Four-Forest Restoration Initiative
Coconino and Kaibab National Forests
Silviculture Specialist Report

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Introduction

The objective of the project is to re-establish forest structure, pattern, and composition, within the ponderosa pine ecosystem which will lead to increased forest resiliency and function. Resiliency increases the ability of the ponderosa pine forest to survive natural disturbances such as insect and disease, fire, and climate change (FSM 2020.5). Restoration activities proposed with this project are expected to put the project area on a trajectory towards comprehensive, landscape-scale restoration with benefits that include improved vegetation biodiversity, wildlife habitat, soil productivity, and watershed function.

Silviculture is the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet diverse needs and values of landowners and society on a sustainable basis (SAF 1998). Forest vegetation composition, density, structure, and diseases such as dwarf mistletoe are the primary forest conditions which can be affected by silvicultural treatments. Stand composition can be altered with silvicultural treatments by manipulating a stand to create early seral[1] stage conditions.

The silviculture specialist report describes the existing vegetation condition and summarizes the forestland and cover types meeting definitions for Mexican spotted owl (MSO) and northern goshawk habitats. It compares those conditions to the desired vegetation conditions for the project area and illustrates the need for change. The report describes the proposed treatments and the effects of those treatments on the vegetation resource by characterizing the post treatment condition over time for each alternative. The report also evaluates each alternative in terms of moving toward the desired vegetation conditions.

The project was developed in consideration of the best available science. The best available science is a composite of the following key elements:

- On-site data and history. The project area was surveyed and Common Stand Exam data was collected.

- Scientific literature. Literature reviewed and cited is listed in the appendix.

- Modeling using currently acceptable analysis. The vegetation management was analyzed using the current Forest Vegetation Simulation model. The model uses Stand Visualization Systems, and stand summary statistics to predict future stand structure, density, and composition.

- Professional knowledge, judgment and experience. The primary specialist who conducted the vegetation management analysis was Neil McCusker. The analysis has been reviewed by resource peers. The collective professional knowledge of the project area, judgment of how to integrate science with local conditions, and the experience gained from implementation of other projects have been incorporated into the analysis.

[1] Seral – a temporal or intermediate stage in the process of succession (SAF 1998)

Purpose and Need for Action

The purpose and need for proposing an action was determined by comparing the objectives and desired conditions in the Coconino NF and Kaibab NF Land Resource and Management Plans (forest plans) to the existing conditions related to forest resiliency and forest function.

Regulatory Requirements

Multiple-Use Sustained Yield Act of 1960. Requires that national forest lands shall be administered for a variety of multiple uses, and that all resources shall be maintained as renewable in perpetuity for regular periodic output of several products and services at a sustainable level.

National Environmental Policy Act of 1969 (NEPA). Established procedures for decision making, disclosure of effects, and public involvement on all major federal actions.

National Forest Management Act of 1976 (NFMA). The Coconino and Kaibab forest plans were developed in accordance with NFMA, as expressed by the 1982 planning rule.

While federal laws like the National Forest Management Act establish the regulatory requirements of forest management for federal agencies, the detailed direction that affects the project-level vegetation analysis being undertaken in this proposed action are contained in the forest plans for the Coconino National Forest (USDA 1987, as updated 2008) and the Kaibab National Forest (USDA 1988, as updated 2008). These include the goals, objectives, direction, and Forest-wide and Management Area standards and guidelines that have relevance to the proposed action.

Coconino National Forest

The project area includes 23 Management Areas (MA) as described in the Coconino NF forest plan (pp. 46 to 206-113). Ponderosa pine and mixed conifer on less than 40 percent slopes (MA-03) makes up approximately 194,464 acres of the project area. Lake Mary Watershed (MA 35), West (MA-03), Doney (MA-11) Cinder Hills (MA 13), unproductive timber land (MA 6) and Deadman Wash (MA 32) comprise another108,724 acres in the project area. The remaining 14 management area acres within the project areas range from as few as 15 acres (Developed Recreation Sites MA 15) to approximately 8,968 acres in the Craters MA (MA 31).

Insect and Disease Management - Cuts are designed to eliminate or reduce dwarf mistletoe infections to manageable levels (CFP, page70).

Integrated Stand Management (ISM) - Establish and maintain stand diversity through ISM to provide suitable habitat for wildlife in lands suitable for timber production, while maintaining or enhancing timber resource production and timber age class distribution (CFP, page70).

Manage the approximately 12,100 acres identified as the pine-aspen capability area for aspen, on a regulated, sustained-yield basis to maintain aspen as a component of the Forest (CFP, MA3, page 118).

Uneven-aged management will be emphasized (CFP, MA3, page 123).

Manage oak to improve wildlife habitat. Maintain oak components wherever they occur (CFP, MA3, page 131).

The alligator juniper component of the ponderosa pine is managed primarily for maintaining and enhancing wildlife habitat (CFP, MA3, page 132).

Reduce competition between closely spaced trees in some areas, to promote future large trees faster and to achieve desired tree sizes and canopy closures outlined in the Forest Plan (Mexican spotted owl and northern goshawk habitat guidelines) (CFP, FLEA, page 206-75).

Reduce competition between closely spaced trees in some areas to promote health and resistance to insects and disease (CFP, FLEA, page 206-75).

Table 12. Vegetation Management Practices for ponderosa pine, oak and aspen vegetation types as it applies to uneven-aged harvest systems , stand improvement thinning, intermediate thinning, and prescribed burning (CFP, page 242-19).

Kaibab National Forest

On the Kaibab NF, the project area includes seven Geographic Areas (GAs) and one Land Use Zone (LUZ). The Williams forestland (GA 2) makes up approximately 183, 462 acres of the project area. Tusayan forestland (GA 10) makes up approximately 40,997 acres. Western Williams Woodlands (GA 1) accounts for approximately 3,360 acres. The remaining two GAs and one LUZ within the project area range from as few as 4 acres (Upper Basin, GA 9) to 1,518 acres (Tusayan Woodland, GA8).

Improve wildlife habitats through…development of habitat quality and diversity, and identification and protection of key habitats (KFP, page 18).

Apply integrated resource management to improve age-class distribution, diversity, and to reduce losses from forest insect and disease pests (KFP, page 18).

In other coniferous forest timberland - encourage and promote oak and aspen; encourage diversity of plant species in the overstory, understory, and ground cover (KFP, GA 2 and 10, page 42).

In seral grassland - maintain existing openings and create additional openings with high forb composition (KFP, GA 2 and 10, page 42).

Apply group selection silviculture system and progress toward uneven-age site conditions (KFP, GA 2 and 10, page 43).

Select tree-groups for regeneration cutting to achieve and maintain, over time, a diverse geographic distribution of tree-groups recognizing forest type, tree-size, and tree-group density (KFP, GA 2 and 10, page 43).

In forested areas, tree-groups may be thinned from below to achieve the desired tree-group conditions; removing, in order: (1) mistletoe infected, (2) suppressed, (3) intermediate, (4) codominant, and (5) dominant trees. Promote varied, irregular spacing between trees within tree-groups; promote interlocking tree crowns (KFP, GA 2 and 10, page 43).

Formulate and execute habitat investments to improve habitat components and diversity through vegetative manipulations (KFP, GA 1, page 50, KFP, GA 3, page 53, KFP, GA 8, page 56 and KFP, GA 9, page 60).

Provide for environmental management of the timber resource with the objective of protecting and enhancing wildlife habitat and watershed values (KFP, GA 3, page 53, KFP, GA 8, page 56 and KFP, GA 9, page 60).

Region Wide Forest Plan Amendment

Forest vegetation management direction in the Coconino National Forest Land Management Plan (USDA 1987, as updated 2008) and the Kaibab National Forest Land Management Plan (USDA 1988, as updated 2008) were amended in 1996 through a region-wide amendment of all forest plans in Arizona and New Mexico (USDA 1996).

Elements that relate to forest vegetation operations for the Mexican spotted owl include:

Provide three levels of habitat management- protected, restricted, and other forest and woodland types to achieve a diversity of habitat conditions across the landscape. Protected areas include delineated protected activity centers; mixed conifer and pine-oak forests with slopes greater than 40% where timber harvest has not occurred in the last 20 years; and reserved lands which include wilderness, primitive areas, research natural areas, wild and scenic rivers, and congressionally recognized wilderness study areas. Restricted areas include all mixed-conifer, pine-oak, and riparian outside of protected areas.

Protected activity centers (PACs)

Allow no timber harvest except for fuelwood and fire risk abatement in established PACS. Allow no timber harvest except for fire risk abatement in mixed-conifer and pine-oak forests on slopes greater than 40% where timber harvest has not occurred in the last 20 years.

Use combinations of thinning trees less than 9 inches in diameter, mechanical fuel treatment and prescribed fire to abate fire risk in the remained of the PAC outside the 100 acre “no treatment” area.

Large woody debris, snags, clumps of broadleaf wood vegetation should be retained and hardwood trees larger than 10 inches at the root collar.

Limit human activity in PACS during the breeding season (March 1 through August 31).

Restricted Areas (Mixed conifer, pine-oak, and riparian forests)

Manage to ensure a sustained level of owl nest/roost habitat well distributed across the landscape. Create replacement owl/roost habitat where appropriate while providing a diversity of stand conditions across the landscape to ensure habitat for a diversity of prey species.

Emphasize uneven-aged management systems. However, both even-aged and uneven-aged systems may be used where appropriate to provide variation in existing stand structure and species diversity.

Save all trees greater than 24 inches dbh.

In pine-oak forests, retain existing large oaks and promote growth of additional oaks.

Encourage prescribed fire and fire for resource benefits to reduce hazardous fuel accumulation. Thinning from below may be desirable or necessary before burning to reduce ladder fuels and the risk of crown fire.

Retain substantive amounts of key habitat components: snags 18 inches in diameter and larger, down logs over 12 inches midpoint diameter, hardwoods for retention, recruitment, and replacement of large hardwoods.

Riparian areas: Emphasize maintenance and restoration of healthy riparian ecosystems through conformance with forest plan riparian standards and guidelines. Management strategies should move degraded riparian vegetation toward good condition as soon as possible. Damage to riparian vegetation, stream banks, and channels should be prevented.

Elements that relate to northern goshawk forest habitat apply to the forest and woodland communities described below that are outside of Mexican spotted owl protected and restricted areas:

Manage for uneven-age forest conditions for live trees and retain live reserve trees, snags, downed logs, and woody debris levels throughout woodland, ponderosa pine, mixed conifer, and spruce-fir forest cover types. Manage for old age trees such that as much old forest structure as possible is sustained over time across the landscape. Sustain a mosaic of vegetation densities (overstory and understory), age classes and species composition across the landscape.

Limit human activity in or near nest sites and Post-Fledgling Family Areas (PFAs) during the breeding season (March 1 through September 30).

The distribution of vegetation structural stages for ponderosa pine, mixed conifer and spruce-fir is 10% grass/forb/shrub (VSS 1), 10% seedling-sapling (VSS 2), 20% young forest (VSS 3), 20% mid-aged forest (VSS 4), 20% mature forest (VSS 5), 20% old forest (VSS 6). Distribution of habitat structures should be evaluated at the ecosystem management area level, at the midscale such as drainage, and at the small scale of site.

Landscapes Outside Goshawk PFAs:

Ponderosa pine: canopy cover for mid-aged forest (VSS 4) should average 40+%, mature forest (VSS 5) should average 40+%, and old forest (VSS 6) should average 40+%. Maximum opening size is up to 4 acres with a maximum width of up to 200 feet. Retain 1 group of reserve trees per acre of 3-5 trees per group for openings greater than 1 acre in size. Leave at least 2 snags per acre, 3 large downed logs per acre, and 5-7 tons of woody debris per acre. Snags are 18 inches or larger dbh and 30 feet or larger in height, downed logs are 12 inches in diameter and at least 8 feet long, woody debris is 3 inches or larger on the forest floor, canopy cover is measured with vertical crown projection on average across the landscape.

Identify and manage dispersal PFA and nest habitat at 2 to 2.5 mile spacing across the landscape.

Within PFAs:

Ponderosa pine: canopy cover for mid-aged forest (VSS 4) should average 1/3 60+% and 2/3 50+%. Mature (VSS 5) and old forest (VSS 6) should average 50+%.

Within Nesting Areas:

Thin from below with non-uniform spacing and use hand tools and fire to reduce fuel loads. Lopping and scattering of thinning debris is preferred if prescribed fire cannot be used. Piling of debris should be limited.

Elements that relate to forest vegetation operations for old growth allocation:

Seek to develop or retain old growth function on at least 20% of the naturally forested area by forest type in any landscape.

All analyses should be at multiple scales-one scale above and one scale below the ecosystem management areas.

Required Monitoring

Areas proposed for harvest under selection cutting can be regenerated using standard reforestation techniques. The reforestation technique and range of desired stocking will be documented in a formal silvicultural prescription. These areas will be monitored by the implementation silviculturist to ensure the areas meet the prescribed post treatment stocking. If the areas do not meet desired stocking after 5 years, conditions that are inhibiting regeneration will be identified and remedial action may be prescribed to ensure regeneration.

4FRI Coconino/Kaibab EIS – Purpose and Need for Action, Silviculture Analysis Questions to be Answered and Key Issues Addressed

The purpose and need for proposing an action was determined by comparing the objectives and desired conditions in the Coconino NF and Kaibab NF Land Resource and Management Plans (forest plans) to the existing conditions related to forest resiliency and forest function. Where plan information was dated or not explicit, local research and the best available science was utilized.

The following are analysis questions and corresponding evaluation criteria specific to the vegetation resource. These analysis questions will be tracked throughout the effects analysis in order to address whether, or to what degree, the project meets purpose and need objectives.

- How would treatments move vegetation structure towards desired conditions by creating a mosaic of interspaces (openness) and tree groups of varying sizes?
    - Acres by treatment intensity.
- How would treatments move towards a diverse forest structure with all age and size classes represented as identified in the 1996 forest plan amendment for northern goshawk and Mexican spotted owl habitat?
    - MSO habitat size class representation; Goshawk habitat structural stage representation.

- How would treatments sustain old age (pre-settlement) trees by implementing an old tree retention strategy
    - MSO and goshawk habitat mature and old forest structural stage representation.
- How would treatments meet the objective of managing for old forest structure overtime across the landscape by moving towards forest plan old growth standards of 20 percent at a forest EMA scale?
    - Percent of area moving toward forest plan old growth criteria.
    - MSO and goshawk habitat mature and old forest structural stage representation.
- How would treatments improve forest health by reducing the potential for stand density-related mortality, by reducing bark beetle hazard and by reducing the level of dwarf mistletoe infection?
    - MSO and goshawk habitat forest density attributes and density zone characterization.
    - Percent of area by beetle hazard.
    - Percent of area by dwarf mistletoe infection level and average percent of trees infected.
- How would treatments move towards desired conditions for vegetation diversity and composition by maintaining and promoting Gambel oak, aspen, grasslands, and pine-sage?
    - Acres of treatments that would maintain and promote grasslands, Gambel oak, aspen and pine sage.

Issues serve to highlight effects or unintended consequences that may occur from the proposed action, giving opportunities during the analysis to reduce adverse effects and compare trade-offs for the decision-maker and public to understand. Key issues pertaining to silviculture identified during scoping and the indicators used to evaluate the issue are:

The large tree retention strategy (LTRS) which was developed by the 4FRI stakeholders was not included in the proposed action.

- Quantitative pre-treatment and post-treatment three-level analysis for Mexican spotted owl, goshawk, old growth, and vegetation structural stage (VSS) for goshawk habitat at the landscape scale (ponderosa pine vegetation type) to gauge movement towards restoration desired conditions

Measuring canopy cover in goshawk habitat at the group level will not meet forest plan stand-scale canopy requirements.

- Pre-treatment and post-treatment distribution of habitat structure within goshawk habitat evaluated at four scales: ponderosa pine extent, restoration unit, restoration subunit, and strata (groups of like stands with like treatments).
- Overall habitat structure (VSS class) and forest density metrics (basal area, stand density index and trees per acre) averaged to a per-acre basis with averages including interspaces, canopy gaps, and all forest structural stages.

- Openness analysis to convey the percentage of the forested area that would be managed as interspace.
- Tree group density stocking guides that will be used to meet the tree group canopy cover requirements within goshawk LOPFA and PFA habitat.

4FRI Coconino/Kaibab EIS - Silviculture Area of Analysis

The 988,764 acre project area is located on the Williams and Tusayan districts of the Kaibab NF and on the Flagstaff, Mogollon Rim and Red Rock districts of the Coconino NF. Of the 988,764 acre total, approximately 379,934 acres have been excluded from this proposal therefore are not analyzed in detail. Areas excluded include approximately 204,957 acres that are being analyzed in separate vegetation analyses; approximately 29,827 acres that are located in special management areas such as wilderness, research natural areas, inventoried roadless areas, the Navajo Army Depot and experimental forest; and approximately 145,156 acres that are non-Forest Service administered lands. Another 15,618 acres were excluded from detailed analysis due to special habitat needs (core areas not eligible for treatment), accessibility issues (Sitgreaves Mountain), or are non-vegetated, shrub or other cover types that are outside the scope of this project (mixed conifer, shrubs, water). The project area minus exclusions is the 593,211 acre analysis area. The focus of this project is on restoration of resiliency and function within the ponderosa pine forest. This report analyzes conditions of the ponderosa pine cover type within the analysis area.

Due to the size of the project area, the 4FRI team stratified the landscape into six restoration units. A restoration unit (RU) is a contiguous geographic area that ranges from 46,000 acres to 335,000 acres in size. A need for change (vegetation structure, pattern, spatial arrangement, potential for destructive fire behavior and effects) was identified for each RU.

RU 1 and 2 include portions of the Flagstaff, Mogollon and Red Rock ranger districts (Coconino NF). RU 1 is generally located south of I-40 and east of I-17 and RU 2 is generally located west of I-17 and south of the Mogollon Rim. RU 3 includes portions of the Williams district (Kaibab NF), Flagstaff and Red Rock districts (Coconino NF) and is generally located south of I-40 and west of I-17. RU 4 includes portions of the Flagstaff district and the Williams district. It is generally located north of I-40 and west of Highway 180. Communities in the vicinity of proposed treatments include Flagstaff, Munds Park, Mormon Lake, Tusayan and Williams, Arizona. Please note, few treatments are proposed in RU 2. Most of this unit is not ponderosa pine.

The team further stratified each RU into several sub-units that range from 4,000 to 109,000 acres in size. Both units (RU and sub-units) are based on 6th code watershed boundaries, state and forest transportation systems and the Forest's administrative boundaries (see Chapter 1 for RU and SU maps). Table 1 summarizes the 593,211 acre analysis area by RU and SU.

Table 1. Summary of Analysis Area Acres by RU and SU

RU1 Subunits	Acres	RU3 Subunits	Acres	RU4 Subunits	Acres	RU5 Subunits	Acres	RU6 Subunits	Acres
1-1	10,169	3-1	23,178	4-1	0	5-1	24,210	6-1	0
1-2	8,054	3-2	32,826	4-2	10,231	5-2	53,520	6-2	5,552

RU1 Subunits	Acres	RU3 Subunits	Acres	RU4 Subunits	Acres	RU5 Subunits	Acres	RU6 Subunits	Acres
1-3	41,577	3-3	48,462	4-3	67,046			6-3	34,156
1-4	18,326	3-4	9,019	4-4	81,541			6-4	3,870
1-5	78,098	3-5	36,392	4-5	6,985				
Total RU 1	**156,225**	**Total RU 3**	**149,876**	**Total RU 4**	**165,803**	**Total RU 5**	**77,730**	**Total RU 6**	**43,578**

Methodology, Assumptions and Limitations

The base unit for characterizing vegetation conditions is the stand. All lands within the Coconino and Kaibab National Forests have been delineated into stands based on similar characteristics such as vegetation type, slope, aspect, tree density, species composition and management history. Stands vary in size, depending upon their uniformity, usually from 10 acres up to several hundred acres. Spatial and general vegetation information about each stand is stored in the stand data base for each forest.

Comprehensive tree data has been collected on a subset of the stands within the project area over the last 25 years. Within each sampled stand, tree characteristics were measured at sample points, using both variable basal area factor plot and fixed plot designs. Specific tree data collected includes species, class, diameter, height, age, growth, damage and disease. Other data sometimes collected depending on design included surface fuels and understory plant species. This stand data is currently stored in the Field Sampled Vegetation (FSVeg) database which is a standard national (Forest Service wide) database used to store field sampled data in a common format. A thorough review of the stand data was done for the project area to ensure validity. Data that did not match on the ground conditions or minimum sampling intensity was culled. Approximately 34 percent of the ponderosa pine forest type within the analysis area has current stand exam data. The remaining area either had no data collected, or the data was no longer valid.

Tree data used in the vegetation analysis of the forest and woodland areas within the analysis area has come from stand exam data (discussed above) and the Most Similar Neighbor (MSN) Analysis computer program within the INFORMS model. The INFORMS model is a software system designed to facilitate project-level and landscape level project planning (Crookston et. al. 2002). The MSN program was used to impute vegetative attributes measured in one stand to another stand without vegetative data. MSN analysis uses satellite imagery, spatial relationships, and topographic information to match a target site (a stand without data) to the nearest reference site (a stand with data) with the greatest similarity in vegetative characteristics. Tree data from the reference site is then assigned to the target site. The quality of MSN imputations is controlled by the extent to which the sample of reference observations covers the range of variation of the target observations. For this project area, the reference observations adequately cover the majority of forested conditions within the ponderosa pine cover type. However, there are very few reference observations for the other cover types therefore the imputations within these cover types have limited reliability. Approximately 33 percent of analysis area has stand data and the MSN analysis was used to impute data for the rest of the analysis area. Of the acres imputed by MSN, 89 percent meets the criteria for being an OK imputation. Table 2 summarizes the category of the data for the forested areas within the analysis area by RU and national forest.

Table 2. Summary of Acres and Percent of Total by Data Type, RU and National Forests within the Analysis Area

Data Category	Percent of Total RU Coconino				Percent of Total RU Kaibab			Total Acres (% of Forested)
	RU 1	RU 3	RU 4	RU 5	RU 3	RU 4	RU 6	
Non-Forested	17%	3%	15%	12%	22%	30%	<1%	50,506
Ponderosa Pine Reference Data	27%	8%	5%	1%	26%	20%	14%	174,654
Other Forest Types Reference Data	17%	1%	3%	0%	37%	23%	1%	4,166
Total Reference Data:								**178,820 (33%)**
Ponderosa Pine MSN OK Imputation	31%	14%	14%	13%	8%	14%	5%	305,424
Other Forest Types MSN OK Imputation	3%	9%	1%	25%	1%	35%	7%	19,833
Total MSN OK Imputation:								**325,307 (60%)**
Ponderosa Pine MSN Poor Imputation	6%	7%	15%	66%	1%	3%	<1%	32,100
Other Forest Types MSN Poor Imputation	11%	1%	<1%	74%	7%	7%	<1%	6,478
Total MSN Poor Imputation:								**38,578 (7%)**
Total Forested Acres:								**542,705**

All of the stand data was then compiled into a database and modeled in the Forest Vegetation Simulator (FVS) tree growth model and updated to the year 2010. This process allowed us to characterize the current stand conditions and determine the need for change and appropriate treatments based on the project purpose and need. A combination of field reconnaissance, GIS analysis and review of stand data was used to determine treatment needs, logging feasibility, and stand health (see the project record for more details on the development of the proposed action). The FVS was then used to simulate cutting and prescribed burning treatments and growth following treatment for each alternative up to the year 2050.

The FVS is a model used for predicting forest stand dynamics throughout the United States and is the standard model used by various government agencies including the USDA Forest Service, USDI Bureau of Land Management, and USDI Bureau of Indian Affairs (Dixon 2002). The FVS is an individual tree, distance independent growth and yield model with linkable modules called extensions, which simulate various insect and pathogen impacts, fire effects, fuel loading, snag dynamics, and development of understory tree vegetation. FVS can simulate a wide variety of

forest types, stand structures, and pure or mixed species stands (Keyser and Dixon 2008). Forest managers have used FVS extensively to summarize current stand conditions, predict future stand conditions under various management alternatives, and update inventory statistics.

Geographic variants of FVS have been developed for most of the forested lands in the United States. New "variants" of the FVS model are created by imbedding new tree growth, mortality, and volume equations for a particular geographic area into the FVS framework (Keyser and Dixon 2008). The Central Rockies (CR) variant covers all forested land in Forest Service Regions 2 and 3 and was used in the vegetation analysis for this project area. This variant was initially developed in 1990 and has been continually updated to correct known deficiencies and quirks, take advantage of advances in FVS technology, incorporate additional data into model relationships, and improve default values and surrogate species assignments (Keyser and Dixon 2008).

For simulation purposes, each data set was grouped by current forest type, VSS code, site class and treatment type. Simulations were developed for each treatment based on desired conditions. A multitude of vegetation and fuels attributes were computed for each growth cycle. Attributes include tree density (trees per acre, basal area and stand density index) by species or species groups and VSS size class, dwarf mistletoe infection, cubic feet of biomass removed, canopy base height and bulk density, live and dead surface fuel loading, live and dead standing wood, coarse woody debris and snags. These attributes were then averaged for all the data sets represented in the simulation. The averaged computed attributes from FVS were also used to calculate other attributes such as dominate VSS size class, canopy density and even-aged or uneven-aged structure. All of these attributes were then compiled into an "effects" database by alternative and used to analyze and display the direct and indirect effects to the vegetation resource.

The following is a list of general modeling assumptions. Table 3 lists modeling assumptions specific to each treatment type in the proposed action.

- All tree data was grown to the common year of 2010 and is considered to represent the existing condition.
- All tree cutting and removal was modeled in the year 2012.
- Two prescribed burns were modeled, the first in the year 2015 and the second in 2019, with the exception of the aspen treatment which modeled one prescribed burn in the year 2015.
- After treatment, the tree data was grown to the common year of 2020 and is considered to represent the post treatment condition.
- The tree data does not indicate tree age. Simulations use diameter as a surrogate for age based on the vegetative structural stage definitions. We acknowledge that there are trees on the landscape where age class overlaps size class. For example there may be: young trees that are larger than 11.9"; or mid-aged trees that are larger than 17.9"; or mature trees that are less than 18".
- Within this project area, the majority of ponderosa pine trees that meet the old tree definition are ≥18". On the ground cutting prescriptions will follow the Old Tree Implementation Strategy (OTIS) and trees larger than 18" that do not meet the OTIS criteria may be cut during implementation.

- The modeling assumptions attempted to meet the spirit of the Large Tree Retention Strategy within the limitations of a non-spatially explicit model. On the ground cutting prescriptions will follow the LTRS as adopted under this EIS and could result in trees larger than 18" being cut during implementation.
- All cutting simulations assume 15% of the cut stems are left on site and 10% of the branchwood from the cut and removed stems is left on site. All other biomass resulting from the cutting is assumed to be removed.
- Default parameters within the model were used to predict tree growth, mortality, and dwarf mistletoe infection intensification.
- Snags and coarse wood amounts are based on the inventory or default parameters within the model if they were not inventoried. Snag fall rates and changes in surface fuels are based on default parameters.

Table 3. Proposed Action FVS Treatment Modeling Assumptions by Treatment Type

Treatment Type	Thinning Intensity	Thinning Cutting Control	Group Selection	Prescribed Burning	Regeneration
Aspen	NA	NA	Cut all PP ≤5" Cut PP 5" to 24" from below to total PP canopy cover of 10%	2015 – Low to moderate intensity; 70% of area; FFE estimates mortality.	Autosprout aspen based on disturbance and species composition.
LOPFA – UEA	10	Cut PP 0" to 18" across diameter range to total PP SDI of 160	Cut all PP ≤18"; Cut 25% of PP 18-24"	2015 – Low intensity; 70% of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; Within thinning - PP natural regen based on change from pre-cut/burn to post-cut/burn density; Within group selection – PP natural regen 50 TPA after 2015 Rx burn and 150 TPA after 2019 Rx burn.
LOPFA – UEA	25	Cut PP 0" to 18" across diameter range to total PP SDI of 130			
LOPFA – UEA	40	Cut PP 0" to 18" across diameter range to total PP SDI of 100			
LOPFA – UEA	55	Cut PP 0" to 18" across diameter range to total PP SDI of 90			
PFA - UEA	10	Cut PP 0" to 18" across diameter range to total PP SDI of 180			
PFA - UEA	25	Cut PP 0" to 18" across diameter range to total PP SDI of 160			
PFA - UEA	40	Cut PP 0" to 18" across diameter range to total PP SDI of 135			
IT	10	Cut PP 0" to 18" from below to total PP SDI of 180; Cutting preference by mistletoe rating.	NA	2015 – Low intensity; 70% of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
IT	25	Cut PP 0" to 18" from below to total PP SDI of 160; Cutting preference by mistletoe rating.	NA		
IT	40	Cut PP 0" to 18" from below to total PP SDI of 135; Cutting preference by mistletoe rating.	NA		
SI	10	Cut PP 0" to 18" across diameter range to total PP SDI of 150	NA	2015 – Low intensity; 70%	No sprout; PP natural regen

Treatment Type	Thinning Intensity	Thinning Cutting Control	Group Selection	Prescribed Burning	Regeneration
SI	25	Cut PP 0" to 18" across diameter range to total PP SDI of 120	NA	of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	based on change from pre-cut/burn to post-cut/burn density;
SI	40	Cut PP 0" to 18" across diameter range to total PP SDI of 90	NA		
Savanna	NA	Cut PP 0" to 18" across diameter range to total PP SDI of 50	NA	2015 – Low intensity; 70% of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
Pine Sage	NA	Cut PP 0" to 18" across diameter range to total PP SDI of 90	NA	2015 – Low intensity; 70% of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
Grassland Restoration	NA	Cut all PP ≤5" Cut PP 5" to 24" from below to total PP canopy cover of 10%	NA	2015 – Low intensity; 70% of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
MSO - Restricted	NA	Cut PP 0" to 18" across diameter range to total PP SDI of 115	Cut all PP ≤18"; Cut 25% of PP 18-24"	2015 – Low intensity; 70% of area; Mortality fixed 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; Within thinning - PP natural regen based on change from pre-cut/burn to post-cut/burn density; Within group selection – PP natural regen 50 TPA after 2015 Rx burn and 150 TPA after 2019 Rx burn.

Treatment Type	Thinning Intensity	Thinning Cutting Control	Group Selection	Prescribed Burning	Regeneration
MSO - Target	NA	Cut PP 0" to 18" across diameter range to total PP SDI of 180; Adjusted to maintain average post treatment BA at 150+ if average pre-treatment BA is 150+.	NA	2015 – Intensity fixed, very low; 70% of area; Mortality fixed 2019 – Intensity fixed, very low; 70% of area; Mortality fixed	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
MSO - Threshold	NA	Cut PP 0" to 18" across diameter range to total PP SDI of 180; Adjusted to maintain average post treatment BA at 150+ if average pre-treatment BA is 150+.	NA	2015 – Intensity fixed, very low; 70% of area; Mortality fixed 2019 – Intensity fixed, very low; 70% of area; Mortality fixed	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
MSO – PAC Trt Strata 1 (Southerly aspect, not pine-oak, currently <150 square feet of basal area)	NA	Cut PP 0" to designated upper diameter, across diameter range to total PP SDI of 160.	NA	2015 – Intensity fixed, very low; 70% of area; Mortality fixed 2019 – Intensity fixed, very low; 70% of area; Mortality fixed	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
MSO – PAC Trt Strata 2 (Not strata 1)	NA	Cut PP 0" to designated upper diameter, across diameter range range to total PP SDI of 200; Adjusted to maintain average post treatment BA at 150+ if average pre-treatment BA is 150+.	NA	2015 – Intensity fixed, very low; 70% of area; Mortality fixed 2019 – Intensity fixed, very low; 70% of area; Mortality fixed	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;
MSO – Protected Burn Only	NA	NA	NA	2015 – Low intensity; 70% of area; FFE estimates mortality 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;

Treatment Type	Thinning Intensity	Thinning Cutting Control	Group Selection	Prescribed Burning	Regeneration
Burn Only	NA	NA	NA	2015 – Low intensity; 70% of area; FFE estimates mortality 2019 – Low intensity; 50% of area; FFE estimates mortality	No sprout; PP natural regen based on change from pre-cut/burn to post-cut/burn density;

Limitations

Stand exam data is an average characterization of the area within the stand boundaries. It is limited by sampling intensity and the variability within the sampled area.

Dwarf mistletoe infections are difficult to detect from satellite imagery. Therefore, the MSN imputation process may have imputed stand data showing mistletoe infections to stands that are not infected and visa-versa.

FVS is not spatially explicit and cannot model tree groups and interspaces. The modeling results are an average approximation of the desired forest structure.

Results from the FVS model depend upon sample data, validity of the model itself and assumptions made by the modeler.

Output from the FVS model used in this analysis is a characterization of the existing condition and relative change over time of management actions or no action. Absolute conditions are neither intended nor implied.

4FRI Coconino/Kaibab EIS - Silviculture Affected Environment Existing Conditions

Historical Context of the Existing Condition

The existing vegetation condition has been shaped by natural processes and past human activities. The following is a summary of activities and processes that occurred during the last century and a general discussion of how they influenced the existing forest structure, pattern, and composition within the project area.

Grazing

The arrival of railroads in the early 1880s caused livestock (cattle and sheep) numbers across most of Arizona to rapidly increase. By the end of the decade, many ranges were overstocked and by the time the first Forest Reserves were established in New Mexico and Arizona in the 1890s, most of the understory in accessible ponderosa pine forests had been intensively grazed (Scurlock and Finch 1997). Overgrazing was most severe in the 1880's and during the war years of 1916-18

primarily due to the demand for wool and beef during WW1 (Schubert 1974). Forest Service regulation and the post-war agricultural depression from 1919 to 1921 resulted in dramatically reduced grazing numbers. This trend of reduced numbers grazed and permitted continued into the 1950s when numbers were stabilized reflecting modern range management techniques (Scurlock and Finch 1997). Heavy grazing resulted in trampling and browsing damage to establishing regeneration. It also resulted in conditions prime for natural regeneration of ponderosa pine.

Logging

Since the 1880s, lumbering has been a primary industry of the region that includes the Coconino and Kaibab National Forests (USDA Forest Service 2006). The earliest logging efforts in the study area supplied local needs and were small in scale using the strategy of setting up small, portable sawmills adjacent to the timber (USDA Forest Service 2006). The development of the Atlantic and Pacific (A&P) Railroad revolutionized the lumber industry, pushing it to an intense new level of operation. Construction of the transcontinental carrier created a tremendous demand for ties as well as a means to export lumber to distant areas (USDA Forest Service 2006). The first large scale lumber mill in the area went into operation in Flagstaff in 1882 which coincided with arrival of the A&P Railroad. This mill was initially supplied by wagons and carts hauling logs overland. By 1888 this system was improved thru development of logging railroads that provided logs to the mills. From the late 1880s to the 1940s, logging railroads supplied several lumber and timber companies operating in the Flagstaff and Williams area (USDA Forest Service 2006).

In the nineteenth century the lumber industry operated relatively free of government regulation and was able to clear the land on which they held timber rights purchased from the transcontinental railroads who owned the land. Cuts on these lands generally removed 70 to 80 percent of the merchantable volume. Some areas were laid waste, and huge amounts of slash accumulated which lead to some high severity fires (Schubert 1974). By 1910, after the establishment of the National Forests, the federal government became actively involved in the management of federal forests and the regulation of timber cutting on those lands. The concept of sustained yield was applied to the cutting contracts the logging companies had with the Forest Service in order to ensure the long-term sustainability of northern Arizona’s forests. Regulation included leaving mature trees to promote forest regeneration and leaving young trees to stock the harvested lands. The objective during this period was to select the old, decadent groups near areas with advance reproduction first. The companies were also required to clear logging slash after their operations in order to reduce the fire hazard (USDA Forest Service 2006).

By 1940, the railroads had removed all the profitable lumber they could access. The only logging railroad still in use after World War II was the line to Allan Lake which continued to operate in support of truck logging until 1966 (USDA Forest Service 2006). Motorized trucking emerged as a technology more flexible for transporting timber from the woods. Logging trucks made their appearance in the project area in the 1920s and slowly gained in importance as railroads declined. Trucks became a more cost-effective transportation tool due to their less expensive roadbeds, lower initial expenses, ability to negotiate sharper curves and steeper grades, and capacity to access isolated units of timber.

Records of timber removal on public and private lands in Arizona and New Mexico indicate timber harvests increased steadily through most of the twentieth century depending on markets. This included a peak in 1929, a downturn during the depression years, leading to another peak

just after WWII, a downturn during the 1950's, a steady output during 1960's and 1970's with another peak in 1964 and a slight downturn during the early 1980's. Harvests continued to rise until 1990, when a total of 433 million board feet were harvested within the region (Scurlock and Finch 1997). A high percentage of the timber removed was large diameter, mature ponderosa pine with the Coconino and south Kaibab forests contributing a significant share to this total especially during the railroad logging era.

From the 1950s-1970s, management within the project area focused on sanitation/salvage of imminent tree mortality and diseased/damaged trees. Minimal forest density management occurred during this period. In the 1960s, the practice of cutting snags to reduce fire risk also reduced the number of snags currently standing but may have increased the number of logs present in some areas.

Starting around 1980, management was focused on even-aged forest management (intermediate thinning and shelterwood silviculture system). Where mature trees dominated, regeneration treatments (shelterwood seed-cuts) focused on removal of most overstory trees and low-density retention of scattered seed trees. Where sapling or mid-aged trees dominated, treatments focused on thinning to manage stand density. Much of the thinning treatments yielded pulpwood products, and the removal and regeneration treatments yielded sawtimber. Treatments were conducted on selected stands and large blocks throughout the project area.

Timber sales within the project area implemented prior to the 1996 Forest Plan amendment targeted the harvest of medium and large diameter trees. This even-aged forest management focus continued until the mid-1990s, leaving the legacy of current forest conditions where much of the landscape is single or two-aged, with homogenous forest canopy structures and high density. The overall majority of the areas where regeneration treatments were conducted have adequately regenerated.

During the recent past (mid 1990s – mid 2000s), selected areas were thinned to reduce fire risk adjacent to public areas such as residential areas and recreational sites. These thinning treatments focused on removal of the smallest trees, producing results similar to the mid-aged stand thinning treatments conducted during the 1980s period.

By 2005, management shifted towards forest health, diversity and restoration objectives with a continued attention toward reducing fire risk. Treatments concentrated on restoring grasslands, savannas and tree group/interspace forest structure with an emphasis on managing for old age trees and sustaining a mosaic of vegetation densities, age classes and species composition across the landscape.

Fires and Fire Suppression

Early Forest Reserve management plans often urged heavy grazing to eliminate the herbaceous fuels that allowed surface fires to sweep across the land (Drake 1910). Early foresters became convinced that any wildfires were detrimental to the forest (Pyne 1982). Organized fire suppression efforts by the Forest Service date back to the first decade of the twentieth century largely in response to unacceptable fire effects due to heavy slash loads left by railroad logging; in 1935 the Forest Service further instituted a policy that all fires were to be extinguished by 10 A.M. of the day following their detection (Pyne 1982). Throughout most of the twentieth century, foresters continued to extinguish all fires regardless of ignition cause, intensity, or degree of

danger to human safety or property. Widespread fire suppression efforts continue today, and a high percentage of federal resources are focused on suppression (Friederici 2003).

Fire exclusion has resulted in changing fuel loads and a shift from frequent, low intensity fires to infrequent mixed and high severity crown fires. Several large-scale fires have occurred around and within the project area. Many of these areas experienced crown fire and large areas of stand mortality. Stand-replacing wildfires on ponderosa pine sites have resulted in conversion from forest to grass or shrub perpetuated for long periods or dense, even age structure. This radical change in forest structure, pattern and composition will not again support old-growth pine trees for centuries (Friederici 2003).

Insects and Disease

As agents of change, forest insects and diseases have a significant role in forest ecosystem dynamics. Forest insect and disease-driven change alters forest ecological processes, forest structure and composition. The following is a summary of historic disturbance information of the major forest insects and diseases specific to the ponderosa pine and associated forest types (piñon-juniper and aspen) within the project area for approximately the last century. More detailed information can be found in Lynch et al. 2008a and 2008b.

At one time or another, all of the vegetation types within the project area have incurred extensive damage by one or more agents. The transitory agents causing the most extensive and severe damage have been piñon ips, *Ips* bark beetle species in ponderosa pine, and multiple biotic and abiotic agents in aspen. In recent years, the most extensive damage has been in the piñon-juniper. The most extensive and damaging persistent agent is southwestern dwarf mistletoe in ponderosa pine. Each of the vegetation types shows distinct periods of increased insect damage, one during the 1950s and another during recent droughts.

Ponderosa Pine – Bark Beetles

Ponderosa pine is attacked and killed by several different bark beetles in the genera *Dendroctonus* and *Ips*. Although *Dendroctonus* species are the most notorious tree killers in the western United States, *Ips* species play a very important role in Southwestern pine forests.

Most bark beetles are considered secondary mortality agents because they prefer weakened host trees. When populations are at endemic levels, bark beetles typically attack scattered individual trees that have been weakened by lightning, disease, old age, or competition, or they are attracted to fresh logs and slash created by logging, windthrow, or snow breakage. However, when environmental factors and stand conditions favor beetle development, populations may increase rapidly and successfully attack healthy trees. During outbreaks, small groups of killed trees become larger and more numerous, eventually merge into large stands of dead trees. Bark beetle outbreaks are initiated and sustained through the supply of susceptible host population and suitable stand conditions, favorable weather, and a relative scarcity of natural enemies (Fettig et al. 2007). Factors that lower tree resistance, such as poor site quality, overcrowding, drought, injury, and disease, favor outbreaks.

Early reports indicate that bark beetle activity in ponderosa pine was less frequent, extensive, and damaging in the Southwest than in other Western regions (Hopkins 1909, Woolsey 1911). There have been periodic reports of bark beetle activity within the project area. The Coconino N.F. experienced significant bark beetle outbreaks in the mid-1920s, late 1930s, mid-1960s, late 1970s

through early 1980s, and late 1990s through the mid-2000s. The 1950s and 2000s outbreaks appear to be more extensive than other outbreaks, damaging at least 200,000 and 72,000 ac, respectively. On the southern Kaibab National Forest, western pine beetle activity was reported in late 1970's and early 1980's. The contemporary (2000s) bark beetle outbreak is probably more severe than past outbreaks. Ponderosa pine mortality approached 100% in some stands (Gitlin et al. 2006), but averaged only 3.4% in a limited number of plots distributed across Williams Ranger District (R.D.) and Tusayan R.D. (Negrón et al. 2009).

There seems to have been a shift in bark beetle activity over time, with pre-1950 outbreaks mostly being *Dendroctonus* species (western pine beetle, roundheaded pine beetle), and the 1950s and contemporary outbreaks being not only much larger but comprised mostly *Ips* species (pine engraver beetle, Arizona fivespined ips) (Yasinski and Pierce 1958, USDA Forest Service 2004). This probably reflects the size and density of host trees available as ponderosa pine forests have transitioned from open stands with even diameter class distributions to denser stands dominated by pole-sized trees (Covington and Moore 1994b). *Dendroctonus* species, such as western pine beetle, commonly attack large-diameter ponderosa pine, while most *Ips* species focus their attacks on smaller diameter pine or the tops of large diameter trees (Furniss and Carolin 1977, Kolb et al. 2006).

Ponderosa Pine – Defoliators and other insects

Southwestern pine tip moth and western pine shoot borer are the most common and damaging tip moth in northern Arizona, but other species occur as well (Long and Wagner 1992). These insects feed on terminal shoots of young trees, impairing height and radial growth and altering tree form (Lessard and Jennings 1976; Long and Wagner 1992). Damage to the primary leader can also deform the main stem. Repeated attacks by tip moths and western pine shoot borer severely deform host trees and retard height growth (Jennings and Stevens 1982). These insects are especially prevalent within areas of planted and naturally regenerated ponderosa pine that established after extensive timber harvesting and large fires, but they are not considered to be major pests.

Ponderosa pine needleminer defoliated over 9,000 ac of ponderosa pine on the Coconino N.F. in 1999, and approximately 48,000 ac on other National Forests in northern Arizona (USDA Forest Service 2000). Damage near Flagstaff by this insect was also noted in 1972 (Germain et al. 1973). This insect defoliates ponderosa pine by mining inside the needles. It and closely related species are capable of large outbreaks in extensive areas of host trees, and are capable of causing mortality (Furniss and Carolin 1977).

Piñon-Juniper Woodlands

Both localized and widespread mortality events have occurred over time in the piñon-juniper woodlands on the Coconino and southern Kaibab National Forests. These events have typically been pinyon ips outbreaks associated with periods of drought, such as occurred in the 1950s, and more recently in the mid-1990s and 2001-2003.

At least for the historic period, the size and severity of the recent drought and pinyon ips-related die-off is unprecedented for northern Arizona (Allen 2007; Mueller et al. 2005). The contemporary piñon die-off is 100 times as large (two orders of magnitude) as any previously recorded acreage for piñon ips for the Coconino N.F., Kaibab N.F., and Grand Canyon N.P.

Factors that may have contributed to the size of this outbreak include changes in woodland character over time, drought, and altered temperature regimes (especially drought combined with warmer temperatures) (Allen 2007).

Juniper species are more drought hardy than piñon, but juniper mortality from wood borers and *Phloeosinus* beetles has occurred in areas of poor site within the project area during the recent drought (Mueller et al. 2005; USDA Forest Service 2002, 2003). Juniper mortality averaged 3.3% within an 80 km radius of Flagstaff, with greater mortality on grassland vs. non-grassland sites (Gitlin et al. 2006).

Aspen Forest

Aspen communities throughout the Southwest have been declining for decades, a phenomenon thought to be the result of: 1) altered fire regimes since European settlement which promoted natural succession to conifer forests (USDA Forest Service 1994, Dahms and Geils 1997) and 2) heavy browsing by large ungulates which prevented successful regeneration of aspen in burned or harvested forests (Shepperd and Fairweather 1994, Rolf 2001). Recent accelerated mortality and decline, due to weather, defoliation, and fire events, coupled with the inability of aspen regeneration to survive browsing, are resulting in conversion of aspen forest to coniferous forest (Fairweather et al. 2006).

This decline has accelerated on the Coconino and Kaibab National Forests after a series of contemporary events resulting in cumulative effects of several abiotic and biotic agents: severity of the 1999 frost damage, severe drought conditions, and western tent caterpillar defoliation in 2004 and 2005. The defoliating insect and disease agents individually do not normally cause significant mortality. However, mortality has been extensive, especially in the low- and mid-elevation areas, and continues to the present day, and accelerated considerably after the 1999 frost event. Although dying trees sprouted, survival has been very low due to ungulate browsing. Aspen mortality has been greatest in the low-elevation range. During the past 5 years, more than 50% of surveyed aspen sites below 7,500 feet elevation experienced 97% mortality (Fairweather et al 2008).

Ungulate browsing has impacted aspen regeneration since the 1960s (Rolf 2001) on the Coconino and since the mid-1980's on the Williams R.D. For these reasons, permanent exclusion fences have proven to be a necessity to regenerate and maintain aspen throughout these forests.

Pathogens – Dwarf Mistletoe

Dwarf mistletoes slowly infect stands and then persist as long as living hosts are present. Dwarf mistletoes are obligate parasites, and infected host trees are slowly weakened and eventually killed. Growth loss projections from the 1980s estimated 20 MMBF – 30 MMBF annually for the Coconino N.F. with similar numbers for the Kaibab N.F. (Hessburg and Beatty 1985).

Survival of host trees is influenced by the severity of dwarf mistletoe infection and site factors. Heavily infected trees are frequently attacked by secondary bark beetles. During the bark beetle outbreak on the Coconino and Kaibab National Forests in 2002-2003 the probability of ponderosa pine mortality within dwarf mistletoe infested stands was greater in severely infected trees (Kenaley et al. 2006).

Spread and intensification of dwarf mistletoe within a stand is a function of stand density, age, and site index, and averages one or two feet a year. Spread is most efficient and rapid from an infected overstory to an understory and slowest through a dense even-aged stand. Overall effects of long-term infestation include increased stand openings (both more openings and increased size of existing openings), lower-hanging crown canopies, denser canopy due to witches' brooms, and fewer large-diameter trees (Lynch et al. 2008a and 2008b).

Southwestern dwarf mistletoe is dispersed throughout the project area where 21-31% of the commercial ponderosa pine type was infected in the 1980s on the northern half of the Coconino N.F. and 25-38% of the commercial ponderosa pine type was infected on the Williams R.D (Hessburg and Beatty 1985).

Southwestern dwarf mistletoe incidence and infection severity have increased within the project area. For example, in the mid-1980s, Hessburg and Beatty (1985) estimated a 2 to 4% increase from a similar survey 30 years earlier (Andrew and Daniels 1960). Based on present understanding of mistletoe ecology (Parmeter 1978, Hawksworth and Weins 1996), increases in host abundance over the past 150 years, decreases in fire frequency, and evidence of previous forest conditions and fire regimes, it can be inferred that Southwestern dwarf mistletoe abundance was likely lower in the historic period (Dahms and Geils 1997), and that current conditions are likely similar to the 1980s estimate. When dwarf mistletoe has been targeted during forest management, silviculture prescriptions have typically tried to reduce infection levels, rather than attempt to eliminate dwarf mistletoe from sites. Some large crown fires have reduced the size of the infected area by eliminating both the host and its dwarf mistletoe, however dwarf mistletoe continue to spread into uninfected areas within the project area.

Pathogens – Root Disease

Root diseases are fairly common in the forests of the Southwest, and are often associated with mortality attributed to bark beetles. They can also predispose trees to windthrow. Root diseases are usually more common in mixed conifer and spruce-fir forests than in ponderosa pine forests. Like dwarf mistletoes, root diseases spread slowly, so overall incidence changes little from year to year. There are very few known root disease centers associated with ponderosa pine within the project area.

Summary of the post-European settlement era ecological changes in terms of forest structure, pattern and composition

- Open, fire-maintained pine forest structure has been altered by logging.
- Large, old ponderosa pines have become rare.
- The remaining large, old ponderosa pines are suffering increased mortality rates as a result of competition with small trees.
- Ponderosa pine forests have increased in density as abundant tree seedlings have regenerated to infill canopy opening and replaced open, multiple age class structure with a dense single age class structure. This resulted from logging practices, protection from fire, reduction in livestock grazing, and a relatively wet climatic cycle (Schubert 1974).

- Competition for moisture and nutrients is intense in these dense stands, and results in stress that increases vulnerability to insect attack by such herbivorous insects as pine bark beetles (*Dendroctonus* spp.) and *Ips* beetles.
- Dwarf mistletoe has become more widespread in some areas due to closed forest conditions and lack of low severity fire.
- Potential fire severity has changed from low to mixed and high. The risk of stand replacing fires has increased.
- Severe burns often result in increased soil erosion and invasion by nonnative species.
- Stand-replacing wildfires on ponderosa pine sites have resulted in conversion from forest to grass or shrub perpetuated for long periods or dense, even age structure. These areas will not again support old-growth pine trees for centuries.
- Coniferous trees have spread widely into grasslands and meadows.

Existing Condition – Cover Types

Cover types are divided into three broad categories that describe vegetative state – non-vegetated, non-forest or forest. The following is a description of the cover types that occur within the analysis area. Table 4 lists the acres within the analysis area by cover type.

Non-Forest Cover Types

Non-vegetated (Barren)

Includes rights of way, mines, quarries, gravel pits and rock, talus or scree.

Grasslands

Laying in a patchwork across the Colorado Plateau, grasslands vary in size from just a few acres to well over 1,000 acres. Grasslands within the project area typically occur between 6,300 and 9,000 feet in elevation and are categorized as the productive Montane/Subalpine and the more arid Colorado Plateau/Great Basin. A wide variety of species of grasses, forbs, shrubs and/or trees characterize their vegetation which varies according to soil type, soil moisture, and temperature.

Historically, these grasslands had less than 10 percent tree cover. Impacts from grazing, logging, and fire suppression practices that started in the late1800s are still discernible on the landscape today. These practices reduced or eliminated the vegetation necessary to carry low-intensity surface fires across the landscape, thereby altering the natural fire regimes and allowing uncharacteristic forest succession to take place. These conditions have been further exacerbated by soil erosion, increases in invasive, nonnative plants and low-density rural home development.

Approximately 48,774 acres within the analysis area are classified as grassland cover type based on stand data (Table 4). The grassland cover type has experienced some degree of conifer (pinyon, juniper, and ponderosa pine) encroachment over the last 100 years as a result of fire exclusion, grazing and agricultural use. Many of the pre-settlement trees that grew along the edges of these grasslands were removed historically. These edges as well as much of the interior of the grasslands have become stocked by sapling and young to mid-aged trees. These trees are growing rapidly due to the open growing conditions and a lack of competition.

Forest Cover Types

Forest cover types are named for the tree species that are presently (not potentially) dominant, using canopy cover as the measure of dominance. Cover type is based on the species type which has the majority of dominance in the upper most layer of the site. In the case of pinyon juniper, several species have been lumped together into a single cover type grouping and codominance is not necessarily implied. The forest cover types have been grouped into communities. The woodland community is dominated by woodland tree species and the forest community is dominated by forest tree species.

Woodland Vegetation Community

Pinyon-Juniper (PJ) - The pinyon-juniper cover type is collectively composed of the pinyon-juniper grassland, pinyon-juniper sagebrush, pinyon-juniper evergreen shrub and pinyon-juniper persistent woodland communities. Within the project area, pinyon-juniper communities generally occur at elevations between 6,100 and 8,000 feet.

Under their natural disturbance regime, these plant communities are dominated by one or more species of pinyon pine and/or juniper with at least 10 percent tree canopy. They can occur with a grass/forb-dominated understory (pinyon-juniper grasslands), a shrub-dominated understory (pinyon-juniper sagebrush, pinyon-juniper evergreen shrub), or a sparse discontinuous understory of some grasses and/or shrubs (pinyon-juniper persistent woodland forest community). Two-needle pinyon pine is common; as well as one-seed, Utah, Rocky Mountain, and alligator juniper. Species composition and stand structure vary by location primarily due to precipitation, elevation, temperature, and soil type.

Most of the pinyon-juniper vegetation communities are currently younger and denser than they were historically, because of changes in wildfire occurrence. Greater tree density has increased competition for water and nutrients. This, in turn, has caused a reduction in understory plant cover and diversity, a loss of ground cover, and subsequent increases in soil erosion.

Oak Woodlands – This community consists of Gambel oak thickets containing various diameter stems, and low-growing, shrubby oak. Some areas contain oak trees with relatively large hollow boles or limbs. When present, coniferous trees are widely scattered and are frequently mature or old. Within the project area, oak woodlands generally occur at elevations between 6,000 and 8,500 feet.

Forest Vegetation Community

Ponderosa Pine (PP)

The ponderosa pine forest vegetation community generally occurs at elevations ranging from 5,800 to 9,200 feet. It is dominated by ponderosa pine and commonly includes other species such as oak, juniper, and pinyon. Species such as aspen, Douglas-fir, white fir, and blue spruce may also be present, but occur infrequently as small groups or individual trees. This forest vegetation community typically occurs with an understory of grasses and forbs although it sometimes includes shrubs.

The majority of the project area is the ponderosa pine plant association. Associations are named for the most shade tolerant tree species successfully regenerating, and for an understory species (shrub or herb) which is most diagnostic of the site. The ponderosa pine associations within the

project area include two major sub-types: Ponderosa pine-bunchgrass and ponderosa pine-Gambel oak.

Ponderosa pine commonly grows in pure stands and currently is found in even-aged[2] and uneven-aged[3] structural conditions across the area. The open park-like stands characteristic of the reference conditions for ponderosa pine forests promoted greater faunal diversity and fire resilience than the dense stands of today. Ponderosa pine forests within the project are generally denser and more continuous than in reference conditions (See Chapter 1) and accumulations of forest litter and woody debris are much higher than would have occurred under the historic disturbance regime. Lack of fire disturbance has led to increased tree density and fuel loads that increase the risk of uncharacteristically intense wildfire and drought-related mortality. When fires occur under current conditions, they tend to kill a lot of trees, including the large and old trees. These trees take longer to replace, moving the forest further from desired conditions, and increasing the time it would take to return to desired conditions. There is a high risk of insect and/or disease outbreak, which is also a function of increased tree density (see Forest Health Section).

Gambel Oak Within Ponderosa Pine Forest

Gambel oak is frequently the only deciduous tree in otherwise pure southwestern ponderosa pine forests, adding diversity to these forests. A portion of the stands have a large enough component of Gambel oak to be considered pine-oak habitat for MSO (as described in the forest plan and MSO Recovery Plan). Similar to pure ponderosa pine forests, pine-Gambel oak forests have become altered since Euro-American settlement in the late 1800s resulting in an overall increase in small- and medium sized Gambel oak stems and a more simplified forest structure (Abella 2008). Oak management strategies within this project includes conservation of all existing large, old oaks, maintaining a variety of growth forms and managing for densities similar to the range of variability of oak's evolutionary environment.

Understory Vegetation Within Ponderosa Pine Forest

Herbaceous vegetation (grass and forbs) are a major understory associate within the ponderosa pine plant associations throughout the analysis area. Research at the Fort Valley Experimental Forest has shown that substantial declines in herbaceous vegetation diversity and growth have occurred over the past century due to increased tree density, increased canopy covers, and increased forest floor depth (Covington et al 1997). This trend indicates a shift away from a more diverse balance across a broad variety of understory plants to productivity dominated by pine trees. The ponderosa pine analysis area is dominated by high stand densities and closed tree canopies (see habitat specific density conditions in Table 13 through Table 15). For a more detailed discussion on tree overstory and herbaceous understory relationships, see the Wildlife Section in Chapter 3.

Of the 512,178 acres within the analysis area classified as a ponderosa pine cover type, 14,665 acres are on Mollisol soils - those soils with a high accumulation of surface organic matter

[2] Even-aged – pertaining to a stand composed of a single age class in which the tree ages are within + 20 percent variability based upon the mature stand age (SAF 1998).

[3] Uneven-aged – pertaining to a stand with trees of three or more distinct age classes (SAF 1998).

common in grasslands. Another 338,055 acres are on Mollic integrade soils - those soils with thinner organic matter accumulations in the soils surface. Approximately 302,926 acres of the Mollic integrade have an open canopy reference condition exemplified by a mosaic of non-interlocking tree crowns and large interspaces between trees (USDA Forest Service 2007 and 2008). The lack of fire disturbance has allowed ponderosa pine to encroach upon the interspace throughout these soil types resulting in a more continuous tree canopy.

Quaking Aspen (QA)

Within the project area, quaking aspen is limited to small patches within a larger forest matrix dominated by ponderosa pine or mixed conifer vegetation. These patches consist of a few overstory trees with a sapling understory component.

Aspen reproduces asexually through root suckers that are a clone of the original parent tree. Fire, insect, disease, wind and human disturbances regenerate this shade-intolerant species by opening up the canopy and removing conifers from the understory. Without disturbance, conifers gradually overtop aspen, closing the canopy and eventually killing mature trees and reducing regeneration. Aspen is highly susceptible to browsing and disease or death due to bark injuries. Aspen patches are regenerating successfully where livestock and wildlife are excluded by fencing. Several aspen patches within the project area show signs of decline marked by mortality and dieback of crowns, similar to what has been observed across Arizona over the past several years (Fairweather et al. 2008).

Table 4 lists the acres of each cover type by restoration unit.

Table 4. Analysis Area Cover Type Acres by Restoration Unit (Acres)

Cover Type	RU 1	RU 3	RU 4	RU 5	RU 6	Total
Non-Vegetated						
Barren	120	134	129	1,301	48	**1,732**
Non-Forest Communities						
Grassland	8,230	12,799	22,665	4,987	93	**48,774**
Forest Communities						
Pinyon Juniper Woodland	1,427	5,884	7,283	8,845	2,219	**25,658**
Oak Woodland	287	1,633	926	523	30	**3,399**
Ponderosa Pine	145,793	129,225	134,301	61,671	41,188	**512,178**
Aspen	368	201	499	403	0	**1,471**
Total Forested Acres:	**147,875**	**136,943**	**143,009**	**71,441**	**43,437**	**542,705**
Total Analysis Area Acres:	**156,225**	**149,876**	**165,803**	**77,730**	**43,578**	**593,211**

The remainder of the existing conditions report analyzes conditions specific to the ponderosa pine cover type (512,178 acres) within the analysis area unless otherwise stated.

Forest Structure (VSS, Density, Canopy Cover, Openness)

Vegetation Structural Stage

Vegetation structural stage (VSS) is a method of describing the development stages of a stand of living trees and is a generalized description of forest age and tree size from seedling to old forests. It is an integrative approach, combining vegetation and forest growth, to describe southwestern forests. Six vegetation structural stages (VSS) have been defined primarily on tree diameters and are based on the time it takes seedlings to become established and subsequent growth rates. Life expectancy of trees determines how long the oldest VSS can be maintained (Reynolds et al. 1992). These stages are: VSS 1, forests dominated by grasses, forbs and shrubs; VSS 2, forests dominated by seedlings and saplings; VSS 3, young forests; VSS 4, mid-aged forests; VSS 5, mature forests; VSS 6, old forests (Reynolds et al. 1992). The VSS classification is based on the tree size class with the highest square foot of basal area. Basal area includes all tree species.

The VSS classification was further defined to include a measure of tree canopy density and age class heterogeneity along with the dominant diameter distribution. Tree canopy density is not a true measure of vertical crown projection, rather it is a relative measure of tree density based on stand density index (SDI). Age class is a measure of the variety of age classes present in relation to the dominant age class and is an indication of canopy layers. A single storied stand resembles an even-aged condition while multiple storied stands are considered uneven-aged. Table 5 describes the VSS coding as defined by the Compendium of NFS Regional Vegetation Classification Algorithms (Vandendriesche 2010).

Table 5. Description of Vegetation Structural Stages (VSS)

VSS (DBH Size Class)	Structural Stage	Tree Canopy Density Category	Canopy Layers (Age Class)
1 (0-.9”)	Grass/Forb/Shrub	Less than 10% tree canopy	NA
2 (1.0-4.9”)	Seedling/Sapling	A – Open B – Moderately Closed C – Closed	NA
3 (5.0-11.9”)	Young Forest	A – Open B – Moderately Closed C – Closed	SS – Single Story MS – Multiple Storied
4 12.0-17.9”)	Mid-age Forest	A – Open B – Moderately Closed C – Closed	SS – Single Story MS – Multiple Storied
5 (18-23.9”)	Mature Forest	A – Open B – Moderately Closed C – Closed	SS – Single Story MS – Multiple Storied
6 (24”+)	Old Forest	A – Open B – Moderately Closed C – Closed	SS – Single Story MS – Multiple Storied

For example, an area classified as 4BMS would be mid-aged and multiple storied with a moderately closed tree canopy.

Table 6 displays the acres by existing dominant VSS class for the ponderosa pine within the analysis area. Much of the landscape has a closed tree canopy, dominated by a single canopy layer and one age class. Approximately 57 percent has a closed tree canopy density, and 46 percent is single storied. The young and mid-age structural stages account for approximately 82 percent of the ponderosa pine analysis area while the grass/forb and seedling saplings stages are approximately 2 percent, the mature tree stage is 10 percent and the old forest stage is 6 percent. The low representation in the seedling/sapling, mature and old classes indicates limited structural stage diversity across the landscape.

Table 6. Existing Dominant VSS by PP Analysis Area and Restoration Unit (Acres)

Dominant VSS Class	RU 1	RU 3	RU 4	RU 5	RU 6	Total Acres	Percent Of Analysis Area
1 and 2 (SS)	1,761	2,004	3,419	225	1,521	8,931	2%
3 A or B MS	1,099	616	2,879	7,877	7,100	19,570	4%
3 A or B SS	8,974	5,245	11,167	860	4,514	30,760	6%
3 C MS	12,403	13,099	7,349	1,765	6,307	40,923	8%
3 C SS	37,121	27,094	23,750	8,075	12,243	108,283	21%
4 A or B MS	11,872	15,266	26,231	11,688	6,216	71,273	14%
4 A or B SS	9,420	2,944	10,891	1,425	0	24,679	5%
4 C MS	27,395	23,261	13,752	3,426	97	67,930	13%
4 C SS	20,388	20,618	14,943	1,270	0	57,219	11%
5 A or B MS	6,810	8,814	14,017	8,444	0	38,085	7%
5 A or B SS	46	1,025	577	0	0	1,648	<1%
5 C MS	3,511	4,671	2,219	728	0	11,129	2%
5 C SS	804	1,177	1,494	173	0	3,648	1%
6 A or B MS	2,210	2,007	1,127	15,394	3,057	23,794	5%
6 A or B SS	73	27	3	0	65	167	<1%
6 C MS	1,884	1,358	481	321	69	4,113	1%
6 C SS	25	0	0	0	0	25	<1%

For the remainder of the Silviculture report, the VSS classification will be used to stratify and characterize goshawk habitat. The full VSS code will not be quantified beyond what is disclosed in Table 6. The Wildlife report will be characterizing various habitats using the full VSS code based on the definitions in Table 5.

Density

Stand density[4] is the dominant factor affecting the health and vigor of conifer forests in the western US (SAF 2005). One of the major factors affecting forest structure and development, specifically the rate at which individual trees grow and advance through successional stages, is inter-tree competition. "Competition" refers to density-related scarcity of one or more environmental factors necessary for growth, such as moisture, nutrients, and sunlight. Early in stand development and prior to closure of the crown canopy, individual trees are growing at their full potential due to a lack of competition with other trees. As stand development advances, relative densities increase as the size of individual trees increase and the crown canopy begins to close. Individual trees begin to experience some competitive interaction with other trees and self-pruning of lower branches begins. At this stage in stand development, individual trees begin to exhibit height growth differentiation due to genetics, microsite differences, and damage caused by biotic and abiotic factors. As stands continue to develop, competition between trees continues to increase as trees increase in size. Growth rates for individual trees decrease as competition increases. Eventually, stands near the point of full site occupancy and self-thinning occurs due to competition-based mortality. At this stage of stand development, trees are growing at much less than full potential.

High forest densities result in increased inter-tree competition, decreased tree health, growth and vigor, decreased regeneration of shade intolerant species, stagnation of structural stage progression, increased insect and disease-related mortality especially in older age classes, decreased horizontal heterogeneity, decreased understory productivity and diversity, and increased fire hazard.

Measures of stand density used in this analysis are basal area, trees per acre and stand density index (SDI). Basal area (BA) is the cross-sectional area of all trees, measured in square feet per acre and trees per acre (TPA) is simply a count of the total number of trees on an acre. These simple measures of stocking do not give an indication of tree sizes and therefore can be biased when used to determine how site resources are being used.

Stand Density Index

SDI is a relative measure of stand density based on the number of trees per acre and the mean diameter (Reineke 1933). SDI expresses the actual density in a stand relative to the theoretical maximum density possible for trees of that diameter and species. By taking both tree size (DBH) and numbers (TPA) into account, SDI is a good indicator of how site resources are being used.

Those who use SDI, or any index of stand density, as an estimate of growing stock, must assume that the index is proportional to site utilization (Long and Smith 1984). Since the contribution of individual stand components to both total SDI and total site utilization is additive, SDI can be used to assess control of growing stock in uneven-aged stands as well as even-aged stands (Long and Smith 1984). Although SDI and the maximum size-density relationship were originally described for pure, even-aged stands, Long and Daniel (1990) have proposed extension of its utility to uneven-aged and multi-aged situations.

[4] Stand density – a measure of the degree of crowding of trees within stocked areas (SAF 1998)

Long (1985) divided SDI percentages into four zones which consider the percent of a stand occupied by trees. Table 7 displays the amount of tree competition and growth based on stand density percentages (percent of maximum stand density index). Based upon established forest density/vigor relationships, density-related mortality from competition begins to occur once the forest reaches 45-50% of maximum stand density (zone 3), and mortality is likely at density levels of 60%+ of maximum stand density (zone 4).

Table 7. Relationships of Forest Density to Forest Stand Development and Tree Characteristics

% Maximum SDI*	Zone	Forest Stand Development and Tree Characteristics
0 – 24% Low Density	1	Less than full site occupancy, maximum understory forage production. No competition between trees, little crown differentiation. Maximum individual tree diameter and volume growth. Minimum whole stand volume growth.
25 – 34% Moderate Density	2	Less than full site occupancy, intermediate forage production. Onset of competition among trees, onset of crown differentiation. Intermediate individual tree diameter and volume growth. Intermediate whole stand volume growth.
35 – 55% High Density	3	Full site occupancy, minimum forage production. Active competition among trees, active crown differentiation. Declining individual tree diameter and volume growth. Maximum whole stand volume growth. **Upper range of zone marks the threshold for the onset of density-related mortality.**
56+% Extremely High Density	4	Full site occupancy, minimum forage production. Severe competition among trees, **active competition-induced mortality.** Minimum individual tree diameter and volume growth, stagnation. Declining whole stand volume growth due to mortality

*Ponderosa pine SDI max basis (450)

Based on these forest density relationships, a variety of stand and tree characteristics will develop by varying the timing, scale, and intensity of density management. A few examples follow:

- Grassy stands of open canopy, large-diameter trees with long, heavy-limbed crowns will develop by maintaining densities in zones 1 and 2.
- Stands of moderately dense canopy, intermediate-sized trees with thrifty, well-pruned crowns will develop by maintaining densities in the upper half of zone 2 and the lower half of zone 3.
- Clumpy, irregular stands containing groups of varying ages will develop by periodically making openings (regeneration group openings) where growing space is made available for seedling establishment. Growing space areas would fall into zone 1.
- Longevity of existing old-growth trees would be enhanced by thinning adjacent smaller trees to create zone 2 or 3 growing conditions.

- Avoiding density-related mortality and maintaining forest vigor can be achieved by maintaining densities at or less than the lower half of zone 3.

Canopy Cover

Canopy cover is defined as "the percentage of a fixed area covered by the crowns of plants delimited by a vertical projection of the outermost perimeter of the spread of foliage" (Reynolds et al. 1992). Estimates of canopy cover as an indicator of forest density have become increasingly relevant in forest management. For example, canopy cover is often viewed as a meaningful expression of stand conditions relating to habitat suitability as well as tree overstory/herbaceous understory relationships. In the southwest, canopy cover estimates figure in management recommendations for both the Mexican spotted owl (USDI Fish and Wildlife Service 1995) and the northern goshawk (Reynolds et al. 1992). For this project, there are specific Forest Plan canopy cover criteria for goshawk habitat and old growth.

Canopy cover is time consuming to measure and difficult to standardize to obtain consistent results with different observers. Even the definition of the term is dependent on the method of measurement. To resolve this issue, we used the FVS crown width model as the basis for developing stocking densities that would achieve desired canopy cover levels. This was accomplished by establishing ponderosa pine seedling tree groups (site index 75) within FVS, and periodically thinning the groups to determine the stocking that would achieve the desired canopy cover when the trees reached 15" DBH (midpoint of the VSS 4 size class). This stocking is considered typical for meeting the canopy cover desired conditions and stocking ranges by tree size class are centered on this value.

These stocking levels were compared to a local study specific to Northern Arizona ponderosa pine forest (as reported by Shepperd et al 2002) that predicted canopy cover at the stand level by inferring the relationship between estimated stand basal area and canopy cover. This comparison indicated the algorithmic relationship between basal area and canopy cover overestimated canopy cover in the larger size classes compared to FVS. Based on this comparison we chose to use the stocking indicated by FVS to meet canopy cover requirements.

The FVS developed stocking guides were then validated thru site visits to areas with variable densities and tree sizes. Comparing the stocking guides to the tree density within VSS 4, 5 and 6 sites that had interlocking or nearly interlocking tree crowns indicated following the stocking guides would meet the desired tree group canopy cover within goshawk habitat.

Table 8 and Figure 1 are the stocking guides that will be used to meet canopy cover requirements in tree groups within goshawk LOPFA habitat. Table 9 and Figure 2 are the stocking guides that will be used to meet canopy cover requirements in tree groups within goshawk PFA habitat.

Table 8. Stocking Guides to Meet Tree Group Canopy Cover Requirements Within Goshawk Habitat Areas Outside of PFAs (LOPFA)

	Typical Number of Trees Per Group Stocking for Different Group Sizes[1]	Typical Intra-Group (within-group) Densities[1] (All Group Acreage Sizes)

VSS	DBH Range	1/10 acre group	1/4 acre group	1/2 acre group	3/4 acre group	1 acre group	Relative Spacing Range (feet)	Basal Area[2] (ft^2/acre)
1 & 2	0 - 4.9”	19	48	96	144	193	12 – 18	N/A
3	5 - 11.9”	14	34	68	102	136	N/A	50
4*	12 - 17.9”	5	12	23	35	46	N/A	60
5*	18 - 23.9”	3	8	15	23	30	N/A	70
6*	24”+	2	5	11	16	21	N/A	85

[1]These are typical values for the desired condition; variation can occur and is desired. However, ranges should center on these values. See chart below.
[2]Rounded to nearest 10 square feet/acre.
* Densities are equivalent to 40% canopy cover.

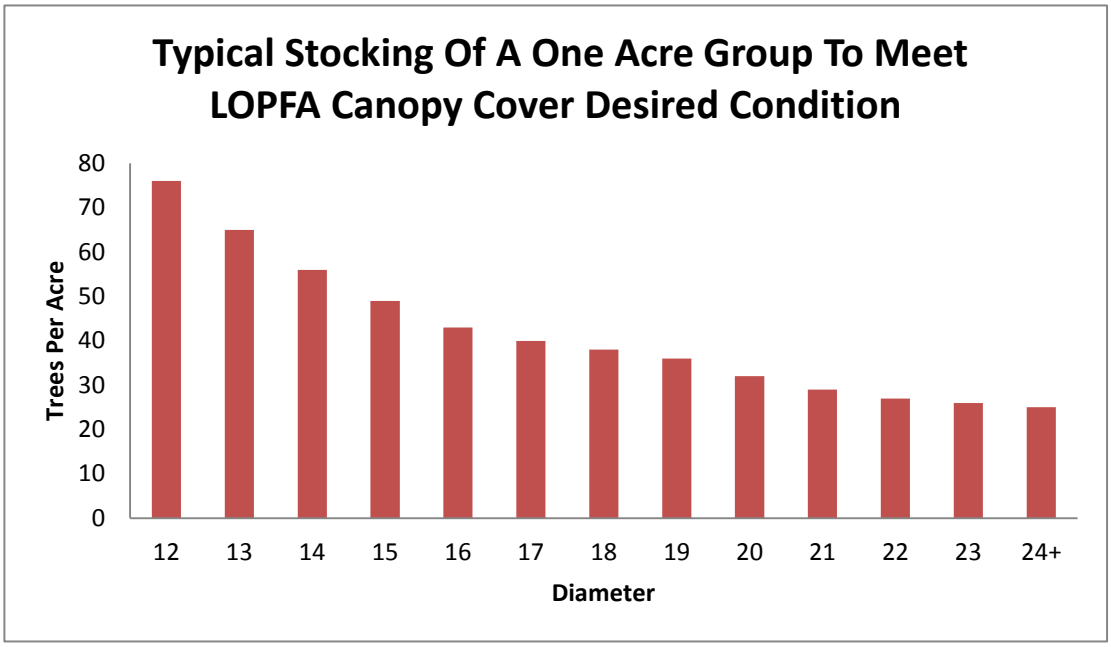

Figure 1. Typical stocking of a one acre group to meet LOPFA canopy cover desired condition.

Table 9. Stocking Guides to Meet Tree Group Canopy Cover Requirements Within Goshawk PFAs

VSS	DBH Range	Typical Number of Trees Per Group Stocking for Different Group Sizes[1]					Typical Intra-Group (within-group) Densities[1] (All Group Acreage Sizes)	
		1/10 acre group	1/4 acre group	1/2 acre group	3/4 acre group	1 acre group	Relative Spacing Range (feet)	Basal Area[2] (ft^2/acre)
1 & 2	0 - 4.9”	19	48	97	145	193	12 – 18	N/A
3	5 - 11.9”	14	34	68	102	136	N/A	50
4*	12 - 17.9”	7	18	35	53	70	N/A	85
5**	18 - 23.9”	4	10	20	29	39	N/A	90
6**	24”+	3	7	14	20	27	N/A	110

[1]These are typical values for the desired condition; variation can occur and is desired. However, ranges should center on these values. See chart below.
[2]Rounded to nearest 10 square feet/acre.
* Densities are equivalent to 55% canopy cover
** Densities are equivalent to 50% canopy cover

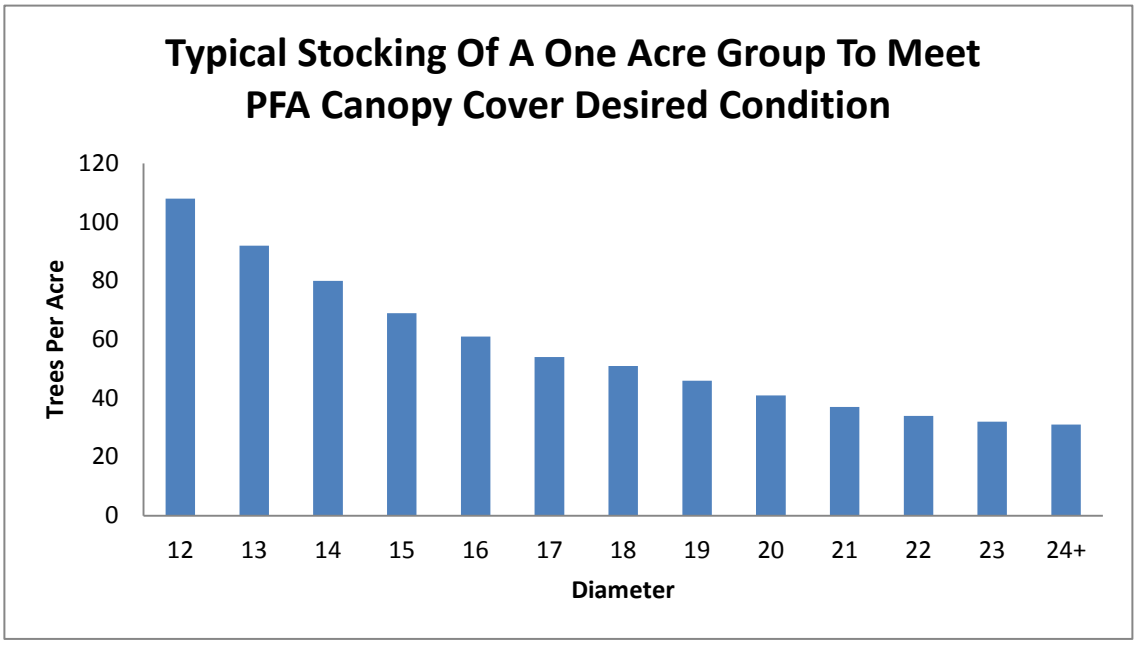

Figure 2. Typical stocking of a one acre group to meet PFA canopy cover desired condition.

Openness

A key characteristic of historical ponderosa pine forests was the grass-forb-shrub (interspace) interspersed among tree groups. This interspace typically comprised a large portion of the landscape. The term openness will be used in this analysis to convey the percentage of the forested area that is grass-forb-shrub interspace. Classifications of openness are as follows:

- Very Open = 70-90% Interspace
- Open = 40-70% Interspace
- Moderately Closed = 25-40% Interspace
- Closed = <25% Interspace

Determining openness is best accomplished thru aerial imagery analysis. At present, this sort of analysis is only available for a small portion of the project area. In the absence of a detailed aerial imagery analysis we determined that stand data was an appropriate substitute to classify the continuous canopy conditions that currently exist within the project area. Therefore, the current openness within the project area was determined using the canopy density measurements described in Table 5. Table 10 is an estimate of the percent of the analysis area ponderosa pine by openness classification within each SU, RU and the ponderosa pine extent.

Table 10. Existing Openness Classification for Ponderosa Pine

Restoration Unit-Subunit	Acres	Very Open /Open	Moderately Closed	Closed	Unknown
1-1	8,914	20%	38%	40%	1%
1-2	6,517	28%	42%	28%	2%
1-3	38,236	18%	26%	55%	0%
1-4	17,285	15%	39%	45%	1%
1-5	74,841	9%	23%	67%	1%
1	145,793	14%	28%	58%	1%
3-1	18,805	16%	34%	49%	1%
3-2	22,885	23%	40%	35%	2%
3-3	44,426	15%	20%	62%	2%
3-4	8,920	7%	17%	76%	0%
3-5	34,190	5%	17%	76%	2%
3	129,225	13%	25%	60%	2%
4-2	7,381	36%	35%	27%	2%
4-3	55,311	17%	35%	45%	3%
4-4	65,003	17%	35%	45%	3%
4-5	6,605	13%	36%	43%	8%
4	134,301	22%	34%	39%	4%
5-1	20,615	29%	31%	20%	19%
5-2	41,055	67%	21%	5%	7%
5	61,671	55%	24%	10%	11%
6-2	5,069	56%	24%	20%	1%
6-3	32,635	28%	44%	26%	2%
6-4	3,484	4%	25%	71%	1%
6	41,188	30%	40%	29%	2%
All Ponderosa Pine	**512,178**	**22%**	**29%**	**45%**	**3%**

Mexican Spotted Owl and Northern Goshawk Habitat

All ponderosa pine forested habitat within the analysis area was stratified to meet analysis requirements in the forest plans (USDA 1987, as updated 2008 and USDA 1988, as updated 2008) for Mexican spotted owl (MSO) and northern goshawk (NOGO) as displayed in Figure 3. Stratification of acres by habitat and forest type is displayed in Table 11 (MSO) and Table 12 (Goshawk).

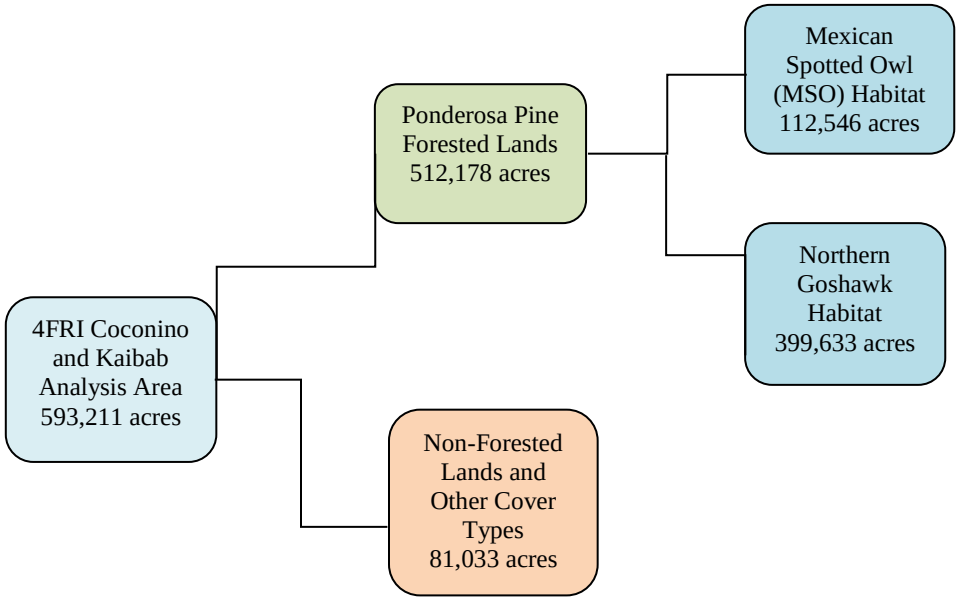

Figure 3. Stratification of ponderosa pine forested lands, other cover types and non-forested land.

Table 11. Mexican Spotted Owl Habitat Stratification within the Analysis Area (Acres within each RU)

MSO Habitat	RU 1	RU 3	RU 4	RU 5	RU 6	Total
Protected Habitat						
Protected Activity Center (PAC)	29,349	4,268	556	1,393	0	35,566
Pine Oak >40% Slope	648	239	3	0	0	889
Total MSO Protected:	29,996	4,507	558	1,393	0	36,455
Restricted Habitat – Pine Oak						
Threshold	873	1,104	0	0	0	1,977
Target	3,941	2,795	0	0	0	6,736
Restricted Other	26,421	38,748	1,575	634	0	67,378
Total MSO Restricted:	**31,234**	**42,648**	**1,575**	**634**	**0**	**76,091**
Total MSO Habitat	**61,231**	**47,155**	**2,134**	**2,026**	**0**	**112,546**

Table 12. Northern Goshawk Habitat Stratification within the Analysis Area (Acres by RU)

Northern Goshawk Habitat	RU 1	RU 3	RU 4	RU 5	RU 6	Total
Nest Habitat	1,126	1,174	3,489	435	616	6,839
Post-fledgling Family Area (PFA)						
Uneven-aged	650	2,405	5,086	1,362	2,852	12,354
Even-aged	2,895	1,873	4,910	1,148	582	11,408
Total PFA :	3,545	4,278	9,996	2,509	3,434	23,761
Total PFA and Nest	**4,670**	**5,452**	**13,484**	**2,944**	**4,050**	**30,600**
Landscapes Outside Post-fledgling Family Areas (LOPFA)						
Uneven-aged	40,073	40,964	60,374	46,808	19,743	207,962
Even-aged	39,820	35,655	58,309	9,892	17,396	161,071
Total LOPFA:	**79,892**	**76,619**	**118,683**	**56,700**	**37,183**	**369,033**
Total Goshawk Habitat	**84,562**	**82,071**	**132,167**	**59,644**	**41,188**	**399,633**

Forest Density and Structure – Mexican Spotted Owl Forest Habitat

The Protected Activity Centers (PACs) provide the best possible owl habitat available with the nest or activity center located near the center. The restricted habitats are managed to ensure a sustained level of owl nest/roost habitat distributed across the landscape. Table 13 displays the total basal area, relative SDI, percent of the total SDI by size class, tree per acre greater than 18" and Gambel oak basal area as a percent of total basal for all MSO habitats. These structural attributes and habitat components are indicators of nest/roost characteristics as outlined in the Coconino and Kaibab Forest Plans.

The average conditions within the restricted target/threshold MSO forest habitats currently have the minimum structural components with the exception of percent density within the 24" + size class and trees per acre in the 18 + size class. The average condition within the restricted other MSO forest habitats are also lacking in trees greater than 18" + and percent density of trees 24"+. The Gambel oak component in both habitats is close to or above the minimum of ≥20% and they are providing the key habitat components of coarse woody debris >12" and snags ≥18".

Table 13. Existing Spotted Owl Habitat Forest Structure and Habitat Components

Habitat	RU	Basal Area	% Max SDI	Avg. Percent of Total SDI by Size Class			Avg. TPA 18"+	Avg. Gambel Oak BA Percent of Total BA	Tons CWD >12"	Snags >18"
				12.0 – 17.9"	18.0 – 23.9"	24.0" +				
Restricted Target/ Threshold Displayed as (avg. target/ avg. threshold) combined avg.	RU 1	(156/204) 164	(81/100) 85%	(30/25) 29%	(12/24) 14%	(7/3) 7%	(13.7/28.0) 16.3	(19/29) 20%	(1.5/2.0) 1.6	(.5/.5) .5
	RU 3	(148/185) 158	(79/99) 84%	(26/26) 26%	(13/19) 15%	(7/8) 8%	(13.4/23.7) 16.3	(23/33) 26%	(.8/.6) .8	(.5/.7) .6
	All	(152/193) 162	(80/100) 85%	(28/25) 28%	(13/21) 15%	(7/6) 7%	(13.6/25.6) 16.3	(21/31) 23%	(1.2/1.2) 1.2	(.5/.6) .5
Restricted Other	RU 1	138	68%	30%	12%	7%	11.5	13%	.4	.4
	RU 3	137	70%	29%	13%	7%	11.6	20%	.5	.4
	RU 4	129	67%	28%	13%	8%	11.6	22%	.4	.5
	RU5	102	51%	24%	10%	10%	8.4	9%	.2	.4
	All	137	69%	29%	13%	7%	11.5	17%	.5	.4
Protected	RU 1	155	78%	31%	13%	8%	14.5	13%	.7	.6
	RU 3	169	82%	31%	15%	9%	18.0	11%	1.1	.7
	RU 4	100	49%	33%	9%	5%	8.6	7%	.4	.4
	RU 5	136	67%	31%	15%	8%	14.2	11%	1.2	.6
	All	155	78%	31%	14%	8%	14.9	12%	.8	.6

Forest Density and Structure – Goshawk Forest Habitat

The post-fledgling family areas (PFA) consist of nest sites and adjacent habitat most likely to be used by fledglings during their early development as well as unoccupied suitable habitat within a 2 to 2.5 mile range of PFAs (dispersal PFA - dPFA). The remaining ponderosa pine forest outside of MSO protected and restricted areas and outside of goshawk PFA is considered goshawk foraging habitat and will be referred to as Landscapes Outside of Goshawk Post-fledgling Family Areas (LOPFA) for the remainder of this report.

The existing distribution of forest structure, habitat components and structural stages within northern goshawk habitat was evaluated at four scales: ponderosa pine extent, restoration unit, restoration subunit and stand. Stands of like structural characteristics and like treatments were grouped. Habitat structure and forest density metrics were averaged by strata to a per-acre basis (see Methodology, Assumptions and Limitations section of this report). Average conditions include trees, interspaces, and canopy gaps as represented by the stand data.

Table 14 and Table 15 display the existing forest structure and habitat components for the goshawk forest habitat. These structural attributes and habitat components are indicators of goshawk habitat (PFA and LOPFA) characteristics as outlined in the Coconino and Kaibab Forest Plans.

Table 14. Existing Goshawk Nest/PFA Habitat Forest Structure and Habitat Components

Restoration Subunit-Unit	SDI % of Max.	TPA	Basal Area	Tons CWD Total	Tons CWD >12”	Snags >18"
1-1	29%	151	67	2.8	.1	.3
1-2	40%	202	94	3.6	.5	.4
1-3	54%	227	133	4.4	.4	.4
1-4	57%	313	134	8.6	4.9	.3
1-5	55%	247	131	4.8	.5	.6
1	52%	240	125	5.0	1.1	.4
3-1	44%	177	107	3.3	.2	.4
3-2	44%	182	108	3.1	.3	.4
3-3	49%	221	118	3.7	.3	.4
3-5	44%	207	105	3.7	.4	.4
3	46%	204	112	3.5	.3	.4
4-2	38%	162	94	2.8	.2	.4
4-3	45%	197	109	3.7	.7	.4
4-4	51%	224	123	4.7	1.3	.4
4-5	46%	226	108	4.2	.6	.4

Restoration Subunit-Unit	SDI % of Max.	TPA	Basal Area	Tons CWD Total	Tons CWD >12”	Snags >18"
4	46%	204	112	3.9	.8	.4
5-1	48%	260	113	4.9	1.3	.4
5-2	42%	191	100	3.9	.5	.5
5	45%	231	107	4.5	.9	.5
6-2	24%	108	53	1.9	.3	.3
6-3	30%	154	64	2.4	.2	.3
6	29%	150	63	2.4	.3	.3
All Nest/PFA	**45%**	**205**	**107**	**3.9**	**.7**	**.4**

Table 15. Existing Goshawk LOPFA Habitat Forest Structure and Habitat Components

Restoration Subunit-Unit	SDI % of Max.	TPA	Basal Area	Tons CWD Total	Tons CWD >12”	Snags >18"
1-1	44%	211	104	3.7	.4	.3
1-2	36%	185	86	3.2	.3	.3
1-3	43%	211	101	3.8	.5	.3
1-4	43%	224	99	3.8	.5	.4
1-5	51%	248	118	4.5	.7	.5
1	46%	227	107	4.0	.6	.4
3-1	41%	175	99	2.8	.2	.4
3-2	39%	147	96	2.7	.3	.4
3-3	47%	208	113	3.8	.5	.3
3-4	53%	240	126	4.7	.7	.4
3-5	54%	263	127	4.8	.7	.4
3	47%	207	112	3.7	.5	.4
4-2	35%	142	86	2.5	.2	.3
4-3	38%	176	91	3.2	.4	.4
4-4	44%	198	107	3.5	.4	.4
4-5	44%	218	106	4.0	.4	.4
4	41%	187	100	3.3	.4	.4

Restoration Subunit-Unit	SDI % of Max.	TPA	Basal Area	Tons CWD Total	Tons CWD >12"	Snags >18"
5-1	31%	171	72	3.2	.4	.4
5-2	27%	120	67	3.0	.4	.4
5	28%	136	69	3.1	.4	.4
6-2	29%	166	63	2.3	.3	.2
6-3	33%	197	71	2.6	.2	.2
6-4	32%	198	67	3.1	.3	.4
6	32%	194	69	2.6	.2	.2
All LOPFA	**40%**	**193**	**96**	**3.5**	**.4**	**.4**

All goshawk habitat was assessed to determine the variety of tree size/age classes present in relation to the dominant size/age class (Table 12). Those stands with one or two classes present have even-aged structure and those stands with three or more classes present have uneven-aged structure. Forest Plan direction for goshawk habitat outside of nest stands is to manage for uneven age stand conditions for live trees. Based upon this direction, the existing even-aged forest structure is not desired for goshawk forest habitat outside of nest stands.

Table 16 through Table 19 demonstrate the distribution of the dominate vegetation structural stages for all stands within each of goshawk habitats and age class strata. This is an indication of structural stage diversity throughout the goshawk habitat. Since the stand level structural stage is based on the tree size class with the highest square foot of basal area, it is a true description of age class diversity in even age stands while in uneven-age stands it does not give a complete portrayal. This is due to the fact that within uneven-age stands there are three or more age classes present and the dominate VSS class only tell us which one has the highest basal area.

Forest Plan direction for goshawk habitat outside of nest stands is the following distribution of vegetation structural stages: 10% each grass/forb/shrub (VSS 1) and seedling-sapling (VSS 2), 20% each young forest (VSS 3), mid-aged forest (VSS 4), mature forest (VSS 5) and old forest (VSS 6).

The even age stands (Table 16 and Table 18) are dominated by the young and mid-aged forest structural stages (over 80 percent within the LOPFA and almost 90 percent in the PFA) with very little representation of the other structural stages.

The existing uneven-aged forest structure does not comprise a balance of VSS classes (Table 17 and Table 19). The young and mid-aged forest structural stages are surplus, and the grass/forb/shrub, seedling-sapling, mature and old forest stages are deficit relative to Forest Plan direction.

Table 16. Existing Forest Structure – Goshawk LOPFA Even-Aged Stands Percent of Area by Vegetative Structural Stages.

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9”)	2 – Seedling/ Sapling (1.0 - 4.9”)	3 – Young Forest (5.0 - 11.9”)	4 – Mid-age Forest (12.0 - 17.9”)	5 – Mature Forest (18.0 - 23.9”)	6 – Old Forest (24.0” +)
SU 1-1	1%	1%	38%	47%	2%	10%
SU 1-2	5%	0%	47%	44%	4%	0%
SU 1-3	1%	1%	48%	45%	1%	4%
SU 1-4	2%	0%	53%	43%	2%	0%
SU 1-5	1%	0%	44%	42%	9%	3%
RU 1	2%	<1%	46%	44%	5%	3%
SU 3-1	2%	1%	31%	53%	13%	0%
SU 3-2	6%	0%	14%	56%	22%	1%
SU 3-3	4%	0%	37%	50%	7%	1%
SU 3-4	0%	3%	29%	58%	8%	2%
SU 3-5	3%	1%	34%	58%	4%	0%
RU 3	4%	0%	31%	54%	10%	1%
SU 4-2	4%	0%	27%	42%	25%	2%
SU 4-3	11%	0%	32%	50%	7%	1%
SU 4-4	4%	0%	33%	54%	8%	1%
SU 4-5	12%	0%	32%	49%	7%	0%
RU 4	7%	0%	32%	52%	8%	1%
SU 5-1	36%	0%	25%	30%	8%	1%
SU 5-2	19%	0%	16%	55%	7%	3%
RU 5	26%	0%	20%	44%	7%	2%
SU 6-2	5%	4%	84%	6%	1%	0%
SU 6-3	4%	2%	78%	11%	5%	1%
SU 6-4	2%	1%	87%	10%	0%	0%
RU 6	4%	2%	79%	10%	4%	1%
All	**8%**	**0%**	**36%**	**47%**	**8%**	**1%**

Table 17. Existing Forest Structure – Goshawk LOPFA Uneven-Aged Stands Percent of Area by Vegetative Structural Stages.

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9”)	2 – Seedling/ Sapling (1.0 - 4.9”)	3 – Young Forest (5.0 - 11.9”)	4 – Mid-age Forest (12.0 - 17.9”)	5 – Mature Forest (18.0 - 23.9”)	6 – Old Forest (24.0” +)
SU 1-1	0%	1%	32%	54%	10%	3%
SU 1-2	0%	4%	45%	41%	8%	2%
SU 1-3	0%	4%	38%	34%	15%	9%
SU 1-4	0%	0%	62%	29%	3%	6%
SU 1-5	0%	1%	27%	52%	14%	5%
RU 1	0%	2%	37%	43%	12%	6%
SU 3-1	0%	5%	42%	36%	12%	4%
SU 3-2	0%	0%	18%	38%	23%	21%
SU 3-3	0%	2%	38%	42%	10%	8%
SU 3-4	0%	0%	17%	47%	24%	12%
SU 3-5	0%	4%	37%	42%	5%	11%
RU 3	0%	2%	32%	41%	13%	11%
SU 4-2	0%	2%	33%	42%	22%	0%
SU 4-3	0%	1%	38%	31%	16%	14%
SU 4-4	0%	1%	34%	43%	14%	8%
SU 4-5	0%	0%	34%	50%	7%	10%
RU 4	0%	1%	36%	38%	15%	10%
SU 5-1	0%	13%	15%	37%	8%	27%
SU 5-2	0%	0%	12%	8%	24%	56%
RU 5	0%	3%	13%	14%	20%	50%
SU 6-2	0%	1%	55%	18%	10%	15%
SU 6-3	0%	5%	64%	18%	5%	7%
SU 6-4	0%	0%	77%	4%	3%	16%
RU 6	0%	4%	64%	16%	6%	10%
All	**0%**	**2%**	**35%**	**32%**	**14%**	**17%**

Table 18. Existing Forest Structure – Goshawk PFA/Nest* Even Aged Stands Percent of Area by Vegetative Structural Stages.

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9”)	2 – Seedling/ Sapling (1.0 - 4.9”)	3 – Young Forest (5.0 - 11.9”)	4 – Mid-age Forest (12.0 - 17.9”)	5 – Mature Forest (18.0 - 23.9”)	6 – Old Forest (24.0” +)
SU 1-1	-%	-%	-%	-%	-%	-%
SU 1-2	0%	0%	71%	29%	0%	0%
SU 1-3	0%	0%	30%	70%	0%	0%
SU 1-4	0%	0%	81%	19%	0%	0%
SU 1-5	0%	0%	25%	75%	0%	0%
RU 1	0%	0%	50%	50%	0%	0%
SU 3-1	2%	0%	34%	51%	13%	0%
SU 3-2	0%	0%	21%	66%	13%	0%
SU 3-3	13%	0%	34%	51%	3%	0%
SU 3-5	32%	0%	0%	68%	0%	0%
RU 3	11%	0%	28%	55%	6%	0%
SU 4-2	4%	0%	22%	36%	38%	0%
SU 4-3	1%	0%	27%	67%	4%	1%
SU 4-4	0%	0%	40%	50%	10%	0%
SU 4-5	0%	0%	34%	61%	5%	0%
RU 4	1%	0%	31%	58%	9%	1%
SU 5-1	4%	0%	60%	25%	9%	2%
SU 5-2	0%	0%	8%	68%	17%	7%
RU 5	3%	0%	42%	40%	12%	4%
SU 6-2	3%	0%	58%	0%	40%	0%
SU 6-3	8%	14%	40%	19%	14%	6%
RU 6	7%	12%	41%	18%	16%	5%
All	3%	1%	35%	52%	8%	1%

*Data analysis for nest areas was constrained by a limited data set and is represented with the PFA acres displayed.

Table 19. Existing Forest Structure – Goshawk PFA/Nest* Un-Even Aged Stands Percent of Area by Vegetative Structural Stages.

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9”)	2 – Seedling/ Sapling (1.0 - 4.9”)	3 – Young Forest (5.0 - 11.9”)	4 – Mid-age Forest (12.0 - 17.9”)	5 – Mature Forest (18.0 - 23.9”)	6 – Old Forest (24.0” +)
SU 1-1	0%	0%	100%	0%	0%	0%
SU 1-2	0%	0%	38%	6%	27%	29%
SU 1-3	0%	0%	21%	71%	7%	0%
SU 1-4	0%	0%	0%	90%	0%	10%
SU 1-5	0%	0%	66%	13%	7%	14%
RU 1	0%	0%	41%	42%	9%	8%
SU 3-1	0%	0%	23%	55%	22%	0%
SU 3-2	0%	0%	8%	84%	8%	0%
SU 3-3	0%	0%	25%	44%	11%	20%
SU 3-5	0%	0%	60%	25%	15%	0%
RU 3	0%	0%	23%	56%	11%	9%
SU 4-2	0%	0%	40%	25%	22%	13%
SU 4-3	0%	2%	33%	49%	14%	2%
SU 4-4	0%	0%	18%	48%	25%	9%
SU 4-5	0%	0%	0%	34%	66%	0%
RU 4	0%	1%	28%	45%	19%	6%
SU 5-1	0%	0%	16%	54%	21%	9%
SU 5-2	0%	0%	10%	44%	25%	20%
RU 5	0%	0%	13%	49%	23%	15%
SU 6-2	0%	1%	6%	58%	11%	24%
SU 6-3	0%	2%	61%	4%	13%	20%
RU 6	0%	2%	56%	8%	13%	20%
All	0%	1%	34%	39%	15%	11%

*Data analysis for nest areas was constrained by a limited data set and is represented with the PFA acres displayed.

Forest Structure - Old Growth Allocation

The forest plans define old growth as a condition of the forest having structural attributes based on the number of large trees per acre, basal area, canopy cover percent, dead standing trees, and down logs (USDA 1987, as amended; USDA 1988, as amended). Ponderosa pine and pinyon juniper are the species identified for allocating old growth in this analysis. Aspen inclusions within the greater ponderosa pine cover type are not large enough to be considered their own ecosystem management area and therefore were not included in the old growth allocation.

Forest plan old growth standards state, “Until the forest plan is revised, allocate no less than 20 percent of each forested EMA to old growth” and, “Allocations will consist of landscape percentages meeting old growth conditions and not specific acres”. Old growth guidelines for both forests state, “All analyses should be at multiple scales - one scale above and one scale below the ecosystem management areas” (USDA 1987, as amended; USDA 1988, as amended).

Four scales of analysis have been developed given the size of this project. The smallest scale is represented at the stand level with stands averaging less than 100 acres in size. The EMA is considered to be the restoration sub-unit. Sub-units range in size from 4,000 to 109,000 acres. The scale above the EMA is the restoration unit which ranges in size from 46,000 to 335,000 acres. The fourth scale for ponderosa pine type is the 512,178 acres of ponderosa pine within the 4FRI analysis area. For pinyon-juniper type, it is the 23,316 acres of pinyon-juniper within the 4FRI analysis area.

Allocations to old growth consist of landscape percentages meeting old growth conditions and not specific areas. The allocations for this project are independent of previous allocations that were part of other projects/analyses that overlap the 4FRI analysis area. This is due to changes in forest conditions since the previous analyses and updates to the MSO and goshawk habitat classifications.

A review of stand data and habitat classifications within the 4FRI analysis area indicates there are approximately 512,178 acres of ponderosa pine.. Of this total, 194,804 acres meet or are moving toward old growth conditions. Old growth allocations are based on current conditions within the project area along with forest plan specific management direction. Currently, all restoration units meet or exceed the 20 percent minimum percentage requirement. Table 20 displays ponderosa pine old growth allocations by restoration sub-unit/unit.

For ponderosa pine, the old growth allocation acreage/percentage within the 4FRI analysis area includes: 100 percent of MSO protected habitat; 100 percent of MSO target/threshold; 40 percent of MSO restricted habitat that is uneven-aged with low dwarf mistletoe infection; 80 percent of MSO restricted habitat that is even-aged, mid-aged to old with low dwarf mistletoe infection; 100 percent of goshawk nest stands; 40 percent of goshawk PFA and foraging areas that are uneven-aged with low dwarf mistletoe infection; and, 80 percent of goshawk PFA and foraging areas that are even-aged, mid-aged to old with low dwarf mistletoe infection. Most sites currently do not fully meet the minimum criteria for ponderosa pine old growth conditions as listed in the forest plans. However, the habitat types noted above are closest to meeting old growth conditions.

Table 20. 4FRI analysis area ponderosa pine old growth allocation acres and percent by restoration sub-unit/unit

Restoration	Ponderosa pine total acres	Ponderosa pine	Old growth

Unit-Subunit		old growth acres	percent (%)
1-1	8,914	3,578	40%
1-2	6,517	2,034	31%
1-3	38,236	18,300	48%
1-4	17,285	6,323	37%
1-5	74,841	34,955	47%
1	145,793	65,189	45%
3-1	18,805	6,216	33%
3-2	22,885	9,317	41%
3-3	44,426	15,626	35%
3-4	8,920	4,201	47%
3-5	34,190	11,160	33%
3	129,225	46,518	36%
4-2	7,381	3,710	50%
4-3	55,311	20,144	36%
4-4	65,003	22,175	34%
4-5	6,605	2,031	31%
4	134,301	48,060	36%
5-1	20,615	6,352	31%
5-2	41,055	18,394	45%
5	61,671	24,745	40%
6-2	5,069	1,689	33%
6-3	32,635	8,210	25%
6-4	3,484	392	11%
6	41,188	10,291	25%
Totals	512,178	194,804	38%

Areas currently allocated do not necessarily meet old growth standards in the forest plan but are managed to move toward those conditions to meet structural attributes over time. Table displays the existing average structural attributes for the ponderosa pine allocated old growth acres by restoration sub-unit and unit.

Table 21. Existing 4FRI Analysis Area Ponderosa Pine Allocated Old Growth Structural Attributes

Restoration Unit-Subunit	OG Acres	Avg. TPA 18"+	Avg. BA	Avg. Tons CWD ≥12"	Avg. Snags Per Acre ≥12"
1-1	3,578	13.3	118	.3	1.4
1-2	2,034	11.0	101	.3	1.1
1-3	18,300	13.3	130	.6	2.0
1-4	6,323	11.6	117	.3	1.7
1-5	34,955	15.0	146	.6	2.8
1	65,189	13.9	134	.6	2.3

Restoration Unit-Subunit	OG Acres	Avg. TPA 18"+	Avg. BA	Avg. Tons CWD ≥12"	Avg. Snags Per Acre ≥12"
3-1	6,216	12.9	121	.3	1.6
3-2	9,317	14.8	113	.3	1.5
3-3	15,626	13.8	132	.4	2.0
3-4	4,201	15.8	148	.7	2.8
3-5	11,160	15.1	147	.8	2.6
3	46,518	14.3	131	.5	2.1
4-2	3,710	13.0	103	.2	1.2
4-3	20,144	11.9	107	.3	1.4
4-4	22,175	13.1	119	.3	1.4
4-5	2,031	14.1	136	.4	2.1
4	48,060	12.7	113	.3	1.4
5-1	6,352	11.9	101	.5	1.5
5-2	18,394	11.9	84	.5	1.3
5	24,745	11.9	88	.5	1.3
6-2	1,689	8.5	84	.2	.6
6-3	8,210	9.1	92	.2	.6
6-4	392	9.3	109	.3	.6
6	10,291	9.0	91	.2	.6
All:	**194,804**	**13.0**	**118**	**.4**	**1.8**

To further address concerns about old growth distribution throughout the entire project area, we compiled old growth allocation summaries from separate vegetation analysis outside of the 4FRI analysis area. Table 22 displays ponderosa pine old growth allocations by restoration unit/forest for all the ponderosa pine within the 4FRI analysis area as well as ponderosa pine within other areas within the project area that were analyzed in separate vegetation analysis (see Silviculture Area of Analysis discussion). Currently, the individual forest percentages meet or exceed the 20 percent minimum percentage requirement in all restoration units.

Table 22. Project area ponderosa pine old growth allocation acres and percent by restoration unit/forest

	Ponderosa pine total acres	Ponderosa pine old growth acres	Old growth percent (%)

Restoration Unit	Coconino NF	Kaibab NF	Coconino NF	Kaibab NF	Coconino NF	Kaibab NF
	(4FRI/Other Projects) Total		(4FRI/Other Projects) Total			
1	(145,793/46,952) 192,745	0	(65,189/11,130) 76,319	0	40%	NA
3	(58,327/29,176) 87,503	(70,898/57,886) 128,784	(21,341/10,894) 32,235	(25,177/13,746) 38,923	37%	30%
4	(56,981/5,941) 62,922	(77,320/14,089) 91,409	(17,718/1,965) 19,683	(30,342/2,140) 32,482	31%	36%
5	(61,671/40,686) 102,357	0	(24,745/7,469) 32,214	0	31%	NA
6	0	(41,188/7,450) 48,638	0	(10,291/1,490) 11,781	NA	24%
Total	(322,772/122,755) 445,527	(189,407/79,425) 268,832	(128,994/31,458) 160,452	(65,810/17,376) 83,186	36%	31%

There are approximately 23,316 acres of pinyon-juniper within the 4FRI analysis area and approximately 6,218 acres of pinyon-juniper within other areas that were analyzed in separate vegetation analysis for a total of 29,534 acres (Table 23). The old growth allocation are those sites/acres that are closest to the minimum criteria for old growth conditions (per the forest plan). The allocation includes approximately 18,428 acres that equates to 68 percent on the Coconino and 58 percent on the Kaibab of the total acres.

	Pinyon-juniper total acres		Pinyon-juniper old growth acres		Pinyon-juniper old growth percent (%)	
Restoration Unit	Coconino NF	Kaibab NF	Coconino NF	Kaibab NF	Coconino NF	Kaibab NF
	(4FRI/Other Projects) Total		(4FRI/Other Projects) Total			
1	(1,141/2,135) 3,276	0	(611/447) 1,058	0	32%	NA
3	(832/0) 832	(3,201/3,533) 6,734	(356/0) 356	(1,747/2,245) 3,992	43%	59%
4	(42/0) 42	(7,123/0) 7,123	(42/0) 42	(4,116/0) 4,116	100%	58%
5	(8,771/0) 8,771	(0/0) 0	(7,302/0) 7,302	(0/0) 0	83%	NA
6	0	(2,206/550) 2,756	0	(1,452/110) 1,562	NA	57%
Total	(10,786/2,135) 12,921	(12,530/4,083) 16,613	(8,311/447) 8,758	(7,315/2,355) 9,670	68%	58%

Table 24 displays the existing average structural attributes for the 4FRI analysis area pinyon-juniper allocated old growth acres by restoration unit.

Table 23. Project area pinyon-juniper old growth allocation acres and percent by forest

Restoration Unit	Pinyon-juniper total acres		Pinyon-juniper old growth acres		Pinyon-juniper old growth percent (%)	
	Coconino NF	Kaibab NF	Coconino NF	Kaibab NF	Coconino NF	Kaibab NF
	(4FRI/Other Projects) Total		(4FRI/Other Projects) Total			
1	(1,141/2,135) 3,276	0	(611/447) 1,058	0	32%	NA
3	(832/0) 832	(3,201/3,533) 6,734	(356/0) 356	(1,747/2,245) 3,992	43%	59%
4	(42/0) 42	(7,123/0) 7,123	(42/0) 42	(4,116/0) 4,116	100%	58%
5	(8,771/0) 8,771	(0/0) 0	(7,302/0) 7,302	(0/0) 0	83%	NA
6	0	(2,206/550) 2,756	0	(1,452/110) 1,562	NA	57%
Total	(10,786/2,135) 12,921	(12,530/4,083) 16,613	(8,311/447) 8,758	(7,315/2,355) 9,670	68%	58%

Table 24. Existing 4FRI Analysis Area Pinyon-Juniper Allocated Old Growth Structural Attributes

Restoration Unit	OG Acres	Avg. TPA 18"+	Avg. BA	Avg. Tons CWD ≥12"	Avg. Snags Per Acre ≥12"
1	611	33	110	.1	1.2
3	2,103	32	100	.1	1.4
4	4,158	28	93	.1	1.2
5	7,302	33	110	.1	1.2
6	1,452	37	119	.3	1.3
All:	15,626	32	104	.2	1.2

Forest Health

For the purposes of this analysis, forest health is defined by the vigor and condition of the forest stands, and the presence of insects and disease that affect the sustainability of the forest. A working definition of a healthy forest is a forest where:

- Native insect and disease activity is within the historic range of variability, and non-native insects/diseases are absent or incidental and; Stand densities are at levels that facilitate overall forest development, tree vigor, and resilience to characteristic disturbances, and; Forest structure represents all age classes necessary for a sustainable balance of regeneration, growth, mortality and decomposition, and; Overall these

conditions are resilient to natural biotic and abiotic disturbances (e.g., insects, diseases, fire, and wind).

Aspen

An accelerated decline of aspen occurred across the project area following a frost event in June 1999, and a long-term drought that included an extremely dry and warm period from 2001 through 2002, and bouts of defoliation by the western tent caterpillar in 2004, 2005, and 2007. Surveys across the Coconino National Forest have shown Aspen on low-elevation xeric sites (<7500 ft) sustained 95% mortality since 2000. Mid-elevation sites (7500–8500 ft) lost 61% of aspen stems during the same time period; mortality is expected to continue in these sites because some remaining trees have 70 to 90% crown dieback. Several insects and pathogens were associated with aspen mortality but appeared to be acting as secondary agents on stressed trees (Fairweather et. al. 2008). Aspen regeneration occurred to some degree on all the sites studied following the death of mature trees although aspen sprouts were nearly nonexistent by the summer of 2007. This loss of spouts was attributed to browsing by elk and deer as none of the sites studied were grazed currently by domestic cattle. Widespread mortality of mature aspen trees, chronic browsing by ungulates, and advanced conifer reproduction is expected to result in rapid vegetation change of many ecologically unique and important sites (Fairweather et. al. 2008). The annual Forest Health Protection aerial survey conducted in 2010 (USDA Forest Service 2011) indicated a continuation of the mortality trend within the project area.

Bark Beetles

An outbreak of bark beetles, starting in 2002 to 2003, resulted in widespread mortality across Arizona, including mortality in the project area. The outbreak was primarily the result of several native bark beetle species responding to the weakened condition of moisture-stressed, over-crowded forests. Trees on stress-prone sites were most affected. A decrease in affected acres began to occur in 2007 (USDA Forest Service 2008).

The annual aerial surveys on the Coconino and Kaibab in the summer of 2010 detected ponderosa pine mortality associated with bark beetles on approximately 6500 acres within the project area. This mortality is most likely associated with the Ips beetle (USDA Forest Service 2011). This survey indicates a 10 fold increase in beetle mortality from the 2008 and 2009 surveys although bark beetle activity in ponderosa pine is currently considered to be at endemic levels. Preliminary results of the 2011 survey indicate a minor reduction in ponderosa pine mortality from 2010.

During the morning of October 6, 2010, four tornados occurred approximately 10 miles to the west of Flagstaff traversing in south to north direction. There was an array of tree damage including windthrown trees, trees snapped off at various heights, and partially windthrown trees that are leaning at various degrees. Engraver beetles (*Ips* species) in particular are most likely to colonize damaged and down ponderosa pine, have successful brood production, and threaten neighboring undamaged trees (USDA Forest Service 2011). There was little beetle related mortality observed within the tornado area in the summer of 2011. Preliminary surveys in the winter of 2012 indicate that adult beetles are overwintering in the storm damaged trees. If conditions are dry and warm in the spring of 2012, there is a heightened chance of beetle caused mortality in adjacent trees in the summer of 2012 and the potential to reach epidemic levels by the end of the summer (Joel McMillin 2012).

When trees are growing at high densities, there is a greater amount of inter-tree competition for resources like light, water, and nutrients compared with trees growing at lower densities (Kolb et al. 1998). Research in the West clearly shows that when trees are stressed from overstocking they are more susceptible to bark beetle attack (DeMars and Roettgering 1982, Schmid and Mata 1992, Schmid et al. 1994, Chojnacky et al. 2000, Negrón et al. 2000,). During the recent landscape-level bark beetle outbreak in Arizona, elevation and tree density were significant variables for estimating the probability of occurance of mortality in ponderosa pine stands on several forests (Negrón et al. 2009). Dwarf mistletoe infection also appears to influence attack patterns of bark beetles on ponderosa pine during drought events (Kenaley et al. 2006, 2008).

A general bark beetle hazard model for southwestern ponderosa pine based exclusively on the tree density relationships developed in the *Dendroctonus* hazard model by Munson and Anhold 1995 (as documented in Chojnacky et al. 2000) and the draft *Ips* hazard model developed by McMillin et al. (2011) indicates that stands of ponderosa pine within the project area with a relative density below 30% of SDImax have a low hazard rating and stands between 30 and 40% of SDImax have a moderate hazard rating. Using these relative density thresholds, approximately 8 percent of the ponderosa pine analysis area has a low bark beetle hazard rating, while 21 percent of the area has a moderate rating and the remaining 71 percent has a high hazard of beetle attack (Table 25).

Table 25. Existing Ponderosa Pine Beetle Hazard Rating (Percent of area in each RU)

Hazard Rating	RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area Acres (% of Total)
Low	3%	6%	8%	25%	0%	38,903 (8%)
Moderate	12%	11%	27%	46%	25%	106,734 (21%)
High	85%	83%	64%	29%	75%	366,542 (71%)

Dwarf Mistletoe

Dwarf mistletoes are the most widespread and damaging forest pathogens (disease-causing organisms) in the Southwest. Damage from dwarf mistletoes includes growth reduction, deformity—especially the characteristic witches' brooms, and decreased longevity. Infected areas often have much higher mortality rates than uninfected areas. Infection is often a major factor in mortality attributed to other damaging agents. For example, severely infected trees are often attacked by bark beetles (USDA Forest Service 2011).

Southwestern dwarf mistletoe infection in ponderosa pine is common throughout the ponderosa pine analysis area. On both the stand and landscape level, the distribution of dwarf mistletoes is usually patchy, with more or less discrete infection centers surrounded by areas without the disease. Infection centers expand very slowly, so overall incidence changes little from year to year (USDA Forest Service 2011).

Table 26 displays ponderosa pine dwarf mistletoe infection in terms of area by infection level and percent of ponderosa pine trees infected within each level. Approximately 66 percent of the area is not infected or has a low infection level, with less than 20% of the trees infected. Thirty four percent of the area is moderately infected (20% to 50% of the trees infected), or heavily infected (50-80% of the ponderosa pine infected). The average percent of trees infected ranges from 5 to

10 percent in none/low group and 33 to 41 percent in the moderate/high group. There are several stands that have an extreme infection rating where 80% or more of the trees are infected.

Table 26. EC - Dwarf Mistletoe Infection Level

Infection Level		RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
None/Low	Percent of Area	52%	57%	73%	91%	82%	66%
None/Low	Average Percent Trees Infected	5%	6%	4%	10%	5%	6%
Moderate/High	Percent of Area	47%	43%	26%	9%	18%	34%
Moderate/High	Average Percent Trees Infected	37%	33%	38%	41%	42%	36%
Extreme	Percent of Area	1%	<1%	<1%	0%	0%	<1%
Extreme	Average Percent Trees Infected	86%	87%	85%	-	-	86%

Salt damage

De-icing salts continue to damage roadside trees (especially ponderosa pines) along many highways within the project area. Mortality from de-icing salt use has increased in northern Arizona and the Arizona department of transportation removes salt damaged trees annually. Additional damage from dust abatement salts has been observed in other areas and is possible wherever they are used.

Climate Change

Southwestern ecosystems have evolved under a long and complex history of climate variability and change. Taking into consideration the number of mega-droughts and other climate-related variation, through time, southwestern systems have some built-in resilience. This EIS focuses on restoring and maintaining resilience in forest and grassland ecosystems. Risks of increased wildfire, insects and disease outbreaks, and invasive species represent ongoing, broad-scale management challenges. These issues are not new. However, climate change has the potential to increase and exacerbate the impacts of these ecosystem risks.

Based on current projections, the primary regional-level effects of climate change most likely to occur in the Southwest that will have an effect on forest vegetation include warmer temperatures, decreasing precipitation, and increased extreme weather events. These changes could result in immediate vegetation disturbance due to wind or flooding, increased wildfire risks, increased outbreaks of insects, diseases, and spread of invasive species, increased drought related mortality and changes in plant species composition.

Carbon - Climate scientists agree that the earth is undergoing a warming trend, and that human-caused elevations in atmospheric concentrations of carbon dioxide and other greenhouse gases are among the causes of global temperature increases. Forests serve as carbon reservoirs; however, large-scale fire events can counter this benefit by releasing significant amounts of carbon into the atmosphere. Restoration treatments (e.g., thinning, prescribed fire) as identified in the proposed action, promote low-density stand structures, characterized by larger, fire-resistant trees. This

strategy should afford for greater carbon storage in southwestern fire-adapted ecosystems over time (Hurteau and North 2009). Although fire-excluded forests contain higher carbon stocks, this benefit is outweighed in the long term by the loss that would be likely from uncharacteristic stand-replacing fires if left untreated (Hurteau et al. 2011). Research has also shown that the long-term gains acquired through prescribed fire and mechanical thinning outweighs short-term losses in sequestered carbon. In the long term (e.g., 100 years) thinning and burning would create more resilient forests, less prone to stand-replacing events, and subsequently, able to store more carbon in the form of large trees.

Finkral and Evans (2008) examined the full effects on carbon of an actual restoration thinning treatment in a ponderosa pine forest. They found that while the treatment initially produced a 30-percent reduction in the carbon held in trees, it significantly reduced the threat of an active crown fire, which they predicted would kill all the trees and release 3.7 tons of carbon per acre in any untreated areas. Such findings are especially important when one considers that climate change is expected to make the conditions for catastrophic fire and insect outbreaks even more prevalent in the western United States.

Desired Conditions

Supporting Science

The project desired conditions have been developed based upon the project Purpose and Need and forest plan direction for forest vegetation management. Current best available science was used for analysis of conditions necessary to meet the project Purpose and Need. Science relative to historic reference conditions has informed this process.

The Desired Conditions for ponderosa pine forests incorporated information on the ecology of the overstory and understory vegetation comprising this type as well as information on its historic or natural range of variability in the composition, structure and pattern of vegetation.

Restoring southwestern ponderosa pine forests revolves around reintroducing a regime of frequent, low-intensity fires like those that historically maintained forest structure and function (Friederici 2004). Restoration treatments that include prescribed burning, often preceded by thinning to reduce fuel loads, have the potential to improve the ecological health of these forests. In order to wisely set the goals that underlie these treatments, it is useful for us to know as much as possible about past forest conditions, especially the “reference conditions” that existed before forest structure and function were altered by Euro-American settlers. Such conditions were not unchanging, but they sustained themselves across what has been called a “natural range of variability” (Friederici 2004).

The natural range of variability (NRV) specific to the Four-Forest Restoration Initiative Coconino NF and Kaibab NF project area comes from early written records, general land office surveys, Forest Service records, oral histories, and photographs as well as old forest remnants, physical remains of old trees and dendrochronology. For example, Cooper (1960) researched the cultural evidence to document the historic condition of southwestern pine forests. Many early travelers, surveyors and government officials left records of their impressions of pine forest country specific to the project area. The 19th century descriptions of ponderosa pine forest conditions by the likes of Lt. Edward Beale, Lt. Ives, C. Hart Merriam, J.B. Lieberg, S.J. Holsinger could be summarized as follows: “The forest was decidedly open and parklike; reproduction was not abundant, and in many areas was markedly deficient; grass was abundant but not universal”

(Cooper, 1960). Other documentation that has informed our current understanding of the NRV includes plot data by early scientists (Woolsey 1911, Pearson 1950), tree ring, dendrochronological, and restoration studies (Covington and Moore 1994, Swetnam and Baisan 1996, Covington et al. 1997), natural area and old growth studies (White 1985), and wildland fuel management strategies (e.g. Pearson 1950, and Fule et al. 1997). The following is a NRV description based on these and many other references.

Natural Range of Variability

All southwestern forests and woodlands are periodically affected by natural disturbances such as fire, insects, disease, wind, and herbivory (Mast et al. 1998 and 1999, Brown et al. 2001, Ehle and Baker 2003). These disturbances have variable effects on forest vegetation depending on the type, frequency, intensity, and spatial scale of disturbances. The type, frequency, and intensity of disturbances varied historically among forest and woodland types. A forest or woodland's characteristic composition, structure, and landscape pattern, the result of vegetation establishment, growth, and succession, combined with the periodic resetting of these by characteristic natural disturbances, constitutes a forest or woodland's natural range of variability. The temporal and spatial variability in vegetation establishment, growth, and mortality, and the consequences of natural disturbances in a forest or woodland define the natural range of variability. Much of the range of variability stems from fine- to landscape scale heterogeneity in aspect, slope, elevation, and soils that can lead to topographically different growing conditions and disturbance regimes (Fule et al. 2003). The ability of a forest ecosystem to absorb and recover from disturbances without drastic alteration of its inherent function is central to the concept of natural range of variability. In the southwestern United States, fire is a primary disturbance agent and fire regimes are central to understanding natural range of variability as it relates to the composition, structure, and pattern in various forest types (Fule et al. 2003).

Species Composition

In this type, ponderosa pine is the dominant seral and climax tree species, but depending on locale may mix with gamble oak, several juniper and pinyon species, quaking aspen, Douglas-fir, or white pine (USDA 1997). Composition of the grass/forb/shrub understory is typically diverse in ponderosa pine forests, especially when canopy openings are present (Moir 1966, Naumburg and Dewald 1999, Laughlin et al. 2006, Abella et al. 2011). Presence of shrubs is variable depending on habitat type and locale (USDA 1997). While grasses and herbs occur in most ponderosa pine types (USDA 1997), the composition, abundance (cover), and productivity is variable depending on soil, aspect, elevation, latitude, moisture, and the presence or absence of tree cover (Moir 1966, Naumburg and Dewald 1999, Laughlin et al. 2006, Abella et al. 2011).

Tree Density and Distribution

Historical tree densities on reconstructed plots throughout the Southwest varied depending on factors such as elevation, aspect, slope, soils, moisture, and a site's unique history. An example of this was a reconstruction study involving 53 2.5-acre plots representing nine different ponderosa pine ecosystem types near Flagstaff, Arizona. Historical tree densities on these sites varied 19-fold, and averaged between 2 -40 trees per acre (Abella and Denton 2009). Moore's et al. (2004) reconstruction study on their 15 2.5 acre Woolsey plots estimated a mean density of 40 trees per acre based on live tree and cut-stump BA (Moore et al. 2004). On the same Woolsey plots, SanchezMeador et al. (2010) found that the number of tree groups ranged from 4-11 per acre and

ranged in size from 0.004 ac to 0.06 acre. Other reports of historical tree densities include 22 trees per acre near Walnut Canyon (Menzel and Covington 1997), 23 trees per acre at Bar-M-Canyon (Covington and Moore 1994a), 24 trees per acre on the Gus Pearson Natural Area (GPNA) on the Fort Valley Experimental Forest (Mast et al. 1999), and 24 trees per acre at Camp Navajo (Fule etal. 1997). A 1938 forest inventory on the long Valley Experimental Forest (central Arizona) showed that 75 trees per acre were present prior to the cessation of frequent fire (between 1880 and 1900). Woolsey (1911) reported an average of 18 trees per acre (> 4 inches dbh) in northern Arizona in the early 20th century.

Structural characteristics widely reported for historical Southwest ponderosa pine are relatively open forests with trees typically aggregated in small groups within a grass/forb/shrub matrix (Cooper 1960, White 1985, Pearson 1950, Covington et a1.1997, Abella and Denton 2009). Recent work in northern Arizona has shown that tree densities across nine different ponderosa pine ecosystems depended to a large extent on soil type and climatic variables such as minimum spring and fall temperatures, and May precipitation (Abella and Denton 2009). This work also showed that the degree to which trees were aggregated into groups was largely explained by ecosystem soil type. Twenty-eight to 74 percent of all trees were in groups; the remaining trees were scattered individuals (Abella and Denton 2009). These structural conditions were maintained by frequent low-intensity surface fires that more often killed small rather than large trees (Weaver 1951, Fiedler et al. 1996, Cooper 1960). Other small-scale disturbances such as insects, disease and others also shaped this characteristic forest structure. Low intensity fires occurred every 2 to 12 years and maintained an open canopy structure (Covington et al. 1997, Moir et al. 1997). Typical historical tree groups ranged from 0.1 to 0.75 acres in size and comprised 2 to 40+ trees per group (White 1985, Fule et al. 2003, Covington et al. 1997). The grass/forb/shrub understory and fine fuels (needles, cones, limbs) from large trees fueled these frequent fires started by lightning and, to an uncertain extent by Native Americans (Kaye and Swetnam 1999, Allen et al. 2002). Regular fire thinned or eliminated thickets of small trees, resulting in open, park-like forests (Cooper 1960, Covington et al. 1997, Allen et al. 2002). Restoration studies on the Fort Valley Experimental Forest near Flagstaff, Arizona, showed an average of 23 trees per acre that were grouped into distinct 0.05- to 0.7-acre groups consisting of 2-40 trees (Covington et al. 1997).

Forest Openings and the Grass/Forb/Shrub Vegetation Matrix

Woolsey (1911) described late 19th century southwestern ponderosa pine forests as follows: "The typical western yellow (ponderosa) pine forest of the Southwest is a pure park-like stand(s) made up of scattered groups of from 2 to 20 trees, usually connected by scattering individual. Openings are frequent and vary in size. Because of the open character of the stand and the fire-resisting bark, often 3 inches thick, the actual loss in yellow (ponderosa) pine by fire is less than with other, more gregarious species." Others also described historical ponderosa pine forests as having low tree density, open, savanna-like stands consisting of groups of pine trees interspersed with grassy or shrubby openings (White 1985). The actual degree of "openness" has received little measurement; instead, most reconstruction/restoration studies focused on tree densities and tree aggregation. Although White (1985) did not define how close trees had to be to constitute a "group" (he used the absence of 1919 regeneration beneath large tree crowns to define groups), he reported 22 percent of his plot on the GPNA was under tree groups. Thus, 78 percent of the 18 acre area would likely have been open before the 1919 regeneration pulse (White 1985). White (1985) reported that 12 percent of the historical trees on his plot were not in groups of three trees;

if he had included single trees and groups of 2 trees, the percent open would have been less than 78 percent. Covington et al. (1997), also working on the GPNA, reported that while canopy cover was high within groups of trees, only 19 percent of the surface area of their study plot was under pine canopy; the balance (81%) represented grassy openings (Covington et al. 1997). Where crown cover was not reported, Gill's et al. (2000) mean crown radius for mature ponderosa pine (19.7 feet)can be used to estimate area under crowns. Of the 53 study plots in Abella and Denton (2009), those with only two trees had less 2 percent under tree crown (98% open). At the opposite extreme, a plot with 40-trees had an estimated 28 percent under crowns (72% open). Using the same approach on the Long Valley Experiment Forest, for the 75 trees present before the cessation of fire (about 1900) resulted in about 52 percent of the per acre area under tree crowns (48% open). Sanchez Meador (unpublished data) found a similar range between 10 and 30 percent on reconstructed Woolsey plots located throughout Arizona and New Mexico.

Sustainability and Resilience

Knowledge of the historical forest composition and structure on a site can provide estimates of forest composition, structure and pattern that was resilient to disturbance agents (insects, fire) and sustainable through at least several generations of trees (Allen et al. 2002, Abella et al. 2011). It may not be necessary, or even desirable in some cases, to have desired conditions that are within the natural range of variability at every site in southwestern forests·and woodlands. However, historical conditions are more synchronous with the natural disturbance regime to which the forest and woodland ecosystems are adapted. Social, political and economic factors are much different today than a century ago and there are valid considerations for leaving areas of higher or lower tree-density or differing composition to meet resource management needs. But restoration on some portion of the landscape to conditions reminiscent of pre-European settlement times would most likely provide for greater biodiversity, and greater ecosystem productivity, stability, sustainability, and services.

Desired Conditions - General

A variety of forest conditions (composition, structure and pattern) exists across the landscape, comparable to historic conditions. Forested landscapes are diverse with groups and patches of variable tree densities, including groups with dense, closed canopies (interlocking crowns); well shaded soil beneath tree groups; dead, deformed and diseased trees; large logs and woody debris; and old, large oaks and aspen. Canopy openings within the forest are common and support a species diverse and productive grass/forb/shrub community. Openness ranges from very open within the savanna and grassland matrix to closed on the highly productive forest sites to achieve a heterogeneous condition across the forested landscape. Forest habitats contain a forest overstory dominated by ponderosa pine, mixed where appropriate with pinyon and juniper species, oaks, aspen, Douglas fir or white pine.

Overall, the project area comprise forest conditions that are resilient to disturbance (insects, disease, fire, climate change) and sustainable through at least several generations of trees. Forest habitats are generally vigorous, with endemic levels of native insect and disease occurrences. Dwarf mistletoe is an element of the forest landscape. There is a varied level of mistletoe across the landscape, comparable to historic conditions. Forest structure and density impedes spread and reduces impacts associated with infection.

The ponderosa pine forest is uneven-aged and composed of a distribution of age classes that comprise a sustainable balance of structural stages. Old trees and old forest structure is common and sustained over time across the landscape. Managed, uneven-aged stands range from 15% to 40% of maximum SDI. In areas outside of MSO protected and restricted target/threshold habitats, basal areas average less than 80 ft2/acre.

Fully stocked, healthy forest conditions facilitate capacity to store carbon and minimize tree losses to wildfires, insects, and diseases. Wood products manufactured from biomass serve to sequester carbon and reduce use of fossil fuels. Forests within the project area provide a sustainable supply of diverse uses and values while contributing to the stabilization of carbon released into the atmosphere.

Desired Conditions – MSO Habitat

The forest plans provide the following management guidelines related to MSO habitat desired conditions.

Pine-Oak Restricted MSO Habitat

Ten percent of the pine-oak forest type (by area) provides for MSO nest/roost characteristics which include:

- Basal area > 150 ft2, Gambel oak basal area >20 ft2, twenty 18"+ trees per acre, and 45% of stocking in trees >12" diameter.
- All trees >24" diameter, substantive amounts of snags >18" diameter, down logs >12" midpoint diameter, and large hardwoods are retained following management treatments. Large oaks are present and vigorous. Oak regeneration is occurring.
- Uneven-aged stands with a diversity of structural stages present.

The remainder of the restricted habitat is managed toward these guidelines while providing a diversity of stand conditions across the landscape to ensure habitat for a diversity of prey species.

This project includes a forest plan amendment for Alternative C which allows for reducing density and improving habitat structure in line with the draft revised MSO recovery plan (USDI Fish and Wildlife Service 2011). Treatments within the target/threshold habitat would allow for a minimum of 110 ft2 of basal area with a desired range of 110-150 ft2.

Pine-Oak Protected MSO Habitat

Manage within the following limitations to minimize effects on the owl:

- Retain key forest species such as oak.
- Retain key habitat components such as snags and large down logs.
- Harvest conifers less than 9 inches in diameter only within those protected activity centers treated to abate fire risk.

An analysis of the PACs within the project area determined that 18 PACs have conditions that warrant mechanical treatment to enhance and retain key MSO habitat elements. This project includes a forest plan amendment which allows for improving habitat structure in addition to managing for fire risk abatement. Treatments within these 18 PACs would range from < 9 inches dbh to 16 inches dbh, depending on individual stand conditions.

MSO Habitat - Desired Forest Density and Habitat Components

Table 27 lists the desired MSO habitat forest density, snags and coarse woody debris related to the forest plan standards and guidelines, project purpose and need, site specific ecological limitations and reference conditions.

Table 27. MSO Habitat Desired Forest Density and Habitat Components

Habitat	Basal Area	% Max SDI[1]	Avg. Percent of Total SDI by Size Class			Avg. TPA 18"+	Avg. Gambel Oak BA Percent of Total BA	Tons CWD >12"	Snags >18"
			12.0 - 17.9"	18.0 - 23.9"	24.0" +				
Protected[2]	NA	≤55%	NA	NA	NA	NA	NA	≥1	≥2.0
Restricted Target/ Threshold	150-170 (Alt. C 110-150)	≤55%	15%	15%	15%	≥20	20%	≥1	≥2.0
Restricted Other	70-90	25-40%	15%	15%	15%	≥20	20%	≥1	2.0

[1]The percent for protected and target/threshold is based on the desire to avoid unsustainable conditions as presented in Table 7.
[2]Within protected habitat, there are no specific Forest Plan desired conditions relative to basal area, SDI, size class distribution, TPA >18" or Gambel oak basal area. The % Max SDI listed for this habitat represents a sustainable condition.

Desired Conditions – Goshawk Habitat

The forest plans describe the following desired conditions for goshawk forest habitat.

Ponderosa Pine Goshawk Nest Areas

Mature to old structural stages having a canopy cover between 50-70%. Tree pattern is non-uniform and clumpy.

Ponderosa Pine Goshawk Post-Fledging Family Area (PFA) Habitat

Provide for a healthy, sustainable forest environment for the post-fledgling family needs of goshawks which includes:

- Balanced uneven-aged condition (stand area basis) with 50% canopy cover within the tree groups >12" diameter. Basal area averages from 70-80 ft2.
- Two snags per acre >18" diameter, 3 downed logs per acre 12" diameter and 8' long, and 5-7 tons of woody debris >3" diameter.

Ponderosa Pine Landscapes Outside Goshawk PFA (LOPFA) Habitat

Provide for a healthy, sustainable forest environment for the habitat needs of goshawk prey species which includes:

- Balanced uneven-aged condition (stand area basis) with 40% canopy cover within the tree groups >12" diameter. Tree density is dependent on site quality. Basal area averages from 50-60 ft2.
- Two snags per acre >18" diameter, 3 downed logs per acre 12" diameter and 8' long, and 5-7 tons of woody debris >3" diameter.

Goshawk Habitat - Desired Forest Structure, Density and Habitat Components

The desired goshawk habitat forest structure, density, snags and coarse woody debris related to the forest plan standards and guidelines, project purpose and need, site specific ecological limitations and reference conditions are listed in Table 28 through Table 30.

Table 28 characterizes the average desired stand structure within the PFA habitat.

Table 28. Average Desired Condition - Stand Structure Ponderosa Pine Goshawk PFA Habitat

			Group Basis (Mean)					Per Acre Basis (Mean)	
VSS Class	DBH Class	% of Area	Mean DBH	SDI	TPA	BA/Ac	Canopy Cover	TPA	BA/Ac
1	0.0 – 0.9"	10%	0.1"	0	203	0	NA	20.3	0
2	1.0 – 4.9"	10%	3"	28	193	9	NA	19.3	1
3	5.0 – 11.9"	20%	8.5"	105	136	54	NA	27.3	11
4	12.0 – 17.9"	7%	15"	137	72	88	60%	4.8	6
4	12.0 – 17.9"	13%	15"	130	68	83	50%	9.0	11
5	18.0 – 23.9"	20%	21"	127	39	93	50%	7.7	19
6	24.0" +	20%	27"	135	27	109	50%	5.5	22
								93.9	69
								Dq* =	13.1
								SDI* =	114

* Includes trees ≥ 1” DBH only.
Note on per acre basis and assumptions:
Reserve trees and interspace are included in these figures. Trees are closely grouped, allowing for open interspace between tree groups.
SDI maximum values = SDI/450 x 100. SDI, TPA and BA are inferred from the forest plan.

Table 29 characterizes the average desired stand structure with the LOPFA habitat.

Table 29. Average Desired Condition - Stand Structure Ponderosa Pine Goshawk LOPFA Habitat

			Group Basis (Mean)					Per Acre Basis (Mean)	
VSS Class	DBH Class	% of Area	Mean DBH	SDI	TPA	BA/Ac	Canopy Cover	TPA	BA/Ac
1	0.0 – 0.9”	10%	0.1”	0	203	0	NA	20.3	0
2	1.0 – 4.9”	10%	3”	28	193	9	NA	19.3	1
3	5.0 – 11.9”	20%	8.5”	105	136	54	NA	27.3	11
4	12.0 – 17.9”	20%	15”	89	46	57	40%	9.3	11
5	18.0 – 23.9”	20%	21”	100	30	73	40%	6.1	15
6	24.0” +	20%	27”	104	21	84	40%	4.2	17
								86.5	54
								Dq* =	12.3
								SDI* =	92

* Includes trees ≥ 1” DBH only.
Note on per acre basis and assumptions:
Reserve trees and interspace are included in these figures. Trees are closely grouped, allowing for open interspace between tree groups.
SDI maximum values = SDI/450 x 100. SDI, TPA and BA are inferred from the forest plan.

Table 30 characterizes the desired range of forest density and habitat components.

Table 30. Goshawk Habitat Desired Per Acre Forest Density and Habitat Components

Habitat	% Max SDI	Basal Area	Total Tons CWD	>12” Tons CWD	Snags >18”
PFA	25-40%	70-80	5-7	≥1	2.0
LOPFA	15-35%	50-70	5-7	≥1	2.0

Desired Conditions – Old Growth

The forest plans provide the following guidance for ponderosa pine and pinyon/juniper old growth.

Allocate no less than 20 percent of each forested ecosystem management area to old growth as depicted by the following minimum structural attributes:

Minimum desired structural attributes for ponderosa pine old growth forested sites:

- 20 TPA 18” DBH and 180 Years Old.
- 1 Snag/acre 14” DBH and 25’ in height.
- 2 down dead tree pieces 12” and 15’ in length.
- Basal area 90 square feet.
- Canopy cover 50%.

Minimum desired structural attributes for pinyon-juniper old growth forested sites:

- 30 TPA 12” DRC and 200 Years Old.
- 1 Snag/acre 10” DRC and 10’ in height.
- 2 down dead tree pieces 10” and 10’ in length.
- Basal area 24 square feet.
- Canopy cover 35%.

Where forested sites do not meet these conditions, allocate sites that represent the closest to meeting these conditions and manage those sites towards the above desired structural attributes.

4FRI Coconino/Kaibab EIS - Silviculture Design

Features specific to the desired condition objectives have been designed into the proposed action and alternatives to prevent impacts and meet the forest plans standards and guidelines as amended under this EIS, and meet the project purpose and need. The comprehensive silviculture design is documented in the Silvicultural Design and Implementation Guide -Appendix A of this report.

4FRI Coconino/Kaibab EIS - Vegetation Effects Analysis

Spatial and Temporal Context for Project Level Effects Analysis

For the effects analysis the spatial context being considered is the 593,211 acre analysis area. The baseline year used for this analysis is the year 2010 as the existing condition. In this analysis, all past activities and events are included in the existing condition description. In the effects discussion, post treatment refers to the time the final activity is accomplished (year 2020), “short-term” effects refers to effects over the 10-year period from the time the final activity was accomplished (year 2030). Beyond 20-years we will be considering effects as “long-term” (year 2050).

Alternative A – No Action

Alternative A is the no action alternative as required by 40 CFR 1502.14(c).. There would be no changes in current management and the forest plans would continue to be implemented. Alternative A is the point of reference for assessing action alternatives B-D.

Direct and Indirect Effects – Alternative A

Mexican Spotted Owl Habitat

Table 31 displays the MSO habitat forest structure and habitat components projected out to the years 2020 and 2050. Density in terms of basal area and SDI continues to increase and remains higher than desired in all habitats. By 2050, the distribution of size classes exceeds desired in the 12-18” and the 18-24” size classes and remains below desired in the 24” + size class. Average trees per acre 18” and larger are above 20 in all habitats except restricted other in RU 5. Average Gambel oak basal area is static between 2020 and 2050 and remains below desired in the restricted other habitat. All habitats show an increase in CWD >12” and snags >18” between 2020 and 2050.

Table 31. Alternative A - 2020 and 2050 Spotted Owl Habitat Forest Structure and Habitat Components

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9"		18.0 – 23.9"		24.0" +		Avg. TPA 18"+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
Restricted Target/ Threshold																		
RU 1	173	191	86%	88%	28%	28%	16%	21%	7%	9%	19.1	26.3	21%	20%	1.8	2.8	.6	1.4
RU 3	168	189	86%	89%	26%	23%	17%	20%	8%	11%	18.8	26.0	26%	25%	1.1	2.2	.7	1.6
All	171	190	86%	88%	27%	26%	16%	20%	7%	10%	19.0	26.2	23%	22%	1.5	2.5	.6	1.5
Restricted Other																		
RU 1	148	170	71%	75%	31%	30%	14%	20%	7%	10%	14.0	22.5	13%	14%	.6	1.4	.4	1.1
RU 3	147	169	73%	77%	29%	26%	15%	21%	7%	10%	14.2	23.0	19%	20%	.7	1.6	.5	1.2
RU 4	141	165	71%	75%	27%	24%	15%	20%	9%	11%	14.1	21.9	22%	23%	.6	1.4	.6	1.3
RU 5	115	146	56%	64%	26%	28%	11%	15%	10%	11%	9.8	16.0	10%	14%	.3	.8	.4	.7
All	147	169	72%	76%	30%	28%	14%	20%	7%	10%	14.1	22.7	17%	18%	.7	1.5	.5	1.1
Protected																		
RU 1	164	181	80%	81%	31%	28%	16%	22%	8%	11%	17.5	27.3	13%	13%	1.0	2.3	.7	1.6
RU 3	177	192	84%	84%	31%	27%	17%	23%	9%	12%	20.8	30.1	11%	11%	1.5	2.9	.9	2.0
RU 4	109	131	51%	56%	35%	38%	14%	23%	5%	8%	10.8	19.8	7%	8%	.7	1.6	.4	1.3

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9”		18.0 – 23.9”		24.0” +		Avg. TPA 18”+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12”		Snags >18”	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
RU 5	147	170	71%	75%	31%	26%	17%	22%	9%	13%	16.9	26.3	11%	11%	1.5	2.7	.7	1.7
All	164	181	80%	81%	31%	28%	16%	22%	8%	11%	17.8	27.5	12%	12%	1.1	2.4	.7	1.7

Goshawk Habitat

Table 32 and Table 33 display the goshawk habitat forest structure and habitat components projected out to the years 2020 and 2050. Density in terms of SDI and basal area continues to increase and remains higher than desired in all habitats. All habitats show an increase in total CWD, CWD >12" and snags >18" between 2020 and 2050 resulting in conditions at or close to desired.

Table 32. Alternative A – 2020 and 2050 Goshawk Nest/PFA Habitat Forest Structure and Habitat Components

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
1-1	32%	39%	151	133	77	103	3.1	4.4	.2	.5	.2	.3
1-2	42%	46%	192	151	102	121	4.2	6.3	.6	1.1	.4	.8
1-3	56%	58%	213	170	141	157	5.5	8.6	.6	1.4	.4	1.0
1-4	60%	61%	290	219	143	159	9.2	11.7	4.7	4.6	.4	.9
1-5	56%	55%	226	164	138	147	6.1	10.3	.7	1.9	.6	1.5
1	54%	55%	223	171	133	147	5.9	9.1	1.2	1.9	.5	1.1
3-1	46%	49%	168	136	115	133	4.1	6.5	.4	1.0	.5	1.0
3-2	47%	50%	172	138	117	134	3.8	6.3	.4	1.1	.5	1.0
3-3	51%	54%	206	164	126	143	4.5	7.2	.4	1.2	.5	.9
3-5	46%	49%	195	156	113	131	4.6	7.5	.5	1.3	.4	.9
3	48%	52%	191	153	121	138	4.2	6.9	.4	1.2	.5	.9
4-2	40%	45%	152	128	102	123	3.2	5.2	.3	.9	.6	.7
4-3	47%	51%	186	149	118	137	4.3	6.8	.8	1.4	.5	.9
4-4	53%	55%	209	163	131	148	5.4	8.2	1.4	1.9	.5	.9
4-5	48%	49%	210	156	117	130	4.9	7.8	.7	1.5	.4	1.3
4	48%	52%	192	152	121	139	4.6	7.2	.9	1.5	.5	.9
5-1	50%	52%	241	185	121	136	5.7	8.6	1.3	1.9	.5	1.0
5-2	44%	45%	180	135	107	121	4.7	7.5	.7	1.6	.6	1.4
5	48%	49%	215	164	115	129	5.3	8.1	1.1	1.2	.5	1.2
6-2	26%	31%	107	90	61	79	2.4	3.8	.3	.5	.3	.4
6-3	32%	36%	148	120	72	90	2.9	4.3	.4	.6	.3	.4

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
6	32%	36%	145	117	71	89	2.8	4.3	.3	.6	.3	.4
All	**47%**	**50%**	**192**	**152**	**115**	**132**	**4.6**	**7.1**	**.8**	**1.4**	**.4**	**.9**

Table 33. Alternative A – 2020 and 2050 Goshawk LOPFA Habitat Forest Structure and Habitat Components

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
1-1	47%	51%	200	165	114	134	4.4	6.4	.5	1.0	.3	.6
1-2	39%	43%	177	140	95	115	3.8	5.8	.4	1.0	.3	.8
1-3	45%	49%	199	159	110	128	4.5	6.8	.6	1.2	.4	.7
1-4	45%	48%	209	161	108	125	4.5	6.9	.6	1.2	.3	.8
1-5	52%	53%	229	167	125	137	5.6	9.0	.9	1.8	.5	1.3
1	48%	50%	212	162	115	131	4.9	7.7	.7	1.4	.4	1.0
3-1	44%	48%	167	136	108	128	3.5	5.7	.4	.9	.4	.8
3-2	41%	46%	142	117	106	126	3.3	5.4	.4	1.0	.4	.9
3-3	49%	52%	195	152	122	139	4.6	7.5	.6	1.3	.4	.9
3-4	54%	55%	221	166	133	146	5.9	9.6	1.0	1.9	.6	1.3
3-5	55%	56%	242	181	134	146	5.9	9.5	.9	1.7	.4	1.1
3	49%	51%	194	151	120	137	4.6	7.4	.6	1.3	.4	.9
4-2	38%	44%	140	119	95	119	3.0	4.6	.3	.7	.3	.6
4-3	40%	44%	168	134	100	119	3.8	6.0	.5	1.1	.4	.8
4-4	47%	50%	186	145	117	135	4.2	6.8	.6	1.2	.4	.9
4-5	47%	50%	204	157	114	131	4.9	7.9	.6	1.3	.4	.9
4	44%	47%	177	140	109	127	4.0	6.4	.6	1.1	.4	.8
5-1	33%	37%	165	128	80	97	3.9	6.3	.5	1.1	.4	.8
5-2	30%	34%	118	96	75	93	3.5	5.4	.5	1.0	.5	.8
5	31%	35%	133	106	76	94	3.6	5.7	.5	1.0	.5	.8

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
6-2	32%	38%	161	133	72	94	2.7	39	.3	.5	.2	.3
6-3	36%	41%	185	144	81	101	3.0	4.7	.3	.5	.2	.4
6-4	33%	35%	183	135	74	85	3.8	6.0	.5	.9	.4	.7
6	35%	40%	182	142	79	99	3.0	4.7	.3	.5	.2	.4
All	**43%**	**46%**	**182**	**142**	**105**	**122**	**4.2**	**6.6**	**.6**	**1.2**	**.4**	**.8**

Table 34 through Table 37 display the VSS distribution for even age and uneven age stands by goshawk habitat projected out to the years 2020 and 2050.

In 2020 the LOPFA even-aged stands (Table 34) are dominated by the young and mid-aged forest structural stages with a combined overall distribution of 84 percent, more than twice the desired. The young forest stage ranges from a low of 12 percent in SU 3-2 to a high of 89 percent in SU 6-2. The mid-age forest stage ranges from a low of 0 percent in SU 6-2 to a high of 59 percent in SUs 1-2, 3-1, and 3-2. Overall distribution of VSS 1 is close to desired at 7 percent while VSS 2 is deficit by 10 percent, VSS 5 is deficit by 13 percent and VSS 6 is deficit by 18 percent.

As stand development continues, the distribution shifts toward the later stages by 2050. The mid-aged and mature forest structural stages are dominating with a combined overall distribution 79 percent. The mid-age forest stage ranges from a low of 19 percent in SU 6-4 to a high of 62 percent in SU 3-5. The mature forest stage ranges from a low of 0 percent in SU 6-2 to a high of 52 percent in SU 5-2. In 2050, there are no VSS 1 stands. The overall distribution VSS 2 is close to desired at 7 percent while, VSS 3 is deficit by 12 percent and VSS 6 is deficit by 15 percent.

Table 34. Alternative A - 2020 and 2050 VSS Distribution for Goshawk LOPFA Even-Aged Stands Percent of Area by Vegetative Structural Stages.

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	1%	0%	0%	1%	39%	15%	47%	41%	2%	31%	10%	10%
SU 1-2	5%	0%	0%	5%	32%	0%	59%	48%	4%	43%	0%	4%
SU 1-3	1%	0%	0%	1%	48%	12%	46%	53%	0%	28%	4%	5%
SU 1-4	2%	0%	0%	2%	53%	8%	43%	51%	1%	38%	1%	1%

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9”)		2 – Seedling/ Sapling (1.0 - 4.9”)		3 – Young Forest (5.0 - 11.9”)		4 – Mid-age Forest (12.0 - 17.9”)		5 – Mature Forest (18.0 - 23.9”)		6 – Old Forest (24.0” +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-5	1%	0%	0%	1%	44%	8%	43%	59%	9%	26%	3%	5%
RU 1	2%	0%	0%	2%	45%	9%	45%	54%	4%	31%	3%	5%
SU 3-1	2%	0%	0%	2%	25%	12%	59%	42%	13%	38%	0%	6%
SU 3-2	6%	0%	0%	6%	12%	4%	59%	33%	23%	47%	1%	10%
SU 3-3	4%	0%	0%	4%	36%	6%	52%	61%	8%	24%	1%	5%
SU 3-4	0%	0%	0%	0%	31%	9%	58%	55%	8%	29%	2%	7%
SU 3-5	3%	0%	0%	3%	35%	6%	58%	62%	2%	25%	2%	3%
RU 3	4%	0%	0%	4%	29%	6%	56%	53%	9%	31%	1%	6%
SU 4-2	4%	0%	0%	4%	21%	5%	49%	45%	13%	23%	0%	23%
SU 4-3	11%	0%	0%	11%	29%	5%	52%	42%	7%	38%	1%	4%
SU 4-4	4%	0%	0%	4%	30%	4%	58%	52%	8%	35%	1%	5%
SU 4-5	12%	0%	0%	12%	28%	4%	53%	50%	7%	33%	0%	1%
RU 4	7%	0%	0%	7%	29%	5%	55%	47%	8%	36%	0%	5%
SU 5-1	36%	0%	0%	36%	25%	0%	30%	28%	7%	30%	2%	6%
SU 5-2	19%	0%	0%	19%	16%	0%	55%	20%	7%	52%	3%	8%
RU 5	26%	0%	0%	26%	20%	0%	44%	23%	7%	43%	2%	7%
SU 6-2	5%	0%	4%	5%	89%	35%	0%	59%	0%	0%	1%	1%
SU 6-3	4%	0%	1%	4%	81%	34%	9%	51%	0%	5%	5%	5%
SU 6-4	2%	0%	1%	2%	87%	76%	10%	19%	0%	3%	0%	0%
RU 6	4%	0%	1%	4%	82%	37%	8%	50%	0%	5%	5%	5%
All	**7%**	**0%**	**<1%**	**7%**	**35%**	**8%**	**49%**	**47%**	**7%**	**32%**	**2%**	**5%**

In 2020 the LOPFA uneven-aged stands (Table 35) are dominated by the young and mid-aged forest structural stages with a combined overall distribution of 70 percent. The young forest stage ranges from a low of 12 percent in SU 5-2 to a high of 70 percent in SU 6-3. The mid-age forest stage ranges from a low of 5 percent in SU 6-4 to a high of 66 percent in SU 4-5. Overall, there are no VSS 1 stands, distribution of VSS 2 is deficit by 9 percent, VSS 5 is deficit by 6 percent and VSS 6 is approaching desired at 16 percent.

As stand development continues, the distribution shifts toward the later stages by 2050. The mid-aged structural stage is dominating with a distribution of 42 percent, ranging from a low of 2 percent in SU 6-4 to a high of 72 percent in SU 6-3. The overall distribution of the mature and old forest stages are slightly above desired at 25 percent each. The VSS 5 range is 1 to 50 percent and the VSS 6 range is 6 to 79 percent. In 2050, there are no VSS 1 or VSS 2 stands. The overall distribution of VSS 3 is deficit by 12 percent.

Table 35. Alternative A - 2020 and 2050 VSS Distribution for Goshawk LOPFA Uneven Aged Stands Percent of Area by Vegetative Structural Stage

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	0%	0%	1%	0%	32%	18%	54%	30%	10%	46%	3%	6%
SU 1-2	0%	0%	4%	2%	43%	10%	42%	54%	8%	25%	2%	8%
SU 1-3	0%	0%	4%	0%	38%	14%	34%	46%	7%	22%	17%	17%
SU 1-4	0%	0%	0%	0%	61%	5%	30%	64%	3%	25%	6%	6%
SU 1-5	0%	0%	0%	0%	28%	6%	52%	44%	12%	41%	6%	8%
RU 1	0%	0%	2%	0%	37%	10%	43%	47%	9%	33%	9%	10%
SU 3-1	0%	0%	0%	0%	46%	15%	37%	48%	15%	25%	2%	11%
SU 3-2	0%	0%	0%	0%	15%	4%	41%	21%	37%	43%	7%	32%
SU 3-3	0%	0%	0%	0%	31%	4%	51%	57%	13%	26%	5%	14%
SU 3-4	0%	0%	0%	0%	14%	2%	50%	36%	24%	50%	12%	12%
SU 3-5	0%	0%	0%	0%	41%	11%	42%	53%	5%	24%	11%	12%
RU 3	0%	0%	0%	0%	31%	7%	45%	45%	18%	31%	7%	17%
SU 4-2	0%	0%	0%	0%	28%	2%	50%	44%	23%	33%	0%	21%
SU 4-3	0%	0%	0%	0%	37%	5%	33%	39%	20%	35%	10%	21%
SU 4-4	0%	0%	0%	0%	33%	9%	45%	41%	18%	34%	4%	16%
SU 4-5	0%	0%	0%	0%	18%	2%	66%	59%	7%	23%	10%	16%
RU 4	1%	0%	0%	0%	34%	7%	41%	41%	19%	34%	7%	19%
SU 5-1	0%	0%	0%	0%	28%	12%	37%	34%	8%	22%	27%	33%
SU 5-2	0%	0%	0%	0%	12%	0%	8%	13%	24%	8%	56%	79%
RU 5	0%	0%	0%	0%	16%	3%	14%	18%	20%	11%	50%	69%

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 6-2	0%	0%	0%	0%	59%	6%	17%	57%	0%	13%	23%	24%
SU 6-3	0%	0%	4%	0%	70%	11%	22%	72%	0%	7%	4%	11%
SU 6-4	0%	0%	0%	0%	78%	56%	5%	2%	0%	1%	17%	17%
RU 6	0%	0%	3%	0%	69%	15%	20%	64%	0%	7%	9%	14%
All	**0%**	**0%**	**1%**	**0%**	**36%**	**8%**	**34%**	**42%**	**14%**	**25%**	**16%**	**25%**

The PFA even-aged stands (Table 36) show a similar trend as the LOPFA even-aged stands. In 2020, they are dominated by the young and mid-aged forest structural stages with a combined overall distribution of 88 percent, more than twice the desired. The young forest stage ranges from a low of 0 percent in SU 3-5 to a high of 81 percent in SU 1-4. The mid-age forest stage ranges from a low of 0 percent in SU 6-2 to a high of 75 percent in SU 1-5. Overall distribution of VSS 1 is deficit by 7 percent, VSS 2 is deficit by 9 percent, VSS 5 is deficit by 13 percent and VSS 6 is deficit by 19 percent.

As stand development continues, the distribution shifts toward the later stages by 2050. The mid-aged and mature forest structural stages are dominating with a combined overall distribution of 84 percent. The mid-age forest stage ranges from a low of 7 percent in SU 6-2 to a high of 92 percent in SU 1-4. The mature forest stage ranges from a low of 0 percent in SUs 6-2 and 6-3 to a high of 53 percent in SU 5-2. In 2050, there are no VSS 1 stands. The overall distribution of VSS 2 is deficit by 7 percent, VSS 3 is deficit by 13 percent and VSS 6 is deficit by 14 percent.

Table 36. Alternative A - 2020 and 2050 VSS Distribution for Goshawk PFA Even Aged Stands Percent of Area by Vegetative Structural Stage

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
SU 1-2	0%	0%	0%	0%	71%	0%	29%	71%	0%	29%	0%	0%
SU 1-3	0%	0%	0%	0%	30%	0%	70%	78%	0%	22%	0%	0%
SU 1-4	0%	0%	0%	0%	81%	0%	19%	92%	0%	8%	0%	0%

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9”)		2 – Seedling/ Sapling (1.0 - 4.9”)		3 – Young Forest (5.0 - 11.9”)		4 – Mid-age Forest (12.0 - 17.9”)		5 – Mature Forest (18.0 - 23.9”)		6 – Old Forest (24.0” +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-5	0%	0%	0%	0%	25%	9%	75%	54%	0%	37%	0%	0%
RU 1	0%	0%	0%	0%	50%	3%	50%	73%	0%	24%	0%	0%
SU 3-1	2%	0%	0%	2%	34%	0%	51%	85%	13%	13%	0%	0%
SU 3-2	0%	0%	0%	0%	21%	0%	66%	53%	13%	47%	0%	0%
SU 3-3	13%	0%	0%	13%	34%	0%	51%	63%	3%	22%	0%	3%
SU 3-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
SU 3-5	32%	0%	0%	32%	0%	0%	68%	57%	0%	12%	0%	0%
RU 3	11%	0%	0%	11%	28%	0%	55%	64%	6%	24%	0%	2%
SU 4-2	4%	0%	0%	4%	29%	8%	36%	50%	30%	11%	0%	27%
SU 4-3	1%	0%	0%	1%	27%	3%	67%	59%	4%	32%	1%	4%
SU 4-4	0%	0%	0%	0%	40%	2%	51%	70%	10%	24%	0%	5%
SU 4-5	0%	0%	0%	0%	34%	10%	61%	29%	5%	62%	0%	0%
RU 4	1%	0%	0%	1%	32%	4%	59%	59%	8%	30%	0%	6%
SU 5-1	4%	0%	0%	4%	60%	38%	25%	38%	11%	9%	0%	11%
SU 5-2	0%	0%	0%	0%	15%	0%	62%	24%	22%	53%	1%	23%
RU 5	3%	0%	0%	3%	44%	25%	38%	33%	15%	24%	1%	15%
SU 6-2	3%	0%	0%	3%	58%	51%	0%	7%	0%	0%	40%	40%
SU 6-3	8%	0%	14%	8%	55%	30%	11%	47%	0%	0%	13%	16%
SU 6-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
RU 6	7%	0%	12%	7%	55%	32%	10%	43%	0%	0%	15%	18%
All	**3%**	**0%**	**1%**	**3%**	**36%**	**7%**	**52%**	**58%**	**7%**	**26%**	**1%**	**6%**

The PFA uneven-aged stands (Table 37) show a similar trend as the LOPFA uneven-aged stands. In 2020 they are dominated by the young and mid-aged forest structural stages with a combined overall distribution of 79 percent. The young forest stage ranges from a low of 0 percent in SUs 1-4 and 4-5 to a high of 100 percent in SU 1-1. The mid-age forest stage ranges from a low of 0 percent in SU 1-1 to a high of 82 percent in SU 6-2. Overall, there are no VSS 1 stands,

distribution of VSS 2 is deficit by 9 percent, VSS 5 is approaching desired at 15 percent and VSS 6 is deficit by 15 percent.

As stand development continues, the distribution shifts toward the later stages by 2050. The mid-aged structural stage is dominating with a distribution 51 percent, ranging from a low of 0 percent in SU 1-4 to a high of 100 percent in SU 1-1. The overall distribution of the mature and old forest stages are slightly above desired at 23 and 21 percent respectively. The VSS 5 range is 0 to 77 percent and the VSS 6 range is 0 to 66 percent. In 2050, there are no VSS 1 or VSS 2 stands. The overall distribution of VSS 3 is deficit by 15 percent.

Table 37. Alternative A - 2020 and 2050 VSS Distribution for Goshawk PFA Uneven-Aged Stands Percent of Area by Vegetative Structural Stage

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	0%	0%	0%	0%	100%	0%	0%	100%	0%	0%	0%	0%
SU 1-2	0%	0%	0%	0%	38%	0%	6%	38%	27%	32%	29%	29%
SU 1-3	0%	0%	0%	0%	21%	0%	71%	74%	7%	18%	0%	7%
SU 1-4	0%	0%	0%	0%	0%	0%	90%	0%	0%	90%	10%	10%
SU 1-5	0%	0%	0%	0%	66%	0%	13%	73%	13%	6%	8%	21%
RU 1	0%	0%	0%	0%	41%	0%	42%	67%	11%	19%	6%	14%
SU 3-1	0%	0%	0%	0%	23%	5%	55%	19%	22%	77%	0%	0%
SU 3-2	0%	0%	0%	0%	8%	0%	84%	27%	8%	66%	0%	7%
SU 3-3	0%	0%	0%	0%	25%	1%	45%	60%	28%	9%	2%	31%
SU 3-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
SU 3-5	0%	0%	0%	0%	60%	0%	25%	81%	15%	4%	0%	15%
RU 3	2%	0%	0%	1%	23%	1%	56%	48%	19%	33%	1%	18%
SU 4-2	0%	0%	0%	0%	40%	11%	25%	29%	35%	39%	0%	21%
SU 4-3	0%	0%	0%	0%	34%	5%	51%	49%	14%	30%	2%	15%
SU 4-4	0%	0%	0%	0%	18%	3%	52%	37%	29%	33%	0%	26%
SU 4-5	0%	0%	0%	0%	0%	0%	34%	34%	66%	0%	0%	66%
RU 4	0%	0%	0%	0%	29%	5%	47%	42%	23%	32%	1%	20%
SU 5-1	0%	0%	0%	0%	16%	0%	54%	26%	21%	44%	9%	30%

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 5-2	0%	0%	0%	0%	10%	0%	44%	52%	35%	3%	10%	45%
RU 5	0%	0%	0%	0%	13%	0%	49%	39%	28%	23%	10%	38%
SU 6-2	0%	0%	1%	0%	6%	11%	82%	29%	0%	39%	11%	21%
SU 6-3	0%	0%	1%	0%	64%	18%	24%	58%	0%	1%	11%	24%
SU 6-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
RU 6	0%	0%	1%	0%	60%	16%	28%	59%	0%	2%	11%	23%
All	**0%**	**0%**	**<1%**	**0%**	**35%**	**5%**	**44%**	**51%**	**15%**	**23%**	**5%**	**21%**

Old Growth

Table 38 displays the old growth structural attributes of the ponderosa pine allocated old growth acres projected out to the years 2020 and 2050 under the no action alternative.

In 2020, the average conditions are at or above the minimum criteria with the following exceptions:

- Trees per acre larger than 18" and 180 years old. This condition is deficit in all SUs ranging from a low of 10 TPA in SU 6-2 to a high of 18.8 TPA in SU 3-4 with an overall average for all acres of 15.9 TPA. The age of these trees is estimated be in the range of 100 to 140 years old with a few relic trees meeting the 180 year old criteria.
- Coarse woody debris greater than 12". This condition is estimated to be deficit with less than the equivalent of 2 pieces per acre throughout RU 4 and 6, and various SUs.
- Snags per acre. This condition is estimated to be deficit with less than 1 snag per acre in SUs 6-2 and 6-3 and for RU 6 overall.

Over time, old growth conditions improve in terms of meeting the minimum criteria. In 2050, all RUs meet or exceed the criteria for TPA larger than 18" with the exception of RU 6. The age of these trees is estimated be in the range of 130 to 170 years old. Coarse woody debris greater than 12" remains deficit in RU 6. It is estimated that all the other criteria will be met throughout the allocated old growth acres.

Table 38. Alternative A – 2020 and 2050 Ponderosa Pine Allocated OG Structural Attributes by Restoration Unit

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
1-1	3,578	16.1	25.4	130	160	.5	.9	1.7	3.2
1-2	2,034	13.8	23.6	112	142	.4	.9	1.6	3.1
1-3	18,300	16.1	25.7	140	165	.8	1.5	2.7	4.8
1-4	6,323	14.5	24.3	129	157	.5	1.1	2.2	4.2
1-5	34,955	18.0	27.7	156	176	.9	1.9	3.6	6.3
1	65,189	16.8	26.4	145	168	.8	1.6	2.9	5.3
3-1	6,216	16.1	26.9	132	159	.4	1.0	2.2	3.9
3-2	9,317	18.2	28.1	124	151	.4	1.0	2.0	3.4
3-3	15,624	16.9	27.2	142	166	.6	1.3	2.8	4.8
3-4	4,201	18.8	28.5	158	178	.9	2.0	3.7	6.4
3-5	11,160	18.2	28.5	157	178	1.0	1.9	3.5	6.1
3	46,518	17.5	27.8	142	166	.6	1.4	2.8	4.8
4-2	3,710	15.9	25.3	114	143	.3	.7	1.6	2.7
4-3	20,144	15.0	25.3	118	146	.4	.9	1.9	3.5
4-4	22,175	16.8	28.5	130	159	.4	.9	2.1	3.7
4-5	2,031	17.9	30.7	147	173	.6	1.3	2.9	5.0
4	48,060	16.0	27.0	125	153	.4	.9	2.0	3.6
5-1	6,352	14.5	23.0	113	141	.7	1.2	1.9	3.6
5-2	18,394	14.0	20.8	94	120	.6	1.1	1.5	2.9
5	24,745	14.2	21.3	98	125	.6	1.1	1.6	3.0
6-2	1,689	10.0	15.7	98	134	.3	.5	.7	1.7
6-3	8,210	10.7	16.9	106	144	.3	.5	.7	1.8
6-4	392	10.7	15.7	122	154	.4	.8	1.2	2.7
6	10,291	10.6	16.6	105	143	.3	.5	.7	1.8
All:	**194,804**	**15.9**	**25.4**	**129**	**156**	**.6**	**1.2**	**2.3**	**4.2**

Table 39 displays the old growth structural attributes of the pinyon-juniper allocated old growth acres projected out to the years 2020 and 2050 under the no action alternative. In 2020, the average conditions are at or above the minimum criteria with the exception of tree age and CWD. The age of the 12" and larger trees is estimated to be approximately 90 to 120 years old with a few relic trees approaching the 200 year old criteria. The CWD is slightly below the equivalent of 2 pieces per acre. By 2050, the average conditions on the old growth acres meet or exceed the minimum criteria with the exception of tree age.

Table 39. Alternative A – 2020 and 2050 Pinyon-Juniper Allocated Old Growth Structural Attributes by Restoration Unit

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
1	611	43	63	125	160	.2	.6	1.7	3.4
3	2,103	41	56	113	145	.2	.6	1.6	3.0
4	4,158	36	50	106	140	.2	.5	1.1	2.3
5	7,302	43	63	125	160	.2	.6	1.7	3.4
6	1,452	40	54	132	161	.4	.8	1.4	2.6
All:	15,626	40	57	118	151	.3	.6	1.5	2.9

Openness

Table 10 lists the existing openness classification for ponderosa pine within the analysis area. In the absence of restoration treatments, existing openness is expected to continue on the same trajectory with at least 75 percent of the ponderosa pine classified as moderately closed to closed by 2020. As the forest develops over time and existing openings gradually fill in, some of the areas will move from an open to moderately closed condition and some of the areas will move from a moderately closed to closed condition.

Forest Structure and Diversity - Mosaic of interspaces and tree groups of varying sizes and shapes

Under alternative A, no treatments would be implemented to create a mosaic of interspaces and tree groups. Existing interspace would continue to be encroached upon by expanding tree crowns and ingrowth. Any large scale tree mortality occurring has the potential to enhance interspace and create tree groups.

Forest Structure - All age and size classes represented

The MSO habitat forest structure analysis above indicates adequate representation in the 12-17.9" size class, stocking trending toward adequate in the 18-23.9" size class and inadequate representation in 24"+ size class (Table 31). There would be no implementation of group

selection within the restricted other habitat. These areas would trend toward a decreased representation of the seedling/sapling age class and low successional stage diversity.

The goshawk habitat structural stage analysis above indicates overall VSS distribution in all goshawk habitats will trend toward the mid-aged and mature structural stages with an overall underrepresentation throughout stages VSS 1, 2, 3 and VSS 6 in the even-aged stands (Table 34 through Table 37).

Old Forest Structure Sustained Over Time Across the Landscape

The MSO habitat forest structure analysis above indicates stocking trending toward adequate in the 18-23.9" size class and inadequate representation in 24"+ size class (Table 31).

The goshawk habitat structural stage analysis above indicates the mature and old forest structural stages to be underrepresented in even-aged stands and to be trending toward desired in uneven-aged stands (Table 34 through Table 37).

The old growth analysis above indicates old growth structural attributes will continue to develop across the landscape under the no action alternative (Table 38).

The sustainability of the large/old tree component across the landscape may be impaired by density related mortality and forest health issues as discussed in following section.

Forest Health

Density related mortality –

Over the next 10 years, stand densities within all MSO habitat would increase to levels ranging from an average of 51-89% of maximum stand density (Table 31). These density levels are at the threshold of, or well within the zone of density related mortality and extremely high density (Table 7). Modeled stand development from 2020 to 2050 indicates growth stagnation and an increase in mortality in much of the protected and target/threshold habitat.

In goshawk habitat, Table 32 shows 2020 ponderosa pine density levels range from an average of 32-60% of maximum density within nest/PFA habitat and Table 33 shows 30-55% in LOPFA habitat. These density levels are within the moderate to extremely high density zones (Table 7). Overall averages show both habitats within the high density zone. In 2050, the nest/PFA habitat in SUs 1-3, 1-4, 1-5 and 4-4 and the LOPFA habitat in SUs 3-4 and 3-5 have reached extremely high density. Overall averages indicate both habitats to be on the upper end of the high density zone and approaching the threshold for the onset of density related mortality.

Bark beetle related mortality –

Table 40 lists the beetle hazard rating for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. The overall hazard in 2020 is high across 83% of the analysis area. This increases to 92% in 2050. Stands with a hazard rating of high would be expected to have low resistance to successful bark beetle attack and be susceptible to large scale mortality.

Table 40. Alternative A – 2020 and 2050 Beetle Hazard Rating (Percent of Areas)

Hazard Rating	RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
Low - 2020	3%	4%	7%	1%	0%	4%
Low - 2050	0%	1%	2%	0%	0%	1%
Moderate - 2020	3%	7%	18%	37%	9%	13%
Moderate - 2050	3%	5%	7%	25%	0%	7%
High - 2020	94%	88%	75%	62%	91%	83%
High - 2050	97%	93%	91%	75%	100%	92%

Dwarf mistletoe infection –

Table 41 lists the dwarf mistletoe infection level and average percent of trees infected for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. For 2020, approximately 59 percent of the area is not infected or has a low infection level and 41 percent has a moderate to high infection level. The average percent of trees infected ranges from 5 to 11 percent in none/low group and 34 to 59 percent in the moderate/high group. The percentages for 2050 show an increase in the percent of area within the moderate/high infection level group and also an overall increase the average percent of trees infected. This is an indication that mistletoe infection is intensifying and spreading over time.

Table 41. Alternative A – 2020 and 2050 Dwarf Mistletoe Infection Level

Infection Level		RU 1		RU 3		RU 4		RU 5		RU 6		Analysis Area	
		20	50	20	50	20	50	20	50	20	50	20	50
None/ Low	Percent of Area	45%	42%	46%	45%	71%	67%	78%	67%	81%	81%	59%	56%
None/ Low	Average Percent Trees Infected	5%	5%	6%	7%	6%	7%	11%	10%	7%	7%	7%	7%
Moderate/High	Percent of Area	54%	57%	54%	55%	29%	32%	22%	33%	19%	15%	41%	43%
Moderate/High	Average Percent Trees Infected	47%	49%	40%	44%	49%	51%	36%	34%	59%	59%	45%	47%
Extreme	Percent of Area	1%	1%	<1%	<1%	<1%	<1%	0%	0%	0%	4%	<1%	1%
Extreme	Average Percent Trees Infected	88%	87%	93%	92%	90%	89%	-	-	-	81%	89%	85%

Climate Change

The dense forest conditions resulting from the no action alternative are at a high risk to density related and bark beetle mortality and have limited resilience to survive and recover from potential

large scale impacts. Under drier and warmer weather conditions, the potential impacts of these risks to ecosystem would be increased.

Carbon stocks under the no action alternative remain high. Individual tree growth is low to the point of stagnation. As tree density increases, many areas would experience higher mortality (release of carbon) than growth (carbon storage). This trend would result in areas becoming a carbon source to the atmosphere.

Vegetation Diversity and Composition

Grasslands –

Ponderosa pine tree canopy would continue to increase, shading out understory herbaceous vegetation and further reducing forage production and species diversity. Historic grasslands, savannas and forest openings would not be restored.

Oak and Aspen –

Ponderosa pine tree canopy would continue to increase, shading out Gambel oak and aspen mid and understory trees. Oak and aspen growth and vigor would continue to be stagnated due to competition with pine resulting in lowered resistance to insects and disease and eventual mortality. Oak and aspen regeneration ability would continue to be impaired.

Pine Sage –

Ponderosa pine tree canopy would continue to increase, shading out understory sage further reducing the sage component and the historic pattern within the pine sage mosaic.

Other Direct and Indirect Effects:

Tractor Yarding and Fuel Treatment

There would be no harvest or tractor yarding of material. There would be no fuel treatments that reduce understory stocking, reduce inter-tree competition, or stimulate understory vegetation (shrubs, forbs, grass). There would be no fireline construction. There would be no cutting treatments, therefore, there would be no activity fuels in need of treatment. Natural fuels would not be reduced, and would continue to accumulate.

Timber and Wood Products

There would be no beneficial effect of timber harvest by meeting the Coconino and Kaibab forest plan goals of providing a sustained-yield of forest products and provide a sustained level of timber outputs to support local dependent industries.

Road Maintenance, Decommissioning, Reconstruction, Opening, and Temp Road Construction

Road maintenance would continue at current levels. No road decommissioning, construction of temporary roads, opening closed roads or reconstructing roads would occur. Vegetation development (ingrowth and mortality) within current road rights of way would continue on the current trajectory.

Aspen Fencing and Barriers

No fences or barriers to protect aspen clones from browsing would be constructed. Browsing of aspen would continue at current levels.

Restoration of Riparian Habitat, Ephemeral Streams and Springs

No treatments adjacent to or within riparian habitat, ephemeral streams, seeps and springs would occur.

Items Common to All Action Alternatives

See Chapter 2 for a list of items common to all action alternatives.

Alternative B - Proposed Action

See Chapter 2 for a complete list of activities and a description of the treatments that are proposed for Alternative B.

The proposed action would implement approximately 587,923 acres of restoration activities (within the 988,764 acre project area). Restoration activities would:

- Mechanically cut trees and burn approximately 388,489 acres. This includes ponderosa pine restoration treatments within 302,548 acres of northern goshawk habitat and 84,177 acres of Mexican spotted owl habitat, 1,229 acres of aspen restoration, 535 acres of pinyon-juniper wildland urban interface treatments.
- Prescribe burn-only approximately 199,435 acres. Burn only treatments would occur within 120,484 acres of ponderosa pine and 223 of acres of aspen with the remaining 78,729 acres occurring in the PJ, oak woodland, grassland and non-vegetated cover types operationally to facilitate burning the ponderosa pine and aspen. Within the ponderosa pine, 96,928 acres are within northern goshawk habitat and 23,519 acres are within Mexican spotted owl habitat.

Table 42 summarizes the vegetation treatments for Alternative B by cover type in each restoration unit.

Table 42. Alternative B mechanical treatment and prescribed fire acres by restoration unit (RU)

Treatment	Cover Type	RU 1	RU 3	RU 4	RU 5	RU 6	Total Treatment Acres
Mechanical treatment with prescribed fire	Ponderosa Pine	121,640	113,344	109,395	12,372*	29,974	386,725
	Aspen	182	201	453	392	0	1,229
	PJ	0	0	0	0	535	535
	All	**121,822**	**113,546**	**109,848**	**12,765**	**30,509**	**388,489**
Prescribed fire only	Ponderosa Pine	20,098	15,202	24,794	49,175	11,215	120,483
	Aspen	167	0	46	10	0	223
	PJ	1,422	5,884	7,282	8,845	1,684	25,117
	Oak Woodland	275	1,633	926	523	30	3,387
	Grassland	8,230	12,519	22,665	4,987	93	48,493

	Non-Vegetated	120	134	129	1,301	48	1,732
	All	**30,311**	**35,371**	**55,843**	**64,841**	**13,069**	**199,435**
Mechanical Treatment and Prescribed Fire Totals		**152,133**	**148,917**	**165,690**	**77,606**	**43,578**	**587,923**

*This figure includes 99 acres of thin by Hand on slopes > 40% and prescribe burn.

Table 43 summarizes alternative B acres of treatment type within goshawk habitat. See chapter 2 for a description of treatment objectives.

Table 43. Alternative B summary of Acres proposed for treatments in ponderosa pine goshawk habitat

Vegetation Treatment Type	Foraging	Post-Fledgling Family Area (PFA)	Dispersal Post-Fledgling Family Area (dPFA)	Total Acres
Prescribed Fire Only	86,933	8,733	1,299	96,965
Mechanical with Prescribed Fire				
Uneven-aged (UEA) – Group Selection/Intermediate Thinning	146,674	9,639	4,446	160,760
Intermediate Thinning (IT)	53,997	3,807	1,022	58,825
Stand Improvement Thinning (SI)	19,980	991	76	21,047
Savanna	45,469	0	0	45,469
Grassland Restoration	11,185	0	0	11,185
Pine-Sage	4,674	392	196	5,261
Total Mechanical with Prescribed Fire:	**281,979**	**14,828**	**5,740**	**302,548**
Total acres proposed for treatment in goshawk habitat	**368,912**	**23,561**	**7,039**	**399,512**

Table 44 summarizes alternative B acres of treatment type within MSO habitat. See chapter 2 for a description of treatment objectives.

Table 44. Alternative B summary of acres of treatments in ponderosa pine MSO habitat

Treatment Type*	Protected	Restricted	Target/ Threshold	Total Acres
Prescribed Fire Only	20,864	2,354	301	23,519
MSO Restricted		65,024		65,024
MSO Target			6,518	6,518
MSO Threshold			1,894	1,894
PAC – Mechanical	10,741			10,741
Total	**31,605**	**67,378**	**8,713**	**107,696**

Direct and Indirect Effects – Alternative B

Mexican Spotted Owl Habitat

Table 45 displays the MSO habitat forest structure and habitat components projected out to the years 2020 and 2050.

- Year 2020 summary: Basal area density is within the desired range in all habitats. SDI is in the extremely high density zone within the target/threshold and protected habitats (with the exception of RU 4) and on the high end of the desired range within restricted other habitat. This is largely due to the limited mechanical treatment in the protected habitat and the high oak stocking in the restricted habitat. The distribution of size classes is at or exceeds desired minimum in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class exceeds desired minimum in the restricted other habitat and is below desired minimum in the target/threshold habitat. Average trees per acre 18” and larger are very close to desired minimum in the target/threshold habitat and well below desired minimum in restricted other. Overall average Gambel oak basal area is above the desired minimum in all habitats but is limited in RU5 and RU 1 restricted other. All habitats are approaching desired minimum CWD >12” and are below desired minimum in snags >18”.
- Year 2050 summary: Basal area is above the desired minimum for target/threshold habitat and above the desired range for restricted other. The SDI density remains in the extremely high zone within the target/threshold and protected habitats and is higher than the desired range in restricted other. The distribution of size classes is at or exceeds desired minimum in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class also exceeds desired minimum in the restricted other habitat and remains below desired minimum in the target/threshold habitat. Average trees per acre 18” and larger exceed desired minimum in the target/threshold habitat and remain below desired minimum in restricted other. Overall average Gambel oak basal area is above the desired minimum in all habitats but remains limited in RU5 and RU 1 restricted other. All habitats show an increase in CWD >12” between 2020 and 2050. Snags >18” also show an increase in target/threshold and protected habitat while remaining static in restricted other.

Table 45. Alternative B - 2020 and 2050 Spotted Owl Habitat Forest Structure and Habitat Components

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9”		18.0 – 23.9”		24.0” +		Avg. TPA 18”+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12”		Snags >18”	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
Restricted Target/ Threshold*																		
RU 1	144	175	73%	81%	29%	24%	20%	25%	9%	11%	19.6	28.4	25%	24%	1.2	2.1	.5	1.4
RU 3	149	181	78%	85%	25%	21%	19%	21%	9%	12%	19.0	26.7	29%	28%	.7	1.8	.7	1.6
All	146	178	75%	83%	28%	23%	20%	23%	9%	11%	19.3	27.6	27%	26%	1.0	1.9	.6	1.5
Restricted Other																		
RU 1	74	107	35%	46%	22%	19%	22%	19%	19%	20%	11.4	16.7	19%	18%	.7	1.5	.8	.8
RU 3	81	114	38%	50%	22%	18%	22%	19%	17%	18%	11.6	17.3	24%	23%	.8	1.7	1.0	.9
RU 4	80	115	39%	52%	20%	17%	21%	17%	19%	19%	11.4	16.4	26%	25%	.7	1.6	1.0	1.0
RU 5	64	98	30%	42%	21%	21%	17%	15%	21%	18%	8.3	12.9	13%	15%	.4	1.0	.6	.6
All	78	111	37%	49%	22%	19%	22%	19%	18%	19%	11.5	17.0	22%	21%	.8	1.6	.9	.9
Protected																		
RU 1	154	175	72%	75%	32%	28%	17%	25%	9%	12%	17.8	28.0	13%	14%	.7	2.0	.7	1.7
RU 3	168	189	79%	82%	31%	26%	18%	24%	10%	13%	20.9	31.0	12%	12%	1.0	2.5	.8	1.9
RU 4	106	128	50%	55%	35%	38%	14%	24%	5%	8%	10.9	19.8	8%	8%	.5	1.5	.4	1.3

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9”		18.0 – 23.9”		24.0” +		Avg. TPA 18”+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12”		Snags >18”	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
RU 5	143	168	68%	74%	31%	26%	17%	22%	9%	13%	16.9	26.5	11%	11%	1.0	2.4	.7	1.7
All	154	175	72%	76%	32%	27%	17%	24%	9%	12%	18.0	28.2	13%	13%	.8	2.1	.7	1.7

*These are average conditions for both target and threshold habitats combined. Treatments within threshold habitat will not reduce forest density/structure or habitat components below threshold conditions.

Goshawk Habitat

Table 46 displays the overall goshawk habitat structure attributes projected out to the years 2020 and 2050. Average conditions include trees, interspaces, and canopy gaps as represented by the stand data. These average habitat conditions are a function of openness and tree group density across the different scales (restoration sub-unit, restoration unit, ponderosa pine extent).

- Year 2020 summary: At the habitat and RU scale all habitats are within the desired density range with the exception of RU 6 PFA. The pre-treatment RU 6 PFAs have low stocking (below the DC of 70 ft²), typical of RU 6 site conditions with patches of dense VSS 3. The treatments focus on thinning the dense patches and maintaining canopy cover in the mid-aged, mature and old (VSS 4, 5 and 6), further reducing overall density. Tons of coarse woody debris and snags per acre are below desired throughout all goshawk habitat.
- Year 2050 summary: At the habitat and RU scale all habitats remain within the desired SDI range. Basal area is at or above the desired of 70 ft². Tons of coarse woody debris exceeds the minimum desired with the exception of RU 6 PFA and LOPFA. Snags remain below desired levels.

Table 46. Alternative B - Goshawk Nest/PFA Habitat Forest Structure and Habitat Components

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
1-1	21%	29%	97	89	55	79	2.2	4.6	.3	1.0	.8	.4
1-2	28%	33%	99	86	72	94	2.9	5.9	.6	1.5	1.1	.8
1-3	25%	32%	79	72	68	93	3.6	6.0	.9	1.7	1.0	.9
1-4	29%	36%	108	94	75	100	6.1	8.4	3.2	3.6	.8	.9
1-5	29%	33%	74	64	79	97	3.7	7.4	.8	2.2	1.4	1.6
1	27%	33%	85	75	73	95	3.9	6.8	1.1	2.1	1.1	1.1
3-1	27%	32%	81	72	71	91	2.6	5.5	.5	1.5	1.2	1.0
3-2	29%	35%	90	79	78	99	2.5	5.8	.5	1.7	1.2	1.1
3-3	27%	33%	89	79	72	95	2.9	5.7	.6	1.5	1.0	.9
3-5	29%	35%	104	91	77	99	3.0	6.7	.6	1.9	1.1	.9
3	28%	34%	90	80	74	96	2.8	5.8	.6	1.6	1.1	1.0
4-2	26%	32%	87	79	69	91	2.2	4.8	.4	1.3	1.1	.8
4-3	29%	35%	96	84	77	100	2.9	6.1	.8	1.8	1.1	.9

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
4-4	29%	35%	92	81	78	100	3.8	6.6	1.4	2.2	1.0	1.0
4-5	31%	36%	98	82	82	101	3.1	6.7	.6	1.8	1.0	1.4
4	29%	35%	94	82	77	99	3.1	6.2	.9	1.9	1.1	.9
5-1	28%	34%	90	79	73	95	3.7	6.9	1.1	2.1	1.1	1.0
5-2	28%	32%	71	63	76	94	2.8	6.4	.7	2.1	1.5	1.5
5	28%	33%	82	72	74	95	3.3	6.6	.9	2.1	1.3	1.2
6-2	19%	23%	56	50	48	66	1.9	4.4	.3	1.0	1.0	.5
6-3	21%	27%	78	71	51	71	1.9	4.4	.4	1.0	.9	.5
6	21%	26%	76	69	51	70	1.9	4.4	.3	1.0	.9	.5
All	**27%**	**33%**	**88**	**78**	**72**	**94**	**3.0**	**6.0**	**.8**	**1.8**	**1.1**	**.9**

Table 47. Alternative B - Goshawk LOPFA Habitat Forest Structure and Habitat Components

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
1-1	21%	28%	74	69	56	78	2.7	4.5	.7	1.3	.8	.6
1-2	17%	22%	52	47	46	62	2.2	4.1	.5	1.2	.8	.8
1-3	19%	24%	59	55	49	68	2.7	4.5	.7	1.3	.8	.7
1-4	21%	26%	68	61	54	73	2.7	4.8	.6	1.3	.8	.8
1-5	24%	28%	65	58	62	80	3.4	6.0	.9	1.9	1.1	1.3
1	21%	26%	64	58	56	74	3.0	5.1	.8	1.6	.9	1.0
3-1	20%	25%	63	58	52	72	2.3	4.3	.5	1.2	.9	.8
3-2	19%	24%	54	49	53	71	2.0	3.9	.6	1.3	1.0	.9
3-3	20%	26%	61	55	53	73	3.0	5.0	.8	1.5	.9	.9
3-4	25%	30%	69	62	67	87	3.6	6.4	1.0	2.1	1.3	1.2
3-5	27%	32%	85	74	71	91	3.9	7.0	.9	2.0	1.1	1.1
3	22%	27%	67	59	59	78	2.9	5.3	.7	1.6	1.0	.9

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
4-2	17%	22%	52	48	45	64	1.9	3.5	.5	1.0	.8	.6
4-3	21%	27%	71	62	57	77	2.5	5.0	.6	1.4	1.0	.8
4-4	21%	27%	66	59	56	76	2.7	4.8	.7	1.4	.9	.9
4-5	23%	29%	79	71	62	83	3.2	5.8	.7	1.6	.9	.8
4	21%	27%	68	61	56	76	2.6	4.9	.6	1.4	.9	.8
5-1	21%	25%	67	60	54	72	2.6	5.4	.5	1.4	1.1	.9
5-2	22%	26%	64	56	61	78	2.2	5.2	.5	1.6	1.4	.9
5	22%	26%	65	57	59	76	2.3	5.3	.5	1.5	1.3	.9
6-2	19%	24%	64	59	46	67	1.8	3.8	.3	.9	.7	.4
6-3	22%	28%	80	72	52	74	1.9	4.3	.3	.8	.6	.4
6-4	22%	27%	81	68	57	74	3.7	7.2	.5	1.5	1.2	.8
6	21%	27%	78	70	52	73	2.1	4.5	.3	.9	.7	.5
All	**21%**	**27%**	**67**	**60**	**57**	**76**	**2.7**	**5.0**	**.6**	**1.4**	**1.0**	**.9**

Table 48 through Table 51 display the VSS distribution for even age and uneven age stands by goshawk habitat projected out to the years 2020 and 2050.

In 2020, overall distribution within the LOPFA even-aged stands (Table 48) shows VSS 1 slightly above desired at 13 percent, no VSS 2, VSS 3 right at desired with 20 percent, VSS 4 almost twice desired at 39 percent, VSS 5 slightly above desired with 24 percent and VSS 6 deficit by 17 percent. There is a more balanced overall distribution compared to the no action alternative with improvement toward the desired representation in the grass/forb/shrub, young, mid-aged and mature forest stages.

As stand development progresses, the distribution shifts toward the later stages by 2050. The mid-aged, mature and old forest structural stages account for a combined overall distribution of 84 percent. This is very similar to the combined distribution of these stages in alternative A with the difference being alternative A results in a higher percentage of VSS 4 while alternative B results in a higher percentage of VSS 6. In 2050, there are no VSS 1 stands and the overall distribution shows VSS 2 close to desired at 13 percent, VSS 3 deficit by 17 percent, VSS 4 and VSS 5 above desired at 29 and 34 percent respectively and VSS 6 right at desired with 21 percent.

Table 48. Alternative B - 2020 and 2050 VSS Distribution for Goshawk LOPFA Even-Aged Stands Percent of Area by Vegetative Structural Stages

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	10%	0%	0%	10%	15%	0%	50%	37%	16%	38%	9%	16%
SU 1-2	7%	0%	0%	7%	0%	0%	50%	30%	42%	19%	0%	44%
SU 1-3	7%	0%	0%	7%	12%	0%	54%	39%	23%	31%	4%	24%
SU 1-4	9%	0%	0%	9%	15%	0%	59%	46%	17%	30%	1%	16%
SU 1-5	7%	0%	0%	7%	16%	0%	49%	32%	25%	38%	3%	23%
RU 1	8%	0%	0%	8%	13%	0%	52%	36%	24%	33%	3%	23%
SU 3-1	10%	0%	0%	10%	21%	11%	31%	18%	33%	35%	6%	25%
SU 3-2	13%	0%	0%	13%	9%	4%	25%	9%	44%	32%	9%	41%
SU 3-3	11%	0%	0%	11%	14%	2%	36%	30%	36%	34%	2%	23%
SU 3-4	8%	0%	0%	8%	13%	0%	36%	21%	41%	48%	2%	24%
SU 3-5	8%	0%	0%	8%	20%	0%	45%	35%	24%	47%	2%	11%
RU 3	10%	0%	0%	10%	16%	3%	36%	25%	34%	38%	4%	23%
SU 4-2	9%	0%	0%	9%	20%	5%	15%	17%	34%	25%	23%	44%
SU 4-3	16%	0%	0%	16%	22%	3%	38%	28%	22%	35%	2%	18%
SU 4-4	11%	0%	0%	11%	13%	3%	43%	23%	31%	37%	2%	27%
SU 4-5	18%	0%	0%	18%	15%	0%	41%	27%	26%	38%	0%	17%
RU 4	13%	0%	0%	13%	17%	3%	40%	25%	27%	36%	3%	23%
SU 5-1	39%	0%	0%	39%	22%	0%	27%	24%	11%	25%	1%	12%
SU 5-2	20%	0%	0%	20%	13%	0%	55%	19%	9%	51%	3%	10%
RU 5	28%	0%	0%	28%	17%	0%	43%	21%	10%	40%	2%	11%
SU 6-2	8%	0%	0%	8%	86%	18%	0%	69%	0%	0%	5%	6%
SU 6-3	8%	0%	0%	8%	77%	16%	8%	62%	0%	7%	7%	8%
SU 6-4	3%	0%	0%	3%	87%	0%	9%	87%	0%	9%	1%	1%
RU 6	8%	0%	0%	8%	78%	15%	8%	64%	0%	7%	6%	7%
All	**13%**	**0%**	**0%**	**13%**	**20%**	**3%**	**39%**	**29%**	**24%**	**34%**	**3%**	**21%**

In 2020, overall distribution within the LOPFA uneven-aged stands (Table 49) shows VSS 1 slightly below desired at 7 percent, no VSS 2, VSS 3 and VSS 4 right at desired with 19 and 20 percent respectively, VSS 5 15 percent above desired and VSS 6 right at desired with 19 percent. This is a more balanced overall distribution compared to the no action alternative with improvement toward desired representation in the grass/forb/shrub, and young, mid-aged and old forest stages.

As stand development progresses, the distribution shifts toward the later stages by 2050. The mid-aged, mature and old forest structural stages account for a combined overall distribution of 92 percent. This is very similar to the combined distribution of these stages in alternative A with the difference being alternative A results in a higher percentage of VSS 4 while alternative B results in a higher percentage of VSS 6. In 2050, there are no VSS 1 stands and the overall distribution shows VSS 2 below desired at 6 percent, VSS 3 deficit by 18 percent, VSS 4 and VSS 5 right at desired with 19 and 20 percent respectively and VSS 6 well above desired with 53 percent.

Table 49. Alternative B - 2020 and 2050 VSS Distribution for Goshawk LOPFA Uneven-Aged Stands Percent of Area by Vegetative Structural Stage

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	13%	0%	0%	13%	23%	0%	10%	12%	50%	11%	4%	64%
SU 1-2	8%	0%	0%	8%	10%	0%	33%	8%	40%	27%	10%	57%
SU 1-3	10%	0%	0%	10%	11%	0%	7%	4%	52%	10%	21%	76%
SU 1-4	7%	0%	0%	7%	7%	0%	39%	19%	40%	28%	6%	46%
SU 1-5	7%	0%	0%	7%	8%	0%	30%	9%	49%	41%	7%	43%
RU 1	8%	0%	0%	8%	10%	0%	23%	10%	48%	27%	10%	55%
SU 3-1	14%	0%	0%	9%	19%	5%	15%	15%	47%	11%	6%	60%
SU 3-2	8%	0%	0%	8%	6%	0%	17%	5%	49%	16%	21%	71%
SU 3-3	6%	0%	0%	6%	13%	0%	19%	9%	51%	20%	10%	64%
SU 3-4	8%	0%	0%	8%	1%	0%	18%	1%	61%	42%	12%	49%
SU 3-5	7%	0%	0%	7%	14%	0%	42%	19%	27%	41%	9%	33%
RU 3	8%	0%	0%	7%	12%	1%	23%	11%	46%	24%	12%	57%
SU 4-2	10%	0%	0%	9%	14%	2%	11%	2%	56%	11%	9%	76%
SU 4-3	5%	0%	0%	5%	25%	0%	25%	26%	32%	21%	12%	47%
SU 4-4	9%	0%	0%	9%	13%	0%	19%	14%	50%	19%	8%	58%

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 4-5	8%	0%	0%	8%	2%	0%	21%	11%	60%	43%	10%	39%
RU 4	7%	0%	0%	7%	18%	0%	22%	18%	42%	20%	10%	54%
SU 5-1	4%	0%	0%	4%	20%	0%	22%	26%	28%	28%	26%	43%
SU 5-2	1%	0%	0%	1%	11%	0%	7%	12%	25%	7%	56%	81%
RU 5	1%	0%	0%	1%	13%	0%	11%	15%	26%	11%	49%	72%
SU 6-2	4%	0%	0%	4%	52%	8%	16%	44%	0%	15%	27%	29%
SU 6-3	9%	0%	1%	9%	53%	15%	23%	50%	1%	12%	13%	14%
SU 6-4	0%	0%	0%	0%	75%	1%	5%	78%	0%	1%	20%	20%
RU 6	7%	0%	1%	7%	55%	12%	20%	52%	1%	12%	16%	17%
All	**7%**	**0%**	**<1%**	**6%**	**19%**	**2%**	**20%**	**19%**	**35%**	**20%**	**19%**	**53%**

In 2020, overall distribution within the PFA even-aged stands (Table 50) shows VSS 1 slightly below desired at 9 percent, no VSS 2, VSS 3 close to desired with 24 percent, VSS 4 more than twice desired at 45 percent, VSS 5 below desired with 14 percent and VSS 6 deficit by 12 percent. There is a more balanced overall distribution compared to the no action alternative with improvement toward the desired representation in the grass/forb/shrub, young, mature and old forest stages.

As stand development progresses, the distribution shifts toward the later stages by 2050. The mid-aged, mature and old forest structural stages account for a combined overall distribution of 89 percent. This is very similar to the combined distribution of these stages in alternative A with the difference being alternative A results in a higher percentage of VSS 4 while alternative B results in a higher percentage of VSS 5. In 2050, there are no VSS 1 stands and the overall distribution shows VSS 2 close to desired at 9 percent, VSS 3 deficit by 18 percent, VSS 4 and VSS 5 above desired at 42 and 38 percent respectively and VSS 6 below desired with 9 percent.

Table 50. Alternative B - 2020 and 2050 VSS Distribution for Goshawk PFA Even Aged Stands Percent of Area by Vegetative Structural Stage

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
SU 1-2	5%	0%	0%	5%	37%	0%	58%	68%	0%	27%	0%	0%
SU 1-3	8%	0%	0%	8%	30%	0%	25%	30%	37%	59%	0%	2%
SU 1-4	8%	0%	0%	8%	24%	0%	21%	75%	0%	17%	47%	0%
SU 1-5	4%	0%	0%	4%	9%	0%	43%	37%	43%	58%	0%	0%
RU 1	6%	0%	0%	6%	23%	0%	36%	52%	22%	41%	13%	0%
SU 3-1	12%	0%	0%	12%	16%	0%	60%	33%	13%	42%	0%	13%
SU 3-2	9%	0%	0%	9%	21%	0%	58%	33%	11%	47%	0%	11%
SU 3-3	19%	0%	0%	19%	26%	0%	41%	33%	14%	45%	0%	3%
SU 3-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
SU 3-5	32%	0%	0%	32%	0%	0%	57%	49%	12%	20%	0%	0%
RU 3	22%	0%	0%	17%	20%	0%	42%	35%	16%	42%	0%	6%
SU 4-2	12%	0%	0%	12%	16%	7%	60%	20%	13%	32%	0%	30%
SU 4-3	7%	0%	0%	7%	22%	3%	58%	43%	9%	42%	4%	4%
SU 4-4	8%	0%	0%	8%	20%	1%	39%	44%	18%	37%	15%	10%
SU 4-5	3%	0%	0%	3%	34%	0%	55%	34%	8%	58%	0%	4%
RU 4	8%	0%	0%	8%	21%	3%	50%	41%	14%	41%	7%	8%
SU 5-1	7%	0%	0%	7%	59%	0%	24%	70%	10%	13%	0%	10%
SU 5-2	3%	0%	0%	3%	0%	0%	75%	13%	20%	62%	1%	21%
RU 5	6%	0%	0%	6%	38%	0%	42%	50%	13%	31%	1%	14%
SU 6-2	3%	0%	0%	3%	58%	0%	0%	58%	0%	0%	40%	40%
SU 6-3	11%	0%	0%	11%	45%	4%	4%	45%	2%	0%	37%	40%
SU 6-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
RU 6	11%	0%	0%	11%	46%	4%	4%	46%	2%	0%	37%	40%
All	**9%**	**0%**	**0%**	**9%**	**24%**	**2%**	**45%**	**42%**	**14%**	**38%**	**8%**	**9%**

In 2020, overall distribution within the PFA uneven-aged stands (Table 51) shows VSS 1 slightly below desired at 8 percent, no VSS 2, VSS 3 slightly below desired with 17 percent, VSS 4 20 percent above desired, VSS 5 5 percent above desired and VSS 6 below desired with 10 percent. This is a more balanced overall distribution compared to the no action alternative with improvement toward desired representation in the grass/forb/shrub, and young, mid-aged and old forest stages.

As stand development progresses, the distribution shifts toward the later stages by 2050. The mid-aged, mature and old forest structural stages account for a combined overall distribution of 92 percent. This is very similar to the combined distribution of these stages in alternative A with the difference being alternative A results in a higher percentage of VSS 4 while alternative B results in a higher percentage of VSS 5 and 6. In 2050, there are no VSS 1 stands and the overall distribution shows VSS 2 close to desired at 8 percent, no VSS 3 stands, VSS 4 and VSS 5 above desired with 28 and 39 percent respectively and VSS 6 slightly above desired with 25 percent.

Table 51. Alternative B - 2020 and 2050 VSS Distribution for Goshawk PFA Uneven Aged Stands Percent of Area by Vegetative Structural Stage

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 1-1	9%	0%	0%	9%	39%	0%	52%	91%	0%	0%	0%	0%
SU 1-2	6%	0%	0%	6%	0%	0%	38%	32%	27%	17%	29%	44%
SU 1-3	10%	0%	0%	10%	6%	0%	30%	19%	50%	64%	4%	7%
SU 1-4	9%	0%	0%	9%	0%	0%	82%	0%	0%	82%	10%	10%
SU 1-5	2%	0%	0%	2%	16%	0%	53%	26%	20%	52%	8%	20%
RU 1	7%	0%	0%	7%	10%	0%	42%	26%	32%	52%	8%	15%
SU 3-1	3%	0%	0%	3%	5%	0%	73%	5%	19%	73%	0%	19%
SU 3-2	5%	0%	0%	5%	7%	0%	81%	7%	8%	81%	0%	8%
SU 3-3	10%	0%	0%	10%	12%	0%	36%	20%	39%	41%	3%	28%
SU 3-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
SU 3-5	10%	0%	0%	10%	4%	0%	67%	51%	18%	23%	0%	15%
RU 3	8%	0%	0%	8%	9%	0%	58%	18%	24%	55%	1%	19%
SU 4-2	10%	0%	0%	10%	22%	0%	38%	36%	30%	24%	0%	30%
SU 4-3	11%	0%	0%	9%	14%	2%	49%	30%	24%	44%	5%	15%
SU 4-4	9%	0%	0%	9%	4%	1%	54%	11%	27%	50%	6%	30%

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
SU 4-5	1%	0%	0%	1%	0%	0%	0%	0%	99%	34%	0%	65%
RU 4	10%	0%	0%	9%	12%	1%	49%	24%	25%	43%	4%	23%
SU 5-1	5%	0%	0%	5%	10%	0%	56%	14%	21%	52%	9%	30%
SU 5-2	3%	0%	0%	3%	4%	0%	22%	9%	61%	44%	10%	44%
RU 5	4%	0%	0%	4%	7%	0%	39%	12%	41%	48%	10%	37%
SU 6-2	1%	0%	0%	1%	5%	0%	20%	5%	0%	20%	74%	74%
SU 6-3	8%	0%	0%	8%	47%	0%	10%	57%	11%	1%	24%	34%
SU 6-4	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%	-%
RU 6	8%	0%	0%	8%	44%	0%	11%	53%	10%	2%	27%	37%
All	**8%**	**0%**	**0%**	**8%**	**17%**	**0%**	**40%**	**28%**	**25%**	**39%**	**10%**	**25%**

Old Growth

Table 52 displays the old growth structural attributes of the ponderosa pine allocated old growth acres projected out to the years 2020 and 2050 under alternative B.

In 2020, the average conditions are at or above the minimum criteria with the following exceptions:

- Trees per acre larger than 18" and 180 years old. This condition is deficit in all SUs ranging from a low of 8.9 TPA in SU 6-2 to a high of 16.6 TPA in SU 3-4 with an overall average for all acres of 13.6 TPA. The age of these trees is estimated be in the range of 100 to 140 years old with a few relic trees meeting the 180 year old criteria.
- Basal area ≥90. This condition is below desired in RUs 3, 4, 5 and 6. Overall average for all acres is 82.
- Coarse woody debris greater than 12". This condition is estimated to be deficit with less than the equivalent of 2 pieces per acre throughout RU 5 and 6, and various SUs.

Over time, old growth conditions improve in terms of meeting the minimum criteria. In 2050, all RUs are very close to or exceed the criteria for TPA larger than 18" with the exception of RU 6. The age of these trees is estimated be in the range of 130 to 170 years old. It is estimated that all the other criteria will be met throughout the allocated old growth acres.

Table 52. Alternative B – 2020 and 2050 Ponderosa Pine Allocated OG Structural Attributes by Restoration Unit

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
1-1	3,578	13.2	18.5	73	103	.6	1.2	3.3	1.3
1-2	2,034	11.1	16.6	63	89	.6	1.2	3.7	1.4
1-3	18,300	14.3	20.9	91	119	.7	1.5	3.8	2.7
1-4	6,323	12.7	19.7	89	116	.5	1.3	3.7	2.8
1-5	34,955	16.5	24.4	117	143	.8	1.8	4.6	4.4
1	65,189	15.0	22.1	101	128	.7	1.6	4.1	3.4
3-1	6,216	12.9	18.8	72	101	.6	1.3	4.0	1.5
3-2	9,317	14.5	19.3	70	96	.6	1.3	3.5	1.5
3-3	15,624	14.0	19.8	80	110	.7	1.5	4.3	2.0
3-4	4,201	16.6	23.6	112	138	.9	1.9	4.8	4.0
3-5	11,160	15.4	22.4	91	120	1.0	2.1	5.7	2.7
3	46,518	14.5	20.5	82	111	.8	1.6	4.5	2.1
4-2	3,710	12.3	17.0	62	87	.5	1.1	3.5	1.2
4-3	20,144	12.4	19.3	70	97	.6	1.4	4.8	1.8
4-4	22,175	13.2	19.4	66	95	.6	1.3	3.7	1.2
4-5	2,031	14.4	22.9	78	111	.8	1.6	5.0	1.6
4	48,060	12.8	19.3	68	96	.6	1.3	4.2	1.5
5-1	6,352	12.8	19.8	79	106	.6	1.6	5.3	2.4
5-2	18,394	12.9	19.5	74	97	.5	1.6	5.8	2.3
5	24,745	12.9	19.6	75	99	.5	1.6	5.7	2.3
6-2	1,689	8.9	14.2	63	94	.3	.9	3.9	1.0
6-3	8,210	9.4	15.0	69	104	.3	.9	3.6	.9
6-4	392	9.5	15.4	78	108	.4	1.5	6.6	2.0
6	10,291	9.3	14.9	69	102	.3	.9	3.8	1.0
All:	**194,804**	**13.6**	**20.1**	**82**	**110**	**.7**	**1.5**	**4.4**	**2.3**

Table 53 displays the old growth structural attributes of the pinyon-juniper allocated old growth acres projected out to the years 2020 and 2050 under alternative B. Alternative B proposes burning in the PJ cover type to facilitate burns in the adjacent ponderosa pine cover type. It is assumed that minimal acres would carry a fire in the PJ cover type under prescribed fire conditions. That assumption is difficult to simulate, so the post treatment conditions listed in the table indicate a worst case scenario in terms of fire effects to the PJ acres.

In 2020, the average conditions are at or above the minimum criteria with the exception of TPA >12" and tree age. The age of the 12" and larger trees is estimated to be approximately 90 to 120 years old with a few relic trees approaching the 200 year old criteria. By 2050, the average conditions on the old growth acres meet or exceed the minimum criteria with the exception of tree age.

Table 53. Alternative B – 2020 and 2050 Pinyon-Juniper Allocated Old Growth Structural Attributes by Restoration Unit

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
1	611	25	38	65	94	.5	2.2	16.4	1.5
3	2,103	25	35	62	88	.5	2.2	15.5	1.6
4	4,158	23	33	58	84	.5	1.8	13.0	1.4
5	7,302	25	38	65	94	.5	2.2	16.4	1.5
6	1,452	22	31	67	96	.5	1.8	8.1	1.3
All:	**15,626**	**24**	**35**	**63**	**90**	**.5**	**2.0**	**14.1**	**1.5**

Openness

The variety of treatment types and desired conditions under alternative B would result in a wide range of openness post treatment. The following lists the openness that is projected to result by implementing the treatment types proposed:

- Very Open
  - Grassland Restoration, Savanna.
- Open
  - Pine Sage, WUI55, IT40, SI40, UEA40.
- Moderately Closed
  - Burn Only within LOPFA, PFA and MSO Restricted Other Habitats; MSO Restricted Other, IT25, SI25 and UEA25.
- Closed

- Burn Only within Goshawk Nest, MSO PAC/Protected and Target/Threshold; PAC, Target/Threshold, IT10, SI10 and UEA10.

Table 54 lists the post treatment openness within the ponderosa pine cover type for alternative B by restoration unit and sub unit. Overall ranges indicate a fairly diverse condition with openness leaning to the closed side of the range. Eleven percent of the ponderosa pine would be very open, 31 percent open, 42 percent moderately closed and 15 percent closed. The unknowns are those areas with no treatment proposed under this alternative.

Table 54. Alternative B – Post Treatment Openness Classification for Ponderosa Pine

Restoration Sub-unit / Unit	Very Open	Open	Moderately Closed	Closed	Unknown*
1-1	3%	50%	36%	11%	<1%
1-2	35%	42%	21%	3%	0%
1-3	16%	36%	26%	20%	2%
1-4	14%	46%	20%	19%	2%
1-5	6%	24%	32%	34%	4%
1	10%	32%	29%	26%	3%
3-1	9%	41%	46%	4%	0%
3-2	20%	45%	26%	9%	1%
3-3	16%	39%	34%	10%	1%
3-4	3%	27%	39%	28%	3%
3-5	6%	26%	58%	10%	<1%
3	12%	36%	41%	10%	1%
4-2	31%	50%	11%	8%	0%
4-3	16%	32%	40%	11%	<1%
4-4	19%	49%	21%	10%	<1%
4-5	7%	30%	44%	19%	0%
4	18%	41%	30%	11%	<1%
5-1	4%	8%	75%	13%	1%
5-2	1%	3%	93%	3%	0%
5	2%	5%	87%	6%	0%
6-2	0%	49%	49%	2%	0%
6-3	0%	19%	65%	16%	0%
6	0%	21%	65%	14%	0%

Restoration Sub-unit / Unit	Very Open	Open	Moderately Closed	Closed	Unknown*
All Ponderosa Pine	11%	31%	42%	15%	1%

* These are areas that will not be treated with mechanical and/or prescribed fire treatments. For Alternative B this includes PAC core areas and the Proposed Garland Prairie RNA.

Forest Structure and Diversity - Mosaic of interspaces and tree groups of varying sizes and shapes

While all treatments with the exception of Grassland Restoration are designed to reestablish forest openings and attain a mosaic of interspaces and tree groups of varying sizes and shapes, the intensity of the treatment affects the relative tendency toward this condition. The lower intensity treatments within MSO PAC, Target/Threshold and goshawk nest habitat will result in irregular tree spacing and subtle expansion of existing forest openings. The higher intensity treatments such as UEA 40, IT 40 and SI 40 will be removing more trees and extends greater flexibility in size and shape of interspaces and tree groups generated.

Table 55 lists alternative B acres by treatment intensity as an indication of the relative ability of the treatment to attain a mosaic of interspaces and tree groups and of the post treatment interspace/tree group condition. Forty one percent of the area treated is considered high, 25 percent is moderate, 24 percent is low and 10 percent is very low.

Table 55. Alternative B - summary of ponderosa pine treatment acres by their relative ability to attain a mosaic of interspaces and tree groups.

Treatment Intensity	Treatment Type	Acres (% of Total Treatment)
High	Grassland Restoration	11,185
	Savanna	45,469
	Pine Sage	5,261
	WUI 55	2,268
	UEA 40	101,044
	IT 40	39,189
	SI 40	12,309
Total High:		**216,725 (43%)**
Moderate	MSO Restricted	65,024
	UEA 25	39,244
	IT 25	11,871
	SI 25	6,824
Total Moderate:		**122,963 (24%)**
Low	UEA 10	18,204
	IT 10	7,766
	SI 10	1,914
	NOGO PFA and LOPFA Burn Only	90,126
	MSO Restricted Burn Only	2,354
Total Low:		**120,363 (24%)**
Very Low	NOGO Nest Burn Only	6,839
	MSO PAC	10,741

Treatment Intensity	Treatment Type	Acres (% of Total Treatment)
	MSO Protected Burn Only	20,864
	MSO Target and Threshold	8,412
	MSO Target and Threshold Burn Only	301
Total Very Low:		**47,157 (9%)**

Forest Structure - All age and size classes represented

The MSO habitat forest structure analysis for alternative B indicates the post treatment distribution of size classes has good representation in the 12-18" and the 18-24" size classes in all habitats. Stocking in the 24" + size class has good representation in the restricted other habitat and is underrepresented in the target/threshold habitat (Table 45). Implementation of group selection as part of the restricted other treatments would result in up to 15 percent of the area trending toward early successional stages, thereby increasing representation of the seedling/sapling age class.

The goshawk habitat structural stage analysis for alternative B indicates overall post treatment VSS distribution in the even-aged goshawk habitats will have good representation of the VSS 1, 3 and 4 age classes, and the VSS 5 age class in the LOPFA; under-representation of the VSS 6 age class and the VSS 5 age class in the PFA; no representation of the VSS 2 age class. The uneven-aged goshawk habitats will have good representation in the LOPFA of VSS 3, 4, 5 and 6 and of VSS 4 and 5 in the PFA; VSS 1 is underrepresented in the LOPFA and VSS 1, 3 and 6 are underrepresented in the PFA; there is no representation of the VSS 2 age class in all habitats (Table 48 through Table 51).

Old Forest Structure Sustained Over Time Across the Landscape

The restoration treatments proposed under alternative B are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Old trees would not be targeted for cutting. Reference the Old Tree Implementation Strategy in Appendix A of this report.

The MSO habitat forest structure analysis for alternative B indicates the post treatment distribution of size classes has good representation in the 18-24" size classes in all habitats. Stocking in the 24" + size class has good representation in the restricted other habitat and is underrepresented in the target/threshold habitat (Table 45).

The goshawk habitat structural stage analysis above indicates the mature and old forest structural stages to be underrepresented in the PFA habitat and LOPFA even-aged stands. Projections show a trend toward improved representation in all habitats (Table 48 through Table 51).

Treatments within areas currently allocated OG would maintain existing old growth structural attributes and are managed to move towards those conditions over time. The ponderosa pine old growth analysis above indicates old growth structural attributes would continue to develop and improve across the landscape (Table 52).

With the implementation of restoration treatments under alternative B, the sustainability of the large/old tree component across the landscape would be improved as presented in the following forest health discussion.

Forest Health

Density related mortality –

Stand density in 2020 in the MSO restricted other habitat (Table 45) would have an overall average 37% of maximum density (range 30-39%) putting these stands at the low end of the high density zone as described in Table 7. The restricted other habitat consists of mixed species pine/oak stands. The pine component within this habitat is estimated to have density within the low to moderate zone. The majority of target/threshold and protected habitat would remain in zone 4 due to the oak stocking and dense forest desired conditions in these habitats. Any areas with mechanical treatments within these habitats would experience reduced density related mortality compared to the no action alternative.

In goshawk habitat, Table 46 shows 2020 ponderosa pine density levels average 27% of maximum density within nest/PFA habitat and 21% in LOPFA habitat. These density levels are within the low to moderate density zones (Table 7). In 2050, overall averages indicate both habitats to be within the moderate density zone with a few of the nest/PFA SUs being on the low end of high density and well below the threshold for the onset of density related mortality.

Bark beetle related mortality –

Table 56 lists the beetle hazard rating for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. The overall hazard in 2020 is high across 26% of the analysis area. This increases to 53% in 2050. Stands with a hazard rating of low or moderate would be expected to be resistant to successful bark beetle attack and large scale mortality.

Table 56. Alternative B - Estimated 2020 and 2050 Beetle Hazard Rating (Percent of Area)

Hazard Rating	RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
Low - 2020	28%	35%	51%	42%	38%	39%
Low - 2050	16%	20%	23%	28%	8%	20%
Moderate - 2020	33%	32%	37%	50%	33%	36%
Moderate - 2050	17%	20%	38%	46%	30%	28%
High - 2020	39%	33%	12%	8%	30%	26%
High - 2050	67%	60%	39%	26%	62%	53%

Dwarf mistletoe infection –

Table 57 lists the dwarf mistletoe infection level and average percent of trees infected for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. For 2020, approximately 61 percent of the area is not infected or has a low infection level and 39 percent has a moderate to high infection level. The overall average percent of trees infected is 6 percent in the none/low

group and 39 percent in the moderate/high group. This reflects an improvement from the no action alternative with two percent more area in the none/low group and 2 percent less area in the moderate/high group. Overall percent of trees infected is one percent less in none/low and 6 percent less in moderate/high. The percentages for 2050 indicate mistletoe infection is intensifying and spreading at a slower rate than alternative A.

Table 57. Alternative B Estimated Post Treatment and Long Term Dwarf Mistletoe Infection Level

Infection Level		RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
None/Low - 2020	Percent of Area	48%	48%	71%	78%	82%	61%
None/Low - 2020	Average Percent Trees Infected	5%	5%	5%	11%	6%	6%
Moderate/High - 2020	Percent of Area	51%	52%	29%	22%	18%	39%
Moderate/High - 2020	Average Percent Trees Infected	41%	34%	42%	31%	56%	39%
Extreme - 2020	Percent of Area	1%	<1%	0%	0%	0%	<1%
Extreme - 2020	Average Percent Trees Infected	88%	100%	-	-	-	88%
None/Low - 2050	Percent of Area	45%	46%	70%	68%	82%	58%
None/Low - 2050	Average Percent Trees Infected	6%	6%	7%	10%	7%	7%
Moderate/High - 2050	Percent of Area	54%	54%	30%	32%	18%	42%
Moderate/High - 2050	Average Percent Trees Infected	47%	41%	49%	32%	61%	44%
Extreme - 2050	Percent of Area	1%	<1%	0%	0%	0%	<1%
Extreme - 2050	Average Percent Trees Infected	88%	100%	-	-	-	88%

Climate change –

Risks associated with dense forest conditions would be reduced and resilience to the impacts of large scale disturbance under drier and warmer conditions would be improved by implementing the treatments proposed under alternative B.

Within forest carbon stocks would be reduced under alternative B. Individual tree growth would improve, resulting in larger average trees size and increased carbon storage over time offsetting short term losses of carbon removed through the mechanical thinning. Some of the carbon within the estimated 366,159,029 cubic feet of biomass removed by mechanical thinning would be sequestered for a time in the form of building materials.

Vegetation Diversity and Composition – Maintain and Promote

Grasslands

Alternative B would restore historic grasslands, savannas and forest openings by removing ponderosa pine tree canopy that is shading out understory herbaceous vegetation and reducing forage production and species diversity as follows:

- 11,185 acres of grassland restoration treatments on mollisol soils;
- 45,469 acres of savanna treatments on mollic integrade soils;
- 310,917 acres of ponderosa pine restoration treatments in PFA, LOPFA and MSO restricted other habitats enhancing small grassland inclusions within the greater forested area.

Oak

Treatments proposed in alternative B are designed to conserve oak and improve conditions that favor oak growth and establishment wherever it exists by reducing pine-oak competition. This would result in improved vigor of existing oak and establishment of a variety of oak size and age classes across the landscape. These conditions would be most prevalent within the 65,024 acres of MSO restricted other habitat treatments. Table 45 shows the overall post treatment oak basal area would be 5 percent higher in this habitat compared to the no action alternative (Table 31).

Aspen

The treatments within 1,452 acres of aspen stands under alternative B are designed to maintain and/or regenerate aspen by reducing pine-aspen competition. These treatments would result in establishment of vigorous aspen regeneration free of competition from overtopping ponderosa pine.

Pine Sage

The 5,262 acres of pine-sage thinning treatments are designed to remove post settlement pine that is currently overtopping and shading out the sage and to manage fire to enhance sage extent. These treatments would result in enhancement of the sage component and restore the historic pattern within the pine sage mosaic.

Other Direct and Indirect Effects:

Tractor Yarding and Fuel Treatment

All merchantable harvested material would be whole-tree tractor yarded from the mechanical treatment units. Fuel treatments proposed for Alternative B includes pile burning, broadcast burns and fireline construction. Some damage to the residual trees would be expected with the felling, tractor yarding and piling operations within 386,762 acres of (PPine) mechanical treatments. Damage would be minimized through contract administration and proper harvest methods. All piling and/or low-severity burning treatments on 507,208 (PPine) acres would reduce understory stocking and reduce inter-tree competition as well as stimulate understory vegetation (shrubs, forbs, grasses). Fireline placement would use existing features with naturally low fuels, skid trails, roads etc. as much as possible. Actual fireline construction would remove herbaceous material to bare mineral soil up to a 6 foot width.

Timber and Wood Products

A Coconino FP goal is to manage the timber resource to provide a sustained-yield of forest products (Coc plan pg 23). A Kaibab FP goal is to manage suitable timberland to provide a sustained level of timber outputs to support local dependent industries (Kai Plan pg 18). Timber harvest of 243,302,331 cubic feet of biomass from the Coconino and 122,856,697 cubic feet of biomass from the Kaibab is a direct beneficial effect of Alternative B.

Road Maintenance, Decommissioning, Reconstruction, Opening, and Temp Road Construction

Road maintenance within the existing road prism would have no effect on the health and growth of the leave trees within the treatment units. Road decommissioning of 904 miles of existing system and unauthorized roads would allow ingrowth of forest vegetation once the road is decommissioned (approximately 2,712 acres). Constructing 245 miles of temporary roads will remove trees and forest vegetation within the road right of ways (approximately 735 acres). Opening 272 miles of decommissioned roads may remove trees and forest vegetation that has become established within the road right of way since the road was last maintained (approximately 816 acres). Reconstructing 10 miles of road will remove trees and forest vegetation within the area being reconstructed (approximately 30 acres). Road reconstruction consists of road improvement activities and road realignments activities. Road realignment of 10 miles of road would remove approximately 30 acres of trees and forest vegetation within the area being reconstructed. 30 miles of road improvement is expected to occur on small discreet areas and is expected to remove about 100 acres of forest vegetation. The above listed effects cover the maximum range of management actions. Possible management actions includes: Reestablish former drainage patterns, stabilizing slopes, and restore vegetation; Block the entrance to a road or installing water bars; Remove culverts, reestablish drainages, remove unstable fills, pull back road shoulders, and scatter slash on the roadbed; Completely eliminate the roadbed by restoring natural contours and slopes; and Other methods designed to meet the specific conditions associated with the unneeded road.

Aspen Fencing and Barriers

Up to 82 miles of protective barriers would be established around aspen clone patches within the ponderosa pine forest. Barriers would consist of fencing and/or felling trees (jack-strawing). Fencing would occur after mechanical and burning treatments and would have no effect to the vegetation. Jack-strawing may occur during the mechanical operation and would utilize trees that have been targeted for removal to meet treatment objectives. Leaving felled material on the ground would forego the opportunity to use that material for wood products.

Restoration of Springs and Ephemeral Channels

Springs and ephemeral channels are inclusions within the mechanical and burn treatment areas. Any tree removal that occurs as part of the restoration of these areas would be part of the design for those mechanical treatments that occur around these areas and the effects to the forest vegetation would be similar to the overall treatment. Up to 4 miles of protective fencing would be established around restored springs. Fencing would have no effect to the vegetation. Bank re-contouring and stabilization would occur along 39 miles of ephemeral channels. This activity would disturb existing forest vegetation. Up to 5 miles of willow re-establishment would occur where evidence indicates historic willow presence. This would create vegetation diversity and

allow natural willow expansion into adjacent areas of suitable habitat. The above listed effects cover the maximum range of management actions. Possible management actions for springs include: Remove tree canopy to pre-settlement condition within 2-5 chains of the spring; Apply for water right if none exists; remove noxious weeds; Prescribe burn; Identify stressor and provide protection measure for the stressor (fence, jackstraw, remove/relocate road/trail etc.); And/or other methods designed to meet the desired conditions.

Alternative C

See Chapter 2 for a complete list of activities and a description of the treatments that are proposed for Alternative C.

Alternative C would implement approximately 593,211 acres of restoration activities (within the 988,764 acre project area). Restoration activities would:

- Mechanically cut trees and burn approximately 434,001 acres. This includes ponderosa pine restoration treatments within 301,699 acres of northern goshawk habitat and 82,344 acres of Mexican spotted owl habitat, 1,229 acres of aspen restoration, 535 acres of pinyon-juniper wildland urban interface treatments and 48,196 acres of grassland mechanical treatments.
- Prescribe burn-only approximately 159,211 acres. Burn only treatments would occur within 128,137 acres of ponderosa pine and 242 of acres of aspen with the remaining 30,833 acres occurring in the PJ, oak woodland, grassland and non-vegetated cover types operationally to facilitate burning the ponderosa pine and aspen. Within the ponderosa pine, 97,987 acres are within northern goshawk habitat and 30,202 acres are within Mexican spotted owl habitat.

Table 58 summarizes the vegetation treatments for Alternative C by cover type in each restoration unit. Compared to the proposed action, alternative C proposes 2,684 less acres of mechanical with prescribed fire treatments in the ponderosa pine cover type and 48,196 more acres in the grassland cover type. Alternative C differences from the proposed action for the prescribed fire only treatment includes 7,654 more acres in ponderosa pine, 19 more acres in aspen, 6 more acres in PJ, 12 more acres in oak woodland and 47,914 less acres in the grassland cover type.

Table 58. Alternative C mechanical treatment and prescribed fire acres by restoration unit (RU)

Treatment	Cover Type	RU 1	RU 3	RU 4	RU 5	RU 6	Total Treatment Acres
Mechanical treatment with prescribed fire	Ponderosa Pine	121,988	111,653	109,054	12,372*	29,974	384,041
	Aspen	182	201	453	392	0	1,229
	PJ	0	0	0	0	535	535
	Grassland	8,133	12,775	22,599	4,595	93	48,196
	All	**129,304**	**124,629**	**132,106**	**17,360**	**30,601**	**434,001**
Prescribed fire only	Ponderosa Pine	24,785	17,572	25,247	49,298	11,215	128,137
	Aspen	186	0	46	10	0	242
	PJ	1,427	5,884	7,282	8,845	1,684	25,123
	Oak Woodland	287	1,633	926	523	30	3,399

	Grassland	97	24	66	392	0	579
	Non-Vegetated	120	134	129	1,301	48	1,732
	All	**26,921**	**25,247**	**33,697**	**60,370**	**12,976**	**159,212**
Mechanical Treatment and Prescribed Fire Totals		**156,225**	**149,876**	**165,803**	**77,730**	**43,578**	**593,211**

*This figure includes 99 acres of thin by Hand on slopes > 40% and prescribe burn.

Table 59 summarizes alternative C acres of treatment type within goshawk habitat. See chapter 2 for a description of treatment objectives. Compared to the proposed action, alternative C proposes a total of 969 acres more burn only treatment within the LOPFA and PFA habitats, 5,496 acres less UEA, 163 acres less IT, 65 acres less SI, 7 acres less Savanna, 45 acres more grassland thinning and 4,837 acres of modified UEA (AZGFD design).

Table 59 .Alternative C summary of Acres Proposed for treatments in ponderosa pine goshawk habitat

Vegetation Treatment Type	Foraging	Post-Fledgling Family Area (PFA)	Dispersal Post-Fledgling Family Area (dPFA)	Total Acres
Prescribed Fire Only	87,879	8,756	1,299	97,934
Mechanical with Prescribed Fire				
Uneven-aged (UEA) – Group Selection/Intermediate Thinning	141,476	9,342	4,446	155,264
Uneven-aged (UEA) – AZGFD Design	4,563	274	0	4,837
Intermediate Thinning (IT)	53,834	3,807	1,022	58,662
Stand Improvement Thinning (SI)	19,915	991	76	20,982
Savanna Thinning	45,469	0	0	45,469
Grassland Restoration	11,230	0	0	11,230
Pine-Sage	4,674	392	196	5,262
Total Mechanical with Prescribed Fire:	**281,154**	**14,805**	**5,777**	**301,699**
Total acres proposed for treatment in goshawk habitat	**369,033**	**23,561**	**7,039**	**399,633**

Table 60 summarizes alternative C acres of treatment type within MSO habitat. See chapter 2 for a description of treatment objectives. Compared to the proposed action, alternative C proposes a total of 6,683 acres more burn only treatment in protected and restricted other habitats, 1,833 acres less mechanical/burn treatment in the restricted other habitat, a diameter limit of up to 18" in select PAC thinning treatments and higher intensity thinning in the target/threshold habitat which follows the draft MSO recovery plan minimum conditions (USDI Fish and Wildlife Service 2011).

Table 60. Alternative C summary acres of treatments in ponderosa pine MSO habitat

Treatment Type*	Protected	Restricted	Target/ Threshold	Total Acres
Prescribed Fire Only	25,714	4,187	301	30,202
MSO Restricted		63,191		63,191
MSO Target			6,518	6,518
MSO Threshold			1,894	1,894
PAC Mechanical	10,741			10,741
Total	**36,455**	**67,378**	**8,713**	**112,546**

Direct and Indirect Effects – Alternative C

Mexican Spotted Owl Habitat

Table 61 displays the MSO habitat forest structure and habitat components projected out to the years 2020 and 2050.

- Year 2020 summary: Basal area density is within the desired range in all habitats. SDI is higher than desired within the target/threshold and protected habitat (with the exception of RU 4) and on the high end of the desired range within restricted other habitat. This is largely due to the limited mechanical treatment in the protected habitat and the high oak stocking in the restricted habitat. The distribution of size classes is at or exceeds minimum desired in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class exceeds minimum desired in the restricted other habitat and is below minimum desired in the target/threshold habitat. Average trees per acre 18” and larger is within 2 TPA of minimum desired in the target/threshold habitat and well below minimum desired in restricted other. Overall average Gambel oak basal area is above minimum desired in all habitats except RU5 restricted other where it is a limited component within that landscape. All habitats are approaching minimum desired CWD >12” and are below minimum desired in snags >18”.
- Year 2050 summary: Basal area is above the desired range for target/threshold habitat. The average overall basal area in restricted other is 112 ft2 which is the low end of the desired range for MSO nesting/roosting habitat (threshold). SDI density exceeds the desired range in all habitats. The distribution of size classes is at or exceeds minimum desired in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class also exceeds minimum desired in the restricted other habitat and remains below minimum desired in the target/threshold habitat. Average trees per acre 18” and larger exceed minimum desired in the target/threshold habitat and remain below minimum desired in restricted other. Overall average Gambel oak basal area is above minimum desired in all habitats except RU5 restricted other. All habitats show an increase in CWD >12” between 2020 and 2050. Snags >18” also show an increase in target/threshold and protected habitat while remaining static in restricted other.

Table 61. Alternative C - 2020 and 2050 Spotted Owl Habitat Forest Structure and Habitat Components

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9"		18.0 – 23.9"		24.0" +		Avg. TPA 18"+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
Restricted Target/ Threshold*																		
RU 1	132	167	68%	79%	23%	22%	20%	21%	10%	12%	18.4	24.2	28%	27%	1.3	2.0	.5	1.2
RU 3	142	176	75%	84%	22%	20%	19%	19%	10%	13%	18.3	24.2	31%	30%	.8	1.7	.7	1.4
All	136	171	71%	81%	23%	21%	20%	20%	10%	12%	18.3	24.2	29%	28%	1.1	1.9	.6	1.3
Restricted Other																		
RU 1	74	107	35%	46%	22%	20%	22%	19%	19%	19%	11.3	16.7	19%	18%	.8	1.5	.9	.8
RU 3	81	115	38%	50%	22%	19%	22%	19%	17%	18%	11.5	17.4	24%	23%	.8	1.7	1.0	1.0
RU 4	80	115	39%	52%	20%	17%	21%	17%	19%	19%	11.4	16.4	26%	25%	.7	1.6	1.0	1.0
RU 5	64	98	30%	42%	21%	21%	17%	15%	21%	18%	8.3	12.9	13%	15%	.4	1.0	.6	.6
All	78	112	37%	49%	22%	19%	22%	19%	18%	19%	11.4	17.0	22%	21%	.8	1.6	1.0	.9
Protected																		
RU 1	151	173	70%	74%	32%	27%	18%	25%	9%	13%	17.8	28.2	14%	14%	.7	2.0	.7	1.7
RU 3	166	188	78%	82%	31%	26%	18%	24%	10%	13%	20.9	31.2	12%	12%	.9	2.4	.8	1.9
RU 4	105	128	49%	55%	35%	38%	14%	24%	5%	8%	10.9	19.9	8%	8%	.4	1.4	.4	1.3

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9”		18.0 – 23.9”		24.0” +		Avg. TPA 18”+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12”		Snags >18”	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
RU 5	143	168	68%	74%	31%	26%	17%	22%	9%	13%	16.9	26.5	12%	11%	.9	2.3	.7	1.7
All	**152**	**174**	**71%**	**75%**	**32%**	**27%**	**18%**	**25%**	**9%**	**13%**	**18.1**	**28.4**	**13%**	**14%**	**.7**	**2.1**	**.7**	**1.7**

*These are average conditions for both target and threshold habitats combined. Treatments within threshold habitat will not reduce forest density/structure or habitat components below threshold conditions.

Goshawk Habitat

An analysis of the goshawk structure attributes for alternative C showed very minor differences in LOPFA habtitat SUs 3-2, 3-5, and 4-3 compared to alternative B (Table 46). All numbers and percentages are the same for alternative C as alternative B for the remaining SUs and at the RU and habitat scales. Therefore, the summary (prior to Table 46) of post treatment and 2050 habitat conditions for alternative B is the same for alternative C.

An analysis of the VSS distribution within goshawk habitat for alternative C showed very minor differences compared to alternative B (Table 48 through Table 51). These differences are listed in Table 62 at the RU and habitat scale. All percentages are the same for alternative C as alternative B for all other stages and years in each of the RUs and habitats. Therefore, the narrative summaries (prior to Table 48 through Table 51) describing post treatment and 2050 VSS distribution by habitat for alternative B are essentially the same for alternative C with the same trends.

Table 62. Alternative C - 2020 and 2050 VSS Distribution Differences Compared to Alternative B Percent of Area by Vegetative Structural Stages

Area	1 – Grass/Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
LOPFA Even Age												
RU 3							37% (+1)	26% (+1)	33% (-1)			24% (+1)
All							40% (+1)					
LOPFA Uneven Age												
RU 3							24% (+1)		45% (-1)	25% (+1)		56% (-1)
RU 4								19% (+1)		21% (+1)		53% (-1%)
PFA Even Age												
RU 3	17% (-5)				21% (-1)		48% (-6)		13% (-3)			
RU 4							52% (+2)				5% (-2)	
All					**25% (+1)**		**46% (+1)**				**6% (-2)**	

Old Growth

Table 63 displays the old growth structural attributes of the ponderosa pine allocated old growth acres projected out to the years 2020 and 2050 under alternative C.

In 2020, the average conditions are at or above the minimum criteria with the following exceptions:

- Trees per acre larger than 18" and 180 years old. This condition is deficit in all SUs ranging from a low of 8.9 TPA in SU 6-2 to a high of 16.6 TPA in SUs 1-5 and 3-4 with an overall average for all acres of 13.6 TPA. The age of these trees is estimated be in the range of 100 to 140 years old with a few relic trees meeting the 180 year old criteria.
- Basal area ≥90. This condition is below desired in RUs 3, 4, 5 and 6. Overall average for all acres is 82.
- Coarse woody debris greater than 12". This condition is estimated to be deficit with less than the equivalent of 2 pieces per acre throughout RU 5 and 6, and various SUs.

Over time, old growth conditions improve in terms of meeting the minimum criteria. In 2050, all RUs are very close to or exceed the criteria for TPA larger than 18" with the exception of RU 6. The age of these trees is estimated be in the range of 130 to 170 years old. It is estimated that all the other criteria will be met throughout the allocated old growth acres.

Table 63. Alternative C – Allocated OG Structural Attributes by Restoration Unit

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
1-1	3,578	13.1	18.4	72	103	.6	1.2	3.3	1.3
1-2	2,034	11.1	16.6	63	89	.6	1.2	3.7	1.4
1-3	18,300	14.1	20.6	89	118	.8	1.5	3.8	2.6
1-4	6,323	12.7	19.7	89	116	.5	1.3	3.7	2.8
1-5	34,955	16.5	24.2	115	141	.8	1.8	4.7	4.2
1	65,189	14.9	21.9	99	127	.7	1.6	4.2	3.3
3-1	6,216	12.8	18.7	71	101	.6	1.3	4.0	1.5
3-2	9,317	14.5	19.3	70	97	.6	1.3	3.6	1.5
3-3	15,624	14.0	19.9	80	110	.7	1.5	4.4	2.0
3-4	4,201	16.5	23.4	111	138	.9	1.9	4.8	3.9
3-5	11,160	15.3	22.5	91	121	1.0	2.1	5.8	2.7
3	46,518	14.4	20.5	82	111	.8	1.6	4.5	2.1
4-2	3,710	12.3	17.0	62	87	.5	1.1	3.5	1.2
4-3	20,144	12.4	19.4	71	98	.6	1.4	4.8	1.8
4-4	22,175	13.3	19.7	67	96	.6	1.3	3.8	1.3

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
4-5	2,031	14.4	22.9	78	111	.8	1.6	5.0	1.6
4	48,060	12.9	19.5	69	97	.8	1.3	4.2	1.5
5-1	6,352	12.8	19.8	79	106	.6	1.6	5.4	2.4
5-2	18,394	12.9	19.5	74	97	.5	1.6	5.8	2.3
5	24,745	1.9	19.6	75	99	.5	1.6	5.7	2.3
6-2	1,689	8.9	14.2	63	94	.3	.9	3.9	1.0
6-3	8,210	9.4	15.0	69	104	.3	.9	3.6	.9
6-4	392	9.5	15.4	78	108	.4	1.5	6.6	2.0
6	10,291	9.3	14.9	69	102	.3	.9	3.8	1.0
All:	**194,804**	**13.6**	**20.1**	**82**	**110**	**.7**	**1.5**	**4.5**	**2.2**

Alternative C proposes the same treatments in the pinyon-juniper cover type as alternative B. See Table 53 and the associated effects discussion for pinyon-juniper old growth.

Openness

The variety of treatment types and desired conditions under alternative C would result in a wide range of openness post treatment. The list of resulting openness by treatment type displayed for alternative B is the same for alternative C. Under alternative C, the closed classification also includes the modified UEA treatment (AZGFD design).

Table 64 lists the post treatment openness within the ponderosa pine cover type for alternative C by restoration unit and sub unit. Overall ranges indicate a fairly diverse condition with openness leaning to the closed side of the range. Eleven percent of the ponderosa pine would be very open, 30 percent open, 42 percent moderately closed and 17 percent closed.

Table 64. Alternative C – Post Treatment Openness Classification for Ponderosa Pine

Restoration Unit-Subunit	Very Open	Open	Moderately Closed	Closed
1-1	3%	50%	36%	11%
1-2	35%	42%	21%	3%
1-3	16%	36%	26%	22%

Restoration Unit-Subunit	Very Open	Open	Moderately Closed	Closed
1-4	14%	46%	20%	21%
1-5	6%	24%	32%	38%
1	10%	32%	29%	29%
3-1	9%	41%	46%	4%
3-2	21%	44%	27%	9%
3-3	16%	36%	35%	13%
3-4	3%	27%	39%	31%
3-5	6%	23%	58%	12%
3	12%	34%	41%	12%
4-2	31%	50%	11%	8%
4-3	16%	30%	40%	13%
4-4	19%	45%	22%	14%
4-5	7%	30%	44%	19%
4	18%	39%	30%	13%
5-1	4%	8%	75%	13%
5-2	1%	3%	93%	3%
5	2%	5%	87%	6%
6-2	0%	49%	49%	2%
6-3	0%	19%	65%	16%
6-4	0%	2%	95%	3%
6	0%	21%	65%	14%
All Ponderosa Pine	**11%**	**30%**	**42%**	**17%**

Forest Structure and Diversity - Mosaic of interspaces and tree groups of varying sizes and shapes

Table 65 lists alternative C acres by treatment intensity as an indication of the relative ability of the treatment to attain a mosaic of interspaces and tree groups and of the post treatment interspace/tree group condition. Forty one percent of the area treated is considered high, 25 percent is moderate, 24 percent is low and 10 percent is very low.

Table 65. Alternative C summary of ponderosa pine treatment acres by their relative ability to attain a mosaic of interspaces and tree groups.

Treatment Intensity	Treatment Type	Acres (% of Total Treatment)
High	Grassland Restoration	11,230
	Savanna	45,462
	Pine Sage	5,261
	WUI 55	2,268
	UEA 40	95,712
	IT 40	39,039
	SI 40	12,244
Total High:		**211,215 (41%)**
Moderate	MSO Restricted	63,191
	UEA 25	39,176
	IT 25	11,858
	SI 25	6,824
Total Moderate:		**121,050 (24%)**
Low	UEA AZGFD Design	4,837
	UEA 10	18,109
	IT 10	7,766
	SI 10	1,914
	NOGO PFA and LOPFA Burn Only	91,057
	MSO Restricted Burn Only	2,354
Total Low:		**126,074 (25%)**
Very Low	NOGO Nest Burn Only	6,839
	MSO PAC	10,741
	MSO Protected Burn Only	25,714
	MSO Target and Threshold	8,412
	MSO Target and Threshold Burn Only	301
Total Very Low:		**52,007 (10%)**

Forest Structure - All age and size classes represented

The MSO habitat forest structure analysis for alternative C indicates the post treatment distribution of size classes has good representation in the 12-18" and the 18-24" size classes in all habitats. Stocking in the 24" + size class has good representation in the restricted other habitat and is underrepresented in the target/threshold habitat (Table 61). Implementation of group selection as part of the restricted other treatments would result in up to 15 percent of the area trending toward early successional stages, thereby increasing representation of the seedling/sapling age class.

The goshawk habitat structural stage analysis for alternative C indicates overall post treatment VSS distribution in the even-aged goshawk habitats will have good representation of the VSS 1, 3 and 4 age classes, and the VSS 5 age class in the LOPFA; under-representation of the VSS 6 age class and the VSS 5 age class in the PFA; no representation of the VSS 2 age class. The uneven-aged goshawk habitats will have good representation in the LOPFA of VSS 3, 4, 5 and 6 and of VSS 4 and 5 in the PFA; VSS 1 is underrepresented in the LOPFA and VSS 1, 3 and 6 are

underrepresented in the PFA; there is no representation of the VSS 2 age class in all habitats (Table 48 through Table 51 and Table 62).

Old Forest Structure Sustained Over Time Across the Landscape

The restoration treatments proposed under alternative C are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Old trees would not be targeted for cutting. Reference the Old Tree Implementation Strategy in Appendix A of this report.

The MSO habitat forest structure analysis for alternative C indicates the post treatment distribution of size classes has good representation in the 18-24" size classes in all habitats. Stocking in the 24" + size class has good representation in the restricted other habitat and is underrepresented in the target/threshold habitat (Table 61).

The goshawk habitat structural stage analysis above indicates the mature and old forest structural stages to be underrepresented in the PFA habitat and LOPFA even-aged stands. Projections show a trend toward improved representation in all habitats (Table 48 through Table 51 and Table 62).

Treatments within areas currently allocated OG will maintain existing old growth structural attributes and are managed to move towards those conditions over time. The old growth analysis above indicates old growth structural attributes will continue to develop and improve across the landscape (Table 63).

With the implementation of restoration treatments under alternative C, the sustainability of the large/old tree component across the landscape will be improved as presented in the following forest health discussion.

Forest Health

Density related mortality –

Stand density in 2020 in the MSO restricted other habitat (Table 61) would have an overall average 37% of maximum density (range 30-39) putting these stands at the low end of the high density zone as described in Table 7. The restricted other habitat consists of mixed species pine/oak stands. The pine component within this habitat is estimated to have density within the low to moderate zone. The majority of target/threshold and protected habitat would remain in zone 4 due to the oak stocking and dense forest desired conditions in these habitats. Any areas with mechanical treatments within these habitats would experience reduced density related mortality compared to the no action alternative.

In goshawk habitat, Table 46 (as a representation of both alternative B and C conditions) shows 2020 ponderosa pine density levels average 27% of maximum density within nest/PFA habitat and 21% in LOPFA habitat. These density levels are within the low to moderate density zones (Table 7). In 2050, overall averages indicate both habitats to be within the moderate density zone with a few of the nest/PFA SUs being on the low end of high density and well below the threshold for the onset of density related mortality.

Bark beetle related mortality –

Table 66 lists the beetle hazard rating for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. The overall hazard in 2020 is high across 26% of the analysis area. This increases to 53% in 2050. Stands with a hazard rating of low or moderate would be expected to be resistant to successful bark beetle attack and large scale mortality.

Table 66. Alternative C Estimated Post Treatment and Long Term Beetle Hazard Rating (Percent of Area)

Hazard Rating	RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
Low - 2020	27%	35%	50%	42%	38%	38%
Low - 2050	15%	20%	23%	28%	8%	19%
Moderate - 2020	33%	32%	37%	50%	33%	36%
Moderate - 2050	16%	20%	37%	46%	30%	27%
High - 2020	40%	33%	12%	8%	30%	26%
High - 2050	68%	61%	40%	27%	62%	53%

Dwarf mistletoe infection –

Table 67 lists the dwarf mistletoe infection level and average percent of trees infected for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. For 2020, approximately 60 percent of the area is not infected or has a low infection level and 40 percent has a moderate to high infection level. The overall average percent of trees infected is 6 percent in the none/low group and 39 percent in the moderate/high group. This reflects an improvement from the no action alternative with one percent more area in the none/low group and one percent less area in the moderate/high group. Overall percent of trees infected is one percent less in none/low and 8 percent less in moderate/high. The percentages for 2050 indicate mistletoe infection is intensifying and spreading at a slower rate than alternative A.

Table 67. Alternative C Estimated Post Treatment and Long Term Dwarf Mistletoe Infection Level

Infection Level		RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
None/Low - 2020	Percent of Area	47%	48%	71%	78%	82%	60%
None/Low - 2020	Average Percent Trees Infected	5%	5%	5%	11%	6%	6%
Moderate/High - 2020	Percent of Area	52%	52%	29%	22%	18%	40%
Moderate/High - 2020	Average Percent Trees Infected	41%	34%	42%	31%	56%	39%
Extreme - 2020	Percent of Area	1%	<1%	0%	0%	0%	<1%

Infection Level		RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
Extreme - 2020	Average Percent Trees Infected	87%	100%	-	-	-	87%
None/Low - 2050	Percent of Area	44%	46%	69%	68%	82%	57%
None/Low - 2050	Average Percent Trees Infected	6%	6%	7%	10%	7%	7%
Moderate/High - 2050	Percent of Area	55%	54%	31%	32%	18%	43%
Moderate/High - 2050	Average Percent Trees Infected	47%	41%	49%	32%	61%	44%
Extreme - 2050	Percent of Area	1%	<1%	0%	0%	0%	<1%
Extreme - 2050	Average Percent Trees Infected	86%	100%	-	-	-	87%

Climate change –

Risks associated with dense forest conditions would be reduced and resilience to the impacts of large scale disturbance under drier and warmer conditions would be improved by implementing the treatments proposed under alternative C.

Within forest carbon stocks would be reduced under alternative C. Individual tree growth would improve, resulting in larger average trees size and increased carbon storage over time offsetting short term losses of carbon removed through the mechanical thinning. Some of the carbon within the estimated 367,737,165 cubic feet of biomass removed by mechanical thinning would be sequestered for a time in the form of building materials.

Vegetation Diversity and Composition

Grasslands

Alternative C would restore historic grasslands, savannas and forest openings by removing ponderosa pine tree canopy that is shading out understory herbaceous vegetation and reducing forage production and species diversity as follows:

- 48,196 acres of grassland mechanical treatments within grassland cover type;
- 11,230 acres of grassland restoration treatments on mollisol soils;
- 45,469 acres of savanna treatments on mollic integrade soils;
- 308,199 acres of ponderosa pine restoration treatments in PFA, LOPFA and MSO restricted other habitats enhancing small grassland inclusions within the greater forested area.

Oak

Treatments proposed in alternative C are designed to conserve oak and improve conditions that favor oak growth and establishment wherever it exists by reducing pine-oak competition. This would result in improved vigor of existing oak and establishment of a variety of oak size and age classes across the landscape. These conditions would be most prevalent within the 63,191 acres of

MSO restricted other habitat treatments. Table 61 shows the overall post treatment oak basal area would be 5 percent higher in this habitat compared to the no action alternative.

Aspen

The treatments within 1,471 acres of aspen stands under alternative C are designed to maintain and/or regenerate aspen by reducing pine-aspen competition. These treatments would result in establishment of vigorous aspen regeneration free of competition from overtopping ponderosa pine.

Pine Sage

The 5,262 acres of pine-sage thinning treatments are designed to remove post settlement pine that currently is overtopping and shading out the sage and to manage fire to enhance sage extent. These treatments would result in enhancement of the sage component and restore the historic pattern within the pine sage mosaic.

Other Direct and Indirect Effects:

Tractor Yarding and Fuel Treatment

All merchantable harvested material would be whole-tree tractor yarded from the mechanical treatment units. Fuel treatments proposed for Alternative C includes pile burning, broadcast burns and fireline construction. Some damage to the residual trees would be expected with the felling, tractor yarding and piling operations within 384,043 acres of (PPine) mechanical treatments. Damage would be minimized through contract administration and proper harvest methods. All piling and/or low-severity burning treatments on 512,178 (PPine) acres would reduce understory stocking and reduce inter-tree competition as well as stimulate understory vegetation (shrubs, forbs, grasses). Fireline placement would use existing features with naturally low fuels, skid trails, roads etc. as much as possible. Actual fireline construction would remove herbaceous material to bare mineral soil up to a 6 foot width.

Timber and Wood Products

A Coconino FP goal is to manage the timber resource to provide a sustained-yield of forest products (Coc plan pg 23). A Kaibab FP goal is to manage suitable timberland to provide a sustained level of timber outputs to support local dependent industries (Kai Plan pg 18). Timber harvest of 245,343,350 cubic feet of biomass from the Coconino and 122,393,816 cubic feet of biomass from the Kaibab is a direct beneficial effect of Alternative C.

Road Maintenance, Decommissioning, Reconstruction, Opening, and Temp Road Construction

Road maintenance within the existing road prism would have no effect on the health and growth of the leave trees within the treatment units. Road decommissioning of 904 miles of existing system and unauthorized roads would allow ingrowth of forest vegetation once the road is decommissioned (approximately 2,712 acres). Constructing 245 miles of temporary roads will remove trees and forest vegetation within the road right of ways (approximately 735 acres). Opening 272 miles of decommissioned roads may remove trees and forest vegetation that has become established within the road right of way since the road was last maintained (approximately 816 acres). Road reconstruction consists of road improvement activities and road

realignments activities. Road realignment of 10 miles of road would remove approximately 30 acres of trees and forest vegetation within the area being reconstructed. 30 miles of road improvement is expected to occur on small discreet areas and is expected to remove about 100 acres of forest vegetation. The above listed effects cover the maximum range of management actions. Possible management actions includes: Reestablish former drainage patterns, stabilizing slopes, and restore vegetation; Block the entrance to a road or installing water bars; Remove culverts, reestablish drainages, remove unstable fills, pull back road shoulders, and scatter slash on the roadbed; Completely eliminate the roadbed by restoring natural contours and slopes; and Other methods designed to meet the specific conditions associated with the unneeded road.

Aspen Fencing and Barriers

Up to 82 miles protective barriers would be established around aspen clone patches within the ponderosa pine forest. Barriers would consist of fencing and/or felling trees (jack-strawing). Fencing would occur after mechanical and burning treatments and would have no effect to the vegetation. Jack-strawing may occur during the mechanical operation and would utilize trees that have been targeted for removal to meet treatment objectives. Leaving felled material on the ground would forego the opportunity to use that material for wood products.

Restoration of Springs and Ephemeral Channels

Springs and ephemeral channels are inclusions within the mechanical and burn treatment areas. Any tree removal that occurs as part of the restoration of these areas would be part of the design for those mechanical treatments that occur around these areas and the effects to the forest vegetation would be similar to the overall treatment. Up to 4 miles of protective fencing would be established around restored springs. Fencing would have no effect to the vegetation. Bank re-contouring and stabilization would occur along 39 miles of ephemeral channels. This activity would disturb existing forest vegetation. Up to 5 miles of willow re-establishment would occur where evidence indicates historic willow presence. This would create vegetation diversity and allow natural willow expansion into adjacent areas of suitable habitat. The above listed effects cover the maximum range of management actions. Possible management actions for springs include: Remove tree canopy to pre-settlement condition within 2-5 chains of the spring; Apply for water right if none exists; remove noxious weeds; Prescribe burn; Identify stressor and provide protection measure for the stressor (fence, jackstraw, remove/relocate road/trail etc.); And/or other methods designed to meet the desired conditions.

Alternative D

See Chapter 2 for a complete list of activities and a description of the treatments that are proposed for Alternative D.

Alternative D would implement approximately 567,279 acres of restoration activities (within the 988,764 acre project area). Restoration activities would:

- Mechanically cut trees and dispose of slash on approximately 388,489 acres. This includes ponderosa pine restoration treatments within 302,547 acres of northern goshawk habitat and 84,177 acres of Mexican spotted owl habitat, 1,229 acres of aspen restoration and 535 acres of pinyon-juniper wildland urban interface treatments.

- Prescribe burn-only approximately 178,790 acres. Burn only treatments would occur within 100,508 acres of ponderosa pine and 32 acres of aspen with the remaining 78,251 acres occurring in the PJ, oak woodland, grassland and non-vegetated cover types operationally to facilitate burning the ponderosa pine and aspen. Within the ponderosa pine, 96,965 acres are within northern goshawk habitat and 3,543 acres are within Mexican spotted owl habitat.

Table 68 summarizes the vegetation treatments for Alternative D by cover type in each restoration unit. Compared to the proposed action, alternative D proposes the same 388,489 acres of mechanical treatments with mechanical slash treatment rather than prescribed fire. Alternative D differences from the proposed action for prescribed fire only includes 19,975 less acres in ponderosa pine, 191 less acres in aspen, 267 less acres in PJ, 70 less acres in oak woodland and 135 less acres in the grassland cover type.

Table 68. Alternative D mechanical treatment and prescribed fire acres by restoration unit (RU)

Treatment	Cover Type	RU 1	RU 3	RU 4	RU 5	RU 6	Total Treatment Acres
Mechanical treatment with slash disposal	Ponderosa Pine	121,640	113,344	109,395	12,372*	29,974	386,724
	Aspen	182	201	453	392	0	1,229
	PJ	0	0	0	0	535	535
	All	**121,822**	**113,546**	**109,848**	**12,765**	**30,509**	**388,489**
Prescribed fire only	Ponderosa Pine	4,874	12,163	24,351	47,906	11,215	100,508
	Aspen	7	0	15	10	0	32
	PJ	1,154	5,884	7,282	8,845	1,684	24,850
	Oak Woodland	204	1,633	926	523	30	3,316
	Grassland	8,100	12,513	22,665	4,987	93	48,358
	Non-Vegetated	114	134	129	1,301	48	1,727
	All	**14,454**	**32,326**	**55,369**	**63,572**	**13,069**	**178,790**
Mechanical Treatment and Prescribed Fire Totals		**136,276**	**145,872**	**165,217**	**76,337**	**43,578**	**567,279**

*This figure includes 99 acres of thin by Hand on slopes > 40% and prescribe burn.

Table 69 summarizes alternative D acres of treatment type within goshawk habitat. See chapter 2 for a description of treatment objectives. Mechanical and burn only treatment acres within goshawk habitat proposed under alternative D would be the same as alternative B. There would be no prescribed fire within the mechanically treated areas. Alternative D proposes to dispose of slash through various other methods including chipping, shredding, mastication, and removal of biomass off-site.

Table 69. Alternative D summary of acres proposed for treatments in ponderosa pine goshawk habitat

Vegetation Treatment Type	Foraging	Post-Fledgling Family Area (PFA)	Dispersal Post-Fledgling Family Area (dPFA)	Total Acres
Prescribed Fire Only	86,933	8,733	1,299	96,965
Mechanical with Slash Disposal				
Uneven-aged (UEA) –	146,674	9,639	4,446	160,760
Intermediate Thinning (IT)	53,997	3,807	1,022	58,825
Stand Improvement Thinning (SI)	19,980	991	76	21,047
Savanna	45,469	0	0	45,469
Grassland Restoration	11,185	0	0	11,185
Pine-Sage	4,674	392	196	5,261
Total Mechanical with Slash Disposal:	**281,979**	**14,828**	**5,740**	**302,584**
Total acres proposed for treatment in goshawk habitat	**368,912**	**23,561**	**7,039**	**399,512**

Table 70 summarizes alternative D acres of treatment type within MSO habitat. See chapter 2 for a description of treatment objectives. Mechanical treatment acres within MSO habitat proposed under alternative D would be the same as alternative B. There would be no prescribed fire within the mechanically treated areas. Alternative D proposes to dispose of slash through various other methods including chipping, shredding, mastication, and removal of biomass off-site. Compared to the proposed action, alternative D also proposes a total of 19,975 acres less burn only treatment in the MSO protected habitat.

Table 70. Alternative D summary of treatments in ponderosa pine MSO habitat

Treatment Type*	Protected	Restricted	Target/ Threshold	Total Acres
Prescribed Fire Only	889	2,354	301	3,543
MSO Restricted		65,024		65,024
MSO Target			6,518	6,518
MSO Threshold			1,894	1,894
PACMechanical	10,741			10,741
Total	**11,630**	**67,378**	**8,713**	**87,721**

Direct and Indirect Effects – Alternative D

Mexican Spotted Owl Habitat

Table 71 displays the MSO habitat forest structure and habitat components projected out to the years 2020 and 2050.

- Year 2020 summary: Basal area density is approaching the high end of the desired range within the restricted other habitat and is within desired for the other habitats. SDI is higher than desired in all habitats with the exception of restricted other RU 5 and protected RU 4. This is largely due to the limited mechanical and fire treatments in the protected habitat and the high oak stocking and lack of post mechanical treatment burning in the restricted habitat. The distribution of size classes is at or exceeds minimum desired in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class exceeds the desired minimum in the restricted other habitat and is below desired minimum in the target/threshold habitat. Average trees per acre 18” and larger are very close to desired minimum in the target/threshold habitat and well below desired minimum in restricted other. Overall average Gambel oak basal area is above desired minimum in all habitats except RU5 restricted other where it is a limited component within that landscape. All habitats are approaching desired minimum CWD >12” and are below desired minimum in snags >18”.
- Year 2050 summary: Basal area and SDI density exceeds desired in all habitats. The distribution of size classes is at or exceeds desired minimum in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class also exceeds desired minimum in the restricted other habitat and remains below desired minimum in the target/threshold habitat. Average trees per acre 18” and larger exceed desired minimum in the target/threshold habitat and remain below desired minimum in restricted other. Overall average Gambel oak basal area is above desired minimum in all habitats but remains limited in RU5 restricted other. All habitats show an increase in CWD >12” and Snags >18” between 2020 and 2050.

Table 71. Alternative D - 2020 and 2050 Spotted Owl Habitat Forest Structure and Habitat Components

					Avg. Percent of Total SDI by Size Class													
RU	Basal Area		% Max SDI		12.0 – 17.9”		18.0 – 23.9”		24.0” +		Avg. TPA 18”+		Avg. Gambel Oak BA Percent of Total BA		Tons CWD >12”		Snags >18”	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
Restricted Target/ Threshold*																		
RU 1	147	176	74%	82%	30%	24%	20%	24%	8%	11%	19.5	28.3	25%	24%	1.9	2.6	.5	1.4
RU 3	152	181	79%	86%	26%	21%	19%	21%	9%	12%	19.0	26.6	29%	27%	1.1	2.1	.7	1.6
All	149	179	76%	84%	28%	23%	19%	23%	9%	11%	19.3	27.6	26%	25%	1.5	2.4	.6	1.5
Restricted Other																		
RU 1	86	123	43%	56%	20%	18%	20%	16%	17%	17%	11.8	16.7	20%	19%	1.1	1.5	.4	.8
RU 3	94	130	48%	60%	20%	18%	20%	17%	16%	16%	12.0	17.4	25%	24%	1.1	1.6	.5	.9
RU 4	96	130	50%	61%	18%	16%	19%	16%	18%	17%	11.9	16.4	27%	26%	1.0	1.5	.5	1.0
RU 5	77	114	38%	51%	19%	20%	15%	13%	19%	16%	8.6	12.7	13%	16%	.6	.9	.4	.6
All	91	127	46%	58%	20%	18%	20%	17%	17%	16%	11.9	17.0	23%	22%	1.1	1.6	.5	.9
Protected																		
RU 1	158	177	74%	76%	32%	28%	17%	24%	9%	12%	17.7	27.8	13%	13%	1.0	2.2	.7	1.7
RU 3	172	191	81%	83%	31%	26%	18%	24%	9%	13%	20.9	30.8	12%	11%	1.5	2.8	.8	1.9
RU 4	109	131	51%	56%	35%	38%	14%	23%	5%	8%	10.8	19.8	7%	8%	.7	1.6	.4	1.3

					Avg. Percent of Total SDI by Size Class													
RU	**Basal Area**		**% Max SDI**		**12.0 – 17.9”**		**18.0 – 23.9”**		**24.0” +**		**Avg. TPA 18”+**		**Avg. Gambel Oak BA Percent of Total BA**		**Tons CWD >12”**		**Snags >18”**	
	2020	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**
RU 5	147	170	71%	75%	31%	26%	17%	22%	9%	13%	16.9	26.3	11%	11%	1.5	2.7	.7	1.7
All	**159**	**178**	**74%**	**77%**	**32%**	**28%**	**17%**	**24%**	**9%**	**12%**	**18.0**	**28.0**	**13%**	**13%**	**1.1**	**2.3**	**.7**	**1.7**

*These are average conditions for both target and threshold habitats combined. Treatments within threshold habitat will not reduce forest density/structure or habitat components below threshold conditions.

Goshawk Habitat

Table 72 and Table 73 display the goshawk habitat structure attributes projected out to the years 2020 and 2050. Average conditions include trees, interspaces, and canopy gaps as represented by the stand data. These average habitat conditions are a function of openness and tree group density across the different scales (restoration sub-unit, restoration unit, ponderosa pine extent).

- Year 2020 summary: At the habitat and RU scale all habitats are within the desired density range with the exception of RU 6 PFA (due to these stands being dominated by young forest structural stage). With the exception of RU6 and LOPFA RU 5, tons of coarse woody debris are at or above desired due to the lack of prescribed fire reducing this attribute. Snags per acre are below desired at all scales.
- Year 2050 summary: At the habitat and RU scale all habitats remain within the desired SDI range. Basal area is at or above the desired with the exception of RU 6 PFA and corresponding canopy cover remains above the desired threshold. Total tons of coarse woody debris exceeds the minimum desired with the exception of RU 6 PFA and LOPFA. Snags have increased yet remain below desired levels.

Table 72. Alternative D - Average Goshawk Nest/PFA Habitat Structural Attributes

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
1-1	25%	34%	129	118	61	88	3.0	4.7	.3	.8	.7	.3
1-2	30%	36%	119	104	77	99	4.0	6.4	.7	1.4	.9	.8
1-3	28%	36%	99	89	74	99	7.2	8.4	1.2	1.7	.6	.8
1-4	32%	40%	131	113	81	107	10.3	11.4	5.0	4.8	.5	.8
1-5	31%	36%	85	74	84	101	6.9	9.4	1.0	2.1	1.0	1.6
1	30%	36%	103	91	78	101	6.9	8.7	1.6	2.2	.7	1.1
3-1	29%	35%	94	83	75	96	4.7	6.6	.7	1.4	.7	1.0
3-2	32%	37%	104	91	83	104	4.2	6.6	.7	1.6	.9	1.1
3-3	30%	37%	109	97	78	102	5.6	7.1	.8	1.4	.6	.9
3-5	32%	39%	127	113	82	106	4.4	7.4	.7	1.7	.9	.9
3	31%	37%	108	96	79	102	5.0	6.9	.8	1.5	.7	1.0
4-2	28%	35%	105	94	73	97	3.7	5.4	.6	1.2	.8	.7
4-3	31%	38%	113	99	82	105	4.8	7.0	1.0	1.8	.8	.9
4-4	32%	38%	112	98	83	106	6.7	8.4	2.1	2.5	.7	1.0
4-5	35%	39%	122	100	89	108	5.2	7.7	.8	1.6	.6	1.4

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
4	31%	38%	112	98	82	105	5.3	7.3	1.3	2.0	.7	.9
5-1	31%	37%	117	101	79	101	6.1	8.3	1.5	2.2	.8	1.0
5-2	30%	34%	83	73	79	97	4.4	7.3	.8	2.0	1.3	1.5
5	30%	36%	103	89	79	100	5.4	7.9	1.2	2.1	1.0	1.2
6-2	21%	26%	72	64	51	70	2.4	4.3	.3	.9	.7	.5
6-3	25%	30%	110	96	56	76	3.1	4.6	.4	.8	.5	.5
6	24%	30%	107	94	56	75	3.0	4.6	.4	.8	.5	.5
All	**30%**	**36%**	**109**	**95**	**77**	**99**	**5.2**	**7.2**	**1.1**	**1.8**	**.7**	**.9**

Table 73. Alternative D - Average Goshawk LOPFA Habitat Structural Attributes

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
1-1	25%	32%	100	92	61	85	5.7	6.3	1.0	1.2	.3	.6
1-2	20%	25%	70	62	50	67	4.8	5.7	.8	1.1	.4	.8
1-3	22%	27%	80	72	54	74	5.9	6.5	1.1	1.3	.4	.7
1-4	24%	30%	92	81	60	80	5.6	6.5	1.0	1.3	.4	.8
1-5	27%	32%	85	73	68	86	7.0	8.3	1.4	1.9	.6	1.3
1	24%	30%	85	75	61	80	6.2	7.2	1.1	1.5	.5	1.0
3-1	22%	28%	81	72	57	78	4.7	5.6	.8	1.1	.5	.7
3-2	22%	27%	68	61	57	76	4.5	5.3	.8	1.2	.4	.8
3-3	23%	29%	78	69	58	79	6.2	7.0	1.1	1.5	.4	.8
3-4	28%	33%	86	76	72	92	7.3	8.8	1.4	2.0	.8	1.2
3-5	30%	35%	101	86	76	96	6.9	9.0	1.3	2.0	.7	1.1
3	25%	30%	82	73	63	83	5.9	7.1	1.1	1.5	.5	.9
4-2	19%	25%	66	60	49	68	4.1	4.7	.7	1.0	.4	.5
4-3	23%	29%	86	75	61	81	4.4	6.0	.8	1.4	.7	.8

Restoration Subunit-Unit	SDI % of Max.		TPA		Basal Area		Tons CWD Total		Tons CWD >12"		Snags >18"	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
4-4	24%	30%	85	75	61	82	5.6	6.5	1.0	1.4	.4	.8
4-5	26%	32%	99	86	66	88	5.9	7.5	1.0	1.5	.6	.8
4	24%	29%	85	75	61	82	5.1	6.3	.9	1.3	.5	.8
5-1	22%	27%	78	68	57	74	3.8	6.1	.6	1.4	.9	.9
5-2	22%	27%	66	58	61	78	2.4	5.3	.5	1.6	1.3	.9
5	22%	27%	70	61	60	77	2.8	5.5	.5	1.5	1.2	.9
6-2	21%	27%	89	80	51	72	2.9	4.2	.4	.8	.5	.3
6-3	26%	32%	116	100	59	81	3.4	4.7	.4	.7	.3	.4
6-4	23%	27%	86	71	58	75	3.9	7.2	.5	1.5	1.2	.8
6	25%	31%	110	95	58	79	3.4	4.9	.4	.8	.4	.5
All	**24%**	**29%**	**109**	**74**	**77**	**81**	**5.2**	**6.4**	**1.1**	**1.4**	**.7**	**.8**

Table 74 is a comparison of the VSS distribution between alternative D and alternative B at the RU and habitat scale. Those cells populated in the table indicate the alternative D percentage and the difference from alternative B. Cells without percentages filled in are the same as indicated in alternative B (Table 48 through Table 51).

Overall the VSS distribution trends under alternative D compared to alternative B indicate an increase in VSS 3, a decrease in VSS 4, a slight decrease in VSS 5 in 2020 followed by a slight increase in 2050 and an overall decrease in VSS 6. The mechanical treatments between these two alternatives is the same, so these differences can be attributed to the lack of prescribed fire mortality associated with alternative D, especially in the VSS 3 class. The denser conditions (Table 72 and Table 73) also affects the VSS distribution trend by slowing stand development and growth. This results in maintaining more of the landscape in the young forest stage and impeding development of the mature and old forest stages.

Table 74. Alternative D - 2020 and 2050 VSS Distribution Differences Compared to Alternative B Percent of Area by Vegetative Structural Stage

Area	1 – Grass/ Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
LOPFA Even Age												
RU 1					42% (+29)	9% (+9)	26% (-26)	35% (-1)	21% (-2)			16% (-7)
RU 3					25% (+9)	5% (+2)	35% (-1)	26% (-1)	26% (-8)	40% (-2)		16% (-7)
RU 4					26% (+9)	5% (+2)	38% (-2)		22% (-5)	39% (+3)	2% (-1)	18% (-5)
RU 5					19% (+2)		41% (-2)					
RU 6					79% (+1)	27% (+12)		54% (-10)		5% (-2)	5% (-1)	6% (-1)
All					32% (+12)	7% (+4)	33% (-6)		19% (-5)	36% (+2)		16% (-5)
LOPFA Uneven Age												
RU 1			2% (+2)	9% (+1)	20% (+10)	8% (+8)	27% (-4)		35% (+13)	31% (+4)	9% (-1)	43% (-12)
RU 3					17% (+5)	10% (+9)		12% (+1)	40% (-13)	26% (+2)	11% (-1)	45% (-12)
RU 4					26% (+8)	9% (+9)	19% (-3)	16% (-2)	37% (-5)	23% (-3)		45% (-10)
RU 5					14% (+1)		13% (+2)		22% (-4)	13% (+2)		71% (-5)
RU 6			2% (+1)		64% (+9)	14% (+2)	18% (-2)	57% (+5)	0% (-1)	7% (-5)	9% (-7)	15% (-2)
All			1% (+<1)		26% (+7)	8% (+6)			29% (-6)	21% (+1)	17% (-2)	45% (-8)

Area	1 – Grass/ Forb/ Shrub (0.0 - 0.9")		2 – Seedling/ Sapling (1.0 - 4.9")		3 – Young Forest (5.0 - 11.9")		4 – Mid-age Forest (12.0 - 17.9")		5 – Mature Forest (18.0 - 23.9")		6 – Old Forest (24.0" +)	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
PFA Even Age												
RU 1					48% (+25)	3% (+3)	32% (-4)	49% (-3)	15% (-7)		0% (-13)	<1% (+<1)
RU 3	17% (-5)				26% (+6)		46% (+4)		10% (-6)	44% (+2)		4% (-2)
RU 4					30% (+9)		51% (+1)	43% (+2)	11% (-3)	39% (-2)	0% (-7)	
RU 5					43% (+5)	25% (+25)	38% (-4)	25% (-25)				
RU 6			1% (+1)		50% (+4)	12% (+8)	10% (+6)	37% (-9)			25% (-12)	
All					34% (+10)	5% (+3)	44% (-1)	40% (-2)	11% (-3)	37% (-1)	2% (-6)	
PFA Uneven Age												
RU 1					24% (+14)	1% (+1)	29% (-13)				7% (-1)	
RU 3					18% (+9)		49% (-9)	20% (+2)		56% (-1)		17% (-2)
RU 4					20% (+8)	2% (+1)	43% (-6)	25% (+1)		46% (+3)	2% (-2)	19% (-4)
RU 5					12% (+5)		37% (-2)		38% (-3)			
RU 6						11% (+11)	26% (+15)	42% (-11)			12% (-23)	
All					25% (+8)	3% (+3)	37% (-3)	26% (-2)	24% (-1)	40% (+1)	6% (-4)	23% (-2)

Old Growth

Table 75 displays the old growth structural attributes of the allocated old growth acres projected out to the years 2020 and 2050 under alternative D.

In 2020, the average conditions are at or above the minimum criteria with the following exceptions:

- Trees per acre larger than 18" and 180 years old. This condition is deficit in all SUs ranging from a low of 9.2 TPA in SU 6-2 to a high of 16.9 TPA in SU 3-4 with an overall average for all acres of 13.9 TPA. The age of these trees is estimated be in the range of 100 to 140 years old with a few relic trees meeting the 180 year old criteria.
- Basal area ≥90. This condition is below desired in RUs 4, 5 and 6. Overall average for all acres is 89.
- Coarse woody debris greater than 12". This condition is estimated to be deficit with less than the equivalent of 2 pieces per acre throughout 6.

Over time, old growth conditions improve in terms of meeting the minimum criteria. In 2050, all RUs are very close to or exceed the criteria for TPA larger than 18" with the exception of RU 6. The age of these trees is estimated be in the range of 130 to 170 years old. It is estimated that all the other criteria will be met throughout the allocated old growth acres.

Table 75. Alternative D – Allocated OG Structural Attributes by Restoration Unit

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
1-1	3,578	13.6	18.8	81	115	.9	1.2	1.4	1.5
1-2	2,034	11.4	17.0	70	99	.8	1.1	2.1	1.6
1-3	18,300	14.6	21.0	98	128	1.1	1.6	2.1	2.9
1-4	6,323	13.0	19.9	97	125	.8	1.3	2.0	3.0
1-5	34,955	16.7	24.4	123	150	1.2	2.0	3.1	4.6
1	65,189	15.3	22.2	108	136	1.1	1.7	2.5	3.6
3-1	6,216	13.4	19.2	81	113	.9	1.2	1.9	1.8
3-2	9,317	15.1	19.8	77	105	.9	1.2	1.7	1.6
3-3	15,624	14.5	20.2	89	120	1.1	1.5	2.4	2.2
3-4	4,201	16.9	23.7	118	146	1.3	2.1	3.2	4.3
3-5	11,160	15.8	22.6	98	130	1.5	2.2	4.1	2.9
3	46,518	14.9	20.8	90	121	1.1	1.6	2.6	2.4

Restoration Sub Unit/ Unit	OG Acres	Avg. TPA 18"+		Avg. BA		Avg. Tons CWD ≥12"		Avg. Snags Per Acre ≥12"	
		2020	2050	2020	2050	2020	2050	2020	2050
4-2	3,710	12.8	17.5	68	96	.7	1.0	1.8	1.3
4-3	20,144	12.7	19.6	76	105	.8	1.3	3.3	1.9
4-4	22,175	13.7	19.9	74	106	1.0	1.2	1.7	1.4
4-5	2,031	14.8	23.2	86	121	1.2	1.6	3.1	1.8
4	48,060	13.3	19.7	75	105	.9	1.2	2.5	1.6
5-1	6,352	13.0	20.0	83	111	.8	1.6	4.5	2.5
5-2	18,394	12.9	19.5	75	97	.5	1.6	5.7	2.3
5	24,745	12.9	19.6	77	101	.6	1.6	5.4	2.4
6-2	1,689	9.2	14.2	71	106	.4	.8	2.6	1.1
6-3	8,210	9.8	15.0	81	118	.4	.7	1.7	1.2
6-4	392	9.6	15.4	80	111	.4	1.4	6.2	2.0
6	10,291	9.7	14.9	79	116	.4	.7	2.1	1.2
All:	**194,804**	**13.9**	**20.3**	**89**	**118**	**.9**	**1.5**	**2.9**	**2.5**

Alternative D proposes the same treatments in the pinyon-juniper cover type as alternative B. See Table 53 and the associated effects discussion for pinyon-juniper old growth.

Openness

The variety of treatment types and desired conditions under alternative D would result in a wide range of openness post treatment. The list of resulting openness by treatment type displayed for alternative B is the same for alternative D.

Table 76 lists the post treatment openness within the ponderosa pine cover type for alternative D by restoration unit and sub unit. Overall ranges indicate a fairly diverse condition with openness leaning to the closed side of the range. Eleven percent of the ponderosa pine would be very open, 31 percent open, 42 percent moderately closed and 11 percent closed. The unknowns are those areas with no treatment proposed under this alternative.

Table 76. Alternative D – Post Treatment Openness Classification for Ponderosa Pine

Restoration Unit-Subunit	Very Open	Open	Moderately Closed	Closed	Unknown*
1-1	3%	50%	36%	10%	2%
1-2	35%	42%	21%	3%	0%
1-3	16%	36%	26%	14%	8%
1-4	14%	46%	20%	9%	12%
1-5	6%	24%	32%	19%	19%
1	10%	32%	29%	15%	13%
3-1	9%	41%	46%	4%	0%
3-2	20%	45%	26%	9%	1%
3-3	16%	39%	34%	10%	1%
3-4	3%	27%	39%	11%	20%
3-5	6%	26%	58%	7%	3%
3	12%	36%	41%	8%	3%
4-2	31%	50%	11%	8%	0%
4-3	16%	32%	40%	11%	1%
4-4	19%	49%	21%	10%	<1%
4-5	7%	30%	44%	19%	0%
4	18%	41%	30%	11%	<1%
5-1	4%	8%	75%	9%	5%
5-2	1%	3%	93%	2%	1%
5	2%	5%	87%	6%	2%
6-2	0%	49%	49%	2%	0%
6-3	0%	19%	65%	16%	0%
6	0%	21%	65%	14%	0%
All Ponderosa Pine	**11%**	**31%**	**42%**	**11%**	**5%**

* These are areas that will not be treated with mechanical and/or prescribed fire treatments. For Alternative D this includes some of the PACs.

Forest Structure and Diversity - Mosaic of interspaces and tree groups of varying sizes and shapes

Table 77 lists alternative D acres by treatment intensity as an indication of the relative ability of the treatment to attain a mosaic of interspaces and tree groups and of the post treatment interspace/tree group condition. Forty three percent of the area treated is considered high, 26 percent is moderate, 25 percent is low and 6 percent is very low.

Table 77. Alternative D summary of ponderosa pine treatment acres by their relative ability to attain a mosaic of interspaces and tree groups.

Treatment Intensity	Treatment Type	Acres (% of Total Treatment)
High	Grassland Restoration	11,222
	Savanna	45,469
	Pine Sage	5,261
	WUI 55	2,268
	UEA 40	101,044
	IT 40	39,189
	SI 40	12,309
Total High:		**216,762 (44%)**
Moderate	MSO Restricted	65,024
	UEA 25	39,244
	IT 25	11,871
	SI 25	6,824
Total Moderate:		**122,963 (25%)**
Low	UEA 10	18,204
	IT 10	7,766
	SI 10	1,914
	NOGO PFA and LOPFA Burn Only	90,089
	MSO Restricted Burn Only	2,354
Total Low:		**120,327 (25%)**
Very Low	NOGO Nest Burn Only	6,839
	MSO PAC	10,741
	MSO Protected Burn Only	889
	MSO Target and Threshold	8,412
	MSO Target and Threshold Burn Only	301
Total Very Low:		**27,182 (6%)**

Forest Structure - All age and size classes represented

The MSO habitat forest structure analysis for alternative D indicates the post treatment distribution of size classes has good representation in the 12-18” and the 18-24” size classes in all habitats. Stocking in the 24” + size class has good representation in the restricted other habitat and is underrepresented in the target/threshold habitat (Table 71). Implementation of group selection as part of the restricted other treatments would result in up to 15 percent of the area trending toward early successional stages, thereby increasing representation of the seedling/sapling age class.

The goshawk habitat structural stage analysis for alternative B indicates overall post treatment VSS distribution in the even-aged goshawk habitats will have good representation of the VSS 1, 3 and 4 age classes, and the VSS 5 age class in the LOPFA; under-representation of the VSS 6 age class and the VSS 5 age class in the PFA; no representation of the VSS 2 age class. The uneven-aged goshawk habitats will have good representation in the LOPFA of VSS 3, 4, 5 and 6 and of VSS 3, 4 and 5 in the PFA; VSS 1 is underrepresented in the LOPFA and VSS 1 and 6 are underrepresented in the PFA; there is no representation of the VSS 2 age class in all habitats (Table 74 and Table 48 through Table 51).

Old Forest Structure Sustained Over Time Across the Landscape

The restoration treatments proposed under alternative D are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Old trees would not be targeted for cutting. Reference the Old Tree Implementation Strategy in Appendix A of this report.

The MSO habitat forest structure analysis for alternative D indicates the post treatment distribution of size classes has good representation in the 18-24” size classes in all habitats. Stocking in the 24” + size class has good representation in the restricted other habitat and is underrepresented in the target/threshold habitat (Table 71).

The goshawk habitat structural stage analysis above indicates the mature and old forest structural stages to be underrepresented in the PFA habitat and LOPFA even-aged stands. Projections show a trend toward improved representation in all habitats (Table 74 and Table 48 through Table 51).

Treatments within areas currently allocated OG would maintain existing old growth structural attributes and are managed to move towards those conditions over time. The old growth analysis above indicates old growth structural attributes would continue to develop and improve across the landscape (Table 75).

With the implementation of restoration treatments under alternative D, the sustainability of the large/old tree component across the landscape would be improved as presented in the following forest health discussion.

Forest Health

Density related mortality

Stand density in 2020 in the MSO restricted other habitat (Table 71) would have an overall average 46% of maximum density (range 38-50%) putting these stands in the middle of the high density zone as described in Table 7. The restricted other habitat consists of mixed species pine/oak stands. The pine component within this habitat is estimated to have density within the low to moderate zone. The majority of target/threshold and protected habitat would remain in zone 4 due to the oak stocking and dense forest desired conditions in these habitats. Any areas with mechanical treatments within these habitats would experience reduced density related mortality compared to the no action alternative.

In goshawk habitat, Table 72 and Table 73 show 2020 ponderosa pine density levels average 30% of maximum density within nest/PFA habitat and 24% in LOPFA habitat. These density levels are within the low to moderate density zones (Table 7). In 2050, overall averages indicate the LOPFA

habitats to be within the moderate density zone and the nest/PFA being on the low end of high density yet well below the threshold for the onset of density related mortality.

Bark beetle related mortality

Table 78 lists the beetle hazard rating for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. The overall hazard in 2020 is high across 45% of the analysis area. This increases to 65% in 2050. Stands with a hazard rating of low or moderate would be expected to be resistant to successful bark beetle attack and large scale mortality.

Table 78. Alternative D - Estimated 2020 and 2050 Beetle Hazard Rating

Hazard Rating	RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
Low - 2020	20%	24%	37%	40%	28%	28%
Low - 2050	10%	16%	16%	26%	8%	15%
Moderate - 2020	21%	22%	31%	44%	17%	26%
Moderate - 2050	12%	11%	25%	44%	20%	20%
High - 2020	59%	54%	32%	15%	55%	45%
High - 2050	78%	73%	58%	30%	72%	65%

Dwarf mistletoe infection

Table 79 lists the dwarf mistletoe infection level and average percent of trees infected for the years 2020 and 2050 by RU and for the ponderosa pine analysis area. For 2020, approximately 60 percent of the area is not infected or has a low infection level and 40 percent has a moderate to high infection level. The overall average percent of trees infected is 6 percent in the none/low group and 40 percent in the moderate/high group. This reflects an improvement from the no action alternative with one percent more area in the none/low group and 1 percent less area in the moderate/high group. Overall percent of trees infected is one percent less in none/low and 5 percent less in moderate/high. The percentages for 2050 indicate mistletoe infection is intensifying and spreading at a slower rate than alternative A.

Table 79. Alternative D Estimated Post Treatment and Long Term Dwarf Mistletoe Infection Level

Infection Level		RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
None/Low - 2020	Percent of Area	47%	48%	71%	78%	82%	60%
None/Low - 2020	Average Percent Trees Infected	5%	5%	6%	11%	6%	6%
Moderate/High - 2020	Percent of Area	52%	52%	29%	22%	18%	40%
Moderate/High - 2020	Average Percent Trees Infected	42%	36%	44%	32%	58%	40%

Infection Level		RU 1	RU 3	RU 4	RU 5	RU 6	Analysis Area
Extreme - 2020	Percent of Area	1%	<1%	0%	0%	0%	<1%
Extreme - 2020	Average Percent Trees Infected	87%	100%	-	-	-	88%
None/Low - 2050	Percent of Area	42%	45%	68%	67%	81%	56%
None/Low - 2050	Average Percent Trees Infected	5%	6%	6%	10%	7%	7%
Moderate/High - 2050	Percent of Area	57%	55%	68%	67%	15%	44%
Moderate/High - 2050	Average Percent Trees Infected	46%	41%	49%	32%	56%	44%
Extreme - 2050	Percent of Area	1%	<1%	0%	0%	0%	<1%
Extreme - 2050	Average Percent Trees Infected	81%	100%	-	-	-	84%

Climate change

Risks associated with dense forest conditions would be reduced and resilience to the impacts of large scale disturbance under drier and warmer conditions would be improved by implementing the treatments proposed under alternative D.

Within forest carbon stocks would be reduced under alternative D. Individual tree growth would improve, resulting in larger average trees size and increased carbon storage over time offsetting short term losses of carbon removed through the mechanical thinning. Some of the carbon within the estimated 366,156,380 cubic feet of biomass removed by mechanical thinning would be sequestered for a time in the form of building materials.

Vegetation Diversity and Composition – Maintain and Promote

Grasslands

Alternative D would restore historic grasslands, savannas and forest openings by removing ponderosa pine tree canopy that is shading out understory herbaceous vegetation and reducing forage production and species diversity as follows:

- 11,185 acres of grassland restoration treatments on mollisol soils;
- 45,469 acres of savanna treatments on mollic integrade soils;
- 305,657 acres of ponderosa pine restoration treatments in PFA, LOPFA and MSO restricted other habitats enhancing small grassland inclusions within the greater forested area.

Oak

Treatments proposed in alternative D are designed to conserve oak and improve conditions that favor oak growth and establishment wherever it exists by reducing pine-oak competition. This would result in improved vigor of existing oak and establishment of a variety of oak size and age classes across the landscape. These conditions would be most prevalent within the 65,024 acres of

MSO restricted other habitat treatments. Table 70 shows the overall post treatment oak basal area would be 6 percent higher in this habitat compared to the no action alternative.

Aspen

The treatments within 1,261 acres of aspen stands under alternative D are designed to maintain and/or regenerate aspen by reducing pine-aspen competition. These treatments would result in establishment of vigorous aspen regeneration free of competition from overtopping ponderosa pine.

Pine Sage

The 5,262 acres of pine-sage thinning treatments are designed to remove post settlement pine that is currently overtopping and shading out the sage and to manage fire to enhance sage extent. These treatments would result in enhancement of the sage component and restore the historic pattern within the pine sage mosaic.

Other Direct and Indirect Effects:

Tractor Yarding and Fuel Treatment

All merchantable harvested material would be whole-tree tractor yarded from the mechanical treatment units. Fuel treatments proposed for Alternative D includes pile burning, broadcast burns and fireline construction. Some damage to the residual trees would be expected with the felling, tractor yarding and slash disposal operations within 386,724 acres of (PPine) mechanical treatments. Damage would be minimized through contract administration and proper harvest methods. All low-intensity burning treatments on 100,508 (PPine) acres would reduce understory stocking and reduce inter-tree competition as well as stimulate understory vegetation (shrubs, forbs, grasses). Fireline placement would use existing features with naturally low fuels, skid trails, roads etc. as much as possible. Actual fireline construction would remove herbaceous material to bare mineral soil to a 3-6 foot width.

Timber and Wood Products

A Coconino FP goal is to manage the timber resource to provide a sustained-yield of forest products (Coc plan pg 23). A Kaibab FP goal is to manage suitable timberland to provide a sustained level of timber outputs to support local dependent industries (Kai Plan pg 18). Timber harvest of 243,299,684 cubic feet of biomass from the Coconino and 122,856,697 cubic feet of biomass from the Kaibab is a direct beneficial effect of Alternative D.

Road Maintenance, Decommissioning, Reconstruction, Opening, and Temp Road Construction

Road maintenance within the existing road prism would have no effect on the health and growth of the leave trees within the treatment units. Road decommissioning of 904 miles of existing system and unauthorized roads would allow ingrowth of forest vegetation once the road is decommissioned (approximately 2,712 acres). Constructing 245 miles of temporary roads will remove trees and forest vegetation within the road right of ways (approximately 735 acres). Opening 272 miles of decommissioned roads may remove trees and forest vegetation that has become established within the road right of way since the road was last maintained (approximately 816 acres). Reconstructing 10 miles of road will remove trees and forest

vegetation within the area being reconstructed (approximately 30 acres). Road reconstruction consists of road improvement activities and road realignments activities. Road realignment of 10 miles of road would remove approximately 30 acres of trees and forest vegetation within the area being reconstructed. 30 miles of road improvement is expected to occur on small discreet areas and is expected to remove about 100 acres of forest vegetation. The above listed effects cover the maximum range of management actions. Possible management actions includes: Reestablish former drainage patterns, stabilizing slopes, and restore vegetation; Block the entrance to a road or installing water bars; Remove culverts, reestablish drainages, remove unstable fills, pull back road shoulders, and scatter slash on the roadbed; Completely eliminate the roadbed by restoring natural contours and slopes; and Other methods designed to meet the specific conditions associated with the unneeded road.

Aspen Fencing and Barriers

Up to 82 miles protective barriers would be established around aspen clone patches within the ponderosa pine forest. Barriers would consist of fencing and/or felling trees (jack-strawing). Fencing would occur after mechanical and burning treatments and would have no effect to the vegetation. Jack-strawing may occur during the mechanical operation and would utilize trees that have been targeted for removal to meet treatment objectives. Leaving felled material on the ground would forego the opportunity to use that material for wood products.

Restoration of Springs and Ephemeral Channels

Springs and ephemeral channels are inclusions within the mechanical and burn treatment areas. Any tree removal that occurs as part of the restoration of these areas would be part of the design for those mechanical treatments that occur around these areas and the effects to the forest vegetation would be similar to the overall treatment. Up to 4 miles of protective fencing would be established around restored springs. Fencing would have no effect to the vegetation. Bank re-contouring and stabilization would occur along 39 miles of ephemeral channels. This activity would disturb existing forest vegetation. Up to 5 miles of willow re-establishment would occur where evidence indicates historic willow presence. This would create vegetation diversity and allow natural willow expansion into adjacent areas of suitable habitat. The above listed effects cover the maximum range of management actions. Possible management actions for springs include: Remove tree canopy to pre-settlement condition within 2-5 chains of the spring; Apply for water right if none exists; remove noxious weeds; Prescribe burn; Identify stressor and provide protection measure for the stressor (fence, jackstraw, remove/relocate road/trail etc.); And/or other methods designed to meet the desired conditions.

Summary of Direct and Indirect Effects

Table 80 provides a summary of the alternatives and the potential effects of implementing each alternative considered in detail. Information in the table focuses on effects related to the purpose and need for the project specific to the vegetation resource and summarizes the detailed discussion of the effects above.

Table 80. Comparison of Effects by Alternative

Indicator	Existing Condition	Desired Condition	Alternative A	Alternative B	Alternative C	Alternative D
Vegetation Structure						
Age and Size Class	Even-aged 46 percent Uneven-aged 54 percent Dominant representation in the young and mid-aged structural stages Low representation in the grass/forb/shrub, seedling/sapling, mature and old structural stages.	Uneven-aged. Distribution of age-classes that comprise a sustainable balance of structural stages.	Even-aged remain even aged. Uneven-aged trending toward even-aged Dominant representation in the young and mid-aged structural stages Low representation in the grass/forb/shrub, seedling/sapling, mature and old structural stages.	Even-aged trending toward uneven-aged. Uneven-aged maintained as uneven-aged Dominant representation in the young and mid-aged structural stages. Improved representation in the grass/forb/shrub, seedling/sapling, mature and old structural stages. Trending toward a balance of structural stages.	Even-aged trending toward uneven-aged. Uneven-aged maintained as uneven-aged Dominant representation in the young and mid-aged structural stages. Improved representation in the grass/forb/shrub, seedling/sapling, mature and old structural stages. Trending toward a balance of structural stages.	Even-aged trending toward uneven-aged. Uneven-aged maintained as uneven-aged Dominant representation in the young and mid-aged structural stages. Improved representation in the grass/forb/shrub, seedling/sapling, mature and old structural stages. Trending toward a balance of structural stages.
Spatial Arrangement	Continuous tree canopy with generally small interspace inclusions	Mosaic of interspaces and tree groups of varying sizes and shapes	Similar to existing. Trending toward reduction of interspace.	Treatment acres with relative ability to attain mosaic of interspaces and tree groups: Very Low – 47,157 Low – 120,363 Moderate – 122,963 High – 216,725	Treatment acres with relative ability to attain mosaic of interspaces and tree groups: Very Low – 52,007 Low – 126,074 Moderate – 121,050 High – 211,215	Treatment acres with relative ability to attain mosaic of interspaces and tree groups: Very Low – 27,182 Low – 120,363 Moderate – 122,963 High – 216,725

Indicator	Existing Condition	Desired Condition	Alternative A	Alternative B	Alternative C	Alternative D
Heterogeneity (Openness within ponderosa pine cover type)	Very Open and Open – 22 percent Moderately Closed – 29 percent Closed – 45 percent Unknown – 3 percent	Ranges from very open to closed. Desired openness determined by soils and site potential.	Similar to existing condition. Trending toward closed.	Very Open – 11 percent Open – 31 percent Moderately Closed – 42 percent Closed – 15 percent Unknown – 1 percent	Very Open – 11 percent Open – 30 percent Moderately Closed – 42 percent Closed – 17 percent Unknown – 0 percent	Very Open – 11 percent Open – 31 percent Moderately Closed – 42 percent Closed – 11 percent Unknown – 5 percent
Forest Health						
Stand Density	Percent of maximum SDI by Habitat: MSO Protected – 78 percent MSO Target/Threshold – 85 percent MSO Restricted – 69 percent NOGO Nest/PFA – 45 percent NOGO LOPFA – 40 percent	Density within ponderosa pine forests is below the zone where density related mortality is prevalent (<56 percent of maximum SDI). Managed, uneven-aged forests range from 15-40 percent of maximum SDI.	Percent of maximum SDI by Habitat: MSO Protected – 80 percent MSO Target/Threshold – 86 percent MSO Restricted – 72 percent NOGO Nest/PFA – 47 percent NOGO LOPFA – 43 percent	Percent of maximum SDI by Habitat: MSO Protected – 72 percent MSO Target/Threshold – 75 percent MSO Restricted – 37 percent NOGO Nest/PFA – 27 percent NOGO LOPFA – 21 percent	Percent of maximum SDI by Habitat: MSO Protected – 71 percent MSO Target/Threshold – 71 percent MSO Restricted – 37 percent NOGO Nest/PFA – 27 percent NOGO LOPFA – 21 percent	Percent of maximum SDI by Habitat: MSO Protected – 74 percent MSO Target/Threshold – 76 percent MSO Restricted – 46 percent NOGO Nest/PFA – 30 percent NOGO LOPFA – 24 percent
Insect and Disease	Beetle Hazard Rating: Low – 8 percent Moderate – 21 percent High – 71 percent Dwarf mistletoe infection level: None/Low – 66 percent Moderate/High – 34 percent Extreme - <1 percent	Forest conditions are resilient to insect and disease. Insect and disease populations are at endemic levels.	Beetle Hazard Rating: Low – 4 percent Moderate – 13 percent High – 83 percent Dwarf mistletoe infection level: None/Low – 59 percent Moderate/High – 41 percent Extreme - <1 percent	Beetle Hazard Rating: Low – 38 percent Moderate – 36 percent High – 26 percent Dwarf mistletoe infection level: None/Low – 61 percent Moderate/High – 39 percent Extreme - <1 percent	Beetle Hazard Rating: Low – 38 percent Moderate – 36 percent High – 26 percent Dwarf mistletoe infection level: None/Low – 60 percent Moderate/High – 40 percent Extreme - <1 percent	Beetle Hazard Rating: Low – 28 percent Moderate – 26 percent High – 45 percent Dwarf mistletoe infection level: None/Low – 60 percent Moderate/High – 40 percent Extreme - <1 percent

Indicator	Existing Condition	Desired Condition	Alternative A	Alternative B	Alternative C	Alternative D
Vegetation Diversity and Composition						
Gambel oak	Acres of pine-oak MSO habitat: 112,546	Conserve oak and improve conditions that favor oak growth and establishment.	Treatment acres that would actively reduce pine-oak competition: 0 acres Treatment acres within pine-oak MSO habitat that would release large oak: 0 acres	Treatment acres that would actively reduce pine-oak competition: 65,024 acres. Treatment acres within pine-oak MSO habitat that would release large oak: 84,177	Treatment acres that would actively reduce pine-oak competition: 63,191 acres. Treatment acres within pine-oak MSO habitat that would release large oak: 82,344	Treatment acres that would actively reduce pine-oak competition:65,024 Treatment acres within pine-oak MSO habitat that would release large oak: 84,177
Aspen	Acres of aspen patches within ponderosa pine forest: 1,471	Maintain and/or regenerate aspen patches	Treatment acres within aspen patches: 0 acres	Treatment acres within aspen patches: 1,452 acres	Treatment acres within aspen patches: 1,471 acres	Treatment acres within aspen patches: 1,452 acres
Grasslands	Acres of encroached grasslands: 48,196 acres Acres of historic grasslands (ponderosa pine cover type on mollisol soils): 14,665 acres Acres of savannas (ponderosa pine cover type on mollic integrade soils with open reference condition): 302,926 acres	Restore grasslands and savannas; Enhance historic grassland inclusions within greater forested area.	Treatment acres within encroached grasslands: 0 acres Treatment acres within historic grasslands: 0 acres Treatment acres within savannas: 0 acres Treatment acres within PFA, LOPFA and MSO restricted habitat that would enhance grassland inclusions: 0 acres	Treatment acres within encroached grasslands: 0 acres Treatment acres within historic grasslands: 11,185 acres Treatment acres within savannas: 45,469 acres Treatment acres within PFA, LOPFA and MSO restricted habitat that would enhance grassland inclusions: 310,917 acres	Treatment acres within encroached grasslands: 48,196 acres Treatment acres within historic grasslands: 11,230 acres Treatment acres within savannas: 45,469 acres Treatment acres within PFA, LOPFA and MSO restricted habitat that would enhance grassland inclusions: 308,199 acres	Treatment acres within encroached grasslands: 0 acres Treatment acres within historic grasslands: 11,185 acres Treatment acres within savannas: 45,469 acres Treatment acres within PFA, LOPFA and MSO restricted habitat that would enhance grassland inclusions: 305,657 acres

Indicator	Existing Condition	Desired Condition	Alternative A	Alternative B	Alternative C	Alternative D
Pine-Sage	Acres with pine-sage potential vegetation type: 16,000	Maintain and enhance the sage understory and restore the historic overstory/understory pattern within the pine-sage mosaic.	Treatment acres the within pine-sage potential vegetation type: 0 acres	Treatment acres the within pine-sage potential vegetation type: 5,262 acres	Treatment acres the within pine-sage potential vegetation type: 5,262 acres.	Treatment acres the within pine-sage potential vegetation type: 5,262 acres.
Ponderosa Pine Acres Moving Toward Landscape-Scale Forest Resiliency and Function (ponderosa pine acres with improved vegetation structure, forest health and vegetation diversity and composition).			0 acres	501,208 acres	510,346 acres	487,233 acres

Alternatives B, C and D - Effects of Not Amending the Forest Plans

The following is a description of how the forest plan amendments under this EIS would modify the forest plans standards and guidelines and what the effects to the vegetation resource would be if the amendment did not occur.

- Coconino NF Amendment #1 – Alternatives B and D. 1) Allows mechanical treatment up to 16" dbh in 18 PACs; 2) Adds definition of MSO restricted and threshold habitat; 3) Defers MSO population and habitat monitoring to the project's USFWS Biological Opinion and defers MSO habitat treatment design to the project's USFWS Biological Opinion.
    - If the amendment did not occur: 1) Mechanical treatments would be limited to a maximum of 9" dbh in the 18 PACs thereby restricting the treatment to a fuels reduction objective and reducing the ability to improve MSO habitat in terms of age class diversity and liberation of overtopped oak; 2) Treatments within MSO habitat would continue to meet the intent of the MSO recovery plan and the MSO habitat definition will not have an effect on the treatments themselves or their outcomes; 3) Following existing Forest Plan language concerning MSO population and habitat monitoring or MSO habitat design will not have an effect on the treatments themselves or their outcomes.
- Coconino NF Amendment #1 – Alternative C. 1) Allows mechanical treatment up to 18" dbh in 18 MSO PACs; 2) Allows prescribed fire in 56 MSO core areas; 3) Adds definition of MSO restricted and threshold habitat; 4) Allows for managing 6,321 acres of MSO restricted target and threshold habitat for a range of 110 to 150 ft^2 of basal area; 5) Defers MSO population and habitat monitoring to the project's USFWS Biological Opinion and defers MSO habitat treatment design to the project's USFWS Biological Opinion.
    - If the amendment did not occur: 1) Mechanical treatments would be limited to a maximum of 9" dbh in the 18 PACs thereby restricting the treatment to a fuels reduction objective and reducing the ability to improve MSO habitat in terms of age class diversity and liberation of overtopped oak; 2) Without the use of prescribed fire in 56 MSO core areas, the opportunity to improve MSO habitat in terms of reducing litter/duff cover and stimulating regeneration and growth of native herbaceous vegetation would be eliminated; 3) Treatments within MSO habitat would continue to meet the intent of the MSO recovery plan and the MSO habitat definition will not have an effect on the treatments themselves or their outcomes; 4) Mechanical treatments within the 6,321acres of target/threshold habitat would follow the denser 150 ft^2 basal area guidance thereby reducing the ability to improve MSO nesting/roosting habitat in terms of sustainability, as indicated by high potential for density related mortality and high bark beetle hazard rating as well as reducing the ability to improve age class diversity and the liberation of overtopped oak; 5) Following existing Forest Plan language concerning MSO population and habitat monitoring or MSO habitat design will not have an effect on the treatments themselves or their outcomes.
- Coconino NF Amendment #2 - Alternatives B, C and D. 1) Adds the desired percentage of interspace; 2) Adds the interspace distance between tree groups; 3) Adds language

clarifying where canopy cover is and is not measured; 4) Allows 29,017 acres to be managed for an open reference condition (up to 90 percent open with less than 3 to 5 reserve trees); 5) Adds a definition to the forest plan glossary for the terms: interspace, open reference condition and stand.

  - If the amendment did not occur: 1) and 2) The lack of clarifying language describing the relationship between non-forested areas (interspace) and natural openings across the landscape could result in interspace establishment being eliminated from the treatment design and the only features contributing to landscape openness would be existing natural openings. If that were to occur, it would inhibit the ability to meet desired conditions in terms of creating a mosaic of interspaces and tree groups of varying shapes and sizes, enhancing the representation of all age and size classes, sustaining old forest structure across the landscape, improving forest health and enriching vegetation diversity and composition; 3) The plans lack explicit language for measuring canopy cover. Treatments within goshawk habitat would continue to meet the intent of the forest plans with regards to canopy cover and the lack of explicit language for how or where it is measured will not have an effect on the treatments themselves or their outcomes; 4) The 29,017 acres would be managed under the current forest plan guidelines and would not meet desired conditions consistent with an open reference condition; 5) Treatments within goshawk habitat would continue to meet the intent of the forest plan guidelines. Defining these terms is for clarification purposes and will not have an effect on the treatments themselves or their outcomes

- Coconino NF Amendment #3 - Alternatives B, C and D – For Cultural Resources, deletes the standard that would require achieving a “no effect” determination and adds the words “or no adverse effect” to the remaining standard.

  - If the amendment did not occur, it could potentially result in areas not being treated in order to attain a “no effect” determination. Without treatment, these areas would not move toward desired conditions in terms of creating a mosaic of interspaces and tree groups of varying shapes and sizes, enhancing the representation of all age and size classes, sustaining old forest structure across the landscape, improving forest health and enriching vegetation diversity and composition.

- Kaibab NF Amendment #1 - Alternatives B, C and D. 1) Adds the desired percentage of interspace; 2) Adds the interspace distance between tree groups; 3) Adds language clarifying where canopy cover is and is not measured; 4) Allows 27,637 in alternatives B and D and 27,675 acres in alternative C to be managed for an open reference condition (up to 90 percent open with less than 3 to 5 reserve trees); 5) Adds a definition to the forest plan glossary for the terms: interspace, open reference condition and stand.

  - If the amendment did not occur: 1) and 2) The lack of clarifying language describing the relationship between non-forested areas (interspace) and natural openings across the landscape could result in interspace establishment being eliminated from the treatment design and the only features contributing to landscape openness would be existing natural openings. If that were to occur, it

would inhibit the ability to meet desired conditions in terms of creating a mosaic of interspaces and tree groups of varying shapes and sizes, enhancing the representation of all age and size classes, sustaining old forest structure across the landscape, improving forest health and enriching vegetation diversity and composition; 3) The plans lack explicit language for measuring canopy cover. Treatments within goshawk habitat would continue to meet the intent of the forest plans with regards to canopy cover and the lack of explicit language for how or where it is measured will not have an effect on the treatments themselves or their outcomes; 4) The 27,637 acres (alternatives B and D) or the 27,675 acres (alternative C) would be managed under the current forest plan guidelines and would not meet desired conditions consistent with an open reference condition; 5) Treatments within goshawk habitat would continue to meet the intent of the forest plan guidelines. Defining these terms is for clarification purposes and will not have an effect on the treatments themselves or their outcomes

- Kaibab NF Amendment #2 - Alternatives B and D. 1) Adds definition of MSO restricted and threshold habitat; 2) Allows managing for less than 10% threshold habitat within the KNF portion of the project area; 3) Defers MSO population and habitat monitoring to the project's USFWS Biological Opinion and defers MSO habitat treatment design to the project's USFWS Biological Opinion.

    - If the amendment did not occur: 1) Treatments within MSO habitat would continue to meet the intent of the MSO recovery plan and the MSO habitat definition will not have an effect on the treatments themselves or their outcomes; 2) Managing for 10% threshold habitat within the KNF portion of the project area could result in habitat that is not capable of maintaining a population of MSOs and that could not be sustained through time being designated as threshold; 3) Following existing Forest Plan language concerning MSO population and habitat monitoring or MSO habitat design will not have an effect on the treatments themselves or their outcomes.

- Kaibab NF Amendment #2 - Alternative C. Adds language that would allow prescribed fire and mechanical treatments in order to maintain and/or restore the ecological qualities of the proposed Garland Prairie RNA.

    - If the amendment did not occur, fire and mechanical treatments would not take place within the Garland Prairie RNA. The effect of no action within the RNA includes continued encroachment of existing interspace by ingrowth and tree crown expansion and no reestablishment historic openings further reducing forage production and understory species diversity; Declining forest health in terms of increased probability of density related mortality, increased beetle hazard, continued forest conditions that encourage mistletoe spread and intensification, and decreased resilience under a warmer, drier climate.

- Kaibab NF Amendment #3 - Alternative C. 1) Adds definition of MSO restricted and threshold habitat; 2) Allows managing for less than 10% threshold habitat; 3) Allows for managing 2,090 acres of MSO restricted target and threshold habitat for a range of 110 to 150 ft^2 of basal area; 4) Defers MSO population and habitat monitoring to the project's

USFWS Biological Opinion and defers MSO habitat treatment design to the project's USFWS Biological Opinion.

- If the amendment did not occur: 1) Treatments within MSO habitat would continue to meet the intent of the MSO recovery plan and the MSO habitat definition will not have an effect on the treatments themselves or their outcomes; 2) Managing for 10% threshold habitat within the KNF portion of the project area could result in habitat that is not capable of maintaining a population of MSOs and that could not be sustained through time being designated as threshold; 3) Mechanical treatments within the 2,090 acres of target/threshold habitat would follow the denser 150 ft^2 basal area guidance thereby reducing the ability to improve MSO nesting/roosting habitat in terms of sustainability, as indicated by high potential for density related mortality and high bark beetle hazard rating as well as reducing the ability to improve age class diversity and the liberation of overtopped oak; 4) Following existing Forest Plan language concerning MSO population and habitat monitoring or MSO habitat design will not have an effect on the treatments themselves or their outcomes.

Cumulative Effects

For the cumulative effects analysis, the spatial context being considered is the 988,764 acre project area. Cumulative effects are discussed in terms of wildfire and vegetation management activities that have occurred since 2001 and as changes in the existing condition due to present and foreseeable activities, including the effects of the alternative being discussed. The time frame considered is approximately 10 years in the future at which time the majority of the actions proposed will have been completed and the vegetation response to these actions has occurred.

Cumulative Effects –Vegetation Management Activities and Wildfire 2001 to 2010

Table 81 lists approximate acres of the various vegetation management, fuels treatment and prescribed burning as well as wildfires that have occurred within the project area from 2001 to 2010.

Mechanical vegetation management activities have mainly consisted of tree thinning. This includes 50,940 acres with a fuels reduction emphasis, 14,950 acres with a ponderosa pine restoration emphasis and 750 acres with an emphasis on improving forest structure, health and growth. There has also been 12,560 acres of tree removal to restore ponderosa pine savannas and encroached grasslands, 2,650 acres of removal of dead, damaged or dwarf mistletoe infected trees to improve forest health, 100 acres of tree removal to restore aspen inclusions and 1,935 acres of habitat improvement treatments that reduced tree density within antelope travel corridors. Within the project area there has been 640 acres of tree and vegetation removal associated with powerline corridor management and protection.

Fuels treatments that have been accomplished in association with the above listed mechanical treatments included 3,910 acres of mechanical fuels treatments (slash lopping, crushing, piling and jackpot burning), 5,070 acres of machine piling and burning and 59,640 acres of broadcast burning. The primary focus of these treatments was to rearrange and reduce activities generated fuels.

Prescribed burns have been implemented on 47,970 acres to reduce natural fuels accumulations and reintroduce fire to fire adapted ecosystems.

Wildfires from 2001 to 2010 have burned on approximately 108,160 acres of the project area. Of these acres, it is estimated that the overall average burn severity to the vegetation was 20 percent high severity, 30 percent mixed severity and 50 percent low severity. There is wide variability among these percentages from fire to fire.

Table 81. 2001 to 2010 – Approximate Acres of Vegetation Management Activities and Wildfire within the Project Area

Treatment	Treatment Type	Approximate Acres
Mechanical Vegetation Management	Thinning – Fuels Reduction Emphasis	50,940
	Thinning – Restoration Emphasis	14,950
	Thinning – Stand Improvement	750
	Savanna/Grassland Restoration	12,560
	Sanitation/Salvage	2,650
	Aspen Restoration	100
	Habitat Improvement	1,935
	Powerline Hazard Tree Removal and Right of Way	640
Total Mechanical:		**84,525**
Fuels Treatments (With Mechanical)	Mechanical Fuels Treatment	3,910
	Pile and Burn	5,070
	Broadcast Burn	59,640
Total Fuels Treatments:		**68,620**
Prescribed Burn (Burn Only)		**47,970**
Wildfire		**108,160**

The following is a discussion of effects of these past management activities and wildfires in terms of the analysis questions specific to the vegetation resource.

Forest Structure and Diversity - Mosaic of interspaces and tree groups of varying sizes and shapes

The thinning with a restoration emphasis and savanna restoration treatments were designed to reestablish forest openings and attain a mosaic of interspaces and tree groups of varying sized and shapes. All other treatments listed were incidental to this desired condition. Mixed severity wildfires resulted in a mosaic of tree mortality and a pattern with indiscriminate interspaces and tree groups. The remaining treatments and low severity wildfire resulted in some irregular tree spacing.

Forest Structure - All age and size classes represented

The main objective of thinning with a fuels reduction emphasis was to reduce canopy fuels and the potential for crown fire initiation. Generally, this type of treatment focused on removal of trees in the subordinate crown positions and retaining those trees in the dominate and co-dominate crown positions and any pre-settlement trees. This type of treatment resulted in a moderately open canopy, even aged forest structure with very little age and size class diversity.

The thinning treatments with restoration objectives were very similar to the goshawk habitat and MSO restricted other habitat treatments proposed under this EIS and have resulted in similar diversity in age and size class.

Prescribed burning and mechanical fuels treatments associated with the above thinning treatments resulted in periodic tree mortality of seedling/sapling size trees and susceptible pre-settlement trees further reducing age class diversity.

High and mixed severity wildfires caused large scale mortality across all age and size classes resulting in a non-stocked or single age class representation. Wildfires that burned with a low severity and prescribed burn only treatments had similar effects to forest structure as the post thinning prescribed fires.

Old Forest Structure Sustained Over Time Across the Landscape

Thinning treatments retained pre-settlement trees and the largest post-settlement trees. Sanitation treatments may have removed some old forest structure. Prescribed burning and low severity wildfire resulted in periodic tree mortality of susceptible pre-settlement trees. Mixed and high severity wildfire killed a large proportion of the old forest structure. Powerline treatments removed any old forest structure that was a hazard to the powerline.

Forest Health

Thinning treatments resulted in forest density within the low to moderate density zones. This in turn had a beneficial effect of improved forest growth, and reducing the potential for density and bark beetle related mortality. Thinning treatments also removed dwarf mistletoe infected trees reducing the percent of trees infected as well as creating conditions that slowed or inhibited mistletoe spread. Prescribed fire and low severity wildfire also led to localized reduction of forest density and dwarf mistletoe infection.

The thinning treatments reduced risks associated with dense forest conditions and improved resilience to the impacts of large scale disturbance under drier and warmer conditions. Within forest carbon stocks were reduced by the thinning. Some of the carbon removed has been sequestered for a time in the form of pallets and building materials. Mixed and high severity wildfires released large amounts of carbon into the atmosphere and resulted in a carbon source as dead material continues to decay. This is especially prevalent in burned areas where the conifer forests have not regenerated.

Vegetation Diversity and Composition – Maintain and Promote

Grasslands

The savanna/grassland restoration treatments implemented restored historic grasslands, savannas and forest openings by removing ponderosa pine tree canopy that was shading out understory herbaceous vegetation. Thinning treatments with a restoration objective also restored historic forest openings.

Oak

Removing conifer competition with mid and understory oak as part of the thinning contributed to maintaining and improving oak growth and vigor. Mixed and high severity wildfire killed large oaks that were replaced by oak sprouts thereby changing oak structure from old to young.

Aspen

Aspen restoration treatments were very similar to the aspen treatments proposed under this EIS and have resulted in aspen regeneration and age class diversity.

Pine Sage

Some of the fuels reduction thinning within pine sage on the Tusayan district removed overtopping young pines and improved conditions for understory sage.

Cumulative Effects – Alternative A

Alternative A would not contribute to improving forest health or vegetation diversity and composition, or sustaining old forest structure over time, or moving forest structure toward the desired conditions.

Cumulative Effects – Alternatives B, C, and D

Alternative B restoration treatments would contribute an additional 509,195 acres toward improving forest health and vegetation diversity/composition, sustaining old forest structure over time, and moving forest structure toward the desired conditions.

Alternative C restoration treatments would contribute an additional 562,380 acres toward improving forest health and vegetation diversity/composition, sustaining old forest structure over time, and moving forest structure toward the desired conditions.

Alternative D restoration treatments would contribute an additional 489,029 acres toward improving forest health and vegetation diversity/composition, sustaining old forest structure over time, and moving forest structure toward the desired conditions.

Cumulative Effects – Present and Foreseeable Vegetation Management Activities

Table 82 lists approximate acres of the various vegetation management, fuels treatment and prescribed burning that are ongoing (as of 2011) or are foreseeable within the project area. The effects of the thinning with restoration emphasis, savanna/grassland restoration, aspen restoration as well as the prescribed burning are similar to what has been described with the proposed treatments for this EIS. The effects of the thinning with a fuels reduction emphasis will be similar to those that occurred from 2001 to 2010 as discussed above. The salvage involves the removal of down trees as a result of the 2010 tornado and has no effect to forest structure or diversity. The maintenance of powerline corridors will continue as needed and will remove any vegetation that is a hazard to the line.

Table 82. Approximate Acres of Present and Foreseeable Vegetation Management Activities within the Project Area

Treatment	Treatment Type	Approximate Acres

Treatment	Treatment Type	Approximate Acres
Mechanical Vegetation Management	Thinning – Fuels Reduction Emphasis	6,670
	Thinning – Restoration Emphasis[5]	80,940
	Thinning – Stand Improvement	0
	Savanna/Grassland Restoration	11,130
	Sanitation/Salvage	4,290
	Aspen Restoration	5,130
	Habitat Improvement	0
	Powerline Hazard Tree Removal and Right of Way	500
Total Mechanical:		**108,660**
Fuels Treatments (With Mechanical)	Mechanical Fuels Treatment	0
	Pile and Burn	0
	Broadcast Burn	102,470
Total Fuels Treatments:		**102,470**
Prescribed Burn (Burn Only)		5,950

Evaluation of Alternatives for Forest Plan Consistency

National Forest Management Act Consistency Finding For Silvicultural Treatments

Finding of Facts Pursuant to the National Forest Management Act

Based on the environmental analysis and prescriptions for stands in the Four Forest Restoration Initiative Coconino NF and Kaibab NF Project Area, the following finding of facts pursuant to the National Forest Management Act, are as follows:

A. The minimum specific management requirements to be met in carrying out projects and activities for the National Forest System are set forth in this section. Under 16 U.S.C. 1604 (g)(3)(E) a Responsible Official may authorize project and activity decisions on NFS lands to harvest timber only where:

1. Soil, slope, or other watershed conditions will not be irreversibly damaged

   The Coconino and Kaibab National Forests Land and Resource Management Plans (LRMP) Forest-wide Standards and Guidelines relating to soil cover, water quality, and riparian system protection, along with Best Management Practices (BMPs) would be implemented to protect and mitigate potential impacts to soil and water quality.

   The Hydrologist for the Coconino and Kaibab National Forests has determined through a Soils and Watershed Analysis that no irreversible or irretrievable commitments of soils, riparian, or water resources are expected for any alternative (see Hydrology and Soils Reports).

2. There is assurance that such lands can be adequately restocked within five years after harvest

[5] This includes 3,670 acres of treatments associated with the 2013 Flagstaff Watershed Protection Project.

All trees proposed for removal under the Four Forest Restoration Initiative Coconino NF and Kaibab NF Project would be by intermediate and/or selection cutting methods. Therefore, no regeneration harvests are proposed under this project. However, the areas proposed for harvest under selection cutting can be regenerated using standard reforestation techniques.

3. Protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat

   The Coconino and Kaibab National Forests LRMP forestwide Standards and Guidelines relating to soil cover, water quality, and riparian system protection, along with BMPs would be implemented to protect and mitigate potential impacts to soil and water quality.

4. The harvesting system to be used is not selected primarily because it will give the greatest dollar return or the greatest unit output of timber.

B. A Responsible Official may authorize project and activity decisions on NFS lands using clearcutting, seed tree cutting, shelterwood cutting, and other cuts designed to regenerate an even-aged stand of timber as a cutting method only where:

Even-aged management would not be applied to the stands at this time.

Forest Plan and Amendments

Alternatives B, C and D are consistent with Forest Plan Standards and the Regionally Consistent Standards and Guidelines as described in the Management Direction section of this report and as amended under this EIS.

Short-Term Use and Long-Term Productivity

Short-term effects of tree removal and prescribed burning will reduce inter-tree competition and free up growing space for residual trees and understory vegetation. Under all alternatives, the proposed actions and associated design features would not affect long-term productivity of forest vegetation and timber resources.

Irreversible and Irretrievable Commitments

Under all alternatives, the proposed actions and associated design features would not involve or invoke irreversible and irretrievable commitments of forest vegetation and timber resources.

Unavoidable Adverse Environmental Effects

There are no unavoidable adverse effects related to forest vegetation and timber resources.

Potential Conflicts with Plans, Policies and Objectives of Other Jurisdictions

There would be no potential conflicts of the alternatives considered with plans, policies, or objectives of NFMA.

References

Abella, Scott R. 2008. Managing Gambel oak in southwestern ponderosa pine forests: the status of our knowledge. Gen. Tech. Rep. RMRS-GTR-218. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 27 p.

Abella, S.R.; Denton, C.W. 2009. Spatial variation in reference conditions: Historical tree density and pattern on a *Pinus ponderosa* landscape. Canadian Journal of Forestry 39:2391-2403.

Abella, S.R.; Denton, C.W.; Brewer, D.G.; Robbie, W.A.; Steinke, R.W.; Covington, W.W. 2011. Using a terrestrial ecosystem survey to estimate the historical density of ponderosa pine trees. Research Note RMRS-RN-45. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 9 pp.

Allen, S.R.; Savage, M.; Falk, D.A.; Suckling, K.F.; Swetnam, T.W.; Shulke, T.; Stacey, P.B.; Morgan, P.; Hoffman, M.T.; Klingel, J.T. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. Ecological Applications 12(5):1418-1433.

Allen C.D. 2007. Interactions across spatial scales among forest dieback, fire, and erosion in northern New Mexico landscapes. Ecosystems 10: 797-808.

Andrews S.R., Daniels J.P. 1960. A survey of dwarf mistletoes in Arizona and New Mexico. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Station Paper 49: 17 p.

Brown, P.M.; Kaye, M.W.; Huckaby, L.; Baisan, C. 2001. Fire history along environmental gradients in the Sacramento Mountains, New Mexico: Influences of local patterns and regional processes. Ecoscience 8:115-126.

Chojnacky, D.C., B.J. Bentz, and J.A. Logan. 2000. Mountain pine beetle attack in ponderosa pine: comparing methods for rating susceptibility. USDA Forest Service Research Paper, RMRS-RP-26, 10 pp.

Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since white settlement. Ecological Monographs 30:129-164.

Conklin, D.A.; Fairweather, M.L. 2010. Dwarf mistletoes and their management in the Southwest. USDA Forest Service, Southwestern Region, R3-FH-10-01. 23p.

Covington, W.W.; Moore, M.M. 1994a. Postsettlement changes in natural fire regimes and forest structure: Ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry 2(1/2):153-181.

Covington W.W., Moore M.M. 1994b. Southwestern ponderosa pine structure: changes since Euro-American settlement. Journal of Forestry 92: 39-47.

Covington, W. W., Fule, P. Z., Moore, M. M., Hart, S. C., Kolb, T. E., Mast, J. N., Sackett, S. S., and M. R. Wagner. 1997. Restoring ecosystem health in ponderosa pine forests of the southwest. Journal of Forestry, 94 (4): 23-29.

Crookston, Nickolas L., Melinda Moeur, and David Renner. 2002. Users guide to the most similar neighbor imputation program version 2. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-96.

Dahms C. W., Geils B.W. (Technical editors). 1997. An assessment of forest ecosystem health in the Southwest. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-GTR-295. 97 p. Fort Collins CO.

DeMars, C.J., and B.H. Roettgering. 1982. Western pine beetle. USDA Forest Service Forest Insect & Disease Leaflet 1. 8 p.

Dixon, Gary E. comp. 2002. Essential FVS: A user's guide to the Forest Vegetation Simulator. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 240p. (Revised: November 24, 2010)

Drake, W.M. 1910. A report on the Coconino National Forest. Unpublished report, Coconino National Forest, Flagstaff, AZ.

Ehle, D.S.; Baker, W.L. 2003. Disturbance and stand dynamics in ponderosa pine forests in Rocky Mountain National Park, USA. Ecological Monographs 73:543-566.

Fettig C.J., Klepzig K.D. Billings R.F. Munson A.S., Nebeker T.E., Negron J.F., Nowak J.T. 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forests of the western and southern United States. Forest Ecology and Management 238: 24–53.

Fairweather M.L., Barton K., Geils B., Manthei M. 2006. Aspen Dieback and Decline in Northern Arizona. National Forest Health Monitoring. USDA, Forest Service, 2006 Poster Presentations.

Fairweather, M., Geils, B., and Manthei, M. 2008. Aspen Decline on the Coconino National Forest. In: McWilliams, M. G. comp 2008. Proceedings of the 55th Western International Forest Disease Work Conference; 2007 October 15-19; Sedona, AZ. Salem, OR; Oregon Department of Forestry.

Fiedler, C.E.; Arno, S.F.; Harrington, M.G. 1996. Flexible silvicultural and prescribed burning approaches for improving health of ponderosa pine forests. Pp 69-74 in Covington, W.W.; Wagner, P.K. (eds.). Conference on adaptive ecosystem restoration and management: Restoration of Cordilleran conifer landscapes of North America. General Technical Report RM-GTR-278. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Frinkral, A.J.; Evans, A.M. 2008. Effects of thinning treatment on carbon stocks in a northern Arizona ponderosa pine forest. Forest Ecology and Management 255:2743-2750.

Friederici, P. (ed.). 2003. Ecological Restoration of Southwestern Ponderosa Pine Forests. Washington, DC: Island Press.

Friederici, P. 2004. Establishing reference condition for southwestern ponderosa pine forest. Working papers in southwestern ponderosa pine forest restoration. Ecological Restoration Institute. Flagstaff, AZ. 16 p.

Fulé, P.Z.; Covington, W.W.; Moore, M.M. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. Ecological Applications 7:895–908.

Fulé, P.Z.; Crouse, J.E.; Heinlein, T.A.; Moore, M.M.; Covington, W.W.; Vankamp, G. 2003. Mixed-severity fire regime in high-elevation forest of the Grand Canyon, Arizona, USA. Landscape Ecology 18:465-486.

Furniss R.L., Carolin V.M. 1977. Western Forest Insects. USDA Forest Service Misc. Publ. No. 1339. 654 p. Washington D.C.

Germain C.J., Weiss M.J., Loomis R.C. 1973. Insect & disease conditions – 1972. USDA Forest Service, Southwestern Forest Insect & Disease Bulletin 3(1): 19 p. Albuquerque NM.

Gill, S.; Biging, G.S.; Murphy, E.C. 2000. Modeling conifer tree crown radius and estimating canopy cover. Forest Ecology and Management 126:405-416.

Gitlin A.R., Sthultz C.M., Bowker M.A., Stumpf S., Paxton K.L., Kennedy K., Muñoz A., Bailey J.K., Whitham T.G. 2006. Mortality gradients within and among dominant plant populations as barometers of ecosystem change during extreme drought. Conservation Biology 20: 1477-1486.

Hawksworth F.G., Wiens D. 1996. Dwarf mistletoes: biology, pathology, and systematics. USDA Forest Service, Agriculture Handbook 709. Washington, DC. 410 p.

Hessburg P.F., Beatty J.S. 1985. Incidence, severity, and growth losses associated with ponderosa pine dwarf mistletoe on the Coconino National Forest, Arizona. US Forest Service, Southwestern Region, R3-85-12, 30 p.

Hopkins A.D. 1909. Practical information on the scolytid bbeetles of North American forests. 1. Bark Beetles in the genus Dendroctonus. Bulletin 83. USDA Bureau of Entomology, Washington D.C., 169 p.

Hurteau, M. and M. North. 2009. Fuel treatment effects on tree-based carbon storage under modeled wildfire scenarios. Frontiers in Ecology and the Environment, 7:409–414.

Hurteau, M. D., M. T. Stoddard, and P. Z. Fule. 2011. The carbon costs of mitigating high-severity wildfire in southwestern ponderosa pine. Global Change Biology, 17:1516–1521.

Jennings D.T., Stevens R.E. 1982. Southwestern pine tip moth. USDA Forest Service, Forest Insect & Disease Leaflet 58.

Kaye, M.W.; Swetnam, T.W. 1999. An assessment of fire, climate, and Apache history in the Sacramento Mountains, New Mexico, USA. Physical Geography 20:305-330.

Kenaley S.C., Mathiasen R.L., Daugherty C.M. 2006. Selection of dwarf mistletoe-infected ponderosa pines by Ips species (Coleoptera: Scolytidae) in northern Arizona. Western North American Naturalist 66(3): 279-284.

Kenaley S.C., R.L., Mathiasen, and E.J. Harner. 2008. Mortality Associated with a Bark Beetle Outbreak in dwarf mistletoe-infested ponderosa pine stands in Arizona. Western Journal of Applied Forestry 23: 113 - 120.

Keyser, Chad E.; Dixon, Gary E., comps. 2008 (revised February 3, 2010). Central Rockies (CR) Variant Overview – Forest Vegetation Simulator. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 66p.

Kolb, T.E., K.M. Holmberg, M.R. Wagner, and J.E. Stone. 1998. Regulation of ponderosa pine foliar physiology and insect resistance mechanisms by basal area treatments. Tree Physiology 18: 375-381.

Kolb T.E. Guerard N., Hofstetter R.W., Wagner M.R. 2006. Attack preference of Ips pini on Pinus ponderosa in northern Arizona: tree size and bole position. Agricultural and Forest Entomology 8: 295–303.

Lata, M. 2012. Fire Ecology Specialist Report. Coconino National Forest. Flagstaff, AZ.

Laughlin, D.C.; Moore, M.M.; Bakker, J.D.; Casey, C.A.; Springer, J.D.; Fulé, P.Z.; Covington, W.W. 2006. Assessing targets for the restoration of herbaceous vegetation in ponderosa pine forests. Restoration Ecology 14:548-560.

Lessard G., Jennings D.T. 1976. Southwestern pine tip moth damage to ponderosa pine reproduction. USDA Forest Service, Rocky Mountain Forest & Range Experiment Station, Research Paper RM-168, 8 p. Fort Collins CO.

Long D.W., Wagner M.R. 1992. Effects of Southwestern pine tip moth and vegetation competition on ponderosa pine growth. Forest Science 38: 173-186.

Long, J.N. and F.W. Smith. 1984. Relation between size and density in developing stands: a description and possible mechanism. For. Ecol. And Management 7:191-206.

Long, J.N. 1985. A practical approach to density management. Forestry Chronicle 61:23-27.

Long, J.N. and T.W. Daniel. 1990. Assessment of growing stock in uneven-aged stands. Western Journal of Applied Forestry. 5:93-96.

Lynch A.M., Anhold J.A., McMillin J.D., Dudley S.M., Fitzgibbon R.A., Fairweather M.L. 2008a. Forest insect and disease activity on the Coconino N.F., 1918-2006. USDA Forest Service, Report for the Coconino N.F./Regional Analysis Team.

Lynch A.M., Anhold J.A., McMillin J.D., Dudley S.M., Fitzgibbon R.A., Fairweather M.L. 2008b. Forest insect and disease activity on the Kaibab N.F. and Grand Canyon N.P., 1918-2006. USDA Forest Service, Draft Report for the Kaibab N.F./Regional Analysis Team.

Mast, J.N.; Fulé, P.Z.; Moore, M.M.; Covington, W.W.; Waltz, A.E.M. 1999. Restoration of presettlement age structure of an Arizona ponderosa pine forest. Ecological Applications 9:228-239.

Mast, J.N.; Veblen, T.T.; Linhart, Y.B. 1998. Disturbance and climatic influences on age structure of ponderosa pine at the pine/grassland ecotone, Colorado Front Range. Journal of Biogeography 25:743-767.

McMillin, Joel D. et al. 2011. Draft hazard rating for Ips beetles during drought in Arizona. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Southwestern Region, State and Private Forestry, Forest Health Protection, Flagstaff, AZ. 1 p.

McMillin, Joel. 2012. Personal communication email: 2/13/2012. U.S. Department of Agriculture, Forest Service, Southwestern Region, State and Private Forestry, Forest Health Protection, Flagstaff, AZ.

Menzel, J.P.; Covington, W.W. 1997. Changes from 1876 to 1994 in a forest ecosystem near Walnut Canyon, northern Arizona. Pp 151-172 in van Riper III, C.; Deshler, E.T. (eds.). Proceedings of the Third Biennial Conference of Research on the Colorado Plateau.

Transactions and Proceedings Series NPS/NRNAU/NRTP-97/12. Dept. of the Interior, National Park Service. 256 pp.

Moir, W.H. 1966. Influence of ponderosa pine on herbaceous vegetation. Ecology 47:1045-1048.

Moir, W.H.; Geils, B.; Benoit, M.A.; Scurlock, D. 1997. Ecology of southwestern ponderosa pine forests. Pp 3-27 in Block, W.M.; Finch, D.M. (tech. eds.). Songbird ecology in southwestern ponderosa pine forests: A literature review. General Technical Report RM-GTR-292. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 152 pp.

Moore, M.M.; Huffman, D.W.; Fulé, P.Z.; Covington, W.W.; Crouse, J.E. 2004. Comparison of historical and contemporary forest structure and composition on permanent plots in southwestern ponderosa pine forests. Forest Science 50:62-176.

Mueller R.C., Scudder C.M., Porter M.E., Trotter R.T., Gehring C.A., Whitham T.G.. 2005. Differential tree mortality in response to severe drought: evidence for long-term vegetation shifts. Journal of Ecology 93:1085-1093.

Naumburg, E.; DeWald, L.E. 1999. Relationships between Pinus ponderosa forest structure, light characteristics, and understory graminoid species presence and abundance. Forest Ecology and Management 124:205-215.

Negrón, J.F., J.L Wilson, and J.A. Anhold. 2000. Stand conditions associated with roundheaded pine beetle (Coleoptera: Scolytidae) infestations in Arizona and Utah. Environmental Entomology 29: 20-27.

Negrón, J. F., J. D. McMillin, J. A. Anhold and D. Coulson. 2009. Bark beetle-caused mortality in a drought-affected ponderosa pine landscape in Arizona, USA. Forest Ecology and Management 257: 1353–1362.

Noble, W. 2012. Wildlife Specialist Report. Coconino National Forest. Flagstaff, AZ.

Parmeter J.R. Jr. 1978. Forest stand dynamics and ecological factors in relation to dwarf mistletoe spread, impact, and control. Scharpf, R.F.; Parmeter, J.R., Jr., tech. coords. Dwarf mistletoe control through forest management; 1978 April 11-13; Berkeley, DA. Berkeley, CA: General Technical Report PSW-31. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station: 16-30.

Pearson, G.A. 1950. Management of ponderosa pine in the Southwest: As developed by research and experimental practice. Agriculture Monograph No. 6. USDA Forest Service, Fort Collins, CO. 34 pp.

Reineke, L.H. 1933. Perfecting a stand-density index for even-aged forests. Journal of Agricultural Research. 46:627-638.

Reynolds, R.T.; Graham, R.T.; Reiser, M.H.; Bassett, R.L.; Kennedy, P.L.; Boyce, D.A., Jr.; Goodwin, G.; Smith, R.; Fisher, E.L. 1992. Management recommendations for the northern goshawk in the Southwestern United States. General Technical Report RMRS-GTR-217. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 90 pp.

Rolf J.A. 2001. Aspen fencing in Northern Arizona: A 15-year perspective. Pp. 193-196 in Shepperd W.D., Binkley D., Bartos D.L., Stohlgren T.J., Eskew L.G. (compilers).

Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-18. Fort Collins, CO.

Sánchez Meador, A.J.; Parysow, P.F.; Moore, M.M. 2010. Historical stem-mapped permanent plots increase precision of reconstructed reference data in ponderosa pine forests of northern Arizona. Restoration Ecology 18:224-234.

Scurlock, Dan, and Deborah M. Finch. 1997. A historical review. Pages 43-68 in Block, William M.; Finch, Deborah M., technical editors. 1997. Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 152 p.

Schubert, Gilbert H. 1974. Silviculture of southwestern ponderosa pine: The status of our knowledge. Res. Paper RM-123. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 71 p.

Shepperd W.D., Fairweather M.L.. 1994. Impact of large ungulates in restoration of aspen communities in a southwestern ponderosa pine ecosystem. Pp. 344-347 In Covington W.S., DeBano L.F. (editors), Sustainable ecological approach to land managemen. USDA Forest Service, Rocky Mountain Forest & Range Experiment Station, General Technical Report RM-247, Fort Collins, CO.

Shepperd, W. D., Asherin, L. A., and Edminister, C. B. 2002. Using individual tree selection silviculture to restore northern goshawk habitat: Lessons from a southwestern study. In Beyond 2001: A Silvicultural Odyssey to Sustaining Terrestrial and Aquatic Ecosystems. Proceedings from the 2001 National Silviculture Workshop, May 6 – 10, 2001, Hood River, Oregon. PNW-GTR-546.

Pyne, S.J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton, N.J.:Princeton University Press.

Schmid, J.M., and S.A. Mata. 1992. Stand density and mountain pine beetle-caused mortality in ponderosa pine stands. USDA Forest Service Research Note, RM-515.

Schmid, J.M., S.A. Mata, R.A. Obedzinski. 1994. Stand hazard rating ponderosa pine stands for mountain pine beetles in the Black Hills. USDA Forest Service Research Note, RM-529.

Society of American Foresters. 1998. The dictionary of forestry. Bethesda, MD: 210 pp.

Society of American Foresters (SAF). 2005. Use of silviculture to achieve and maintain forest health on public lands. Position Statement Available at: http://www.safnet.org/policyandpress/psst/silviculture.pdf

Swetnam, T.W.; Baisan, C.H. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. Pp 11-32 in Allen, C.D. (ed.). 2nd La Mesa Fire Symposium; Los Alamos, NM. General Technical Report RM-GTR-286. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 216 pp.

Thompson, Walter, G. 1940. A growth rate classification of southwestern ponderosa pine. Journal of Forestry 38: 547-552.

USDA Forest Service. 1987. Coconino National Forest Land Management Plan, as amended.

USDA Forest Service. 1988. Kaibab National Forest Land Management Plan, as amended.

USDA Forest Service. 1994. Sustaining our aspen heritage into the twenty-first century. USDA Forest Service, Southwestern Region and Rocky Mountain Forest and Range Experiment Station. 7 p.

USDA, 1996. Record of decision for amendment of forest plans, Arizona and New Mexico. United States Department of Agriculture, Forest Service, Southwestern Region.

USDA Forest Service. 1997. Plant associations of Arizona and New Mexico. 3rd ed. Vol. 1. USDA Forest Service, Southwestern Region, Albuquerque, NM. 291 pp.

USDA Forest Service. 2000. Forest insect and disease conditions in the Southwestern Region, 1999. USDA Forest Service, Southwestern Region, R3-00-01: 17 p. Albuquerque NM.

USDA Forest Service. 2002. Forest insect and disease conditions in the Southwestern Region, 2001. USDA Forest Service, Southwestern Region, R3-02-01: 17 p. Albuquerque NM.

USDA Forest Service. 2003. Forest insect and disease conditions in the Southwestern Region, 2002. USDA Forest Service, Southwestern Region, R3-03-01: 33 p. Albuquerque NM.

USDA Forest Service. 2004. Forest insect and disease conditions in the Southwestern Region, 2003. USDA Forest Service, Southwestern Region, Forestry and Forest Health, R3-04-02, 34 p. Albuquerque, New Mexico.

USDA Forest Service. 2006. Cultural Resources Management. Logging Railroads of the Coconino and Kaibab National Forests. Supplemental Report to a National Register of Historic Places Multiple Property Nomination. 1993. Report No. 19. USDA Forest Service. Southwestern Region. Flagstaff, AZ. 302.pp.

USDA Forest Service. 2007. Historic ponderosa pine stand structure of mollisol and mollic integrade soils on the Coconino National Forest. Flagstaff, AZ. Unpublished document on file at the Coconino National Forest Supervisors Office.

USDA Forest Service. 2008a. Historic ponderosa pine stand structure of mollisol and mollic integrade soils on the Kaibab National Forest. Williams, AZ. Unpublished document on file at the Kaibab National Forest Supervisors Office.

USDA Forest Service. 2008b. Forest insect and disease conditions in the Southwestern Region, 2007. USDA Forest Service, Southwestern Region, Forestry and Forest Health, PR-R3-16-4, 47 p. Albuquerque, New Mexico.

USDA Forest Service. 2011. Forest insect and disease conditions in the Southwestern Region, 2010. USDA Forest Service, Southwestern Region, Forestry and Forest Health, PR-R3-16-7, 45 p. Albuquerque, New Mexico.

USDI Fish and Wildlife Service. 1995. Recovery Plan for the Mexican Spotted Owl : Vol.I. Albuquerque, New Mexico. 172pp.

USDI Fish and Wildlife Service. 2011. Draft Recovery Plan for the Mexican Spotted Owl (Strix occidentalis lucida), First Revision. U.S. Fish and Wildlife Service. Albuquerque, New Mexico, USA. XX pp.

Vandendriesche, Don, comp. 2010. A compendium of NFS regional vegetation classification algorithms. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 74p.

Weaver, H. 1951. Fire as an ecological factor in southwestern ponderosa pine forests. Journal of Forestry 49:93-98.

White, A.S. 1985. Presettlement regeneration patterns in a Southwestern ponderosa pine stand. Ecology 66:589-594.

Woolsey T.S. Jr. 1911. Western yellow pine in Arizona and New Mexico. USDA Forest Service, Bulletin 101. Washington, DC.

Yasinski F.M., Pierce D.A. 1958. Forest insect conditions in Arizona, New Mexico and west Texas -- 1957. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station #30, 10p. Fort Collins CO.

Appendix A - Silvicultural Design and Implementation Guide

The silvicultural design and implementation guide has been developed to ensure implementation of the forest vegetation treatments would meet the project purpose and need and meet the forest plan standards and guidelines as amended under this EIS. It is the foundation for the formal silvicultural prescriptions which document the desired conditions presented in the EIS and lays out a course of action to move towards those desired conditions. The treatment type specific parts of sections A, B, C and D provide direction to and will be utilized by the implementation personnel.

Section A – Existing forest plan management direction, desired conditions and treatment specific silvicultural design.

Section B – Decision matrix for establishing tree groups, interspace and regeneration openings as appropriate for each individual treatment .

Section C – Old tree descriptions and illustrations. Guidance used to implement Old Tree Implementation Plan.

Section D - The relationship between treatment intensity, tree group density and overall average density. Density management and stocking guidelines.

Section A – Existing Forest Plan Management Direction, Desired Conditions and Treatment Design

The following forest plan management direction is based on the existing Coconino and Kaibab Forest Plans. The implementation guide will be updated as the forest plans are amended or revised. Forest plan amendments as documented in this EIS have been incorporated into the treatment design. Where the design is different between alternatives, only the design for the selected alternative will be incorporated into the implementation guide.

This EIS analyzed the maximum range of treatments. Implementation of the selected alternative would have the ability to adjust to on the ground conditions and allowance would be made to implement a lesser intensity treatment where a higher intensity treatment was planned. There would be no allowance to implement a treatment of higher intensity than the treatment that was planned.

Mexican Spotted Owl Habitat - Protected Habitat

Protected Activity Center (PAC)

Vegetation Management Direction: Retain key forest species such as oak; retain key habitat components such as snags and large down logs; harvest conifers less than 9 inches in diameter only within those PACs treated to abate fire risk and avoid treatment in 100 acre nest cores as described in the MSO Recovery Plan. Further 4FRI guidelines as documented in the forest plan amendments: Allows mechanical treatment up to 18” dbh in 18 PACs in all alternatives with the primary objective of improving MSO habitat; Allows prescribed fire in 56 MSO core areas in alternative C.

Desired Conditions: Table III.B.1 (USFWS 1995) lists guidance for minimum desired structural elements within MSO nesting/roosting habitat. This includes 150 square feet of basal area, 30 percent or more of the stand density index in ponderosa pine trees ≥18-inch dbh, 15 percent or

more of the stand density index in ponderosa pine trees between 12- and 18-inch dbh, ≥20 trees per acre ≥18-inch dbh, and ≥20 Gambel oak basal area (BA). Other key habitat components includes snags 18 inches plus, down logs >12-inch midpoint diameter, hardwoods, and an understory vegetation layer that includes shrubs and herbaceous species.

PAC Mechanical Thin and Burn Treatment Design:

- Each PAC has 100-acre no treatment area around the known nest or roost sites.
- Outside the 100-acre no treatment area, trees may be thinned and/or prescribed burns may be used to treat fuels and mitigate fuel hazards where feasible.
- Each PAC to be thinned would have an upper diameter limit of trees that may be cut. All trees above that limit would be retained.
- Intermediate thinning would be used to increase residual tree health and vigor and reduce fire hazard.
- Manage for 150 square feet of BA where present or to attain 150 square feet of BA in areas with site potential capable of sustaining high tree density in alternative B and D. In alternative C, manage for a minimum of 110 square feet of BA where present or to attain 150 square feet of BA in areas with site potential capable of sustaining high tree density.
- Manage for irregular tree spacing to create canopy gaps and other structural conditions that would be conducive to low intensity prescribed fire treatment.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to the treatment diameter limit that do not meet the old tree definition and whose crowns are outside the old tree crown drip line 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks
- Gambel oak, juniper and pinyon species would not be cut as part of the treatments. These species may only be cut when there is no other option to facilitate logging operations (skid trails and landings).
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height and reducing litter/duff cover and other

surface fuel loading. Prescribed fires are designed to maintain and enhance desired MSO PAC habitat forest structure, tree densities, snag densities, and CWD levels.

PAC Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height and reduce litter/duff cover and other surface fuel loading.
- Prescribed fires are designed to maintain and enhance desired MSO PAC habitat forest structure, tree densities, snag densities, and CWD levels.

Steep Slopes

Vegetation Management Direction: Treat fuel accumulations to abate fire risk. Use combinations of thinning trees less than 9 inches in diameter, mechanical fuel removal, and prescribed fire; retain woody debris larger than 12 inches in diameter, snags, clumps of broad-leafed woody vegetation, and hardwood trees larger than 10-inch drc.

Desired Conditions: Table III.B.1 (USFWS 1995) lists structural elements. Other key habitat components includes snags 18 inches plus, down logs >12-inch midpoint diameter, hardwoods, and an understory vegetation layer that includes shrubs and herbaceous species.

Steep Slopes Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height and reduce litter/duff cover and other surface fuel loading.
- Prescribed fires are designed to maintain and enhance desired MSO protected forest structure, tree densities, snag densities, and CWD levels.

Restricted Habitat

Definition: Pine-oak – ponderosa pine habitat type series; within the Gambel oak or Gambel oak phase of the habitat type; ≥10 percent of the stand basal area or 10 ft²/ac of basal area consists of Gambel oak ≥5 inches drc.

General Vegetation Management Direction: Manage to ensure a sustained level of owl nest/roost habitat well distributed across the landscape. Habitat variables are documented in table III.B.1 of the MSO recovery plan (USFWS 1995). Management would attempt to mimic natural disturbance patterns by incorporating natural variation, such as irregular tree spacing and various patch sizes. Allow natural canopy gap processes to occur, thus producing horizontal variation in stand structure. Emphasize uneven-aged management systems. Both even-aged and uneven-aged systems may be used where appropriate to provide variation in existing stand structure and species diversity. Save all trees greater than 24-inch dbh. Retain existing large oaks and promote growth of additional large oaks. Encourage prescribed fire to reduce hazardous fuel accumulation. Retain substantive amounts of key habitat components (snags 18 inches plus, down logs >12-inch

midpoint diameter, and hardwoods). Further 4FRI guidelines allows for managing MSO target/threshold habitat for a range of 110 to 150 ft² of basal area under alternative C.

***Table 83*. MSO Restricted Habitat Target/Threshold Conditions for Pine-oak Forests**

Stand Averages	
Basal area (BA)	Alternatives B and D ≥150 BA; Alternative C 110 to 150 BA
18 inch + trees/ac (TPA)	≥20 TPA
Oak basal area	≥20 BA
Percent Total Existing SDI by Size Class	
12-18”	≥15
18-24”	≥15
24+”	≥15

Threshold Habitat

Vegetation Management Direction: Stand averages currently meet or exceed threshold values in table III.B.1 of the MSO recovery plan. Management would not reduce variables below the threshold values.

Desired Conditions: Irregular tree spacing and various patch size. Horizontal variation in stand structure. Other key habitat components includes snags 18 inches plus, down logs >12-inch midpoint diameter, hardwoods.

Threshold Mechanical Thin and Burn Treatment Design:

- Intermediate thinning would be used to increase residual tree health and vigor and reduce fire hazard.
- Manage for ≥150 square feet of BA where present, with a portion of those acres ≥170 square feet of BA in alternative B and D. In alternative C, manage for a minimum 110 square feet of BA and manage for ≥ 150 square feet of BA where present in areas with site potential capable of sustaining high tree density.
- Manage to attain 150 square feet of BA in areas with site potential capable of sustaining high tree density in all alternatives.
- Manage for irregular tree spacing to create canopy gaps and other structural conditions that would be conducive to low intensity prescribed fire treatment.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition and whose crowns are outside the old tree crown drip line 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- No trees larger than 24-inch dbh would be cut.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC

or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerlyside of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks

- Gambel oak, juniper and pinyon species would not be cut as part of the treatments. These species may only be cut when there is no other option to facilitate logging operations (skid trails and landings).
- Snags would be managed for two per acre ≥18 inches and at least 30 feet in height, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches and a minimum of 8 feet in length.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height and reducing litter/duff cover and other surface fuel loading. Prescribed fires are designed to maintain and enhance desired MSO restricted threshold habitat forest structure, tree densities, snag densities, and CWD levels.

Threshold Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height and reduce litter/duff cover and other surface fuel loading.
- Prescribed fires are designed to maintain and enhance desired MSO restricted threshold habitat forest structure, tree densities, snag densities, and CWD levels.

Target

Vegetation Management Direction: Stand averages currently meet or exceed some threshold values in table III.B.1 of the MSO recovery plan. Management would not reduce variables that are currently at or above the threshold value below the threshold values. Management would encourage development of threshold values that are lacking.

Desired Conditions: Irregular tree spacing and various patch size. Horizontal variation in stand structure. Other key habitat components includes snags 18 inches plus, down logs greater than 12 inches midpoint diameter, hardwoods.

Target Mechanical Thin and Burn Treatment Design:

- Intermediate thinning would be used to increase residual tree health and vigor and reduce fire hazard.
- Manage for 150 square feet of BA where present or to attain 150 square feet of BA in areas with site potential capable of sustaining high tree density in alternative B and D. In alternative C, manage for a minimum 110 square feet of BA and to attain 150 square feet of BA in areas with site potential capable of sustaining high tree density.
- Manage for irregular tree spacing to create canopy gaps and other structural conditions that would be conducive to low intensity prescribed fire treatment.

- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition and whose crowns are outside the old tree crown drip line 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- No trees larger than 24-inch dbh would be cut.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks
- Gambel oak, juniper, and pinyon species would not be cut as part of the treatments. These species may only be cut when there is no other option to facilitate logging operations (skid trails and landings).
- Snags would be managed for two per acre ≥18 inches and at least 30 feet in height, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches and a minimum of 8 feet in length..
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height and reducing litter/duff cover and other surface fuel loading. Prescribed fires are designed to maintain and enhance desired MSO restricted target habitat forest structure, tree densities, snag densities, and CWD levels.

Target Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height and reduce litter/duff cover and other surface fuel loading.
- Prescribed fires are designed to maintain and enhance desired MSO restricted target habitat forest structure, tree densities, snag densities, and CWD levels.

Restricted Other

Vegetation Management Direction: Current stand averages meet few of the threshold values in table III.B.1 of the MSO recovery plan (USFWS 1995). Management would encourage development of threshold values that are lacking.

Desired Conditions: Uneven aged (3 plus age classes) - Irregular tree spacing and various patch size. Horizontal variation in stand structure. Other key habitat components includes snags 18 inches plus, down logs >12-inch midpoint diameter, hardwoods.

Restricted Other Mechanical Thin and Burn Treatment Design:

- Uneven age thinning and group selection would be used to establish interspace between tree groups, thin tree groups and create regeneration openings.
- Treatments would strive to attain the following overall average density and structural characteristics:

***Table 84*. Restricted Other Habitat Treatment Criteria**

Stand Averages	
Basal area (BA)	70-90 ft²
Stand density index - % of max	25-40
18 inch + trees/acre (TPA)	≥20
Oak basal area (square feet)	≥20+
Percent Total SDI by Size Class	
12-18”	≥15
18-24”	≥15
24+”	≥15

- Manage for a range of density and structural characteristics by thinning areas with a southerly aspect to an overall average of 60 to 80 square feet of BA and areas with northerly aspect to an overall average of 80 to 100 square feet of BA. Density would vary within these ranges depending on existing stand structure.
- Individual trees and tree groups would occupy approximately 60 to 75 percent of the area.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- No trees larger than 24-inch dbh would be cut.
- Tree groups, on average, would range in size from 0.1 to 1 acre with northerly aspects and highly productive microsites having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.
- Manage for tree groups with different age classes by retaining individual and clumps of vigorous ponderosa pine seedlings, sapling, and poles within larger mid-aged, mature or old tree groups.

- Trees within the dominant and co-dominant crown position would have priority for retention within groups. Where age class diversity is not present, 1-10 suppressed and intermediate trees per group would be retained for vertical diversity.
- Interspace would occupy approximately 25 to 40 percent of the area.
- Interspace width between tree groups would average from 25 feet to 60 feet with a maximum width of 200 feet.
- Regeneration openings (group selection) account for 10 to 20 percent of tree groups. The percentage would vary within this range depending on current age class distribution. They would average 0.3 to 0.8 acre and would not exceed 200 feet wide. In general, regeneration openings would not be larger than 2 acres. However, they may extend up to 4 acres in specific areas where ponderosa pine mistletoe infections are heavy. They would only be established by removing groups of trees comprised of the most abundant tree size classes. Regeneration openings would be created adjacent to tree groups and would not be surrounded by interspace.
- Manage moderate to heavy dwarf mistletoe infection centers that are not intended for regeneration openings for improved tree vigor and growth by retaining the best growing dominant and co-dominant trees with the least amount of mistletoe.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows: 1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks
- Gambel oak, juniper and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches and at least 30 feet in height, CWD would be managed for 5 to 7 tons per acre; downed logs would be managed for three per acre ≥12 inches and a minimum of 8 feet in length.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired MSO restricted other habitat forest structure, tree densities, snag densities, and CWD levels.

Restricted Other Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.

- Prescribed fires are designed to increase tree canopy base height, reduce litter/duff cover, and produce effects that stimulate regeneration and growth of native herbaceous vegetation.
- Prescribed fires are designed to maintain and enhance desired MSO restricted other forest structure, tree densities, snag densities, and CWD levels.

Goshawk Habitat

General – Ponderosa Pine

Vegetation Management Direction: Manage for uneven-age stand conditions for live trees and retain live reserve trees, snags, downed logs, and woody debris levels throughout ponderosa pine forest cover types. Manage for old age trees such that as much old forest structure as possible is sustained over time across the landscape. Provide for groups of trees with interlocking crowns. Sustain a mosaic of vegetation densities (overstory and understory), age classes and species composition across the landscape. Encourage aspen and oak regeneration. Provide habitat for goshawk prey.

Desired Conditions: Highly interspersed, heterogeneous pattern and size of tree groups and interspace across the landscape. Tree groups are dominated by trees of a similar age and range from young to old (uneven aged). Interspace has a robust herbaceous layer.

Landscapes Outside of Goshawk Post-fledgling Areas (LOPFA) – Ponderosa Pine

Vegetation Management Direction: Distribution of vegetation structural stages for ponderosa pine – 10 percent grass/forb/shrub (VSS 1), 10 percent seedling-sapling (VSS 2), 20 percent young forest (VSS 3), 20 percent mid-aged forest (VSS 4), 20 percent mature forest (VSS 5), 20 percent old forest (VSS6). The distribution of VSS, tree density, and tree age are a product of site quality in the EMA. Use site quality to guide in the distribution of VSS, tree density and tree ages. Snags are ≥18-inch dbh and ≥30 feet in height, downed logs are 12 inches in diameter and are ≥8-feet long, woody debris is ≥3 inches on the forest floor, canopy cover is measured with vertical crown projection on average across the landscape. Canopy cover guidelines apply only to mid-aged to old forest structural stages (VSS 4, VSS 5, and VSS 6). Further 4FRI direction as documented in the forest plan amendments: Adds the desired percentage of interspace; Adds the interspace distance between tree groups; adds language clarifying where canopy cover is and is not measured; Allows savanna/grassland restoration areas to be managed for an open reference condition (up to 90 percent open with less than 3 to 5 reserve trees); Adds a definition to the forest plan glossary for the terms: interspace, open reference condition and stand.

Desired Conditions: Uneven aged – balance of age classes. Within group structure specific to mid-aged to old classes (VSS 4 to 6) includes open understories, interlocking to nearly interlocking tree crowns with some vertical structure, abundant large limbs, and shade.

LOPFA, WUI55, UEA40, UEA25 and UEA10 Mechanical Thin and Burn Treatments Design:

- Uneven age thinning and group selection would be used to establish interspace between individual trees and tree groups, thin tree groups, and create regeneration openings within LOPFA sites with none to low dwarf mistletoe infections that are uneven age or even age with a quadratic mean diameter (QMD) ≥ 8.5 inches.

- Treatments would strive to attain an overall average density of 50 to 70 square feet of basal area and 15 to 35 percent of maximum stand density index (SDI) inclusive of groups, interspaces and regeneration openings. Density would vary within this range depending on treatment intensity and existing stand structure. See section D for more detail on the relationship of overall density to interspace, tree groups and regeneration openings.
- Individual trees, tree groups, and interspaces would occupy the following percent of the area by treatment intensity as follows:

***Table 85*. Percent of Trees, Tree Groups, and Interspaces by Treatment Intensity (LOPFA)**

Treatment Type and Intensity	Percent of Area Occupied by Individual Trees and Tree	Percent of Area Occupied by Interspace
WUI55	30 - 45	55 - 70
UEA40	45 - 60	40 - 55
UEA25	60 - 75	25 - 40
UEA10	75 - 90	10 - 25

- Individual trees, tree groups, and interspaces would be managed to move towards a balance of age classes, both within and from tree group to tree group, by reducing the most abundant tree size classes and maintaining the under-represented tree size classes.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- Tree groups, on average, would range in size from 0.1 to 1 acre with lower treatment intensities having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.
- Tree group density would be managed to meet the canopy cover requirement of 40 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups and to assure that immature tree groups (VSS 2 and 3) are managed to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and exceed the canopy cover requirements. Stocking guidelines for tree groups

for the WUI55, UEA40, UEA25, and UEA10 mechanical thin treatments are as follows:

***Table 86*. LOPFA WUI and UEA Treatments Stocking Guidelines for Tree Groups**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
1 & 2 (20)	0-4.9	19	48	96	144	193	134-302	NA	NA
3 (20)	5-11.9	14	34	68	102	136	83-215	NA	NA
4 (20)	12-17.9	5	12	23	35	46	35-115	70-146	89-185
5 (20)	18-23.9	3	8	15	23	30	19-59	43-79	54-96
6 (20)	≥24	2	5	11	16	21	18-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4, 5, and 6 classes are equivalent to 40 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6

[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Manage mid-aged, mature and old (VSS 4, 5 and 6) tree groups for a range of density and structural characteristics by thinning approximately 50 percent of the mid-aged, mature and old tree groups to the lower density stocking, approximately 20 percent each to the middle density and upper density of desired stocking conditions as displayed in the stocking guideline table, and approximately 10 percent remain unthinned.
- Manage for tree groups with different age classes by retaining individual and clumps of vigorous ponderosa pine seedlings, sapling, and poles within larger mid-aged, mature or old tree groups.
- Trees within the dominate and co-dominant crown position would have priority for retention within groups. Where age class diversity is not present, 1-10 suppressed and intermediate trees per group would be retained for vertical diversity.
- Interspace width between tree groups would average from 25 feet to 120 feet with a maximum width of 200 feet. Average interspace width would vary depending on treatment intensity as follows:

***Table 87*. Interspace Percent and Width in LOPFA WUI and UEA Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Interspace	Average Interspace Width (feet)
WUI55	55 -70	80 - 120
UEA40	40 - 55	60 - 100
UEA25	25 - 40	40 - 60
UEA10	10 - 25	25 - 40

- Regeneration openings (group selection) account for 10 to 20 percent of tree groups. The percentage would vary within this range depending on depending on current VSS distribution. They would average 0.3 to 0.8 acre and would be no larger than 4 acres or 200 feet wide. They would only be established by removing groups of trees comprised of the most abundant tree size classes. Regeneration openings would be created adjacent to tree groups and would not be surrounded by interspace.
- One group of reserve trees, three to five trees per group, would be left in created regeneration openings greater than an acre in size.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks
- Gambel oak, juniper and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired LOPFA UEA forest structure, tree densities, snag densities, and CWD levels.

LOPFA UEA – AZGF Design Mechanical Thin and Burn (Alternative C) Design:

- Same as LOPFA UEA 10 with the exception of group size. Tree group size is dependent on experimental design and would range in size from 1 to 15 acres.

LOPFA Intermediate Thin (IT) 40, 25, and 10 Mechanical Thin and Burn Treatments Design:

- Intermediate thinning (IT) would be used to establish interspace between individual trees and tree groups and thin tree groups within LOPFA sites with moderate to high dwarf mistletoe infection that are uneven age or even age with a QMD ≥ 8.5 inches.
- Treatments would strive to attain an overall average density of 70 to 90 square feet of BA and 25 to 40 percent of maximum SDI inclusive of groups, and interspaces. Density would vary within these ranges depending on treatment intensity and existing stand structure. See section D for more detail on the relationship of overall density to interspace and tree groups.
- Individual trees, tree groups, and interspaces would occupy the following percent of the area by treatment intensity as follows:

***Table 88*. Percent of Area Occupied by Trees, Tree Groups, and Interspace in LOPFA IT**

Treatment Type and Intensity	Percent of Area Occupied by Individual Trees and Tree Groups	Percent of Area Occupied by Interspace
IT40	45 - 60	40 - 55
IT25	60 -75	25 - 40
IT10	75 - 90	10 - 25

- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- Tree groups, on average, would range in size from 0.1 to 1 acre with lower treatment intensities having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.
- Tree groups would be managed to improve tree vigor and growth by retaining the best growing dominant and co-dominant trees with the least amount of mistletoe within each group.
- Tree group density would be managed to meet the canopy cover requirement of 40 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and

exceed the canopy cover requirements. Stocking guidelines for VSS 4, 5, and 6 tree groups for the IT40, IT25, and IT10 mechanical thin treatments are as follows:

***Table 89*. Stocking Guidelines for VSS 4 - 6 Tree Groups in LOPFA IT treatments**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
4 (20)	12-17.9	5	12	23	35	46	35-115	70-146	89-185
5 (20)	18-23.9	3	8	15	23	30	19-59	43-79	54-96
6 (20)	≥24	2	5	11	16	21	18-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4, 5, and 6 classes are equivalent to 40 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6

[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Interspace width between tree groups would average from 25 feet to 80 feet with a maximum width of 200 feet. Average interspace width would vary depending on treatment intensity as follows:

***Table 90*. Percent and Width of Interspace in LOPFA IT Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Interspace	Average Interspace Width (feet)
IT40	40 - 55	60 - 80
IT25	25 - 40	40 - 60
IT10	10 - 25	25 - 40

- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak, juniper, and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired LOPFA IT forest structure, tree densities, snag densities, and CWD levels.

LOPFA Stand Improvement (SI) 40, 25, and 10 Mechanical Thin and Burn Treatments Design:

- Stand improvement thinning would be used to establish interspace between individual trees and tree groups and thin tree groups within LOPFA sites with none to low dwarf mistletoe infection and are even age sites with a QMD $\leq$ 8.5 inches.
- Treatments would strive to attain an overall stand average density of 20 to 25 percent of maximum SDI inclusive of groups and interspaces. Density would vary within this range depending on treatment intensity and existing stand structure. See section D for more detail on the relationship of overall density to interspace and tree groups.
- Individual trees, tree groups, and interspaces would occupy the following percent of the area by treatment intensity as follows:

***Table 91*. Percent of Area Occupied by Individual Trees, Tree Groups, and Interspace in LOPFA SI Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Individual Trees and Tree Groups	Percent of Area Occupied by Interspace
SI40	45 - 60	40 - 55
SI25	60 - 75	25 - 40
SI10	75 - 90	10 - 25

- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- Tree groups, on average, would range in size from 0.1 to 1 acre with lower treatment intensities having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.
- Tree groups would be managed to improve tree vigor and growth by retaining the best growing dominant and co-dominant trees.

- Tree group density would be managed to meet the canopy cover requirement of 40 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups and to assure that immature tree groups (VSS 2 and 3) are managed to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and exceed the canopy cover requirements. Stocking guidelines for tree groups for the SI40, SI25, and SI10 mechanical thin treatments are as follows:

***Table 92*. Stocking Guidelines for Tree Groups in LOPFA SI Treatments**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
1 & 2 (20)	0-4.9	19	48	96	144	193	134-302	NA	NA
3 (20)	5-11.9	14	34	68	102	136	83-215	NA	NA
4 (20)	12-17.9	5	12	23	35	46	35-115	70-146	89-185
5 (20)	18-23.9	3	8	15	23	30	19-59	43-79	54-96
6 (20)	≥24	2	5	11	16	21	18-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4, 5, and 6 classes are equivalent to 40 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6

[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Interspace width between tree groups would average from 25 feet to 80 feet with a maximum width of 200 feet. Average interspace width would vary depending on treatment intensity as follows:

***Table 93*. Interspace Percent and Width LOPFA SI Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Interspace	Average Interspace Width (feet)
SI40	40 -55	60 - 80
SI25	25-40	40 – 60
SI10	10-25	25 – 40

- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak, juniper, and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).

- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired LOPFA SI forest structure, tree densities, snag densities, and CWD levels

LOPFA Pine Sage Mechanical and Burn Treatment Design:

- Restore pre-settlement tree density and pattern using pre-settlement evidence as guidance.
- Treatment would strive to attain an overall average density of 30 to 50 square feet of BA and 15 to 25 percent of maximum SDI inclusive of individual trees, tree groups and interspaces. Density would vary within this range depending on existing stand structure. See section D for more detail on the relationship of overall density to interspace and tree groups.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Retain all pre-settlement trees and the largest post-settlement trees available that most closely resemble old trees in size and form as replacement trees adjacent to pre-settlement tree evidences. Some younger trees would also be retained to maintain uneven-aged structure.
- Replacement tree density would be managed to meet the canopy cover requirement of 40 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and exceed the canopy cover requirements. Stocking guidelines for VSS 4, 5, and 6 tree groups for the pine sage mechanical thin treatments are as follows:

***Table 94*. Stocking Guidelines for VSS 4 – VSS 6 Tree Groups in LOPFA Pine Sage Treatments**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
4 (20)	12-17.9	5	12	23	35	46	35-115	70-146	89-185
5 (20)	18-23.9	3	8	15	23	30	19-59	43-79	54-96
6 (20)	≥24	2	5	11	16	21	18-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4, 5, and 6 classes are equivalent to 40 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6

[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak would not be cut unless there is no other option to facilitate logging operations (skid trail and landing locations).
- Juniper and pinyon species in the seedling/sapling, young and mid-aged stages would generally be cut except where needed as replacements for pre-settlement trees. Mature juniper and pinyon would only be cut when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired understory composition and cover as well as LOPFA pine sage forest structure, tree densities, snag densities, and CWD levels.

Savanna/Grassland Restoration Mechanical and Burn Treatments Design:

- Restore pre-settlement tree density and pattern using pre-settlement evidence as guidance. Manage for an open reference condition with 10 to 30 percent of the area under ponderosa pine and deciduous tree crowns.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Tree group arrangement, size, and density are a function of existing pre-settlement trees and evidence. Retain all pre-settlement trees and the largest post-settlement trees that most closely resemble old trees in size and form as replacement trees

adjacent to pre-settlement tree evidences at a 1:1 ratio. Some younger trees would also be retained to maintain uneven-aged structure. A higher leave tree to evidence ratio may be required to maintain the desired tree cover range.

- Manage for a range of 70 percent to 90 percent of the treatment area as interspace (grass/forb) between tree groups or individuals. Amount of interspace would vary within this range depending on current conditions.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak would not be cut unless there is no other option to facilitate logging operations (skid trail and landing locations).
- Juniper and pinyon species in the seedling/sapling, young and mid-aged stages would generally be cut except where needed as replacements for pre-settlement trees. Mature juniper and pinyon would only be cut when there is no other option to facilitate logging operations (skid trail and landing locations).
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired LOPFA savanna/grassland forest structure, tree densities, snag densities, and CWD levels.

LOPFA Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height, reduce litter/duff cover, and produce effects that stimulate regeneration and growth of native herbaceous vegetation.
- Prescribed fires are designed to maintain and enhance desired LOPFA forest structure, tree densities, snag densities, and CWD levels.

Goshawk Post-fledgling Areas (PFA) – Ponderosa Pine

Vegetation Management Direction: Provide for a healthy, sustainable forest environment for the post-fledgling family needs. The principle difference between “within the post-fledgling family area” and “outside the post-fledgling family area” is the higher canopy cover and smaller opening size within the post-fledgling family area. Vegetative structural stage distribution and structural conditions are the same within and outside the post-fledgling family area. Ponderosa pine canopy cover for mid-aged forest (VSS 4) should average one-third 60 plus percent and two-thirds 50 plus percent. Mature (VSS 5) and old forest (VSS 6) should average 50 plus percent. Further

4FRI direction as documented in the forest plan amendments: Adds the desired percentage of interspace; Adds the interspace distance between tree groups; adds language clarifying where canopy cover is and is not measured; Allows savanna/grassland restoration areas to be managed for an open reference condition (up to 90 percent open with less than 3 to 5 reserve trees); Adds a definition to the forest plan glossary for the terms: interspace, open reference condition and stand.

Desired Conditions: Uneven aged – balance of age classes. Within group structure specific to mid-aged to old classes (VSS4 to 6) includes open understories, interlocking to nearly interlocking tree crowns with some vertical structure, abundant large limbs, and shade.

dPFA/PFA UEA40, dPFA/PFA UEA25 and dPFA/PFA UEA10 Mechanical Thin and Burn Treatments Design:

- Uneven age thinning and group selection would be used to establish interspace between individual trees and tree groups, thin tree groups, and create regeneration openings within dPFA/PFA sites with none to low dwarf mistletoe infections that are uneven age or even age with a QMD $\geq$ 8.5 inches.
- Treatments would strive to attain an overall average density of 70 to 80 square feet of BA and 25 to 40 percent of maximum SDI inclusive of groups, interspaces and regeneration openings. Density would vary within this range depending on treatment intensity and existing stand structure. See section D for more detail on the relationship of overall density to interspace, tree groups and regeneration openings.
- Individual trees, tree groups and interspaces would occupy the following percent of the area by treatment intensity as follows:

Table 95. **Percent of Area Occupied by Individual Trees, Tree Groups, and Interspace in dPFA/PFA UEA Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Individual Trees and Tree Groups	Percent of Area Occupied by Interspace
UEA40	45 - 60	40 - 55
UEA25	60 - 75	25 - 40
UEA10	75 - 90	10 - 25

- Individual trees, tree groups, and interspaces would be managed to move towards a balance of age classes, both within and from tree group to tree group, by reducing the most abundant tree size classes and maintaining the under-represented tree size classes.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that

are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.

- Tree groups, on average, would range in size from 0.1 to 1 acre with lower treatment intensities having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.
- Tree group density would be managed to meet the canopy cover requirement of 50 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups and to assure that immature tree groups (VSS 2 and 3) are managed to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and exceed the canopy cover requirements. Stocking guidelines for tree groups for the dPFA/PFA UEA40, UEA25, and UEA10 mechanical thin treatments are as follows:

***Table 96*. Stocking Guidelines for Tree Groups in dPFA/PFA UEA Treatments**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
1 & 2 (20)	0-4.9	19	48	96	144	193	134-302	NA	NA
3 (20)	5-11.9	14	34	68	102	136	83-215	NA	NA
4 (20)	12-17.9	7	18	35	53	70	51-115	70-146	89-185
5 (20)	18-23.9	4	10	20	29	39	28-59	43-79	54-96
6 (20)	≥24	3	7	14	20	27	26-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4 classes are equivalent to 55 percent canopy cover; Densities within the VSS 5, and VSS 6 classes are equivalent to 50 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6.
[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Manage mid-aged, mature and old (VSS 4, 5, and 6) tree groups for a range of density and structural characteristics by thinning approximately 50 percent of the mid-aged, mature and old tree groups to the lower density stocking, approximately 20 percent each to the middle density and upper density stocking as displayed in the stocking guideline table, and approximately 10 percent remain unthinned.
- Manage for tree groups with different age classes by retaining individual and clumps of vigorous ponderosa pine seedlings, sapling, and poles within larger mid-aged, mature or old tree groups.

- Trees within the dominate and co-dominant crown position would have priority for retention within groups. Where age class diversity is not present, 1-10 suppressed and intermediate trees per group would be retained for vertical diversity.
- Interspace width between tree groups would average from 25 feet to 70 feet with a maximum width of 200 feet. Average interspace width would vary depending on treatment intensity as follows:

***Table 97*. Interspace Percent and Width in dPFA/PFA WUI and UEA Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Interspace	Average Interspace Width (feet)
UEA40	40 - 55	55 - 70
UEA25	25 - 40	40 - 55
UEA10	10 - 25	25 - 40

- Regeneration openings (group selection) account for 10 to 20 percent of tree groups. They would average 0.3 to 0.8 acre and would be no larger than 2 acres or 200 feet wide. They would only be established by removing groups of trees comprised of the most abundant tree size classes. Regeneration openings would be created adjacent to tree groups and would not be surrounded by interspace.
- One group of reserve trees, three to five trees per group, would be left in created regeneration openings greater than an acre in size.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks. Gambel oak, juniper, and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch drc may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired dPFA/PFA UEA forest structure, tree densities, snag densities, and CWD levels.

dPFA/PFA UEA – AZGF Design Mechanical Thin and Burn (Alternative C) Design:

- Same as dPFA/PFA UEA 10 with the exception of group size. Tree group size is dependent on experimental design and would range in size from 1 to 15 acres.

dPFA/PFA IT40, 25 and 10 Mechanical Thin and Burn Treatments Design:

- Intermediate thinning would be used to establish interspace between individual trees and tree groups and thin tree groups within dPFA/PFA sites with moderate to high dwarf mistletoe infection that are uneven age or even age with a QMD ≥ 8.5 inches.
- Treatments would strive to attain an overall average density of 70 to 90 square feet of BA and 25 to 40 percent of maximum SDI inclusive of groups, and interspaces. Density would vary within this range depending on treatment intensity and existing stand structure. See section D for more detail on the relationship of overall density to interspace and tree groups.
- Individual trees, tree groups and interspaces would occupy the following percent of the area by treatment intensity as follows:

***Table 98*. Percent of Area Occupied by Trees and Interspace for dPFA/PFA IT**

Treatment Type and Intensity	Percent of Area Occupied by Individual Trees and Tree Groups	Percent of Area Occupied by Interspace
IT40	45 - 60	40 - 55
IT25	60 - 75	25 - 40
IT10	75 - 90	10 - 25

- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- Tree groups, on average, would range in size from 0.1 to 1 acre with lower treatment intensities having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.
- Tree groups would be managed to improve tree vigor and growth by retaining the best growing dominant and co-dominant trees with the least amount of mistletoe within each group.
- Tree group density would be managed to meet the canopy cover requirement of 50 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and

exceed the canopy cover requirements. Stocking guidelines for VSS 4, 5, and 6 tree groups for the dPFA/PFA IT40, IT25, and IT10 mechanical thin treatments are as follows:

Table 99. **dPFA/PFA IT Treatments Stocking Guidelines for VSS 4 – 6 Tree Groups**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
4 (20)	12-17.9	7	18	35	53	70	51-115	70-146	89-185
5 (20)	18-23.9	4	10	20	29	39	28-59	43-79	54-96
6 (20)	≥24	3	7	14	20	27	26-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4 classes are equivalent to 55 percent canopy cover; Densities within the VSS 5, and VSS 6 classes are equivalent to 50 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6.
[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Interspace width between tree groups would average from 25 feet to 80 feet with a maximum width of 200 feet. Average interspace width would vary depending on treatment intensity as follows:

Table 100. **Interspace Percent and Width in dPFA/PFA IT**

Treatment Type and Intensity	Percent of Area Occupied by Interspace	Average Interspace Width (feet)
IT40	40 - 55	60 - 80
IT25	25 - 40	40 - 60
IT10	10 - 25	25 - 40

- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak, juniper, and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).

- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired dPFA/PFA IT forest structure, tree densities, snag densities, and CWD levels.

dPFA/PFA SI40, 25, and 10 Mechanical Thin and Burn Treatments Design:

- Stand improvement thinning would be used to establish interspace between individual trees and tree groups and thin tree groups within dPFA/PFA even age sites with a QMD ≤ 8.5 inches and with none to low dwarf mistletoe infection.
- Treatments would strive to attain a stand average density of 20 to 25 percent of maximum SDI inclusive of groups and interspaces. These ranges would vary depending on treatment intensity and existing stand structure. See section D for more detail on the relationship of overall density to interspace and tree groups.
- Individual trees, tree groups and interspaces would occupy the following percent of the area by treatment intensity as follows:

***Table 101*. Percent of Area Occupied by Individual Trees, Tree Groups, and Interspaces in dPFA/PFA SI Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Individual Trees and Tree Groups	Percent of Area Occupied by Interspace
SI40	45 - 60	40 - 55
SI25	60 - 75	25 - 40
SI10	75 - 90	10 - 25

- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Manage for the sustainability of individual/isolated old ponderosa pine trees as defined in the Old Tree Implementation Strategy by reducing crown competition and increasing growing space adjacent to these trees. Remove ponderosa pine trees up to 18 inches dbh that do not meet the old tree definition 1) within a 50-foot radius that are in the intermediate or suppressed crown positions; 2) that would eliminate direct crown competition on two of the four sides of the old tree.
- Tree groups, on average, would range in size from 0.1 to 1 acre with lower treatment intensities having larger average group sizes. Overall average group size would vary within this range depending on site quality, existing stand structure and pre-settlement tree evidence.

- Tree groups would be managed to improve tree vigor and growth by retaining the best growing dominant and co-dominant trees.
- Tree group density would be managed to meet the canopy cover requirement of 50 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups and to assure that immature tree groups (VSS 2 and 3) are managed to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and exceed the canopy cover requirements. Stocking guidelines for tree groups for the dPFA/PFA SI40, SI25, and SI10 mechanical thin treatments are as follows:

***Table 102*. Stocking Guidelines for Tree Groups in dPFA/PFA SI Treatments**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
1 & 2 (20)	0-4.9	19	48	96	144	193	134-302	NA	NA
3 (20)	5-11.9	14	34	68	102	136	83-215	NA	NA
4 (20)	12-17.9	7	18	35	53	70	51-115	70-146	89-185
5 (20)	18-23.9	4	10	20	29	39	28-59	43-79	54-96
6 (20)	≥24	3	7	14	20	27	26-38	40-49	51-61

[1]These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4 classes are equivalent to 55 percent canopy cover; Densities within the VSS 5, and VSS 6 classes are equivalent to 50 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6.
[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Interspace width between tree groups would average from 25 feet to 80 feet with a maximum width of 200 feet. Average interspace width would vary depending on treatment intensity as follows:

***Table 103*. Interspace Percent and Width in dPFA/PFA SI Treatments**

Treatment Type and Intensity	Percent of Area Occupied by Interspace	Average Interspace Width (feet)
SI40	40 - 55	60 - 80
SI25	25 - 40	40 - 60
SI10	10 - 25	25 - 40

- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak, juniper, and pinyon species would not be cut with the following exceptions: seedling/sapling, young and mid-aged pinyon and juniper up to 11-inch DRC may be cut within a 50-foot radius of individual or groups of old ponderosa pine (as defined in the Old Tree Implementation Strategy); and when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.

- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired dPFA/PFA SI forest structure, tree densities, snag densities, and CWD levels.

dPFA/PFA Pine Sage Mechanical and Burn Treatment Design:

- Restore pre-settlement tree density and pattern using pre-settlement evidence as guidance.
- Treatments would strive to attain an overall stand average density of 30 to 50 square feet of BA and 15 to 25 percent of maximum SDI inclusive of individual trees, tree groups and interspaces.. Density would vary within this range depending on existing stand structure. See section D for more detail on the relationship of overall density to interspace and tree groups.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Retain all pre-settlement trees and the largest post-settlement trees available that most closely resemble old trees in size and form as replacement trees adjacent to pre-settlement tree evidences. Some younger trees would also be retained to maintain uneven-aged structure
- Replacement tree density would be managed to meet the canopy cover requirement of 50 plus percent within mid-aged forest (VSS4), mature forest (VSS5), and old forest (VSS6) tree groups. By following the stocking guidelines and maintaining interlocking or nearly interlocking tree crowns, tree group density would meet and exceed the canopy cover requirements. Stocking guidelines for VSS 4, 5, and 6 tree groups for the pine sage mechanical thin treatments are as follows:

Table 104. **Stocking Guidelines for VSS 4 – 6 Tree Groups in dPFA/PFA Pine Sage Treatments**

VSS Class (% of area)	DBH Class (inches)	Typical Trees Per Group Stocking at the Midpoint Diameter of the VSS Class[1]					Within Group Trees Per Acre Range[2]		
		1/10 ac group	1/4 ac group	1/2 ac group	3/4 ac group	1 ac group	Lower Density	Middle Density	Upper Density
4 (20)	12-17.9	7	18	35	53	70	51-115	70-146	89-185
5 (20)	18-23.9	4	10	20	29	39	28-59	43-79	54-96
6 (20)	≥24	3	7	14	20	27	26-38	40-49	51-61

[1] These are typical values for the mid-point diameter of the VSS class. Densities within the VSS 4 classes are equivalent to 55 percent canopy cover; Densities within the VSS 5, and VSS 6 classes are equivalent to

50 percent canopy cover. Densities within the VSS 1, 2 and 3 classes are to maintain tree stocking necessary to provide for desired canopy cover as the groups mature to VSS 4, 5, and 6.
[2]Variation in tree group stocking above the minimum required to maintain canopy cover can occur and is desired. The smallest TPA number for the range pertains to the largest diameter of the VSS class, the highest TPA number for the range pertains to the smallest diameter of the VSS class. See section D for further detail on stocking by diameter.

- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak would not be cut unless there is no other option to facilitate logging operations (skid trail and landing locations).
- Juniper and pinyon species in the seedling/sapling, young and mid-aged stages would generally be cut except where needed as replacements for pre-settlement trees. Mature juniper and pinyon would only be cut when there is no other option to facilitate logging operations (skid trail and landing locations).
- Gambel oak, juniper, and pinyon species greater than 5-inch DRC may be considered as residual trees in the target group spacing and stocking.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired dPFA/PFA savanna/grassland forest structure, tree densities, snag densities, and CWD levels.

dPFA/PFA Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height, reduce litter/duff cover, and produce effects that stimulate regeneration and growth of native herbaceous vegetation.
- Prescribed fires are designed to maintain and enhance desired dPFA/PFA forest structure, tree densities, snag densities, and CWD levels.

Nest Area

Vegetation Management Direction: Provide unique nesting habitat conditions for goshawks. Important features include trees of mature to old age with high canopy cover. The structure of the vegetation within nest areas is associated with the forest type, and tree age, size and density, and the developmental history of the stand. Table 105 represents GTR-RM-217 attributes required for

goshawks on location with “low” and “high” site productivity. The nesting area contains only mature to old forest (VSS 5 and 6) having a canopy cover (measured vertically) between 50 to 70 percent with old forest VSS 6 trees 200 to 300 years old. Non-uniform spacing of tree and clumpiness is desirable.

Desired Conditions: Even aged dominated by mature and/or old forest structural stages.

Goshawk Nest Area Burn Only Treatment Design:

- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible.
- Prescribed fires are designed to increase tree canopy base height and reduce litter/duff cover and other surface fuel loading.
- Prescribed fires are designed to maintain and enhance desired dPFA/PFA forest structure, tree densities, snag densities, and CWD levels. Desired goshawk nest stand structural attributes are as follows:

Table 105. Minimum Structural Attributes in Suitable Goshawk Nest Stands*

Structural Attribute	Minimum Metrics	
Site Index	<55	≥55
Trees/Acre	40	30
Mean DBH (in.)	16	22
Age (yrs.)	200+	200+
Total BA (sq. ft./acre)	120	140
Overstory canopy cover	50+	60+
VSS	5B-6	5B-6

* GTR-RM-217, southwest ponderosa pine cover types

Landscapes Outside of Goshawk Post-fledgling Areas (LOPFA) – Pinyon Juniper

Vegetation Management Direction: Manage for uneven age conditions to sustain a mosaic of vegetation densities (overstory and understory), age classes, and species composition well distributed across the landscape. Provide for reserve trees, snags, and down woody debris.

Desired Conditions: Mosaic of young and mature, species diverse patches of trees interspersed with interspace across the landscape to promote the growth of sagebrush, oak, cliffrose, and other shrubs and herbaceous understory species. Mature patches would be structurally diverse, containing large live and dead standing trees as well as trees with dead or broken tops, gnarls, and burls. The structure and composition reflects the natural range of variation.

Pinyon Juniper (PJ) WUI Mechanical Thin and Burn Treatment Design:

- Uneven age thinning would be used to establish interspace between tree groups and thin tree groups within LOPFA PJ sites.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting.

Live conifer trees with existing cavities and dead tops would also be favored for retention.

- Retain one to three groups per acre containing approximately 5 to 30 trees each (averaging 30 to 60 trees per acre across the site). Form groups around existing concentrations of large, mature trees. Retain additional healthy, young, free-to-grow trees within groups where possible.
- Between groups, thin-from-below to 16-inch DRC for pinyon and juniper and 16-inch DBH for ponderosa pine (see next).
- Where ponderosa pine is presents, retain all pre-settlement yellow pines and one to two replacement blackjacks per existing yellow pine or pre-settlement evidence (i.e. to approximate the naturally-occurring stand composition). Replacement blackjacks should be comprised of a variety of size classes. Blackjacks would be retained within 100 feet of the yellow pine or pre-settlement evidence they are replacing.
- Manage for the sustainability of large oaks by removing ladder fuels and overtopping trees. Remove ponderosa pine that are within 30 feet of the base of oak 10-inch DRC or larger as follows:1) On the southerly side of the oak (135 to 315 degrees) trees up to 18-inch DBH; 2) On the northerly side of the oak (316 to 134 degrees) trees in the intermediate or suppressed crown positions up to 18-inch DBH. Exceptions to removal would be trees that meet the old tree definition and trees that have interlocking crown with oaks.
- Gambel oak would not be cut with the exception of when there is no other option to facilitate logging operations (skid trail and landing locations).
- Snags would be managed for one per acre over 75 percent of the area and CWD would be managed for an after treatment average of 1 to 3 tons per acre. Where available, a portion of the CWD would include two logs ≥10 inches and ≥10 feet in length.
- Prescribed burns may be used to treat fuels and mitigate fuel hazards where and when feasible by increasing tree canopy base height, reducing litter/duff cover, and producing effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired LOPFA PJ WUI forest structure, tree densities, snag densities, and CWD levels.

Other Areas Outside MSO and Goshawk Habitats

Aspen

Vegetation Management Direction: Conifer removal, partial removal of overstory aspen, ground disturbing activities, and fire would be used to stimulate aspen sprouting in areas that have or previously had aspen.

Desired Conditions: Aspen is successfully regenerating and recruiting into older and larger size classes. Size classes have a natural distribution, with the greatest number of stems in the smallest classes. Coniferous species comprise less than 10 percent of the overstory.

Aspen Mechanical Thin and Burn Treatment Design:

- Inclusions of aspen remnants within portions of ponderosa pine stands would be regenerated by removing all post-settlement conifers from within 100 feet of the aspen clone. Some removal of aspen within the clone as well as ground disturbing activity or burning may occur to stimulate suckering.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities, dead tops, and lightning scars would also be favored for retention.
- Snags would be managed for two per acre ≥18 inches, CWD would be managed for 5 to 7 tons per acre, and downed logs would be managed for three per acre ≥12 inches.
- Each clone would be evaluated as to need for fencing or creation of other barriers to reduce ungulate browsing of regenerating aspen.
- Prescribed burns may be used where and when feasible to treat fuels; mitigate fuel hazards; and to produce effects that stimulate aspen suckering and regeneration, and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired aspen forest structure, tree densities, snag densities, and CWD levels.

Aspen Burn Only Treatment Design:

- Inclusions of aspen remnants within portions of ponderosa pine stands would be regenerated by prescribed burning to stimulate suckering.
- Prescribed burns are designed to reduce post-settlement conifer stocking within 100 feet of the aspen clone and disturb the site with sufficient intensity to encourage aspen regeneration.
- Each clone would be evaluated as to need for fencing or creation of other barriers to reduce ungulate browsing of regenerating aspen.

Grassland

Vegetation Management Direction: Reduce conifer encroachment within grasslands as identified by mollisol soils.

Desired Conditions: Restore historic grassland/forest edge as indicated by existing pre-settlement conifers and evidence of pre-settlement conifers.

Grassland Mechanical Thin and Burn Treatment Design (Alternative C Only):

- Treatments are designed to promote and re-establish the historic meadow edge as defined by pre-settlement trees and evidences and the current forest structure of young trees encroaching on the edge of the grassland.
- Treatments are designed to manage for old age trees in order to have and sustain as much old forest structure as possible across the landscape. Treatments would follow the Old Tree Implementation Strategy and old trees would not be targeted for cutting. Live conifer trees with existing cavities and dead tops would also be favored for retention.

- Tree group arrangement, size, and density are a function of existing pre-settlement trees and evidence. Retain all pre-settlement trees and the largest post-settlement trees that most closely resemble old trees in size and form as replacement trees adjacent to pre-settlement tree evidences at a 1:1 ratio. Ponderosa pine, pinyon, and juniper not meeting long-lived characteristics may be removed.
- Gambel oak would be retained.
- Prescribed burns may be used where and when feasible to treat fuels, mitigate fuel hazards and to produce effects that stimulate regeneration and growth of native herbaceous vegetation. Prescribed fires are designed to maintain and enhance desired grassland conditions.

Section B – Decision Matrix

***Table 106*. Section B Decision Matrix for Establishing Tree Groups, Interspace, and Regeneration Openings**

Feature	Placement	Reserve Trees within Feature	Thinning	Thinning Leave Tree Criteria	Large Tree Implementation Strategy (LTIS) Exception Category (Alternative C)
Tree Group	#1 – Abundance of pre-settlement tree evidence #2 – Under-represented tree classes (e.g. free to grow seedling/saplings; trees of different cohort than neighboring trees) #3 – High percentage of trees exhibiting good health and vigor	#1 – Old tree characteristics (OTIS) regardless of size #2 – Oak, pinyon, and juniper with exceptions #3 – Wildlife trees (cavities, dead tops)	Tree group stocking guidelines	#1 – Trees in the dominant and co-dominant crown position exhibiting vigor relative to age regardless of size #2 – Crown ratio >40% desirable; crown ratio 25-40% acceptable #3 – Free of mistletoe or low dwarf mistletoe rating relative to neighboring trees; Free of pine beetle activity #4 – Trees >12" high percentage of interlocking crown; Trees <12" ability to develop interlocking crown	Heavily-Stocked Stands (with High Basal Area) Generated by a Preponderance of Large, Young Trees Does the decision matrix meet the conditions described by the LTIS category: Yes _____ No _____ If no, describe what the condition(s) is, and why it does not meet the exception: _____ _____ Ponderosa Pine/Gambel Oak Forest Does the decision matrix meet the conditions described by the LTIS category: Yes _____ No _____ If no, describe what the condition(s) is, and why it does not meet the exception: _____ _____

Feature	Placement	Reserve Trees within Feature	Thinning	Thinning Leave Tree Criteria	Large Tree Implementation Strategy (LTIS) Exception Category (Alternative C)
Interspace	#1 – Little to no pre-settlement tree evidence #2 – Existing non-stocked openings #3 – High percentage of trees exhibiting poor health and vigor #4 - Contiguous area of well represented cohorts	#1 – Old tree characteristics (OTIS) regardless of size. #2 – Oak, pinyon and juniper #3 – Wildlife trees (cavities, dead tops)	NA	NA	Within-Stand Openings: Does the decision matrix meet the conditions described by the LTIS category: Yes _____ No _____ If no, describe what the condition(s) is, and why it does not meet the exception: _____ _____
Regeneration Opening	#1 – Contiguous area of well represented cohort. #2 – Isolated patch of mistletoe infected trees within the well represented cohort. #3 – Adjacent to seed bearing tree groups that are free of mistletoe infection.	#1 – Old tree characteristics (OTIS) regardless of size. #2 – Oak, pinyon and juniper #3 – Wildlife trees (cavities, dead tops #4 – Largest, healthiest, seed bearing PP (within openings >1 ac)	NA	NA	NA

Section C – Old Tree Implementation Plan

Old trees (approximately $\geq$ 150 years old) would be retained, with few exceptions, regardless of their diameter within the Four-Forest Restoration Initiative on the Coconino & Kaibab EIS area. Removal of old trees would be rare. Exceptions would be made for threats to human health and safety and those rare circumstances where the removal of an old tree is necessary in order to prevent additional habitat degradation. Old trees would not be cut for forest health issues or to balance age or size class distributions.

One example of a situation where the removal of an old tree is necessary in order to prevent additional habitat degradation is in the rare case of an old tree growing on the side of an existing curve in a road. Logging equipment may require a wider turning radius. The options are to relocate the road or cut the old tree and widen the curve to accommodate the larger turning radius. Relocating the road would result in a larger area of the forest being permanently disturbed, versus cutting the large tree and widening the curves radius. This is an example where cutting the old tree would result in less habitat degradation then relocating a road.

Old Tree Descriptions and Illustrations

Old trees would be determined by the following characteristics described by Thomson (1940) as age class 3 (intermediate-mature) and age class 4 (mature-overmature).

- Age – Approximately 150 years and older.
- dbh – Site dependent.
- Bark – ranging from reddish brown, shading to black in the top with moderately large plates between the fissures to reddish brown to yellow, with very wide, long, and smooth plates.
- Tops – ranging from pyramidal or rounded (occasionally pointed) to flat (making no further height growth).
- Branching – ranging from upturned in upper third of the crown, horizontal in the middle third and drooping in the lower third of the crown to mostly large, drooping, gnarled, or crooked. Branch whorls range from incomplete and indistinct except at the top to completely indistinct and incomplete.

Figure 4 and Figure 5 display illustrations of age class 3 (intermediate-mature) and age class 4 (mature-overmature) from Thompson 1940.

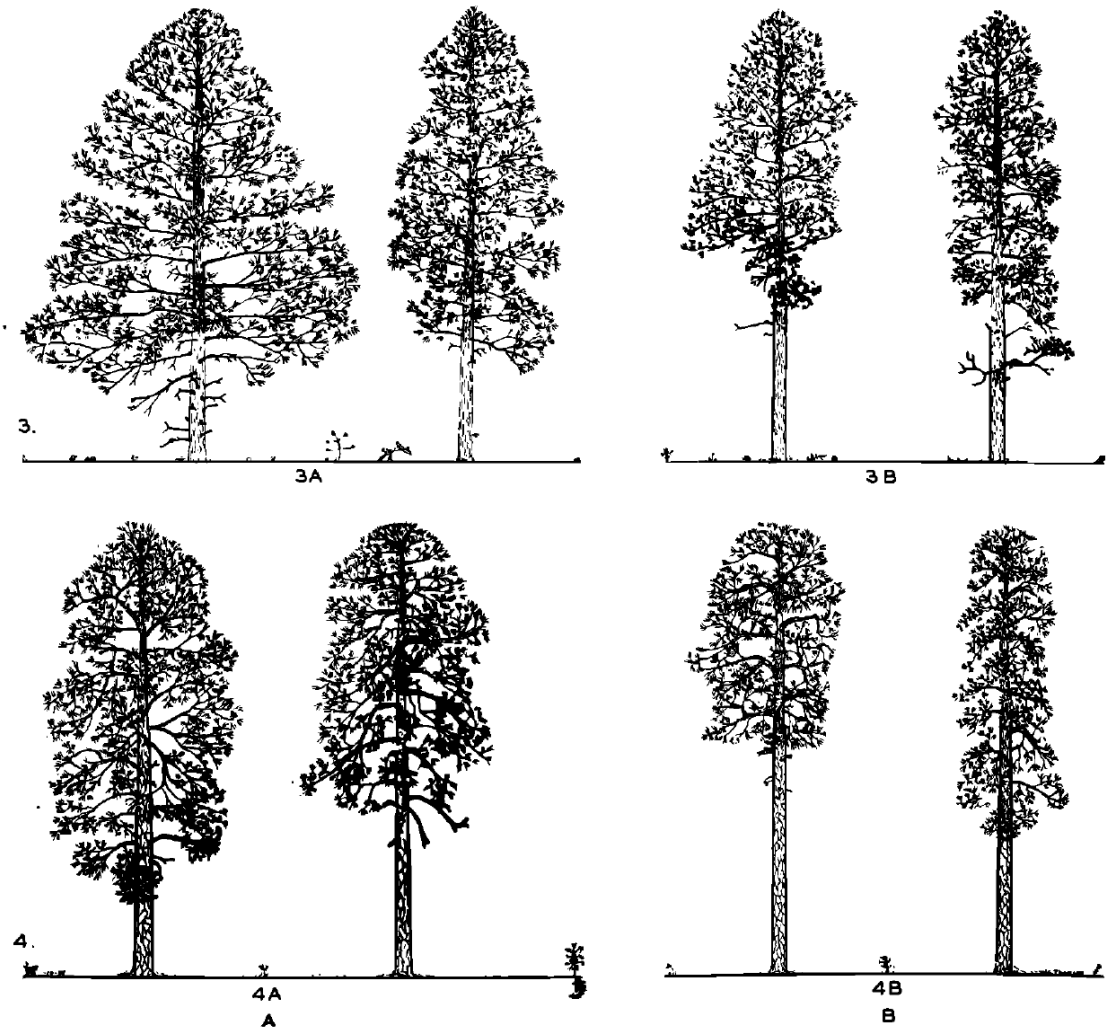

***Figure 4*. Old Tree Characteristics (Thompson 1940)**

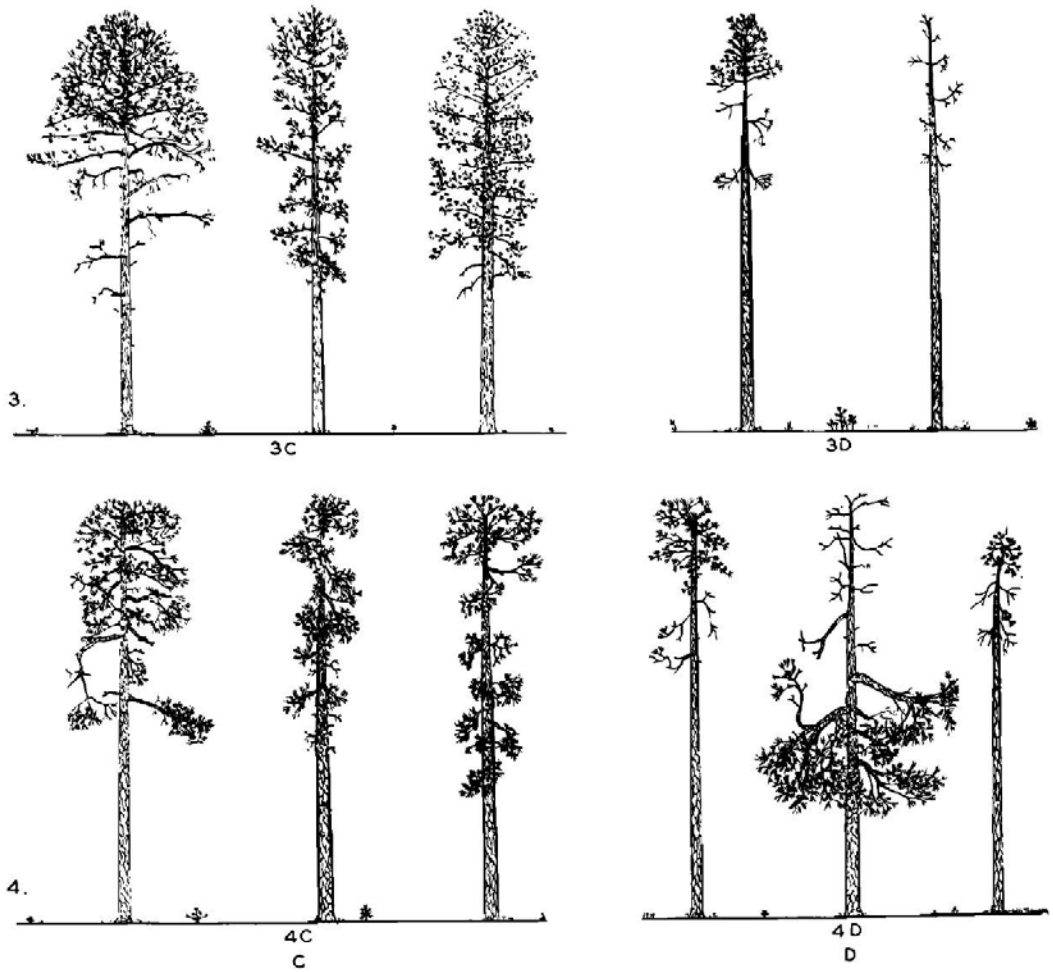

***Figure 5*. Old Age Tree Characteristics Continued(Thompson 1940)**

Section D – Density Management and the Relationship Between Treatment Intensity, Tree Group Density and Overall Average Density.

***Table 25*. Section D The Relationship Between Treatment Intensity, Tree Group Density and Overall Average Density.**

Treatment Intensity	Pct. Of Area		Pct. Of Tree'd Area		Avg. Group BA to Achieve Overall BA of:					
	Interspace	Tree	Groups and Individuals	Regeneration	**40**	**50**	**60**	**70**	**80**	**90**
10-25	**10**	**90**	90	0		56	67	78	89	100
			85	5		59	71	82	94	
			80	10		63	75	88	100	
			75	15		67	80	93	107	
			70	20		71	86	100	114	
	15	**85**	85	0		59	71	82	94	106
			80	5		63	75	88	100	
			75	10		67	80	93	107	
			70	15		71	86	100	114	
			65	20		77	92	108	123	
	20	**80**	80	0		63	75	88	100	113
			75	5		67	80	93	107	
			70	10		71	86	100	114	
			65	15		77	92	108	123	
			60	20		83	100	117	133	
25-40	**25**	**75**	75	0		67	80	93	107	120
			70	5		71	86	100	114	
			65	10		77	92	108	123	
			60	15		83	100	117	133	
			55	20		91	109	127	145	
	30	**70**	70	0		71	86	100	114	129
			65	5		77	92	108	123	
			60	10		83	100	117	133	
			55	15		91	109	127	145	
			50	20		100	120	140	160	
	35	**65**	65	0		77	92	108	123	138
			60	5		83	100	117	133	
			55	10		91	109	127	145	
			50	15		100	120	140	160	
			45	20		111	133	156	178	
40-55	**40**	**60**	60	0	67	83	100	117	133	150
			55	5	73	91	109	127	145	
			50	10	80	100	120	140	160	
			45	15	89	111	133	156	178	

			40	20	100	125	150	175	200	
	45	**55**	55	0	73	91	109	127	145	164
			50	5	80	100	120	140	160	
			45	10	89	111	133	156	178	
			40	15	100	125	150	175	200	
			35	20	114	143	171	200	229	
	50	**50**	50	0	80	100	120	140	160	180
			45	5	89	111	133	156	178	
			40	10	100	125	150	175	200	
			35	15	114	143	171	200	229	
			30	20	133	167	200	233	267	
55-70	**55**	**45**	45	0	89	111	133	156		
			40	5	100	125	150	175		
			35	10	114	143	171	200		
			30	15	133	167	200	233		
			25	20	160	200	240	280		
	60	**40**	40	0	100	125	150	175		
			35	5	114	143	171	200		
			30	10	133	167	200	233		
			25	15	160	200	240	280		
			20	20	200	250	300	350		
	65	**35**	35	0	114	143	171	200		
			30	5	133	167	200	233		
			25	10	160	200	240	280		
			20	15	200	250	300	350		
			15	20	267	333	400	467		

Note: Red fill indicates red SDI zone for all diameters. Red zone group BA ranges from 125 BA for 8" QMD to 195 BA for 24" QMD.

Table 107. Section D Density Management and Stocking Guidelines

TPA by QMD and BA:

Grp QMD	Grp BA 55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195
8	158	172	186	200	215	229	243	258	272	286	301	315	329	344	358														
9	125	136	147	158	169	181	192	204	215	226	238	249	260	272	283	294													
10	101	110	119	128	138	147	156	165	174	183	193	202	211	220	229	238	248	257											
11	83	91	99	106	114	121	129	136	144	152	159	167	174	182	189	197	205	212	220										
12	70	76	83	89	96	102	108	115	121	127	134	140	146	153	159	166	172	178	185	191									
13	60	65	71	76	81	87	92	98	103	109	114	119	125	130	136	141	147	152	157	163	168								
14	51	56	61	66	70	75	80	84	89	94	98	103	108	112	117	122	126	131	136	140	145	150							
15	45	49	53	57	61	65	69	73	77	81	86	90	94	98	102	106	110	114	118	122	126	130							
16	39	43	47	50	54	57	61	65	68	72	75	79	82	86	90	93	97	100	104	107	111	115	118						
17	35	38	41	44	48	51	54	57	60	63	67	70	73	76	79	83	86	89	92	95	98	102	105	108					
18	31	34	37	40	42	45	48	51	54	57	59	62	65	68	71	74	76	79	82	85	88	91	93	96	99				
19	28	31	33	36	38	41	43	46	48	51	53	56	58	61	63	66	69	71	74	76	79	81	84	86	89	91			
20	25	28	30	32	34	37	39	41	43	46	48	50	53	55	57	60	62	64	67	69	71	73	76	78	80	83			
21	23	25	27	29	31	33	35	37	40	42	44	46	48	50	52	54	56	58	60	62	64	67	69	71	73	75	77		
22	21	23	25	27	28	30	32	34	36	38	40	42	44	46	47	49	51	53	55	57	59	61	63	64	66	68	70	72	
23	19	21	23	34	26	28	30	31	33	35	36	38	40	42	43	45	47	49	50	52	54	56	57	59	61	62	64	66	
24	18	19	21	22	24	26	27	29	30	32	33	35	37	38	40	41	43	45	46	48	49	51	53	54	56	57	59	61	62

Color coding key:

Green = SDI zones 1 and 2 (15 to 35% of maximum SDI). This is considered the lower range of stocking.

Yellow = SDI zone 3 (36 to 45% of maximum SDI). This is considered the middle range of stocking.

Orange = SDI zone 3 (46 to 55% of maximum SDI). This is considered the upper range of stocking.

Red = SDI zone 4 (56% + of maximum SDI). Tree groups will not be managed within this zone.

Note: SDI "zones" are explained in the silviculture report.