest relates to the higher elevations of much of the Forest and the greater precipitation volumes received at these higher elevations. Of particular note is the number of springs in the Rio Peñasco Sub-basin. Although this sub-basin is small in aerial extent, it hosts almost half of the springs within the Plan Area. Local geology and the abundance of shallow perched aquifers in the Sacramento Mountains contribute to the high number of springs on this part of the Forest (see Groundwater section). With one exception, each sub-basin that makes up the Context Area contains a greater percentage of springs within the Forest boundary than the percentage of land area of Forest within that sub-watershed boundary (Table 149). In the Upper Pecos Black Sub-watershed, the Forest contains 7.1 percent of the springs but 8.9 percent of the land area.

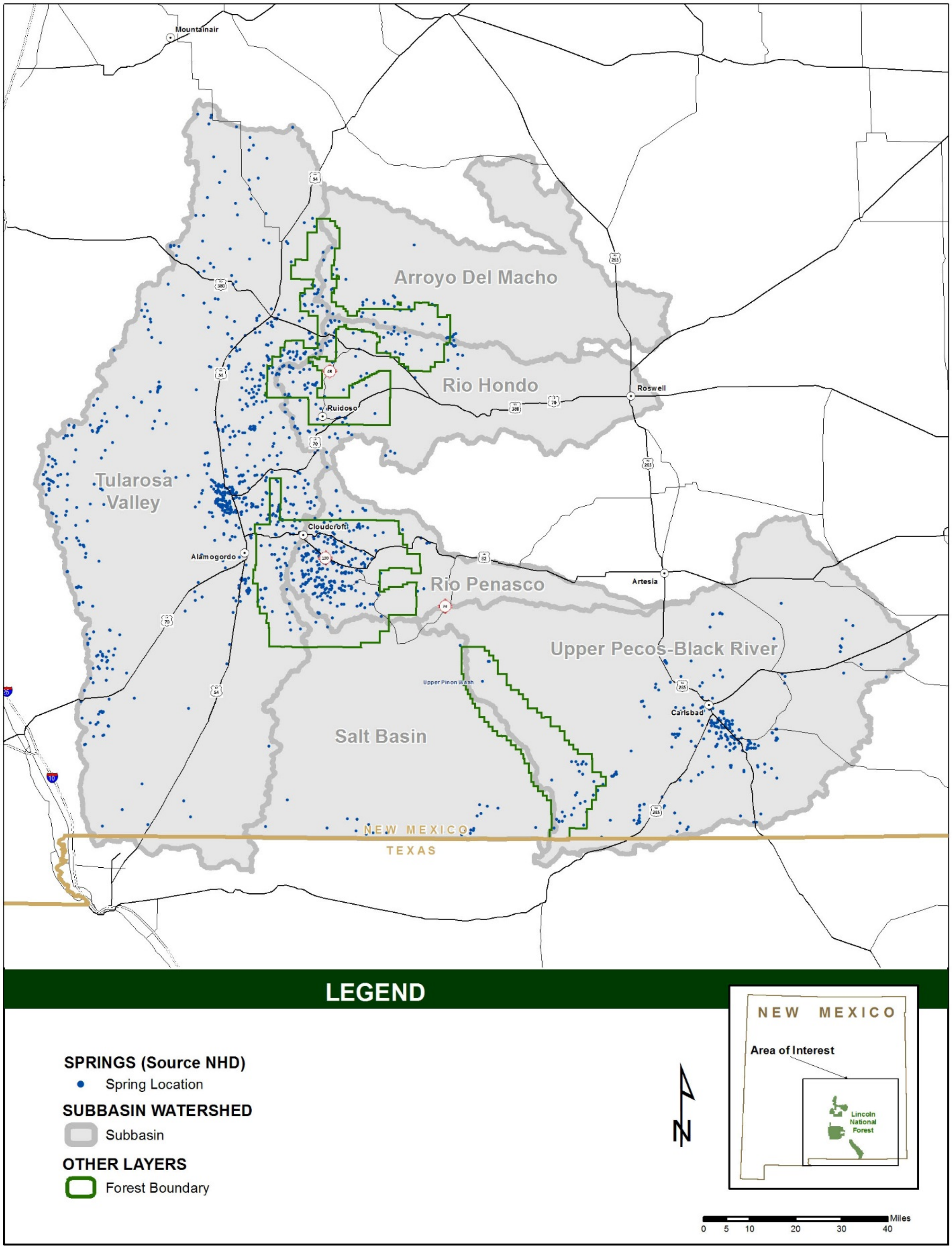

Figure 94. Map of springs and sub-basins in the Context Area

Table 149. Number and percentage of springs in the Context and Plan Areas by Sub-basin

Sub-basin		Lincoln NF (Plan Area)			Springs		
Number	Name	Acres	Area (acres)	% of Watershed	# of Springs in Context Area	# of Springs in Plan Area	% of Springs in Plan Area
13050003	Tularosa Valley	4,293,040	248,230	5.8	748	121	16.2
13050004	Salt Basin	1,513,628	116,419	7.7	40	4	10
13060005	Arroyo Del Macho	1,196,971	99,242	8.3	80	22	27.5
13060010	Rio Peñasco	685,882	319,730	46.6	301	249	82.7
13060008	Rio Hondo	1,063,594	227,510	21.4	197	77	39.1
13060011	Upper Pecos-Black	2,803,496	249,689	8.9	396	28	7.1
Total		**11,556,613**	**1,260,821**	**10.9**	**1,762**	**501**	**28.4**

Representativeness and Redundancy of Springs

Table 150 provides an example of how to determine whether springs within a sub watershed are underrepresented, representative, or overrepresented. The proportion of springs in the sub-watershed that lie within the Plan Area (“N” in Table 150) is divided by the proportion of sub-watershed acreage that lie within the Forest (“D” in Table 150). If the ratio “N/D” is 0.8 to 1.2, then the springs in that sub-watershed (sixth level [twelve digit] HUC) are representative of what lies within that watershed (fifth level [ten digit] HUC). If “N/D” is less than 0.8, then springs within that sub-watershed are underrepresented relative to that watershed. If N/D is greater than 1.2, the springs are overrepresented relative to the larger watershed.

Table 150. Examples showing calculations of representative, underrepresented, and overrepresented perennial springs in sub-watersheds (Rep=representativeness) on the Lincoln National Forest

Sub watershed	Total Area (Acres)	Forest Area within sub watershed (Acres)	% Forest in sub watershed (D)	Total # of Springs in Sub watershed	Total # of Springs in sub watershed (Forest)	% Springs on Forest (N)	Ratio (N/D)	Rep
Nogal Draw	36,418	12,786	35.1	11	7	63.6	63.6/35.1 = 1.81	Over
Nogal Canyon	22,069	3,493	15.8	12	2	16.7	16.7/15.8 =1.06	Rep

Sub watershed	Total Area (Acres)	Forest Area within sub watershed (Acres)	% Forest in sub watershed (D)	Total # of Springs in Sub watershed	Total # of Springs in sub watershed (Forest)	% Springs on Forest (N)	Ratio (N/D)	Rep
Domingo Canyon	11,074	2,426	21.9	13	2	15.4	15.4/21.9 =0.74	Under

Underrepresented: <0.8; Representative: 0.8-1.2; Overrepresented: greater than 1.2.

Redundancy in the Ancho Gulch Watershed is determined to be "no" because springs exist in only one of the two sub-watersheds and are not considered to be repetitive or recurring within the watershed. In the Rio Bonito Watershed redundancy is determined to be "yes" because springs exist in all eight sub-watersheds and are determined to be repetitive and recurring within the watershed. To assess risk for spring features on the Forest, representativeness and redundancy are calculated for each sub-watershed.

Figure 94 shows the locations and risks for springs, based on the representativeness/ redundancy model, according to sub-watershed. Table 152 lists representativeness, redundancy, and the resultant risks assigned to each sub-watershed. The sub-watersheds that have high or moderate-high risk ratings are evenly distributed throughout the Forest. In the Rio Peñasco Sub-basin, a majority of the springs are in the Plan Area as opposed to the other 5 sub-basins, where a majority of the springs are outside of the Plan Area (Table 150). There are 87 sub-watersheds fully or partially within the Forest boundary that contain springs and have been assigned a risk rating of high, moderate/high, moderate, moderate/low, or low.

Table 151. Example of redundancy determination in two watersheds on the Lincoln National Forest

Sub-watershed (sixth level; 12 digit HUC)	Number of Springs in Sub-watershed	Redundancy of Springs within Watershed
Ancho Gulch Watershed		
Headwaters Ancho Gulch	4	No
Cottonwood Creek	0	
Rio Bonito Watershed		
Upper Rio Bonita	17	Yes
Magado Canyon	3	
Headwaters Salado Creek	10	
Gyp Spring Canyon	5	
Outlet Salado Creek	4	
Salazar Canyon	8	
Middle Rio Bonita	8	
Lower Rio Bonita	5	

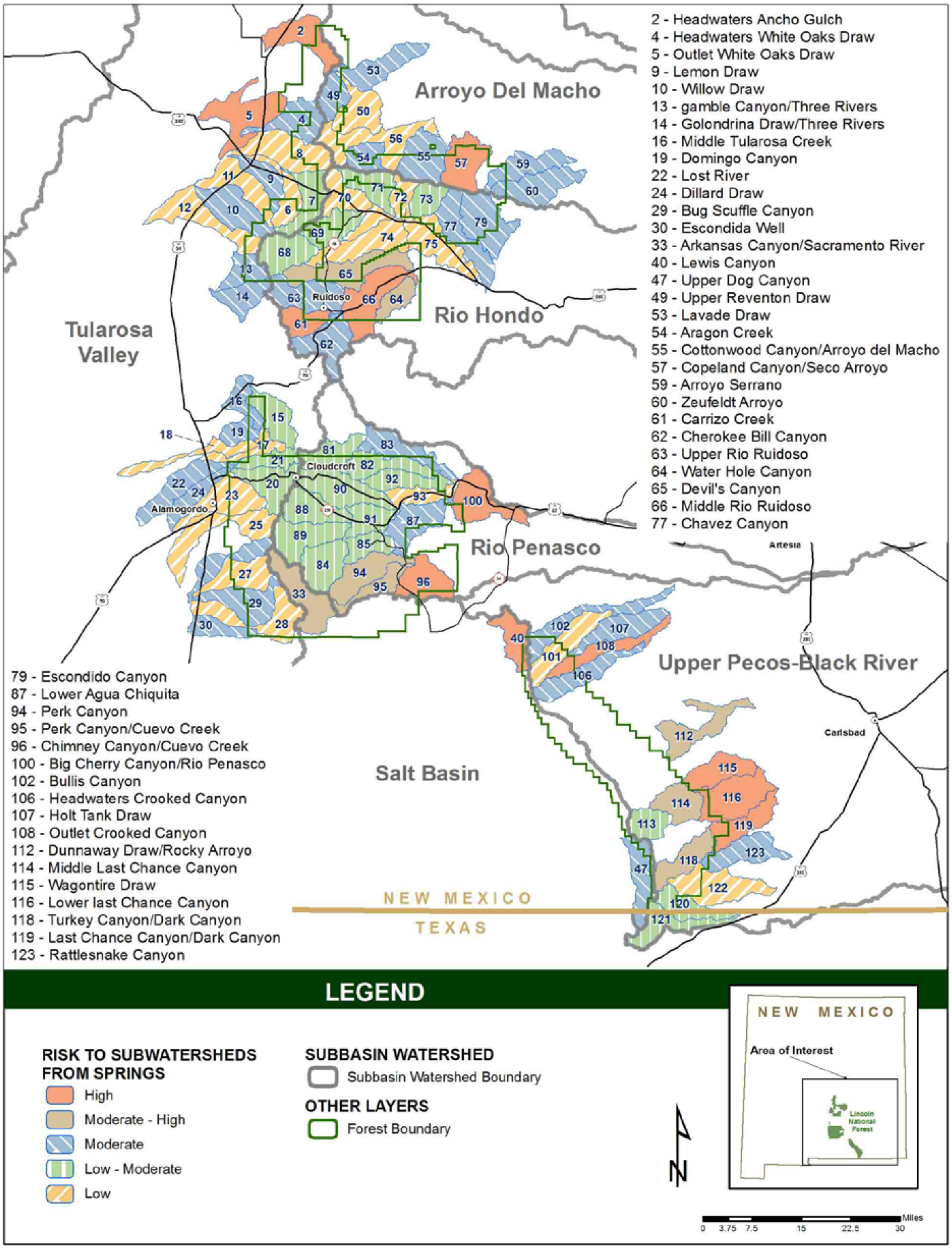

Figure 95. Risk categories for springs, based on representativeness/redundancy combinations, by sub-watershed. More detailed sub-watershed maps can be found in the Scales of Analysis section of this chapter.

Table 152. Representativeness, redundancy, and combined risk category for springs in sub-watersheds that are fully or partially within the Forest boundary

Sub-watershed Name	Spring Representative	Spring Redundancy	Springs Risk
Tularosa Valley Sub-basin			
Ancho Gulch Watershed			
Headwaters Ancho Gulch	Under	No	High
White Oaks Draw Watershed			
Headwaters White Oaks Draw	Over	No	Moderate
Outlet White Oaks Draw	Under	No	High
Cottonwood Draw Watershed			
Tortolita Arroyo	Over	Yes	Low
Nogal Creek	Representative	Yes	Moderate/Low
Nogal Draw	Over	Yes	Low
Lemon Draw	Under	Yes	Moderate
Willow Draw	Under	Yes	Moderate
Harkey Draw-Nogal Arroyo	Over	Yes	Low
Cottonwood Creek	Over	Yes	Low
Bitter Creek Watershed			
Gamble Canyon-Three Rivers	Under	Yes	Moderate
Golondrina Draw-Three Rivers	Under	Yes	Moderate
Tularosa Creek Watershed			
Nogal Canyon	Representative	Yes	Moderate/Low
Middle Tularosa Creek	Under	Yes	Moderate
Sheep Camp Draw Watershed			
Cottonwood Wash	Over	Yes	Low
Sabinata Flat Arroyo	Over	Yes	Low
Domingo Canyon	Under	Yes	Moderate
Lost River Watershed			
Fresnal Canyon	Representative	Yes	Moderate/Low
La Luz Canyon	Representative	Yes	Moderate/Low
Lost River	Under	Yes	Moderate
Garton Lake Watershed			
Dry Canyon 06	Under	Yes	Moderate
Dillard Draw	Under	Yes	Moderate
Three Hermanos Watershed			
Alamo Canyon 01	Over	Yes	Low
Mule Canyon (east Sacramento)	Under	Yes	Moderate
Dog Canyon	Over	Yes	Low
Grapevine Canyon	Over	Yes	Low
Bug Scuffle Canyon	Under	Yes	Moderate
Escondida Well	Under	Yes	Moderate
Salt Basin Sub-basin			
Sacramento River Watershed			
Arkansas Canyon-Sacramento River	Representative	No	Moderate/High
Piñon Creek Watershed			
Lewis Canyon	Under	No	Moderate/Low

Sub-watershed Name	Spring Representative	Spring Redundancy	Springs Risk
Big Dog Canyon Watershed			
Upper Dog Canyon	Over	No	Moderate
Arroyo Del Macho			
Reventon Draw Watershed			
Upper Reventon Draw	Under	Yes	Moderate
Middle Reventon Draw	Over	Yes	Low
Hasparos Canyon Watershed			
Lavade Draw	Over	No	Moderate/Low
Upper Arroyo del Macho Watershed			
Aragon Creek	Under	Yes	Moderate
Cottonwood Canyon-Arroyo del Macho	Under	Yes	Moderate
Reventon Draw-Arroyo del Macho	Over	Yes	Low
Headwaters Salt Creek Watershed			
Copeland Canyon-Seco Arroyo	Under	No	High
Arroyo Serrano	Over	No	Moderate
Zeufeldt Arroyo	Over	No	Moderate
Rio Hondo Sub-basin			
Rio Ruidoso Watershed			
Carrizo Creek	Under	No	High
Cherokee Bill Canyon	Over	No	Moderate
Upper Rio Ruidoso	Over	No	Moderate
Water Hole Canyon	Representative	No	Moderate/High
Devils Canyon	Representative	No	Moderate/High
Middle Rio Ruidoso	Under	No	High
Rio Bonito Watershed			
Upper Rio Bonita	Representative	Yes	Moderate/Low
Magado Canyon	Representative	Yes	Moderate/Low
Headwaters Salado Creek	Representative	Yes	Low
Gyp Spring Canyon	Representative	Yes	Moderate/Low
Outlet Salado Creek	Over	Yes	Low
Salazar Canyon	Representative	Yes	Moderate/Low
Middle Rio Bonita	Representative	Yes	Low
Lower Rio Bonita	Under	Yes	Low
Headwaters Rio Hondo Watershed			
Chavez Canyon	Over	No	Moderate
Black Water Canyon Watershed			
Escondido Canyon	Under	Yes	Moderate/Low
Agua Chiquito Creek - Blackwater Canyon	Under	Yes	Moderate/Low
Rio Peñasco Sub-basin			
Elk Canyon Watershed			
Silver Springs Canyon	Representative	Yes	Moderate/Low
Sixteen Springs Canyon	Representative	Yes	Moderate/Low
Outlet Elk Canyon	Under	Yes	Moderate
Agua Chiquita Watershed			
Upper Agua Chiquita	Representative	Yes	Moderate/Low

Sub-watershed Name	Spring Representative	Spring Redundancy	Springs Risk
Middle Agua Chiquita	Representative	Yes	Moderate/Low
Mule Canyon 02	Under	Yes	Moderate
Lower Agua Chiquita	Under	Yes	Moderate
Upper Rio Peñasco Watershed			
Cox Canyon	Representative	Yes	Moderate/Low
Cox Canyon-Rio Peñasco	Representative	Yes	Moderate/Low
James Canyon	Representative	Yes	Moderate/Low
James Canyon - Rio Peñasco	Representative	Yes	Moderate/Low
Burnt Canyon	Representative	Yes	Moderate/Low
Burnt Canyon-Rio Peñasco	Over	Yes	Low
Cuevo Creek Watershed			
Perk Canyon	Representative	No	Moderate/High
Perk Canyon-Cuevo Creek	Representative	No	Moderate/High
Chimney Canyon-Salt Creek	Under	No	High
Long Canyon-Cuevo Creek	Under	No	High
Middle Rio Peñasco Watershed			
Big Cherry Canyon-Rio Peñasco	Under	No	High
Upper Pecos-Black Sub-basin			
Fourmile Draw Watershed			
Bear Canyon	Over	Yes	Low
Bullis Canyon	Under	Yes	Moderate
North Seven Rivers Watershed			
Headwaters Crooked Canyon	Over	No	Moderate
Holt Tank Draw	Under	No	Moderate
Outlet Crooked Canyon	Under	No	High
Rocky Arroyo Watershed			
Dunnaway Draw-Rocky Arroyo	Under	No	Moderate/High
Last Chance Canyon Watershed			
Upper Last Chance Canyon	Representative	Yes	Moderate/Low
Middle Last Chance Canyon	Representative	No	Moderate/High
Wagontire Draw	Under	No	High
Lower Last Chance Canyon	Under	No	High
Black River Watershed			
Big Canyon	Representative	Yes	Moderate/Low
Big Canyon-McKittrick Canyon	Under	Yes	Moderate/Low
McKittrick Canyon-Black River	Over	Yes	Low
Rattlesnake Canyon	Under	Yes	Moderate

Figure 95 shows, the watersheds (HUC 5) within each sub-basin and the number each risk ratings for the sub-watersheds (HUC 6) within each watershed. The Cottonwood Draw Watershed (left side of graph in the Tularosa Valley) has four sub-watersheds with a low risk rating, one with a moderate/low and two with a moderate risk rating. The Rio Ruidoso, Cuevo Creek, and Last Chance Canyon Watersheds have the highest number of high and moderate/high risk ratings of all the watersheds in the Plan Area. These high and high/moderate risk watersheds have no redundancy. In other words, they are not widely distributed throughout the landscape. They are also either under-represented or represented within their respective sub-watersheds.

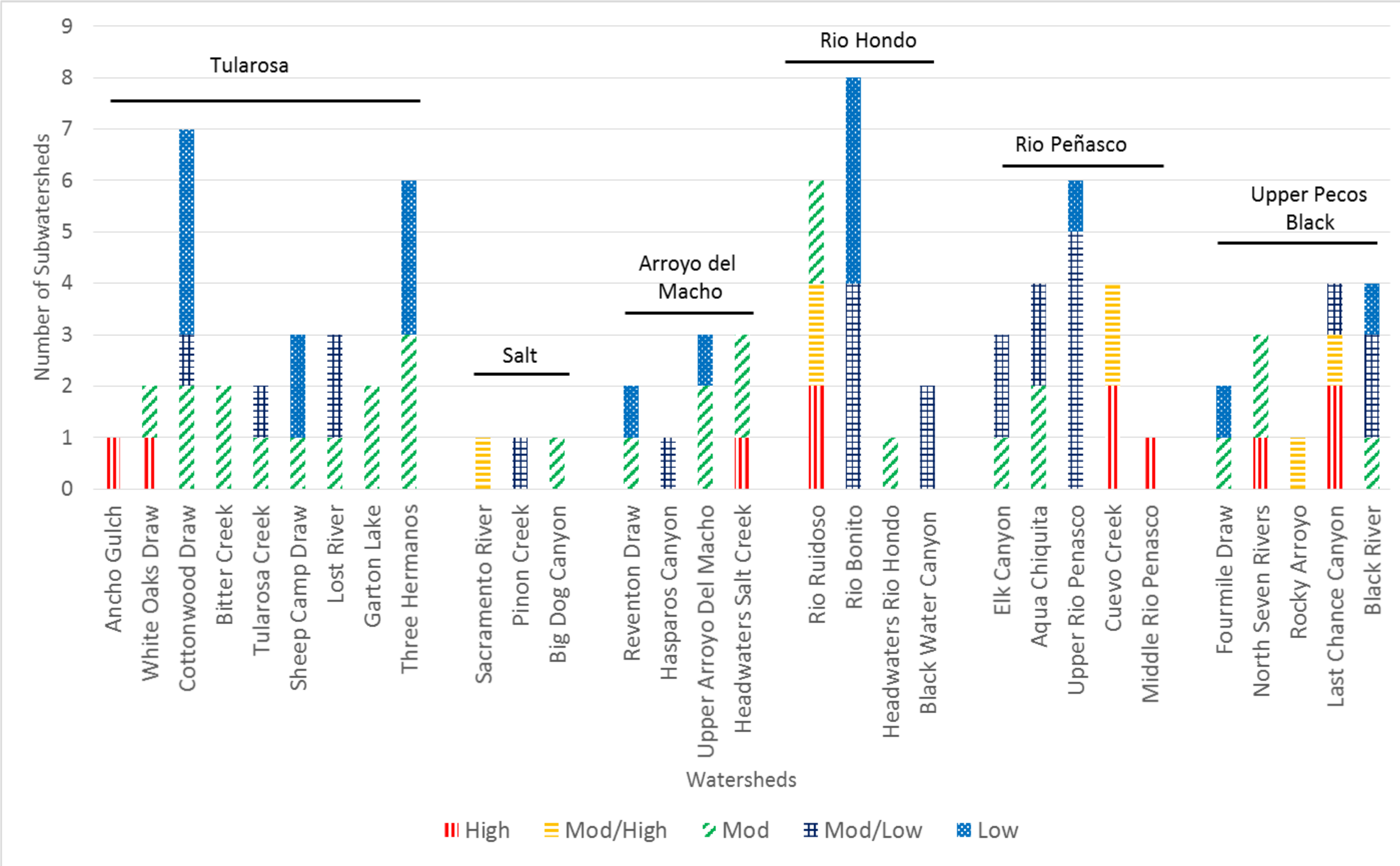

Figure 96. Springs risk analyses by watershed

Spring Data from the 2012 Sacramento Mountains Hydrogeology Study

A spring inventory was completed by the New Mexico Bureau of Geology and Mineral Resources as part of the Sacramento Mountains Hydrogeology Study. Site conditions were rated as “undisturbed”, “slight”, “moderate”, or “high”. These ratings are general, qualitative, and based on observer estimates, and are thus subjective. A majority of the springs inventoried as part of this study were in the Upper Rio Peñasco and Agua Chiquita Watersheds. Although this data represents only a one-time sampling over a limited area of the Forest, it is likely representative of springs over the entire Lincoln National Forest and is therefore included in this chapter. Overall, 17 of the 64 spring sites were rated as “undisturbed”, 16 as “slight”, 21 as “moderate”, and 5 as “high”. Three springs were not given a rating or the rating was not recorded. Major factors that lead to moderate and high ratings are spring developments and livestock disturbances.

A spring inventory was completed by the New Mexico Bureau of Geology and Mineral Resources as part of the Sacramento Mountains Hydrogeology Study. Although this data represents only a one-time sampling over a limited area of the Forest, it is likely representative of springs over the entire Lincoln National Forest and is therefore included in this chapter. These ratings are general, qualitative, and based on observer estimates, and are thus subjective. Sixty-four springs were inventoried (see Figure 96 for spring locations). Table 153 below shows the results of this inventory. Site conditions were rated as “undisturbed”, “slight”, “moderate”, or “high”. Overall, 17 of the 62 spring sites were rated as “undisturbed”, 16 as “slight”, 21 as “moderate”, and 5 as “high”. Three springs were not given a rating or the rating was not recorded. Major factors that lead to moderate and high ratings are spring developments and livestock disturbances. A majority of the springs inventoried as part of this study were in the Cox Canyon-Rio Peñasco and Agua Chiquita sub-watersheds. In the Cox Canyon-Rio Peñasco sub-watershed many of the springs that were sampled were near the perennial streams along the Upper Rio Peñasco and Wills Canyon. A large number of springs in the Sacramento Mountains are found in this area (Newton et al, 2012). Most of these were undisturbed or slightly disturbed. In the Upper Agua Chiquita sub-watershed, there was a fairly even distribution of degrees of disturbance and there appears to be little or no spatial distribution of degree of disturbance. All surveyed springs in the James Canyon-Rio Peñasco sub-watershed were rated as high and moderate disturbance (one was not rated). Most of these have diversion structures associated with them and many are impacted by livestock. In the James Canyon sub-watershed four are rated as undisturbed or slight disturbance. Two were rated as moderate disturbance and two are not rated. The two surveyed springs in the Silver Springs sub-watershed were both rated as undisturbed. This allotment has been closed to livestock grazing since 1995 but elk and feral horses frequent this area. An Alamo Canyon well used for municipal water supply has a high disturbance rating while a spring half a mile to the south in Bug Scuffle Canyon is only slightly disturbed.

Other than in the James Canyon-Rio Peñasco sub-watershed where most springs are rated as moderate disturbance, there does not appear to be any kind of spatial relation as to the degrees of disturbance nor are there any sub-watersheds that appear to have a preponderance of any degree of disturbance. We can infer from this survey that areas on the Forest where livestock are grazed and have access to the springs (no fences around the springs) are more likely to have serious impacts. Springs that are developed are also likely to be more highly impacted.

Field measurements of spring flow, pH, and conductivity were also collected as part of this sampling and are likely representative of spring data throughout the Forest. Spring flows varied from less than ½ gallon per minute to hundreds of gallons per minute. This is a result of the local geology and to a degree the yearly climatic patterns. Increasing water use in nearby areas may impact spring flow and may even cause some springs to become dry. Measurements of pH ranged from 6.75 to 7.85, indicating most of the groundwater from where the spring water is derived is close to neutral, being not too acidic and not too basic for groundwater in the Sacramento Mountains. Although management activities can and do impact the pH of ground and surface water, forest management activities in the Sacramento Mountains have very little impact on the overall pH of ground and surface water in this area. Large scale mining activities, if they were to occur in the Sacramento Mountains, may result in acid mine drainage which *could* result in more acidic water and lower pH. Conductivity measurements ranged from 234 µS/cm (microSiemens per centimeter) to 2,068 µS/cm. This is a measure of the ionic content of the water and is frequently correlated with the amount of total dissolved solids. If the highest three readings were discarded the range would be from 234 µS/cm to 696 µS/cm. These are low measurements and if the three highest were included (808, 1,397, and 2,068 µS/cm), these are still considered low. Management activities in the Sacramento Mountains would not likely affect conductivity. However, if oil exploration and production were to occur large scale on the Forest, conductivity in water may increase as total dissolved solids may increase. If large-scale mining activities were to occur, this may also affect conductivity.

Table 153. Site conditions, spring discharges, pH, and conductivity of sampled springs as part of the Sacramento Mountains Hydrogeology Study

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Tularosa Valley Sub-basin							
Three Hermanos Watershed							
Bug Scuffle Canyon	SM1050	422853 N 3631247 E	Slight—cow prints and wildlife prints; 3 dammed pools downstream	Low	~2	7.14	984 (1397)
Alamo Canyon	SM1051	422629 N 3632336 E	High—diversion; City of Alamogordo Well; looks not used	High	2-3	7.35	426.7
Alamo Canyon	SM1053	422750 N 3633347 E	Not listed—flooding; recently flash(flush) flooded	--	<1	7.02	2068
Tularosa Creek Watershed							
South Fork Tularosa Creek (off Forest)	SM1062	433893 N 3658720 E	Slight—livestock cows prints stink	Low	50	7.47	387.2
Rio Peñasco Sub-basin							
Upper Rio Peñasco Watershed							
Cox Canyon-Rio Peñasco	SM1016	432368 N 3633068 E	Slight; Hillslope Erosion	Low	~1	7.67	466
Cox Canyon-Rio Peñasco	SM1028	430465 N 3632876 E	Undisturbed	Low	>1/2	7.76	440
Cox Canyon-Rio Peñasco	SM1029	430603 N 3632921 E	Undisturbed	Low	~3	7.85	573

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Cox Canyon-Rio Peñasco	SM1030	430660 N 3632480 E	Undisturbed	Low	3	7.69	413
Cox Canyon-Rio Peñasco	SM1032	432350 N 3634430 E	Moderate—livestock, foot and hoof prints	Moderate	½ to 1	7.83	432.4
Cox Canyon-Rio Peñasco	SM1033	433178 N 3634157 E	Undisturbed	Low	4-6	7.65	357.5
Cox Canyon-Rio Peñasco	SM1034	433621 N 3634744 E	Moderate—livestock, muddy pool with footprints and tapeworms	Moderate	<<1	______	______________
Cox Canyon-Rio Peñasco	SM1035	433979 N 3634450 E	Moderate—livestock, footprints	Moderate	<1	__	__
Cox Canyon-Rio Peñasco	SM1036	436270 N 3634872 E	Slight—livestock hoof prints	Low	<1	7.4	309
Cox Canyon-Rio Peñasco	SM1037	432402 N 3631266 E	Undisturbed	Low	5-10	7.41	234
Cox Canyon-Rio Peñasco	SM1038	431943 N 3630299 E	Undisturbed	Low	≤ ½	7.06	402.5
Cox Canyon-Rio Peñasco	SM1039	431635 N 3629988 E	Slight—livestock, diversion; footprints; two pipes in main orifice	Low	10-15	6.94	354.7
Cox Canyon-Rio Peñasco	SM1040	429860 N 3628683 E	Undisturbed	Low	Many 10s	6.95	376.6

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Cox Canyon	SM1063	433285 N 3637763 E	Moderate—livestock; many cows prints here	Low	2	6.75	415.8
Cox Canyon	SM1064	431843 N 3637259 E	Slight—livestock, many cows around, small pool at spring; some footprints	Low	1	7.15	525
James Canyon	SM1057	441600 N 3640549 E	Undisturbed—flows down toeslope onto road	Low	25-50	7.69	406.8
James Canyon	SM1058	442075 N 3640901 E	Undisturbed	Low	2-3	7.51	463
James Canyon	SM1059	444065 N 3640734 E	Slight—recreation; camping hunting camp here	Low	50	7.59	420
James Canyon	SM1060	440886 N 3647604 E	Not listed—livestock-some prints; diversion- old spring box-flows from PVC pipe;	--	__	7.27	640
James Canyon	SM1061	441402 N 3647014 E	Moderate—Diversion—spring house and pipe system	Moderate	200	7.59	473
James Canyon	SM1056	441094 N 3640596 E	Slight—flooding; spring in channel w/grass cover and storm water runoff flowing	Low	5-10	7.63	397.7
James Canyon	SM1077	444060 N 3644834 E	Slight—springbox	Low	10s?	7.51	639
James Canyon	SM1078	444212 N 3645680 E	Moderate—dredging; excavated pit; old pipes	Moderate	10	7.54	427.1

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
James Canyon-Rio Peñasco	SM1079	454723 N 3638504 E	Moderate--Livestock	Moderate	---	7.28	665
James Canyon-Rio Peñasco	SM1080	449068 N 3634478 E	Diversion; concrete box and piping	--	--	7.31	474
James Canyon-Rio Peñasco	SM1081	447577 N 3633503 E	--	--	--	7.68	575
James Canyon-Rio Peñasco	SM1082	450957 N 3636622 E	Moderate—springbox, fenced pasture	Moderate	2	7.28	495
James Canyon-Rio Peñasco	SM1083	447725 N 3638038 E	Moderate—Diversion; sprinbox at top of mound	Moderate	>50	7.37	518
James Canyon-Rio Peñasco	SM1084	446471 N 3637398 E	Moderate—livestock/recreation/diversion; trough, road in area; cattle prints	Moderate	Several 100	7.46	490
James Canyon-Rio Peñasco	SM1085	450375 N 3634275 E	Moderate—diversion; two old steel tanks; fencing	Moderate	1	7.36	696
James Canyon-Rio Peñasco	SM1102	444030 N 3635594 E	High—road construction; dredging of channel	High	--	--	--

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Middle Rio Peñasco Watershed							
Big Cherry Canyon-Rio Peñasco	SM1099	473173 N 3645251 E	Moderate/High—Livestock/Diversion; fences and spring box	Moderate	8	7.73	440
Elk Canyon Watershed							
Silver Springs Canyon	SM1054	438199 N 3651058 E	Undisturbed—roadside seep	Low	2	7.65	370
Silver Springs Canyon	SM1055	437842 N 3651133 E	Undisturbed	Low	100s	7.76	268.4
Agua Chiquita Watershed							
Upper Agua Chiquita	SM1065	435449 N 3625132 E	Moderate—livestock/diversion, spring box with pipe; pool cattle prints around pool	Moderate	1 quart/26 seconds	7.33	431
Upper Agua Chiquita	SM1066	435297 N 3625233 E	High—livestock/diversion; springbox, pipe, muddy pool with cow prints, smells of cow	High	1 quart/45 seconds	7.4	372.7
Upper Agua Chiquita	SM1067	436485 N 3625470 E	High—diversion; spring box, piping to tanks, water supply for camp	High	100 (estimate)	7.34	353.8
Upper Agua Chiquita	SM1068	440173 N 3623047 E	Moderate—livestock/diversion; numerous cattle prints, dammed pond	Moderate	5	7.53	490
Upper Agua Chiquita	SM1069	440129 N 3622956 E	Undisturbed	Low	2	7.22	454.5

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Upper Agua Chiquita	SM1043	440191 N 3627605 E	Undisturbed	Low	2-4	7.04	480
Upper Agua Chiquita	SM1044	439688 N 3627800 E	Slight—recreation path to spring; some trash around	Low	3-4	7.2	438.4
Upper Agua Chiquita	SM1045	437888 N 3626550 E	Moderate—livestock, cattle prints	Moderate	2-3	6.98	423.2
Upper Agua Chiquita	SM1046	438287 N 3626457 E	Slight—livestock some hoof prints	Low	1	7.1	401
Upper Agua Chiquita	SM1047	439520 N 3626817 E	Slight—livestock hoof prints	Low	1-2	6.8	437.3
Upper Agua Chiquita	SM1048	439040 N 3625464 E	Undisturbed	Low	Many 10s	7.0	405
Upper Agua Chiquita	SM1009	440226 N 3630745 E	Slight (Livestock, Recreation)	Low	1	7.25	649
Upper Agua Chiquita	SM1049	440837 N 3627783 E	Slight—livestock hoof prints	Low	<1	—	—
Upper Agua Chiquita	SM1089	441607 N 3626932 E	Moderate—old spring house	Moderate	30 (est.)	7.33	354
Upper Agua Chiquita	SM1089	441607 N 3626932 E	Moderate—old spring house	Moderate	30 (est.)	7.33	354
Middle Agua Chiquita	SM1072	448626 N 3629529 E	Moderate—diversion with springbox	Moderate	10	7.45	462

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Middle Agua Chiquita	SM1073	449334 N 3630362	Moderate—diversion with springbox	Moderate	100s (huge)	7.23	480
Middle Agua Chiquita	SM1088	444888 N 3627273 E	Undisturbed	Low	>50	7.23	495
Cuevo Creek Watershed							
Perk Canyon	SM1070	440803 N 7617798 E	High—Livestock/ diversion; lots of prints and pies; spring in pipe in wooden structure	High	10-70	7.18	475
Salt Creek Sub-basin							
Pinon Creek Watershed							
Lick Canyon-Pinon Creek	SM1086	448175 N 3616264 E	Moderate—Livestock/diversion; spring box, stream goes into pasture	Moderate	20 (est.)	7.08	522
Lick Canyon-Pinon Creek	SM1087	450656 N 3616748 E	Moderate—livestock/diversion; cattle pies, structure over main outlet, dam downstream	Moderate	7	7.1	534
Sacramento River Watershed							
Arkansas Canyon-Sacramento River	SM1101	431421 N 3622267 E	Undisturbed—wildlife (deer and elk)	Low	--	7.09	593
Arkansas Canyon-	SM1076	438399 N 3615789 E	Slight—Livestock/diversion; a few cow prints; concrete box at outlet; some pipe	Low	1000? (estimate—a lot)	7.21	422.8

Sub-watershed	Spring ID	Universal Transverse Mercator	Site Condition (Other Observations)	Risk	Discharge (Gallons per Minute)	pH	Conductivity
Sacramento River							
Arkansas Canyon-Sacramento River	SM1031	430654 N 3623088 E	Undisturbed	Low	5	7.74	408.8

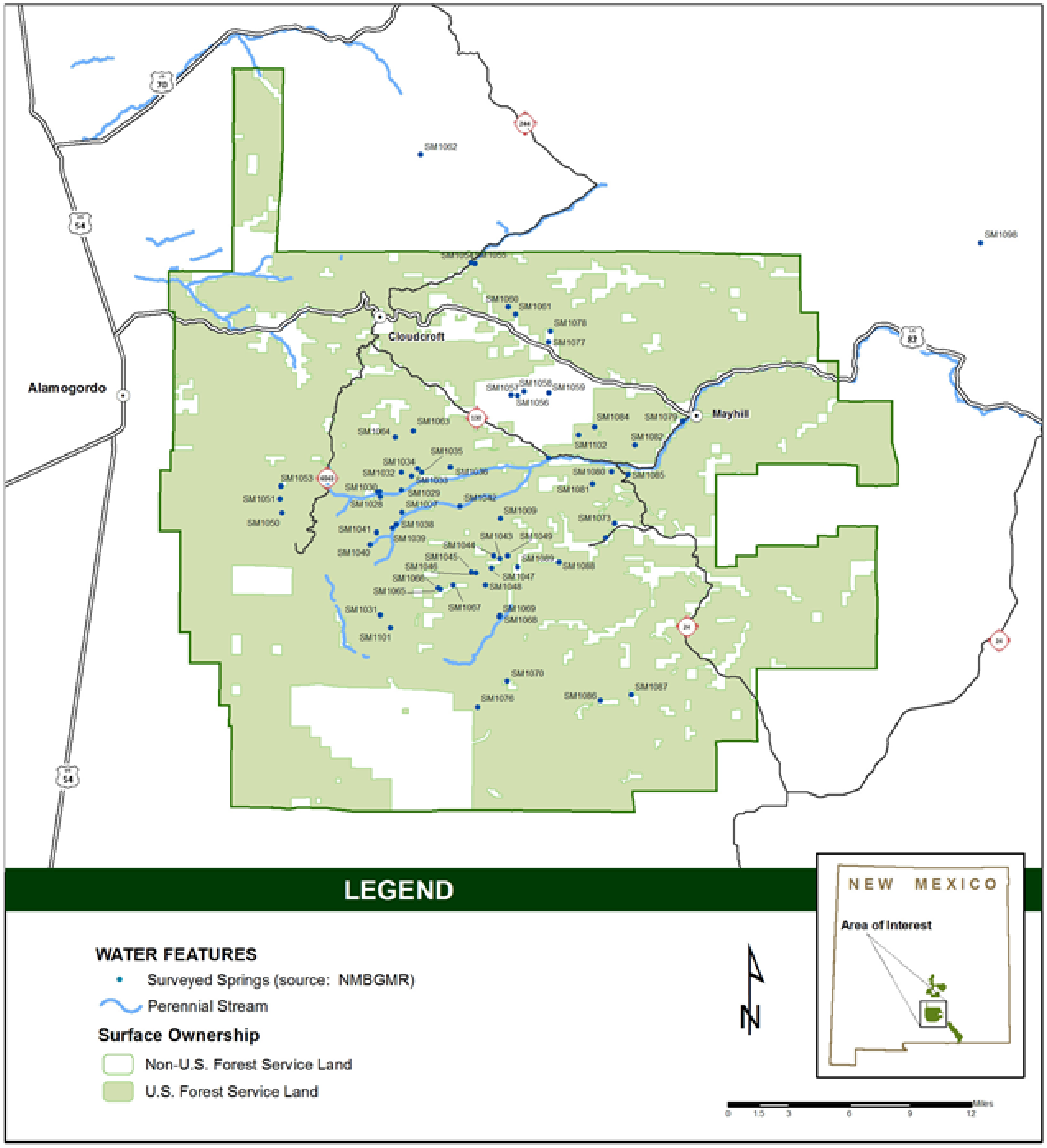

Figure 97. Map of springs inventoried as part of Sacramento Mountain hydrogeology study (Newton et al. 2012)

<u>Risk and Trends for Inventoried Springs as part of the Sacramento Mountains Hydrogeology Study</u>

Risk ratings are applied to each individual inventoried spring with undisturbed and slight disturbances being low risk, moderate disturbance being moderate risk, and high disturbance being high risk. Overall, 5 springs are at high risk, 21 springs are at moderate risk, and 33 springs are at low risk. Trends are stable due to consistent livestock numbers and the likelihood of few new spring developments in the future. There are areas where spring developments may occur over the next 10-15 but these will likely be minimal so as not to cause an overall downward trend in spring conditions.

Overall, 17 of the 64 spring sites were rated as “undisturbed”, 16 as “slight”, 21 as “moderate”, and 5 as “high”.

Spring Developments

A number of springs on the Lincoln NF are developed for livestock and wildlife use as well as for domestic purposes. The Forest database identifies spring developments within 44 sub-watersheds on the Forest. Table 154 shows the total number of springs verses the number of developed springs within these sub-watersheds. There are a total of 409 springs identified within these 44 sub-watersheds with 140 of these that are developed. Approximately 1/3 of these are in the Rio Peñasco Sub-basin. The James Canyon, James Canyon-Rio Peñasco, and Upper Agua Chiquita sub-watersheds have the highest number of spring developments. These sub-watersheds also host a high number of total springs. Figure 97 shows the locations of the springs and spring developments within these 44 sub-watersheds on the Lincoln National Forest. To put these numbers into context of the Plan Area, table 12 shows that there are total of 501 identified springs on the Lincoln National Forest and a total of 87 sub-watersheds that are fully or partially within the Forest boundary that contain springs. The condition of these springs is not identified but as part of the Sacramento Mountains Hydrogeology Study conducted by New Mexico Bureau of Geology and Mineral Resources, a select number of springs in the Sacramento Mountains were sampled and their conditions characterized. These results are described above and summarized in Table 153 above.

Spring developments capture and divert varying amounts of spring water discharge to troughs and tanks. The amount of water diverted from each spring is no longer available for sustaining the ecological values supported by the spring. Some ecological value can be supported by the volume of water remaining at the spring. Grazing of wetland and riparian vegetation supported by springs can damage the ecological values supported by springs if grazing exceeds levels needed to sustain the vegetation. Livestock trampling can also damage ecological values supported by springs. Where wetland and riparian vegetation supported by springs and seeps is fenced to exclude livestock, damage from grazing and trampling is reduced. The Groundwater section describes the impacts groundwater pumping can have on springs.

Stock tanks, dirt tanks, troughs, wells, and windmills have been constructed across the landscape. These features seek to distribute livestock use so that grazing pressure at traditional water sources is reduced. Livestock tend to congregate close to these features and reduce soil and vegetative condition in close proximity to these areas. Although the aerial extent of these impacts are small, the intensity of impacts around such features may be high. Stock tanks, dirt tanks, and trick tanks are vulnerable to drought conditions and are less reliable water sources than perennial streams, springs, and seeps.

Risk is assigned to each sub-watershed having developed springs. Watersheds having 0 to 33 percent of their springs developed are assigned a low risk rating, 34-66% a moderate risk rating, and 67 to 100 percent a high risk rating. Some sub-watersheds only have one or two springs that are all developed. These are still given a high risk rating.

Table 154. Spring developments within sub-watersheds on Lincoln NF

Sub-watershed	# of Springs in Sub-watershed on Lincoln NF	# of Springs in Sub-watershed on Lincoln NF with Developments	Percent of Springs Developed	Risk
Tularosa Basin Sub-basin				
White Oaks Draw Watershed				
Headwaters White Oaks Draw	8	6	75	High
Cottonwood Draw Watershed				
Nogal Draw	7	6	86	High
Nogal Creek	11	7	64	Moderate
Tortolita Arroyo	9	3	33	Low
Harkey Draw-Nogal Arroyo	2	1	50	Moderate
Willow Draw	1	1	100	High
Cottonwood Creek	5	5	100	High
Tularosa Creek Watershed				
Nogal Canyon	11	1	9	Low
Lost River Watershed				
Fresnal Canyon	11	4	36	Moderate
Bitter Creek Watershed				
Dry Canyon	4	4	100	High
Three Hermanos Watershed				
Bug Scuffle Canyon	1	1	100	High
Dog Canyon	7	2	29	Low
Grapevine Canyon	5	2	40	Moderate
Total	74	37		
Salt Basin Sub-basin				
Sacramento River Watershed				
Arkansas Canyon Sac River	3	1	33	Low
Big Dog Canyon Watershed				
Upper Dog Canyon	1	1	100	High
Total	4	2		
Arroyo Del Macho Sub-basin				
Reventon Draw Watershed				

Sub-watershed	# of Springs in Sub-watershed on Lincoln NF	# of Springs in Sub-watershed on Lincoln NF with Developments	Percent of Springs Developed	Risk
Upper Reventon Draw	2	1	50	Moderate
Middle Reventon Draw	3	1	33	Low
Upper Arroyo Del Macho Watershed				
Reventon Draw Arroyo Del Macho	4	3	75	High
Aragon Creek	1	1	100	High
Cottonwood Canyon Arroyo Del Macho	2	2	100	High
Headwaters Salt Creek Watershed				
Copeland Canyon-Seco Arroyo	3	1	33	Low
Arroyo Serrano	1	1	100	High
Zeufeldt Arroyo	4	3	75	High
Total	20	13		
Rio Peñasco Sub-Basin				
Upper Rio Peñasco Watershed				
James Canyon	34	10	29	Low
Burnt Canyon-Rio Peñasco	1	1	100	Low
James Canyon - Rio Peñasco	26	13	50	Moderate
Cox Canyon	42	3	7	Low
Cox Canyon-Rio Peñasco	47	2	5	Low
Elk Canyon Watershed				
Sixteen Springs Canyon	16	3	19	Low
Agua Chiquita Watershed				
Lower Agua Chiquita	1	1	100	High
Middle Agua Chiquita	15	3	20	Low
Upper Agua Chiquita	45	11	24	Low
Cuevo Creek Watershed				
Perk Canyon	11	1	9	Low

Sub-watershed	# of Springs in Sub-watershed on Lincoln NF	# of Springs in Sub-watershed on Lincoln NF with Developments	Percent of Springs Developed	Risk
Total	238	48		
Rio Hondo Sub-basin				
Rio Bonito Watershed				
Headwaters Salado Creek	10	4	40	Moderate
Lower Rio Bonita	2	2	100	High
Upper Rio Bonita	17	9	53	Moderate
Middle Rio Bonita	7	7	100	High
Blackwater Canyon Watershed				
Escondido Canyon	2	2	100	High
Rio Ruidoso Watershed				
Devils Canyon	5	2	40	Moderate
Headwaters Rio Hondo Watershed				
Chavez Canyon	3	1	33	Low
Total	49	27		
Upper Pecos Black Sub-basin				
Fourmile Draw Watershed				
Bear Canyon	2	2	100	Low
Last Chance Canyon Watershed				
Middle Last Chance Canyon	8	3	38	Moderate
Dark Canyon Watershed				
Turkey Canyon-Dark Canyon	10	5	50	Moderate
Black River Watershed				
McKittrick Canyon-Black River	4	3	75	High
Total	24	13		
Grand Total	409	140		

Risk and Trends for Watersheds with Developed Springs

Table 154 shows that of the 44 number of sub-watersheds having spring developments, 17 are rated as high risk, 11 as moderate risk, and 16 as low risk. Trends are stable since the number of spring developments are not expected to increase substantially. There may be places where spring developments will occur, such as in the Cox Canyon-Rio Peñasco and Upper Agua Chiquita sub-watersheds where off-site water sources will be explored over the next 10 to 15 years.

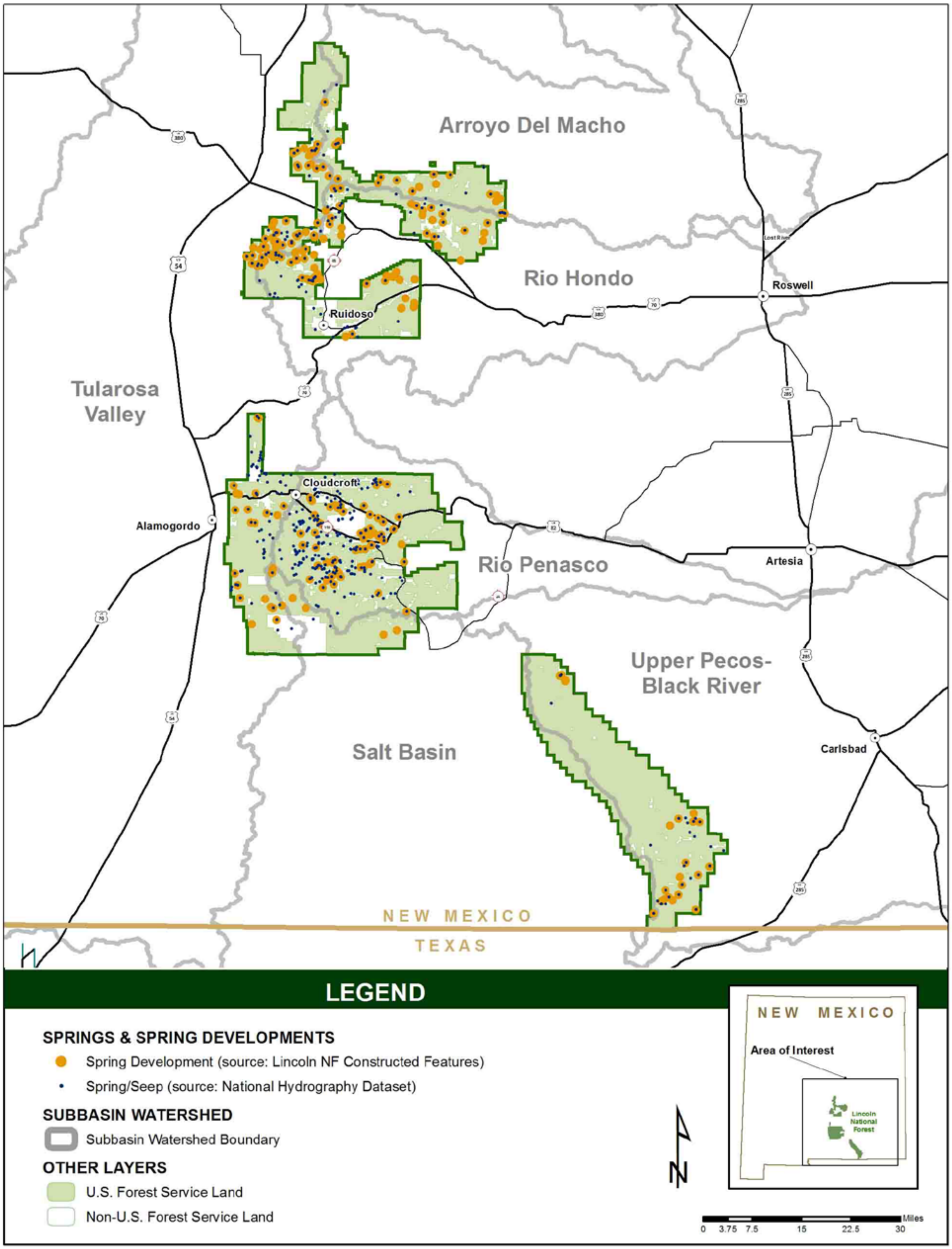

Figure 98. Spring developments on the Lincoln NF

Groundwater Resources

Groundwater basins that overlap the Plan Area include the Tularosa, Hondo, Peñasco, Salt, Roswell Artesian, and Carlsbad Basins (Figure 98). Groundwater basins that overlap the Context Area include those five plus the Capitan and Lea County Basins in the southeast part of NM. Table 155 shows the portion of each basin within the context and Plan Areas. Although some basins only have a small amount of land within the Plan Area, these areas provide a substantial amount of recharge for the basin and therefore provide substantial ecosystem services to those that utilize these groundwater resources. This section describes the characteristics of these six basins and constitutes the current conditions for this resource. Key ecosystem characteristics for this resource include groundwater recharge, discharge, and withdrawals.

All ground-water basins in New Mexico are now considered “declared” basins by the New Mexico Office of the State Engineer. A **declared underground water basin** is an area of the State proclaimed by the State Engineer to be underlain by a ground water source having reasonable ascertainable boundaries. The State Engineer assumes jurisdiction over the appropriation and use of ground-water from the source and a permit is required before ground water can be diverted and used. Prior to being a declared basin, no permit was required and that historic groundwater use could be claimed in a declaration (i.e., vested water right). (Bushnell, 2012)

In response to continued drought in New Mexico, the State Engineer created the “Active Water Resource Management Program” in 2004. Seven priority basins were identified. Within these basins, proactive measures are taken to more intensively manage the water resources (both surface and ground-water), including installing metering devices and the development of stricter regulations. The Rio Gallinas Basin has been designated as a priority basin. This basin incorporates the Roswell Artesian, Carlsbad, Peñasco, Hondo, and Capitan ground-water basins within the Context Area. Information on water rights is covered more extensively in the Multiple Uses chapter of Volume II of this Assessment.

Groundwater pumping can intercept groundwater moving through aquifers before the water discharges at springs and seeps. Degraded upland watershed conditions from poor watershed management practices can reduce rainfall and snowmelt infiltration into the ground and reduce recharge to aquifers. Reduced recharge can reduce discharge from springs and seeps and their ecological sustainability functions.

Table 155. Groundwater basins, and the proportion of each basin, within the Context and Plan Areas

Groundwater Basin	Total Acres	Acres Within Context Area	Percent of Basin Within Context Area	Acres within Plan Area	Percent of Basin Within Plan Area
Tularosa	4,277,855	4,024,656	94.1	246,890	5.8
Hondo	684,185	592,744	86.6	207,125	30.3
Peñasco	572,604	520,292	90.9	321,928	56.2
Salt	1,507,165	1,486,441	98.6	105,654	7.0
Roswell Artesian	6,924,605	2,982,707	43.1	341,047	4.9
Carlsbad	1,525,430	1,117,373	73.2	38,213	2.5
Capitan	1,008,888	476,799	47.3	0	0
Lea County	1,774,054	22,028	1.2	0	0

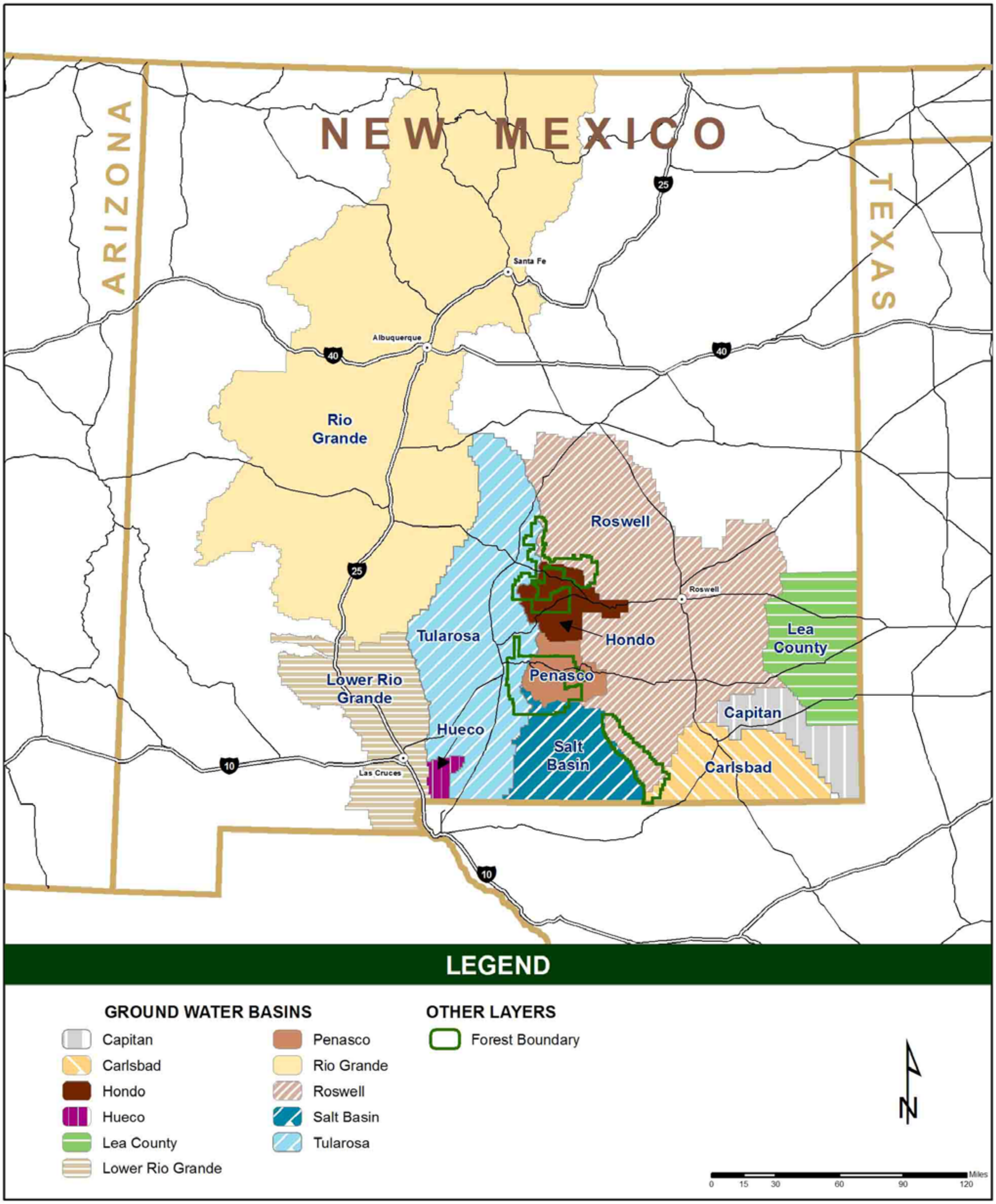

Figure 99. Map of Groundwater Basins in Relation to the Plan Area

Most of the groundwater basins coincide with the HUC 4 Sub-basins with the exception of the Roswell Groundwater Basin. Assessing risk and trends is on a qualitative basis according to groundwater uses and accompanying stresses to the aquifers. Risks and trends are assessed by groundwater basin, not HUC 6 sub-basin. A general description of the groundwater basins and their general geographic overlaps are as follows:

- Tularosa Groundwater Basin—Tularosa Valley Sub-basin
- Salt Groundwater Basin—Salt Sub-basin
- Peñasco Groundwater Basin—Western part of Rio Peñasco Sub-basin
- Hondo Groundwater Basin—Western Part of Rio Hondo Sub-basin
- Roswell Groundwater Basin—All of the Arroyo Del Macho Sub-basin, Eastern part of Rio Hondo Sub-basin; Eastern part of Rio Peñasco Sub-basin; northwestern part of Upper Pecos Black Sub-basin
- Carlsbad Groundwater Basin—Southern part of Upper Pecos Black Sub-basin
- Capitan Groundwater Basin—Small portion on east side of Upper Pecos Black sub-basin

Reference and Current Conditions

Historically, groundwater basins were recharged directly by precipitation, mostly in the higher elevations, and by water flow in perennial, intermittent, and ephemeral streams, which in turn is driven by climatic events. Historic recharge and discharge was within the NRV and varied depending mostly on natural events such as floods and droughts. Other natural occurrences such as wildfire and insect infestations could have had a lesser, and more indirect effect on groundwater recharge. Influences of early inhabitants would not have had much influence on recharge or discharge and any groundwater withdrawals would have been insignificant. With large scale settlement during the late 1800s, groundwater pumping began, surface water diversion occurred on a scale that would cause changes from the NRV. These influences would have greater impacts locally than regionally. Major changes in the fire regime, vegetation structure, riparian areas, wetlands, and in the soil structure in many areas occurred during this time of large scale settlement. All these factors contributed to changes in the groundwater regime as recharge, discharge, and especially groundwater withdrawals began to move outside the NRV.

Future Conditions with Current Management

Current National Forest management would have some impact locally on aquifers as riparian areas and wetlands are impacted by current management activities. These activities are likely to affect springs and seeps that are in perched aquifers in high elevation areas (i.e., Sacramento Mountains). Impacts on the context scale will likely not be realized as a result of current forest management. Under the current management scenario trends for ground water conditions would be site specific and variable, with some local areas moving upwards and some downwards. For example, as the condition of riparian areas and wetlands improve, conditions of the local aquifer adjacent to the stream begins to move in an upward trend. The opposite occurs when riparian areas and wetlands continue to degrade.

Tularosa Basin

The Tularosa Basin covers a large portion of the southern part of New Mexico. It is bounded on the east by the Sacramento, Sierra Blanca, and Carrizo Mountains. On the west this basin lies adjacent to the Oscura, San Andres, Organ, and Franklin Mountains. The portion of this basin that lies within the Plan

Area is 5.8 percent. These areas lie within the Sacramento Mountains and the Sierra Blanca Highlands and provide a significant amount of recharge for this basin.

The basin itself is a fault bounded basin in the southern Rio Grande Rift. It is internally drained and contains extensive deposits of gypsum, especially in the lower parts of the basin near White Sands National Monument. The geology of the Sierra Blanca Mountains consist of volcanic rocks, volcaniclastic sediments, and igneous intrusions, making up a network of fractured aquifers with an abundance of sills and dikes that act as barriers to groundwater flow. This area has an abundance of springs. To the south, near the town of Carrizozo, there are several permeable sedimentary units composed of interbedded sandstone channel-fills and lower permeable floodplain deposits, which together make productive aquifers. Further south and to the east of the city of Alamogordo is the steep escarpment of the south Sacramento Mountains. The Sacramento Mountains consist of fractured carbonates, conglomerates, sandstones, and siltstones, which dip to the east.

Along the eastern border of the Tularosa Basin is the Alamogordo Fault, which is responsible for the down dropped basin and the high topographic relief of the Sacramento Mountains. Thick, unconsolidated basin fill deposits are found on the western down dropped side of the fault. These deposits constitute the major aquifer in the basin. Recharge enters the aquifers from high elevation snowmelt and summer monsoonal rain. Much of the recharge is conveyed to the basin by means of perennial and ephemeral stream channels, which obtain their water from seasonal snowmelt, monsoonal rain, and nearby springs. The water enters the basin at the proximal end of the alluvial fans as the stream channels cross the Alamogordo Fault and then disappears into the subsurface. These areas constitute the primary source of groundwater throughout the basin and are made up of coarse unconsolidated streambed sediments and valley fill, mainly cobbles, sand, and silt, making it a very productive aquifer where it is saturated (New Mexico Bureau of Geology and Mineral Resources 2014). Very little water recharges the aquifers by direct precipitation into the valley fill sediment. This is due to lesser amounts of precipitation that fall in the lower elevation desert environment coupled with the higher amounts of water loss via evapotranspiration. One study shows that about 68,000 acre feet per year of groundwater enters the basin throughout a study area comprising a portion of the Tularosa Basin from Alamogordo north to Carrizozo (New Mexico Bureau of Geology and Mineral Resources 2014).

Risk and Trends

Groundwater supplies about 70 percent of the water used in this basin (Region 5Tularosa Regional Water Plan). Many of the groundwater monitoring wells evaluated show a decline in water levels over time. Water level declines are a concern and modeling studies predict that the aquifer in the vicinity of Alamogordo and Tularosa will experience an average annual water level decline of more than 2 feet per year over a 10-year period due to the full exercise of existing permits and declarations (Emid and Finch, 2011). The communities of Tularosa and Alamogordo have conducted extensive groundwater pumping for over 100 years. Before the growing season starts in March, water levels are at their highest. As pumping begins, water levels rapidly begin to decline and continue to do so until the end of the growing season in September. Rates of water level declines can be variable when the summer monsoonal rains begin in July and pumping rates may decrease. In September, when the growing season ends and pumping ceases, water levels quickly rebound through December and then level out by March, when the cycle starts again. One study showed that 63 percent of the wells showed depletion, meaning the water levels did not recover from 2009 to 2010 (New Mexico Bureau of Geology and Mineral Resources, 2014).

Use continues to increase along the western front of the Sacramento Mountains as new sources of water are explored to meet the demands of water users in the local communities and surrounding areas. There is a high concentration of use in this area. In an attempt to maximize the use of groundwater in this basin, the city of Alamogordo has explored the possibility of desalinizing some of the groundwater resources to help meet their water needs. Much of the water that eventually feeds this basin's aquifers originates in the high elevation areas of the Sacramento Mountains, much of which is administered by the Lincoln NF. The basin's groundwater is predominantly saline due to the long amount of time it is in contact with the gypsum dominated strata throughout much of the center of the basin. Fresher water is found in recharge areas where alluvial fans lie at the base of the mountain front.

The accepted regional water plan (Livingston and JSAI, 2002) provided the following calculated estimates of recharge in the Tularosa Basin:

- Approximately 70 percent of the watershed yield in the *northern Tularosa Basin*, or 30,000 ac-ft/yr, was estimated to result in recharge.
- Recharge in the *western Tularosa Basin* was estimated at 9,291 ac-ft/yr. This is the total mean annual streamflow from the San Andres Mountains estimated by the USGS and represents the probable maximum recharge available.
- In the *eastern Tularosa Basin*, 60 percent of the watershed yield, or 47,099 ac-ft/yr, was estimated to result in recharge.
- More recent recharge estimates for the region include:
- Mountain front recharge simulated in the NMOSE Administrative Model for the Tularosa
- Basin is 11,890 ac-ft/yr (Keyes, 2005). This estimate was based on high precipitation periods for 16 watersheds on the east side of the basin. The original model (Morrison 1989) estimated recharge at 14,847 ac-ft/yr based on 22 watersheds.
- The USGS (Huff, 2004) model of the Tularosa Basin includes recharge on both east and west sides of the basin. Average annual recharge to the basin-fill aquifer was estimated to be approximately 143,000 cubic meters per day (42,315 ac-ft/yr) from the steady-state model calibration.

The major well fields in the planning region are:

- La Luz Well Field (City of Alamogordo): Water from these wells requires dilution with surface water to reduce salinity.
- Prather Well Field (City of Alamogordo).
- Boles, San Andres, Douglas, and Escondido/Frenchy well fields (Holloman AFB): These well fields are located in the eastern Tularosa Basin, south of Alamogordo along the eastern edge of the basin-fill aquifer, where well yields are high and water quality is good (Livingston and JSAI, 2002).
- Carrizozo's Municipal Well Field (Carrizozo): This well field consists of two wells, completed in the basin fill of the northern Tularosa Basin, that yield 160 to 260 gallons per minute (gpm) (Livingston and JSAI, 2002).
- Village of Tularosa (two wells).
- Community of La Luz (five wells).

Recharge to the aquifers will vary from year to year and is not dependent upon management. Based on increasing uses in this basin and a pattern of decreasing snowfall in the adjacent Sacramento Mountains, risk to the aquifers in this basin to continue to provide the ecosystem services that this resource has provided in the past is high. Based on previous studies, monitoring of groundwater levels over time, and projections of groundwater use into the future, there will likely be a continued downward trend and increasing risk over time. Administrative water supply may be unsustainable into the future as aquifers are being depleted. This will likely result in more difficulty in getting water permits and increased mandates for monitoring and reporting. We will also see efforts at exploring additional opportunities for accessing water, such as salinization plants, new dams, and other options.

Hondo Basin

This basin comprises only a little over a half million acres with almost a third of it within the Plan Area. As many as 12 hydrostatigraphic units serve as aquifers, with rock strata ranging from Permian through Mesozoic to Tertiary in age. Valley alluvium can also serve as an aquifer for shallow wells. The Ruidoso Fault Zone runs northeast to Southwest along the foot of Sierra Blanca and has extensively fractured and consolidated rock units. Regionally, the aquifer systems are interconnected and continuous. Streamflow and aquifers are closely interconnected with a number of gaining and losing reaches. The Tinnie-Dunken Anticlinorium creates groundwater mounding, increasing saturated aquifer thickness and creating groundwater discharge to the east of the basin. This mounding creates a gaining stream reach that constitutes most of the discharge from the Hondo Basin as surface discharge to the Roswell Artesian Basin (Darr et al. 2010).

Three hydrogeologic terranes have been defined based on aquifer characteristics, geologic structure, and hydrologic behavior. These include the Mountain Block, the Central Basin, and the Hondo Slope Terranes. The Mountain Block Terrane is associated with the Sierra Blanca and Capitan Mountains. These are made up of young (Tertiary age) extrusive as well as intrusive volcanic rock strata. Because this is high elevation terrane, precipitation exceeds evapotranspiration and this area is the source of runoff for the Upland Rio Hondo Basin. The central basin terrain is composed of west dipping, fractured sedimentary rocks. Water from here is diverted to serve the population of Ruidoso and the surrounding area. The Hondo slope terrain gently slopes down into the margin of the Roswell Artesian Basin. The Yeso Formation is the main aquifer (Darr et al. 2010).

An estimated 13,400 acre feet per year of recharge occurred as base flow or mountain front recharge from local aquifers in the upland watersheds. **Groundwater recharge** is the hydrologic process where water moves downward from surface water to groundwater. Recharge is the primary method through which water enters an aquifer. The aquifers in this basin are generally characterized by low storage capacity and respond to short and long term variations in recharge with short and long term water-level fluctuations. Some areas have exhibited extreme declines in water levels as a result of drought and groundwater withdrawals. Some areas have shown rapid aquifer recharge resulting from extreme monsoon and heavy snowmelt events. The Eagle Creek Basin is one of these areas where rapid response to storm events as well as to nearby pumping imply a strong surface water-groundwater connections. The Alto Lakes area is another such area where groundwater levels responded rapidly to pumping as well as extreme summer monsoon events. In general, the aquifers of the upper Rio Hondo Basin are characterized by rapid recharge following heavy monsoon or snowmelt events. Changing water use patterns, concentrated areas of groundwater withdrawal, and variations in precipitation have created localized areas where water-table declines and diminished surface water flows have been of concern (Darr et al. 2010).

The Hondo Groundwater Basin is part of the Rio Gallinas priority basin. There has been, and will continue to be, much demand for this ground-water due to extensive population growth in this area. The Multiple Uses chapter of Volume II of this Assessment describes the history of population growth, water development, and use of water in this basin. The high elevation areas administered by the Lincoln NF serve as recharge areas for much of the ground-water in this basin.

Risk and Trends

Well hydrographs in the Rio Hondo Basin were analyzed for 75 wells. In general, wells show lower water levels in the 1950s, broad water-level rises in the late 1980s and early 1990s, lower water levels in 2003, and water-level rises from 2006 to 2010. These decadal-scale water-level changes are broadly coincident with periods of drought in the 1950s, wet periods in the late 1980s and early 1990s, periods of drought in the early to mid-2000s, and wet periods from 2006 to 2010 (Darr et al. 2010). Even with extended pumping associated with growth in the Ruidoso and surrounding areas, the rise and fall of water levels over the long term is strongly correlated with long-term precipitation patterns. Demands for groundwater have increased in the upper Rio Hondo Basin due to increases in development and population. A comparison of water level data from March 2003 to water levels in 1963 (Donohoe, 2004) indicated a decline in water levels near the Rio Ruidoso but a rise in water levels near the Rio Bonita. The major well field in this basin where water is drawn is the Ruidoso Water System. Risk to the groundwater resource in this basin is moderate based on monitoring of water levels which show a general water level trend that follows precipitation patterns. Development and increased demands in the Ruidoso area will put increased stress on groundwater resources but past water well monitoring shows that water level rises and declines have been site specific.

Peñasco Basin

The high elevation Sacramento Mountains, east of the divide that separates the western escarpment from the gently sloping eastern block of the mountain range, encompasses a majority of the Peñasco Groundwater Basin. This area serves as a recharge area for wells and springs in the upper part of the Rio Peñasco Basin and contributes to recharge in the Roswell Artesian Basin. The geologic formation that serves as the main water bearing aquifer in this area is the Yeso Formation. The Yeso Formation consists mostly of carbonate rocks such as limestone, dolomite, and calcareous sediments. Groundwater flow occurs along the many fractures that exist within this rock strata. In the upper part of the Yeso Formation, solution-enlarged fracturing is common, subsequently leading to collapse features and disrupting the steady flow of groundwater. This is referred to as **karst terrain**. As carbonate dissolution occurs, existing fractures within the strata enlarge, increasing the localized transport of groundwater. In some areas this has resulted in tufa (travertine) mounds and sinking streams. However, vertical movement of water is limited by the size of the fractures in underlying less soluble rocks, which are not significantly affected by karst processes.

Recharge in this a area occurs mostly in the high elevation zones of the Sacramento Mountains, mostly above 8,200 feet, through fractures and conduits on ridges and upper hill slopes as well as in stream beds. Water from **perched aquifers** (local zones of saturation above the regional water table) subsequently provides water for springs and seeps which in turn feeds high elevation streams such as the upper part of the Rio Peñasco. These streams then recharge perched aquifers at lower elevations, which then discharge at lower elevation springs, feeding lower elevation sections of stream. This interconnected network of perched aquifers, springs, and streams is common in the high elevation areas of the Sacramento Mountains.

The general flow of groundwater is to the east, although localized flow in the high elevation Sacramento Mountains as described above may be in a number of different directions, both laterally and vertically. As groundwater migrates east towards the Roswell Artesian Basin, it flows through the Pecos Slope Aquifer, which is one large regional aquifer system as opposed to a number of small systems common in the higher elevations of the Sacramento Mountains. The significance of the Yeso Formation begins to diminish further east while the San Andrus Formation becomes more significant. This formation is composed mostly of gray limestone, and like the Yeso Formation, has a series of fractures and exhibits karst processes. Recharge from the high elevation Sacramento Mountains provides groundwater to both the Artesian Basin to the east and the Salt Basin to the South.

A majority of the groundwater recharge comes from winter snowmelt, although a significant portion of the annual precipitation comes from summer monsoons. This is due to the significantly lower amounts of water loses from evapotranspiration during the winter and early spring, when snowmelt is occurring. However, studies have shown that significant water level increases are observed during times of extreme monsoonal rain events, such as during the summers of 2006 and 2008. During these two monsoon seasons, groundwater wells drilled in shallow perched aquifers or in shallow regional aquifers showed a quick rise in water levels from one to three months after significant rain events. At the end of the 2006 season, the water levels quickly receded and did not rise again in response to rain events until the next extreme monsoon season of 2008. The 2007 monsoon season showed above average precipitation, but was not enough to induce immediate rises in the ground water hydrographs. Wells drilled in the deeper regional aquifers showed a delayed response of three months or more after the 2006 season before gradually rising. Afterwards, the hydrographs leveled off and remained level until the next season (2008) of extreme monsoon events.

Risk and Trends

Ground-water use is minimal in this basin compared to the other basins in the Context Area. Most of the groundwater entering this basin is recharged in the Sacramento Mountains, a large portion of which is administered by the Lincoln NF. Groundwater throughout this basin would be considered at low risk, especially on a regional scale because of the lack of large-scale pumping and groundwater extraction from the basin. Regionally, groundwater levels are mostly dependent on long-term precipitation trends.

Salt Basin

The Salt Basin aquifer encompasses the southern margin of the mountain block and extends north up the Sacramento River drainage to include Timberon. The northern boundary east of Timberon coincides with the surface drainage divide separating east-flowing and south-flowing drainages. The San Andres Formation and a carbonate facies of the Yeso Formation make up the principal aquifer in the Salt Basin, and the karst character of the aquifer beneath Otero Mesa is well-documented (Mayer and Sharp 1998). Wells in the vicinity of Timberon are completed in the Yeso Formation and range from 86 to 1200 feet deep. South and east of Timberon, wells in the Salt Basin range from 500 to 1638 feet deep and are completely in both the Yeso and San Andres Formations. Groundwater flows south and southeast from the Sacramento Mountains to Otero Mesa and the Salt Basin under steep hydraulic gradients resulting from steep topography, faulting, and heterogeneity in the Yeso Formation. Shallow gradients reflect high-transmissivity fractures and cavernous zones in the San Andres Formation (New Mexico Bureau of Geology and Mineral Resources 2012).

The New Mexico part of the Salt Basin covers about 2,400 square miles of the south central part of the State. The principal aquifers in the basin are included in the San Andres Limestone, the Yeso Formation and the Abo Formation, all of Permian age. Groundwater recharge to the basin is about 35,078 acre-feet per year with about half of the recharge coming from the watershed feeding the Sacramento River. Discharge from the basin occurs as groundwater withdrawal, evapotranspiration, and underground flow into the Salt Basin of Texas. Large amounts of groundwater in the basin are known to be of good water quality. The recent discovery of natural gas within the Salt Basin of New Mexico has raised concerns over potential impacts to groundwater quality from natural gas production.

The Salt Basin is an extensional feature, typical of Basin and Range tectonics, which covers about 6,400 square miles of New Mexico and Texas. The New Mexico part of the basin covers about 2,400 square miles (Bjorklund 1957). Groundwater recharge to the New Mexico part of the Salt Basin is derived from precipitation in watersheds within elevated terrain located on the western flank of the basin. Discharge from the basin occurs as groundwater withdrawal, evapotranspiration, and underground flow into the Salt Basin of Texas (Bjorklund 1957).

Risk and Trends

Ground-water use is minimal in this basin as population centers are mostly absent. This basin extends south into Texas where some additional use may occur. High elevation recharge occurs in the Sacramento Mountains and to a small extent may occur on the western rim of the Guadalupe Mountains. Recharge to this aquifer is dependent upon yearly precipitation patterns in the recharge zones and is not a factor of management of the Forest. Portions of both of these ranges are administered by the Lincoln NF. Groundwater is presently considered low risk here with an even trend due to minimal use. If portions of the area are developed for oil and natural gas exploration and development, both water quality and quantity may be impacted. Water use of the portion of the aquifer that is in Texas may also have future impacts to the resource. If either or both of these scenarios materialize, it could put the groundwater in this aquifer at a moderate or high risk and the trends towards a degraded condition may ensue. Groundwater levels are dependent on long-term precipitation trends. Any degradation or improvements would be minimal.

Roswell Artesian Basin

The Roswell Artesian Basin consists of an eastward-dipping carbonate aquifer overlain by a leaky evaporitic confining unit, overlain in turn by an unconfined alluvial aquifer. The carbonate aquifer is artesian to the east but under water table conditions in the western outcrop area on the Pecos Slope. Historically, the carbonate aquifer in the Roswell Basin is referred to as the “artesian aquifer”, regardless of its confined or unconfined state. The alluvial aquifer is commonly referred to as the “shallow aquifer”.

> “Water-producing zones in the carbonate aquifer rise stratigraphically from north to south and from west to east. Some wells may penetrate as many as five water-producing zones. Secondary porosity is developed in vuggy and cavernous limestone, solution-collapse breccia, and solution-enlarged fractures. Recharge occurs by direct infiltration of precipitation and by runoff from intermittent losing streams flowing eastward across a broad area east of the Sacramento Mountains”. (http://water.usgs.gov/ogw/karst/aquifers/roswell/index)

> “During the initial development of the artesian aquifer, many wells flowed to the surface and high volume springs fed the Pecos River. Decades of intensive pumping have caused substantial declines in hydraulic head in the aquifer, and by the mid-20th century it was estimated that withdrawals exceeded recharge. Most down-gradient flow is intercepted by irrigation wells in the Artesian Basin. Mineral content of the water rapidly increases in an eastward direction. The freshwater-saltwater interface migrates westward during periods of low rainfall”. (http://water.usgs.gov/ogw/karst/aquifers/roswell/index)

The estimated average natural discharge to both aquifers is about 300,000 acre-feet per year (DBS&A, 1995). About two-thirds of the natural recharge that feeds the Roswell Artesia Aquifer is derived from the Sacramento Mountains to the west. Recharge to the alluvial aquifer also occurs from irrigation return flow. After metering began in 1967, groundwater diversions from the artesian aquifer system stabilized at a level of about 250,000 ac-ft/yr. Shallow aquifer diversions were about 110,000 ac-ft/yr in the 1990s. The agricultural sector dominates groundwater diversion in the Roswell Artesia Aquifer (DBS&A, 1995).

The Roswell Basin is one of the most intensively farmed areas in New Mexico. The Basin derives virtually all of its irrigation water from groundwater stored in a shallow alluvial aquifer and an artesian aquifer formed principally in the San Andres Limestone. The Roswell Artesian Basin has been described as a world-class example of a rechargeable artesian aquifer system. Part of the ground-water in this basin is recharged in the high elevation Sacramento Mountains, large portions of which is administered by the Lincoln NF.

Risk and Trends

Most of the risk to this basin is due to extensive groundwater pumping for farming and irrigation. Very little, if any, of the activities that contribute to risk in this basin occurs on the Lincoln National Forest.

Groundwater is under pressure in the Roswell artesian aquifer, and before major development of the aquifer, wells flowed freely at the surface. Groundwater development had resulted in a decline in water levels by as much as 100 feet from the 1920s through the 1950s, but then water levels stabilized and recovered in response to increased precipitation (and recharge) during the 1980s and 1990s (DBS&A, 1995). Summer water levels drop more than 100 feet below winter levels in some areas, indicating that the aquifer is heavily stressed during the summer irrigation season. The extensive development of the Roswell artesian aquifer system has also reduced the amount of water entering the Pecos River as baseflow gain, thereby reducing available surface water supplies for downstream users as compared to historical flows. (State of New Mexico Interstate Stream Commission Office of the State Engineer, Lower Pecos Valley Regional Water Plan, December 2016)

Risk is high due to extensive use and impacts to water levels and to the base flow to the Pecos River. Trends are either at a level or downward trend due to continued stress on the groundwater system.

Carlsbad Groundwater Basin

Ground-water use in the Carlsbad Ground-water Basin is extensive, much of which is used by the oil and gas industry. Ground-water contamination is also a concern in this area due to extensive oil and gas exploration and development. A small section of this basin lies in the southeast section of the Guadalupe Mountains, administered by the Lincoln NF.

The Carlsbad Basin includes the Pecos Valley Alluvium, the Capitan Reef Aquifer and the Permian Castile and Salado Formations. The Pecos Valley Alluvium extends in a narrow strip along the Pecos River from a few miles north of the City of Carlsbad to the mouth of Dark Canyon. In the vicinity of the CID, the saturated thickness of the alluvium reaches 150 feet between Otis and Loving (Bjorklund and Motts, 1959). In the far southwestern part of the aquifer, the saturated thickness is on the order of 50 feet thick (Barroll et al., 2004). The Pecos River is generally considered the eastern limit of the Pecos Valley Alluvium. The Capitan Reef aquifer is composed of the Carlsbad and Capitan limestones and extends from the Capitan Basin in the east up to the Guadalupe Mountains in the west. The Capitan Reef aquifer is highly transmissive and of good quality west of the Pecos River. East of the Pecos River the reef is less transmissive and the salinity is much higher. Near the City of Carlsbad, a small part of the alluvial aquifer directly overlies the Capitan Reef aquifer, and the two aquifers are hydrologically connected.

West of the Pecos River, where the reef aquifer is not present, the alluvial aquifer is directly underlain by the Permian Castile and Salado formations, which together comprise up to 2,500 feet of evaporate beds. In addition to forming the basal boundary of most of the alluvial aquifer, these units form the southern and northern boundaries of the Pecos Valley Alluvium. The Permian Castile Formation is a source of water for some relatively deep wells in the western part of the basin (Barroll et al., 2004). The Castile Formation and Pecos Valley Alluvium wells are hydrologically connected in the western part of the basin (Barroll et al., 2004).

The Capitan Reef aquifer receives an estimated 10,000 to 20,000 ac-ft/yr of natural recharge from precipitation in the Guadalupe Mountains and seepage from flood flows in Dark Canyon west of Carlsbad (Barroll et al., 2004). Estimated recharge to the Pecos Valley Alluvium from local precipitation is highly variable, depending on climatic conditions; annual values range from near zero to almost 30,000 acre-feet, with an average value of 8,000 acre-feet. In addition, seepage of irrigation water provides about 20,000 to 50,000 ac-ft/yr (36,000 ac-ft/yr average) of recharge to the Pecos Valley Alluvium, predominantly within the CID. Leakage of Pecos River water from Lake Avalon provides about 15,000 ac-ft/yr of recharge to both the Capitan Reef and Pecos Valley Alluvium aquifers north of Carlsbad.

The major groundwater users in this area include irrigators (both CID (Carlsbad Irrigation District) and non-CID), the City of Carlsbad, and the potash and oil and gas industries. Within CID more than 100 active supplemental wells augment supply when surface flows are not sufficient to provide CID rights holders a full allotment of 3.697 acre-feet per acre. During the recent drought, limited surface supplies resulted in surface water deliveries of only 1.4 and 0.8 acre-feet per acre in 2011 and 2012 respectively, thereby necessitating significant reliance on groundwater supplies. By 2014, increased surface supplies were sufficient to provide a full allotment without the use of supplemental wells. Under the terms of the 2003 Settlement Agreement, when groundwater diversions combined with surface deliveries within a single calendar year exceed CID's maximum allotment of 3.697 acre-feet per acre, CID is required to deliver that excess volume to the NMISC (New Mexico Interstate Stream Commission) for compact compliance purposes. In addition to supplemental groundwater rights, some CID rights holders own primary groundwater rights for irrigation purposes.

Historically, the Pecos River gained water in this area as base inflow from the Pecos Valley Alluvium and the Capitan Reef aquifer; however, groundwater pumping from the two aquifers has reduced the base inflow of groundwater to the Pecos River. When groundwater levels are drawn down sufficiently, the direction of flow can be reversed altogether, pulling water from the river into the aquifer system. Groundwater depletions in the Carlsbad area, through groundwater pumping in the Carlsbad Basin, directly impact New Mexico's ability to comply with the Pecos River Compact and the U.S. Supreme Court's 1988 Amended Decree. East of the Pecos River within the Carlsbad Basin, the Rustler Formation, Santa Rosa Sandstone and alluvium are the primary sources of water.

Risk and Trends

Risk is high due to extensive groundwater pumping, water level drawdowns, and impacts to the Pecos River. As use continues in this area, trends can be expected to continue downward. If precipitation in the recharge zones decrease, this will continue to put more stress on the aquifer system which will continue to cause trends to go in a downward direction.

Capitan Groundwater Basin

The Capitan Reef is a curved geologic structure, over 100 miles long, 10 to 14 miles wide, composed of limestone and dolomite in which large solution channels and caverns (such as Carlsbad Caverns) have been formed. East of the Pecos River the Capitan Reef extends from the Carlsbad UWB into the Capitan UWB and becomes progressively deeper. Within the Capitan UWB, the Santa Rosa Sandstone and alluvium are the primary sources of water. (State of New Mexico Interstate Stream Commission Office of the Engineer, Lower Pecos Valley Regional Water Plan, December 2016).

Oil and gas development in the Capitan and Carlsbad basins raises concerns over potential impacts to the Pecos River and stress on the aquifers. Domestic, stock, and commercial wells permitted under 72-12-1.3 (underground public waters temporary use), along with new appropriations permitted under 72-12-3, are used to supply the oil and gas industry. With respect to wells permitted under 72-12-1.3, the NMOSE allows well owners to pump up to 9 acre-feet a year per well under three separate temporary commercial permits that are approved without advertising the change of use in the legal section of the newspaper. Well owners must reapply each year for these temporary permits. (State of New Mexico Interstate Stream Commission Office of the Engineer, Lower Pecos Valley Regional Water Plan, December 2016)

Wells in the Carlsbad and Capitan UWBs respond rapidly to changes in pumping and recharge. Review of 115 wells in the basins (PVWUO, 2001) showed a decline in 45 of the alluvial wells while water rose in 35 from 1987 to 1993. Of the 31 wells in the Capitan Reef aquifer, 20 showed a decline and 8 showed an increase over the same period. Declines are greatest around Loving and Carlsbad. (State of New Mexico Interstate Stream Commission Office of the Engineer, Lower Pecos Valley Regional Water Plan, December 2016)

Risk and Trends

Risk is high due to impacts from oil and gas development and impacts to the Pecos River. Trends are considered stable due to variabilities in water levels and quick responses to pumping and recharge. Groundwater mining does not appear to be occurring.

Lea County Groundwater Basin

The primary source of water in the LCUWB is ground water from the unconfined High Plains aquifer, which is composed of late Tertiary age rocks of the Ogallala Formation, re-worked Ogallala sediments, and more recent valley-fill deposits. For administrative purposes in Lea County, the Cretaceous age rocks, which are in hydrologic communication with the Ogallala, are assumed to be a part of the High Plains aquifer. The High Plains aquifer includes mostly unconsolidated deposits of clay, silt, fine to coarse-grained sand, and gravel. Hydraulic conductivities vary within the aquifer because of stratification, irregular mixing of sediments, and differences in cementation.

The current saturated thickness ranges from zero to about 200 feet with depths to water varying between 25 to 300 feet below land surface (Tillery 2008). Groundwater diversions have led to mining of the High Plains aquifer in Texas and New Mexico. Prior to well pumping, groundwater flow was generally in a southeasterly direction towards the state of Texas. Intensive pumping has shifted the direction of groundwater flow in the vicinity of some of the major pumping centers. Due to this shift, flows from New Mexico to Texas have declined over the past 50 years (Musharrafieh and Chudnoff 1999).

Irrigated agriculture continues to be the major water use in the county comprising about 73 percent of the 185,952 acre-feet per year (af/yr) diverted in 2005 (Longworth and others, 2008). The total diversion in 2005 represents about 42 percent of the permitted or declared water rights within the basin, which are about 440,000 acre-feet per year.

Groundwater recharge to the High Plains aquifer occurs primarily by direct infiltration of areal precipitation and infiltration of runoff into playas and arroyos. Basin recharge is about 63,000 af/yr (Musharrafieh and Chudnoff, 1999).

Natural discharge occurs through evapotranspiration where the water table is close to the land surface, and through surface evaporation from lakes and playas where these intercept the water table. In general, discharge in the area through evapotranspiration is of limited extent, and is associated with areas of shallow water table. Subsurface flow into Texas is the largest component of natural discharge from the High Plains aquifer in New Mexico.

Water-level data obtained from the U. S. Geological Survey's (USGS) Ground Water Site Inventory (GWSI) database were analyzed to determine historical trends. Water levels have declined as much as 97 feet along the state-line (Tillery, 2008). Water level decline data are summarized in Table 156.

Table 156. Summary of water-level data, Lea County Basin

Period (# of years)	Number of Well Level Data for Each Period Indicating:			Maximum Decline over the Period (feet)	Average Decline (feet)	Maximum Annual Decline Rate (feet per year)	Average Annual Decline Rates (feet per year)
	Decline	Rise	Total				
1951-2000 (50)	50	2	52	72.30	35.11	1.45	0.70
1996-2000 (5)	136	22	158	25.92	4.15	5.18	0.83
2004-2007 (3)	N/A	N/A	209	21.2	2.4	7.06	0.80

Other geologic formations such as the Triassic rocks underlie the High Plains aquifer and may be saturated. The rocks consist primarily of consolidated shale, mudstone, siltstone, and fine-grained sandstone. These rocks are less permeable and where saturated contain groundwater with a significantly higher total dissolved solid (TDS) content compared to the overlying High Plains aquifer. Generally, the Triassic Chinle Group provides a distinctive red bed (mudstone and siltstone) that delineates the bottom boundary or base of the High Plains aquifer. The High Plains aquifer is absent where topographic highs of red bed units outcrop at the surface.

In 2005 the Lea County UWB was extended by an order of the State Engineer. State Engineer Order 166, September 23, 2005. In 2009, the State Engineer closed the High Plains aquifer within the limits of the Lea County UWB to applications for new water appropriations. State Engineer Order, September 14, 2009. The review of water right applications is governed by the *Lea County Underground Water Basin Guidelines for Review of Water Right Applications* (NMOSE, 2014e), which were issued to replace the administrative procedures adopted in the 1950s. The guidelines set forth the review procedures for applications proposing to divert from the High Plains aquifer, the primary water supply source in the Lea County UWB. Under the guidelines, all applications for new water appropriations from the High Plains aquifer will be denied by the State Engineer. The guidelines define the criteria for designating critical management areas and prohibit any applications for appropriation within such areas. The guidelines also mandate the metering of non-domestic and livestock water wells.

Risks and Trends

Risk is high due to extensive pumping and drops in water levels. Groundwater mining has occurred. Trend is stable due to limited pumping and new permits in the basin.

Table 157 below summarizes the risks and trends for the eight groundwater basins in the Context Area. Risks are either high, moderate, or low with trends being upward, downward, or stable. Assessments are qualitative.

Table 157. Risk and trend for groundwater basins in the Context Area

Groundwater Basin	Risk	Trend	Explanation
Tularosa	High	Downward	Closed basin; water level drawdown; high use;
Salt	Low	Stable	Minimal use; possible future stresses with oil and gas activities and use by Texas
Hondo	Moderate	Stable	Water level fluctuations have been variable; continued development will result in increased demands
Peñasco			Lack of large-scale pumping and groundwater extraction
Roswell	High	Downward	Extensive pumping; water level drawdowns,

Groundwater Basin	Risk	Trend	Explanation
			reduced baseflow in Pecos River
Carlsbad	High	Downward	Extensive pumping; water level drawdowns, reduced baseflow in Pecos River
Capitan	High	Stable	Extensive pumping; impacts from oil and gas; impacts to Pecos River; quick recoveries from pumping
Lea County	High	Stable	Extensive pumping and historic declines in water levels; groundwater mining; no new appropriations

Water Quality

The primary source of pollution from National Forest System lands are nonpoint source (NPS) pollutants. Nonpoint source pollutants are derived from diffuse overland sources in contrast to point sources of pollutants which discharge from identifiable outlets such as pipes, ditches, agricultural fields, or industrial or sewage treatment sources. Polluted runoff, or *nonpoint source pollution* (NPS), is defined by the EPA as "caused by rainfall or snowmelt moving over and through the ground and carrying natural and human-made pollutants into lakes, rivers, streams, wetlands, estuaries, and other coastal waters and groundwater. Atmospheric deposition and hydrologic modification are also sources of nonpoint source pollution." Nonpoint source pollution is the leading cause of water quality degradation in the United States and poses a substantial problem for the health of New Mexico's rivers, wetlands, lakes and streams. Activities such as agriculture, construction, forestry, and mining, are sources of nonpoint pollutants. Activities generating nonpoint source pollutants on the forest include: past and present mining activities, livestock grazing, road construction, timber and fuelwood harvesting, recreational uses, and ground disturbance created by off-highway vehicle use. Natural and unknown sources of pollutants may also contribute to nonpoint source pollution on the forest. Primary nonpoint source pollutants causing impairment to surface waters within the Forest include:

- Nutrients or related parameters (Total Phosphorus/Nutrient/Eutrophication)

- *E. coli* bacteria
- Turbidity/Sedimentation/Siltation

Water quality is assessed by comparing existing conditions with water quality standards established for designated uses identified by the State under the authority of the Clean Water Act (CWA). The New Mexico Environment Department (NMED) is the regulating authority for water quality in New Mexico. NMED identifies designated uses for individual stream reaches and water bodies across the state that water quality standards are intended to protect. Designated uses include:

- Coldwater Aquatic Life
- Coolwater Aquatic Life
- Domestic Water Supply
- Fish Culture
- High Quality Coldwater Aquatic Life
- Industrial Water Supply
- Irrigation
- Limited Aquatic Life
- Livestock Watering
- Marginal Coldwater Aquatic Life
- Marginal Warmwater Aquatic Life
- Primary Contact
- Public Water Supply
- Secondary Contact
- Warmwater Aquatic Life
- Wildlife Habitat

Individual water bodies are categorized based on how well they attain the water quality standards for the designated uses identified for the water body. NMED prepares an assessment report of the quality of the state's surface waters every two years to comply with the Clean Water Act (known as the "State of New Mexico Clean Water Act Section 303d/Section 305b Integrated Report"). A list of accessed surface water bodies and water bodies that do not meet water quality standards (impaired water bodies) is available at https://www.env.nm.gov/swqb/303d-305b/2014-2016/index.html and is used for assessing the current water quality condition of streams on the Lincoln National Forest as well as the larger Context Area.

Figure 99 shows the locations of impaired streams in the Plan and Context Areas. Specific impairments include e. coli, total phosphorus, temperature, turbidity, low flow alterations, nutrient/eutrophication, sedimentation/siltation, PCB in fish tissue, and DDT in fish tissue. The most common impairments are temperature and turbidity/sedimentation/siltation, followed by low flow alterations and e. coli. The less common impairments are total phosphorus and nutrient/eutrophication. Presence/absence of benthic macroinvertebrates do not constitute an impairment. However, they are good indicators of water quality conditions and are listed because macroinvertebrate sampling results show impairment of the respective water body.

Table 158 shows a breakdown of impaired stream miles verses total stream miles in watersheds having impaired streams. The Rio Peñasco Sub-basin contains four watersheds that have a total of more than 145 miles of impaired stream miles. There are all along the Rio Peñasco and Agua Chiquita and the impairments are for turbidity and sedimentation.

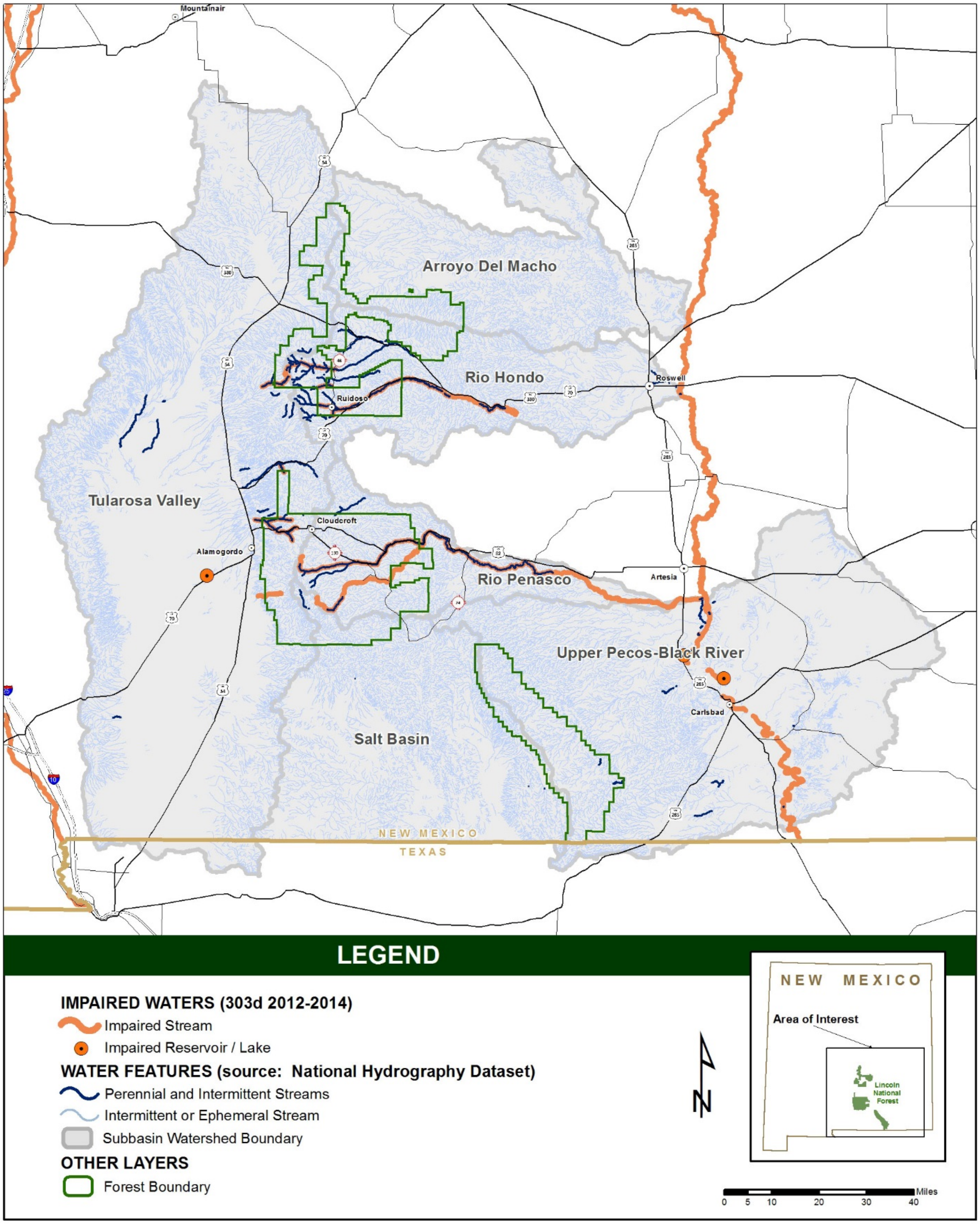

Figure 100. Impaired streams in the Context and Plan Areas

Risk

Table 158 below lists all the watersheds (HUC 5) in the Context Area having perennial streams. Also shown are the miles of impaired streams verses total miles of perennial stream within the watersheds. Watersheds having 0-33 percent of impaired streams are rated as low risk; those with 34 to 66 percent impaired streams have moderate risk; and those with 67-100 percent impaired streams have high risk. Some watersheds with perennial streams have no impairments and are rated as low risk.

Four out of the five watersheds in the Rio Peñasco Sub-basin with perennial streams are at high risk, with the Rio Peñasco and Agua Chiquita having a significant number of miles of impairment. The Rio Peñasco Sub-basin contains four watersheds that have a total of more than 145 miles of impaired stream miles. There are all along the Rio Peñasco and Agua Chiquita and the impairments are for turbidity and sedimentation. The Rio Peñasco flows east with its headwaters being on the Lincoln National Forest along Sunspot Highway and it's confluence with the Pecos River is over a hundred miles downstream. The entirety of the Rio Peñasco and Agua Chiquita are impaired. Most of the headwaters for both of these streams are on the Lincoln National Forest. However, many of the stream miles run through private land and then flows outside the boundary of the Forest.

The Rio Hondo Sub-basin has the next highest number of impaired stream miles (96.93) contained within three watersheds. Impairments include e-coli, nutrients, temperature, turbidity, and low flow alterations. The Rio Ruidoso, which drains east, has approximately 60 miles of impaired stream. It flows into the Rio Hondo, which continues to flow east. Most of these sections of stream are surrounded by the Lincoln National Forest but are on private land. Almost 13 miles of the mainstem of the upper part of the Rio Bonita is impaired for e-coli. The uppermost portion at the headwaters is on the Lincoln National Forest but further downstream much of the stream is on private inholdings that are surrounded by the Forest.

In the Tularosa Sub-basin there are four watersheds that contain almost 35 miles of impaired streams. All of these flow off the east flank of the Sacramento Mountains. Fresnal and La Luz Canyons have a number of diversions so low flow alterations contribute to water quality impairments. These impairments include e-coli, temperature, and sedimentation/siltation. Most of these impaired stream sections run through private inholdings with very few sections of stream being on the Forest. Other small sections of stream in this sub-basin are impaired with low flow alterations, temperature, and e-coli.

In the Upper Pecos-Black Sub-basin, all of the stream miles are impaired with PCB or DDT in fish tissue, which are based on New Mexico's current fish consumption advisories. The impaired designated use is the associated aquatic life even though human consumption of the fish is the actual concern. Although these watersheds are in the Context Area, they are spatially far removed from the Lincoln National Forest and the impacts from the Forest are either absent or extremely minimal.

Table 158. Risk factors for watersheds having perennial streams in the Context Area

Sub-basin	Watershed	Impaired Stream Miles	Total Stream Miles	Percent Miles Impaired	Risk
Tularosa	Middle Salt Creek	0	8	0	Low

Sub-basin	Watershed	Impaired Stream Miles	Total Stream Miles	Percent Miles Impaired	Risk
	Lower Salt Creek	0	17	0	Low
	Cottonwood Draw	0	4	0	Low
	Bitter Creek	7.35	9.35	78.6	High
	Tularosa Creek	2.08	12.29	16.9	Low
	Sheep Camp Draw	0	5	0	Low
	Lost River	19.22	22.1	86.9	High
	Three Hermanos	5.84	7.28	80.2	High
	Parker Lake	0	2	0	Low
Salt	Sacramento River	0	5	0	Low
Upper Pecos-Black	Rocky Arroyo	0	3	0	Low
	Last Chance Canyon	0	2	0	Low
	Dark Canyon	0	4	0	Low
	Black River	0	4	0	Low
	Red Bluff Draw	0	4	0	Low
	Dark Canyon-Pecos River	20.06	20.06	100	High
	Black River-Pecos River	16.15	16.15	100	High

Sub-basin	Watershed	Impaired Stream Miles	Total Stream Miles	Percent Miles Impaired	Risk
	Delaware River-Pecos River	30.71	30.71	100	High
Rio Peñasco	Elk Canyon	0	9	0	Low
	Upper Rio Peñasco	37.28	51.36	72.6	High
	Agua Chiquita	35.67	39.95	89.3	High
	Middle Rio Peñasco	31.96	31.96	100	High
	Lower Rio Peñasco	40.84	40.84	100	High
Rio Hondo	Rio Bonita	12.98	76.31	17	Low
	Rio Ruidoso	60.51	113.77	53.2	Moderate
	Headwaters Rio Hondo	23.44	23.44	100	High

Water Rights and Uses

The cities of Ruidoso, Ruidoso Downs, Glencoe, High Rolls, Timberon, Sacramento, Weed, Mayhill, and Queen lie within the exterior boundaries of the forest. The communities of Ancho, Carrizozo, White Oaks, Nogal, Capitan, Alto, Lincoln, San Patricio, Hondo, Alamogordo, La Luz, Tularosa, and Piñon lie immediately adjacent to the Forest Boundary. The community of Mescalero is on the Mescalero Apache Indian Reservation and is also adjacent to the Forest. Roswell, Artesia, and Carlsbad lie further to the east but much of the water used in these areas originate on the Forest. Water usage is increasing in most of these areas. The community of Ruidoso is a tourist town and has experienced tremendous growth in the last several decades (more detailed information is in the Rio Hondo section of this chapter). Four municipal supply water wells for the Village of Ruidoso are located on National Forest System land in the North Fork Eagle Creek drainage and constitute a substantial component of the municipal water supply system that the Village of Ruidoso residents and visitors rely upon. The town of Artesia and the surrounding area has high water use due to the oil industry. The Roswell Artesian Basin, which includes Roswell and Artesia, is one of the most intensively farmed areas in the state of New Mexico (https://geoinfo.nmt.edu/resources/water/projects/roswell/home.html). The city of Alamogordo has obtained a substantial supply of its' municipal water from Bonito Reservoir, which is fed by the Rio Bonito, whose sub-watershed lies entirely within the Forest. Table 159 shows the types and number of points of diversion (POD) within each sub-basin in the Context Area. PODs are where water rights exist and water is diverted and put to beneficial use. The point of use, or where the water is actually used, may be in a different location than the POD. Figure 100 shows the locations of points of diversion (POD) in the Context Area.

Table 159. Type of water use and number of points of diversion (PODs) within the Context Area

Type of Use	Number of PODs
Commercial	152
Domestic	1,820
Irrigation	429
Municipal	16
Other	374
Unknown	1,904

The greatest concentrations of PODs of all types are in the population centers on the west side of the Sacramento Mountains and around Carlsbad. Concentrations are also found around Roswell and in the municipalities in the vicinity of the Smokey Bear Ranger District of the Lincoln National Forest. Because the Tularosa Basin hosts the municipalities west of the Sacramento Mountains and some of the municipalities on the west boundaries of the Smokey Bear Ranger District, a large number of PODs are in this sub-basin. The Upper Pecos-Black Sub-basin around Carlsbad also hosts a heavy concentration of PODs. The Rio Hondo sub-basin has moderate concentrations of PODs while the Salt, Rio Peñasco, and Arroyo Del Macho sub-basins all have low concentrations (Figure 100).

Historic Conditions

Disturbances that affect water yield, streamflow, and groundwater are described in the general discussion of water resource disturbances in the Watershed and Perennial Streams sections. Water withdrawals through surface water diversions and groundwater pumping exceed the natural range of variation. Natural disturbances from floods and droughts are within the historical range of variation except where floods in smaller watersheds are derived from unnatural high severity wildfires.

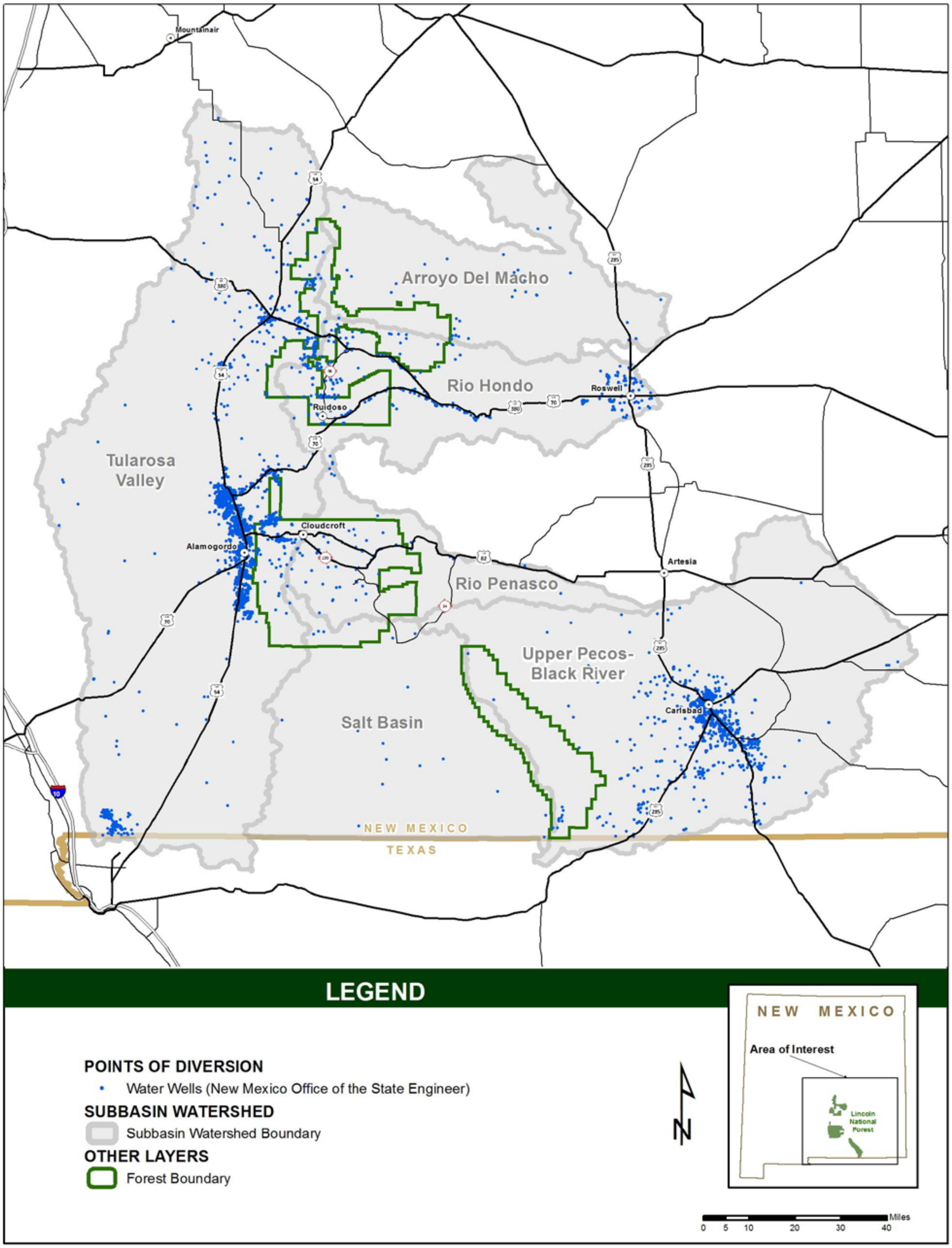

Figure 101. Points of diversions in Context and Plan Areas

Table 160. Points of diversion by sub-basin

Sub-basin	Number of PODs in Context Area	Number of PODs in Plan Area (Lincoln NF)	Percentage of PODs in Plan Area
Tularosa	6,923	994	14.4
Salt	288	87	30.2
Arroyo Del Macho	170	52	30.6
Rio Peñasco	1,642	1513	92.1
Rio Hondo	4,385	1915	43.7
Upper Pecos-Black	3,802	107	2.8
Total	**17,210**	**4,668**	**27.1**

Forest Service Water Uses

The Lincoln National Forest has a number of permits that are state appropriative uses, meaning the Forest has applied for water rights through the Office of the State Engineer to put the water to beneficial use. These uses include administrative, domestic, fire suppression, recreation, livestock watering, fish game propagation, irrigation, and mining. By far the highest use is livestock watering.

Historic Conditions

Historically, water uses and water developments were limited to what was used by the early Native American tribes and later the Spanish who inhabited the area. Prehistoric farmers were few and widely scattered, and the effects of their use of the land and water resources were minimal compared to the effects that have occurred after large scale settlement began in the late 1800s. Disturbances which affect water yield, streamflow, and groundwater are described in the general discussion of water resource disturbances in the Watershed and Perennial Streams sections.

Comparison of Current to Reference Conditions

Beginning in the late 1800s and continuing to the present, water withdrawals through surface water diversions and groundwater pumping has exceeded the historical range of variation. The public water code in New Mexico was established on March 19, 1907. Prior to this date, a person acquired a water right by simply putting the water to beneficial use, posting a notice at the point of diversion and often filing that notice at the local county courthouse. After March 19, 1907, a water right was obtained by filing an Application for Permit to Appropriate with the state water agency. The Office of the State Engineer administers water rights and uses in the State of New Mexico and keeps records of amounts of water withdrawn.

Future Conditions with Current Management

Surface and groundwater withdrawals will continue to be managed by the State of New Mexico through the Office of the State Engineer. Applications for new permits will continue to occur in areas of growth and other areas where the need to divert water exists. Some of these uses would include recreation, livestock grazing, mining, agriculture, and domestic uses. Under current management, the water resources that provide water for beneficial use to the public would continue to degrade in some areas and would improve in others.

Aquatic Biota (Native and Non-native Fish)

Introduction

Trends in aquatic biota reflect trends in watershed and stream health. In this analysis, the biota will include fish species only, as there is little to no survey data available to draw from regarding native aquatic macro-invertebrates. Macro-invertebrates are good indicators of water quality conditions and are mentioned since macroinvertebrate sampling results can be used to indicate the condition or relative impairment of the water resources. There is no trend information available for non-native fish or invertebrates. Fish surveys have been conducted somewhat sporadically and numerous data gaps exist on the Lincoln NF, which is the analysis area for this characteristic. For those streams that have survey information, population trend data is typically lacking because there has not been consistent sampling. Queries were made of the Natural Heritage New Mexico database, USFS fish biologists (Cibola NF and RO), Museum of Southwestern Biology, and New Mexico Department of Game and Fish. Fishes of New Mexico (Sublette et al. 1992) was reviewed for historic data on fish distribution. Additional information was gathered from species abstracts located on BISON-M (NMDGF) and NatureServe Web sites. These sources are included in the references section.

Due to the ephemeral nature of the drainages and the monsoonal rains, most of the watersheds are not able to support native fisheries, either historically or currently. Sixty percent of the HUC 6 watersheds are ephemeral in nature and have no historical documentation of supporting native fish. Most of these ephemeral drainages occur on the west slopes of the Sacramento Mountains, and along most of the Guadalupe Mountains. Because of the relative lack of permanent water or streams on the Lincoln NF, few streams support fish. Of those that do contain fish, the majority contain non-native, introduced species. The Nature Conservancy reports general declining trends rangewide for native fish known to occur historically on the Forest, including Rio Grande chub, Rio Grande cutthroat trout, headwater catfish, and greenthroat darter, while the longnose dace is considered to be relatively stable (Natureserve, 2016). The Rio Grande sucker is not included, as it did not historically occur on the Forest (Sublette, 1990), and although it has been introduced into the Rio Hondo (BISON-M), several miles east of the forest boundary, it has not been documented to occur on or near the Forest. Most of the drainages that empty into the west side of the Sacramento and Guadalupe Mountain ranges are ephemeral in nature, and for the most part do not support native fish populations. Two exceptions to this are the Sacramento River and the Three Rivers system. The native longnose dace has been reported in these two systems, and non-native trout occur as well.

Presence of non-native aquatic species and poor habitat conditions are correlated with functioning at risk and impaired function ratings for many watersheds. As described in the drivers and stressors section, drivers and stressors that affect some key factors in aquatic ecosystems include surface water diversions and use, groundwater extraction, NFS and non-NFS roads, trails, and stream crossings, ungulate foraging and grazing, climate, upland vegetation condition, modification of seeps and springs, habitat fragmentation, unmanaged recreation. The stream and hydrological analysis indicate a high departure from desired condition. The high departure from desired conditions indicated in the stream analysis matches what is indicated in the range of the aquatic species departure, which places riparian areas in a high risk category.

Removal of non-native species is difficult and expensive. Presence of these species is not expected to change substantially into the future except for cooperative efforts with New Mexico Department of Game and Fish to reestablish native species. In a number of water bodies non-native species are currently stocked by the New Mexico Department of Game and Fish to provide sport fishing opportunities. Removal of non-native species and re-establishment of native species has occurred in a few locations (Pine Lodge Creek) and occurred through post fire effects of the Little Bear fire. The Lincoln NF has 3 main non-native aquatic species that have been introduced: brown trout, rainbow trout and brook trout. Of these three, the brook trout are the most pervasive and persistent, surviving even drought years when the perennial streams become intermittent in nature. Except for a few locations, aquatic biota conditions are expected to remain similar to current conditions.

On the east side of the Sacramento and Guadalupe mountains, native fish within the Pecos River Basin have experienced declines in their distribution because of loss or modification of habitat and from competition and predation by introduced nonnative fishes. Historically, there have been collections of five native fish species within the watersheds of the Pecos River Basin that occured on the Forest. Of these, four fish species, the Rio Grande chub, Rio Grande cutthroat trout, headwater catfish, and longnose dace, are still assumed or were found to be present on the Forest.

Current Condition

Prior to Euro-American settlement, only native fish and aquatic macroinvertebrates were present in these watersheds, their populations were more widespread and interconnected, and the aquatic habitat had all necessary components needed for them to persist. This pre-Euro-American status of aquatic biota is used as the reference condition. Though, it is likely that aquatic habitat conditions have changed over time, it is assumed the perennial stream miles should have only been inhabited by native aquatic species.

Historic land uses and introduction of non-native species that occurred within the last hundred years or more have resulted in significant negative impacts to aquatic communities and their watersheds. As a result, native fish populations have been reduced from a large interconnected population to isolated populations within altered and degraded habitats (Alves et al. 2008). Because of the altered habitat and reduced, increasingly isolated populations, all native fish species have lost much of their population redundancy within and outside the Lincoln NF. These are indicators of watershed health.

Historically, five native fish are documented to have occurred within the Forest (Sublette et al. 1990). Table 161 lists the historical and current occurrences of the native fish species found within Lincoln NF, according to sub-watersheds (HUC 6) and watersheds (HUC 5). The mean departure at both the HUC 5 and HUC 6 scales is moderate, at 56 percent.

At the HUC 6 scale, four of 19 units had no historic or current occurrence of the five native species noted in Table 161. In the remaining 15 units, species occurrence ranged from two to four, historically (none had all five). Species occurrence in these units currently ranges from one to two. Black River and Last Chance Canyon are the only watersheds with all historic species considered extant. Dark Canyon is the only watershed with all historic species considered extirpated. In the non-native fish columns, the number 1 indicates Brook Trout, 2 indicates rainbow and brook trout, and 3 indicates brown, rainbow and brook trout. All other watersheds show reduction in species occurring currently.

Table 161. Historical and current occurrences of the native fish species found within Lincoln NF, according to local units (HUC 6) and watersheds (HUC 5). C denotes a species observed as currently present. C* denotes a species not observed but expected due to lack of human influence. R denotes a species considered present historically by observation and range. Blank cells denote no data and no assumed current or historic presence. The number of current /current and historic occurrences (C/C+R) is expressed as a fraction.

Aquatics	Native Fish Species within HUC 6 Watersheds								Non-Native
Watershed (HUC5) (White) Sub-watershed (HUC6) (Gray)	Rio Grande Cutthroat Trout	Rio Grande Chub	Headwater Catfish	Longnose Dace	Greenthroat Darter	Current/Historic Numbers	Percent Departure of Current From Historic	Risk Ranking	Brook Trout, Brown Trout, Rainbow Trout
Bitter Creek						n/a	n/a	n/a	1
Gamble Canyon-Three Rivers						n/a	n/a	n/a	1
Golondrina Draw-Three Rivers						n/a	n/a	n/a	1
Tularosa Creek						n/a	n/a	n/a	1
Nogal Canyon						n/a	n/a	n/a	1
Middle Tularosa Creek						n/a	n/a	n/a	1
Lost River						n/a	n/a	n/a	1
Fresnal Canyon						n/a	n/a	n/a	1
La Luz Canyon						n/a	n/a	n/a	1
Lost River						n/a	n/a	n/a	1
Sacramento River						n/a	n/a	n/a	2
Arkansas Canyon-Sacramento River						n/a	n/a	n/a	1
Ben WIlliams Canyon-Sacramento River						n/a	n/a	n/a	2
Prather Ranch-Sacramento River						n/a	n/a	n/a	2
El Paso Canyon						n/a	n/a	n/a	1
Reventon Draw	R	R		C		1/3	67%	High	1
Upper Reventon Draw	R	R		C		1/3	67%	High	1
Middle Reventon Draw	R	R		C		1/3	67%	High	1
Hasparos Canyon	R	R		C		1/3	67%	High	1
Upper Hasparos Canyon	R	R		C		1/3	67%	High	1

Aquatics	Native Fish Species within HUC 6 Watersheds								Non-Native
Watershed (HUC5) (White) Sub-watershed (HUC6) (Gray)	Rio Grande Cutthroat Trout	Rio Grande Chub	Headwater Catfish	Longnose Dace	Greenthroat Darter	Current/Historic Numbers	Percent Departure of Current From Historic	Risk Ranking	Brook Trout, Brown Trout, Rainbow Trout
Carrabajal Cemetery						n/a	n/a	n/a	1
Lavade Draw						n/a	n/a	n/a	1
Upper Arroyo del Macho	R	R		C		1/3	67%	High	1
Aragon Creek	R	R		C		1/3	67%	High	1
Cottonwood Canyon-Arroyo del Macho	R	R		C		1/3	67	High	1
Reventon Draw-Arroyo del Macho	R	R		C		1/3	67%	High	1
Headwaters Salt Creek	C	R		C		2/3	33%	Low	1
Copeland Canyon-Seco Arroyo	R	R		C		1/3	67%	High	1
Red Lick Canyon	R	R		C		1/3	67%	High	1
Arroyo Serrano	C	R		C		2/3	33%	Low	1
Zeufeldt Arroyo	R	R		C		1/3	67%	High	1
Rio Ruidoso	R	R		C		1/3	67%	High	1
Carrizo Creek						n/a	n/a	n/a	1
Cherokee Bill Canyon	R	R		C		1/3	67%	High	0
Upper Rio Ruidoso	R	R		C		1/3	67%	High	1
Devils Canyon	R	R		C		1/3	67%	High	0
Middle Rio Ruidoso		R		C		1/2	50%	Medium	3
Lower Rio Ruidoso		R		C		1/2	50%	Medium	3
Rio Bonito	R	R		C		1/3	67%	High	3
Upper Rio Bonita	R	R		C		1/3	67%	High	1
Middle Rio Bonita	R	R		C		1/3	67%	High	3
Lower Rio Bonita		R		C		1/2	67%	High	3
Casey Canyon	R	R		C		1/3	67%	High	1
Maverick Canyon	R	R		C		1/3	67%	High	0

Aquatics	Native Fish Species within HUC 6 Watersheds								Non-Native
Watershed (HUC5) (White) Sub-watershed (HUC6) (Gray)	**Rio Grande Cutthroat Trout**	**Rio Grande Chub**	**Headwater Catfish**	**Longnose Dace**	**Greenthroat Darter**	**Current/Historic Numbers**	**Percent Departure of Current From Historic**	**Risk Ranking**	**Brook Trout, Brown Trout, Rainbow Trout**
Elk Canyon	R	R		C		1/3	67%	High	1
Silver Springs Canyon	R	R		C		1/3	67%	High	1
Sixteen Springs Canyon	R	R		C		1/3	67%	High	1
Outlet Elk Canyon	R	R		C		1/3	67%	High	1
Agua Chiquita	R	R		C		1/3	67%	High	1
Upper Agua Chiquita	R	R		C		1/3	67%	High	1
Middle Agua Chiquita	R	R		C		1/3	67%	High	1
Mule Canyon 02		R		C		1/2	50%	Medium	1
Lower Agua Chiquita		R		C		1/2	50%	Medium	1
Upper Rio Peñasco	R	R		C	R	1/4	75%	High	1
Cox Canyon	R	R		C	R	1/4	75%	High	1
Cox Canyon-Rio Peñasco	R	R		C	R	1/4	75%	High	1
James Canyon	R	R		C		1/3	67%	High	1
James Canyon - Rio Peñasco	R	R		C	R	1/4	75%	High	1
Cuevo Creek						n/a	n/a	n/a	1
Perk Canyon						n/a	n/a	n/a	1
Perk Canyon-Cuevo Creek						n/a	n/a	n/a	1
Middle Rio Peñasco		C		C	R	2/3	33%	Low	1
Big Cherry Canyon		R		C	R	1/3	67%	High	0
Big Cherry Canyon-Rio Peñasco		C		C	R	2/3	33%	Low	1
Last Chance Canyon		C	C			2/2	0%	Low	0
Middle Last Chance Canyon		C	C			2/2	0%	Low	0
Lower Last Chance Canyon		C	C			2/2	0%	Low	0
Dark Canyon		R	R			0/2	100%	High	0

Aquatics	Native Fish Species within HUC 6 Watersheds								Non-Native
Watershed (HUC5) (White) Sub-watershed (HUC6) (Gray)	**Rio Grande Cutthroat Trout**	**Rio Grande Chub**	**Headwater Catfish**	**Longnose Dace**	**Greenthroat Darter**	**Current/Historic Numbers**	**Percent Departure of Current From Historic**	**Risk Ranking**	**Brook Trout, Brown Trout, Rainbow Trout**
Turkey Canyon-Dark Canyon		R	R			0/2	100%	High	0
Last Chance Canyon-Dark Canyon		R	R			0/2	100%	High	0
Black River		C*	C*			2/2	0%	Low	0
Big Canyon		C*	C*			2/2	0%	Low	0
Big Canyon-McKittrick Canyon		C*	C*			2/2	0%	Low	0
McKittrick Canyon-Black River		C*	C*			2/2	0%	Low	0
Rattlesnake Canyon		C*	C*			2/2	0%	Low	0
Current/Historic numbers of HUC 5 watershed with fish occurrences by species	1/10	3/14	2/3	11/11	0/2				
Percent departure of current from reference	90%	79%	33%	0	100%				
Current/Historic numbers of HUC 6 watershed with fish occurrences by species	1/25	7/40	6/8	32/32	0/5				
Percent departure of current from reference	96%	82%	25%	0%	100%				

Currently, four (80 percent) of these five native species still occur, while one, the greenthroat darter, is only found downstream of the Forest boundary. At least two (40 percent) of the species still occurring in the Plan Area have declined in their distributions on the Forest. Currently, 13 HUC 6 units contain only native fish. In the Guadalupe Mountains, this is due to the reduced flows and increasing stream temperatures from historic times, which do not provide conditions for non-native trout to persist, although stocking of non-native fish continued until the 1970s (USFS 1970). For the Capitan Mountains, these native-only streams are generally found in headwaters, or in areas where the intermittent flows allow the persistence of native fish, but are not conducive to the persistence of non-native species. For example, genetically pure populations of Rio Grande cutthroat trout are isolated by a physical barrier (man-made and natural; RGCTWG 2013). This includes Pine Lodge Creek, which has 1.3 miles of protected Rio Grande cutthroat trout (reintroduced). Currently, 61 percent of the Rio Grande cutthroat trout range occurs on public lands (State, BLM, and FS).

Habitat for native species is also diminished or eliminated due to unfavorable changes in riparian and upland ERUs (see the Terrestrial Vegetation chapter and the Riparian Vegetation chapterCH_2_R_Veg) which have affected native fish diversity and distribution. Most riparian ERUs currently exhibit altered structure, species composition, and canopy cover. In adjacent frequent fire ERUs, shifts in the fire regimes have increased the potential for high severity wildfire. The impacts from user-created roads, hiking trails, camping, and ungulate grazing have increased in the uplands and near streams. Increased forage removal associated with ungulate, camping, and hiking use removes protective vegetation cover from underlying soils and results in increased sedimentation, altered peak run-off flows, and greater habitat fragmentation. Existing user-created (motor vehicle) routes on the landscape, in combination with ungulate grazing, has degraded overall water quality and negatively impacted soil and vegetation conditions in floodplains and uplands.

The HUC 5s and HUC 6s that contain no historic or current populations of native fish species are included because they did have non-native fish introduced into them by the New Mexico Department of Game and Fish in the 1950 to 1970 era. All of these are on the Tularosa Basin side of the drainage, and these streams have very different characteristics from the drainages that are part of the Pecos River Basin. The drainages into the Tularosa Basin have been documented as having a high salinity and gypsum content, described as brackish water (Newton 2016), often toxic to native fish. The water temperatures are warm (even hot water in some cases), which do not allow for the survival of cold water fisheries. The tributaries and watersheds contain existing geographic physical barriers that prohibit fish from progressing back up the streams into the headwaters to spawn. Even in historic times, with no water diversions, and thus more available water, the waters draining into the Tularosa Basin would have contained high salinity, warm waters, and physical boundaries, preventing spawning. The traditional historical ranges of the fish on the Lincoln NF did not include any watersheds draining into the Tularosa Basin (Sublette 1990).

Depredation and competition from non-native fish have likely contributed to diversity and distribution declines in native fish as well. There are three non-native species that currently inhabit the streams on the Forest. These are brook trout, rainbow trout and brown trout, introduced by NMDGF. Non-native fish currently inhabit 43 watersheds on the Lincoln NF. Although native fish may still inhabit these streams, their population and condition are likely in a diminished state (Alves et al. 2008). Native fish populations will likely continue to diminish in the presence of non-natives, which may even cause extinctions of some native species. Barrier installations to protect and restore native fish streams will continually be required to protect or restore native fish.

Stakeholder Input

Input from the public through Forest Plan revision public engagement efforts has been collected beginning in 2014. In the initial scoping efforts conducted thus far, comments relating to hydrological systems and their conditions, trends, and issues included these topics: impaired watershed function with impacts to all other resource values; reduced water quality; increased stream turbidity; decreased available water and moisture; poor or limited recovery of watersheds following fire; sedimentation of streams following catastrophic fire; increased soil erosion, compaction, headcutting, and downcutting associated with livestock grazing; reduced watershed recharge due to tree harvest; increase in frequency and size of flooding and flash floods; reduced water base flows; ecosystem services, multiple uses; increase in human populations near streams and available water; overregulation of ground and surface water and acquisition, with infringement/taking of water rights without public input, and or biased, non-inclusive and non-transparent; lack of emphasis on watershed restoration/improvement; and also listed in the Terrestrial Vegetation chapter, overgrown, dense forests and canopies; stunted, diseased and unhealthy trees; loss of open, grass-dominated areas (savannah-like) and meadows on the landscape impacting forest health, forage, wildlife, scenic, and other values; woody encroachment; decreased regeneration; decreased precipitation and moisture; increase in resource damage associated with OHV/ATV proliferation and travel rules; impacts to vegetation and hydrology due to 300 foot travel allowance for motor vehicles use off of forest routes; reduced/limited fisheries and suitable waters; reduced focus on fisheries and stream-based recreation management; riparian areas in general; loss of riparian areas that, decades ago, flowed regularly and supported many riparian species that are now gone; overgrazing and concentrated use by livestock; riparian area damage, vegetation trampling, and invasive species infestation due to livestock grazing; and disappearance of riparian vegetation likely due to overgrazing and timber removal (plus climate change), and subsequent loss of biodiversity. Expressed values (desires, for terrestrial, riparian and aquatic systems) included healthy, intact forests and ecosystems; forest products and multiple uses; human safety and livelihoods; and effective communication, collaboration, and decision-making. Comments will be incorporated or addressed. Additional information will be sought based on the results of further public review of this draft, and a revised draft assessment will be submitted for Regional Office approval prior to finalizing it.

Summary of Findings for Water Resources

Past management practices have resulted in a decline in the ecological integrity of hydrological features on the Forest. Streams and springs were used by Native Americans for domestic water and potentially for small scale irrigation. The scale of disturbance was less than current conditions wherein some springs are diverted and piped for many miles. Native Americans did not manage livestock and would not have developed springs for livestock use. Springs would not have been affected by pumping or mining. Stock tanks and trick tanks are a recent development and did not exist prior to the arrival of non-indigenous peoples. Many of these were constructed during the mid to late 1900s.

Limited information is available about the NRV of springs and seeps. Constructed features are a recent development and often fall beyond the NRV for various characteristics. Variability in discharge of springs and seeps occurs in response to wet periods and drought periods and possibly following fires. In the absence of NRV trend data, the representativeness and redundancy of these features within the Forest and Context Area were assessed as an index of current conditions. Springs and seeps are over-represented in 24 of 88 watersheds, under-represented in 38 of the 88 watersheds, and proportionally represented in 26 of the 88 watersheds. Springs and seeps are not found either within or beyond the Forest boundary in 34 watersheds. The majority of the watersheds rated as overrepresented for springs and seeps are watersheds where the Forest is higher in elevation and more mountainous than the off-Forest portions of the watersheds.

Trends for springs and seeps are somewhat comparable to those for perennial streams. Trends are variable depending on local conditions. Climate change may result in drier conditions and more erratic rainfall patterns that may reduce aquifer recharge and consequently discharge from springs and seeps. Stock tanks may become a less reliable source of water with the drier and more erratic rainfall patterns anticipated with climate change. Higher intensity storms may result in increased maintenance requirements for stock tanks. Springs and seeps are attractive for livestock, wildlife and human use and require management to prevent excessive use which can lead to degradation.

Historically, groundwater basins were recharged directly by precipitation, mostly in the higher elevations, and by water flow in perennial, intermittent, and ephemeral streams, which in turn is driven by climatic events. Historic recharge and discharge varied depending mostly on natural events such as floods and droughts. Other natural occurrences such as wildfire and insect infestations could have had a lesser, and more indirect effect on groundwater recharge. Influences of early inhabitants would not have had much influence on recharge or discharge and any groundwater withdrawals would have been insignificant. With large scale settlement during the late 1800s, groundwater pumping began, surface water diversion occurred on a scale that would exceed the NRV and cause changes. These influences would have greater impacts locally than regionally. Major changes in fire regimes, vegetation structure, riparian area, wetlands, and in the soil structure in many areas occurred during this time of large scale settlement. All these factors contributed to changes in the groundwater regime as recharge, discharge, and especially groundwater withdrawals began to move outside the NRV.

Continued current NF management would have some impact locally on aquifers as riparian areas and wetlands are impacted by management activities. These activities are likely to affect springs and seeps that are in perched aquifers in high elevation areas (i.e., Sacramento Mountains). Impacts on the regional scale would likely not be realized as a result of current Forest management. Under the current management scenario trends for ground water conditions would be site specific and variable, with some local areas moving upwards and some downwards. For example, as the condition of riparian areas and wetlands improve, conditions of the local aquifer adjacent to the stream begins to move in an upward trend. The opposite occurs when riparian areas and wetlands continue to degrade.

Aquatic species and habitat are projected to persist, but these resources would continue to be stressed under current management practices. Non-native fish species are expected to persist due to the economic importance of sport fishing. Invasive aquatic species distribution and aquatic diseases are expected to persist or increase. Watersheds would continue to be influenced by the ecological integrity level of surrounding ERUs and soils, which are substantially departed from reference conditions. User-created roads and grazing would continue to influence riparian vegetation condition and water quality. Many aquatic ecosystems have the ability to trend towards reference condition given the opportunity for restoration. Implementation of native fish restoration projects are expected to increase on the Lincoln NF.

Aquatic invertebrates have a limited distribution in the Plan Area and have not been adequately surveyed or documented. However, aquatic invertebrates are critical to healthy stream systems, acting as filters and food sources for other aquatic species, and are often indicative of high quality stream conditions. Overall, the decrease in native fish species populations and occurrences, the increase in non-native fish species, and the decreased water flows in the remaining perennial streams all indicate a negative trend in the aquatic biota, consistent with the decrease in the ecological integrity of other water resources discussed above.

Chapter 8 - Air Resources

Introduction

The purpose of this assessment is to evaluate the best available scientific information regarding current conditions and trends in air quality and to project future conditions on and affecting the Lincoln NF. In this assessment, air quality is considered a key ecosystem characteristic since it is relevant to maintaining and/or restoring the ecological integrity of terrestrial, aquatic, and riparian ecosystems in the Plan Area. The assessment provides a basis for the evaluation of risk (departure) to air quality at the end of this chapter and will inform any needs for change to current Forest Plan direction. Additionally, this assessment identifies information gaps and discloses any uncertainty associated with air quality data.

Ecosystem Services of Air Resources

Air resources on the Lincoln NF provide many ecosystem services, or benefits, to society. Air, like water, is necessary for the existence of life, supplying oxygen for respiration and carbon dioxide for plant photosynthesis. It provides supporting ecosystem services as it contributes to primary production, nutrient cycling and soil formation and, therefore, contributes to provisioning services derived as fuelwood, fiber and food, such as meat from game and livestock. The chemical constituents of air provide regulating services as they influence climate and the water cycle. Where high air quality exists, this resource also provides cultural ecosystem services as fresh air, sweeping views, and high recreational value on National Forest System lands.

Analysis and Findings- Conditions, Trends and Sustainability of Air Resources

Airsheds are similar to watersheds in that they are defined geographic areas that are frequently affected by the same air mass because of topography, weather patterns and/or climate. The difference is that air masses and air pollutants move between airsheds due to larger weather and/or climatic patterns, whereas surface water does not naturally move between watersheds. Like watersheds, airsheds can be defined at multiple scales. This assessment defines the relevant airshed as the area within 300 kilometers (186.4 miles) of the Lincoln NF (Figure 101), hereafter referred to as the Lincoln airshed. This airshed was selected as the scale of analysis since it is consistent with the area typically considered during effects analysis and for certain permitting requirements under the Clean Air Act. Although the Lincoln NF occurs across four counties in New Mexico, the Lincoln airshed covers most of New Mexico, plus all, or portions of, 36 counties in southwest Texas and part of the State of Chihuahua in Mexico.

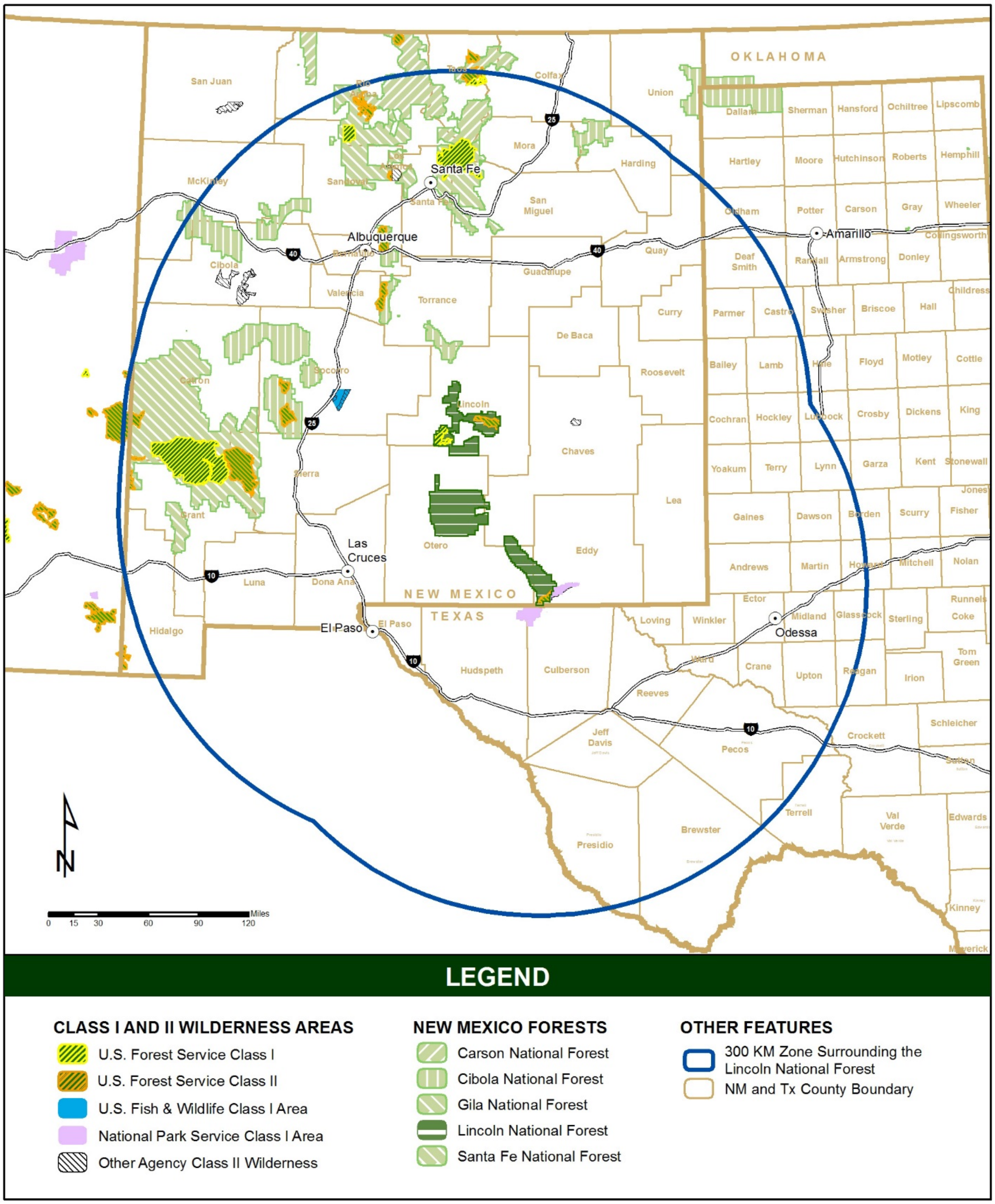

Figure 102. Airshed and counties surrounding the Lincoln National Forest

Sensitive Air Quality Areas

Sensitive air quality areas include Class I, Class II, non-attainment, and maintenance areas. Class I areas are congressionally designated under the Clean Air Act as deserving the highest level of air quality protection and include, but are not limited to, wilderness areas over 5,000 acres. The White Mountain Wilderness (47,219 ac) on the Lincoln NF is a Class I area. Class II areas are also designated by the Clean Air Act but are not as restrictive related to air quality protection. The Capitan Mountain Wilderness (36,034 ac) is a Class II area (Figure 102).

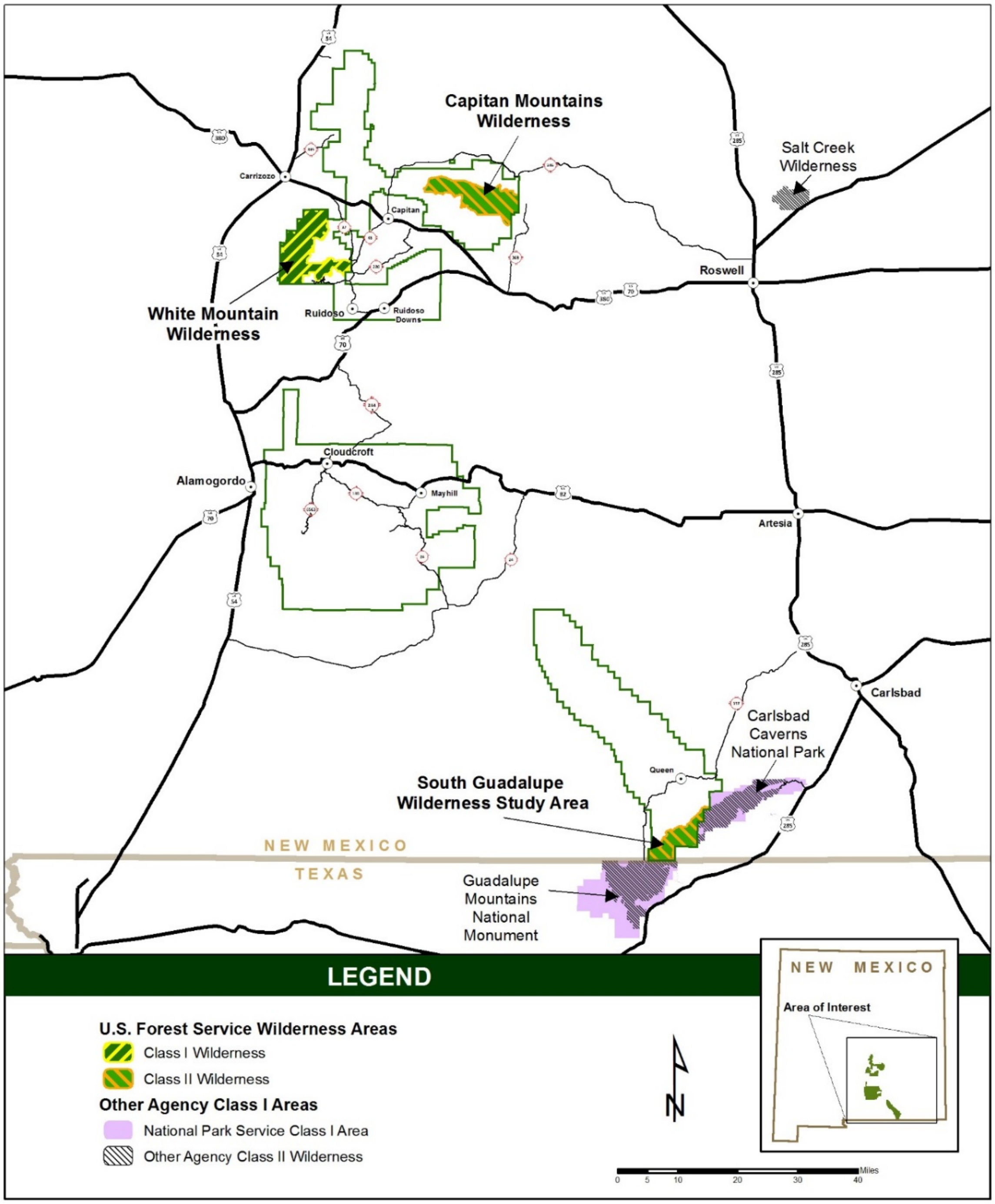

Figure 103. Class I and Sensitive Class II Areas near the Plan Area

Non-attainment areas are those areas that are not meeting the National Ambient Air Quality Standards (NAAQS) established by the EPA. Maintenance areas are former non-attainment areas that are now meeting air quality standards. Currently, there are no non-attainment or maintenance areas in the Plan Area.

Federal, State, and Tribal State Plans

The Federal Clean Air Act provides the basic framework for controlling air pollution, however the States or Tribes are delegated the primary enforcement responsibility. The Clean Air Act provides a framework of tools for protecting air quality in pristine areas from both new and existing sources of pollution. Typically, air pollution generated outside National Forest System lands is the chief concern for impacts within the national forests and grasslands.

The New Mexico Environment Department, Air Quality Bureau, is responsible for air quality management in the State of New Mexico except on Tribal lands where the Tribal government holds primary responsibility, and in Bernalillo County, which maintains a separate jurisdiction. States may develop their own air quality standards, provided that they are at least as restrictive as the national standards. New Mexico Ambient Air Quality Standards (NMAAQS) include standards for total suspended particulate matter (TSP), hydrogen sulfide and total reduced sulfur for which there are no national standards. Table 162 lists national and state ambient air quality standards. Currently, the Plan Area meets all national and New Mexico ambient air quality standards.

Table 162. National and New Mexico ambient air quality standards

Pollutant	Averaging Time	New Mexico Standards	National Standards[a] Primary[b,c]	National Standards[a] Secondary[b,d]
Ozone	8-hour	—	0.070 ppm	Same as primary
Carbon monoxide	8-hour	8.7 ppm	9 ppm	—
	1-hour	13.1 ppm	35 ppm	—
Nitrogen dioxide	Annual	0.05 ppm	53 ppb	Same as primary
	24-hour	0.10 ppm	—	—
	1-hour		100 ppb	—
Sulfur dioxide	Annual	0.02 ppm	—	—
	24-hour	0.10 ppm	—	—
	3-hour	—	—	0.5 ppm
	1-hour		75 ppb	—
Hydrogen sulfide	1-hour	0.010 ppm	—	—
Total Reduced Sulfur	½-hour	0.003 ppm	—	—
PM_{10}	24-hour	Same as Federal	150 µg/m^3	Same as primary
$PM_{2.5}$	Annual (arithmetic mean)	Same as Federal	12 µg/m^3	15 µg/m^3

Pollutant	Averaging Time	New Mexico Standards	National Standards[a] Primary[b,c]	National Standards[a] Secondary[b,d]
	24-hour	Same as Federal	35 μg/m^3	Same as primary
Total Suspended Particulates (TSP)	Annual (geometric mean)	60 μg/m^3	—	—
	30-day Average	90 μg/m^3	—	—
	7-day	110 μg/m^3	—	—
	24-hour	150 μg/m^3	—	—
Lead	Rolling 3 month average	—	0.15 μg/m^3	Same as primary

The Prevention of Significant Deterioration (PSD) permitting program was established in 1977 to preserve the clean air usually found in pristine areas while allowing for economic growth. Its purpose is to prevent violations of National Ambient Air Quality Standards (NAAQS) and protect air quality and visibility in pristine areas. Under this program, new major sources of air pollution or modifications to existing major sources of pollution may be required to assess the impacts of pollution on soil, water, vegetation and visibility of lands managed by the Forest Service. Unless specific issues arise, individual national forests and grasslands are not generally responsible for conducting PSD reviews. Forest Service involvement, oversight, and environmental analysis are provided for at the regional level. Ultimately, the Forest Service may dispute the terms of a permit if analyses demonstrate unacceptable impacts could occur in Class I and II areas.

For existing sources of air pollution, the 1999 Federal Regional Haze Rule (RHR) requires states to develop programs to assure reasonable progress toward meeting the national goal of preventing any future visibility impairment in Class I areas, and remedying any existing impairments. The RHR includes requirements for State Implementation Plans (SIPs) and revisions thereof, as well as period progress reviews. It also includes a provision for New Mexico, and other western states, to incorporate recommendations for emission reduction strategies developed by the Grand Canyon Visibility Transport Commission (GCVTC) designed to improve visibility in the 16 Class I areas on the Colorado Plateau.

The GCVTC was established in a 1990 amendment to the Clean Air Act. The commission released its final report in 1996 and initiated the Western Regional Air Partnership (WRAP), a partnership of state, tribal and Federal land management agencies. The WRAP was created to help coordinate implementation of the GCVTC recommendations related to air pollution prevention, clean air corridors, stationary and mobile sources, road dust, emissions from Mexico, fire, and areas in and near parks and wilderness areas.

Since the RHR was established, the New Mexico Environment Department (NMED) has been working to establish a SIP consistent with direction from the above entities. The process has entailed multiple EPA reviews, litigation and revisions. In 2012, the EPA approved the NMED SIP with one exception related to the San Juan Generating Station 77 (the subject of litigation). The revised SIP was submitted to EPA on

October 8, 2013, for review and possible approval after consideration of public comment. If approved by EPA, the SIP revision will satisfy all of New Mexico's remaining obligations with respect to regional haze Best Available Retrofit Technology (BART) (NMED 2014). The SIP also includes Forest emissions estimates as appropriate. As described in the following section, the primary tool Federal land managers use is the critical load concept. Currently the Lincoln has critical loads based on a national assessment developing empirical critical loads for major ecoregions across the United States. However, there are no Forest-specific critical loads developed for the Lincoln NF, and therefore none are included in the New Mexico SIP.

Regional Forest Service Air Resource Management (ARM) staff act as points of contact with the State to receive and review permit applications filed with state and local regulatory agencies associated with new or modified emission sources. The Forest Service regional office provides air quality analysis to determine if proposed actions are likely to cause, or significantly contribute to, an adverse impact to visibility or other air quality related values within the national forest system.

The Lincoln NF complies with the Clean Air Act, RHR, and New Mexico State Smoke Management Program, as required under the SIP. This program includes requirements for burn registration, notification of local communities and the state of the burn date(s), visual tracking and post-fire reports for all prescribed fire or the utilization of fire on a landscape of greater than 10 acres (NMED 2011).

Additionally, the Forest Service complies with the New Mexico State Smoke Management Programs (SMP), which is described in New Mexico Section 309(g) Regional Haze SIP (NMED 2011). New Mexico's administrative code (NMED 2003)(20.2.65 NMAC-Smoke Management) stipulates that all burners must comply with requirements of the Clean Air Act and Federal Regional Haze Rule (RHR), as well as all city and county ordinances relating to smoke management and vegetative burning practices.

Emissions

This section presents current and historical data related to air quality and trends in the Lincoln airshed that may affect resources on the Lincoln NF. Emissions information is important as adverse air quality impacts on the Lincoln NF can usually be traced to air emissions. Emissions inventories are useful tools for understanding regional sources of pollution that could affect the Forest. Knowing the magnitude of emissions and recognizing trends in emissions over time is pertinent because emissions are usually correlated to the type and severity of air quality impacts. Often, adverse air quality impacts to air quality related values can be mitigated through programs that reduce associated air emissions. However, the Forest Service typically lacks direct authority to control air emissions that impact a particular forest.

For emissions, the information presented in this section represents an aggregation of county emissions including emissions from the State of Chihuahua, Mexico, within the Lincoln airshed (Figure 101). Emissions inventories were analyzed and are available on the Intermountain Data Warehouse (IWDW 2015, IWDW 2015) Web site. Emissions inventories are created by quantifying the amount of pollution that comes from point sources (e.g., power plants, factories) and area sources (e.g., automobiles, oil and gas development). Emissions can also originate from natural events like wildfires.

A summary of baseline emissions from 2011 and projected emissions for 2025 for counties within 300 km of the Lincoln is provided below (IWDW 2015, WRAP 2015) (Figure 103 through Figure 108). The summary examines the following pollutants: carbon monoxide, nitrogen oxides, sulfur oxides, volatile organic compounds (VOCs), coarse particulate matter (surrogate for PM10), and fine particulate matter (PM2.5). Nitrogen oxides and VOCs are included in the assessment since they are precursors to ozone formation which can impact both human health and forested systems.

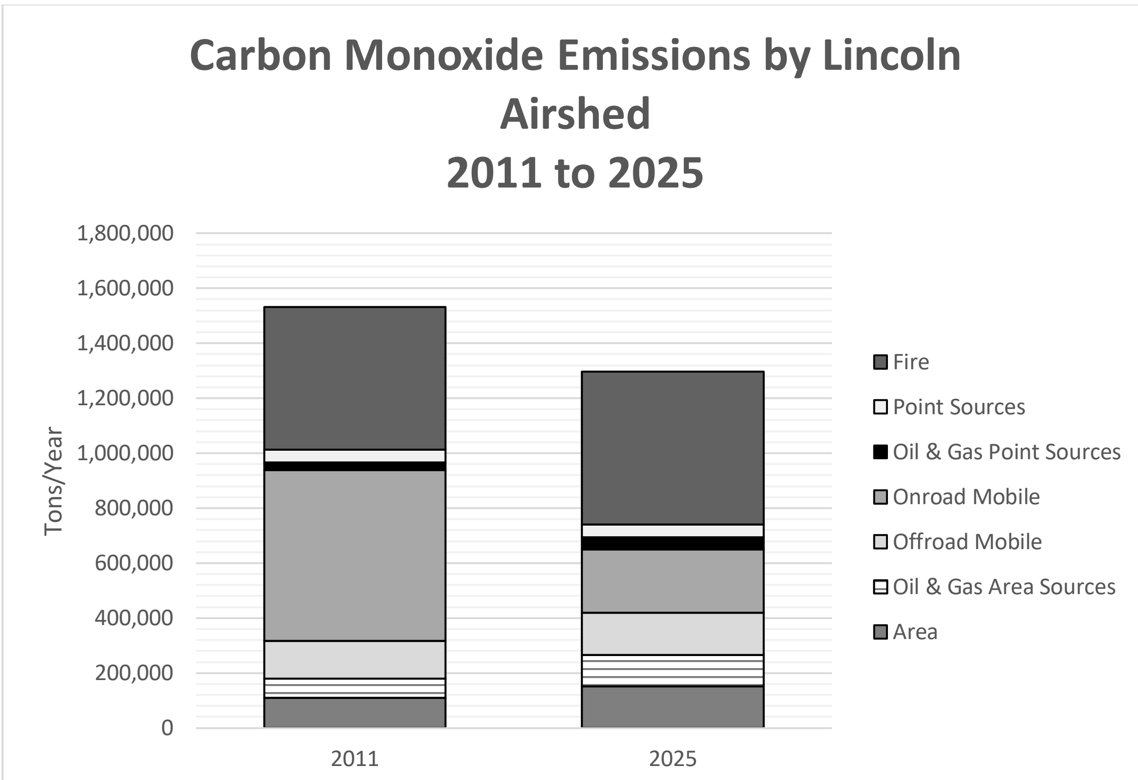

Figure 104. Baseline and projected carbon monoxide emissions

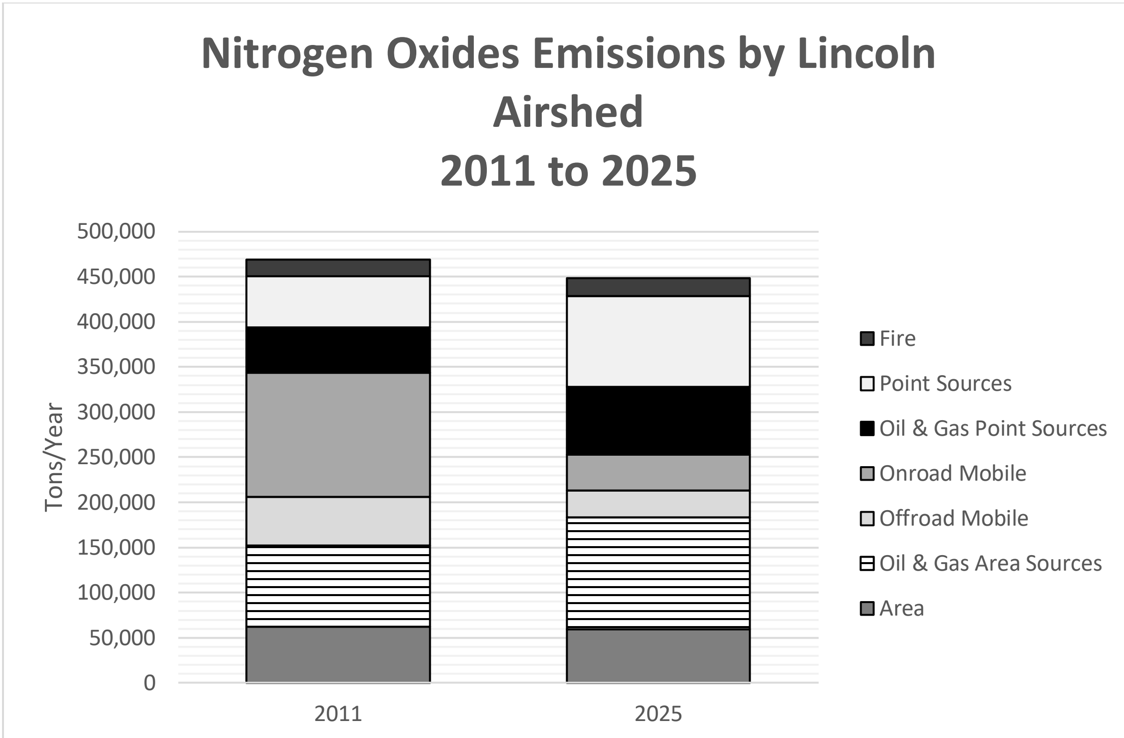

Figure 105. Baseline and projected nitrogen oxide emissions

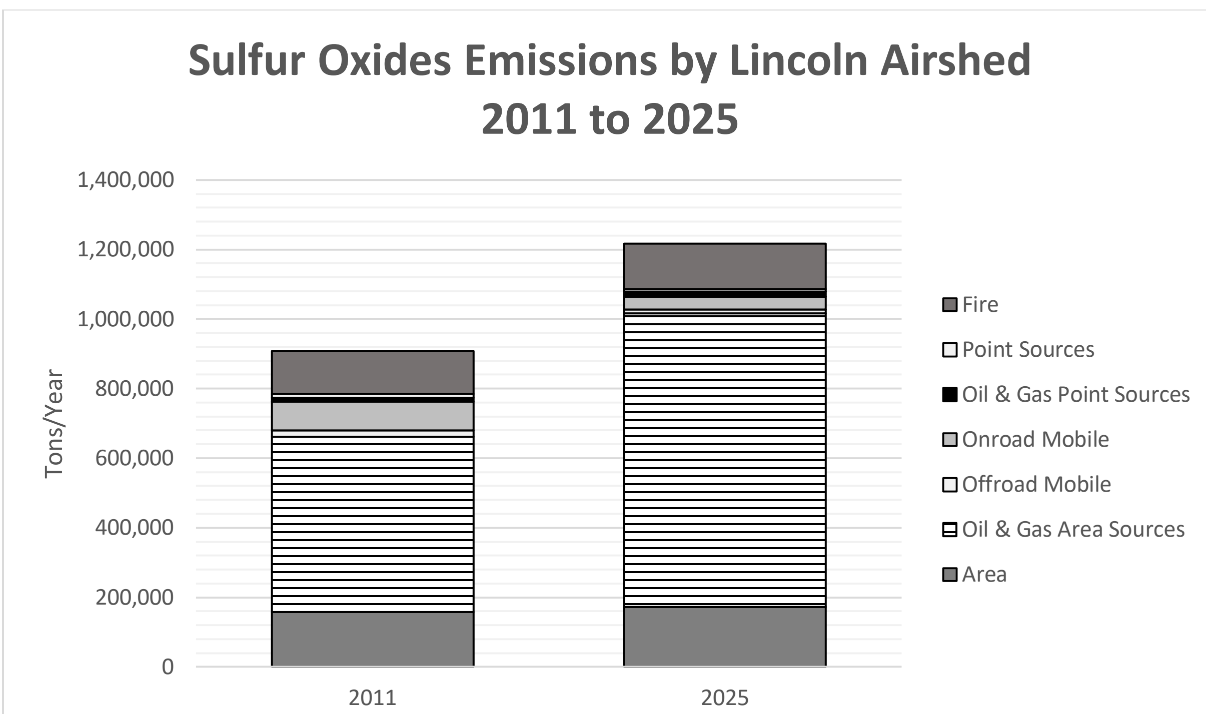

Figure 106. Baseline and projected sulfur oxide emissions

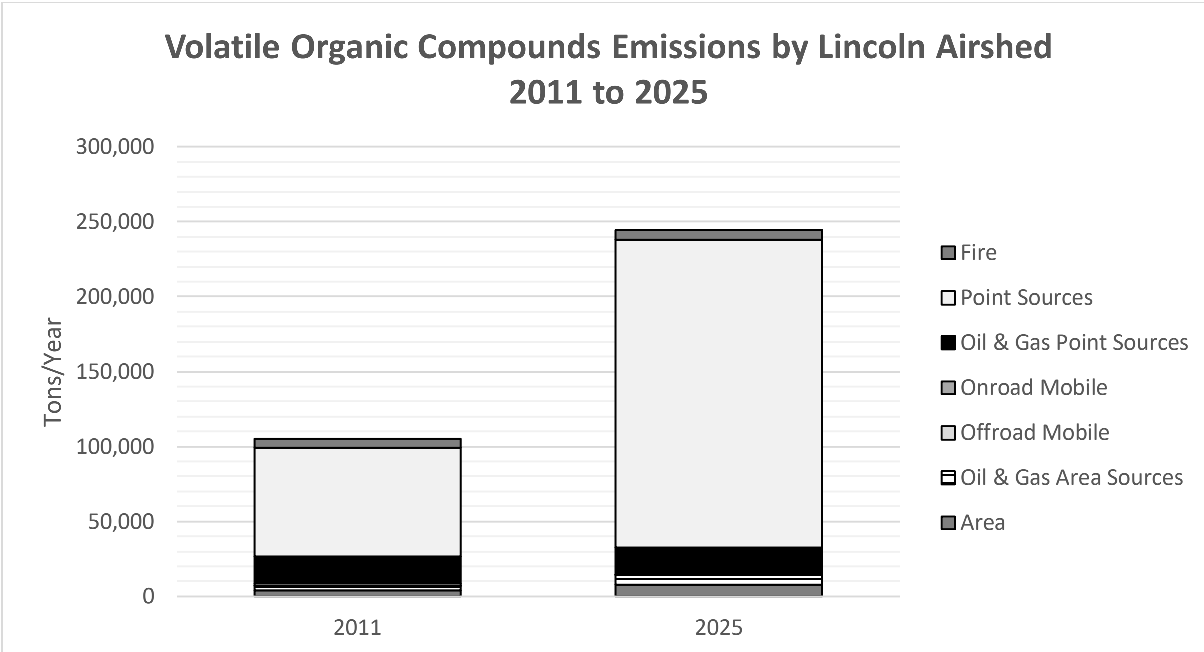

Figure 107. Baseline and projected VOC emissions

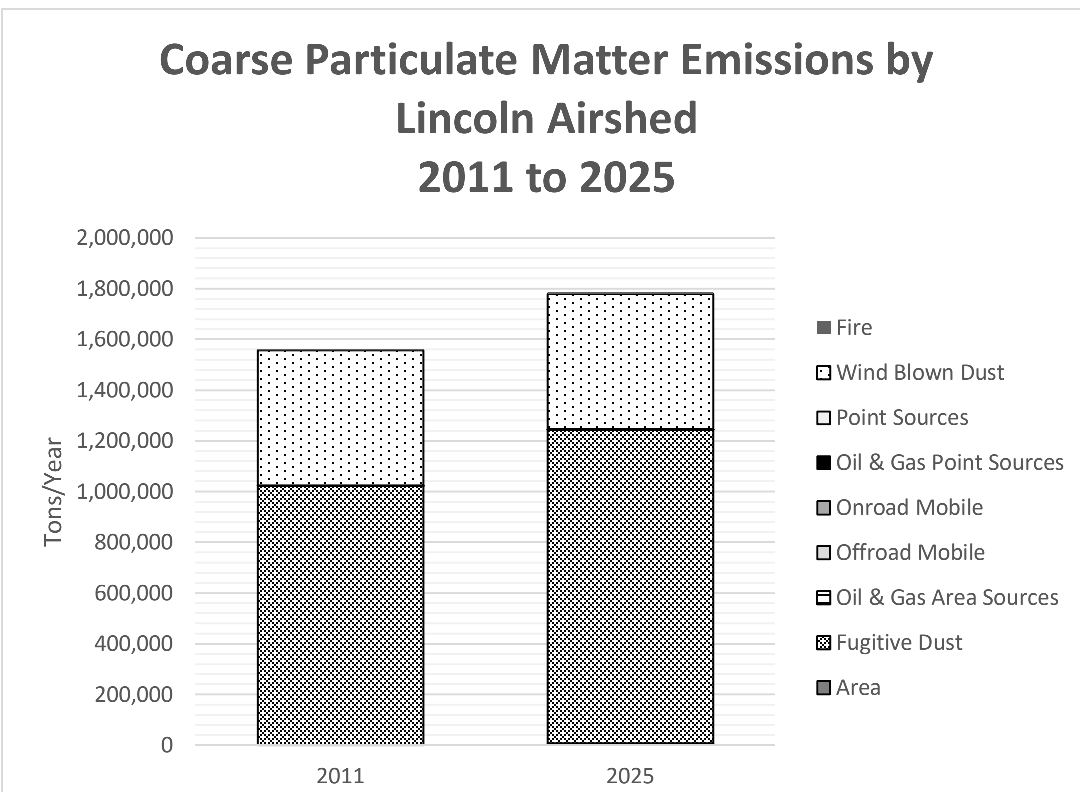

Figure 108. Baseline and projected nitrogen oxide emissions

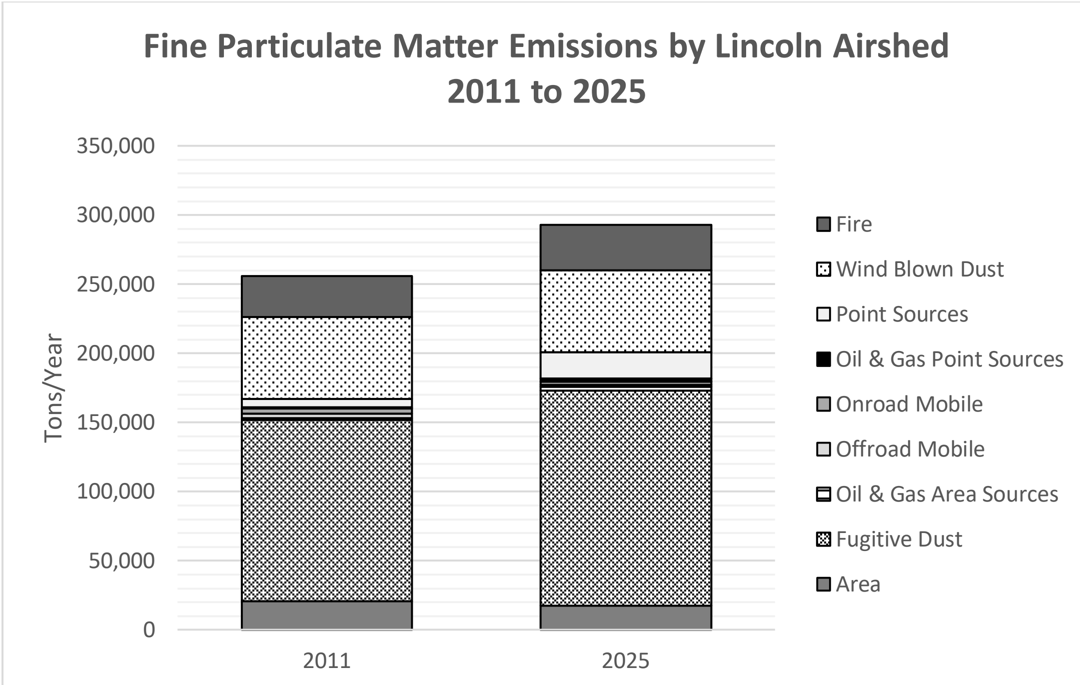

Figure 109. Lincoln airshed 2011 baseline and projected 2025 emission summaries, coarse particulate mass (top) and fine particulate mass (bottom)

The data indicate that the majority of the emissions in the Lincoln airshed originate in counties with large cities (El Paso, Texas; Las Cruces, Albuquerque, and Las Cruces, New Mexico; and Juarez, Mexico) and in counties that contain a significant amount of oil and gas development (the Permian Basin in eastern New Mexico and west Texas). Particulate emissions are dominated by fire and dust across the entire Lincoln airshed.

Trend analysis for carbon monoxide (CO) and nitrogen oxide (NOx) shows a projected decrease in emissions through 2025 for the Lincoln airshed. Most of the emissions reductions for CO and NOx emissions are the result of fewer mobile source emissions and the introduction over time of lower emitting vehicles, cleaner transportation fuels, and improved vehicle gas mileage. This is partially offset by increases in both area and point source emissions from Mexico and increases in oil and gas emission in Texas.

Sulfur oxide (SO_2) emissions are expected to increase in the Lincoln airshed, primarily driven by significant increases in point source emissions from Mexico. In 2011, Mexico point source SO_2 emission accounted for approximately 35 percent of the total emissions in the airshed and is expected to increase to over 80 percent of total emissions by 2025. During this same period, United States SO_2 emissions in this airshed are expected to decrease by approximately 37 percent.

Volatile organic compound (VOC) emissions in the Lincoln airshed are dominated by oil and gas area emission sources primarily from Texas. Further, total VOC emissions in the Lincoln airshed are projected to increase through 2025, when area oil and gas emissions in Texas are expected to increase from 41 percent to over 50 percent of total VOC emissions.

Particulate emissions, both coarse particulate matter (CPM) and fine particulate matter (FPM), are expected to increase slightly across the Lincoln airshed through 2025 by approximately 14 percent. Particulate emissions are dominated by windblown and fugitive dust and to a lesser extent by fires (wildfires, prescribed fires, and agricultural fires). Due to climatic conditions (i.e. drought, wind) particulate emissions associated with fire and dust can vary significantly over space and time. Higher temperatures and persistent drought, such as those predicted under climate change, may increase fire- and dust-related emissions (Prospero and Lamb 2003). Therefore, there is some uncertainty in estimating current conditions and trends for these emission types.

Generally, for most pollutants (CO, NOx, SO2, and VOCs) in the Lincoln airshed, mobile source emissions are decreasing in the United States. However, these improvements are largely negated by increases in emissions from oil and gas production in the Permian Basin and point sources in Mexico. There is some uncertainty in the data from Mexico in that data is only provided for area, point, and on-road mobile sources (other data for the U.S. is more detailed). Also, the State of Chihuahua is significantly larger than the smaller United States counties evaluated in the assessment. Finally, the majority of emissions for Chihuahua originate along the border where there are known air quality issues.

Ambient Air Quality

This section summarizes ambient air quality measurements collected between the years 2005 and 2014 at monitoring sites in and near the Lincoln NF. Ambient air quality data depict concentrations of air pollutants which have the potential to cause adverse health effects or adverse ecological effects. Ozone, particulate matter, and nitrogen and sulfur dioxides are assessed to determine whether these pollutants may be impacting Forest resources including visibility. The NAAQS and NMAAQs described above provide the reference condition used to assess air quality and the potential for departure for this characteristic. Where regulatory standards are met for air, there is no departure in terms of air quality.

Ozone

Ozone is one of the major components of smog. It is not emitted into the atmosphere, but is formed in reactions involving nitrogen oxides and volatile organic compounds. Elevated ozone levels can cause breathing problems, trigger asthma, reduce lung function and increase the occurrence of lung disease. Ozone also has potentially harmful effects on vegetation and can be a threat to wilderness areas. Elevated ozone may cause yellowing, reduced growth, or premature death in vegetation.

Ozone data were collected at seven sites in and near the Lincoln NF from 2009 through 2013 (USEPA 2015). Only one of these monitoring locations, the Eddy County monitor at Carlsbad Caverns National Park, is located in a rural area. The remaining monitoring sites represent urban locations yet are the nearest ozone monitoring sites to the Lincoln NF. Therefore, data from these sites likely indicate worse conditions for ozone than what exist in the Plan Area. Two monitoring sites, Carlsbad and Mount Cristo Rey, exceeded the NAAQS standard for ozone concentrations. However, all seven monitoring sites except Las Cruces showed at least one year where concentrations exceeded standards for ozone. These data indicate a potential departure from reference conditions for ozone concentrations.

Particulate Matter

As discussed in the emissions section above, most PM emissions in the Lincoln airshed are associated with fugitive and windblown dust and wildland fire. Chronic exposure to elevated PM concentrations leads to an increased risk of developing cardiovascular and respiratory diseases, including lung cancer, where the emissions contain toxic constituents such as heavy metals (WHO 2014).

Fine particulate matter data are available from two monitoring sites, Las Cruces and Hobbs, from 2009 to 2015. Coarse particulate matter data are available at two monitoring sites, Las Cruces and Franklin Mountain, from 2009 to 2015 (USEPA 2015). Similar to ozone data, particulate matter (PM) data from these sites do not necessarily represent air quality on the Lincoln NF. However, PM data from adjacent monitoring sites are evaluated as an indication of potential impacts to air quality values on the Forest (USEPA 2015).

Data from these sites indicate fine particulate matter concentrations in the Plan Area comply with NAAQS. However, the data show that coarse particulate matter concentrations in Dona Ana County, New Mexico, often exceed the NAAQS. Further, elevated coarse particulate matter is a known issue in southern New Mexico due to naturally occurring, windblown dust. Therefore, while the Lincoln NF occurs outside of Dona Ana County, it is possible that similar conditions exist on the Forest.

Nitrogen Dioxide and Sulfur Dioxide

Nitrogen and sulfur dioxides occur as a result of fuel combustion, including industrial or commercial emission sources such as power generation facilities, automobiles, or aircraft. Sulfur dioxide emissions may also result from smelting and refining of copper ores, due to the liberation of sulfur compounds contained in the ore body. Both pollutants are also linked to the formation of nitrate and sulfate aerosols, which have potential adverse effects on visibility and increases in acid deposition.

Health effects from exposure to elevated concentrations of nitrogen oxide include inflammation of the airways for acute exposures and increases in the occurrence of bronchitis for children and other sensitive individuals chronically exposed to elevated levels (WHO 2014). Health effects from sulfur dioxide exposure include changes in pulmonary function and increases in respiratory symptoms along with irritation of the eyes. Inflammation of the respiratory tract may result in coughing, mucus secretions, and aggravation of asthma and chronic bronchitis. Persons exposed to elevated sulfur dioxide levels are also more prone to infections of the respiratory tract (WHO 2014).

Nitrogen dioxide monitoring data are available for the Carlsbad site from 2009 to 2015 (USEPA 2015). Again, the data were assessed as an indication of nearby air quality with potential implications for ecological integrity in the Plan Area. These data indicate that ambient nitrogen dioxide comply with NAAQS. Sulfur dioxide monitoring data are currently not available for the region of interest.

Visibility

Visibility refers to conditions that permit an appreciation of the landscape in terms of form, contrast, detail and color of near and distant features. Particulate and gaseous air pollutants can interfere with the ability to see and distinguish landscape features. Visibility was recognized and valued as early as 1977 under Clean Air Act amendments including the Class I provision for wilderness areas. Pursuant to the Act, the National Visibility Goal is to return visibility in Class I areas to "natural background conditions" no later than 2064. To meet this goal, the Act requires measures for emissions control for large stationary sources that contribute to visibility impairment.

For the purpose of this assessment, data from the White Mountain Wilderness and Guadalupe Mountains National Park IMPROVE monitoring sites are analyzed due to proximity to the Forest (White Mountain is within and Guadalupe is adjacent to the Lincoln NF). Presented below are IMPROVE data from 2001 to 2014 for the White Mountain Wilderness monitoring site for the 20 percent worst-case (haziest) days, the 20 percent clearest days, and what natural conditions should look like without anthropogenic impacts (Figure 109) (FED 2016). The 2064 National Visibility Goal for achieving natural conditions is represented by the red-hatched line. These data provide a measure of visibility improvement needed to achieve National Visibility Goal in this Class I area.

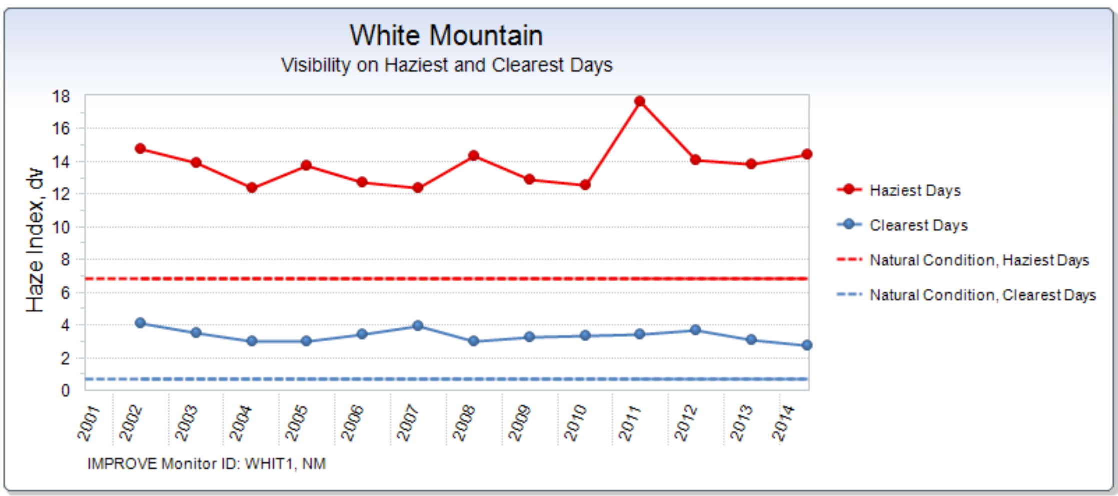

Figure 110. IMPROVE visibility monitoring data for the White Mountain monitoring site

In general, IMPROVE data for both the White Mountain Wilderness and Guadalupe Mountains National Park sites indicate relatively good visibility conditions, except for the 20 percent haziest days. The general trend in visibility is toward a moderate improvement in conditions on the clearest days with slightly hazier conditions on the haziest days. Visibility conditions at both sites are similar, though the clearest days show decreased visibility and occur more often at the more southern part of the Forest, near and downwind of the El Paso-Juarez metro area. Analysis of pollutants indicate that the haziest days are a result of ammonium sulfate (typically associated with industrial and mobile pollution), coarse mass (typically associated with windblown and fugitive dust), and organic carbon (typically associated with wildfire smoke).

Atmospheric Deposition

Nitrogen and Sulfur

Air emissions of nitrogen oxides and sulfur dioxide can lead to atmospheric transformation of these pollutants to acidic compounds including nitric acid and sulfuric acid. Nitrogen compounds can act as a fertilizer and its deposition onto land and water surfaces can result in negative ecological effects. Documented effects of nitrogen and sulfur deposition include acidification of lakes, streams and soils, leaching of nutrients from soils, injury to high-elevation forests, changes in terrestrial and aquatic species composition and abundance, changes in nutrient cycling, unnatural fertilization of terrestrial ecosystems, and eutrophication of aquatic ecosystems. At certain concentrations, nitrate is also toxic to humans including infants which are the most vulnerable.

Deposition impacts are generally described in terms of the critical load, defined as “the quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment are not expected to occur based on present knowledge” (NADP 2009). In other words, critical load determines the tipping point at which harmful effects start to occur to an ecosystem due to pollutant deposition. Critical loads have been established at some, but not all, wilderness areas in the United States. For the Lincoln NF, critical loads for nitrogen and acid deposition have been established based on a national-scale assessment, as discussed below, but site-specific data are lacking for a robust assessment (Pardo 2011, Pardo, Robin-Abbott et al. 2011).

Nitrogen and sulfur deposition data have been collected at two monitoring stations near the Lincoln National Forest from 1984 to 2014 (Figure 110 through Figure 113). These include the Mayhill and Guadalupe Mountains National Park National Atmospheric Deposition Program (NADP) monitoring sites operated for the National Trends Network (NADP 2015). Totals are shown for wet deposition for both nitrogen and sulfur. Wet deposition accounts for just a portion of the deposition on the Forest; there are no monitors on the Lincoln NF that measure dry deposition. Therefore, the data likely underestimate deposition levels occurring on the Forest.

From 1984 to 2014, inorganic nitrogen deposition has been fairly constant, with no noticeable trend, while sulfur deposition has decreased significantly. Increased nitrogen and sulfur deposition rates at the Guadalupe Mountains National Park site is consistent with IMPROVE monitoring results discussed above, suggesting higher nitrogen and sulfur deposition in the southern part of the Forest. These conditions may be attributable to pollutant transport from Mexico and the El Paso-Juarez metro area and nearby oil and gas development in the Permian Basin. Given that nitrogen emissions are expected to decrease in the Lincoln airshed over time, nitrogen deposition would also be expected to decrease in the near future in the Plan Area. Despite regulations for addressing sulfur emissions, the overall trend for sulfur deposition in the Lincoln airshed suggests that this pollutant may increase in the Plan Area.

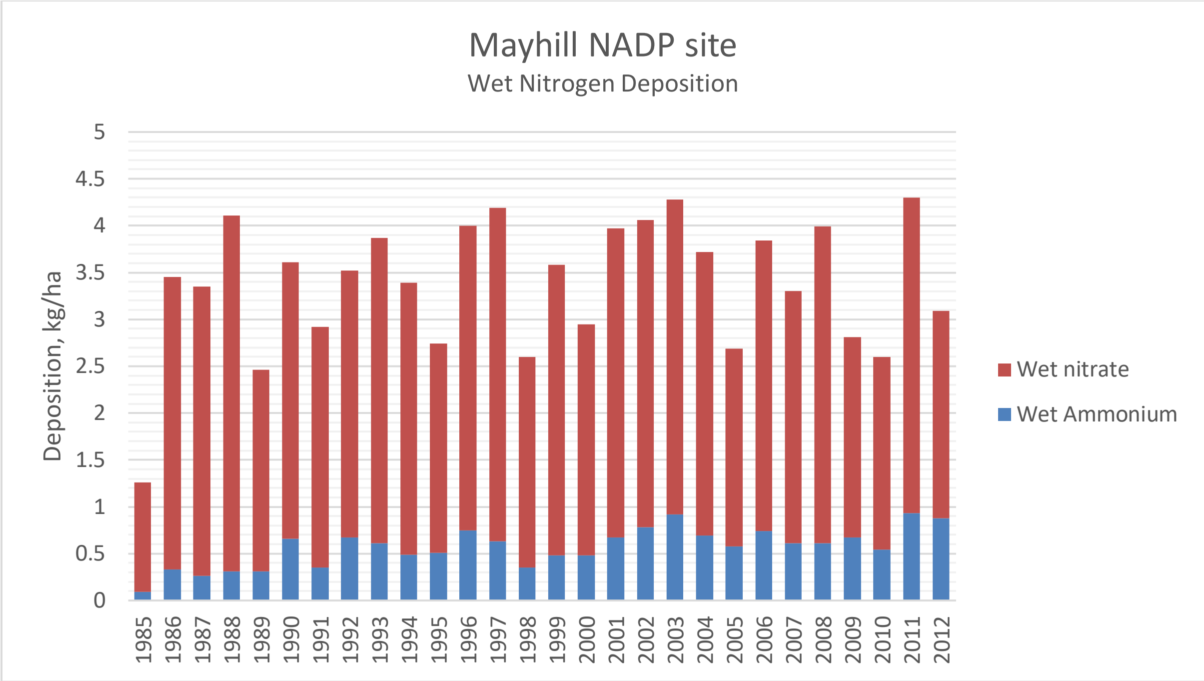

Figure 111. Wet nitrogen deposition (Mayhill NADP site, 1985-2012)

(Data obtained from http://nadp.sws.uiuc.edu/data/sites/map/?net=NTN)

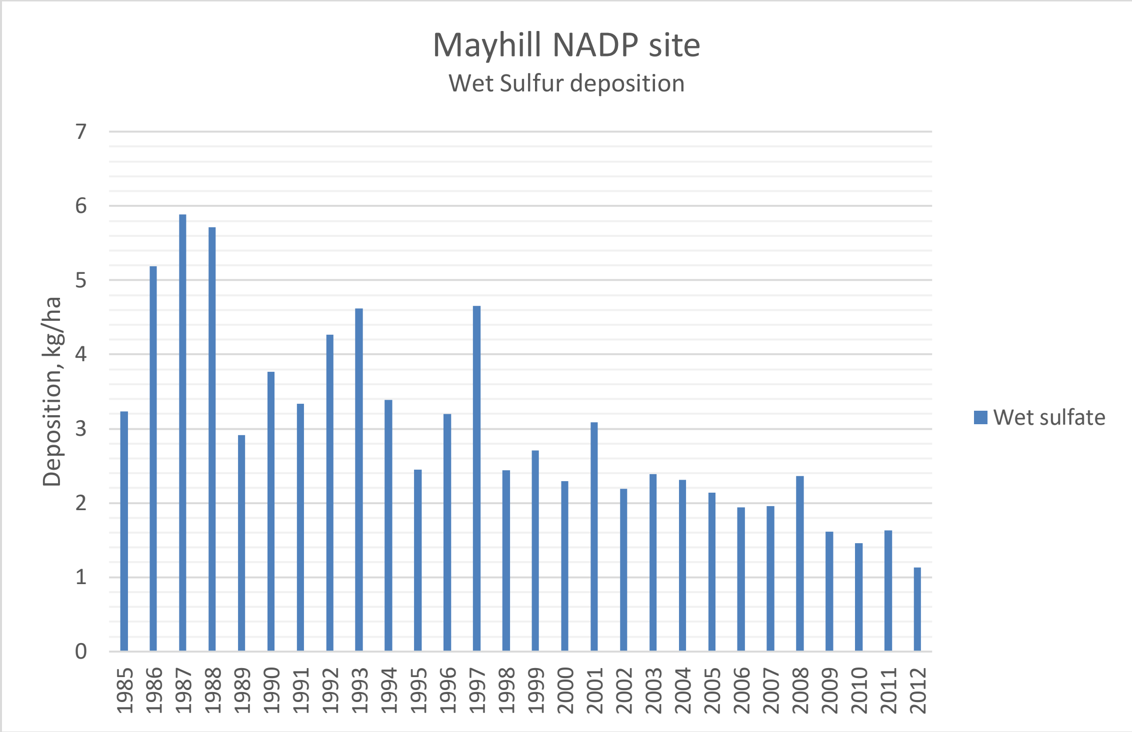

Figure 112. Wet sulfur deposition (Mayhill NADP site, 1985-2012)

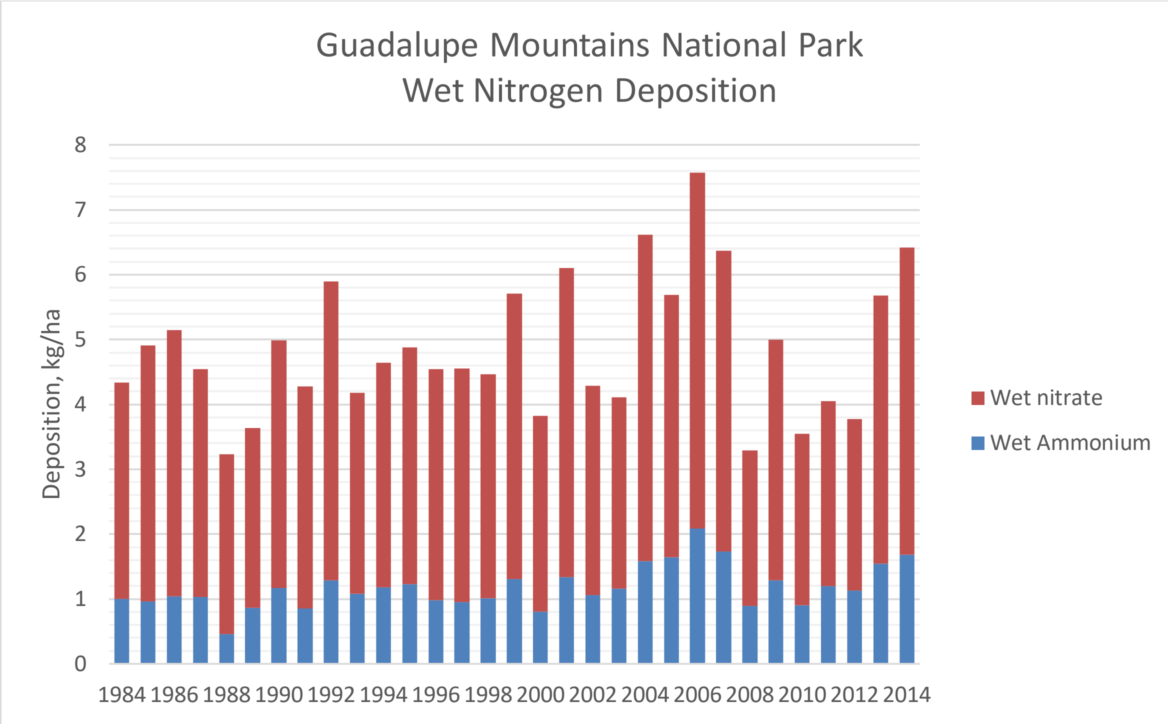

Figure 113 Wet nitrogen deposition (Guadalupe Mountains NADP site, 1984-2014)

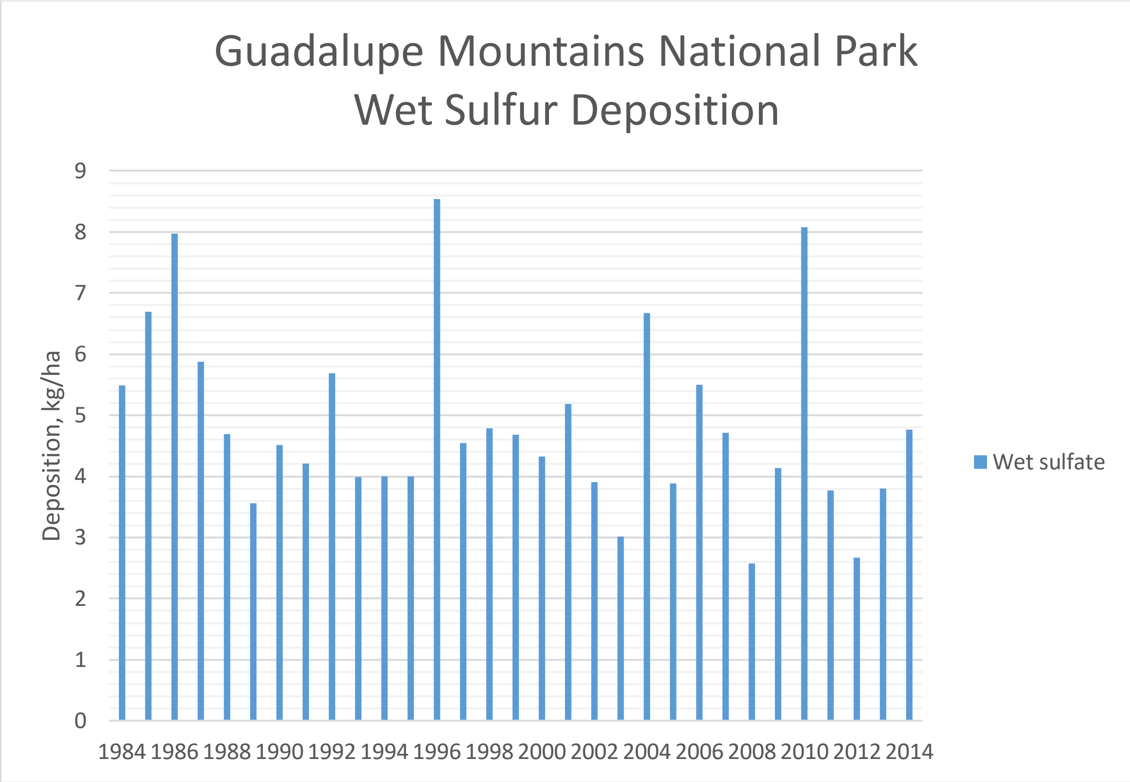

Figure 114 Wet sulfur deposition (Guadalupe Mountains NADP site, 1984-2014)

Mercury

Mercury is a toxin which can persist in the environment for long periods of time, cycling between air, water and soil. Mercury falls on the earth's surface through wet or dry deposition and can accumulate in the food chain and bodies of water. Toxic air contaminants like mercury, are emitted primarily by coal-fired utilities, and may be carried thousands of miles before entering lakes and streams as mercury deposition. Mercury can accumulate and become concentrated in the food chain via fish, animals, and humans. Eating fish is the main way that people are exposed to methylmercury, a potent neurotoxin known to have detrimental effects to human health behavioral and reproductive health in wildlife. Nearly every state including New Mexico has consumption advisories for certain lakes and streams regarding mercury-contaminated fish and shellfish. Mercury is the number one cause of impairment in New Mexico Lakes (NMED 2012), and many of the lakes on or near the Lincoln NF are subject to consumption advisories for mercury for some species of fish.

The Mercury Deposition Network collects and provides a long-term record of mercury concentrations and deposition in precipitation. As a result of coal-fired utilities in the Southwest, and the limited levels of mercury pollution controls at those sites, the total concentration of mercury in the air in the Southwest is fairly high relative to other areas in the United States (MDN 2013). However, due to the relatively low precipitation rates except at higher elevations, mercury from wet deposition is comparatively low (MDN 2013).

Monitoring data for mercury deposition is currently unavailable in or near the Lincoln NF, so it is difficult to assess conditions and trends in the Plan Area. Other information suggests both an increase and decrease in mercury deposition over time. As discussed above, new regulatory controls at a few regional coal fired power plants should reduce the total mercury emissions over the next several years. However, these gains may be negated as sulfur emissions and deposition are projected to increase over time. As sulfates increase in aquatic systems, sulfur reducing bacteria will reduce more sulfur, and this will lead to more inorganic mercury being methylated. Based on this information, the overall trend in mercury deposition on the Forest is expected to be stable.

Ozone

Ground-level ozone interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, drought, and higher temperatures. Some plants have been identified as particularly sensitive to the effects of ozone and are reliable indicators of toxic levels of the pollutant on plant growth. Ozone levels have not been directly measured on the Lincoln NF, nor have any studies been conducted to evaluate effects to Forest vegetation from ozone.

Critical Loads

As discussed above, critical loads describe the threshold of air pollution deposition below which there are no significant harmful effects to ecosystems. Critical loads are based on scientific information for expected ecosystem responses to a given level of atmospheric deposition. Air pollution emitted from a variety of sources is deposited from the air into ecosystems. These pollutants may cause ecological changes, such as long-term acidification of soils or surface waters, soil nutrient imbalances affecting plant growth, and loss of biodiversity. For ecosystems impacted by air pollution, critical loads help determine the degree of improvement in air quality needed for recovery. Similarly, in ecosystems where critical loads have not been exceeded, critical loads help determine requirements for maintaining and protecting those areas into the future.

U.S. scientists, air regulators, and natural resource managers have developed critical loads for areas across the United States through collaboration with scientists developing critical loads in Europe and Canada. Critical loads can be used to assess ecosystem health, inform the public about natural resources at risk, evaluate the effectiveness of emission reduction strategies, and guide a wide range of management decisions.

Currently, critical load information relevant to the Plan Area is limited to research conducted in the Temperate Sierras ecoregion (which includes the Lincoln NF) for a national-scale critical loads assessment. Research was conducted to determine whether critical loads were exceeded for nutrient nitrogen (Pardo 2011, Pardo, Robin-Abbott et al. 2011), acidity to forested ecosystems (McNulty, Cohen et al. 2007), and acidity to surface water (Lynch, Pardo et al. 2012). Nutrient nitrogen critical load information for the southwest United States is scarce and the effects of nitrogen deposition and its effects are little known. Currently, nitrogen critical loads are only available for lichens, herbaceous, and grass communities, as described below. Critical loads are not available for mercury or ozone on the Lincoln NF.

Nutrient Nitrogen

While increased nitrogen may increase productivity in many terrestrial ecosystems which are typically nitrogen- limited, it is not necessarily desirable in protected ecosystems or where natural ecosystem function is desired. Excess nitrogen can lead to an imbalance of nutrients, changes in species composition, and ultimately declines in forest health.

Lichens contribute to biodiversity of ecosystems and are some of the most sensitive species to nitrogen deposition (Pardo 2011, Pardo, Robin-Abbott et al. 2011) and are, therefore, an important early indicator of impacts from air pollution. As noted above, critical loads for lichens are based on research for the Temperate Sierras ecoregion and expert judgment. Based on these values, 14 percent of the Lincoln exceeds critical loads for lichens. In 2013 and 2014, the Forest Service and researchers collected lichen tissue for elemental analysis at 4 locations in or near the White Mountains Wilderness. Based on analysis of that data, 6 of the 8 species analyzed showed elevated levels of nitrogen (St. Clair 2014).

Herbaceous plants and shrubs comprise the majority of the vascular plants in North America (USDA Forest Service 2010). They are less sensitive to nitrogen deposition than lichens; however, they are more sensitive than trees due to rapid growth rates, shallow roots, and shorter life span (Pardo 2011, Pardo, Robin-Abbott et al. 2011). Currently, there are no established critical loads for nitrogen in herbaceous plants and shrubs for the Lincoln NF. However, critical loads for herbaceous plants and shrubs for the North American Deserts ecoregion indicates impacts may occur with critical loads in the range of three to 8.4 kilograms per hectare per year, including changes in vegetation composition, an increase in biomass of invasive grasses, and a decrease in native forbs (Inouye 2006, Allen, Rao et al. 2009, Rao, Parker et al. 2009, Rao, Allen et al. 2010).

Currently, there are no critical loads for nutrient nitrogen for mycorrhizal fungi in the Lincoln NF, nor is there other relevant scientific information to help make this determination. Mycorrhizal fungi reside in the ground, between plants roots and the soil. They play an important ecological role in a symbiotic relationship with host plants by exchanging nutrients and minerals for carbon. Atmospheric deposition of nitrogen exceeding the critical load can alter community structure and composition, root colonization, and decrease species richness (Pardo 2011, Pardo, Robin-Abbott et al. 2011).

Currently, there are no critical loads for nutrient nitrogen for forested ecosystems in the Lincoln NF, nor is there other relevant scientific information to help make this determination. Adding nitrogen to forests can have adverse effects such as increased soil acidification, biodiversity impacts, susceptibility to secondary stressors (freezing, drought, insects), changes in growth, and increased mortality (Pardo 2011, Pardo, Robin-Abbott et al. 2011). As atmospheric nitrogen deposition onto forests and other ecosystems increases, the enhanced availability of nitrogen can lead to chemical and biological changes collectively called “nitrogen saturation.”

Currently, there are no critical loads for nutrient nitrogen for nitrate leaching in the Lincoln NF, nor is there other relevant scientific information to help make this determination. Atmospheric deposition of nitrogen can saturate some terrestrial ecosystems leading to nitrate leaching. High alpine lakes are particularly susceptible due to limited retention of nitrogen as a result of little vegetation, poorly developed soils, short hydrologic residence time and, steep topography .

Acid

The potential for impacts from acid deposition on forests in the United States has been recognized for more than 30 years. Research has shown that deposition of nitrogen and sulfur results in acidifying effects with negative effects to ecosystem health including aquatic resources, forest sustainability, and biodiversity (McNulty, Cohen et al. 2007). Acidifying effects can lead to mortality of tree species, reduced forest productivity, reduced biological diversity, and increased stream acidity (Driscoll, Lawrence et al. 2001).

Multiple factors influence acidic conditions in forested ecosystems. These include soil condition and composition including organic matter and base cations content (i.e., calcium, potassium, magnesium, and sodium), all of which play a role in buffering (neutralization) of soils against acid deposition. Also important are the tree species present due to variable rates in uptake of nitrogen and base cations by species, which can either counteract effects of acid deposition or reduce soil buffering capacity. In conifer forests, with needle breakdown, soils are naturally acidic thereby increasing the system’s vulnerability to acidification. Another important factor is the rate at which sulfur and nitrogen compounds are deposited on the ground (wet or dry) due to emissions and air pollution. Finally, elevation influences acidity due to increased precipitation at higher elevations and a concurrent increase in the rate of acid deposition.

This assessment of critical acid load for the Lincoln NF was based on research and estimated critical loads and exceedances for forested soils across the United States (McNulty, Cohen et al. 2007) and surface water critical acid loads (Lynch, Pardo et al. 2012). The data indicate there are no exceedances of acid critical loads on the Lincoln NF, similar to the rest of New Mexico and other parts of the western United States.

Likewise, water quality and pH data indicate there are no impaired surface waters associated with acidification on the Lincoln NF (NMED 2014). Stream and lake acidification can occur as result of acid gas deposition, reducing the pH of surface water and a subsequent reduction in the diversity and abundance of aquatic species. As described above for soils, multiple factors contribute to acidification of surface water. Surface water acidification begins with acid deposition in adjacent terrestrial areas (Pidwirny 2006) and is influenced by the system’s capacity to neutralize it before leaching into surface water.

Risk

Air quality and the ecosystem services provided by air are generally stable but are at moderate risk based on current conditions and trends for air quality measures on the Lincoln NF (Table 163). A moderate risk to air quality exists due to:

- A decreasing trend in pollutants of concern including sulfur dioxide, coarse particulate matter, and ozone;
- An exceedance in nitrogen for critical loads for lichen species;
- Fairly stable visibility over the last 10 years; and
- Air quality within regulatory levels for National Ambient Air Quality Standards (NAAQS), although the trend based on projected emission inventories is of concern for ozone, coarse particle pollution, and sulfur dioxide.

Table 163. Summary of conditions and trends of air quality measures; and reliability of data, modeling, and conclusions

Air Quality Measure	Current Conditions	Trend	Reliability
NAAQS[a]			
CO	Good	Improving	High
NO_2	Good	Stable to Improving	High
SO_2	Good	Declining	High
Pb	Good	Stable	High
O_3	Good	Declining	High
$PM_{2.5}$	Good	Stable to Declining	High
PM_{10}	Marginal	Stable to Declining	High
Visibility[b]			
Visibility	Departed	Stable	High
	Critical Loads- Deposition[c]		
Nutrient Nitrogen			
Lichens	Low risk	Improving	Moderate
Herbaceous Plants and Shrubs	Unknown	Improving	Low
Mycorrhizal Fungi	Unknown	Improving	Low
Forests	Unknown	Improving	Low
Nitrate Leaching	Unknown	Improving	Low

Air Quality Measure	Current Conditions	Trend	Reliability
Acid Deposition			
Soils	Good	Improving	Low
Surface Water	Good	Stable to Improving	Moderate
Deposition (other)			
Mercury	Low risk	Stable	Low
Ozone	Unknown	Unknown	N/A

[a] Relative to NAAQS

[b] Relative to 2064 Regional Haze Goal

[c] Level of risk, is based on the extent of potential impact on the Forest. Break points are 0-33 percent- Low risk; 34-66 percent- Moderate risk; and 67-100 percent- High risk. Where there is conflicting data, data are limited, or uncertainty is high, best professional judgment was used to assign risk.

Reliability of data, modeling, and conclusions are summarized above (Table 162). There are many factors that contribute to the reliability and confidence of an assessment. Typically, a collection of direct measurements taken over time will provide the greatest level of confidence regarding the current state and trends of air quality. In the absence of direct measurements, models can assess relative risk of systems due to air pollution, but this creates greater uncertainty in the results. In addition, model assumptions as well as how they perform in a given environment determine confidence levels.

Direct measurement data over time are available for ambient air quality, visibility, and deposition. However, there are limited studies from the Lincoln NF that directly measure impacts from air pollution on forest health, such as lichen surveys. Modeled results currently available indicate a very low risk from nitrogen deposition to lichen communities on the Lincoln NF, while some recent research indicate elevated levels of nitrogen in lichen samples. Very little research has been conducted on the effects of nitrogen deposition on ecosystems similar to the Lincoln NF. Further, modeled atmospheric nitrogen deposition estimates and critical loads are influenced by several factors, including the difficulty of quantifying dry deposition on complex mountainous terrain in arid climates with sparse data (Pardo et al. 2011), all of which exist on the Lincoln NF. At this time, there is a fair amount of uncertainty with the critical load estimates, resulting in a low level of confidence for their assessment.

Research is limited related to critical loads on the Forest, and there is significant uncertainty in the assessment regarding the magnitude of impacts from nitrogen deposition. The primary results in the assessment were based on modeled critical loads and have not been verified on the Forest. The rate of deposition of nitrogen, which can lead to impacts affecting forest health, appear to be decreasing based on projected emissions in the airshed. Modeled results also indicate that the levels of acid gases are not at levels significant enough to result in impacts to either soils or surface water. There are no direct measurements on the Forest that indicate otherwise. There is some indication that mercury deposition at higher elevations on the Forest may be significant, however, atmospheric mercury, based on regional emissions, is also expected to decrease.

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments included concern about air quality. Additional comment topics that may be related to air resources are listed in the Stakeholder Input sections of the other chapters in this volume, as pertinent. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for regional office approval prior to finalizing it.

Summary of Findings for Air Resources

Air quality and the values dependent on air quality on the Lincoln NF are generally in good condition or are improving as most pollutants are decreasing; however, visibility and ambient air quality conditions associated with particulate matter are expected to continue to have episodic periods of very high levels—as a result of wildfires and increases in fugitive dust due to the effects of climate change. Also, impacts from emissions along the US-Mexico border are a significant concern and also an area of significant uncertainty in terms of the magnitude and subsequent impacts. Lastly, modeled critical loads from nitrogen deposition are insufficient to assess the full range of possible impacts to the ecosystems potentially affected.

Chapter 9 - Carbon Stocks

Introduction

The emission of greenhouse gases (GHGs) by human activities and natural processes contribute to the warming of the Earth's climate. Warming could have significant ecological, economic, and social impacts at regional and global scales (IPCC, 2007). In 2005, US forests were estimated to be sequestering nearly 220.5 million tons of carbon (Cameron et al., 2013), suggesting that forests and woodlands of the Southwest could have a significant role to play in the sequestration of carbon and climate change mitigation. The USDA Forest Service has directed a baseline assessment of carbon stocks as part of the Forest Plan revision assessment process (36 CFR 219.6(b)(4)).

In this chapter, the major carbon components of Southwest ecosystems are considered including biomass, carbon emissions, and soil organic carbon. Some estimates are provided for biomass and soil carbon on the Lincoln NF in southern New Mexico. At present, the carbon emissions component has been characterized by using a case study synthesis from the Apache-Sitgreaves NF. The description of other carbon components, such as forest products, would provide a fuller accounting of carbon stocks and flux. This is not currently available for Lincoln NF; only the major components, biomass, emissions, and soil carbon, are included in this assessment.

Analysis and Findings- Conditions, Trends and Sustainability of Carbon Stocks

Vegetation Carbon (Biomass Carbon)

Vegetative biomass serves an integral component in forest carbon cycles. Forest vegetation, through the process of photosynthesis, converts atmospheric carbon dioxide to carbohydrates (referred to as carbon fixation). These carbohydrates (sugars) are used by plants to grow both aboveground biomass in the form of stems and leaves, and belowground biomass in the form of roots and tubers. Conversely, through the process of decay, dead plant material slowly releases carbon into the atmosphere as it decomposes. Total carbon stored in vegetative biomass is referred to as the biomass carbon stock, and this is a value that changes through time. The primary influences on biomass carbon stock are plant growth (primary productivity) which serves to increase biomass carbon stock, decay and decomposition which slowly decreases biomass carbon stock, and disturbance in the form of fire and harvest. Wildland fire provides a major source of carbon emissions in a forest setting, and is discussed in detail in the carbon emissions section of this document. Biomass harvest plays a varying role in carbon emissions, depending largely on the use of the wood products. For example, wood products utilized as saw timber in construction tends to provide long term carbon storage with slow release, while wood products used as fuelwood and burned for heat provide increased carbon emissions into the atmosphere. As forest and grassland ecosystems are constantly changing through natural succession and disturbance, biomass carbon stock also changes through time. This section will focus on biomass carbon stocks over time on lands of the Lincoln National Forest (NF). For the purpose of this chapter, biomass carbon stock includes aboveground live biomass, standing dead biomass, downed woody debris, litter and duff, and belowground live biomass (in forest and woodland systems; not yet quantified for grassland and shrubland systems). Belowground nonliving plant material is considered in soil organic carbon. The methods for deriving biomass values for seral states within forest and woodland ecosystems are included in the Carbon Assessment Methods report on file at the Supervisor's Office for the Lincoln NF, and below for seral states within grassland and shrubland systems.

The Lincoln NF can be stratified into ten major ecosystem types referred to as ecological response units or ERUs (Table 164). Each ERU contributes differently to carbon stocks and their flux based on its spatial extent, vegetation community composition and structure, and ecosystem dynamics. Generally speaking, relative contributions to carbon stocks are lowest in desert and grassland ERUs, with increasing contributions by shrubland, woodland, and forest ERUs, respectively.

Table 164. Major Ecological Response Units on the Lincoln NF in acres and percent

System Type	Ecological Response Unit	ERU Code	Acres	Percent of Lincoln NF
Grassland	Montane Subalpine Grasslands	MSG	11,230	1.0%
	Semi-Desert Grassland	SDG	65,888	6.0%
Shrubland	Mountain Mahogany Mixed Shrubland	MMS	52,528	4.8%
Woodland	Juniper Grassland	JUG	9,755	0.9%
	Piñon Juniper Grassland	PJG	165,432	15.0%
	Piñon Juniper Evergreen Shrub	PJC	53,976	4.9%
	Piñon Juniper Woodland	PJO	319,105	28.9%
Forest	Ponderosa Pine Forest	PPF	123,156	11.2%
	Mixed Conifer – Frequent Fire	MCD	163,674	14.8%
	Mixed Conifer with Aspen	MCW	35,568	3.2%
Non-Major ERUs (each <1% of Lincoln NF extent)		various	103,129	9.3%
	Total Area of Major ERUs on Lincoln NF		1,000,312	90.7%
	Total Area of Lincoln NF Plan Area		1,103,441	

The figures and tables presented in this chapter represent carbon stock for current conditions, reference conditions, and for all major ERUs, modeled future conditions under current management intensities. Each ERU is referred to by its assigned two- to three-letter code; for reference, these appear in the third column of Table 164.

It is worthwhile to consider changes in biomass carbon stocks in two ways. Looking at the percent change within an ERU reveals information about the degree of change within that ERU alone. However, ERUs vary greatly in their reference biomass carbon stocks, and a large percent change in one ERU may not translate to as many tons of carbon as a smaller percent change in another ERU. The impact of the percent change per ERU on overall biomass carbon stock levels also depends on the spatial extent of the ERU on the Lincoln NF. Looking at the tonnage of biomass carbon on its own reveals a clearer portrait of the actual amount of carbon stored in each ERU and accounts for spatial extent, but these figures on their own do not adequately reflect the degree of change within the ERU. Both aspects are presented below.

Reference and Current Conditions/Trends

Carbon stock values are presented below both by ERU and collectively for the Lincoln NF. For each seral state in each ERU, carbon stock coefficients were assigned based on either information gleaned from the scientific literature and Web resources (for desert, grassland, and shrubland ERUs: Boyd and Bidwell 2001; Brooks and Pyke 2001; Scott and Burgan 2005; USDA Forest Service 2012) or (for woodland and forest ERUs) from Forest Inventory and Analysis (FIA) sample data and the carbon submodel of the Forest Vegetation Simulator (Weisz et al. 2010) – Fire and Fuels Extension (Rebain et al. 2015). Carbon stock totals for each ERU are derived by multiplying the current or forecasted total acreage in each seral state by the corresponding carbon coefficient, and summing across all seral states.

The current total biomass carbon stock on the Lincoln NF is about 87 percent of that present in reference conditions in its major ERUs, which translates to almost 3.6 million tons under the historic 28 million tons (Table 165). While this overall change from reference condition biomass carbon levels is not great, a more complete picture can be drawn by looking at the relative contributions from individual ERUs and the percent departure for each (Table 166).

Table 165. Biomass carbon stock per ERU in reference and current conditions

System Type	ERU	Reference Condition (tons)	Current Condition (tons)	Percent Departure from Reference Condition
Grassland	MSG	40,710	246,211	505%
	SDG	202,778	228,217	13%
Shrubland	MMS	924,249	1,254,399	36%
Woodland	JUG	141,959	72,531	-49%
	PJG	2,350,098	1,288,167	-45%
	PJC	655,209	518,976	-21%
	PJO	6,999,133	3,652,535	-48%
Forest	PPF	3,997,649	3,712,295	-7%
	MCD	9,599,458	10,681,475	11%
	MCW	3,120,204	2,784,386	-11%
	Totals	28,031,447	24,439,190	-13%

Note: Shading in orange indicates an increase in carbon stock, and shading in blue indicates a reduction in carbon stock. In both cases, deeper hues reflect greater departure from reference conditions.

Future Conditions/Trends

Vegetation conditions on the Lincoln NF have been modeled into the future for most of its predominant ERUs using State and Transition Modeling (STM), including assumptions based on current management and disturbance patterns[2]. This allows the projection of relative biomass carbon contributions through time for key ERUs. Using past observations of vegetation dynamics for future projections is admittedly problematic in light of projected climate changes. Many additional factors will influence future carbon stocks on the Lincoln NF, and this assessment is in no way a comprehensive accounting of all possible outcomes. Factors such as climate change, fire frequency and severity, and management budgets are all outside the control of Lincoln forest managers, and as such, this assessment may be useful in conveying only broad patterns and trends. However, the general ecosystem dynamics in southwestern systems which underlie our STMs are

[2] Modeling was conducted by the Lincoln National Forest and Region 3 staff, April – July 2016.

fairly well understood, and the model projections provide a good starting point for assessing trends in biomass carbon stocks.

Figure 114 and Table 166 depict the results of 100-year projections for primary Lincoln NF ERUs, paired with current and reference condition biomass carbon stocks. These projections assume a continuation of current management, and are not reflective of changes in management that may emerge from the Lincoln's ongoing effort to revise its land management plan.

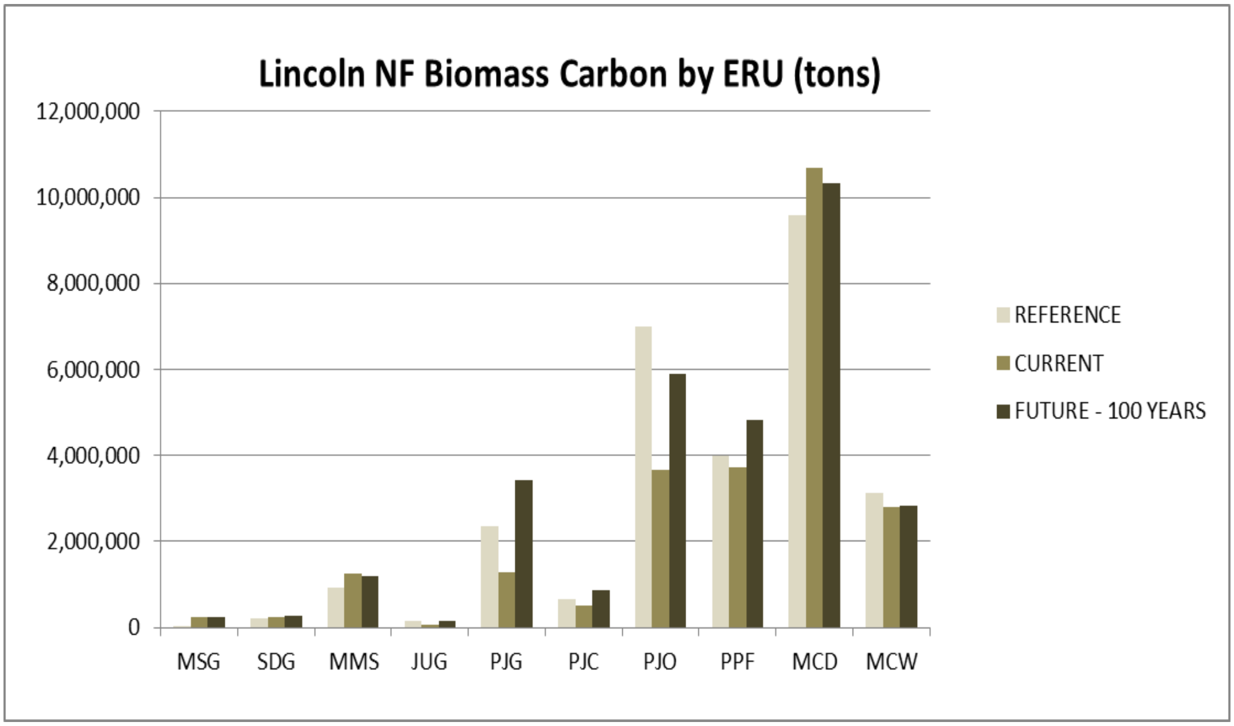

Figure 115 Trends in Carbon Stocks for Lincoln NF ERUs

Table 166. Reference, current and projected carbon biomass for major ERUs of the Lincoln NF

	Reference Condition		Current Condition			100 Year Projection			
ERU	Avg. Tons / Acre	Total Tons	Avg. Tons / Acre	Total Tons	% Difference from Reference	Avg. Tons / Acre	Total Tons	% Change from Current	% Difference from Reference
MSG	4	40,710	22	246,211	505%	21	237,013	-4%	482%
SDG	3	202,778	3	228,217	13%	4	273,026	20%	35%
MMS	18	924,249	24	1,254,399	36%	23	1,182,568	-6%	28%
JUG	15	141,959	7	72,531	-49%	16	154,863	114%	9%
PJG	14	2,350,098	8	1,288,167	-45%	21	3,427,038	166%	46%
PJC	12	655,209	10	518,976	-21%	16	849,776	64%	30%
PJO	22	6,999,133	11	3,652,535	-48%	19	5,905,591	62%	-16%
PPF	32	3,997,649	30	3,712,295	-7%	39	4,833,702	30%	21%
MCD	59	9,599,458	65	10,681,475	11%	63	10,333,954	-3%	8%
MCW	88	3,120,204	78	2,784,386	-11%	79	2,815,654	1%	-10%
Total	**28**	**28,031,447**	**24**	***24,439,190***	**-13%**	**30**	***30,013,186***	***23%***	**7%**

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments relating to carbon stocks and their conditions, trends, and issues included these topics: dense, overgrown forests susceptible to insect infestations and severe fires and associated carbon releases; carbon in residual slash on the Forest; not utilizing small diameter trees for forest products; prescribed fires by the Forest Service are limited in size and effectiveness; unmanaged carbon loads in wilderness areas; and Species of Conservation Concern (SCC) and Endangered Species Act (ESA) species contribute to the carbon load problem due to management restrictions and burdens on timber harvest operations. Expressed values included a desire for a balanced carbon cycle and carbon sequestration with benefits to communities and human safety. Additional comment topics that may be related to carbon stocks are listed in Stakeholder Input sections of other chapters in this volume, as pertinent. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for regional office approval prior to finalizing it.

Chapter 10 – At-Risk Species

Introduction

The Lincoln NF consists of several mountain ranges that are surrounded by low basins and plains, isolating their montane forests as sky islands, distant from other high ranges. The ranges encompassed within Lincoln NF, along with a couple small highlands in west Texas, represent the extreme south and eastern extent of spruce-fir and mixed montane coniferous forest in the United States. They also constitute the edge of the range for a substantial number of species, including the eastern, western, northern, or southern extent depending on the species. The unique setting contributes to the Forest's biodiversity, with substantial contributions of flora and fauna from the north (Rocky Mountains), south (Chihuahuan Desert, Madrean Region), east (southern Great Plains), and west (Great Basin, Colorado Plateau).

In developing a revised Forest Plan, the 2012 planning rule requires the Forest Service to assess the Forest's at-risk species. Direction for this assessment was derived from the Forest Service Handbook (FSH) 1909.12 – Land Management Planning – Chapter 10 – The Assessment; Section 12.5 – Identifying and Assessing at-risk species. There are two categories of at risk species. At-risk species include those recognized under the Endangered Species Act (ESA) as endangered, threatened, proposed or candidates (FSH 1909.12_10 sec. 12.51), plus species of conservation concern (SCC) on the Forest.

ESA recognized species and SCC will each play a role in informing the development of plan components. National forests are managed to contribute to the recovery of federally listed species and to not jeopardize those species or their habitats. Plan components will be developed to provide the ecological conditions necessary to maintain viable populations of at risk species within the Plan Area. This assessment will briefly describe three key factors for each at risk species: status on the Lincoln NF; key ecological conditions needed to support the species; and key risk factors that affect the species.

SCC are a new concept introduced by the 2012 planning rule. The planning rule defines SCC as follows (FSH 1909.12_10 sec. 12.52):

> "A species of conservation concern is a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the Plan Area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species capability to persist over the long-term in the Plan Area."

The purpose of identifying at-risk species (collectively, ESA listed species and SCC) is to help develop forest plans that maintain the diversity of plant and animal communities and provide for the persistence of native species in the Plan Area (36 CFR 219.9). At-risk species are part of a dual coarse-filter/fine-filter approach to maintain the diversity of plant and animal communities and native species in a Plan Area, as required by NFMA. Forest plans revised using the 2012 planning rule will provide the ecological conditions necessary to maintain and restore ecosystem integrity (including structure, function, composition and connectivity) and ecosystem diversity throughout the Plan Area. Addressing the ecosystem integrity or "coarse filter" requirements will provide habitat for the persistence of the majority of species within the Plan Area and thus, diversity of plant and animal communities. For most species, habitat needs will be encompassed by the coarse filter plan components (desired conditions, objectives, standards, guidelines, and land suitability determinations) that will be developed to provide for broad ecosystem integrity and ecosystem diversity.

Other species may require additional species-specific plan components, if the course filter components that provide for broad ecosystem integrity and diversity would be insufficient to provide conditions to sustain them. Where the coarse filter alone is not enough to support a species at risk, the 2012 planning rule requires that plans include additional ("fine filter") plan components to provide the necessary ecological conditions to do so. Accordingly, species specific plan components will identify specific habitat needs of species with known conservation concerns or for which long-term persistence in the Plan Area is at risk, including fine filter elements for which the coarse filter elements are insufficient. For example, some SCC may require specific management actions in order to maintain a viable population, if the broader management for ecosystem integrity and diversity are insufficient to provide conditions for the given SCC within the Plan Area.

Staff at the Lincoln NF used the direction at FSH 1909.10 to develop and refine the list of at-risk species, which includes plants, invertebrates, fish, amphibians, reptiles, birds, and mammals that are known to occur in the Plan Area. Based on the information obtained, we (USDA Forest Service Lincoln NF) identified and documented a draft set of at-risk species and assessed ecological conditions for those species within the Plan Area. This document presents the overall process and rationale being used, and the findings regarding at risk species.

Scales of Analysis, Data, and Methods for At-Risk Species

Scales of Analysis

Scales of analysis for the assessment include the Plan Area (NFS lands covered by the plan [36 CFR 219.19]; in this case, Lincoln NF lands) and Local Units. As part of the assessment of at-risk species, we identify whether potential at risk species occur on the Forest. We also attempted to identify which Local Units each potential species is reported to occur in, and make comparisons of resources and conditions among the different Local Units. Generally six Local Units are considered in this assessment (see Local Unit Distribution section of the Terrestrial Vegetation chapter). In this chapter, we consider the distribution of species with respect to eight Local Units, in which the Tularosa Valley unit is differentiated between the Smokey Bear and Sacramento Ranger Districts, and the Salt Basin unit is differentiated between the Sacramento and Guadalupe Ranger Districts. For consideration of at-risk species, the Local Units are as follows (respective Districts are indicated by number): 1AM=Arroyo Macho; 1TV=Tularosa Valley; 1RH=Rio Hondo; 2SB=Salt Basin; 2TV= Tularosa Valley; 2RP=Rio Peñasco; 3SB=Salt Basin; and 3UP=Upper Pecos. The range of most species includes portions of the landscape outside the Forest, and that context is considered to the extent it influences the distribution and viability of at risk species on the Forest.

Information relevant to at-risk species and sources of that information

Directives provide the following guidance for evaluating relevant information for at-risk species (FSH1909.12 (10)(12.53)):

> "The Interdisciplinary Team shall consider available information on the set of at-risk species to understand the ecological conditions necessary to sustain them. The assessment phase focuses on rapidly evaluating available information, not on developing new information, about ecological conditions or about individual species. The assessment report should document information gaps relevant to at-risk species that may be filled in through inventories, plan monitoring program, or research. Information may come from a variety of sources, including Federal and State agencies, literature, local information on occurrence and population status, sub-basin analyses, broad-scale assessments, and information available from local species experts and other organizations."

> "The Interdisciplinary Team should consider information about at risk species such as the following, when available: Current taxonomy; Distribution (including historical and current trends), especially species known from only a relatively few, discrete locations, and the status of those locations; Abundance (including historical and current trends); Demographics and population trends, including population effects resulting from hunting, fishing, trapping, and natural population fluctuations if available; Diversity (phenotypic, genetic, and ecological); Ecological condition (habitat) requirements

at appropriate spatial scales (fine-scale, home range, geographic range); Ecological condition (habitat) amount, quality, distribution, connectivity, status, and trends in the Plan Area; Ecological function of at-risk species; Important biological interactions and ecological processes, such as periodic fire, flooding, groundwater discharge, and so on; Ecological conditions that are threats or limiting factors to persistence; Influence and occurrence of uncharacteristic natural events like severe wildfire or insect epidemics; Effects of climate change and susceptibility to stressors caused by human disturbances or activities like air and water pollution, invasive species, trails, roads, and dams; and Endangered Species Act information, such as reasons for listing and species status, set out in recovery plans and biological opinions, and critical habitat designations."

Accordingly, information required for this assessment included lists of potential at risk species, and data regarding their taxonomy, distribution, life history, population status and trends, human-related stressors, other risk factors, and the current and projected status of ecological conditions needed to meet their requirements. Sources of data for compiling initial lists of potential SCC and additional information on those species included the scientific literature, such as various data-bases and published and unpublished reports. In addition, we collected information from the public during forest plan revision public engagement efforts beginning in 2014, experts on taxonomic groups, and from Forest Service staff. We also relied heavily on publically available and contributed plans and strategies pertinent to the area, such as the State Wildlife Action Plan (SWAP; NMDGF 2016) and bird conservation plans. Initial lists of ESA listed species and potential SCC for the Lincoln NF were assembled (details below). Key sources of data for initial lists of potential at risk species and additional data for those species are summarized here and cited throughout this chapter.

We accessed USFWS Information and Planning Conservation System (https://ecos.fws.gov/ipac/) to identify federally listed threatened and endangered species, species proposed for federal listing, and candidate species in the Plan Area (FSH1909.12 (10)(12.51)).

Species accounts in the Biota Information System of New Mexico (denoted in this chapter as BISON-M; NMDGF 2016) were queried for any animal that might meet criteria as an at risk species on the Lincoln NF. BISON-M is a primary source of lists and information about the State's special status species including Species of Greatest Conservation Need (SGCN). The NM Comprehensive Wildlife Conservation Strategy (CWCS; NMDGF 2006) and the recently completed SWAP (NMDGF 2016) provided additional information on SGCN. The SWAP represents the 2016 assessment of New Mexico's wildlife and their habitats by the NMDGF, including status, potential threats or constraints, and potential conservation actions. It is based on a review and revision of the 2006 CWCS. The Texas Parks and Wildlife Department SGCN lists (TPWD 2011) and Texas Conservation Action Plan 2012–2016 (TPWD 2012), Chihuahuan Deserts and Arizona – New Mexico Mountains sections, were consulted as well.

Natural Heritage New Mexico's NMBiotics database (NHNM 2016) and NatureServe Explorer (NatureServe 2016) were consulted for any potential at risk species of plant and animal. The New Mexico Rare Plants Technical Council's Rare Plants List (denoted as RPTC; NMRPTC 1999, 2016) data was consulted for every potential plant, as was NM Energy, Minerals and Natural Resources Department's (EMNRD) State Endangered Plant Species List (Section 75-6-1 NMSA 1978; 19.21.2.8 NMAC), EMNRD- Forestry Division's (2017) New Mexico Rare Plant Conservation Strategy, and USDA BLM (2002). RPTC includes rare plants in addition to those listed as Endangered by EMNRDs Forestry Division. The Southwest Environmental Information Network (SEINet 2016), which includes herbarium and museum records and collaborates in the Symbiota information framework, was consulted for most plants. The New Mexico Biodiversity Collections Consortium (NMBCC 2013) online database was also consulted. The USFS (2015) Region 3 Forester's Sensitive Species List (denoted as RFSSL) was consulted for species attributed to Lincoln NF.

Depending upon the taxonomic category of plant or animal, Hutchins (1974), Worthington (2015a, b) (flora); Nekola and Coles (2010), Worthington (2010, 2015c), Metcalf and Smartt (1997) (gastropods); Cary and Holland (1992), Toliver et al (1996, 1998), Cary (2005), Hager and Stafford (1999) (butterflies); West (2003,

2005) (birds); Frey (2004), Bailey (1931) (mammals); and Taylor 2011 (bats) were cross-checked and searched for data on all potential SCC. Symbiota, FishNet2, HerpNet, VertNet and Arctos electronic database portals and collection information management systems were also consulted for various species, as were ITIS, PLANTS, International Union for Conservation of Nature (IUCN 2016) Red List of Threatened Species, iNaturalist, and the internal database, Natural Resources Manager (USDA Forest Service, 2016).

Cornell Laboratory of Ornithology's online database of bird distribution and abundance (denoted as eBird; Sullivan et al 2009, eBird 2016) was consulted for every prospective bird species pertaining to the Plan Area. Likewise, State, Regional, National and International bird plans were consulted for all birds. Cornell University's Birds of North America (Rodewald 2015, Ed.) was consulted on most. Those are cited as BNA in this chapter, but individual species accounts are listed in the reference section. We also consulted the New Mexico Avian Conservation Partners' (NMACP 2016) species accounts, species assessment scores and habitat types; Partners in Flight Species Assessment Database, an online database in collaboration with Rocky Mountain Bird Observatory (PIF; PIF Science Committee 2012); PIF Landbird Conservation Plan (Rosenberg et al. 2016); NM PIF Bird Conservation Plan version 2.1 (NMACP 2016); Intermountain West Joint Venture 2013 Implementation Plan (IWJV 2013); and USFWS Birds of Conservation Concern list (BCC; USFWS 2008). NM Ornithological Society's (NMOS) Field Notes database (provided in collaboration with NHNM) and conference abstracts, and Hubbard's (1978) revised check-list of the birds of New Mexico were consulted for various birds. We made extensive queries of the USGS Breeding Bird Survey data (BBS; Sauer et al. 1997, 2014).

We also consulted additional online, electronic databases, such as the American Museum of Natural History Amphibian Species of the World (denoted as ASW; Frost 2016); AmphibiaWeb (2016), which includes species accounts and museum records; and HerpMapper (2016), a global atlas and data hub for herpetological information. Others included Animal Diversity Web (ADW; Myers et al 2016); Biota of North America Program (BONAP), North American Vascular Flora, Floristic Synthesis of North America (Kartesz 2015a, 2015b); Butterflies and Moths of North America (BMONA; Lotts and Naberhaus 2015); Butterflies of America (BOA; Warren et al 2013), which includes type specimens and their localities; New Mexico Herpetological Society's website (NMHS 2016); Smithsonian Institution's North American Mammals (NAM; Wilson and Ruff 1999, Kays and Wilson 2002); USGS National Amphibian Atlas (ARMI; USGS 2016); USGS Nonindigenous Aquatic Species (NAS; USGS 2016), and Rocky Mountain Research Station's Fire Effects Information System (FEIS; USDA FS 2016), all accessed on one or multiple occasions in 2016 or 2017.

Methods for determining at risk Species

Overview of process used to identify at risk species for Lincoln NF

At-risk species known to occur within Lincoln NF will be comprised of two major categories, those listed as threatened, endangered, proposed, or candidate under the ESA and those designated by the Regional Forester as SCC, once the plan revision processes described in this assessment are completed. The list of at-risk species is identified by the Regional Forester, in coordination with the Lincoln NF Supervisor.

In order to identify federally listed threatened and endangered species, candidate species, and species proposed for federal listing (ESA species), we accessed the USFWS Information and Planning Conservation system to identify ESA species in the four county area (Chaves, Eddy, Lincoln and Otero) encompassing the Forest. We identified which of those occur in the Plan Area. Results are provided in the Analysis and Findings Section.

An SCC is a species, other than ESA endangered, threatened, proposed and candidate species, that is known to occur in the Plan Area and for which the Regional Forester of the Southwest Region has determined that the BASI indicates substantial concern about its capability to persist over the long-tern in the Plan Area. The 2012 Planning Rule directives provide direction for the process of identifying and assessing potential SCC.

A short, simplified outline of our process for assessing and delineating potential SCC is presented here, with more details below. The generalized steps for this assessment (items 1 to 5) and for later stages (items 6 to 7) are:

1. Assemble a list of rare, vulnerable and sensitive species that occur within the four county area encompassing the Forest, in order to initiate a list of potential SCC for the Forest.
2. Screen that list to determine which species have populations that exist partly or wholly within the Forest, or are in the process of developing a population on the forest.
3. For those species occurring on the Forest, determine life history attributes, ecological needs and trends, population status and trends, threat status and trends, and overall risk on the Forest. Identify groups of species that share common ecological characteristics on the Forest.
4. Based on the findings from steps 1 through 3, summarize risk for all at risk species and for groups of at risk species.
5. Based on the findings from steps 1 through 4, determine whether each species constitutes a SCC (i.e., whether the best available scientific information (BASI) indicates substantial concern about its capability to persist over the long-term in the Plan Area). Identify the list of proposed SCC.
6. Publish this assessment. Attain public review and further input from all interested parties. Revise the list of proposed SCC if needed.
7. Regional Forester consults with Forest Supervisor and identifies initial potential SCC list.

In this assessment, lists of SCC are purposefully referred to as potential, or proposed, because they can be refined to add or remove species as the plan revision process progresses. Figure 115 provides a visual summary of the process used to identify at risk species for Lincoln NF. In the following sections, we provide a more detailed description of the directives and process.

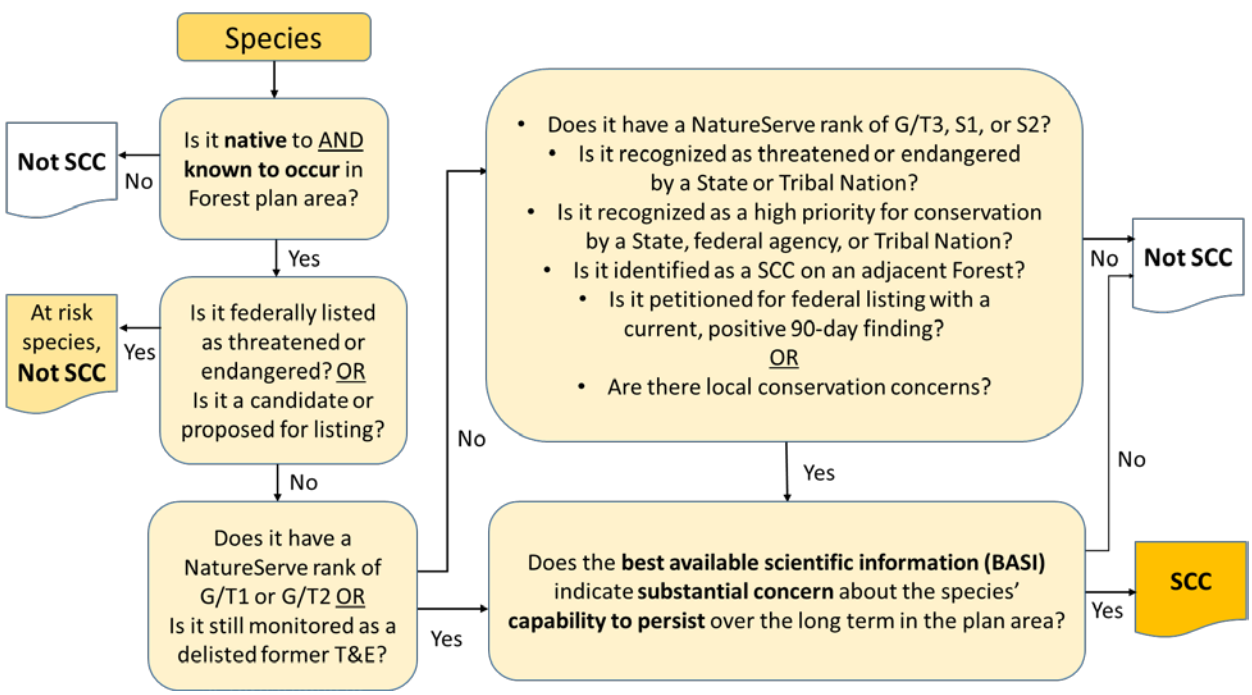

Figure 116 Summary of the decision process used to identify at risk species for Lincoln NF

As we progressed through steps 1, 2, and 3 of the process, we assembled increasing amounts of information regarding distribution, life history, population status and trends, human-related stressors, other risk factors, and the current and projected status of ecological conditions needed to meet requirements of the species considered. Results of the analyses are presented in the Analysis and Findings Section. For each species considered, greater detail is provided in the Assessment Details for all Species of Conservation Concern, including additional detail regarding the justification for determinations of SCC status for each species. That report also provides synonyms for species that are named differently in various databases and references, and species specific details about information gaps. Later sections of this chapter focus more on groups of species based on ecological affinities and shared threats.

Screening data to develop initial lists of potential SCC for Lincoln NF

The handbook sets forth the following criteria to determine which species to consider as potential SCC (FSH 1909.12_10 sec. 12.52c):

1. Species native to and known to occur in the Plan Area.

2. Species in the following categories must be considered:

a) a. Species with status ranks of G/T1 or G/T2 on the NatureServe ranking system.

b) b. Species that were removed within the past 5 years from the Federal list of threatened or endangered species, and other delisted species that the regulatory agency still monitors.

3. Species in the following categories should be considered:

c) Species with status ranks of G/T3 or S1 or S2 on the NatureServe ranking system.

d) Species listed as threatened or endangered by relevant states, federally recognized tribes, or Alaska Native Corporations.

e) Species identified by Federal, State, federally recognized tribes, or Alaska Native Corporations as a high priority for conservation.

f) Species identified as species of conservation concern in adjoining National Forest System Plan Areas (including Plan Areas across regional boundaries).

g) Species that have been petitioned for Federal listing and for which a positive “90-day finding” has been made.

h) Species for which the best available scientific information indicates there is local conservation concern about the species' capability to persist over the long term in the Plan Area due to:

  1) Significant threats, caused by stressors on and off the Plan Area, to populations or the ecological conditions they depend upon (habitat). These threats include climate change.

  2) Declining trends in populations or habitat in the Plan Area.

  3) Restricted ranges (with corresponding narrow endemics, disjunct populations, or species at the edge of their range).

  4) Low population numbers or restricted ecological conditions (habitat) within the Plan Area.

Those criteria allow for a starting point in the form of an initial list of potential SCC (i.e., step 1). In order to develop the initial list of potential SCC, we identified all species that were attributed to any of the four counties that encompass Lincoln NF and which met any of the additional criteria for potential SCC. These included all ‘must’ consider (in our case, NatureServe G1-2 or T1-2) and all ‘should’ consider species as defined in FSH 1909.10 section 12.52. To accomplish this, each of the key databases and lists (NatureServe, RPTC, SGCN, BISON, NHNM, RFSSL, BCC) were searched for any species that were attributed to any of the four counties. Plans (e.g., SWAP, PIF, IWJV) and other sources were also searched for additional species that might be potential SCC. Results were combined into a data table.

Refining the initial list to identify proposed SCC for Lincoln NF

Not all species initially considered as a potential SCC will be carried forward as SCC. The Handbook has guidance on which species to include or exclude from the potential SCC list, as follows:

1. The species is native to, and known to occur in, the Plan Area.

A species is known to occur in a Plan Area if, at the time of plan development, the best available scientific information indicates that a species is established or is becoming established in the Plan Area. A species with an individual occurrences in a Plan Area that are merely “accidental” or “transient,” or are well outside the species’ existing range at the time of plan development, is not established or becoming established in the Plan Area. If the range of a species is changing so that what is becoming its "normal" range includes the Plan Area, an individual occurrence should not be considered transient or accidental.

2. The best available scientific information about the species indicates substantial concern about the species’ capability to persist over the long term in the Plan Area.

If there is insufficient scientific information available to conclude there is a substantial concern about a species’ capability to persist in the Plan Area over the long-term that species cannot be identified as a species of conservation concern. If the species is secure and its continued long-term persistence in the Plan Area is not at risk based on knowledge of its abundance, distribution, lack of threats to persistence, trends in habitat, or responses to management that species cannot be identified as a species of conservation concern.

The directives provide additional guidance for determining the status of at-risk species (FSH1909.12 (10)(12.55)):

> The Interdisciplinary Team shall determine the status of at-risk species, by considering the existing plan direction, ecological conditions needed to support the species (FSH1909.12 (10)(12.53)), status of ecological conditions in the Plan Area (FSH1909.12 (10)(12.14c)), and other relevant information. The assessment should identify influences on ecological conditions needed to support the species, key risk factors to those ecological conditions, and limiting factors both on and off the Plan Area.
>
> The following is a suggested approach to determining the status of each at-risk species:
>
> 1. Describe current distribution of each at-risk species in the Plan Area.
>
> 2. Identify ecological conditions in the Plan Area necessary to meet the requirements of 36 CFR 219.9(b) for each at-risk species (FSH1909.12 (10)(12.53)) and at-risk species grouping (FSH1909.12 (10)(12.54)). These are the ecological conditions to be considered for at-risk species in the assessment.
>
> 3. Identify those ecological conditions assessed by the assessment of key ecosystem characteristics.
>
> 4. Identify ecological conditions in the Plan Area necessary to meet the requirements of 36 CFR 219.9(b) for each at-risk species that were not addressed by the assessment of key ecosystem characteristics as follows:
>
> a. Describe the current and likely future status of the ecological conditions necessary to meet

the requirements of 36 CFR 219.9(b) for each at-risk species, assuming management continues under the current plan.

b. Compare the species' current and likely future status described in paragraph 4a for each at-risk species to the ecological conditions of the natural range of variation, or an alternative ecological reference model (FSH1909.12 (10)(12.14b)).

c. Assess human-related stressors (for example, roads, human disturbance and displacement, dams) and whether they can be managed under Forest Service authorities.

d. Identify other threats or limiting factors (for example, naturally small and isolated populations, climate change) and whether they can be managed under Forest Service authority.

5. Describe the current and projected overall status of the ecological conditions necessary to meet the requirements of 36 CFR 219.9(b) for at-risk species considering the combined ecological conditions addressed through the assessment of key ecosystem characteristics and, if needed, for specific at-risk species or groupings.

6. For those ecological conditions not currently meeting or expected to meet the requirements of 36 CFR 219.9(b) for at-risk species, describe the potential outcome of the at-risk species status and identify the key risk factors, taking into account factors such as time (for example, short-term, long-term, planning period, generations of species), affected life history requirement (for example, loss of part of foraging habitat, loss of all spawning habitat), or affected population dynamic (for example, loss of recolonization routes).

7. Identify those key risk factors influencing the ecological conditions not expected to meet the requirements of 36 CFR 219.9(b) for at-risk species that are or can be influenced by Forest Service management of the Plan Area.

8. Describe any differences in likely future status of groups of individuals in the Plan Area that are known to be or highly suspected to be reproductively isolated and separate from the rest of the individuals of at-risk species.

9. Summarize the overall status of each at-risk species or species group with explanations of which key risk factors weighed most heavily in determining status. Describe the effect of key risk factors on species in simple terms such as the level of resulting vulnerability and the trend in that vulnerability. State the conclusions of the vulnerability status process for each species in a way that is helpful in identifying the need for change and in developing plan components that provide the ecological conditions necessary to sustain the species.

For each potential SCC found to occur on the Forest, we used the BASI (including but not limited to the information sources outlined above) to compile and interpret as many of those nine data elements as possible in order to determine whether a given species met criteria for SCC status. The data elements were compiled and interpreted for ESA species as well. As noted above, the findings were incorporated into extensive data tables, with key elements and conclusions summarized in this chapter and detailed in the Assessment Details for all Species of Conservation Concern.

Grouping of Species

We used the compiled information to group species according to distribution and ecological affinities, and with respect to common threats. Ecological affinities included shared habitat (i.e., use of ERUs and other habitat elements) and landscape settings. Grouping at risk species in the assessment phase is strictly an analysis and evaluation tool that may be used to improve planning efficiency (FSH1909.12 Chapter 10.12.54). The grouping factors are useful for summarizing the distribution of at risk species across the Forest, and for evaluating relevant information about conditions, trends and sustainability of multiple species in an ecosystem setting. Findings for groups of species, and details regarding assumptions and methods for specific groupings, are provided in the relevant sections of this chapter.

Information Gaps

Many species that occur on Lincoln NF are known to be impacted by various threats, or exhibit declines in abundance or distribution over some timeframe in all or part of their broader range. In the case of a relatively well documented taxonomic category such as birds, there may be population trend estimates for large areas such as states or regions. But even in that case, trends specific to the Plan Area may not be known. Such population trend estimates, and the particular level of confidence in the estimates, pertains to the larger area. The large area estimates do not directly step down to smaller areas. Actual trends among different scales may be similar, but could also be poorly correlated in terms of magnitude and even direction.

The geographic scope of the various, widely recognized bird conservation regions (BCRs; NABCI 2016), for which systematic population estimates are generated, exemplify the case that Lincoln NF is in a unique geographical and ecological setting. In terms of BCRs, Lincoln NF and the associated mountains are something of a geographical outlier, falling within the Chihuahuan Desert BCR, near the southern ends of the Shortgrass Prairie and Southern Rockies/Colorado Plateau BCRs. Lincoln NF contains some ecological elements from all of those regions, as well as from the Sierra Madre Occidental BCR to the southwest. However, while the forest birds of the Plan Area have more in common with forest birds of the Gila NF and Cibola NF (Southern Rockies/Colorado Plateau BCR), Lincoln NF falls in the Chihuahuan Desert BCR. But even for shared species, populations respond differently among the areas, based on more localized conditions. In terms of bird conservation joint ventures, Lincoln NF falls near the extreme southeast corner of the Intermountain Joint Venture (IMJV), which spans northward, throughout the intermountain west, to the Canada border. For these reasons, larger area bird population estimates are informative, but we do not assume they scale down directly to Lincoln NF populations. In all cases, more localized BBS data were also assessed. However, few routes occur on the Forest and several of those extend to areas off the Forest as well.

Unfortunately, for many other taxonomic groups, there are even fewer population data from any geographic scale. However, if the BASI for the smallest geographic scale indicates that persistence of a given species is imperiled throughout that area, and encompasses populations on the Forest, we do not assume the Forest is different. For example, if a species that occurs on the Forest is reported to have a rangewide status of critically imperiled according to NatureServe, and there are no alternative rangewide or localized status information from another source, we apply the available status information for that species to the Forest (i.e., a critically imperiled species will be advanced as a proposed SCC).

Systematic inventories to document the contemporary presence or absence of most at-risk species do not exist. The New Mexico Rare Plant Conservation Strategy (EMNRD Forestry Division 2017) provides a discussion of this problem with respect to NM plants. Historic distribution and population estimates are not known for most species, although more data generally exists for federally listed species. General accounts from the last 100 years from naturalists, and studies from recent decades allow for some inferences about abundance and distribution. The information gaps must be considered in the context of current and admittedly altered, drivers and stressors. In some cases, due to human encroachment into the wildlands, permanent or semi-permanent alteration of habitats due to land use changes, and fundamental alteration of disturbance regimes, it may be difficult to assess whether restoration to historic species distributions and population levels might be realistically expected going forward.

Similarly, key life history information is lacking or has not been made available for some species. For most species, there was sufficient information to categorize general habitat types that sustain them. For many of those, there are gaps in detail about habitat (or other factors). For a few, only a very general habitat characterization is available. For all species considered in this assessment, we sought to determine whether there are records of occurrence in each of the Local Units. Despite extensive searches in the aforementioned sources and other sources cited in this assessment, the record of occurrences is undoubtedly incomplete for some species. We will continue to update such distribution records with information from the public and all partners.

Additional information will be sought for inclusion in the final assessment and throughout the planning process, as needed. Subsequently, many information gaps relevant to at-risk species may be filled in through inventories, plan monitoring processes, or research.

Examples of topics that will benefit from review are as follows: did we incorrectly conclude that any species from the four county area does not occur on the Forest?; for species on the forest, did we miss local unit occurrences?; and, are ERU and habitat associations with species accurately portrayed?

Order of species in lists

In this chapter, species lists are ordered as follows (within each of the groups, species are listed alphabetically by scientific name): Fungi (lichen); fern; conifer; ephedra/Mormon tea (Gnetophyta); flowering plants: monocots (by family), then dicots (by family); invertebrates: arthropods ([arachnida: mites, harvestman, pseudoscorpions]; [myriapoda: centipedes, millipedes], [crustaceans: brine and fairy, tadpole, then clam shrimp, crayfish, isopods, amphipods], [hexapoda: springtails, then insects (mayfly, dragon and damsel flies, crickets, grasshoppers, stoneflies, mirid plant bugs, beetles, dobsonflies, bees, caddisflies, butterflies, moths, and bee, long-legged, then soldier flies)]); mollusks (gastropods [terrestrial, then freshwater snails], mussels, then peaclams); the vertebrates: fish; frogs; salamanders; turtles; lizards (collared, spiny, banded gecko, skinks, Gila monster, whiptails); snakes (milks, rat, Tantilla, water, garter, rattle); birds: (quail, doves, swifts, nighthawks, cukoos, hawks/eagles, falcons, owls, trogon, woodpeckers, flycatchers, vireos, shrikes, crows/jays, titmice, larks, swallows, phainopepla, nuthatches, creepers, wrens, gnatcatchers, dipper, thrushes, thrashers, olive warbler, pipits, true finches, longspurs, sparrows, towhees, buntings, blackbirds, warblers, tanagers, grosbeaks); then waterbirds (ducks, grebes, cranes, shorebirds [terns, plovers, sandpipers], waders, pelicans); mammals: rodents (beaver, tree squirrels, ground [squirrels, prairie dogs, chipmunks], gophers, kangaroo rats, pocket, then jumping mice, voles, pygmy mouse, woodrats, cotton/deer mice, *Reithrodontomys*, cotton rats); rabbits/hares, shrews/moles, bats, carnivores (cats, dogs, bears, ringtails, weasels, skunks; then deer).

Analysis and Findings- At-Risk Species

Federally Recognized Species

Twenty-four species that are listed by USFWS as threatened, endangered, or candidate were reported for the four county area (Chaves, Eddy, Lincoln and Otero; USFWS 2016). Nine of those species have established populations on Lincoln NF (Table 167).

Table 167. Nine ESA endangered, threatened, and candidate species occurring on Lincoln NF

Taxonomic Group/ Common Name	Scientific Name	ESA Listing	Critical Habitat Delineated	Recorded in Smokey Bear RD	Recorded in Sacramento RD	Recorded in Guadalupe RD
Plants						
Sacramento Mountains Thistle	*Cirsium vinaceum*	Threatened	No	yes	yes	no
Wright's Marsh Thistle	*Cirsium wrightii*	Candidate	No (Candidate)	no	yes	no
Lee's Pincushion Cactus	*Coryphantha sneedii var leei*	Endangered	No	no	no	yes
Kuenzler's Hedgehog Cactus	*Echinocereus fendleri var. kuenzleri*	Endangered	No	yes	yes	yes
Todsen's Pennyroyal	*Hedeoma todsenii*	Endangered	Final	no	yes	no
Sacramento Prickly-poppy	*Argemone pleiacantha ssp. pinnatisecta*	Endangered	No	no	yes	no
Vertebrates						
Mexican Spotted Owl	*Strix occidentalis lucida*	Threatened	Final	yes	yes	yes
Peñasco least chipmunk	*Neotamias minimus atristriatus*	Candidate	No (Candidate)	yes	yes	no
New Mexican Meadow Jumping Mouse	*Zapus hudsonius luteus*	Endangered	Final	no	yes	no

The additional 15 species occur in one or more of the four counties encompassing the Forest (FWS 2016; Table 168). Most of those species range entirely outside of, and are not documented on Lincoln NF. The least tern, piping plover, Southwestern willow flycatcher, and yellow-billed cuckoo (Western DPS) may have accidental occurrences on the Forest, but do not have populations established on Lincoln NF. In no instances are those species becoming established or poised for establishment on the Forest.

Table 168. Fifteen ESA endangered, threatened, and candidate species reported for Chaves, Eddy, Otero or Lincoln County but not established on Lincoln NF

Taxonomic Group/Common Name	Scientific Name	ESA Listing
Plant, flowering		
Pecos Sunflower	*Helianthus paradoxus*	Threatened

Taxonomic Group/Common Name		Scientific Name	ESA Listing
	Lee's Pincushion Cactus	*Coryphantha sneedii var leei*	Threatened
	Gypsum Buckwheat	*Eriogonum gypsophilum*	Threatened
Invertebrate, crustacean			
	Noel's Amphipod	*Gammarus desperatus*	Endangered
Invertebrate, mollusc			
	Pecos Assiminea Snail	*Assiminea pecos*	Endangered
	Koster's springsnail	*Juturnia kosteri*	Endangered
	Roswell Springsnail	*Pyrgulopsis roswellensis*	Endangered
Invertebrate, mollusc (bivalve)			
	Pope's Mussel; Texas Hornshell	*Popenaias popeii*	Candidate
Vertebrate, fish			
	Pecos gambusia	*Gambusia nobilis*	Endangered
	Pecos Bluntnose Shiner	*Notropis simus pecosensis*	Threatened
Vertebrate, bird			
	Yellow-billed cuckoo [Western DPS]	*Coccyzus americanus [Western DPS]*	Threatened
	Northern Aplomado Falcon	*Falco femoralis septentrionalis*	Experimental /Non-Essential
	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Endangered
	Piping Plover	*Charadrius melodus*	Threatened
	Least Tern	*Sternula antillarum*	Endangered

Species accounts for ESA listed species associated with the Forest are provided in the following subsection. Species that were removed from the Federal list of threatened or endangered species within the past 5 years and other delisted species that the regulatory agencies (USFWS and NOAA) still monitor, and species that have been petitioned for Federal listing and for which a positive “90-day finding” has been made, are to be considered as potential SCC. No species associated with Lincoln NF were found to be delisted under the ESA in the last five years. The Rio Grande chub was subject of a listing petition with a positive 90-day finding by USFWS on March 15, 2016 (FR 2016-05699). The Rio Grande chub is therefore a potential at risk species. If proposed during this plan revision process, it will be treated as a Federally-recognized at-risk species.

Species Accounts for ESA Endangered, Threatened, Candidate, and Proposed Species

Sacramento Mountains thistle (*Cirsium vinaceum*)

Species Status on the Lincoln NF

Sacramento Mountains thistle is a narrow endemic that is restricted to wet deposits of travertine (calcium carbonate) in wetlands, meadows, or sub-irrigated areas associated with springs, streams, and seeps at high elevations in the Sacramento Mountains. The vast majority of Sacramento Mountains thistle individuals occur on lands managed by the Lincoln NF within a range of approximately 150 square miles. At the time of listing, there were 20 known populations or sites, with an estimated 10,000 to 15,000 individuals, occurring within six large canyon drainages (USFWS 1993). Since then, approximately 104 potential sites have been identified (USFWS 2010) within approximately 10 geographically distinct subpopulations (i.e., canyon drainages) spanning approximately 66 acres of suitable habitat on the Lincoln NF (Roth 2013).

Key Ecological Conditions Needed to Support the Species

Sacramento Mountains thistle is not closely associated with any one particular ERU because the ecological conditions that best suit this species (i.e. wet travertine deposits) are localized, and may be surrounded by several different ERUs. It occurs in a variety of riparian ERUs such as *Ponderosa Pine/Willow*, *Herbaceous wetland*, *Upper Montane Conifer/Willow*, *Arizona Alder – Willow,* and *Mixed Conifer with Aspen*; and, it is found among ERUs that have variable moisture levels, such as *Ponderosa Pine Forest, Mixed Conifer – Frequent Fire, and Montane/Subalpine Grassland* (ERUs are described in the Terrestrial Vegetation and Riparian Vegetation chapters). Wet travertine deposits, though rare and spotty in distribution, vary in size from several square feet to five acres (Roth 2013). These deposits are the most densely populated expanses of suitable habitat, while wet areas downstream are more sparsely inhabited by Sacramento Mountains thistle. While several areas around the Sacramento District contain suitable spring habitat for the Sacramento Mountains thistle, these sites remain unoccupied (USFWS 1993). However, restricted distribution of this species within suitable habitat is likely the result of habitat degradation and land use along streams between travertine seeps (Craddock and Huenneke 1997). Craddock and Huenneke (1997) note that where riparian habitat conditions have improved, Sacramento Mountains thistle has successfully colonized corridors between more discrete populations. Their study revealed that certain characteristics of Sacramento Mountains thistle seeds (i.e., high viability, float time, and distance traveled) may indicate a specific adaptation to aquatic seed dispersal (Craddock and Huenneke 1997). Therefore, the trend and condition of spring sites and riparian habitat is most critical for the continued existence of Sacramento Mountains thistle.

Sacramento Mountains thistle populations are found among seven HUC 6 watersheds, including Silver Springs Canyon, James Canyon, Cox Canyon, Cox Canyon-Rio Peñasco, Fresnal Canyon, Alamo Canyon, and Arkansas Canyon-Sacramento River. The population within Silver Springs Canyon watershed is the single largest occupied site and is associated with streamside and wet-meadow habitat. Conversely, the Cox Canyon-Rio Peñasco watershed contains the highest number of occupied sites, which are primarily associated with travertine springs that flow into the Rio Peñasco stream.

Key Risk Factors

Key ecosystem characteristics used to assess the ecological integrity of riparian areas consisted of the Proper Functioning Condition method, which is a qualitative method for assessing the condition of riparian-wetland areas. A proper functioning riparian-wetland area will:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality
- filter sediment, capture bedload, and aid floodplain development
- improve flood-water retention and ground water recharge
- develop root masses that stabilize streambanks against cutting action

Currently, all riparian ERUs are in a state that is departed from the reference conditions.

Despite the fact that travertine springs are the most densely populated expanses of suitable habitat and the majority of HUC 6 watersheds containing populations of Sacramento Mountains thistle are rated at moderate to low or low risk of losing ecological integrity, the number of flowering Sacramento Mountains thistles have decreased since 1998 (Table 169). This decline may be due to the decline of riparian habitat conditions or a number of other key ecosystem characteristics that were not addressed in this assessment.

Table 169. Rates of decline in total flowering Sacramento Mountains thistle numbers (Cirsium vinaceum) (USFWS 2010)

Survey Period*	Decline (%)
1999 - 2000	12.9
2000 - 2003	12.2
2003 - 2005	7.9
2005 - 2007	14

***Data collection methods were not standardized prior to 1998, which is when the bolted-stem count was adopted.**

Additional ecosystem conditions and characteristics not evaluated as part of this assessment are also important to the species. Many of those constitute known risk factors that pertain to Sacramento Mountains thistle, including:

- **Presence and distribution of non-desirable invasive species**. Non-native invasive species have been known to alter suitable habitat for native plant species by altering disturbance regimes, nutrient cycles, and hydrologic cycles. With regard to the Sacramento Mountains thistle, teasel (*Dipsacus sylvestris*) has been shown to directly displace individuals through competitive pressure (Huenneke and Thomson 1995). It appears this is partially due to teasel’s superior ability to germinate under lower light conditions (i.e., in closed canopy). A number of other non-native invasive species have been observed with Sacramento Mountains thistle including musk thistle (*Carduus nutans*), mullein (*Verbascum thapsus*), bull thistle (*Cirsium vulgare*), tamarisk (*Tamarix chinensis*), and Siberian elm (*Ulmus pumila*) (Roth 2013).
- **Insect predation**. Although not initially considered a threat in the original listing and recovery plan (USFWS 1993), insect predation is now considered a serious threat to Sacramento Mountains thistle (USFWS 2010, Roth 2013). A number of native and exotic insect species prey on Sacramento Mountains thistle. However, the most persistent of these predators are a native stem boring weevil, *Lixus pervestitus,* and a non-native seed-head weevil, *Rhinocyllus conicus*, which was introduced in 1968 as a biological control agent for musk thistle (USFWS 2010, Roth 2013). These two predators have been documented annually in the largest occupied site, Silver Springs, since 2006 and have resulted in almost complete failure of seed production.

- **Travertine formation.** This embedded geological formation is found sporadically throughout the seeps and springs and riparian communities. The percentage of springs and riparian communities containing deposits of travertine is currently unknown. However, these areas need to be kept intact, open and with no interruption of the hydrological flow. Encroachment and interruption of the water flow have been noted to result in loss of Sacramento Mountains thistle individuals and a reduction in the colonies.
- **Stressors that reduce or truncate connectivity**. Livestock grazing has been identified as a threat to Sacramento Mountains thistle. Several populations of Sacramento Mountains thistle occur in approximately four grazing allotments on the Lincoln NF. The largest occupied site, Silver Springs, is located within the James Canyon allotment, which is currently vacant. However, the vast majority of occupied sites are located within the Sacramento allotment. Of these, approximately 37 percent are accessible by livestock, while 63 percent are inaccessible to livestock because of topographic barriers or they reside in an exclosure. Throughout the Sacramento District, an estimated 30 percent of Sacramento Mountains thistle individuals are currently accessible to livestock, while an estimate 70 percent are inaccessible.
- **Channelization and Habitat Fragmentation.** Roads and off-highway vehicle trails are two causes of channelization, contributing to habitat fragmentation. This reduced connectivity limits a species ability to move into adjacent areas, to colonize suitable habitat or utilize habitat that fulfills its life cycle needs, including gene flow (Craddock and Huenneke 1997). In addition, roads and trails often channelize water flow, and block water from reaching down-slope habitat, which results fragmentation of the habitat and decreased succession of individuals. Timber management, with temporary roads, landings and logging decks may also contribute to channelization. In addition, soil compaction resulting from these management activities has the potential to alter hydrological regimes and could contribute to habitat fragmentation.
- **Recreation activities.** Development of recreation sites on travertine formations has the potential to reduce or extirpate colony sites. Unmanaged recreation has the biggest impact, as vehicle use and foot traffic can alter hydrological flow through increased channelization, direct impact to plants and soil compaction.
- **Mistaken Identity.** The Sacramento Mountain thistle can superficially bear a resemblance to a non-native invasive thistle, musk thistle, to the general visitor. Without proper identification or physical protection of the colonies, this can result in Sacramento Mountain thistle being pulled up, dug out or otherwise destroyed in a mistaken attempt to control what is perceived to be a non-native invasive plant.

Status Summary for the Sacramento Mountains thistle

The Sacramento Mountains thistle was listed as threatened in 1987 due to its limited range and significant threats. At the time of listing, population numbers were estimated at 10,000 to 15,000 individuals. Based on a regression analysis of the decreasing number of flowering stocks from 1999 to 2007, the predicted trend indicates that the number of flowering stocks would further decrease to 14,264 by 2013 (USFS 2008, USFWS 2010). Conditions that have contributed to the decline of Sacramento Mountains thistle are ongoing. Therefore, there is still a concern for the continued persistence of this species. It is not represented across all the available habitat. Additionally, with the low resiliency and reduced condition of the riparian habitat, this species remains at high risk.

Wright’s marsh thistle (Cirsium wrightii)

Species Status on the Lincoln NF

Wright’s marsh thistle is a candidate species that occurs in wet meadows associated with alkaline springs, seeps, and marshy edges of streams at elevations of 3,450 to 7,850 ft. Historically, Wright’s marsh thistle occurred in Arizona, New Mexico, and northern Mexico. However, the current status of this species is unknown in Mexico and the only extant populations within the United States, occur in New Mexico (Sivinski 2012). Range-wide, there is approximately 110 acres of known suitable habitat for Wright's marsh thistle that supports between 33,000 and 42,000 individuals (Sivinski 2012). Within the Plan Area, six spring-wetland sites are occupied by Wright's marsh thistle; however, only two of these sites occur on lands managed by the Lincoln NF. The remaining four sites are located on private property.

Key Ecological Conditions Needed to Support the Species

The two sites located on the Lincoln NF are found in the Silver Springs Canyon and La Luz Canyon HUC 6 watersheds. Within these watersheds, Wright's marsh thistle is closely associate with spring sites connected to riparian Ecological Response Units (ERUs), mainly *Fremont Cottonwood/Shrub* and *Herbaceous Wetland.* The Wright's marsh thistle population located in La Luz Canyon consists of approximately 0.06 acres of suitable habitat and supports about 100 individuals. Suitable habitat at the Silver Springs is roughly 0.03 acres and supports approximately 130 individuals (Sivinski 2012). Since these populations were last surveyed in 1995, the La Luz population has remained stable, while the Silver Springs population slightly increased (Sivinski 2012).

Key Risk Factors

Key ecosystem characteristics used to assess the ecological integrity of spring sites included the combined measure of representativeness and redundancy. Representativeness is a measure of the number of spring sites within the Plan Area compared to the total number of spring sites, inside and outside of the Plan Area, within each HUC 6 watershed. Whereas, redundancy calculates the distribution of repeated occurrences of spring sites across the landscape. Together, representativeness and redundancy provide a rating of overall risk (low/moderate/high) to ecological integrity of spring sites. The overall risk for both watersheds in moderate to low (Water Resources chapter).

Key ecosystem characteristics used to assess the ecological integrity of riparian areas consisted of the Proper Functioning Condition method, which is a qualitative method for assessing the condition of riparian-wetland areas. A proper functioning riparian-wetland area will:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality
- filter sediment, capture bedload, and aid floodplain development
- improve flood-water retention and ground water recharge
- develop root masses that stabilize streambanks against cutting action

Currently, all riparian ERUs are substantially departed from reference conditions for certain key characteristics (Riparian Vegetation chapter). Hydrological alterations in riparian systems is one of the biggest threats to Wright's marsh thistle. Throughout its range, suitable habitat has been altered or degraded because of past land and water management activities, which have included agriculture and urban development, diversion of springs, and groundwater capture. Furthermore, these declining habitat conditions are exacerbated by prolonged drought and climate change. Changes in water table levels have resulted in diminished discharge of springs and complete loss of surface water, which contributes to the impairment of riparian-wetland habitat (USFWS 2010). The lower portion of La Luz Canyon exhibits conditions of severe channel down-cutting, while the hydrology of the upper portion is altered by ground water capture for local agriculture and municipal use (Sivinski 2012).

Addition threats or known risk factors that may affect the continued existence of Wright's marsh thistle, include:

- Stressors that reduce or truncate habitat connectivity. Immediately adjacent to the La Luz Canyon site there is a well-developed illegal off-highway vehicle trail that across through riparian. This trail appears to truncate suitable habitat for Wright's marsh thistle. On the up-hill side of this site, a road parallels the riparian corridor, which is likely contributing to degraded riparian conditions.
- Livestock grazing. The Silver Springs site was once part of the James Canyon Allotment. This allotment is currently vacant; however, it may once again be open to livestock grazing in the foreseeable future. It is estimated that livestock grazing has resulted in damage to 80 percent of the stream and riparian systems in arid west. This damage consists of stream channelization, increased sedimentation, altered hydrologic flows, decreased water quality, soil compaction, and trampling and overgrazing of stream banks where succulent forage resides (Belsky et al. 1999).

Status Summary for the Wright's marsh thistle

Wright's marsh thistle occupies six spring-wetland sites in the Sacramento Mountains; however, only two of these sites occur within the plan area, on lands managed by the Lincoln NF. Although the populations of these two sites have remained fairly stable over the past two decades, the riparian habitat associated with this species is severely departed from its reference and desired conditions. The combined effect of highly destructive, historical grazing practices (Belsky et al. 1999), long-term drought, and ground and surface water withdrawal pose a current and future threat to Wright's marsh thistle and its habitat (USFWS 2010). This species is currently listed as a candidate species. However, in a recent finding, the U.S. Fish and Wildlife Service have determined there is sufficient reason to warrant listing Wright's marsh thistle as a threatened or endangered species (USFWS 2010).

Lee's Pincushion Cactus (Coryphantha sneedii var. leei); Sneed's Pincushion Cactus (Coryphantha sneedii var. sneedii)

Species Status on the Lincoln NF

Both Lee's (*Coryphantha sneedii* var. *leei*) and Sneed's (*C.s.* var. *sneedii*) pincushion cactus were federally-listed (threatened and endangered, respectively) in the fall of 1979, without designated critical habitat. At the time of listing, it was thought that Lee's pincushion cactus only occurred at one location in the Carlsbad Cavern NP, Eddy County, New Mexico. Sneed's pincushion cactus was thought to occur at 20 locations across west Texas and southern New Mexico, including: nine in the Franklin Mountains, two in the Organ Mountains, and nine in the Guadalupe Mountains (USFWS 1986). Of the nine Guadalupe Mountains populations, three were located on the Lincoln NF. However, there is a great deal of variability in the plants found in the Guadalupe mountains; therefore, a number of treatments and opinions regarding varietal status, morphological variation with elevation, and likely hybridization or zones of introgression have been advanced by various field botanists and taxonomic experts. As a result, USFWS now follows the idea set forth by Zimmerman (1985) and adopted by the RPTC (1999) that all cacti formerly considered Sneed's pincushion cactus located within the Guadalupe Mountains, including Carlsbad Cavern NP and Lincoln NF, are now considered Lee's pincushion cactus (USFWS 2015)[3].

Key Ecological Conditions Needed to Support the Species

Lee's pincushion cactus is restricted to the Tansil-Limestone formation and generally grows on north-facing ledges. This formation is hard and resistant to erosion, and supports sparse CDS with low shrubs, numerous succulents, and herbaceous species. It generally occurs between 1,200-1,500 meters (3,900-4,900 feet) in elevation. On the Lincoln NF, this habitat occurs on steep slopes that are difficult to access and unsuited for

[3] According to the USFWS (2015), it should be noted that no population of this plant (Lee's pincushion cactus) has been accurately delimited and mapped.

most management activities. As a result, population surveys are not regularly conducted for the Lee's pincushion cactus on the Lincoln NF.

Key Risk Factors

In the 1986 Recovery Plan, threats listed for Lee's pincushion cactus included commercial and private collection, destruction or modification of habitat, and natural limiting factors (USFWS 1986). At present, collection is not thought to be a major threat since populations on Lincoln NF are relatively inaccessible, and these areas are unsuited for most management activities. While its habitat offers protection from many threats, it also results in a highly restricted range. Seemingly suitable habitat does occur in and around known populations, where occurrences of the cactus drops abruptly in areas with apparently continuous habitat. Therefore, it is not practical to infer likely occupied habitat by extrapolating beyond known localities.

Other threats may include wildfire, climate change, and severe, long-term drought (USFWS 2015). Due to the highly restricted habitat of Lee's pincushion cactus, a wildfire or prescribed burn could impact a significant portion of occupied habitat. Regardless, more research is needed to determine the impact of fire on Lee's pincushion cactus (USFWS 1986). Although these species have likely experienced and rebounded from periods of drought in the past, the increased severity and frequency of drought that is predicted to result from climate change, will likely increase challenges to long-term survival of this species (USFWS 2015).

Status Summary for the Lee's pincushion cactus

This pincushion cactus was federally designated due to the restricted range, extremely specialized habitat and small population sizes. The habitat is limited by size and geological setting, and with no demonstrated resiliency, these populations will continue to be small and vulnerable to extirpation. Even within the limited habitats used, it appears to be absent in some areas. This may indicate that there is an unknown limiting factor, if not special needs that are not apparent. Climate change and high severity wildfire can be expected to threaten some locations.

Under the current management there are no human related threats to populations located on the Lincoln NF. Given that these sites are not in grazing allotments or other active management areas, natural threats such as limited suitable habitat, wildfire, and climate change pose the greatest risk of extinction.

Kuenzler hedgehog cactus (Echinocereus fendleri var. kuenleri)

Species Status on the Lincoln NF

Kuenzler's hedgehog cactus is an endangered species that is endemic to the eastern slopes of the Capitan, Guadalupe, and Sacramento mountains in south central New Mexico. Kuenzler's hedgehog cactus is mainly distributed along drainages of the Rio Hondo and the Rio Peñasco of Lincoln, Otero and Chavez counties, New Mexico. The species was listed as endangered in 1979 after less than 500 individuals were located (USFWS 1985). Most of the occupied habitats are located on private land. As of 2004, a total of 3,276 Kuenzler's hedgehog individuals were documented on federal lands (USFWS 2005).

Key Ecological Conditions Needed to Support the Species

Kuenzler's hedgehog cactus occurs locally on all three districts. On the Smokey Bear Ranger District, Kuenzler hedgehog cactus is situated within the pinyon-juniper, MMS, and JUG ERUs. On the Sacramento Ranger District, Kuenzler hedgehog cactus is found in pinyon-juniper ERUs; and, on the Guadalupe Ranger District, it is found in SDG and pinyon-juniper ERUs.

Kuenzler's hedgehog cactus are primarily situated in pinyon-juniper woodlands, at an elevational range of about 5800 to 6400 feet. Locally, those woodlands are dominated by either *Juniperus monosperma,* or by *Juniperus deppeana* and *Pinus edulis.* Key habitats for the Kuenzler's hedgehog cactus include cracks of limestone outcrops of moderate slopes, or shallow soils on flat steps of hillsides that exhibit a 'step and riser' configuration. Preferred soils are skeletal with a limestone parent material, including Lithic Argiustolls or Lithic Haplustolls (USFWS 1985).

Key Risk Factors

Factors imposing threats and risks to the survival of the Kuenzler's hedgehog cactus involve collection, habitat fragmentation, livestock use and altered fire regimes.

The leading threat to the Kuenzler's hedgehog cactus is collection. Initially there were only two sites in which the Kuenzler's cactus was known to habituate. Both had less than 500 individuals. This made the cactus novel, rare and sought after by cactus collectors that harvested many of the individuals, greatly decreasing the population size. Both of these initial sites were located on private or state land. Range-wide, poaching of the plant continues to be documented.

Habitat fragmentation due to roads and development have also contributed to the decline of Kuenzler's hedgehog populations. The initial site in which the cactus populations were discovered was reportedly destroyed during the reconstruction of Highway 83. Highway maintenance operations such as mowing, grading and the application of herbicide has contributed to the mortality of some individuals. The development of subdivisions in occupied suitable habitats has also contributed to the mortality rate of the Kuenzler's hedgehog populations.

Livestock present in Kuenzler's hedgehog cactus habitats can increase damage and mortality both directly and indirectly. Livestock can directly damage the cactus through trampling. Livestock have also been reported to indirectly contribute to increased mortality by inhibiting seedling establishment as a result of erosion due to the lack of vegetation after grazing (USFWS 1985).

Sivinski (1999) suggested that prescribed fires and wildfires can have adverse effects on the Kuenzler's hedgehog cactus. In his study, Sivinski measured the population of the Kuenzler's Hedgehog cactus seven years after a wildfire. Only one-third of the population was observed within the burned area in comparison to the population present in the adjacent unburned cactus habitat. In addition, regeneration rates of the burned population were minimal (Sivinski 1999). Wester and Britton (2007) found that smaller cacti have a higher probability of mortality in a prescribed fire setting than larger cacti. That study also suggests that higher fuel loads lead to high mortality rates, regardless of cacti size. However, under conditions of average amounts of fine fuel, Kuenzler's hedgehog cactus is not negatively affected by fire (Wester and Britton 2007).

Status Summary for the Kuenzler's hedgehog cactus

The Kuenzler's hedgehog cactus was federally listed as an endangered species in 1979 primarily due to over harvest of the cactus from collectors and poachers. Initial research documented a population of less than 500 total individuals. Additional efforts resulted in finding 3,276 individuals as of 2004 (USFWS 2005), and more recent surveys suggest this species is more common than previously thought (Westor and Britton 2007). The USFWS 5-Year Review of the species status recommended change in listing from Endangered to Threatened (USFWS 2005). However, factors contributing to the decline in the cactus populations such as cactus collecting, fires, habitat fragmentation and livestock are still present. These factors substantiate a concern for the continued persistence of this species.

Todsen's pennyroyal (*Hedeoma todsenii*)

Species Status on the Lincoln NF

Todsen's pennyroyal is an endangered species that is found in the San Andres and Sacramento Mountains of south-central New Mexico (USFWS 2001). At the time of listing, this species was known from only two locations in the San Andres Mountains on the White Sands Missile Range. Critical habitat was designated when the species was listed, but only included those original areas on WSMR. In the early 1990s, sixteen additional Todsen's pennyroyal sites were found, including one in the San Andres Mountains and fifteen in the Sacramento Mountains on and adjacent to the Forest (USFWS 2001).

Key Ecological Conditions Needed to Support the Species

Suitable habitat consists of gypseous-limestone soils on north-facing slopes in pinyon-juniper woodland at elevations of 6,200 to 7,400 feet. Almost half of Lincoln NF is comprised of pinyon-juniper woodland communities; however, Todsen's pennyroyal occupies less than 100 acres of habitat on the Forest. One thought as to why this species is so restricted is that Todsen's pennyroyal may be a relict species from more than 10,000 years ago when the region was cooler and suitable habitat was more contiguous (USFWS 2001, Sivinski 2009).

On the Lincoln NF, pinyon-juniper woodland is often comprised of large even-age structured patches, dominated by moderate to high density tree canopy with limited to scarce understory. Typical stressors and drivers such as fire, and insect and disease outbreaks, are high severity and occur infrequently, which create and maintain the even-aged nature of this vegetation type. However, fire is infrequent in areas occupied by Todsen's pennyroyal (i.e., rocky scarps or moist gypseous-limestone soil), due to the edaphically-influenced conditions in such areas. On these sites, factors such as insect and disease may be the only disturbance agents that affect woodland development.

Of the key ecosystem characteristics used to assess the ecological integrity of the pinyon-juniper woodland, fire return-interval, snag density (8-18 inch class), ecological status and patch size are highly departed from the reference condition; while the seral state distribution, and the amount of coarse woody-debris, large snags (>18 inches), and ground cover are moderately departed from the reference condition (Terrestrial Vegetation chapter). Although suitable habitat for Todsen's pennyroyal accounts for a very small portion of the pinyon-juniper woodland vegetation type, the departure of some of these ecosystem characteristics may have greater implications with regard to threats and risk factors for Todsen's pennyroyal.

Key Risk Factors

Currently there are no direct threats resulting from land use or management activities that affect Todsen's pennyroyal. Todsen's pennyroyal populations occurring on the Lincoln NF are located in the La Luz Management Area, which was classified as unsuitable and non-appropriate for timber management and fuelwood production (USFS 1986). This area is also currently closed to livestock grazing as the livestock permit has been withdrawn. Conversely, natural threats to Todsen's pennyroyal consist of low sexual reproduction, limited dispersal ability, limited suitable habitat, and possibly wildfire (USFWS 2001).

The effects of fire on Todsen's pennyroyal are not currently known. This species has an extensive rhizome system that may help it rebound quickly following a wildfire. In addition, there might be less interspecific competition for resources following fire, which may result in increased vigor and/or reproductive success. However, vegetative removal caused by wildfire may expose soil, subsequently increasing soil temperature and erosion, which could potentially diminish population numbers (Sivinski 2009). Therefore, for the broader pinyon-juniper woodland (PJO ERU), those ecosystem characteristics that relate to wildfire conditions (seral state distribution, coarse woody debris and snag density, and insect and disease mortality) may be most relevant.

The ecological niche of Todsen's pennyroyal, including fire relationships, is not fully understood. Accordingly, it is not clear whether long term climate shifts patterns (i.e., status as Pleistocene relict) or historical changes in fire regime, impose greater risk on this species.

Status Summary for Todsen' pennyroyal

Todsen's pennyroyal was designated an endangered species because of its extremely restricted range and small population size. At the time of listing, this species was known from only two locations in the San Andres Mountains of the White Sands Missile Range (USFWS 2001). However, subsequent surveys revealed sixteen additional occupied sites. Under the current management regime, there are no human related threats to populations located on the Lincoln NF. In fact, if the present management remains unchanged, natural threats such as low sexual reproduction, limited dispersal ability, limited suitable habitat, and wildfire may pose the greatest risk of extinction (USFWS 2001). However, it is not clear how much concern for the continued existence of this species is attributable to such natural factors, and how much is related to human factors, in particular disrupted fire regimes. If Todsen's pennyroyal is actually a relict species from more than 10,000 years ago when the region was cooler and suitable habitat was more contiguous (USFWS 2001, Sivinski 2009), it may occupy the last remains of suitable habitat. In light of this fact, climate change, although not mentioned in the Revised Recovery Plan (USFWS 2001), may also be a threat to the perpetuation of this species.

Sacramento prickly poppy (Argemone pleiacantha ssp. pinnatisecta)

Species Status on the Lincoln NF

The Sacramento prickly poppy was listed as an endangered species on August 24, 1989. It is known to occur on lands managed by the State of New Mexico (Oliver Lee State Park), the Bureau of Land Management (BLM), the City of Alamogordo, and private properties; however, approximately 80 percent of the Sacramento prickly poppy populations are found on lands managed by the Lincoln NF (USFWSU 1994). Sacramento prickly poppy is an herbaceous perennial endemic to the western escarpment of the Sacramento Mountains in south-central New Mexico. Historically, populations of Sacramento prickly poppy have occurred in 13 canyons within eight canyon systems on the Lincoln NF. These eight canyon systems included Fresnal Canyon which encompasses Salado and La Luz canyons; Dry Canyon; Marble Canyon; Alamo Canyon, which includes Caballero, Gordon and Deadman Canyons; Mule Canyon; San Andreas Canyon; Dog Canyon; and Escondido Canyon.

Key Ecological Conditions Needed to Support the Species

Suitable habitat characteristics for the Sacramento prickly poppy include steep, rocky canyons among piñon-juniper and Chihuahuan desert scrublands and grasslands. Suitable habitat is also found among the lower elevation of ponderosa pine woodlands (USFWS 2013). This species has been documented at elevations from ranging from 4,200 feet, in Dog Canyon, to 7,120 feet in the upper part of Alamo Canyon (Malaby 1987). Sacramento prickly poppy is found in xeric uplands and mesic sites that are in arid canyon beds, stream banks, areas surrounding springs and seeps, and in dry terraces situated above riparian zones. It also grow between rocks and gravel of stream beds; on bars of silt, rock, and gravel with vegetation present; and on cut slopes (USFWS 2013). The poppy is primarily found in soils that have limestone, sandstone and gypsum parent materials (USFWS 1994).

On the Lincoln NF, naturally-occurring populations of Sacramento prickly poppy are associated with a variety of Ecological Response Units (ERU), including: *Sparsely Vegetated, Chihuahuan Desert Scrub, Desert Willow, PJ Grassland-Cold, PJ Woodland-Cold, Herbaceous Wetland and Fremont Cottonwood/Shrub* (Terrestrial Vegetation chapter). Four transplant populations are associated with *Mountain Mahogany Mixed Shrubland* (near Potato Knob)*; Fremont Cottonwood/Shrub, PJ Grassland, and Herbaceous wetland*

(Alamo Canyon)*;* and *Fremont Cottonwood/Shrub* and *Sparsely Vegetated* (Salado and La Luz Canyons). In almost all currently and historically occupied canyons, Sacramento prickly poppy is associated with the *Sparsely Vegetated* ERU (i.e., Mule [historic], San Andres, Escondido [private property], Marble [historic], Fresnal, Salado, Dry [historic], Dog, and La Luz Canyons. However, populations that are most persistent and have the highest population numbers appear to be more closely associated with the *Fremont Cottonwood/Shrub.*

The largest occupied site within the Plan Area occurs in the Alamo Canyon system, which includes Caballero, Gordon and Deadman Canyons. In 1987, the Alamo Canyon system contained 73 percent of the known population of Sacramento prickly poppy (USFWS 2013). However, since this initial documentation, the number of adult and seedling individuals located within the Alamo Canyon system, on Forest Service lands, has decreased from 818 to 316 plants in 2011. This illustrates a very steep decline in population size (approximately 62 percent in 23 years). In addition, the Sacramento prickly poppy is currently thought to be extirpated from Mule and Dry Canyons, and individuals once located in Marble Canyon have not been relocated since 2009. However, range-wide population trends are difficult to determine due to past inconsistencies in monitoring (USFWS 2013).

In accordance with the conservation measures set forth by the U.S. Fish and Wildlife Service (USFWS) in the 2012 Biological Opinion (BO) for the reauthorization of continued livestock grazing on the Sacramento and Dry Canyon Allotments (Cons. # 22420-2000-F-473), the Lincoln NF conducts annual population surveys within the Alamo Canyon system (Table 170)*.* In addition, data is collected from one additional canyon system known to support prickly poppy colonies (i.e., Fresnal/La Luz/Salado; Marble, San Andres, and Dog Canyon systems), with the goal of surveying each canyon system at least once by the end of 2016 (USFWS 2012). Population counts tend to vary significantly from year to year within Alamo Canyon (Table 167); however, the reason for this variation is not fully understood. It may be the result of interaction among several factors such as impacts associated with livestock grazing, drought, water diversion, disease, flood events, and road and pipeline maintenance or be a result of the number of resources available for annual surveys.

Key Risk Factors

Some flooding has been documented to aid with contributing water, silt and nutrients that increase the success rates for germination and establishment. However, flooding and soil erosion can also result in the decline in Sacramento prickly poppy populations. In 1977, up to 100 plants expired due to flash floods in the lower Alamo Canyon. Individuals that are susceptible to the highest risks in mortality are individuals that occur in and along arroyos. Destruction of poppy habitat from floods associated with the monsoon rains in the year 2006 led to increased mortality rates, a decrease in suitable habitat and thus a decrease in seedling establishment. Once suitable habitat is destroyed, it may not be suitable again for several years due to the loss of imperative soils and vegetation needed to develop adequate soil structure, to support the Sacramento prickly poppy (USFWS 2013).

Livestock grazing within the Sacramento Prickly Poppy habitat contributes to trampling and destruction of individuals, and an increase in soil erosion. Soil erosion can remove crucial substrate along riparian zones and can be exacerbated by flooding. Furthermore, the degradation of habitat can lead to the encroachment of weedy and invasive species, which ultimately increase competitive pressure. The Sacramento allotment contains around 40 miles of perennial streams, with less than ten percent of the riparian zones associated with perennial waters classified in satisfactory condition. It was reported that the populations of Sacramento prickly poppy were steadily increasing when livestock grazing in the Sacramento allotment was suspended and the populations declined after livestock grazing was permitted again in 1991 (USFWS 2013).

In 2007 it was reported that three plants were killed from herbicide use along the U.S. Highway 82 right-of-way, near High Rolls, New Mexico. This incident resulted in the prohibition of herbicide use in Sacramento prickly poppy habitat (USFWS 1994).

Table 170. Forest-wide Sacramento prickly poppy monitoring data collect by the Lincoln NF between 2012 and 2015. Dash symbol (--) indicates an absence of data for a particular year.

	Alamo Canyon*		Fresnal/La Luz/ Salado Canyon		San Andres Canyon		Dog Canyon		Marble Canyon	
	Mature	Sub-Adult	Mature	Sub-Adult	Mature	Sub-Adult	Mature	Sub-Adult	Mature	Sub-Adult
2011	316	--	--	--	--	--	--	--	--	--
2012	551	94	159	8	21	3	--	--	--	--
2013	479	17	--	--	--	--	--	--	--	--
2014	638	49	--	--	--	--	124	31	--	--
2015	409	141	--	--	--	--	--	--	0	0

***includes Caballero Canyon, and populations located on the City of Alamogordo property**

The destruction of suitable habitat from road maintenance has led to the demise of many mature individuals. In 2008, a maintenance road was cleared by the City of Alamogordo in upper Alamo Canyon which resulted in the destruction of poppy individuals in which only a few had re-sprouted afterwards (USFWS 1994). Mowing is another roadside maintenance procedure that has been restricted due to the threat it may pose to Sacramento prickly poppy individuals.

Water diversion and the addition of water pipelines running through La Luz, Fresnal, Alamo, and Caballero Canyons along the western slope of the Sacramento Mountains has resulted in a loss in water resources previously available to the Sacramento prickly poppy. Changes in natural hydrology has made the upland areas of the canyon more arid and less suitable for Sacramento prickly poppy habitat. The large, heavy equipment used for the installation and maintenance of the water pipelines also poses a threat to poppy populations (USFWS 1994).

Although off- highway vehicles are permitted in Alamo, Caballero, Fresnal and La Luz Canyons, they may negatively impact poppy populations by destabilizing soils, destroy or disturb individuals, and adversely impact germination and establishment.

Status Summary for the Sacramento prickly poppy

The Sacramento prickly poppy was listed as an endangered species in 1989 due to its limited range and high degree of threat. At the time of listing, population numbers were estimated at 1,313 individuals range-wide. Since this initial documentation, the number of adult and seedling individuals located within the Alamo Canyon system (the population core) decreased approximately 62 percent over 23 years. The reason for this decrease is not fully understood. However, it may be the result of interaction among several threats; chief among them are water diversion, impacts from livestock grazing and prolonged drought. Despite changes in land management practices for the benefit of the Sacramento prickly poppy (refer to USFWS 2012, Consultation # 22420-2000-F-473), population numbers remain unstable.

Mexican Spotted Owl

Species Status on the Lincoln NF

The Mexican spotted owl (MSO) occurs from southern Utah and Colorado south through the mountains of Arizona, New Mexico, and west Texas into the mountains of central Mexico (McDonald et al. 1991 cited in USDI Fish and Wildlife Service 2013c). The widespread but patchy distribution reflects the availability of forested mountains and canyons, and rocky canyonlands.

The Lincoln NF has conducted habitat and presence/absence surveys for MSO since the late 1980s. To date, over 150 MSO Protected Activity Centers (PACs) have been established on the Lincoln NF, with 140 in the Sacramento Mountains, and another 12 in the canyonlands of the Guadalupe Mountains. The Sacramento Mountain range is considered the most saturated MSO habitat in the Basin and Range East critical habitat unit, with most of the sites occurring on the Sacramento RD. A variety of suitable nesting habitat for the MSO occurs on the Lincoln NF, including cool micro-sites containing small dense collections of mature softwoods with a dense canopy, thus providing nesting cover and protection from aerial predation. In the Guadalupe Mountains, the canyons are often steep and narrow, and MSO are often documented nesting among the stalactites and other formations of caves.

Key Ecological Conditions Needed to Support the Species

Key habitat variables required to fulfill MSO life history requirements include nesting, roosting, and foraging habitat patches with structural, compositional, and successional diversity, as well as connectivity among suitable patches, which is critical for the MSO. Management recommendations for three categories of MSO habitat (i.e., protected activity centers, recovery habitat, and other forest and woodland types) are provided within the MSO Recovery Plan (USDI Fish and Wildlife Service 2012).

Throughout their range MSOs nest, roost, forage, and disperse most commonly in mixed- conifer forests that may include Douglas-fir and/or white fir, with codominant species including southwestern white pine, limber pine, and ponderosa pine. The understory often contains the above coniferous species as well as broadleaved species such as Gambel oak, maples, box elder, and/or New Mexico locust (Kertell 1977, Reynolds 1990, Rinkevich 1991, Willey 1993, cited in USDI Fish and Wildlife Service 2013c).

Foraging occurs in a variety of habitats including managed and unmanaged forests, pinyon-juniper woodlands, mixed-conifer and ponderosa pine forests, cliff faces and terraces between cliffs, and riparian zones (Ganey and Balda 1994, Willey 1998a, b; Ganey et al. 2003, Willey and Van Riper 2007, all cited in USDI Fish and Wildlife Service 2012). Reported prey items include woodrats, mice, voles, rabbits, gophers, bats, birds, reptiles, and arthropods.

MSOs in the Basin and Range East Unit are found primarily in the Spruce Fir, high elevation dry and wet Mixed Conifer, Mixed Conifer/Pine and Ponderosa Pine ERUs. Reference conditions for dry Mixed Conifer and Ponderosa Pine ERUs include small dispersed clumps across the landscape, with open grassy areas and single large trees in small groups or solitary. Reference conditions for wet Mixed Conifer and Spruce Fir include closed canopy forests, with older large trees and some openings for regeneration of trees, with correspondingly smaller montane subalpine grasslands. In areas that have experienced high burn intensity, the MSO persist in small clumps of surviving mature trees, but have also moved into nearby drainages for better canopy cover for nest trees.

The canyonland habitat in the Guadalupes often contains ponderosa pine in the canyon bottoms along the riparian areas, and up onto the more protected slopes, with pinyon-juniper growing on the mesa tops (USDI Fish and Wildlife Service 2012). In the southern part of the Guadalupes, in higher elevations, the habitat contains mature Douglas-fir, white fir, and Mexican longleaf pine along the ridges. Individuals in the canyonlands of the Guadalupe Mountains are limited by the cave habitat and accessibility for nesting. They prey mainly on bats, supplementing their diet with insects and small rodents from the upper mesa tops.

The cave habitat must have a fairly large opening and contain formations suitable for establishing nests close to the entrance.

Both the wet and dry mixed conifer ERUs are moderately departed from reference conditions, with little change predicted for the future. The dry mixed conifer ERU is expected to increase in early seral states at the expense of larger sized closed forest. The lower size classes are 95 percent departure. Insect and disease, as well as landscape-wide highs severity wildfires are impacting these ERUs, contributing to departure of key ecological characteristics from reference conditions. Amendments to the 1986 forest plan restrict ability to treat forest areas within PACs, which has contributed to some of the departure, and perpetuating this trend. The revision will provided means to incorporate the new MSO recovery plans (USDI FWS 2012) and manage the vegetation to restore system sustainability. The CWD and Snags components are a little low for the dry Mixed Conifer ERU and the Ponderosa Pine ERU, and high for the wet Mixed Conifer ERU. There is expected recruitment from the >10” closed canopy size classes in future years. In areas where there has been extensive bug kill, the abundance of dead and down woody material and snags is departed, but skewed into higher than average amounts.

Critical Habitat (designated by USFWS) contain Primary Constituent Elements (PCEs), which are physical and biological features necessary to ensure conservation of the species. The USFWS (2005) identified these PCEs in the August 204 designation of the MSO Critical Habitat.

The PCEs related to forest structure include:

- Range of Tree Sizes: A range of tree species, including mixed conifer, pine-oak, and riparian forest types, composed of different tree sizes reflecting different ages of trees, 30 percent to 45 percent of which are large trees with a trunk diameter of 12 inches or more when measured at 4.5 feet from the ground;
- Canopy Closure: A shade canopy created by the tree branches covering 40 percent or more of the ground;
- Large Snags: Large dead trees with a trunk diameter of at least 12 inches when measured at 4.5 feet from the ground;

The PCEs related to the maintenance of adequate prey species include:

- Dead and Down Woody Debris: high volumes of fallen trees and other woody debris
- Plant Species Richness: a wide range of tree and plant species, including hardwoods
- Residual Plant Cover: Adequate levels of residual plant cover to maintain fruits and seeds, and allow plant regeneration.

Key Risk Factors

Two primary reasons cited for the original Federal listing of MSO in 1993 were (1) historical alteration of its habitat as the result of timber-management practices, and (2) the threat of these practices continuing as evidenced in existing national forest plans. The danger of stand-replacing wildland fire was also cited as a threat at that time. With recent forest management now emphasizing sustainable ecological function and a return toward pre-settlement fire regimes, the primary threats to the MSO population in the United States have since transitioned from timber harvest to an increased risk of stand-replacing wildland fire. For example, during the Little Bear Fire, on the Smokey Bear RD, sixteen of the twenty PACs on the district were impacted by the fire, with 6 core nesting areas destroyed and 3 occupied PACs found to have mortality. Climate variability combined with current forest conditions may also synergistically result in increased loss of habitat from fire. More intense natural drought cycles and the ensuing stress placed upon forested habitats could result in even larger and more severe wildland fires in owl habitat (USDI Fish and Wildlife Service 2012).

Additional threats to MSO include, but are not limited to, predation, loss of nest trees, herbicides, high levels of noise during nesting season, and removal of core areas. Additional threats to MSO habitat include, but are not limited to, climate change, new road development, new trail development next to core areas, developed recreation, and unmanaged recreation (e.g., unauthorized trails). These threats are clearly described in the 2010 MSO recovery plan (USDI Fish and Wildlife Service 2012).

Status Summary for the MSO

The habitat on the Sacramento RD is fairly well represented, or distributed across the District. However, the northern edge of this population (Smokey Bear RD) continues to be widely spaced and not well distributed across the landscape. The Guadalupe Mountain canyonland MSOs exhibit low redundancy (limited occurrences) across the landscape.

The MSO requires mature dense timber for nest core areas, as well as specific PCEs of dead and down woody material, residual plant cover, and open meadows or grassy habitat for foraging. Populations of the MSO have been determined to need nearly continuous suitable habitat with PACs of 600-800 acres. Rangewide the species needs multiple resilient populations to support redundancy in each geographic management area. Distribution across the range is also important in order to facilitate dispersal and recolonization of uninhabited areas.

Given the continued trend of departure from reference conditions in the ERUs, this species is in a high risk category. Without active conservation, the Lincoln NF populations could be vulnerable to further habitat loss. In addition, climate change and high impact wildfire can be expected to threaten many current locations with habitat loss for decades, as this species needs large mature timber for nesting core areas.

Peñasco least chipmunk

Species Status on the Lincoln NF

The Peñasco least chipmunk (least chipmunk) is endemic to the Sacramento Mountains of New Mexico (Frey 2007). There is currently one occupied site for the species, which is on the Smokey Bear RD of the Lincoln NF (Frey et al. 2016). Sites of historic occupation within the Sacramento RD have been surveyed, did not yield any recent evidence of least chipmunks presence, and least chipmunks may be extirpated from those sites.

The least chipmunk was first discovered and named in 1902 east of Cloudcroft, in the Sacramento RD, along the Rio Peñasco from 7000 to 8000 feet in the yellow pine zone (Bailey 1902). However, further investigation reveals the collections to have been along the James Canyon River and at the confluence of James Canyon and the Rio Peñasco (Frey et al. 2009).

Key Ecological Conditions Needed to Support the Species

Little is known about Peñasco least chipmunk foraging, nesting or hibernation habits. However, based on other least chipmunk species, it may well subsist on insects, seeds, leaves, fungus and the occasional bird egg (Verts and Carraway 2001). Nesting of other least chipmunk species show them to dig a burrow 2-3 feet underground (IUCN Red List 2016) and fill it with grass, shredded bark, feathers, fur and other soft materials, in addition to storing food (Verts and Carraway 2001). Other least chipmunk species hibernate between September and April, depending on snowfall and the length of cold weather (IUCN Red List 2016). Most least chipmunk species do not store up winter fat, instead they rely on waking up during the hibernation season to eat stored food (Verts and Carraway 2001).

The Peñasco least chipmunk is generally believed to have limited ability for travel between open grassy subalpine grasslands and high elevation meadows that contain fragmented habitat. This fragmented habitat appears to be a limiting factor possible dispersal capabilities (Frey et al 2016). Other habitat considerations appear to include elevations at or above 10,000 feet, presence of rocks or talus slope, open tundra/subalpine above treeline, and open meadow with escape cover (Frey et al 2016).

The main ERU linked to this species' Smokey Bear RD location is MSG. Other embedded habitat components include rock outcrops and talus slopes. Prior historic locations included montane meadows. The species can also be found in transition zones where grassland and shrubs meet.

Conditions of the habitat appears to be minimally adequate for maintaining the species. MSG seral state proportions are highly departed from reference conditions (97 percent; see Riparian Vegetation chapter), suggesting limited resiliency in the ecosystem currently. Rangewide, there are no other occupied sites. With only a single site of occurrence, the least chipmunk appears to have a high potential for extirpation.

Key Risk Factors

Threats to the species include:

- Unmanaged Grazing - eliminates herbaceous vegetation, reducing the cover and available food sources. The loss of cover contributes to the potential for increased predation, as well as a loss of travel corridors and a reduction in the amount of food sources available.
- Reduction in available water – whether due to drought conditions or abnormally low snowfall, lack of available water results in loss of saturated soils and a reduction in the habitat constituents used for dispersal, foraging, nesting and daily travel for the least chipmunk.
- Presence and distribution of non-desirable invasive species - Non-native invasive species have been known to alter suitable habitat for native faunal species by altering disturbance regimes, nutrient cycles, and hydrologic cycles. Some non-native invasive species have been observed in the least chipmunk habitat including Kentucky bluegrass (USFS 2015), which can outcompete native grasses, displacing preferred food sources for the least chipmunk.
- Encroachment of trees and shrubs - on the open grassy habitat encourages competition from the gray-footed chipmunk. This more aggressive and generalized species appears to out-compete the least chipmunk in food and nesting resources, further reducing the population.
- Pigs

Threats to the habitat include:

- Lack of water from drought conditions or diversion results in loss of saturated soils and loss of herbaceous vegetation.
- Encroachment of trees and shrubs – Encroachment of drier tree and shrub species have been noted to result in loss of wet meadow and subalpine grasslands, reducing the amount of habitat available to the least chipmunk and contributing to further habitat fragmentation.
- Unmanaged grazing - Livestock grazing has been identified as a threat to the least chipmunk. Livestock grazing can greatly reduce herbaceous vegetation, in effect, reducing the cover, forage and nesting material available.
- Channelization and Habitat Fragmentation - Roads and off-highway vehicle trails are two causes of destruction of open wet grasslands and subalpine meadows, contributing to habitat fragmentation. This reduced connectivity limits a species ability to move into adjacent areas, to colonize suitable habitat or utilize habitat that fulfills its life cycle needs, including gene flow (Craddock and Huenneke 1997). In addition, the roads and trails channelize the water flow, and block water from reaching down-slope habitat, which results in further fragmentation of the habitat and decreased succession of individuals. Timber management, with temporary roads, landings and logging decks could also contribute to channelization. In addition, soil compaction resulting from these management activities has the potential to alter hydrological regimes and could contribute to habitat fragmentation.

- Future climate change - may be expected to bring less rainfall in future years, further reducing the amount of water available to support the wetland conditions. In addition the increased ambient temperatures may raise the temperatures above conditions where the least chipmunk can persist.
- Recreation activities - Development of recreation sites in wet meadows has the potential to reduce colony numbers and discourage use by the least chipmunk. These activities can include, but are not limited to, unmanaged off-road recreation, user-created trails, developed recreation, and dispersed recreation. Unmanaged recreation may potentially have the biggest impact, as vehicle use and foot traffic can alter hydrological flow through increased channelization, direct impact to habitat and contributing to soil compaction.
- Other activities that reduce or truncate connectivity - Additional habitat loss and fragmentation can occur with user-created roads and high intensity wildfire. Secondary sources of temporary reduction in habitat for the least chipmunk include moderate intensity wildfire, flooding and vegetation mowing.

Status Summary for the Peñasco least chipmunk

The least chipmunk requires open grassy montane habitat, including dry and wet high elevation meadows. It may also depend on adjacent transition zones with trees and shrubs, possibly to support travel corridors or to support breeding. Ecological conditions in these systems are highly departed from reference conditions.

Currently, there is only one occupied site known to exist, with no other presence detected in historically occupied locations. The population is very small and isolated, conditions which tend to limit the probability of persistence. The least chipmunk appears to have a high potential for extirpation. In addition, climate change and high impact wildfire can be expected to threaten this species. Furthermore the single site of occupancy prohibits genetic exchange. Without active conservation this population will remain very small and highly vulnerable to extirpation (which may mean extinction for the species as a whole). The least chipmunk falls in a very high risk category.

New Mexico Meadow Jumping Mouse

Species Status on the Lincoln NF

The New Mexico meadow jumping mouse (jumping mouse) is endemic to New Mexico, Arizona, and a small area of southern Colorado (Hafner et al. 1981, pp. 501-502; Jones 1999, p. 1). There are currently 4 occupied sites on the Sacramento RD, and 5 areas of Designated Critical Habitat. Rangewide, four of eight geographic management areas (Sacramento RD being one) have two or more locations occupied by the mouse, but are too small and isolated to be resilient. The other four geographic management areas currently have only one recent location occupied by the mouse, and are too small to be resilient. While some diversity is maintained across the eight geographic management areas, resiliency of existing populations is adequate.

The jumping mouse is active only during the growing season of the grasses and forbs on which it depends. During the growing season, the jumping mouse accumulates fat reserves by consuming seeds. Preparation for hibernation, including weight gain and winter nest building, seems to be triggered by day length but may also be aided by temperature decline. The jumping mouse hibernates about nine months out of the year, longer than most other mammals (Morrison 1990, p. 141; VanPelt 1993, p. 1; Frey 2005, p. 59).

Based on studies of similar species, jumping mice (Zapus spp.) diets are varied, consisting of seeds, insects, fruits, and fungi (Quimby 1951, pp. 85–86; Hoffmeister 1986, p. 455; Morrison 1990, p. 141). Morrison (1990, p. 141) reported that jumping mice feed primarily on seeds of grasses and forbs, with seeds of sedges, bulrush (Scirpus spp.), and cattail (Typha latifolia) infrequently eaten.

Although little is known about the reproductive needs of the jumping mouse, the breeding season appears to begin in June/July, with one litter produced each year (Morrison 1987, pp. 14–15; 1989, 22; Frey and Wright 2011, p. 69; 2012b, p. 5). Jumping mice (Zapus spp.) breed shortly after emerging from hibernation and may give birth to 2 to 7 young after an average 17- to 21-day gestation (Quimby 1951, p. 63; Frey and Wright 2011, p. 69).

Key Ecological Conditions Needed to Support the Species

The jumping mouse is a habitat specialist (Frey 2006, p. 3). It nests in dry soils, but uses moist, streamside wetland and riparian vegetation (Frey 2006, pp. 34- 45) up to an elevation of about 9,500 feet (USFS 2016). The species appears to utilize two riparian community types: (1) persistent emergent herbaceous wetlands and (2) scrub-shrub wetlands (Frey 2005, p. 53). Patches or stringers of tall dense sedge habitats on moist soil along the edge of permanent water are very important to the species.

The main ERUs linked to this species are small specialized riparian communities along rivers and streams, springs and wetlands, and wet meadows that contain:

- Persistent emergent herbaceous wetlands especially characterized by presence of primarily forbs and sedges (*Carex spp*. or *Schoenoplectus pungens*); or
- Scrub-shrub riparian areas that are composed of willows (*Salix* spp.) or alders (*Alnus spp*.) with an understory of primarily forbs and sedges;
- Flowing water that provides saturated soils throughout the New Mexico meadow jumping mouse’s active season that supports tall (average stubble height of herbaceous vegetation of at least 61 cm (24 inches) and dense herbaceous riparian vegetation composed primarily of sedges (*Carex* spp. or *Schoenoplectus pungens*) and forbs, including, but not limited to one or more of the following associated species: spikerush (*Eleocharis macrostachya*), beaked sedge (*Carex rostrata*), rushes (*Juncus* spp. and *Scirpus* spp.), and numerous species of grasses such as bluegrass (Poa spp.), slender wheatgrass (*Elymus trachycaulus*), brome (*Bromus* spp.), foxtail barley (*Hordeum jubatum*), or Japanese brome (*Bromus japonicas*), and forbs such as water hemlock (*Circuta douglasii*), field mint (*Mentha arvense*), asters (Aster spp.), or cutleaf coneflower (*Rudbeckia laciniata*);
- Sufficient areas of 9 to 24 kilometers (5.6 to 15 miles) along a stream, ditch, or canal that contains suitable or restorable habitat to support movements of individual New Mexico meadow jumping mice; and
- Include adjacent floodplain and upland areas extending approximately 100 meters (330 feet) outward from the boundary between the active water channel and the floodplain (as defined by the bankfull stage of streams) or from the top edge of the ditch or canal.

These areas occur in the herbaceous wetland, and montane conifer willow, upper montane-willow, willow-thinleaf alder, and ponderosa pine-willow ERUs. In each of these, the shrub cover is intermittent. The jumping mouse requires dense herbaceous vegetation of sedges and forbs (24 inches or taller) along flowing streams to support feeding and sheltering. It depends on adjacent uplands to support breeding and hibernation. Populations of the jumping mouse have been determined to need nearly continuous suitable habitat along at least 5.6 miles with 68 or more acres of streams to support resilient populations. Rangewide the species needs multiple resilient populations to support redundancy in each geographic management area.

Where a functioning floodplain dynamic occurs, streambank and floodplain interaction will support extensive graminoid vegetation with diverse species and structure. In the absence of properly functioning stream systems, graminoid vegetation is less extensive, diverse and structured. Many areas of floodplain riparian and wet meadows are either impaired or non-functioning due to past land management practices and ongoing stressors (Systems Drivers and Stressors chapter). Adverse conditions may be compounded due to periods of inadequate moisture such as during the past several years, rendering adequate contiguous habitat suitable for the jumping mouse sparse. Within the inhabited ERUs, departure of key ecosystem characteristics is considered at least moderate, due to the presence of non-riparian species dominance in former wet meadows and riparian areas. Terracing, increased or accelerated erosion, wetland draining and the introduction of non-native grasses help define this departure from the expected condition. Additional current conditions (and trends) include overstocking of overstory trees and a closed shrub state. At least one occupied site habitat has been significantly degraded since 2010.

Key Risk Factors

Threats to the species include:

- Unmanaged Grazing - eliminates herbaceous vegetation, reducing the cover and available food sources. The loss of cover contributes to the potential for increased predation, as well as a loss of travel corridors and a reduction in the amount of food sources available for the jumping mouse.
- Reduction in available water – whether due to drought conditions or diversion, this lack of available water results in loss of saturated soils and a reduction in the corridors used for dispersal, foraging, nesting and daily travel for the jumping mouse.
- Presence and distribution of non-desirable invasive species - Non-native invasive species have been known to alter suitable habitat for native faunal species by altering disturbance regimes, nutrient cycles, and hydrologic cycles. For example, teasel (Dipsacus sylvestris) has been shown to directly displace native plants in the habitat through competitive pressure (Huenneke and Thomson 1995). It appears this is partially due to teasel’s superior ability to germinate in the dark (i.e., in closed shrub canopy or overstocked trees). A number of other non-native invasive species have been observed in the jumping mouse habitat including musk thistle (Carduus nutans), mullein (Verbascum thapsus), bull thistle (Cirsium vulgare), tamarisk (Tamarix chinensis), and Siberian elm (Ulmus pumila) (Roth 2013).
- Pigs

Threats to the species habitat include:

- Lack of water from drought conditions or diversion results in loss of saturated soils and loss of herbaceous vegetation.
- Modification of seeps and springs – many of the headwaters of the streams and riparian communities depend on intact seeps and springs, with little to no interruption of the hydrological flow. Encroachment of upland species and interruption of the water flow have been noted to result in loss of wetland habitat, reducing the amount of habitat available to the jumping mouse.
- Unmanaged grazing - Livestock grazing has been identified as a threat to New Mexico meadow jumping mouse. Livestock grazing can greatly reduce herbaceous vegetation, in effect, reducing the cover, forage and nesting material available.
- Channelization and Habitat Fragmentation - Roads and off-highway vehicle trails are two causes of channelization, contributing to habitat fragmentation. This reduced connectivity limits a species ability to move into adjacent areas, to colonize suitable habitat or utilize habitat that fulfills its life cycle needs, including gene flow (Craddock and Huenneke 1997). In addition, the roads and trails channelize the water flow, and block water from reaching down-slope habitat, which results fragmentation of the habitat and decreased succession of individuals. Timber management, with

temporary roads, landings and logging decks could also contribute to channelization. In addition, soil compaction resulting from these management activities has the potential to alter hydrological regimes and could contribute to habitat fragmentation. Entrenchment, poorly vegetated floodplains, terracing of older floodplains all contribute to this.

- Climate change - Climate change can be expected to further stress currently occupied wetland systems and habitats.
- Recreation activities - Development of recreation sites in wet meadows has the potential to reduce colony numbers and discourage use by the jumping mouse. These activities can include, but are not limited to, unmanaged off-road recreation, user-created trails, developed recreation, and dispersed recreation. Unmanaged recreation has the biggest impact, as vehicle use and foot traffic can alter hydrological flow through increased channelization, direct impact to habitat and contributing to soil compaction.
- Other activities that reduce or truncate connectivity - Additional habitat loss and fragmentation can occur with user-created roads and high intensity wildfire. Secondary sources of temporary reduction in habitat for the jumping mouse include moderate intensity wildfire, flooding and vegetation mowing.

New Mexico meadow jumping mice are believed to have limited ability for travel along a riparian corridor that contains fragmented habitat. Fragmented habitat appears to be a limiting factor for dispersal capabilities (Morrison 1988, p. 13; Frey and Wright 2012, pp. 43, 109).

Status Summary for the New Mexico Meadow Jumping Mouse

The jumping mouse requires dense herbaceous vegetation of sedges and forbs (24 inches or taller) along flowing streams to support feeding and sheltering, and depends on closely adjacent uplands to support breeding and hibernation. Conditions of the habitat for the species appears to be minimally adequate for persistence, and lacks resiliency. Accordingly, jumping mouse populations appear to have limited resiliency and exhibit a high potential for extirpation. The populations are very small and isolated. The number of subpopulations (i.e., redundancy) also remains small, and opportunities for genetic exchange are limited, characteristics which further reduce population viability. Without active conservation each of the populations will remain small and vulnerable to extirpation, putting the species into a high risk category, consistent with its ESA listing.

Initial list of Potential Species of Conservation Concern

We found 259 species (excluding ESA listed species) to be associated with at least one of the four counties that encompass Lincoln NF and to meet an initial criteria for consideration as potential SCC (including all must- and should-consider species). Table 171shows the major information resources contributing to that initial list of potential SCC.

Table 171. Major information sources contributing to the initial list of SCC. These are species that are associated with at least one of the four counties that encompass Lincoln NF and meet an initial criteria for consideration as potential SCC if they are established on LNF.

	NS	SGCN	RPTC	RFL	BCC	TOTAL UNIQUE
Fungi	1					1
Plant	79		62	11		87

	NS	SGCN	RPTC	RFL	BCC	TOTAL UNIQUE
Arthropod	16	19		4		24
Mollusc	18	9		6		19
Vertebrate	65	84		18	45	128
Grand Total	**179**	**112**	**62**	**39**	**45**	**259**

Note that many species occur on multiple lists. The TOTAL UNIQUE column accounts for species overlap among contributing lists. NS=NatureServe, SGCN=NMDGF's Species of Greatest Conservation Need, RPTC=species on the NM Rare Plant Technical Committee rare plant list, RFL=Regional Forester's Sensitive Species List, and BCC=USFWS (2008) Birds of Conservation Concern.

For each of the species in the four county list, we compiled additional taxonomic and distribution data in order to assess whether it occurs on the Forest as an accepted taxonomic entity. Additionally, resource specialists reviewed the initial list of potential SCC in order to refine it with regard to whether the species occur on Lincoln NF Districts.

Potential Species of Conservation Concern Not Put Forward as Proposed

Eighty-eight of the 259 species in the four county list are not established on the Forest. Accordingly, those were not further assessed as potential SCC for Lincoln NF. A list of those species is provided in the Assessment Details for all Species of Conservation Concern. That left 171 species that regularly occur on Lincoln NF and meet one or more criteria for consideration as SCC (must consider or should consider). Those 171 species required further assessment prior to being put forward as proposed SCC or dropped from further consideration. The 171 potential SCC included 1 conifer, 59 flowering plant, 16 arthropod (2 crustacean and 14 insect, mostly butterflies and moths), 15 mollusk (gastropod), and 80 vertebrate (3 fish, 3 amphibian, 2 reptile, 62 bird, and 10 mammal) species. For each of the remaining species associated with Lincoln NF, additional abundance, trend, habitat, and threat related data from all sources were compiled into the original data tables and further assessed (available information varied among taxonomic group and among species within groups).

Of the 171 species on the initial list and determined to occur on the Forest, 122 species were not carried forward as potential SCC (Table 172). The species removed from the initial list of potential SCC were those for which we could not document substantial concern regarding capability to persist over the long term in the Plan Area. Some were found to have stable populations on the Forest, or widespread distribution on the Forest combined with little or no threat, and no declines, reported for populations on the Forest. Those included cases where the BASI did not specify or clearly indicate that the species is: declining overall or in terms of a decreasing number of local sub-populations on the Lincoln NF; limited to small populations that are declining due to ongoing threats on the Forest; or vulnerable to extirpation in the foreseeable future due to management actions or other potential threats on the Forest. We viewed those cases to represent a lack of substantial concern, in the BASI, about the species' capability to persist over the long term in the Plan Area. The remaining 49 are proposed as SCC for LNF; they are presented in the next section.

Reasons for consideration, distribution among local units, and justifications for SCC status determinations are summarized in Table 172 and Table 173. For some species, information gaps, uncertainties or topics of desirable information are indicated. For species put forward as proposed SCC, additional ecological data is summarized in the Conditions, Features, and Trends for At-Risk Species section. For all species considered, the Assessment Details for all Species of Conservation Concern provides additional details on SCC determinations, uncertainties, and other topics.

The table illustrates NatureServe G, T, and S ranks; whether the species is on the 2015 Region 3 Forester's Sensitive Species List (RFSSL) and attributed to Lincoln NF or the Birds of Conservation Concern list (BCC); and whether the species is on the RPTC rare plant list or the SGCN list (including NM threatened and endangered species). This table also illustrates specific Ranger Districts and Local Units for which we found records of each species: 1AM=Arroyo Macho; 1TV=Tularosa Valley; 1RH=Rio Hondo; 2SB=Salt Basin; 2TV= Tularosa Valley; 2RP=Rio Peñasco; 2SB=Salt Basin; and 3UP=Upper Pecos. Additional details and analyses are provided in the Assessment Details for all Species of Conservation Concern for every species.

Table 172. Species that occur on Lincoln NF and were considered as potential SCC, but which are not being carried forward as proposed SCC for the Lincoln NF (122 in number)

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Subalpine Fir/Corkbark Fir; Abies lasiocarpa var. arizonica	G5T2T4 Q	T3	SNR			1RH	Available info did not specify threats or declines on Lincoln NF (or more generally), other than mortality in a high intensity fire. Not included on NM rare plant list.
Giant Helleborine; Epipactis gigantea	G4		S2?			2TV; 2RP; 3UP	Available info did not specify threats or declines on Lincoln NF (or more generally). Considered but not included on RPTC list: “Populations of this species are widespread and abundant across western U.S." (RPTC). However, it does occupy riparian seeps and ledges (BLM 2002), so perhaps should receive some surveillance going forward, to affirm that threats are negligible or absent.
Guadalupe Needlegrass; Achnatherum curvifolium	G3		S2			2TV; 3SB; 3UP	No threats identified as substantial conservation concerns for the species. This is partly attributed to habitat, at which potential threats are substantially avoided due to inaccessibility. Additional populations are being found with further botanical exploration. It was once on the RPTC rare species list and the R3 RFSS list, however, additional information revealed that this species is prevalent throughout portions of its range, which exceeds 100 miles (RPTC 2005). Synonym: *Stipa curvifolia*.
Trans Pecos False Mountain-parsley;	G4?		S2			2TV; 3	Widespread in the Plan Area with frequent occurrences in the Sacramento Mountains; does not qualify as a rare plant (RPTC). No threats identified as

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Pseudocymopterus longiradiatus							conservation concerns for the species on Lincoln NF.
Guadalupe Cliffdaisy; Chaetopappa hersheyi	G3		S3	RFL	RPTC	3UP	Locally abundant. May be susceptible to collecting in a few frequently visited places, but most plants are inaccessible (RPTC; NatureServe). Rock-inhabiting. Limited to Guadalupe Mountains.
Cloudcroft Thistle; Cirsium inornatum	G4		S4		RPTC	1TV; 1RH; 2TV; 2RP	Restricted to Sacramento Mountains.Limited range, but “relatively frequent” within it (RPTC). Occupies mountain meadows and roadsides, and appears to respond favorably to some disturbances (RPTC). No threats listed for the species on the Lincoln NF. “Some authors believe this species is an insignificant variant of Cirsium parryi” (RPTC).
Rubber Rabbitbrush; Ericameria nauseosa var. texensis	G5T3	T3	S3		RPTC	3SB; 3UP	Locally common. Surveys showed no declines. Other than being restricted in terms of range and habitat, no threats identified as conservation concerns for the species on the Lincoln NF. This is partly attributed to habitat, at which potential threats are substantially avoided due to inaccessibility. Endemic to the Guadalupe Mountains.
Sacramento Mountain Fleabane; Erigeron	G3		S3		RPTC	1RH; 2TV; 2RP	Locally abundant. No threats identified as conservation concerns for the species on the Lincoln NF. Endemic to the White Mountains and Sacramento Mountains.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
rybius							
Guadalupe Mountains Rabbitbrush; Lorandersonia spathulata	G3		S3			1TV; 1RH; 2TV; 3	Widespread and relatively common in the Plan Area. Does not qualify as a rare plant; dropped from RPTC list. No threats identified as conservation concerns for the species on the Lincoln NF. Synonyms: Chrysothamnus spathulatus (RPTC; NatureServe). Socorro County to the Guadalupe Mountains of New Mexico.
White Mountain Groundsel/White Mountain ragwort; Packera cynthioides	G3?		S3?			1; 2TV	More widespread than previously thought; dropped from NM rare plant list. "Occasionally occupies road cuts where it could be impacted by road maintenance operations". Otherwise, no threats identified for species on the Lincoln NF.
Five-flower Rockdaisy ; Perityle quinqueflora	G4		S3		RPTC	3UP	No threats identified as conservation concerns for the species on the Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided due to inaccessibility. Rock-inhabiting.
New Mexico Rockdaisy; Perityle staurophylla var.	G4T3T4	T3	SNR		RPTC	2TV	No threats identified as conservation concerns for the species on the Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided due to inaccessibility. Rock-inhabiting.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
staurophylla							
Small Rock-lettuce; Pinaropappus parvus	G3		S3?			2SB; 2RP; 3UP	Reported locally common on limestone ledges and cliffs (SEINet). No threats identified as conservation concerns for the species on the Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided due to inaccessibility. Dropped from RPTC list. Rock-inhabiting. Edge of Range.
Sacramento Groundsel; Senecio sacramentanus	G3		S3		RPTC	2TV; 2RP	“Not particularly threatened and its populations appear to be stable” (NatureServe). No specific threats identified, although responses to potential stressors have not been studied (RPTC). Endemic to the Sacramento and White Mountains in Lincoln and Otero counties.
Payson Hiddenflower; Cryptantha paysonii	G3		S3			3SB; 3UP	Locally common across southern NM; dropped from NM rare plant list. No threats identified as conservation concerns for the species on the Lincoln NF.
Strong Bladderpod; Lesquerella valida	G3		S3			1; 2TV; 3	Common in the Plan Area (NatureServe); dropped from NM rare plant list. No threats identified as conservation concerns for the species on Lincoln NF. Synonyms: *Physaria valida*.
Las Vegas Tumble Mustard; Thelypodiops	G3?		SNR			2RP	Various authors have noted the restricted range, but didnt indicate that it is rare (SEINet). Dropped from RPTC rare plant list. No threats reported in the sources

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
is vaseyi							consulted. Synonyms: *Sisymbrium vaseyi*
Chihuahuan Fishhook Cactus; Glandulicactus uncinatus var wrightii	G4T3	T3	S2			2TV; 3UP	Described as "not rare", with a "large range and a large number of individuals protected on military lands in New Mexico" (NatureServe). Dropped from RPTC list. Overall, the few records near Lincoln NF (SEINet) were ambiguous as to whether any actually occur within the Forest (due to position precision). Synonyms: *Sclerocactus uncinatus* var. *wrightii* (NatureServe).
Horned Spurge; Euphorbia brachycera	G5		S2			2RP	Fairly widespread in southern NM; dropped from NM rare plant list. No threats identified as conservation concerns for the species on Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided due to inaccessibility. Endemic to the western escarpment of the Sacramento Mountains and northern Franklin Mountains.
New Mexico Milk-vetch; Astragalus neomexicanus	G3		S3		RPTC	1RH; 2RP	No threats identified as conservation concerns for the species. It "appears to respond favorably to soil disturbance and is frequently found on roadcuts and overgrazed ranges" (RPTC). Limited distribtion, Sacramento Mountains.
White Mountain Lupine; Lupinus sierrae-	G3		S3		RPTC	1AM; 1RH; 2RP	Restricted range but locally common. No threats identified as conservation concerns for the species on Lincoln NF. Occurs on open roadsides and road banks in addition to montane meadows. Endemic to the Sacramento Mountains.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
blancae							
Mescalero Currant; Ribes mescalerium	G4?		S4?		RPTC	1RH	Literature does not delineate it as very rare or highly threatened. No specific threats identified, although responses to potential stressors have not been studied (RPTC). Limited to Sacramento and Guadalupe Mountains.
Silver-cup Mock Orange; Philadelphus argyrocalyx	G4		S3		RPTC	1RH; 2TV; 2RP	Literature does not delineate it as very rare or highly threatened. No specific threats identified (RPTC). However, it is restricted to the Guadalupe Mountains.
Yellowseed Fiddleleaf; Nama xylopodum	G4?		S4?		RPTC	3SB; 3UP	No threats identified as conservation concerns for the species on Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided or minimized due to inaccessibility. Rock-inhabiting. Limited to Franklin and Guadalupe Mountains.
Mckittrick Pennyroyal; Hedeoma apiculata	G3		S3		RPTC	3UP	Formerly ESA listed as threatened, this species was removed from the Federal list in 1993 (58 FR 49244) following discovery of additional populations in inaccessible locations with little or no threats. No threats identified as conservation concerns for the species on Lincoln NF. Endemic to Guadalupe Mountains.
Great Sage;	G3?		S3?		RPTC	3UP	No threats identified as conservation concerns for the species on Lincoln NF. This is partly attributed to

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Salvia summa							habitat, at which potential threats are avoided or minimized due to inaccessibility.
Huachuca Mountains Skullcap; Scutellaria potosina var. tessellata	G2G4		SNR			3UP	No threats identified as conservation concerns for the species on Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided or minimized due to inaccessibility. Rock-inhabiting. Not on NMRPTC rare plant list. Synonym: Scutellaria tessellata (NatureServe).
Guadalupe Milkwort; Polygala rimulicola var. rimulicola	G3T3	T3	S2		RPTC	3UP	Limited to Guadalupe and Sierra Diablo Mountains. However, no threats identified as conservation concerns for the species on Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided or minimized due to inaccessibility. Rock-inhabiting. Synonym: *Rhinotropis rimulicola* var. *rimulicola*.
Alamo Beardtongue; Penstemon alamosensis	G3		S3		RPTC	2	Few scattered, but large populations (NatureServe). May be susceptible to collecting in a few frequently visited places (NatureServe). Otherwise, its habitats are relatively inaccessible and current land uses apparently pose no threat to this species". Cultivated at local native plant nurseries (NatureServe).

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
New Mexico Beardtongue; Penstemon neomexicanus	G4		S4		RPTC	1TV; 1RH 2TV; 2RP	Locally common. No threats identified as conservation concerns for the species on the Lincoln NF.
Guadalupe Valerian; Valeriana texana	G3		S3		RPTC	1TV; 1RH; 3UP	Restricted range but locally abundant. No threats identified as conservation concerns for the species on the Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided or minimized due to inaccessibility.
Limestone Violet; Viola calcicola	G3		S3		RPTC	3UP	No threats identified as conservation concerns for the species on the Lincoln NF. This is partly attributed to habitat, at which potential threats are avoided or minimized due to inaccessibility. Rock-inhabiting. Limited to Guadalupe Mountains.
Clam Shrimp; Eulimnadia follisimilis	GNR		SNR		SGCN	1	No threats specified for species in the Lincoln NF or Context Area. SGCN criteria were: Vulnerable; & Endemic/ Disjunct/ Keystone; but not declining. Tier score is 3 and tier rank is 3 (NMDGF 2016).
Viola Yucca Borer; Megathymus ursus violae	G4G5T 3T4	T3	SNR		SGCN 2016 SWAP	2TV-?	No threats identified for species. Lack of sufficient scientific information regarding the species status in the general area and Lincoln NF.
Four-spotted Skipperling;	G3		SNR		SGCN	1AM; 1TV;	Limited, disjunct areas in Arizona, NM and a tiny area in the Davis Mountains of west Texas, and south to

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Piruna polingii						1RH; 2TV; 2RP	Guerrero, Mexico (NatureServe). Toliver et al (1998) reported it from several locations on the Forest. Cary (2005) did not report any from the Scott Able fire area. Some threats reported for species range. However, we did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. More information is needed. Index of departure for reported ERUs and Local Units (current, 10-, and 100-year) are respectively: 0.66, 0.61, 0.49.
Hobomok Skipper; Poanes hobomok	G5		SNR		SGCN 2016 SWAP	1AM;1RH; 2RP	No threats identified for species. Lack of sufficient scientific information regarding the species status in the general area and Lincoln NF.
Mountain Checkered-Skipper; Pyrgus xanthus	G3G4		SNR		SGCN	1RH; 2TV; 2RP	Occupies parts of Colorado, Arizona, Utah and NM, including Sacramento Mountains (the southeast-most populations for this species; Cary 2005). Toliver et al (1998) reported it from several locations on the Forest. NatureServe reports: “Principal threats are closure of forest openings due to long-term fire suppression, and invasion of exotic plants that might displace caterpillars' plants. ... Additionally, habitat is impacted by grazing, recreational development, and other anthropogenic disturbance throughout the range”. In a study of butterflies in the area of the Scott Able fire, Cary (2005) did not detect any until the fifth year of study. Permanent resident, non-migrant. More

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
							information is needed. Index of departure for reported ERUs and Local Units (current, 10-, and 100-year) are 0.59, 0.62, and 0.58, respectively.
Capitan Mountains Fritillary Butterfly; Speyeria hesperis capitanensis	G5	TNR	SNR		SGCN	1RH; 2TV; 2RP	Lack of sufficient scientific information to indicate substantial concern about its capability to persist over the long term in the Plan Area. Threats listed for subspecies overall include grazing, forest management, hydrological alterations, and exotic species (any exotic plants that may impact host plants or host plant or nectar plant habitats). Also recorded in or very near to 1AM and 1TV.
Nokomis Fritillary; Speyeria nokomis	G3		SNR			2	Lack of sufficient scientific information to indicate substantial concern about its capability to persist over the long term in the Plan Area. BISON has no account of *S.n.*, but has one for subspecies *S.n. nokomis*, apparently not occurring on Lincoln NF. Toliver et al (1998) had no account of the species, but only of *S.n.nokomis* and *S.nitocris* (neither on the Forest apparently). Presence of bog violet (*Viola nephrophylla*) reported as the only confirmed larval food source, and thus essential (NatureServe).
A Notodontid Moth; Heterocampa incongrua	G2G4		SNR			2RP	Lack of sufficient scientific information to indicate substantial concern about its capability to persist over the long term in the Plan Area. Threats listed for subspecies overall include development and altered fire regimes.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Bottleneck Snaggletooth ; Gastrocopta contracta	G5		S2			3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the planning area. Concurrence by J. Nekola (pers. comm., 2016).
Rio Grande Snaggletooth ; Gastrocopta riograndensis				RFL			We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Concurrence by J. Nekola (pers. comm., 2016). Local unit occurrences are uncertain.
Distorted Metastoma; Metastoma roemeri	G4		S2		SGCN	2TV?; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Concurrence by J. Nekola (pers. comm., 2016).
Spruce Snail; Microphysula ingersolli	G5		SNR		SGCN	2	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Concurrence by J. Nekola (pers. comm., 2016).
Oscura Mountain Land Snail; Oreohelix neomexicana	G3		S3		SGCN	2TV	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Concurrence by J. Nekola (pers. comm., 2016).
Multirib Vallonia; Vallonia	G5Q		S1			??	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Concurrence by J.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
gracilicosta							Nekola (pers. comm., 2016). Asif, Ball & DeLorenzo (1997 Surveys) categorized it, generally, as common in forested zones above 7,000 feet on the Forest, and reported it to be among the most numerous species at Pine Spring Canyon (about 8,200 foot elevation; large numbers of Vertigo modesta, Vallonia gracilicosta and Vallonia cyclophorella).
Ovate Vertigo Snail; Vertigo ovata	G5		S1		SGCN	3UP	J. Nekola (pers. comm., 2016) reported that it is limited to permanent seep or fen wetlands with relatively stable water tables. He did not find it at Bluff Springs, which has appropriate habitat. Globally, V. ovata is one of the most wide-ranging of any Vertigo, extending from the East coast to the West coast, central Alaska, and in to Japan and Taiwan. Metcalf and Smartt (1997) reported it from Blue Spring south of Carlsbad, the only known living population (BISON). Worthington (2010) listed records from drift in Last Chance Canyon (museum specimen UTEP 906) and as a fossil in Sitting Bull Falls Canyon (UTEP 921). Thus it is not clear whether it still inhabits Lincoln NF. If it were to, it would clearly merit SCC status.
Blunt Ambersnail; Oxyloma retusum	G5		S1		SGCN	2SB	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Concurrence by J. Nekola (pers. comm., 2016).
Rio Grande Cutthroat	G4T3	T3	S2	RFL	SGCN	1	Rio Grande cutthroat trout with native status are not

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Trout; Oncorhynchus clarkii virginalis							established on Lincoln NF.
Rio Grande Leopard Frog; Lithobates berlandieri	G5		S3		SGCN	3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. More information needed. Habitat is very limited on the Forest and has declined due to grazing and other factors that impact streams. Permanent resident; edge of Range (far NW corner).
Plains Leopard Frog; Lithobates blairi	G5		S4		SGCN	1RH; 2RP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. More information needed. Range and habitat is very limited in the Plan Area, and the species and habitat are subject to multiple threats, including hydrology issues and bullfrogs. Permanent resident; edge of Range (far NW corner).
Sacramento mountain salamander; Aneides hardii	G3		S3	RFL	SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP	Widespread and relatively common in the Plan Area. While severe wildfire may be a threat locally, there is no evidence of substantial or widespread decline in the Plan Area. Permanent resident.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Western Ribbon Snake; Thamnophis proximus (including diabolicus)	G5		S3	RFL	SGCN	3UP	Far southestern edge of range. VertNet and other sources yielded no records on the Forest; nearest records are at or near the Pecos River near Carlsbad, Roswell, and Bitter Lake NWR. However, Forest staff reported informal sightings on 3UP. In NM inhabits streams, ponds, marshes, and even some stock tanks. Associated vegetation is riparian and emergent aquatic types, including willows (*Salix*), cattails (*Typha*), and bulrushes (*Scirpus*). It forages in and along the water and on the adjacent land (BISON); but while it can be found in terrestrial habitats, it is semiaquatic, generally close to water, often in water-edge vegetation in the vicinity of streams, lakes, ponds, sloughs, ditches, swamps, and marshes (NatureServe). While we did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area, it is possible that it would merit SCC status if knowledge was more complete. The NatureServe ranks may not be indicative of its status on the Forest. Its habitat in the Guadalupe Mountains (3UP) would be highly limited, sensitive, and vulnerable. Permanent resident.
Mottled Rock Rattlesnake; Crotalus lepidus lepidus	G5T4T5	T4	S2	RFL	SGCN	3UP	NM is northern edge of its range. Though it has been refered to as a rare and localized inhabitant of the Guadalupe Mountains, we believe it to be fairly common on 3UP, as at Carlsbad Caverns National Park. It has been collected or observed at Sitting Bull Falls (BISON). It has also been verified west of the mountains, on the White Sands Missile Range (BISON).

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
							We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Permanent resident.
Broad-Billed Hummingbird ; Cynanthus latirostris	G4		S1B,S 1N	Not LNF	SGCN	1RH	Accidental in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Mexican Whip-poor-will; Antrostomus arizonae	GNR		S4B,S 4N		SGCN (2016 SWAP)	1RH; 2SB; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Summer resident, rarer in other seasons.
Common Nighthawk; Chordeiles minor	G5		S4B,S 4N		SGCN (2016 SWAP)	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area.
Yellow-billed Cuckoo; Coccyzus americanus	G5		S3B,S 3N		SGCN	1RH; 3UP	No population established or being established in the Plan Area. Very rarely recorded on Lincoln NF or adjacent Carlsbad Caverns and Guadalupe Mountains National Parks in bird studies over the last 50 years (at least). Note that the Western DPS (ESA listed population) occurs west of the Sacranento and

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
							Guadalupe Mountains.
Northern goshawk; Accipiter gentilis	G5		S2B,S 3N	RFL	SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3SB; 3UP	Management has stabilized populations on the Forest. We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Permanent resident. Key ecological conditions are diverse forest habitats including structural diversity for prey and nesting, and snags (habitat for prey). Key risk factors include fire (loss of nesting habitat) and habitat loss (from timber harvest, fire, and drought related tree mortality).
Golden eagle; Aquila chrysaetos	G5		S3B,S 4N	BCC	SGCN	1TV; 1RH; 2SB; 2TV; 2RP; 3SB; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations appear stable on and adjacent to the Forest, not known to be declining. Year-round.
Ferruginous hawk; Buteo regalis	G4		S2B,S 4N		SGCN	1RH; 2RP	Rare transient in the Plan Area, mostly late fall or winter. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Swainson's Hawk; Buteo swainsoni	G5		S4B,S 4N	BCC		1TV;1RH ;2SB; 2TV;2RP ; 3UP	Rare summer resident and spring and fall migrant; Neotropical migrant (NTMB). We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Threats reported for species overall include

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
							grazing, surface mining, r-o-w's, insecticides (via prey) and lead (BISON).
Common Black-Hawk; Buteogallus anthracinus	G4G5		S2B,S3N		SGCN	1RH; 2RP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining in the context or Plan Area. Summer resident. On RFL overall, but not with regard to LNF.
Northern harrier; Circus cyaneus	G5		S2B,S5N	BCC	SGCN	1RH; 2RP; 3UP	Rare transient in the Plan Area, mostly late fall or winter. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. Migrant.
Bald eagle; Haliaeetus leucocephalus	G5		S1B,S4N	RFL; BCC	SGCN	1RH; 2SB; 2RP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining in the context or Plan Area.
Mississippi Kite; Ictinia mississippiensis	G5		S2B,S3N	BCC		1; 2	Very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Osprey; Pandion haliaetus	G5		S2B,S4N		SGCN	1; 2	Rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Permanent resident in Context Area.
Harris's Hawk;	G5		S2B,S			1TV;	Very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Parabuteo unicinctus			3N			3UP	influence species through management actions on Lincoln NF.
Prairie Falcon; Falco mexicanus	G5		S4B,S 4N	BCC		3UP	Year-round (rare) in the 4 county area. We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Threats reported for species overall include r-o-w's, insecticides (via prey) and climate change (BISON).
American Peregrine Falcon; Falco peregrinus anatum	G4T4	T4	S2B,S 3N	RFL; BCC	SGCN	1RH; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations stable on the Forest.
Burrowing Owl; Athene cunicularia hypugaea	G4T4	T4	S3B,S 3N	RFL; BCC	SGCN	3UP	Very rare, apparently only transient, on Lincoln NF. Rarely recorded on Lincoln NF or adjacent Carlsbad Caverns or Guadalupe Mountains National Parks in either specific bird studies or observation databases going back more than 50 years. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Elf Owl; Micrathene whitneyi	G5		S3B,S 3N	BCC	SGCN	3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Permanent resident.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Flammulated Owl; Otus flammeolus	G4		S3B,S 3N	BCC	SGCN (2016 SWAP)	1TV; 2TV; 2RP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Migrates southward by late December.
Red-headed Woodpecker; Melanerpes erythrocepha lus	G5		S3B,S 3N	BCC	SGCN	3UP	Very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Williamson's Sapsucker; Sphyrapicus thyroideus	G5		S4B,S 5N	BCC	SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed.
Olive-sided Flycatcher; Contopus cooperi	G4		S3B,S 4N	BCC	SGCN	1TV; 1RH; 2SB; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed.
Willow flycatcher; Empidonax	G5		s4n	BCC	NO	1AM; 2TV	BCC (breeding) in the four county area, but very infrequent on LNF. More information needed. Key Ecological Conditions: Wet meadows with woody

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
traillii							riparian shrubs; Key Risk Factors: Standing water in meadows; Meadow drying (roads, historic impacts, water diversions); Nest disturbance (predators and nest parasitism).
Bell's vireo; Vireo bellii	G5		S2B,S 3N	BCC	SGCN	3UP	Very rare visitor in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Gray Vireo; Vireo vicinior	G4		S4B,S 3N	RFL; BCC	SGCN	3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Summer resident.
Loggerhead shrike; Lanius ludovicianus	G4		S3B,S 4N	BCC	SGCN	1TV; 1RH; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed. Permanent resident.
Clark's Nutcracker; Nucifraga columbiana	G5		S4B,S 4N		SGCN (2016 SWAP)	1TV;1RH ;2SB; 2TV	Has been reported to be a rare transients in the Sacramento Mountains of the Lincoln NF (sources in BISON), but may be a permanent resident as in other mountains in NM. Few records in resources consulted (e.g., eBird). However, we did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
							More information needed.
Juniper Titmouse; Baeolophus ridgwayi	G5		S4B	BCC	SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed. Permanent resident.
Bank Swallow; Riparia riparia	G5		S2B,S 5N		SGCN	1TV; 1RH; 2RP	No population established or being established in the Plan Area. Rarely recorded on Lincoln NF or adjacent Carlsbad Caverns and Guadalupe Mountains National Parks in bird studies or observation databases.
Pygmy Nuthatch; Sitta pygmaea	G5		S3B,S 3N		SGCN (2016 SWAP)	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Thinnings of PP and MC on the Forest benefit the species directly, and would need to continue to maintain benefits for the nuthatch. Permanent resident.
Marsh Wren; Cistothorus palustris	G5		S1B,S 5N			2; 3	Rare winter visitor in the Plan Area. Suitable habitat is limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Mountain Bluebird; Sialia	G5		S4B,S 4N		SGCN (2016	1TV; 1RH; 2SB;	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
currucoides					SWAP)	2TV; 2RP; 3UP	to be declining on the Forest. More information needed.
Western Bluebird; Sialia mexicana	G5		S4B,S 4N		SGCN (2016 SWAP)	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Permanent resident.
Eastern Bluebird; Sialia sialis	G5		S1B,S 5N			1; 3	Very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Cassin's Finch; Haemorhous cassinii	G5		S3B,S 5N		SGCN (2016 SWAP)	1TV; 1RH; 2TV; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed. Permanent resident (West 2003).
American Goldfinch; Spinus tristis	G5		S2B,S 5N			1; 2; 3	Rare winter visitor in the Plan Area. Suitable habitat is limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
McCown's Longspur; Calcarius	G4		S3N	BCC	SGCN	Near 1RH	Very rare transient in (or at least very near) the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
mccownii							management actions on Lincoln NF. We found no indications of substantial concern about its capability to persist over the long term in the Plan Area, or of population decline on the Forest. Threats to the species in general include grazing, towers, insecticides, and climate change (BISON). Synonym: *Rhynchophanes mccownii*.
Chestnut-collared Longspur; Calcarius ornatus	G5		S3N	BCC	SGCN (2016 SWAP)	1	Rare/very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. We found no indications of substantial concern about its capability to persist over the long term in the Plan Area, or of population decline on the Forest.
Lark Bunting; Calamospiza melanocorys	G5		S3B,S 5N	BCC		2TV;2RP ;3UP	Uncommon in the Plan Area. Nomadic, relating to summer precipitation. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. We found no indications of substantial concern about its capability to persist over the long term in the Plan Area, or of population decline on the Forest. Threats to the species in general include agriculture, grazing, towers, insecticides, climate change (BISON).
Cassin's Sparrow; Peucaea cassinii	G5		S5B,S 5N		SGCN (2016 SWAP)	1; 2TV; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
(Aimophila cassinii)							to be declining on the Forest.
Rufous-crowned sparrow; Aimophila ruficeps	G5		S5B,S 5N	BCC		1AM;1R H;2SB; 2TV;2RP ;3UP	Uncommon year round residents in the Lincoln NF. We found no indications of substantial concern about its capability to persist over the long term in the Plan Area, or of population decline on the Forest. Threats to the species in general include insecticides (BISON).
Sagebrush Sparrow; Artemisiospiz a nevadensis	G5		S3B,S 4N		SGCN	2	Rare transient and possible irregular winter visitor in the Plan Area. Suitable habitat is limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. Vagrant, rare.
Lincoln's Sparrow; Melospiza lincolnii	G5		S2B,S 5N			1RH; 2SB; 2TV; 2RP; 3UP	Rare (Sacramento Mountains) or very rare (Guadalupe Mountains) winter visitor or transient in the Plan Area. Suitable habitat is limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. No report of decline found for Lincoln NF.
Savannah Sparrow; Passerculus sandwichensi s	G5		S2B,S 5N			2; 3	Rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Fox sparrow; Passerella	G5		S4N	BCC		1RH; 3UP	Rare migrant and winter visitor in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
iliaca							management actions on Lincoln NF. We found no indications of substantial concern about its capability to persist over the long term in the Plan Area, or of population decline on the Forest. Threats to the species in general include grazing and towers (collision).
Vesper Sparrow; Pooecetes gramineus	G5		S5B,S 4N		SGCN (2016 SWAP)	1RH; 2TV; 2RP; 3SB; 3UP	Uncommon transient in Lincoln NF. We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest.
Black-chinned Sparrow; Spizella atrogularis	G5		S3B,S 3N	BCC	SGCN (2016 SWAP)	1AM; 1TV; 1RH; 2TV; 2RP; 3SB; 3UP	Occupies arid brushlands in lower elevations in summer, rarer in other seasons. We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Summer resident, rarer in other seasons.
Brewer's Sparrow; Spizella breweri	G5		S3B,S 4N	BCC	SGCN-2016-NEW	2TV;2RP ; 3UP	Uncommon migrant and winter visitor to Lincoln NF. We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest.
Red-Faced Warbler; Cardellina	G5		S3B,S 4N		SGCN	2TV; 2RP; 3SB	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
rubrifrons							to be declining on the Forest. It breeds in high elevation fir, pine, and pine-oak forests, often favoring wetter environments (including steep canyons) that includes deciduous vegetation such as quaking aspen and canyon maple (*Acer grandidentatum*) mixed with conifers (BNA). More information needed.
Grace's Warbler; Dendroica graciae	G5		S3B,S 4N	BCC	SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3SB; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed. Summer resident.
Black-throated Gray Warbler; Dendroica nigrescens	G5		S3B,S 4N	BCC	SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. Summer resident.
Painted Redstart; Myioborus pictus	G5		S4B,S 4N		SGCN	1TV; 1RH; 2SB	Rare transient in the Plan Area. Suitable habitat is limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Virginia's Warbler;	G5		S3B,S	BCC	SGCN (2016	1AM; 1TV;	Generally considered an uncommon summer resident in the Sacramento Mountains of the Lincoln NF. We

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Oreothlypis virginiae			4N		SWAP)	1RH; 2TV; 2RP; 2SB; 3UP	did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed. Synonym: Vermivora virginiae.
Wilson's Warbler; Wilsonia pusilla	G5		S2B,S 5N			1AM; 1TV;1RH ;2SB; 2TV; 2RP;3UP	Considered due to NatureServe state rank for the breeding population (S2B). However, Plan Area is not included in NM breeding range. Only breeds north-central NM, thus S2B rank is not pertinent to LNF as such. Transient only (West 2003) in the Plan Area (fairly common migrant). Synonym: *Cardellina pusilla* (NatureServe).
Evening Grosbeak; Coccothraust es vespertinus	G5		S4B,S 4N		SGCN (2016 SWAP)	1RH; 2SB; 2TV; 2RP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed.
Painted Bunting; Passerina ciris	G5		S4B,S 4N	BCC	Forme r SGCN	3UP	Rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Dickcissel; Spiza americana	G5		S1B,S 4N			1RH	Rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
Ring-necked Duck; Aythya collaris	G5		S1B,S 5N			1; 2	Rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Eared Grebe; Podiceps nigricollis	G5		S3B,S 5N		SGCN	2RP	Accidental or non-existent in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF.
Wilson's Snipe; Gallinago delicata	G5		S2B,S 5N			2; 3	Very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. T (Vagrant), Accidental essentially.
Long-billed curlew; Numenius americanus	G5		S3B,S 4N	BCC	SGCN	1	Very rare transient in the Plan Area. Suitable habitat is very limited on Lincoln NF. Very limited ability to influence species through management actions on Lincoln NF. Migrant at most.
Black-tailed prairie dog; Cynomys ludovicianus ludovicianus	No Acc-ount	No Acc-ounT	No Acc-ount		SGCN	1	No population established or being established in the Plan Area. Rare and localized in adjacent areas. Non-migratory.
Manzano Mountain Cottontail; Sylvilagus	G1G3		SNR			LNF?	Status as a species on the Lincoln NF is not clear.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
cognatus							
Merriam's Shrew; Sorex merriami	G5		S2			1RH	Occurs in Sacramento Mountains. Often associated with dry habitats, more so than other shrews in the state. Include grass, shrub, woodland and forest habitats; often near water, but not along (limited to) streams. Rare; however we did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest.
Dwarf shrew; Sorex nanus	G4		S2			1RH	Highly restricted and isolated distribution. Often associated with rocky habitats such as talus, rockslides, and rocky slopes. Occurs in lush meadows and sheltered canyons in coniferous and aspen forest, but also brushy hillsides and open woodland, including areas without permanent water. We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest.
Pale Townsend's Big-eared Bat; Corynorhinus townsendii	G3G4t3 t4	T3	S3S4	RFL	SGCN (2016 SWAP)	1RH; 2RP; 3UP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed.

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
pallescens							
Spotted Bat; Euderma maculatum	G4		S3	RFL	SGCN	2RP	We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. More information needed.
Western Red Bat; Lasiurus blossevillii	G4		S3	RFL	SGCN	LNF?	Status and distribution for the Lincoln NF are not clearly described. The western red bat was formerly recognized as a subspecies of L. borealis (as L. borealis teliotis, conspecific with L. b. borealis [eastern red bat]). Uncertain whether it occurs on LNF. Taylor (2011) recorded the calls of a red bat at Bailey Meadow, and caught an adult male red bat at Long Canyon Tank that has been tentatively identified as an eastern red bat (Lasiurus borealis; a new species record for the Lincoln NF if confirmed). We did not find specific or clear indications of substantial concern about its capability to persist over the long term in the Plan Area. Populations not known to be declining on the Forest. The best available science does not specify or clearly indicate that the species is declining overall or in terms of a decreasing number of local sub-populations on the Lincoln NF, or limited to small populations that are declining due to ongoing threats on the Forest, or vulnerable to extirpation in the foreseeable future due to management actions or other potential threats on the Forest. More

Common & Scientific Names	G Rank	T Rank	S Rank	RF SSL/ BCC	SGCN/ RPTC	Local Units	Justification
							information needed.
Swift fox; Vulpes velox	G3		S2		SGCN	1AM	Rare transient in the Plan Area, if occurs at all. Rare "swift fox" sighting may represent kit fox (J. Frey, pers. comm., 2016).

Proposed Species of Conservation Concern

Species carried forward from the initial list of potential SCC, to proposed SCC, will be those that both occur on the Forest and for which there is substantial concern about the species' ability to persist over the long term on the Forest. Substantial concern is determined by considering whether the BASI indicates there is local conservation concern about the species' capability to persist over the long term in the Plan Area due to:

1. Significant threats, caused by stressors on and off the Plan Area, to populations or the ecological conditions they depend upon (habitat). These threats include climate change.
2. Declining trends in populations or habitat in the Plan Area.
3. Restricted ranges (with corresponding narrow endemics, disjunct populations, or species at the edge of their range).
4. Low population numbers or restricted ecological conditions (habitat) within the Plan Area.

Of the 171 species on the initial list and found to occur on the Forest, 122 species were removed (as described above), leaving 49 species carried forward as proposed SCC for the Lincoln NF (Table 173. Proposed Species of Conservation Concern for Lincoln NF (numbering 49 species)). The list is based on evaluating the species status rankings from the NatureServe ranking system and other criteria that could indicate a substantial concern as defined in the directives. The list will be further refined and finalized, based on the BASI and public input, concurrent with the NEPA phase of the Forest Plan development process. With 49 proposed SCC and 9 ESA listed species, the total number of proposed at risk species for Lincoln NF numbers 58.

The table includes 49 proposed SCC (that have not yet been approved by the Regional Forester). It table illustrates NatureServe G, T, and S ranks; whether the species is on the 2015 Region 3 Forester's Sensitive Species List (RFSSL) attributed to Lincoln NF or the Birds of Concervation Concern list (BCC); and whether the species is on the RPTC rare plant list or the SGCN list (including NM threatened and endangered species). This table also illustrates specific Ranger Districts and Local Units for which we found records of each species: 1AM=Arroyo Macho; 1TV=Tularosa Valley; 1RH=Rio Hondo; 2SB=Salt Basin; 2TV= Tularosa Valley; 2RP=Rio Peñasco; 2SB=Salt Basin; and 3UP=Upper Pecos. Additional details and analyses are provided in the Assessment Details for all Species of Conservation Concern for every species.

Table 173. Proposed Species of Conservation Concern for Lincoln NF (numbering 49 species)

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
Goodding's Onion; Allium goodingii	G4		S1		RPTC	1RH	Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Occurs in the Sierra Blanca area. Risk factors: Threats include climate change, logging, and potentially grazing (NatureServe; RPTC). This plant is very palatable and can be heavily grazed. The greatest threats are fire (and to some extent, logging) that will open up and dry out the moist habitat (NatureServe). Uncertainties: Responses to fire patterns needs further study. The impact of wildfires on this species is currently under review. As much as 90 percent of this species habitat has recently been affected by wildfire on GIla and Lincoln NFs, and apparently adversely affected to some degree.
Wood Lily; Lilium philadelphicum	G5		S3?	YES	RPTC	2TV; 2RP	Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Very rare in New Mexico. Usually found in wetlands associated with mature conifer forest. Sensitive to wetland damage and alteration, including impacts from intensive grazing. Only a few records from Lincoln NF (NH; SEI). Risk factors: Include drought, water management, grazing, ORVs, and collecting (including picking of flowers by visitors to meadows). It has very limited occurrences on Lincoln NF and in New Mexico more generally. It is a wetland plant that is sensitive to wetland damage and alteration.
Crested Coralroot; Hexalectris arizonica	G5T2 T4	T3	SNR		RPTC	2RP	Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Rare and localized on the Forest. Existing populations may be subject to altered fire regimes and collecting. Synonyms: Hexalectris spicata var. arizonica.
Green Medusa Orchid; Microthelys rubrocallosa	GNR		S1		RPTC	2RP	Substantial concern exists about the species' capability to persist over the long term in the Plan Area. In the U.S., known only from a very small area on Lincoln NF that was affected by the Scott Able fire in 2004, and targeted for timber harvest and fuel reduction projects (Jim Lewis Project Area). Uncertainties: Ecology and management needs for this species are poorly known. Risk factors: This orchid is known in the U.S. from a single population. At this time little is known about its

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
							ecology and management needs. Further investigations into the impacts of fire and timber harvest are needed for this species (RPTC). The one known population is within the Jim Lewis Project area; here, dense canopies are targeted for timber harvest and fuel reduction.
Sierra Blanca Cliff Daisy; Ionactis elegans	G2		S2		RPTC	1TV; 1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Very limited range, known only from a few locations around Sierra Blanca in the White Mountains, in close proximity to the Ski Apache Ski Area. One of the few known locations was burned over in the 2012 Little Bear fire (assessment of potential impacts not yet completed). May be sensitive to climate change. Risk factors: Narrow endemic, known from a few locations on Sierra Blanca in the White Mountains. Found on cliffs where it is typically protected from direct human impacts, but climbers could impact them locally, and fire could potentially harm some populations (NatureServe; RPTC). Narrow endemic, known from a few locations on Sierra Blanca in the White Mts.
Gypsum Blazingstar; Mentzelia humilis var. guadalupensis	G4T2	T2	SNR		RPTC	3SB	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Endemic to open gypsum outcrops of the Yeso Formation on the west slope of the northern Guadalupe Mountains. Very limited range, known only from an area that extends about 12 kilometers in length (RPTC).
Golden Bladderpod; Lesquerella aurea	G2		S2		RPTC	2TV; 2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists abut the species' capability to persist over the long term in the Plan Area. Population size varies among years, apparently dependent in part on the timing and amount of precipitation. Often found in disturbed habitats, so “some populations along roads and trails could be adversely affected by the absence of repeated disturbance and the closure of its habitat by dense, long-lived vegetation” (RPTC). Synonyms: Physaria aurea. Risk factors: Restricted to the southern Sacramento Mountains in New Mexico. Year-to-year population sizes fluctuate, which appears to depend partly on the timing and amount of precipitation. Local development is a

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
							potential threat, although the species is often found in disturbed habitats has colonized roadsides. Methods of road maintenance may affect populations (NatureServe; RPTC). "Populations along roads and trails could be adversely affected by the absence of repeated disturbance and the closure of its habitat by dense, long-lived vegetation" (RPTC). Endemic to the southern Sacramento Mountains.
Lincoln County Bladderpod; Lesquerella lata	G1?Q		S1?		RPTC	1TV; 1RH; 2TV; 2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Uncertainties: There is a question as to whether these plants represent a distinct species or are only sporadic individuals of Physaria pinetorum with sparsely pubescent siliciles. However, *Lesquerella lata* is listed in PLANTS (and the synonym, *Physaria lata*, is listed as valid in ITIS). Synonyms: *Physaria lata*. Risk factors: Known from the Sacramento Mountains. There is a question as to whether these plants represent a distinct species or are only sporadic individuals of *Physaria pinetorum* with sparsely pubescent siliciles (NatureServe; RPTC).
Fanmustard; Nerisyrenia hypercorax	G1		S1		RPTC	3SB	Meets Critically Imperiled G and S rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Recently described species, not listed in PLANTS or ITIS at present, but listing and acceptance in PLANTS is likely. Highly restricted distribution on the western rim of the Guadalupe Mountains (NatureServe). Occurs in remote areas subject to little disturbance, and the gypsum outcrops that it inhabits appear to be rarely visited by cattle. "Applications of the herbicide tebuthiuron have been conducted adjacent to this band of gypsum to remove shrubs and, although the effects of this herbicide on *N. hypercorax* are not known, extension of these vegetation treatments onto gypsum would be a cause for concern" (RPTC).
Sparsely-flowered Jewelflower; Streptanthus	G2Q		S2		RPTC	3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Population size varies among years, apparently dependent on rainfall (NatureServe). Risk factors: Endemic, range limited to the Guadalupe Mountains

Common & Scientific Names	G Rank	T Rank	S Rank	FSSL	SGCN/ RPTC	Local Unit	Justification
sparsiflorus							(western Texas and NM). One authority proposed *Streptanthus sparsiflorus* to be in synonymy under *Streptanthus platycarpus* (FNA). However, *Streptanthus sparsiflorus* is recognized in PLANTS, and RPTC treat it as distinct.
Sacramento Mountain Foxtail Cactus; Escobaria villardii	G2Q		S2	YES	RPTC	2TV	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Endemic, small range.
New Mexican Stonecrop; Rhodiola integrifolia ssp. Neomexicana	G5T1	T1	SNR	YES	RPTC	1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Limited to the high meadows of Sierra Blanca Peak, on and adjacent to Ski Apache. Sierra Blanca is heavily used for recreational skiing and summer hiking. Some of the stonecrop sites occur within ski runs and on road cuts along the highway leading to Ski Apache, and adjacent to radio towers (RPTC). Synonyms: *Sedum integrifolium* ssp. *neomexicanum* (RPTC). Risk factors: Inhabits the high montane grassland (“alpine tundra”) of Sierra Blanca Peak. Extreme rarity, limited habitat, recreation, road improvements, communications facilities (NatureServe). “Sierra Blanca is heavily used for recreational skiing and summer hiking. A few locations of New Mexico stonecrop occur within ski runs and on road cuts along the highway leading up to Ski Apache. The radio towers and access road on Buck Mountain also occur within this plant's habitat” (RPTC). Endemic to high meadows of Sierra Blanca Peak.
Winged Milk-vetch; Astragalus altus	G2		S2	YES	RPTC	2TV; 2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Uncertainties: Population responses and ecology of soil disturbance relationships poorly described. Risk factors: Known only from the Sacramento Mountains around Cloudcroft and tribal lands. Threats include highway and roadside maintenance and development (but also often inhabits road cuts and other sites for some years after disturbance) and herbicide application for weed control (NatureServe). Residential and recreational development in the area is extensive. The effects of forest fire on this species have not been studied. Occasionally browsed by deer or elk, but its

Common & Scientific Names	G Rank	T Rank	S Rank	F FSSL	SGCN/ RPTC	Local Unit	Justification
							palatability to livestock has not been determined (RPTC). Limited distribution, rare endemic of Sacramento Mountains.
Kerr's Milk-vetch; Astragalus kerrii	G2		S2	YES	RPTC	1AM; 1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Uncertainties: Population responses and ecology of soil disturbance relationships needs further study. Appears to require some form of active soil erosion and deposition, including rain driven gravel deposits in otherwise dry arroyos (Sivinski and Knight 1996). Risk factors: Known only from a 165-260 square km area confined to the eastern half of the Capitan Mountains. Rare; only about 1500 individual plants known. Many of those are probably clonal (vegetative propagules with same genes as 'parent'). Pipelines, grazing, fire, recreation and vehicle disturbance may impact some plants. Requires active soil erosion and deposition; natural habitat is sand bars and banks deposited by floods into drainage channels that are otherwise dry, and also occurs on the sides of roads that intersect with habitat (NatureServe; Sivinski and Knight 1996). Fire/fire suppression relationships with this plant have not been studied in detail or quantified (RPTC). Endemic to the eastern Capitan Mountains in Lincoln County.
Guadalupe Mescal bean; Sophora gypsophila var. guadalupensis	G1T1	T1	S1	YES	RPTC	3SB	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Synonyms: Dermatophyllum guadalupense (NH; RPTC). Known range is less than 250 square km. Risk factors: Rare, narrow distribution, restricted to specialized habitat in an area less than 250 square km (NatureServe). Oil and gas development (NatureServe). Endemic to the Guadalupe Mountains.
Shootingstar Geranium; Geranium dodecatheoides	G1?		S1?		RPTC	1TV	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Known from one location in the White Mountains (Three Rivers Canyon on the western slope of Sierra Blanca) and one location in the Capitan Mountains (east of Capitan Gap). "This species is presently known from two localities in the Lincoln NF. The very small size of the known populations make it vulnerable to stochastic extinction

Common & Scientific Names	G Rank	T Rank	S Rank	F FSSL	SGCN/ RPTC	Local Unit	Justification
							events" (RPTC). Uncertainties: Very little is known about this recently described species; not listed in PLANTS at present (recently described). Risk factors: known range is very small. Very little is known about the taxon (NatureServe).
Cloudcroft Scorpionweed; Phacelia cloudcroftensis	G1		S1		RPTC	2TV	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Known from only a few occurrences (NatureServe), some of which are in the U.S. Highway 82 right-of-way, "and thus may be vulnerable to mowing, herbicide application, roadside construction, maintenance, and related disturbances" (RPTC). Risk factors: Known from few occurrences. Some of those are situated in the right-of-way of U.S. Highway 82 and thus may be vulnerable to mowing, herbicide application, roadside construction, maintenance, and related disturbances (NatureServe; RPTC). Limited distribution: Sacramento Mountains.
White Mountain False Pennyroyal; Hedeoma pulcherrima	G2		S2		RPTC	1RH; 2TV; 2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: Endemic to mountains of south central New Mexico. Only about seven occurrences are documented even though surveys for this species have been done. May be threatened by development, grazing, and competition with encroaching plants (NatureServe).
James' Wild Buckwheat; Eriogonum wootonii	G5T2	T2	S2		RPTC	1RH; 2TV; 2RP	Restricted range but locally abundant. No threats identified as conservation concerns for the species on the Lincoln NF. Endemic to the Sacramento, White and Gallinas Mountains. The 2006 discovery in the Gallinas in 2006 represents a 60 mile range (disjunct) extension.
Chapline's Columbine; Aquilegia chaplinei	G4T2	T2	S2		RPTC	2; 3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Has an extremely small range, few occurrences and limited habitat (including seeps, springs and moist canyon bottoms). Vulnerable to habitat loss from diversion of water or any influence that lowers water tables. Vulnerable to recreation and grazing pressures, and collecting. Synonyms: Aquilegia chrysantha var. chaplinei

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
							(NatureServe). Risk factors: Few occurrences; low numbers of individuals; extremely small range. Restricted to rare, moist habitat. Well known garden plant. Most occurrences are in remote canyons, but some of the canyons and waterfalls where it occurs are popular sites for hikers to visit. The Sitting Bull Falls population is accessible and has been impacted by recreational activities. (RPTC; NatureServe). Although there are commercially available plants, collecting near trails at heavily visited National Park Service and Lincoln NF land may still occur. Populations on the western slope of the Sacramento Mountains are vulnerable to habitat loss from diversion of water for municipal uses (NatureServe). Endemic to limestone canyons of the Guadalupe and southern Sacramento mountains; adjacent Texas.
White Mountain Larkspur; Delphinium novomexicanum	G2		S2		RPTC	1RH; 2TV; 2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Vulnerable to "any land use practice that results in drying riparian zones and wet meadows" (NatureServe). Risk factors: Reasons: Delphinium novomexicanum is restricted to two mountain ranges in south central New Mexico. Few documented occurrences and little information on its distribution or abundance (NatureServe). Any land use practice that results in drying riparian zones and wet meadows are likely to pose a threat to this species. Potential man-made threats include activities associated with livestock grazing, logging, and diverting water resources for control of forest fire and other uses. It is unknown whether livestock use this species of Delphinium. Some Delphiniums are poisonous to cattle, so the genus as a whole is sometimes targeted for poisonous weed control by the ranching industry. The importance of fire in the life-history of this species is not studied in detail. It is possible that either restricting forest fire or allowing unchecked wildfire may pose a threat (NatureServe; RPTC). Endemic to Sacramento and White Mountains.
Wooton's Hawthorn; Crataegus wootoniana	G2		S2	YES	RPTC	1RH; 2	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Most frequently reported from riparian zones. "Any activity that reduces riparian habitat will pose a threat to the species and riparian habitat is known to be declining within

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
							its range" (NatureServe). Risk factors: Few occurrences; grows in sensitive habitat. Most occurrences are on or near stream banks. Any land use practice that results in drying or damaging riparian zones are likely to pose a threat to this species; riparian habitat is known to be in decline within the range, often associated with livestock grazing. This understory tree could be sensitive to overstory removal. The effect of fire is not studied in detail (NatureServe). Additional field study of abundance, distribution, and habitat requirements are needed (RPTC). Limited distribtion, Sacramento Mountains and Pinos Altos Mountains.
Sierra Blanca Cinquefoil; Potentilla sierrae-blancae	G2?		S2?		RPTC	1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Potentially vulnerable to increased activity or development at Ski Apache and climate change (RPTF). Risk factors: Restricted range (NatureServe). Increase summer use of Ski Apache and climate change could affect this species (RPTC). Endemic to the higher elevations of the Sacramento Mountains.
Capitan Peak Alumroot; Heuchera woodsiaphila	G1		S1		RPTC	1AM	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Very limited distribution on the north and northeastern sides of Capitan Peak. This species was named in 2008. Risk factors: Very limited distribution; occurs on the north and northeastern sides of Capitan (NatureServe; RPTC). Named in 2008, there is little information on this species. Limited to Capitan Mountains.
Eggleaf Coral-drops; Besseya oblongifolia	G2		S2	YES	RPTC	1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Extremely rare ("between 6 and 20 small occurrences are known" [NatureServe]). Limited to the high meadows of Sierra Blanca Peak, on and adjacent to Ski Apache. Sierra Blanca is heavily used for recreational skiing and summer hiking (RPTC). Synonyms: Synthyris oblongifolia (RPTC). Risk factors: Very localized, limited to a single small area on Sierra Blanca. Extremely rare; few occurrences are known. Primary threat is recreation related actions in the area which includes Ski Apache

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
							(NatureServe). Endemic to high meadows of Sierra Blanca Peak.
Scerlet Penstemon; Penstemon cardinalis ssp. cardinalis	G3T2	T2	S2		RPTC	1AM ; 1TV; 1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: Known only from the Sacramento and Capitan Mountains; occurs as small scattered populations (NatureServe). It is becoming a popular landscape plant. Commercially grown seed and plants grown from seed are available through local native plant nurseries (NatureServe; RPTC). Endemic to New Mexico where it is known only from the Sacramento and Capitan Mountains.
Royal Red Penstemon; Penstemon cardinalis ssp. regalis	G3T2 T3	T2	S2	YES	RPTC	1AM ; 3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Very limited range. Risk factors: Very limited range in the Guadalupe Mountains, rarity, collecting, oil and gas exploration (NatureServe).
Western Spruce Dwarf-mistletoe; Arceuthobium microcarpum	G2?		SNR			2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Limited to higher elevations in a small geographic range. Risk factors: Small geographic range; restricted to higher elevations (NatureServe).
Dumont's Fairy Shrimp; Streptocephalus henridumontis	G4G5		SNR	YES	SGCN	1	Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Occurs in ephemeral wetlands which are rare in the landscape and sensitive to multiple types of disturbances. Risk factors: Limited range; considered critically imperiled both globally and within NM; in the U.S. it is known from several localities in Arizona and NM (NatureServe). In the overall Context Area, loss of ephemeral wetlands from agricultural practices, improper grazing, point and nonpoint discharge of contaminants, road improvement, mosquito abatement, natural systems modification, wetland jurisdiction, and hydroperiod alteration are listed (NMDGF 2016). Permanent resident.

Common & Scientific Names	G Rank	T Rank	S Rank	F SSL	SGCN/ RPTC	Local Unit	Justification
Bonita Diving Beetle; Stictotarsus neomexicanus	G2		SNR	YES	SGCN	1	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Aquatic habitats vulnerable to multiple threats. Uncertainties: habitat associations and needs are poorly known. Risk factors: Natural systems modification, degradation of habitat, loss of water or water quality (NMDGF 2016). Permanent resident.
Caddisfly; Psychoronia brooksi	G1		SNR	YES	SGCN	1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Known range is extremely small (only known from the type locality at the Ski Apache Ski Area in the North Fork Rio Ruidoso [NatureServe]). Aquatic habitats vulnerable to multiple threats. Uncertainties: recently described; poorly known. Risk factors: This species, recently described, is known only from the type locality in the North Fork Rio Ruidoso in Lincoln Co. Permanent resident; Non-Migrant.
Carlsbad Agave Borer/ Orange Giant-Skipper; Agathymus neumoegeni carlsbadensis	G4G5 T2T3	T2	SNR		SGCN	3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists aout the species' capability to persist over the long term in the Plan Area. Uncertainties: subspecies diagnoses often lacking or uncertain. Risk factors: Human intrusions and disturbance impacts to host plant; overcollection (NMDGF 2016).
Henry's Elfin; Callophrys henrici solatus	G5T2 T3	T2	SNR		SGCN (Callophrys henrici solatus)	2; 3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Natural systems modification and climate change listed as stressors in NMDGF (2015). Uncertainties: subspecies diagnoses often lacking or uncertain (some records from the area don't diagnose to the subspecies level). Risk factors: Natural systems modification, climate change (NMDGF 2016).
Sacramento Mountains Checkerspot; Euphydryas anicia	G5T1	T1	SNR	YES	SGCN	2TV; 2RP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Previously proposed for listing as endangered under the ESA. The primary host plant is a geographically restricted perennial forb, and "areas of suitable habitat,

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
cloudcrofti							such as sunny meadows with adequate host-plant, nectar, structural (pupal attachment), and litter (diapause location) resources, may be small and capable of supporting only low numbers of butterflies", and are impacted by grazing, hydrological changes, and changes in fire regimes which results in woody encroachment (USFWS 2005). Risk factors: Very limited range, found only on and near the Lincoln NF. Livestock grazing, feral horses, invasive plants, development, recreation activities associated with OHVs and camping, stochastic events such as drought and wildfire, and threats from collection (NMDGF 2006; NatureServe; FWS 2005). Constant cattle presence in wetlands and drainages can alter soil and water properties, which may serves to create drier conditions in riparian areas and meadows. Fire suppression combined with selective herbivory by grazers and has enabled woody species encroachment into meadows, yielding dense stands of small-diameter trees. This alters fire patterns in the spruce-fir communities within the higher elevations, which naturally exhibited relatively infrequent, mixed-severity fires and yielded open stands of mature trees with relatively high moisture availability (FWS 2005). Previously proposed for federal listing as endangered by the FWS. Permanent resident; Limited range endemic restricted to Sacramento Mountains.
Poling's Hairstreak; Satyrium polingi	G2		SNR		NO ACCOUNT for S.p. (S.p. organensis is a SGCN)	1AM; 1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Highly restricted range. Uncertainties: subspecies diagnoses often lacking or uncertain. Risk factors: Very restricted range, but probably occupies much of the oak woodland in the range. Habitats are subject to overgrazing by livestock and ungulates which may reduce survival of host seedlings. Invasion of alien weeds may be possible but is unreported (NatureServe). Fire events of unnatural frequency or intensity are likely to have negative impacts on host plant (oak) communities (BISON). Agriculture and aquaculture, invasive and problematic species, human intrusions and disturbance, overgrazing, possible exotic weeds and over-collection are potential threats to the species in NM (NMDGF 2016). Permanent resident, non-migrant.

Common & Scientific Names	G Rank	T Rank	S Rank	F SSL	SGCN/ RPTC	Local Unit	Justification
Zephyr Eyed Silkmoth; Automeris zephyria	G2G3		SNR		SGCN	2	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Management actions on Lincoln NF indicated as a conservation concern (NatureServe). Uncertainties: few records and limited information on Lincoln NF. Risk factors: Small number of element occurrences; fragmented habitat. Lack of specific management or adverse impacts of management activities on Lincoln NF (NatureServe). The use of mercury vapor lights is a widespread source of mortality for adult moths in this family (Saturnidae). The moths congregate around the lights and die without breeding (BISON). Spraying programs and different management programs in its fragmented range, over-collection (NMDGF 2006). Permanent resident; Non-Migrant.
Guadelupe Woodlandsnail; Ashmunella carlsbadensis	G1		SNR			3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: Fire is likely the potential threat of highest magnitude and imminence for this and other land snails, depending on the particular microhabitats used and the surrounding matrix of ERUs. The snails occupy tiny patches of suitable habitat over small areas. Such population areas are potentially extirpated by fires that reach the occupied habitat patches, which may be comprised of leaf litter that can be completely consumed by fire. This poses additional management challenges for using fire as a tool for restoration in the larger matrix of surrounding ERUs (J. Nekola, personal communication 2016). Permanent resident.
Capitan Woodlandsnail; Ashmunella pseudodonta	G1		SNR	YES		1	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: Fire, mining, climate warming, disturbance to talus. Limited distribution. Considered critically imperiled globally (NatureServe). Permanent resident.
Sierra Blanca Woodlandsnail; Ashmunella rhyssa	G1G2		SNR			1RH; 2TV	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: Range restricted (NMDGF 2006). Permanent resident.

Common & Scientific Names	G Rank	T Rank	S Rank	F SSL	SGCN/ RPTC	Local Unit	Justification
Ruidoso Snaggletooth; Gastrocopta ruidosensis	G1		S3	YES	SGCN	1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: highly restricted range on Lincoln NF (eastern slope of the Sacramento Mountains); the only other living occurrences are believed to be along the eastern slopes of the Sangro de Cristo Mountains (NatureServe). Permanent resident.
Vagabond Holospira; Holospira montivaga	G2		S2	YES		3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: fire, climate change, mining. Narrow endemic, species is restricted to the Guadalupe Mountains of TX and NM. Considered imperiled both globally and within the state of NM (NatureServe). Fire is likely the potential threat of highest magnitude and imminence for this and other land snails, depending on the particular microhabitats used and the surrounding matrix of ERUs. The snails occupy tiny patches of suitable habitat over small areas. Such population areas are potentially extirpated by fires that reach the occupied habitat patches, which may be comprised of leaf litter that can be completely consumed by fire. This poses additional management challenges for using fire as a tool for restoration in the larger matrix of surrounding ERUs (J. Nekola, personal communication 2016). Permanent resident.
Northern Threeband; Humboldtiana ultima	G2		S2	YES	SGCN	3SB; 3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Geographically restricted and limited to mesic sites. Risk factors: Limited range and numbers; narrow endemic limited to mesic sites in the Guadalupe mountains. Fire, climate change, destabilization of talus sprawls (NatureServe). Fire is likely the potential threat of highest magnitude and imminence for this and other land snails (J. Nekola, personal communication 2016). Permanent resident.
Mountainsnail; Oreohelix strigosa nogalensis	G5T2	T2	S1	YES		1RH	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Geographically restricted and limited to small localized populations. Synonyms: *Oreohelix nogalensis* (BISON). Risk factors: Fire, climate change, deforestation.

Common & Scientific Names	G Rank	T Rank	S Rank	FSSL	SGCN/ RPTC	Local Unit	Justification
							"Narrow endemic with potential for extinction due to chance events acting on small localized populations. Species is considered critically imperiled both globally and in NM" (NatureServe). Permanent resident.
Rio Grande Chub; Gila pandora	G3		S3	YES	SGCN	1RH; 2RP; 3UP	The Rio Grande chub was subject of a listing petition with a positive 90-day finding by USFWS on March 15, 2016 (FR 2016-05699). Occupies very limited and substantially stressed aquatic systems.
Headwater Catfish; Ictalurus lupus	G3	N2	S1	YES	Former SGCN	3UP	Restricted to portions of NM, Texas, and northern Mexico. It is detrimentally impacted by hybridization and or competition with channel catfish (I. punctatus). Eliminated from most of its original range in NM due to the highly disturbed condition of streams. They persist in headwater streams and in tailwaters of dams in the Pecos River drainage, but populations are diminishing. It is one of the least studied fishes in North America (NatureServe, BISON).
Pinyon Jay; Gymnorhinus cyanocephalus	G5		S3B, S3N		SGCN	1AM; 1TV; 1RH; 2SB; 2TV; 2RP; 3UP	In contrast to the modest NatureServe ranks, this species has high conservation concern ranks for the Chihuahuan BCR, adjacent conservation regions, and NM; overall the highest of all birds considered. It is listed as a species of continental importance in the PIF 2016 Continental Plan (yellow watch list), for the Intermountain West Joint Venture area, in the pinyon-juniper woodland category; exhibiting an area importance of 96%, half-life of 19 years, and long-term change of -85%. The short-term trend is -3.7%. Threats include loss, degradation, or fragmentation of pinyon-juniper woodlands from conversion, clearing, firewood cutting, improper grazing practices, and altered fire regimes, and illegal shooting (Balda 2002; NMDGF 2006). Permanent resident.
Guadalupe Pocket Gopher; Thomomys bottae guadalupensis	G5T2	T2	S1	YES		3UP	Meets an Imperiled/Critically Imperiled rank criteria. Substantial concern exists about the species' capability to persist over the long term in the Plan Area. Risk factors: Limited range confined to the Guadalupe Mountains. Within Guadalupe Mountains NP, not found to be abundant. Subject to habitat loss due to drought and climate change (NatureServe). Permanent resident.

Common & Scientific Names	G Rank	T Rank	S Rank	F F SSL	SGCN/ RPTC	Local Unit	Justification
Robust Cottontail/ Davis Mountain cottontail; Sylvilagus robustus	G1G2		S1			3UP	Small range in NM, Texas, and adjacent Mexico; occupies only several sky island settings. The robust cottontail is declining in its limited range which includes the Guadalupe Mountains (3UP). It has disappeared from one of the four mountain ranges from which it is known (Lee et al 2010, NatureServe). Because of geographic isolation, climate change may be a factor impacting the species, as well as drought, wildfire, grazing, and potentially insect infestation if the overstory is damaged (Texas Parks and Wildlife 2011). Permanent resident.
New Mexico Shrew; Sorex neomexicanus	G3Q		S2	Y ES	SGCN	1RH; 2SB; 2RP	Endemic with small range in the Capitan and Sacramento Mountains. Inhabits streams, meadows, sheltered canyons and other moist habitats in coniferous and aspen forest, including areas without permanent water. Likely declining due to loss and degradation of those riparian and meadow habitats (J. Frey, pers. comm., 2016). Permanent resident.

Conditions, Features, and Trends for At-Risk Species

The complete list of at-risk species will include all species in the Plan Area that are listed as threatened, endangered, or candidate by USFWS, plus SCC identified by the Regional Forester. The 2012 Planning Rule requires the Forest Service to identify the status of at-risk species by considering existing plan direction as well as the ecological conditions needed to support the species and the status of the ecological conditions in the Plan Area. To this end, staff from the Lincoln NF compiled data about current status and distribution of species and ecological conditions for those species within the Plan Area, as well as risk factors faced by at risk species. The following sections consider attributes of all at risk species (proposed SCC plus ESA listed) combined.

As the above analyses commenced and additional data were added, increasingly detailed sets of attributes were selected and incorporated into data tables in order to refine the description of ecological needs and risk factors for each species. Detailed attributes pertaining to distribution (e.g., local units), abundance and trend, threats, and habitats (ERUs and other general habitats, microhabitat, special features, landscape settings) were added, and key information gaps and uncertainties were identified. We also grouped species according to distribution, habitat and risk factors. For each species considered for at risk status, further details regarding all attributes, information gaps, and status determinations are presented in the Assessment Details for all Species of Conservation Concern.

Taxonomic and Distribution Patterns

Of the 58 at risk species (9 ESA listed and 49 proposed SCC), 28, 28, and 19 are reported from the Smokey Bear, Sacramento, and Guadalupe Ranger Districts, respectively. Forest wide, more than half are flowering plants. There are no amphibians or reptiles proposed. In order to standardize the count of at risk species to the area in each local unit, we tabulated the number of at risk species per acre of local unit (number of species divided by total area of local unit), and multiplied that quotient by 100,000 (so that the values are converted from very small decimal numbers, or small “fractions of species”, to larger numbers). This index of the relative abundance of at risk species provides a different ranking than the raw counts, with the greatest concentration in 3SB (equivalent of about 13 species per 100,000 acres), followed by 2TV and 1RH (each with about 11 per 100,000 acres; Table 176). As with raw counts, flowering plants contributed the largest amount in all local units, ranging from about 1 per 100,000 acres in 2SB to nearly 9 in 2TV

Table 174 provides totals by taxonomic category and District, and Forest totals. Sixteen of the species are restricted to the Smokey Bear RD only. Fourteen are restricted to the Sacramento RD, and 14 occur only in the Guadalupe RD. Twelve species are shared by the Smokey Bear and Sacramento Ranger Districts only, and 2 occur in both the Sacramento and Guadalupe Ranger Districts.

In terms of local units, 1RH has the most at risk species (25), followed by 2RP (2), 2TV (17) and 3UP (15; Table 175). The high number in 1RH is partly due to several rare endemic plants localized to the Sierra Blanca Mountain area.

In order to standardize the count of at risk species to the area in each local unit, we tabulated the number of at risk species per acre of local unit (number of species divided by total area of local unit), and multiplied that quotient by 100,000 (so that the values are converted from very small decimal numbers, or small “fractions of species”, to larger numbers). This index of the relative abundance of at risk species provides a different ranking than the raw counts, with the greatest concentration in 3SB (equivalent of about 13 species per 100,000 acres), followed by 2TV and 1RH (each with about 11 per 100,000 acres; Table 176). As with raw counts, flowering plants contributed the largest amount in all local units, ranging from about 1 per 100,000 acres in 2SB to nearly 9 in 2TV.

Table 174. Count of at risk species (ESA listed and proposed SCC), by taxonomic category and District, including Forest totals. Note that some species occur in more than one area.

District	Flowering Plant	Mollusc	Crustacean	Insect	Fish	Amphibian	Reptile	Bird	Mammal	Total
Smokey Bear RD	16	4	1	3	0	0	0	2	2	28
Sacramento RD	19	1	0	3	0	0	0	2	3	28
Guadalupe RD	8	3	0	2	2	0	0	2	2	19
LNF	34	7	1	7	2	0	0	2	5	58

Table 175. Count of proposed at risk species (ESA listed and SCC), by taxonomic category and local unit. Note that some species occur in more than one area.

Local Unit	Flowering Plant	Mollusc	Crustacean	Insect	Fish	Amphibian	Reptile	Bird	Mammal	Total
1AM	4	0	0	1	0	0	0	1	0	6
1TV	7	0	0	0	0	0	0	2	0	9
1RH	14	3	1	3	0	0	0	2	2	25
2SB	1	0	0	0	0	0	0	2	1	4
2TV	13	1	0	1	0	0	0	2	0	17
2RP	14	0	0	1	0	0	0	2	3	20
3SB	3	1	0	1	0	0	0	1	0	6
3UP	5	3	0	2	1	0	0	2	2	15
LNF	34	7	1	7	2	0	0	2	5	58

Table 176. Number of proposed at risk species (ESA listed and SCC) per 100,000 acres, by taxonomic category and District. Note that some species occur in more than one area

Local Unit	Flowering Plant	Mollusc	Crustacean	Insect	Fish	Amph-ibian	Rep-tile	Bird	Mam-mal	Total
1AM	5.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	**7.1**
1TV	5.2	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	**7.2**
1RH	6.2	1.3	0.4	0.9	0.4	0.0	0.0	0.9	0.9	**11.0**
2SB	1.3	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.3	**5.2**
2TV	8.6	0.7	0.0	0.7	0.0	0.0	0.0	1.3	0.0	**11.2**
2RP	3.8	0.0	0.0	0.3	0.3	0.0	0.0	0.6	0.9	**5.9**
3SB	7.7	2.6	0.0	0.0	0.0	0.0	0.0	2.6	0.0	**12.9**
3UP	2.0	1.2	0.0	0.8	0.4	0.0	0.0	0.8	0.8	**6.0**
LNF	2.7	0.6	2.4	0.6	0.1	0.0	0.0	0.2	0.4	**4.5**

Habitat Relationships and Conditions

Methods for Habitat Relationships

General habitat relationships of risk species

For every species assessed, we sought to identify prominent habitat associations based on available information. We ascribed every species to each of the Ecological Response Units (ERUs) that it was reported to use. In many cases, the vernacular used to describe a species habitat corresponded clearly with an ERU; for example when “spruce-fir forest” was specified in the literature. In some cases, the relationship was not as distinct or clear, such as when only a general forest or woodland type was specified. For example, when mixed conifer forest was reported as habitat for a species, it was often not evident whether the species used MCD and or MCW.

In order to accommodate habitat characterizations for all species, we combined certain ERUs and delineated some additional habitat categories. The full set of habitat categories allowed us to assign important habitats to every species, and to group those species accordingly. The categories (Table 177) will be referred to simply as habitat elements where needed to distinguishing them from the ERUs defined in Terrestrial Vegetation chapter. A few general habitat elements were added for these purposes: oak (OAK), aspen (ASP), meadow (MDW), riparian (RIP), aquatic (AQU), and springs (SPR). The inclusion of these habitat elements, in addition to defined ERUs, was necessary in order to depict habitat associations for the full suite of species considered. However, maintaining the connection to ERUs in the habitat elements also allowed us to maintain and use information about ERU characteristics.

Oak, aspen, and meadows constitute important habitat elements for many species. Literature that associated species with those habitat elements did not always specify particular ERUs as well, and those elements do not always equate directly to ERUs analyzed in the ecosystem portion of this assessment (Terrestrial Vegetation). Accordingly, we chose to delineate OAK, ASP, and MDW habitat associations for each pertinent species, in addition to any ERUs known to be used by the given species. RIP encompasses all types of riparian ERUs. For a given species, the specific riparian ERU may or may not be specified in the literature. AQU was delineated for species that actually rely on a water medium or habitats with open water or marsh for all or some part of their life. SPR was delineated for species that associate with springs and related features.

Table 177. General Habitat Elements and their relationship to ERUs

Habitat	Description	Relationship to ERUs
SF	Spruce-fir	SF
MC	Montane mixed-conifer	MCW, MCD combined
PP	Ponderosa pine	PPE, PPF combined
MMS	Mountain mahogany shrub	MMS
PJ	Pinyon-juniper	PJC, PJG, PJO combined
JUG	Juniper and juniper grassland communities	JUG
SDG	Semi-desert grassland	SDG
CDS	Chihuahuan desert scrub	CDS
MSG	Montane-subalpine grassland	MSG

Habitat	Description	Relationship to ERUs
OAK	Oak, either as a dominant of a specific oak community, or as a component of other woodlands or forest communities	In the context of our broader ecosystem based assessment, Gambel's oak is a major component in the PPF and MMS ERUs, and also occurs in other ERUs. Species that used OAK were alsp attributed to such other ERUs, as applicable.
ASP	Aspen as a dominant of a specific aspen community or as a component within forest communities	In the context of our broader ecosystem based assessment, aspen is predominantly a component of the MCW ERU. Aspen may also occur in association with SF, MCD, PPF and meadows. Species that used ASP were often attributable to one of those ERUs as well.
MDW	Meadows associated with drainage basins	In the context of our broader ecosystem based assessment and ERU mapping units, specific MDW areas often fall within the MSG ERU and or overlap with various riparian ERUs. However, MDW habitats are important to a variety of species, many of which are not attributed to using MSG or other ERUs specified in Chapter 4. Streams are often, but not necessarily present; other features such as ephemeral ponds or seeps are often situated within meadows.
RIP	Riparian communities	Riparian ERUs (see Chapter 4). In tables within this chapter, dry arroyos are included under this heading, but denoted as "DRY", not RIP.
AQU	Aquatic communities	No equivalent ERUs. Streams, marshes, cienegas, ephemeral pools, ponds, wildlife and stock tanks. In tables within this chapter, emergent marshes are included under this heading, but denoted as "EM", not AQU.
SPR	Springs, seeps, spring runs	No equivalent ERUs. Springs and related features (see Chapter 7).

In addition to habitat elements, soil attributes were documented for each species in which a soil relationship was found in the literature. In tables, under the soil heading, we indicated whether an association with a particular parent material or substrate was specifically identified in the sources consulted for each species.

Special habitats associated with at risk species

In addition to delineating general habitats, we delineated additional habitat elements (special habitats, features and conditions) in order to more fully categorize habitat associations and needs for all species. Those include rock (e.g., talus, cliffs, and ledges), cave (including crevices and mines), snag, CWD, mature and old growth trees, openings and open habitats, disturbance and disturbed habitats, and any other special features. In this chapter (and the Assessment Details for all Species of Conservation Concern), table headings for those elements are ROCK, CAVE, SNAG, CWD, OLD, OPEN, DISTURB, and OTHER, respectively.

We distinguished species reported to use habitat gaps (openings or clearings) or relatively open canopy or parklike areas in otherwise denser canopy cover, and those that use open habitats. Species that use parklike settings, particularly open canopies in an otherwise denser cover type, or habitat openings, clearings or the edges of those were designated with the attribute "Open/Openings" in tables. Those cases most often pertained to openings in, or relatively open canopied patches of, SF, MC, PP, MMS, PJ and JUG.

For species in which predominant habitat use occurs in environments that are inherently open (i.e., lacking forest or dense woodland, sparsely vegetated areas), we identified those as open habitat species (designated “OH” in tables below). We also identified species that use combinations of open and more densely vegetated habitats, including those that frequent openings or meadows but also use adjacent patches of dense shrubs or other vegetation (designated “oh” in tables). Use of open habitat (OH/oh) was attributed to species that use SDG, CDS, MSG, and MDW, and depending on the details for a given species, JUG, RIP, AQU and ROCK.

Species that were specifically noted in the literature to occupy areas of, or respond positively to, small scale disturbances were identified as such (designated “DISTURB” in tables). We did not automatically apply the attribute to species that associate with habitat openings, park-like settings or savannah, if consulted reference materials did not specifically attribute a disturbance to the habitat structure used by the given species. We recognize that such open attributes may depend upon unknown or unspecified disturbance regimes. We also recognize that fire plays a role in habitat structure across the landscape, but reserve the DISTURB attribute for cases wherein disturbance was specifically reported as a species habitat component, and the source of that disturbance was other than fire or not specified.

Dominance of General vs. Special Habitat Associations

Overall, at risk-species associations were tabulated for the following habitat elements: SF, MC, PP, MMS, PJ, JUN, SDG, CDS, MSG, OAK, ASP, MDW, RIP, AQU, SPR, ROCK, CAVE, SNAG, CWD, OLD, OPEN, DISTURB, and OTHER. For each species, we identified associations with each habitat element (based on available information), which also allowed for grouping of species. We also delineated whether species were predominantly associated with general habitats (SF, MC, PP, MMS, PJ, JUN, SDG, CDS, MSG, or OAK) or special habitats and conditions (ASP, MDW, RIP, AQU, SPR, ROCK, CAVE, SNAG, CWD, OLD, OPEN, DISTURB, and OTHER). General habitats comprise the widespread habitat matrix of the landscape (and largely correspond with ERUs). Special habitats are smaller, rarer or more localized, and are encompassed within the general habitat matrix. Course filter plan components that reduce departure values for key characteristics in ERUs are anticipated to benefit most species; species that predominantly use special habitats may require specific fine filter components in the plan.

For many species, the importance of associations with particular habitat elements are relative. For example, there are a variety of species (including invertebrates, birds, and mammals) that are not attributed to relying on caves or frequently using caves, but may make occasional use of caves. Also most vertebrates and many invertebrates make use of ponds, pools, springs and other water sources for attaining free standing water or other resources. Those special features were only ascribed to species (e.g., various bats) that rely on them or make extensive use of them relative to use of general habitats. In the case of ASP, it was considered a special feature for species that exhibit strong reliance on it. If the species used ASP but more generally relied on multiple forest types, then the species was dominantly ascribed to the more general forest type (such as SF or MC). Accordingly, many species regularly and predominantly use general habitat types, but also make occasional or substantial use of RIP, AQU, SPR, ROCK, CAVE, SNAG, CWD, OLD, OPEN, DISTURB, or OTHER. If use of general habitat types is relatively dominant, such species are considered to be predominantly inhabitants of (the associated) general habitats, not the special features used less extensively. Below, in Table 178, those species are delineated as “ERU” in the ERU/SPEC column.

For some species, predominant or critical habitat use is more closely and accurately attributed to special or unique habitat features than to general habitat types. For example, a fish, crustacean, or bat may require streams, ephemeral pools, and caves, respectively. Those special features are inextricably related to surrounding ERUs, and the ecological integrity of the surrounding ERUs, but more specifically delineate what habitat is directly associated with and critical to the species specialized needs. In those cases, the inhabited feature falls within the context of various ERUs. However, those ERUs are not the directly occupied habitat but instead a matrix habitat that encompasses the directly occupied habitat feature. For those species, the special features are more indicative of the direct needs of the species than are the adjacent ERUs (surrounding matrix). Those species are delineated as “SPEC” in the ERU/SPEC column of Table 181.

Condition of the Habitats Associated with At Risk Species

For each species, we developed an index of the overall departure of seral states from reference conditions based on the ERUs associated with the species. The index values were derived from the seral state departure values of corresponding ERUs in the ecosystem analyses (Terrestrial Vegetation chapter). The index accounted for the combination of ERUs and Local Units occupied by the given species. It expresses the average departure for the combined ERUs associated with each species, weighted by the acreage of those ERUs in the Local Units reported to be occupied by the species. We calculated the index of departure for occupied habitat elements (corresponding with ERUs) for the 10- and 100-year extrapolations of departure (based on current management practices) as well as for current departure. In calculating this index, we were able to cross-walk and incorporate values for SF, MC, PP, MMS, PJ, JUN, SDG, CDS, MSG, and RIP. The resulting indices of seral state departure for habitat associated with each proposed at risk species are provided in the Results for Habitat Relationships section.

For a number of the specific riparian ERUs, we did not have the full combination of departure values by local unit. For weighing in the use of RIP, we calculated the Forest wide average departure of riparian ERUs and applied that departure value in proportion to the overall acreage of riparian ERUs in Local Units known to be occupied by the species. We were not able to calculate weights and incorporate values for OAK, ASP and MDW in the same manner as for SF, MC, PP, MMS, PJ, JUN, SDG, CDS, MSG, and RIP. For species that rely on meadows, meadow acreages were not attributable to total acreage of the MSG ERU, because the acreage of MDW is a small subset of MSG. Similarly, OAK and ASP are components of various ERUs. However, many species that use OAK or ASP were also attributed to using PP, MC or other general habitats, and departure indices for such species were calculated accordingly (i.e., calculations incorporated use of PP, MC or other general habitats used by a given species).

We delineated general habitats (i.e., ERUs) used by all species, regardless of whether the general habitats are the dominant habitats used or only constitute a matrix containing special features that are critical to the species. As noted above, we also delineated whether each species is more closely aligned with general habitat types (SF, MC, PP, MMS, PJ, JUN, SDG, CDS, or MSG), or with special features (MDW, RIP, AQU, SPR, ROCK, and CAVE). While this allowed for more detailed subgrouping of species, it is also important with regard to interpretations of the index of departure for occupied ERUs.

For a given species, use of special habitat features, if more prominent than use of general habitats, delineates a special habitat case, and is indicated as “SPEC” in Table 181. Species for which the general habitats are relatively more important are indicated as “ERU” in that table. Species that regularly make extensive use of many general habitats may be considered habitat generalists, per se. In some cases, species are attributed to making regular, substantial use of special features (e.g., MDW, RIP), but also make regular, substantial use of multiple general habitats. Those species are attributed as “ERU”. Dominant habitats for a given species (often referred to as important in the literature) are indicated by upper case letters, and relatively less important elements are indicated by lower case letters, in Table 181.

If general habitat elements are shown in upper case (they are used more directly by the species), the indices for those habitats pertain directly to departure values for corresponding ERUs (and incorporate acreage according to local units occupied). If special features (for which there is no departure data) are more important (upper case), and general habitats (for which there is departure data) only surround the special features as matrix habitat (lower case), then the indices of departure for habitat pertain only to those matrix (general) habitats surrounding the special features. Accordingly, the departure indices are indirect in the case of species for which special features are the more direct or dominant habitats. For example, if habitat elements for a species are “sdg, cds, ROCK, OH”, then only an indirect departure index (calculated from sdg and cds use) will be available for the species; those will apply only to the matrix habitats (sdg and cds), not the special features (ROCK and OH) for which no departure values are available.

There were no systematic, landscape wide values available for calculating habitat departure, on both a local unit- and ERU-basis, for OAK, ASP and MDW (as distinct elements), DRY (dry arroyos or streambeds), SPR, ROCK, CAVE, OPEN, DISTURB, or OTHER. To the extent available, qualitative descriptions of these elements, as they relate to species habitat or risk factors, are summarized in later sections or the Assessment Details for all Species of Conservation Concern.

Climate change vulnerability assessments relating to habitats used by at risk species

In order to relate the Climate Change Vulnerability Assessments (CCVAs) to the habitats associated with at risk species, we employed the use of vulnerability indicators from the CCVA (see System Drivers and Stressors chapter, CCVA section). The Forest level frequency of high and very high vulnerabilies were summed for each ERU (and cross-walked to corresponding habitat elements for each species, as described above). Based on those indicators, we developed an index of the climate change vulnerability of habitats used by each species. The index expresses the average proportion of habitats in the high and very high climate change vulnerability categories, weighted by the area of corresponding ERUs used by the species in the local units reported to be occupied by each species. These indices are provided in Table 181 for each proposed at risk species, and in the Assessment Details for all Species of Conservation Concern for all species considered.

Results for Habitat Relationships

The highest numbers of proposed at risk species were associated with PP. The proportion of all proposed at risk species that use PP was 50 percent, followed closely by MC (47), and by PJ (40), RIP (29), SF (28), CDS (22), MMS (19), JUG (19), SDG (16), and MSG (7; Table 178). Accordingly, more of the proposed at risk species on the Lincoln NF occur in higher elevation habitats than at lower elevations. OAK, MDW and ASP, respectively, were important elements for 26, 19, and 10 percent of the species. For a few species, OAK was delineated as a habitat element, while oak-related general habitats (e.g., whether PP, PJ, MMS) were not specified. Accordingly, it is likely that values for PP, PJ and MMS (ERUs that frequently have an oak component) may be low on the order of a few instances.

Table 178. Numbers of proposed at risk species attributed to using the various general habitat elements, by taxonomic group, and by District and Forest totals

	SF	MC	PP	MMS	PJ	JUG	SDG	CDS	MSG	OAK	ASP	MDW	RIP
Flowering Plant	9	14	14	4	13	4	6	8	2	4	1	6	6
Gastropod	1	2	4	1	3	3	0	1	0	4	2	1	3
Bird	1	1	2	1	2	1	0	0	0	2	1	0	1
Fish	0	2	2	2	2	2	2	1	1	1	0	0	2
Mammal	3	3	4	1	2	1	1	1	1	2	1	3	2
Crustacean	0	1	1	0	0	0	0	0	0	0	0	0	0
Insect	2	4	2	2	1	0	0	2	0	2	1	1	3
Smokey Bear RD All Species	12	18	19	4	10	4	1	0	3	6	6	7	9
Sacramento RD All Species	10	16	16	3	11	2	3	4	1	5	3	9	10

	SF	MC	PP	MMS	PJ	JUG	SDG	CDS	MSG	OAK	ASP	MDW	RIP
Guadalupe RD All Species	1	3	7	7	11	7	7	11	1	10	1	0	6
LNF All Species	16	27	29	11	23	11	9	13	4	15	6	11	17
LNF All (Percent)	28	47	50	19	40	19	16	22	7	26	10	19	29

Note: The bottom row gives the proportion of all proposed at risk species on the Forest that use the general habitat elements. Note that most species use more than one of these elements. These tabulations encompass matrix-only, as well as more direct, habitat associations.

When these values are calculated for all 180 SCC and ESA species considered (including those in a lesser tier of vulnerability, not put forward as proposed SCC on the Forest), the general patterns are somewhat different, although PP, MC and PJ remained in the top three most frequent. In the larger data set corresponding with all species considered, PP use remained the highest (approximately 44 percent), followed by MC (41), PJ (41), RIP (42), CDS (37), SDG (32), JUN (28), SF (25), MMS (23), and MSG (8). OAK, MDW and ASP, respectively, were important elements for 32, 18, and 18 percent of the species. Thus for the larger community of species (including less vulnerable species) that intersect the Forest, forest types were again frequently associated, but mid- and low-elevation habitats were also represented prominently. An increase in the number of species with at risk status might be expected with further deterioraton of a given habitat, especially for habitats in which these percentages (representing 180 species) are similar to or higher than the percentage for corresponding habitat of the 58 currently proposed at risk species.

There are 9 ESA listed and candidate species established on the Forest. For those more critically imperiled species, the most frequently associated habitat elements were RIP, MDW, SF, MC, PP and PJ (each associated with 44 percent of ESA species). SDG was associated with 33 percent, followed by CDS (22 percent, or 2 of the 9). The other habitat elements were used by only one or none of the 9. Risk factors are discussed in a following section of this chapter.

When use of habitat elements by proposed at risk species are broken out by Districts as well, use of MC and PP on the Smokey Bear and Sacramento Ranger Districts stand out prominently, with 16 to 19 species attributed to each of those on both Districts. The next most frequented habitat-District associations are SF on the Smokey Bear and Sacramento Ranger Districts, which are each used by 10 to 12 of the at risk species that occur on those Districts. PJ follows, with 10 to 11 species using PJ on all three Districts.

In order to standardize the count of at risk species to the area in each general habitat element and local unit, we tabulated the number of at risk species per 10,000 acres of each general habitat in each local unit (number of species divided by total area of the general habitat in the given local unit, with that quotient multiplied by 10,000). This provides an index of the relative concentration of at risk species in each habitat-district combination. These tabulations are limited to prominently used habitat elements (relatively important habitats, not matrix-only habitats). Results for all species associations with a given habitat element, whether as a relatively important habitat or just as a general matrix habitat, have very similar outcomes. Results are provided in Table 179 for all habitat-District combinations for which calculations are available. Note that the Forest total for a given habitat may be substantially different than values for Districts, because the Forest totals depend on the contribution of acreages determined by combinations of species that occur in, and the specific acreage of the habitat among, the various Districts.

Table 179. Number of proposed at risk species per acre in each habitat

District	SF	MC	PP	MMS	PJ	JUG	SDG	CDS	MSG	RIP
Smokey Bear RD	**2.7**	**1.3**	**1.2**	**8.5**	**0.3**	**5.3**	**12.7**	**na**	**3.1**	**69.6**
Sacramento RD	**na**	**0.5**	**1.5**	**0.9**	**0.5**	**na**	**3.9**	**0.0**	**2.1**	**87.5**

District	SF	MC	PP	MMS	PJ	JUG	SDG	CDS	MSG	RIP
Guadalupe RD	na	5.6	2.4	0.4	0.2	3.3	0.3	12.8	na	27.6
LNF	3.6	0.5	0.9	1.0	0.2	4.1	0.3	2.0	1.8	31.9

Note: District-general habitat combination, multiplied by 10,000 acres to provide an index of the relative concentration of at risk species within each of those areas.

Forest-wide, the relative contribution of at risk species on a per area basis is greatest by far in RIP (about 32 species equivalents per 10,000 acres of RIP on the Forest). This is true for each District as well, with the equivalent of about 70, 88, and 28 per 10,000 acres of RIP. The next greatest value at the Forest level is for JUG, at about 4 per 10,000 (5 and 3 on the Smokey Bear and Sacramento Ranger Districts, respectively). Next is SF, at nearly 4 per 10,000. The Smokey Bear Ranger District has a limited amount of SF, but it does not show up in ERU map units (acreage) on that District. If the 7 species associated with SF in the Smokey Bear Ranger District were calculated, the small acreage of SF on that District would almost certainly bring the Forest-wide SF value to more than 4.

At the District level, the Guadalupe Ranger District stands out in terms of the relative importance of CDS, with a value of about 13 species equivalents per 10,000 acres of CDS on the Guadalupe Ranger District (none on other Districts; Forest value for CDS is 2). Even with just one species associated with MC, Guadalupe Ranger District also stands out in terms of the relative importance of MC due to the small area of MC on the Guadalupe RD. On the Smokey Bear and Sacramento Ranger Districts, 6 and 8 species directly associated with MC equates to about 1, and less than 1, per 10,000 acres, respectively (Forest value for MC is 0.5). The Smokey Bear Ranger District stands out in terms of SDG, with the equivalent of about 13 per 10,000 acres of SDG (<1 on other Districts; Forest value is low, 0.3). The Smokey Bear District also stands out in terms of MMS, with the equivalent of almost 9 at risk species per 10,000 acres of MMS (<1 on other Districts; Forest value is 1). Other than for RIP, the highest values on all Districts are for SDG, SDG (but see SF comments above), and CDS, respectively. The small areas of those habitats on those Districts equate to relatively high numbers of at risk species on a per acre basis. In contrast, while the raw numbers given above illustrate that the highest counts of at risk species are associated with MC and PP, those habitats cover larger areas of the Forest.

For special habitat features, frequency of use by the proposed at risk species is provided in Table 180. This table illustrates the importance of ROCK related features (33 percent of species) to proposed at risk species, especially plants and gastropods, for Lincoln NF. OPEN is attributed to the habitat use of 21 percent of the species. This relates to use of openings or relatively open cover, including habitat gaps, openings, clearings or the edges of those, and relatively open canopy or parklike areas in otherwise denser canopy cover. Part of the reason for the high frequency of OPEN associated with at risk species in a forest and woodland environment likely relates to seral state departures from reference condition in associated ERUs. In many cases, the skew is toward high densities of mid-sized or smaller trees, and may relate to altered fire and other disturbance regimes, and in some cases, reduced areas in old seral stages (which include canopy gaps and other aspects of structural heterogeneity). For many species, the available range of variation in terms of openings and or older age classes, as well as other structural and compositional characteristics, are likely skewed. Complex interrelationships between fire regime, herbivory, stand age composition, canopy heterogeneity, and canopy (and ecotone) openness influence the habitats of forest species.

Open habitats (OH/oh), which pertain to outright open country (e.g., SDG) species (OH) plus those that make substantial use of open habitat types some of the time or occupy special features in an otherwise open environment matrix (oh), rated very high in terms of the proportion of species (52 percent of proposed at risk species). The proportion of species that use some sort of openings (OPEN) and or open habitats (OH/oh) combined is 72 percent. This further illustrates the importance of open features and habitats.

Table 180. Special habitat features associated with proposed species (number of species)

	AQU	SPR	ROCK	CAVE	SNAG	CWD	OLD	OPEN	OH
Flowering Plant	0	3	11	0	0	0	0	11	15
Bird	0	0	1	1	1	1	1	0	1
Fish	2	0	1	0	0	1	0	0	1
Mammal	0	0	1	0	0	2	0	0	5
Crustacean	1	0	0	0	0	0	0	0	1
Insect	2	0	0	0	0	0	0	1	2
Gastropod	0	0	5	0	0	0	0	0	5
Smokey Bear RD All Proposed	**3**	**1**	**6**	**1**	**1**	**2**	**1**	**6**	**14**
Sacramento RD All Proposed	**0**	**3**	**4**	**1**	**1**	**2**	**1**	**10**	**12**
Guadalupe RD All Proposed	**2**	**1**	**11**	**1**	**1**	**2**	**1**	**1**	**13**
LNF All Proposed	**5**	**3**	**18**	**1**	**1**	**3**	**1**	**12**	**30**
LNF % All Proposed (n=58)	**9%**	**5%**	**33%**	**2%**	**2%**	**7%**	**2%**	**21%**	**52%**
LNF % All (n=180) Considered	**11%**	**11%**	**32%**	**3%**	**11%**	**8%**	**9%**	**18%**	**53%**

When calculated for all of the species initially considered (including those not retained as proposed SCC) in addition to those considered and put forward as proposed at risk species, values for SPR, SNAG, and OLD are substantially higher (bottom row of Table 180) relative to values for the smaller set of proposed species. This is due to additional, currently somewhat less vulnerable, aquatic, bird, bat and other species, for which those features are important.

Habitat relationships for each of the proposed at risk species are presented in Table 181. It includes habitat elements used by each species, as well as indices of the combined condition of habitats used.

General and special habitat elements are listed, and each species is designated as to whether its predominant habitats are general (ERU) or special features (SPEC). Habitats shown in large case indicate that the particular element constitutes relatively important habitat for the species. Those shown in small case indicates that the particular element is relatively less important (a matrix habitat in the case of species attributed more prominently to special habitats). If special habitats are large case and general habitats are all small case, then the special habitats are considered prominent for the species and the general elements represent the surrounding environment or matrix habitat. For those cases, the indices of seral state departure for occupied habitat elements merely represents the matrix habitats surrounding the more specialized features used by the species. More detailed habitat information (as well as information on distribution, trends, and threats) for all of these species, as well as all species not carried forward as proposed SCC, are provided in the Assessment Details for all Species of Conservation Concern. Soil categories are as follows: G, gypsum or gypseous limestone; L, limestone; I, igneous; A, alkaline.

Table 181. Habitat elements associated with proposed At-risk Species (49 potential SCC and 9 ESA listed) on the Lincoln NF

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
Goodding's Onion; Allium gooddingii	sf, mc, asp, Open/ Openings	SPEC	0.57	0.59	0.56	0.82	Open meadows, avalanche chutes and ski runs. The majority occur at the base of steep slopes and moist drainage bottoms (RPTC).	I
Wood Lily; Lilium philadelphicum	sf, mc, MDW, RIP, Open/ Openings	SPEC	0.60	0.63	0.59	0.76	Open marshy meadows, stream margins and bogs. Usually found in wetlands associated with mature conifer forest.	
Crested Coralroot; Hexalectris arizonica	PJ, JUN, OAK	ERU	0.60	0.50	0.33	0.69	In heavy leaf litter in woodlands.	L
Green Medusa Orchid; Microthelys rubrocallosa	MC	ERU	0.60	0.63	0.59	0.76	Occur under dense forest canopies in duff, without substantial herb layer; in shaded, presumably moisture-holding, soil.	
Sacramento Mountains Thistle; Cirsium vinaceum	sf, mc, pp, MDW, rip, SPR, OH	SPEC	0.71	0.73	0.68	0.83	Springs, seeps, wet meadows and along moist streambanks in meadows or forest margin (RPTC, NatureServe). Remaining populations are mostly in the vicinity of outflows from limestone springs (NatureServe).	L
Wright's Marsh Thistle; Cirsium wrightii	sdg, cds, MDW, RIP, EM, SPR, OH	SPEC	0.17	0.18	0.18	0.57	Marshy wetlands (cienegas), moist soil along streams, wet, alkaline soils in spring runs and marshy edges of streams and ponds near springs; in otherwise semi-arid to arid areas.	A
Sierra Blanca Cliff Daisy; Ionactis elegans	mc, rock, OH	SPEC	0.60	0.63	0.59	0.76	Granite cliffs.	I

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
Gypsum Blazingstar; Mentzelia humilis var. guadalupensis	CDS, ROCK, OH	SPEC	0.05	0.05	0.05	0.61	Gypsum outcrops.	G
Golden Bladderpod; Lesquerella aurea	MC, PP, DISTURB, Open/ Openings	ERU	0.70	0.73	0.67	0.81	Open, dry sites including bare areas of rocky soil, rocky south-facing slopes, road banks, and openings in coniferous forest; often found along roadcuts.	L
Lincoln County Bladderpod; Lesquerella lata	MC, PP, PJ, OAK, DISTURB, Open/ Openings	ERU	0.66	0.62	0.50	0.75	Rocky places and disturbed soils in open woods and forests (relatively dry sites).	L
Fanmustard; Nerisyrenia hypercorax	CDS, ROCK, OH	SPEC	0.05	0.05	0.05	0.61	Gypsum outcrops, especially along the deeply-incised ravines (RPTC).	G
Sparsely-flowered Jewelflower; Streptanthus sparsiflorus	mms, pj, jun, sdg, cds, oak, DRY, ROCK, oh	SPEC	0.64	0.57	0.45	0.60	Limestone canyon bottoms and montane scrub (RPTC); shaded places in dry, gravelly, limestone canyons and arroyos (NatureServe); Among gravel and boulders.	L
Lee’s Pincushion Cactus; Coryphantha sneedii var leeii	sdg, cds, ROCK, OH	SPEC	0.91	0.94	0.95	0.34	Cracks, cliffs, ledges in broken terrain and steep slopes.	L
Kuenzler's Hedgehog Cactus; Echinocereus fendleri var. kuenzleri	PJ, SDG, OH	ERU	0.62	0.54	0.38	0.66	On ledges and cracks in gentle, gravelly to rocky slopes and benches along the lower fringes of the pinyon-juniper woodland (USFWS 2013, RPTC, NatureServe).	L

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
Sacramento Mountain Foxtail Cactus; Escobaria villardii	sdg, cds, rock, OH	SPEC	0.17	0.17	0.17	0.57	On flat 'benches' between or atop steeper slopes. Well developed loamy or gravelly soils.	L
New Mexican Stonecrop; Rhodiola integrifolia ssp. Neomexicana	sf, msg, ROCK, Open/ Openings	SPEC	0.59	0.58	0.56	1.00	Rock loving. Sub-alpine rock/talus/scree (NatureServe). Rocky openings in subalpine forest (NatureServe). Damp mountain slopes and wooded rocky outcrops (Hutchins 1974).	I
Winged Milk-vetch; Astragalus altus	PP, DISTURB, Open/ Openings	ERU	0.97	0.98	0.88	0.94	Openings in ponderosa pine forest, steep slopes and road cuts. Will inhabit roadcuts and other sites for some years after disturbance (RPTC, NatureServe).	L
Kerr's Milk-vetch; Astragalus kerrii	mc, pp, pj, jun, DRY, DISTURB (water scour), oh	SPEC	0.68	0.63	0.50	0.76	Dry, well-drained sandy or gravelly bars or benches of granitic alluvium in woodland and forest, particularly dry arroyos or ephemeral drainage channels that are frequently disturbed by water runoff (water-scoured). Also occurs on old logging roads and apparently needs some form of soil disturbance for successful establishment (RPTC). In sun or partial shade (NatureServe).	I
Guadalupe Mescal bean; Sophora gypsophila var. guadalupensis	mms, pj, jun, sdg, cds, ROCK, oh	SPEC	0.74	0.74	0.70	0.45	Outcrops of sandstone (slightly gypeous). Often among gravel or cobble.	G
Shootingstar Geranium; Geranium dodecatheoides	sf, mc, pp, RIP, ROCK	SPEC	0.79	0.81	0.74	0.87	Primarily among boulders and outcrops near the edge of canyon-bottom riparian forest (RPTC).	A

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
Cloudcroft Scorpionweed; Phacelia cloudcroftensis	mc, pp, pj, DRY, DISTURB, oh	SPEC	0.65	0.59	0.47	0.74	Disturbed sites in arroyo channels or along roads (RPTC).	
White Mountain False Pennyroyal; Hedeoma pulcherrima	MC, PP, PJ, DISTURB, Open/ Openings	ERU	0.66	0.62	0.50	0.75	Steep hillsides in rocky and or disturbed habitats, including roadsides. Does well in open, moderately disturbed areas. Dry soil.	
Todsen's Pennyroyal; Hedeoma todsenii	PJ, Open/ Openings	ERU	0.60	0.50	0.33	0.69	Steep, gravelly, loose soils in open woodland. Relatively cool, moist soils, often on north or east-facing slopes. Positioned immediately below the Yeso Formation.	G
Sacramento Prickly-poppy; Argemone pleiacantha ssp. pinnatisecta	pj, DISTURB, Open/ Openings	SPEC	0.60	0.50	0.33	0.69	Loose, gravelly soils of open disturbed sites, canyon bottoms and slopes. Usually in areas of enhanced soil moisture (north facing slopes, canyon bottoms, along drainages, and near leaks in water pipelines) (NatureServe). Also found along roadsides (tolerant of disturbance).	L
James' Wild Buckwheat; Eriogonum wootonii	SF, MC, PP, MMS, PJ, Open/ Openings	ERU	0.65	0.61	0.50	0.75	Mountain slopes; small forest openings.	
Chapline's Columbine; Aquilegia chaplinei	cds, RIP, SPR, ROCK, CREVICES	SPEC	0.39	0.40	0.40	0.61	Rock loving. Canyon bottom seeps and springs and riparian. Moist, shaded crevices or among boulders along streambanks. May be subjected to periodic flooding.	L

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
White Mountain Larkspur; Delphinium novomexicanum	mc, pp, MDW, disturb, Open/ Openings	SPEC	0.73	0.75	0.69	0.82	Along drainages, canyon bottoms, forest meadows and road banks in lower and upper montane coniferous forest (RPTC; NH).	
Wooton's Hawthorn; Crataegus wootoniana	pp, RIP, oh	SPEC	0.96	0.97	0.87	0.94	Along streams, canyon bottoms, riparian and forest understory, and grassy areas in lower montane coniferous forest.	
Sierra Blanca Cinquefoil; Potentilla sierrae-blancae	MSG, OH	ERU	0.94	0.92	0.83	0.51	Harsh, open windswept ridgecrests, mountain tops and outcrops on igneous rock substrate with thin soil; occasionally on igneous cliffs and outcrops in canyons.	I
Capitan Peak Alumroot; Heuchera woodsiaphila	sf, mc, mdw	SPEC	0.59	0.62	0.58	0.78	Moist soil pockets in stable granitic talus on north and northeastern slopes, montane coniferous forest (RPTC; NatureServe).	I
Eggleaf Coral drops; Besseya oblongifolia	sf, MSG, OH	ERU	0.46	0.46	0.46	1.00	High elevation (alpine tundra-like) montane meadows (RPTC).	
Scerlet Penstemon; Penstemon cardinalis ssp. cardinalis	PP, PJ	ERU	0.69	0.62	0.47	0.75	Canyon bottoms and rocky slopes in woodland and coniferous forest (RPTC, NatureServe).	
Royal Red Penstemon; Penstemon cardinalis ssp. regalis	pp, mms, pj, oak, ROCK	SPEC	0.64	0.56	0.41	0.69	Cliffs and boulders on steep slopes and canyon bottoms.	L
Western Spruce Dwarf-mistletoe; Arceuthobium microcarpum	SF	ERU	na	na	na	na	Inhabits spruce foliage.	

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
Dumont's Fairy Shrimp; Streptocephalus henridumontis	mc, pp, AQ, oh	SPEC	0.80	0.82	0.75	0.86	Ephemeral pools; playas; stock tanks. Turbid, warm water (NatureServe).	
Bonita Diving Beetle; Stictotarsus neomexicanus	mc, pp, rip, AQ	SPEC	0.80	0.82	0.75	na	Streams, bordered by riparian vegetation. Yet to be described in detail or quantified.	
Caddisfly; Psychoronia brooksi	sf, mc, asp, rip, AQ	SPEC	0.56	0.59	0.56	0.82	Streams. Pupae aggregate on boulders, just below the water surface (NatureServe).	
Carlsbad Agave Borer/Orange Giant-Skipper; Agathymus neumoegeni carlsbadensis	CDS, OH	ERU	na	na	na	na	Shrubby grassland or open woodland. Caterpillar host plant is Parry's agave (Agave parryi)(Toliver et al 1998).	
Henry's Elfin; Callophrys henrici solatus	cds, oak, RIP, Open/ Openings	SPEC	0.39	0.40	0.40	0.61	Ravines and streamsides with woody scrub (NatureServe). Edges and openings in and around pine or pine-oak woodland (BMONA 2016).	
Sacramento Mountains Checkerspot; Euphydryas anicia cloudcrofti	sf, mc, MDW, OH	SPEC	0.60	0.63	0.59	0.76	Sunny meadows with moist soils and adequate host-plant (New Mexico penstemon [Penstemon neomexicanus] and valerian [Valeriana edulis]), nectar (e.g., orange sneezeweed [*Helenium* (=*Hymenoxys*) *hoopesii*] and others), structural (pupal attachment), and litter (diapause location) resources, within upper montane and subalpine mixed-conifer forest (FWS 2005).	
Poling's Hairstreak; Satyrium polingi	MMS, OAK,	ERU	na	na	na	na	Oak woodland with gray (also called scrub) oak. This is also the larval host plant, with caterpillars feeding on new growth, and probably on male flowers as well. Adults use a	

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
							variety of flowers for nectar, including milkweed and catslaw acacia. Probably also uses *Q. emoryi* (NatureServe).	
Zephyr Eyed Silkmoth; Automeris zephyria	MC, PP, MMS, PJ, willow	ERU	na	na	na	na	Known caterpillar host (larval food) is willow (Salix) species, but a variety of plants may be found to be used. Adults do not feed (B; BMONA 2016).	
Guadelupe Woodlandsnail; Ashmunella carlsbadensis	jun, cds, oak, ROCK, oh	SPEC	0.64	0.45	0.44	na	Inhabits drier microsites (relatively dry microclimates) compared to other terrestrial snails in this assessment. Lower slopes of canyon walls, where talus and deep leaf litter have accumulated, with isolated populations extending down to "arid foothills of the Guadalupe Mountains" (BISON). Dry cliffs to some extent. Patches of scrub (oak, sumac) in ravines.	
Capitan Woodlandsnail; Ashmunella pseudodonta	pj, jun, ROCK, oh	SPEC	na	na	na	na	Talus	
Sierra Blanca Woodlandsnail; Ashmunella rhyssa	sf, mc, pp, asp, mdw, rip, ROCK, oh, willow	SPEC	0.75	0.76	0.70	na	Talus, over a wide altitudinal range. Also along canyon bottoms and streams.	
Ruidoso Snaggletooth; Gastrocopta ruidosensis	PP, MMS, PJ, JUN, OAK, oh	ERU	0.68	0.60	0.45	0.75	Bare soil, under stones, and in accumulations of grass thatch and juniper litter on mid-elevation carbonate cliffs and xeric limestone grasslands (Nekola and Coles 2010).	
Vagabond Holospira; Holospira montivaga	pp, pj, oak, oh	SPEC	0.62	0.53	0.36	0.70	Like Ashmunella carlsbadensis, inhabits drier microsites (relatively dry microclimates) compared to other terrestrial snails in this assessment. Canyon walls and steep slopes.	

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
							Occurs on the fairly exposed, arid, western slope of the Guadalupe Mountains as well as the more mesic, higher parts of the range (NatureServe).	
Northern Threeband; Humboldtiana ultima	RIP, rock, oh	SPEC	0.39	0.40	0.40	na	Leaf litter in moist canyons; in soil, under rocks (NatureServe). Inhabits tiny habitat patches in north facing cliffs, burrowing under riparian (e.g., maple) leaf litter.	
Mountainsnail; Oreohelix strigosa nogalensis	mc, pp, oak, asp, rip	ERU	0.80	0.82	0.75	0.86	Canyon habitats above 7000 feet (BISON). Inhabits “steep, leafy slopes with very little rock, near the canyon bed, the trees mostly maple; higher, close under the peak, it was taken among aspens" (Pilsbry 1939). Occupies more open habitat in the pine-oak woodland surrounding Nogal Peak (Metcalf and Smartt 1997).	
Rio Grande Chub; Gila pandora	rip, AQ, ROCK, CWD, oh	SPEC	0.65	0.58	0.47	0.61	Clear, cold flowing streams with gravel and cobble substrates; pools with overhanging banks, debris, and vegetation.	
Headwater Catfish; Ictalurus lupus	Mc, pp, mms, pj, jun, sdg, cds, msg, oak, rip, AQ, spr	SPEC	0.65	0.58	0.47	0.61	Clear temperate headwater streams, small rivers, and springs, and fluctuating tailwaters of dams in the Pecos, generally with a moderate gradient; among sandy and rocky riffles, runs, and pools of clear creeks. Omnivorous bottom feeder (NatureServe; BISON).	
Mexican Spotted Owl; Strix occidentalis lucida	sf, MC, PP, pj, OAK, asp, RIP, rock, caves, SNAGS, CWD, OLD	ERU	0.65	0.59	0.47	0.74	Predominantly mixed montane forest and riparian areas on slopes and canyons. Typically with complex structure including uneven-aged, multistoried canopies with substantial canopy cover and high densities of snags. On Guadalupe Ranger District, nest in deep canyons in caves and crevices.	

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
Pinyon Jay; Gymnorhinus cyanocephalus	pp, mms, PJ, JUN, oak, oh	ERU	0.66	0.58	0.44	0.72	Foothills and mid elevations, in piñon-juniper mostly (flocks also breed in sagebrush, scrub oak [*Quercus*] and chaparral communities in some portions of the range (and inhabits Jeffrey [(*Pinus jeffreyi*) California] and ponderosa [Arizona, California]) (BNA). "No known detailed quantification of habitat anywhere within its range" (BNA). Known to nest in piñon pines and junipers in Arizona and New Mexico.	
Peñasco Least Chipmunk; Neotamias minimus atristriatus	sf, mc, pp, MSG, MDW, cwd, OH	ERU	0.72	0.74	0.69	0.82	High elevation montane-subalpine grassland. Exterpated from mixed conifer and ponderosa pine habitats.	
Guadalupe Pocket Gopher; Thomomys bottae guadalupensis	PP, MMS, PJ, JUN, SDG, OAK, oh	ERU	0.65	0.58	0.47	0.75	Pocket gophers requires soil that is suitable for digging tunnels and sufficient tuberous roots and plant material for food. It occurs in shallow, rocky soil, often in association with *Agave lecheguilla*. This subspecies frequently feeds on the roots of *Agave lecheguilla*. (BISON).	
New Mexican Meadow Jumping Mouse; Zapus hudsonius luteus	sf, mc, pp, MDW, rip, OH, willow, sedge, rush	SPEC	0.70	0.72	0.67	0.81	Low-lying, moist, dense (grass, sedge, forb, brush) habitats, including streamsides, meadows, and marshes. Hibernates (and young born) in an underground burrow or under vegetative debris upslope from water saturated habitats.	
Robust Cottontail/Davis Mountain cottontail; Sylvilagus robustus	PJ, CDS, oak, oh	ERU	0.60	0.50	0.33	0.69	Desert shrublands and evergreen woodlands. Often associated with large boulders.	

Common & Scientific Names	Habitat Elements	ERU/ SPEC	DEP	DEP 10	DEP 100	CCVA	Comments	Soil
New Mexico Shrew; Sorex neomexicanus	SF, MC, PP, ASP, MDW, RIP, ROCK, cwd, oh	ERU	0.71	0.73	0.68	0.83	Often along streams, meadows, sheltered canyons and other moist habitats in coniferous and aspen forest, including areas without permanent water.	

Landscape Associations

In addition to general habitat types and special habitat features, we delineated additional, landscape, elements in order to further define conditions associated with each at risk species. They include elevation bands, two landscape settings (general landscape setting and general landform type), and one relative moisture category. Attributes for proposed at risk species are presented in the Results for Landscape Association section, and for every species considered in the Assessment Details for all Species of Conservation Concern.

Methods for Landscape Associations

General Landscape Settings Associated with At-risk Species

Three General Landscape Settings were defined and associated with at-risk species. The categories are Basin/Lower Slope, Upland, and for species than span both positions in the landscape, Basin/Lower Slope-Upland. They are defined as follows:

Table 182. Definitions of general landscape settings associated with at risk species

Basin/Lower Slope
Local basins (streams, meadows, floodplains) and lower slopes (streamsides, canyon bottoms).
Upland
Mountain sides and tops, mesas, broad flats, ridges, plateaus, foothills, alluvial fans, or broad, dry basins; upper canyon walls, broad benches, outcrops. Includes montane subalpine grassland (MSG) slopes. May include small arroyos and ravines not attributed as canyon bottoms.
Basin/Lower Slope-Upland
Species that regularly inhabit both Upland as well Basin/Lower Slope settings. This includes species that exhibit substantial and regular use of upland habitat types as well as basin settings (such as riparian communities) to some extent. Examples include juniper titmouse, Grace's warbler, Mississippi kite, and olive-sided flycatcher, as well as bats and peregrine falcon (which use combinations of widely differing landscape types including cliffs and mountain sides as well as streams and riparian areas).

General Landform Types Associated with At-risk Species

Eight General Landform Types were defined. The categories are General Upland Slopes and Plains; Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges; Cliffs, Canyons, Rocky Slopes, Crevices; Steep, Gravelly or Disturbed Slopes, Arroyos, Roadcuts; Canyon Bottoms, Streamsides, Lower Slopes; Meadows, Marshes, Springs, Riparian; Aquatic; and Combinations of Landform Types. Each at-risk species was associated with one of those. While not all categories are truly mutually exclusive categories, species were reasonably attributed to and grouped within a dominant category. Attributes for every species considered are included in the Assessment Details for all Species of Conservation Concern. They are defined as follows (Table 183):

Table 183. Definitions of general landform types associated with at risk species

Cliffs, Canyons, Rocky Slopes, Crevices
Exposed cliffs and features on cliffs.
Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges
Outcrops, caprock, upper canyon walls, steep rocky upper slopes, rocky ridges, ledges and benches.
General Upland Slopes and Plains
Mountainsides and mountaintops, plateaus, mesas, foothills, alluvial fans, or broad, dry basins, and alluvial valleys.
Steep, Gravelly or Disturbed Slopes, Arroyos, Roadcuts
Roadcuts are included among the habitats mentioned for all species attributed to this category except for Todsen's Pennyroyal (*Hedeoma todsenii*), for which roadcuts are not listed among the habitats used.
Canyon Bottoms, Streamsides, Lower Slopes
Lower portions of basins other than the next two categories.
Meadows, Marshes, Springs, Riparian
RIP, MDW, SPRING, and marsh habitats.
Aquatic
Aquatic features (streams, pools, ponds).
Combinations of Landscape Positions or Types
Combinations of substantialy different landforms.

Relative Wetness/Dryness of Habitats or Microhabitats Associated with At-risk Species

This characteristic attributes species to groups based on the wettest (most mesic) habitat or micro-environment they inhabit. Attributes for every species considered are included in the Assessment Details for all Species of Conservation Concern. The categories are Aquatic, Wet, Moist, and Dry.

- ***Aquatic***– Includes aquatic, and may range from aquatic to dry, habitats.
- ***Wet*** – Includes wet, and may range from wet to dry, habitats.
- ***Moist*** – Includes moist, and may range from moist to dry, habitats.
- ***Dry*** – Restricted to dry habitats.

Elevation Bands Associated with At-risk Species

Elevation is an important gradient influencing the distribution of species. We collected elevation information for each potential SCC. We ascribed each species to the general elevation belts (High, Mid, or Low) or the range of elevation belts, that each was reported to associate with. Accordingly, this allowed for grouping of species by elevation belts. In most cases, species that span a very broad range of elevations are generalists in terms of the ERUs used. Elevation details for every species considered are included in the Assessment Details for all Species of Conservation Concern.

Table 184 illustrates the habitat elements that correspond with the general elevation belts.

Table 184. Habitat elements that correspond with the general elevation belts

Elevation Band	SF	MC	PP	MMS	PJ	JUN	SDG	CDS	MSG	MDW
High	SF	MC	PP						MSG	MDW
High-Mid	SF	MC	PP	MMS	PJ	JUN			MSG	MDW

Elevation Band	SF	MC	PP	MMS	PJ	JUN	SDG	CDS	MSG	MDW
High-Low	SF	MC	PP	MMS	PJ	JUN	SDG	CDS	MSG	MDW
Mid				MMS	PJ	JUN			MSG	MDW
Mid-Low				MMS	PJ	JUN	SDG	CDS		MDW
Low							SDG	CDS		MDW

Results for Landscape Associations

Regarding elevation, the largest number of proposed at risk species are associated with the High elevation belt (and corresponding habitats). Well over half are associated with High or High-mid elevations (Table 185). Species associated with Aquatic and Wet numbered 8. This equates to 14 percent of the proposed species, while aquatic and wet environments account for a very small fraction of the landscape (far less than Riparian ERUs, for example, which only make up about 0.3 percent of the Forest). Most (43) of the species are associated with Aquatic, Wet, or relatively Moist microenvironments and habitats, with 15 attributed to Dry environments. Regarding landform type, the largest number of species (12) were associated with Canyon bottoms, streamsides, and lower slopes (the wetness/dryness attribute corresponded with Moist in each case). Combined, Aquatic, Meadows, marshes, springs, riparian, and Canyon bottoms, streamsides, and lower slopes were attributed to 24 of the 58 species. Table 185 lists proposed at risk species according to general landform types and landscape setting. The Basin/lower slope landscape setting was attributed to 26 species, and 5 were attributed to prominently inhabiting both Basin/lower Slope and Upland settings. Upland was attributed to 27 species.

Table 185. Numbers of proposed at risk species according to relative wetness/dryness of habitats (left-most column), landscape types, and general elevation bands

	Landform type (below); Elevation bands (right)	High	High-Mid	High-Low	Mid	Mid-Low	Low	Grand Total
Aquatic	Aquatic	1	2	1			1	5
Wet	Meadows, Marshes, Springs, Riparian	2				1		3
Moist	Canyon Bottoms, Streamsides, Lower Slopes	4	2		2	2	2	12
	Cliffs, Canyons, Rocky Slopes, Crevices	2	1					3
	Combinations of Landscape Types	1	1					2
	General Upland Slopes and Plains (Mountains, Plateaus, Mesas, Foothills, Fans, or Broad, Dry Basins)	3	4		1	2	1	11
	Meadows, Marshes, Springs, Riparian	4						4
	Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges	1						1
	Steep, Gravelly or Disturbed Slopes, Arroyos, Roadcuts	1			1			2
Dry	Cliffs, Canyons, Rocky Slopes, Crevices	1						1
	General Upland Slopes and Plains (Mountains, Plateaus, Mesas, Foothills, Fans, or Broad, Dry Basins)	3						3
	Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges				1	2	4	7

	Landform type (below); Elevation bands (right)	High	High-Mid	High-Low	Mid	Mid-Low	Low	Grand Total
	Steep, Gravelly or Disturbed Slopes, Arroyos, Roadcuts	1	3					4
Total		**24**	**13**	**1**	**5**	**7**	**8**	**58**

Table 186. Proposed at risk species according to general landform and landscape setting

General Landform (below)	General Landscape Setting Basin/Lower Slope	Upland	Basin/Lower Slope-Upland
Cliffs, Canyons, Rocky Slopes, Crevices	Royal Red Penstemon	Sierra Blanca Cliff Daisy	Vagabond Holospira
	Shootingstar Geranium		
Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges		Fanmustard	
		Guadalupe Mescal bean	
		Gypsum Blazingstar	
		Kuenzler's Hedgehog Cactus	
		Sacramento Mountain Foxtail Cactus	
		Lee’s Pincushion Cactus	
		New Mexican Stonecrop	
		Ruidoso Snaggletooth	
General Upland Slopes and Plains (Mountains, Plateaus, Mesas, Foothills, Fans, or Broad, Dry Basins)		Crested Coralroot	
		Eggleaf Coral-drops	
		Green Medusa Orchid	
		James' Wild Buckwheat	
		Lincoln County Bladderpod	
		Sierra Blanca Cinquefoil	
		Western Spruce Dwarf-mistletoe	

General Landform (below)	General Landscape Setting Basin/Lower Slope	Upland	Basin/Lower Slope-Upland
		Zephyr Eyed Silkmoth	
		Carlsbad Agave Borer; Orange Giant-Skipper	
		Poling's Hairstreak	
		Pinon jay	
		Guadalupe Pocket Gopher	
		Peñasco Least Chipmunk	
		Robust Cottontail; Davis Mountain cottontail	
Steep, Gravelly or Disturbed Slopes, Arroyos, Roadcuts	Cloudcroft Scorpionweed	Golden Bladderpod	
	Kerr's Milk-vetch	Todsen's Pennyroyal	
		White Mountain False Pennyroyal	
		Winged Milk-vetch	
Canyon Bottoms, Streamsides, Lower Slopes	Capitan Peak Alumroot		Sacramento Prickly-poppy
	Capitan Woodlandsnail		Scerlet Penstemon
	Chapline's Columbine		
	Guadelupe Woodlandsnail		
	Henry's Elfin		
	Mountainsnail		
	Northern Threeband		
	Sierra Blanca Woodlandsnail		
	Sparsely-flowered Jewelflower		
	Wooton's Hawthorn		
Meadows, Marshes, Springs, Riparian	Goodding's Onion		

General Landform (below)	General Landscape Setting Basin/Lower Slope	Upland	Basin/Lower Slope-Upland
	Sacramento Mountains Thistle		
	Wright's Marsh Thistle		
	White Mountain Larkspur		
	Wood Lily		
	Sacramento Mountains Checkerspot		
	New Mexican Meadow Jumping Mouse		
Aquatic	Bonita Diving Beetle		
	Caddisfly		
	Dumont's Fairy Shrimp		
	Headwater Catfish		
	Rio Grande Chub		
Combinations of Landscape Types			Mexican Spotted Owl
			New Mexico Shrew

Risk Factors for At-Risk Species

For each species, we derived threat data from the information sources consulted. We tabulated those threats for all proposed at risk species, and aggregated threats according to the habitat and landscape elements with which the species associate. For purposes of this portion of the assessment, we did not attribute threats to species across the board based on habitats, taxonomic group, or other assumptions. Instead, we relied on the stated threats found in the information sources consulted. Accordingly, the results constitute a survey of threats from the consulted literature for each species, and a tabulation of the frequencies of occurrence of threats according to the habitat elements associated with at risk species. The results are shown in tables below; the Assessment Details for all Species of Conservation Concern lists each threat attributed to each species screened for SCC status.

We recognize that the values (i.e., proportion of species or habitats that each threat is attributed to) are likely conservative for most threats, but view the tabulation of results from existing data sources as a good starting point for identifying patterns. We also recognize that the significance (i.e., spatial extent, magnitude and imminence) of different threats for a given species varies, as does the significance of a given threat to different species. The relative significance of different threats is not addressed here, but is embodied in the species by species process of identifying SCC presented in prior sections, with details provided in the Assessment Details for all Species of Conservation Concern. Additionally, feedbacks and other interactions among threat categories (e.g., interactions among altered fire regimes, grazing, altered hydrological regimes, and climate) are not captured in these tabulations. Authors generally reported more direct threats as opposed to underlying or interacting stressors. For a number of species, the information source specified that impacts of fire and or grazing have not been studied adequately (accordingly, those were not attributed to such species).

Consistent with New Mexico's SWAP, we used threat categories derived from the threats classification scheme (Version 3.2) adopted by the International Union for Conservation of Nature (IUCN). Those include Residential and Commercial Development (including housing and urban, commercial and industrial areas); Agriculture and Aquaculture (including farming, grazing and ranching); Energy Production and Mining (oil and gas, mining and quarrying, and renewable energy); Transportation and Service Corridors (roads and railroads, utility and service lines; including impacts from vehicles along those corridors); Biological Resource Use (hunting, gathering plants, collecting, logging and wood harvesting); Human Intrusions and Disturbance (recreational, military, and work activities); Natural System Modifications (altered fire regimes [including increases or decreases in fire frequency or intensity], and altered hydrological regimes); Invasive and Other Problematic Species, Genes and Diseases (includes competition, predation and hybridization issues); Pollution (domestic, urban, industrial, military, agricultural and forestry waste water, sewage, runoff, spills, and effluents, including soil erosion, sedimentation nutrient loads, herbicides and pesticides, and air born pollutants); Geological Events; and Climate Change and Severe Weather (habitat shifts and alteration, droughts, temperature extremes, and storms and flooding). We made some modifications. We separated Agriculture and Aquaculture into two categories, Agriculture, and Grazing. We separated Biological Resource Use into two categories, Logging/Wood Harvesting, and Hunting/Collecting. We separated Natural System Modifications into two categories, Fire Regime Modifications, and Hydrological Modifications. We separated Diseases from the other components of the Invasive and Other Problematic Species, Genes and Diseases category. We did not include the Geological Events category, as none of the species were specifically reported to have Geological Events (e.g., volcanic eruptions) as a threat. Fourteen threat categories resulted.

To determine what proportion of at risk species a given threat is attributed to, we divided the number of species for which the threat is attributed, by the total number of proposed at risk species (58). Fire Regime Modification issues were attributed to 47 percent of those species. Grazing was attributed to 31 percent, and Climate Change/Severe Weather was attributed to 31 percent of at risk species. Rec/Mil/Work Disturbance was attributed to 29 percent. Hydrological Modifications, Invasive/Problematic Species and Hunting/Collecting and were attributed to 24, 22 and 21 percent of the species, respectively. Transpo/Service Corridors were attributed to 19 percent of species based on the resources consulted. Logging/Wood Harvesting was attributed to 12 percent. These were followed by Res/Comm Development (10 percent), Pollution (7), Agriculture (5), Energy Prod/Mining (3), and Diseases (2).

For the 58 proposed at risk species, there were 670 instances of species-threat-habitat combinations. As a proportion of all those instances, Fire Regime Modifications, Grazing and Climate Change/Severe Weather were the most frequently reported threats (17, 12 and 12 percent, respectively). Those were followed by Hydrological Modifications (11), Rec/Mil/Work Disturbance (11 percent), and Invasive/Problematic Species (10). Transpo/Service Corridors, Hunting/Collecting, and Logging/Wood Harvesting comprised 7, 7 and 5 percent of all instances, respectfully. Res/Comm Development accounted for 3 percent, and Pollution accounted for about 2 percent of all instances. Agriculture and Energy Prod/Mining related threats each accounted for about 1 percent of species-threat-habitat combinations, consistent with the relatively high elevation ranges of the species in general. Diseases accounted for about 1 percent.

The majority of at risk species occupy higher elevation habitats (40 of 58 are largely restricted to habitats in high or high-to-mid elevation bands [PP up through SF, and MSG]). Consistent with the count of at risk species associated with the different habitat elements, the largest number of species-habitat-threat combinations occurred in PP and MC (12 and 12 percent of all instances, repectively; Table 187 provides detailed breakdowns). Among different habitat elements, the prominence of threats based on threats per species is considerably different than the count of species. The average number of threats per species was particularly high in CAVE (4.5), MDW (4.5), SPR (3.8), MSG (3.8), AQU (3.3), SF (3.2), and OPEN (3.2). SDG associated species had about 3.1 threats on average. Species associated with MC, RIP, PP, ASP, MMS, OAK, PJ, JUN and ROCK ranged from 3, down to 2, threats per species. Species associated with CDS and had 1.9 reported threats per species. Overall, the average number of threat categories attributed to each at risk species was about 2.8. While high elevation forests had the greatest accumulation of species-threat combinations due to having the highest numbers of associated species, CAVE, MDW, wet features, MSG, SF and OPEN features have a higher concentration of threats on a per species basis.

Note: The table is read as follows, as exemplified by values for SF. Of 16 species associated with SF, 6% have Res/Comm Development related threats, and so on. There were 51 threat-habitat-species combinations attributed to SF associated species.

Ten percent of species-threat combinations were attributed to species that associate with aquatic habitats or open water (e.g., streams, pools) some or all of the time (9 percent of the 58 species were associated with aquatic habitats; Table 188 provides detailed breakdowns). This stands in contrast to the small portion of the landscape that is comprised of aquatic habitats (well under one percent). Another 10 percent of species-threat combinations were attributed to species that associate some or all of the time with wet habitats (e.g., stream-sides, emergent marsh), also a very small portion (under one percent) of the landscape (5 percent of species were associated with wet habitats). The highest proportion of species-threat combinations (48 percent) were attributed to species that associate with relatively moist habitats or micro-environments some or all of the time (47 percent of species were associated with moist habitats). Together, 68 percent of species-threat combinations were attributed to species that associate with aquatic, wet, or moist habitats or micro-environments some or all of the time (61 percent of species were associated with those conditions). The other 31 percent of species-threat combinations were attributed to species that were associated with dry habitats (40 percent of species were associated with dry habitats). Climate Change/Severe Weather was among the threats attributed to 37 percent of the species (13 out of 35) associated with aquatic, wet and moist habitats, and 22 percent of the species (5 out of 23) associated with dry habitats, in the literature consulted.

There were 5 threats per species for those attributed to the wet habitat category, 3.2 for the aquatic, 2.7 for the moist, and 2.1 for dry habitat species. Of those species associated with the aquatic or wet habitat categories, at least 7 out of 8 were reported to have Hydrological Modification related threats, and 5 out of 8 were reported to have Grazing related threats. For those at risk species associated with the moist habitat category, the most frequently attributed threat category was Fire Regime Modifications (14/27), followed by Climate Change/Severe Weather (11/27). For those species associated with the dry habitat, the most frequently attributed threat category was Fire Regime Modifications (11/23), followed by Grazing (7/23) and Hunting/Collecting (7/23).

Regarding the general landform types associated with at-risk species, threat counts were highest in species attributed to the Meadows, Marshes, Springs, and Riparian landform category (25 percent of 153 species-threat combinations, with only 12 percent of the 58 species attributed to that category). Table 189 provides detailed breakdowns). General Upland Slopes and Plains were attributed with 23 percent of species-threat combinations and 24 percent of the species. Canyon Bottoms, Streamsides, and Lower Slopes were attributed with 15 percent of species-threat combinations and 21 percent of the species. Aquatic was attributed with 10 percent of species-threat combinations and 9 percent of the species. Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges were attributed with 9 percent of species-threat combinations and 14 percent of the species. Steep, Gravelly or Disturbed Slopes, Arroyos, or Roadcuts were attributed with 8 percent of species-threat combinations and 10 percent of the species. Combinations of Landscape Types were attributed with 5 percent of species-threat combinations and 3 percent of the species. Cliffs, Canyons, Rocky Slopes, and Crevices were attributed with only 4 percent of species-threat combinations while 7 percent of the species were associated with that type.

Table 187. Threats to at-risk species, according to habitat element

Habitat Element	Res/Comm Development	Agriculture	Grazing	Energy Prod/Mining	Transpo/Service Corridors	Logging/Wood Harvesting	Hunting/Collecting	Rec/Mil/Work Disturbance	Hydrological Modifications	Fire Regime Modifications	Invasive/Problematic Species	Disease	Pollution	Climate Change/Severe Weather	Number of habitat-species instances	# threat-habitat-species instances
SF	6%	6%	38%	0%	25%	19%	19%	56%	25%	50%	31%	0%	0%	44%	16	51
MC	11%	7%	37%	0%	26%	19%	15%	33%	33%	44%	37%	0%	7%	33%	27	82
PP	10%	7%	34%	3%	28%	21%	14%	28%	31%	45%	31%	3%	10%	31%	29	86
MMS	9%	9%	36%	9%	9%	18%	36%	18%	18%	45%	27%	9%	9%	27%	11	31
PJ	13%	0%	35%	4%	26%	13%	22%	17%	13%	39%	13%	4%	9%	30%	23	55
JUN	0%	0%	36%	0%	18%	9%	18%	18%	18%	55%	18%	9%	0%	27%	11	25
SDG	22%	0%	44%	0%	22%	0%	22%	33%	33%	56%	33%	0%	0%	44%	9	28
CDS	8%	0%	23%	0%	0%	0%	23%	15%	31%	38%	15%	0%	0%	31%	13	51
MSG	0%	0%	25%	0%	50%	0%	0%	75%	50%	75%	50%	0%	0%	50%	4	82
OAK	0%	7%	27%	7%	7%	13%	27%	13%	13%	67%	13%	7%	0%	40%	15	86
ASP	0%	0%	17%	0%	33%	50%	17%	33%	0%	83%	0%	0%	0%	50%	6	31

Habitat Element	Res/Comm Development	Agriculture	Grazing	Energy Prod/Mining	Transpo/Service Corridors	Logging/Wood Harvesting	Hunting/Collecting	Rec/Mil/Work Disturbance	Hydrological Modifications	Fire Regime Modifications	Invasive/Problematic Species	Disease	Pollution	Climate Change/Severe Weather	Number of habitat-species instances	# threat-habitat-species instances
MDW	**9%**	**9%**	**64%**	**0%**	**18%**	**27%**	**27%**	**64%**	**55%**	**55%**	**64%**	**0%**	**0%**	**55%**	**11**	**55**
RIP	**0%**	**6%**	**35%**	**6%**	**12%**	**18%**	**12%**	**41%**	**59%**	**47%**	**35%**	**0%**	**0%**	**41%**	**17**	**25**
AQU	**0%**	**17%**	**50%**	**0%**	**33%**	**0%**	**0%**	**33%**	**83%**	**17%**	**67%**	**0%**	**17%**	**17%**	**6**	**28**
SPRING	**0%**	**0%**	**75%**	**0%**	**0%**	**0%**	**25%**	**75%**	**100%**	**25%**	**75%**	**0%**	**0%**	**0%**	**4**	**24**
ROCK	**6%**	**0%**	**11%**	**11%**	**11%**	**11%**	**17%**	**22%**	**11%**	**61%**	**6%**	**0%**	**0%**	**33%**	**18**	**15**
CAVE	**0%**	**0%**	**50%**	**0%**	**50%**	**50%**	**50%**	**100%**	**50%**	**50%**	**0%**	**0%**	**0%**	**50%**	**2**	**36**
OPEN	**17%**	**0%**	**33%**	**0%**	**33%**	**17%**	**17%**	**42%**	**33%**	**33%**	**33%**	**0%**	**17%**	**42%**	**12**	**17**
Average across habitats	**6%**	**4%**	**37%**	**2%**	**22%**	**16%**	**20%**	**40%**	**37%**	**49%**	**31%**	**2%**	**4%**	**36%**	**234**	**670**

Table 188. Stressors, aggregated for at-risk species grouped according to general landscape type

Habitat Element	Res/Comm Development	Agriculture	Grazing	Energy Prod/Mining	Transpo/Service Corridors	Logging/Wood Harvesting	Hunting/Collecting	Rec/Mil/Work Disturbance	Hydrological Modifications	Fire Regime Modifications	Invasive/Problematic Species	Disease	Pollution	Climate Change/Severe Weather	Number of at risk species
Aquatic	0%	20%	40%	0%	40%	0%	0%	20%	80%	20%	60%	0%	20%	20%	**5**
Wet	0%	33%	100%	0%	0%	0%	0%	100%	100%	33%	100%	0%	0%	33%	**3**
Moist	7%	0%	22%	7%	22%	19%	19%	33%	26%	52%	19%	0%	7%	41%	**27**
Dry	17%	4%	30%	0%	13%	9%	30%	17%	0%	48%	9%	4%	4%	22%	**23**
Total Number	6	3	18	2	11	7	12	17	14	27	13	1	4	18	**58**

Table 189. Stressors, aggregated for at-risk species grouped according to general landscape type

Habitat Element	Res/Comm Development	Agriculture	Grazing	Energy Prod/Mining	Transpo/Service Corridors	Logging/Wood Harvesting	Hunting/Collecting	Rec/Mil/Work Disturbance	Hydrological Modifications	Fire Regime Modifications	Invasive/Problematic Species	Disease	Pollution	Climate Change/Severe Weather	Number of at risk species
Aquatic	0%	20%	40%	0%	40%	0%	0%	20%	80%	20%	60%	0%	20%	20%	**5**
Canyon Bottoms, etc.	0%	0%	17%	8%	8%	8%	8%	17%	33%	50%	0%	0%	8%	33%	**12**
Cliffs, etc.	0%	0%	0%	25%	0%	0%	25%	25%	0%	50%	0%	0%	0%	25%	**4**
General Upland	7%	7%	36%	0%	7%	14%	36%	29%	7%	50%	14%	7%	7%	29%	**14**
Meadows, etc.	14%	14%	86%	0%	14%	29%	43%	86%	71%	43%	86%	0%	0%	57%	**7**
Outcrops, etc.	25%	0%	13%	0%	25%	0%	25%	13%	0%	63%	0%	0%	0%	13%	**8**
Steep Slopes, Arroyos, etc.	33%	0%	33%	0%	50%	0%	0%	17%	0%	17%	33%	0%	17%	17%	**6**

Habitat Element	Res/Comm Development	Agriculture	Grazing	Energy Prod/Mining	Transpo/Service Corridors	Logging/Wood Harvesting	Hunting/Collecting	Rec/Mil/Work Disturbance	Hydrological Modifications	Fire Regime Modifications	Invasive/Problematic Species	Disease	Pollution	Climate Change/Severe Weather	Number of at risk species
Combinations	0%	0%	0%	0%	50%	100%	0%	50%	0%	100%	0%	0%	0%	100%	**2**
Grand Total	6	3	18	2	11	7	12	17	14	27	13	1	4	18	**58**

Among the different landform types, reported threats per at risk species were as follows, in descending order: Meadows, Marshes, Springs, and Riparian landform category (5.4 threats per species); Combinations of Landscape Types (4); Aquatic (3.2); General Upland Slopes and Plains (2.5); Canyon Bottoms, Streamsides, and Lower Slopes (1.9); Steep, Gravelly or Disturbed Slopes, Arroyos, or Roadcuts (2.2); Outcrops, Caprock, Exposed Ledges, Benches, Rocky Slopes, or Ridges (1.8); and Cliffs, Canyons, Rocky Slopes, and Crevices (1.5 threat per species). The low number of threats attributed to species associated with Cliffs, Canyons, Rocky Slopes, and Crevices relates directly to why a number of plant species, from the initial list of species considered, were not put forward as potential SCC (i.e., threats were considered minimal due to the inaccessibility of the rocky habitats). Such details are provided in the Assessment Details for all Species of Conservation Concern for each species.

Stakeholder Input

We have been collecting input from the public through Forest Plan revision public engagement efforts beginning in 2014. In the initial scoping efforts conducted thus far, comments relating to at risk species and their conditions, trends, and issues included these topics: Barbary sheep have displaced native desert bighorn and impacted native plant communities; Humboltiana ultima's (landsnail) range is limited to the Guadalupe Mountains and is of concern; range and population sizes of Montezuma quail have declined due to drought and overgrazing; increased prevalence of northern mockingbirds in the Guadalupe RD, suggesting this common species may be replacing more rare or uncommon species such as spotted towhee (reduction in bird diversity); fewer people volunteering in wildlife management; SCC and ESA species contribute to the carbon load problem due to management restrictions and burdens on timber harvest operations; forest health and projects are constrained by single species and listed species management (e.g., Mexican spotted owl and timber management); trending away from multiple use management and toward single species management; not enough is being done for listed species; irrigation and spring development/use by agricultural interests are negatively impacting watersheds and fisheries; less focus on fisheries, and reduced/limited fisheries and suitable waters and stream-based recreation opportunities; excessive regulatory control over cave use due to whitenose syndrome risks; and impacts to wildlife and habitats due to OHV activity. Expressed values included healthy and diverse wildlife and plant species and habitats; and effective communication, collaboration, and decision-making. Additional comment topics relating to habitat and other factors important to plants and wildlife are listed in Stakeholder Input sections of other chapters in this volume, as pertinent. We will incorporate comments and additional information based on the results of further public review of this draft, and submit a revised draft assessment for regional office approval prior to finalizing it. Based on the results of public engagement, we will finalize the list of SCC and attributes for all at-risk species for regional office approval. It is possible that public review of information in this assessment and any additional information will result in some changes to the list of potential SCC, though this is expected to be few.

Summary of Findings for At-Risk Species

At-risk species are defined as: 1) the federally recognized threatened, endangered, proposed, and candidate species; and 2) SCC known to occur within the Plan Area. The list of at-risk species will ultimately be identified by the Regional Forester in coordination with the Lincoln NF Supervisor. SCC are identified using distribution information along with the NatureServe ranking system and other sources to highlight those species for which there is a substantial concern about their capability to persist over the long term in the Plan Area, considering local information and local conditions. A process to identify SCC, consistent with Forest Service Handbook directives (FSH 1909.12 Section 12.5), is summarized in this chapter along with the resulting, proposed list and conditions, features, population trends, habitat trends, and risks for those species.

We developed an initial list of potential SCC containing all species in the four county area known to be moderately or highly vulnerable to threats or imperiled. We confirmed which of those potential SCC were native to the Plan Area and for which persistence was at risk. These species, in addition to federally listed species relevant to the Plan Area, will be considered as the Lincoln NF evaluates needs for change to the current forest plan.

Nine species relevant to the Forest are at risk consistent with their ESA listing status. In addition we found 259 species that occur within the four county area and would meet a criteria for initial consideration as an SCC if found to occur on the Forest. Of those, 171 were reported to occur on the Forest. One-hundred twenty-two of those did not have information to indicate substantial risk of extirpation on the Forest. The remaining 49 are proposed SCC.

More than half of the 58 proposed at risk species (ESA listed and proposed SCC) are flowering plants. No amphibians or reptiles were proposed. Approximately 28, 28, and 19 are reported to occur in the Smokey Bear, Sacramento, and Guadalupe Ranger Districts, respectively. In terms of local units, 1RH has the highest number of proposed at risk species (25). On a per acre basis, the greatest concentration occurs in 3SB (equivalent of 15.4 per 100,000 acres). Forest-wide, there are approximately 4.6 per 100,000 acres.

The highest numbers of proposed at risk species occur in higher elevations, associated with PP (used by 50 percent of species) and MC (47 percent). A substantial proportion are associated with PJ (40 percent). For ESA-related species on the Forest, the most frequently associated habitat element was RIP, followed by MDW, SF, MC, PP and PJ (4 of 9 species in each case). A relatively large number of at risk species are associated with MC, PP and SF on the Smokey Bear and Sacramento Ranger Districts, and PJ on all three Ranger Districts. Standardized to a per area basis (at risk species associated with a given habitat element per 10,000 acres of that element), the concentration of at risk species on the Forest and in each District is greatest in RIP. RIP is followed by JUG and SF. On the Guadalupe Ranger District, CDS and MC have relatively important concentrations of at risk species. The Smokey Bear Ranger District stands out in terms of SDG and MMS. On the Sacramento Ranger District, the highest concentration is in SF and SDG.

Regarding special habitat elements and conditions, frequency of use by the proposed at risk species, especially plants, is particularly high for species associated with ROCK- (33 percent of species) and OPEN-related conditions (21 percent). Prominent or occasionally use of open habitats was very common among proposed at risk species (52 percent). Combined, 72 percent of species that use some sort of openings (OPEN) and or open habitats (OH/oh). A relatively high proportion of at risk species were also associated with AQU, SPR and CWD.

Regarding elevation, the largest number of proposed at risk species are associated with the High elevation belt (and corresponding habitats). Regarding the wetness/dryness gradient, the number of species associated with Aquatic and Wet was disproportionately high relative to the area of aquatic and wet environments in the landscape, and the proportion attributed with using moist microenvironments and habitats was high. Regarding landform type, the largest number of species (12) were associated with Canyon bottoms, streamsides, and lower slopes. Combined with Aquatic (5) and Meadows, marshes, springs, and riparian associated species (7), they include 24 of the 58 species. Regarding landscape setting, Basin/lower slope was attributed to 25 species, prominent habitation of both Basin/lower Slope and Upland settings were attributed to 5, and predominant use of Upland was attributed to 27.

Threats most frequently attributed to at risk species were related to Fire Regime Modification issues (47 percent of species), followed by Grazing issues (31 percent), Climate Change/Severe Weather (31), Rec/Mil/Work Disturbance (29), Hydrological Modifications (24), and Invasive/Problematic Species (22). As a proportion of all instances of species-threat-habitat combinations, Fire Regime Modifications and Grazing were also most frequently reported. Consistent with the count of at risk species associated with the different habitat elements, the highest number of species-threat-habitat combinations occurred in PP and

MC (and accordingly, the high elevation belt), followed by RIP, SF, MDW, and PJ. The number of threats per species, however, was particularly high in CAVE, MDW, SPR, MSG, and AQU, followed by SF, OPEN, SDG, MC, RIP, PP, ASP, MMS, OAK, PJ, JUN, ROCK, and CDS. Threats per species was fewest for ROCK associated species.

Ten percent of species-threat combinations (9 percent of species) were attributed to species that associate with aquatic habitats or open water (e.g., streams, pools), which is far greater than the portion of the landscape that is comprised of aquatic habitats (well under one percent). Another 10 percent were attributed to species that associate some or all of the time with wet habitats (e.g., stream-sides, emergent marsh), also far less than one percent of the landscape. Together, 68 percent of species-threat combinations were attributed to species that associate with aquatic, wet, or moist habitats or micro-environments some or all of the time. Regarding the general landform types associated with at-risk species, threats were most frequent in species attributed to the Meadows, marshes, springs, and riparian landform category (25 percent of species-threat combinations, but only 12 percent of species, are attributed to that category; 5.4 threats per species).

Identifying and assessing at-risk species (and conditions associated with them) is an ongoing process. At-risk species decisions are based on best available scientific information. Unfortunately many species lack specific information on current population status, distribution, or abundance making it difficult to quantify risk factors. Another confounding issue is scale. Although some species information indicate increase or a decline on a large geographic scale (i.e. nationwide or statewide), Forest-level information may not suggest a similar determination. Should any new information become available, this assessment can be amended to accommodate the new information. The list of proposed SCC may be refined, to add or remove species, as the plan revision process commences. Lincoln NF continues to seek public feedback in pursuit of rigorous data to support plan development and subsequent phases, including implementation, monitoring and adaptive management.

Some SCC identified in this assessment have been linked to current ERUs in moderate or high departure from reference condition, or to management actions under the current plan that may be negatively affecting either key ecosystem characteristics and or species populations on the Forest. Many of these species are also affected by activities outside the Plan Area or beyond Forest Service control; it is important to recognize the limits to agency authority and the inherent capability of the Lincoln NF.

These at risk species will be considered as the plan revision process moves forward and need for change to the existing forest plan is considered. The coarse-filter/fine-filter approach used to assess species will also be carried forward through the next steps. Plan components will be developed to maintain or restore conditions for ecological integrity and diversity in the Plan Area. The fine filter approach will provide for specific habitat needs or other ecological conditions for those species for which needs are not met through the coarse-filter approach. Adaptive management will contribute to achieving goals relating to improving ecosystem integrity and diversity (including connected habitats that can absorb and recover from disturbance) and restoring and maintaining conditions that support the abundance, distribution, and long-term persistence of native species (including widespread and secure, as well as declining and vulnerable species). The species for which the 2012 Final Planning Rule requires fine-filter plan components, as needed, are ESA listed threatened, endangered, proposed, and candidate species, and SCC.

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