Helena and Lewis & Clark National Forests

Forest Plan Assessment

Chapter 3, Watershed, Aquatic, Soil, and Air Resources

2015

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Introduction

The physiography of the Helena and Lewis & Clark National Forests is varied, and the climate midcontinental. Central Montana occupies an area transitional between the main range of the Rocky Mountains and the vast continental slope known as the Northern Great Plains in Montana and the Dakotas. It consists of frontal ranges, intermountain basins, and tablelands. The surface features in most of the area result from the dynamic and volcanic forces that produced the mountain ranges and warped the plains during the cretaceous and Tertiary periods and from subsequent erosion and deposition of colluvial and alluvial materials. The mountains in the plan area enclose intermountain basins.

Geographic Areas of the Helena and Lewis & Clark National Forests

The landforms in the assessment area have been formed by erosion and by disposition of both water and ice. Glaciers have affected parts of the area, creating U-shaped valleys, cirques, steep-sided mountain peaks, and rolling glacial moraines. Also, stream erosion has produced V-shaped mountain valleys, terraces, and flood plains. Following are descriptions of the landforms of the 10 geographic areas (GAs).Information was taken from general maps and area information as well as published reports (Cunningham 1995, Hargrave et al. 1998, and Metesh et al. 1998).

Big Belts Geographic Area

The Big Belt Mountains lie primarily between the Missouri River drainage to the west and the Smith River drainage to the east. Two of the primary drainages on the east side, which flow to the Smith River, are Beaver Creek within the Gates of the Mountains Wilderness Area and Camas Creek. The gulches on the western slopes of the Big Belts were sites of gold placer strikes in the early 1900s, including Confederate and Avalanche Gulches. This range was formed by a broad folded-arched uplift, which has been eroded and dissected to produce rounded peaks and deep intervening streams valleys. The Belt Supergroup series of rocks, which are primarily Precambrian mudstones, were named after this mountain range and the adjacent Little Belt Mountains. A particularly well-known example of exposed Belt Group mudstones in alternating purplish-red or pale bluish-green layers in the Big Belt Mountains is in Wolf Creek Canyon along Interstate 15 between Helena and Great Falls. The highest point, Mount Edith, is at 9, 504 feet, and the primary land uses are logging and recreation.

Castles Geographic Area

This island range has granite and diorite, eroded into fantastic forms, which are exposed in the higher mountains. The western portions of the Castles are moist, while the eastside is dry, porous limestone hills. The range gets its name from "castle turrets", 50-foot high igneous rock spires on the western slopes. The highest peak is Elk Peak, at 8,589 feet. The range was the focus of mining activity in the previous century, and remains of old miners' cabins and diggings are present throughout the area. The landscape is characterized by a central cluster of peaks over 8,000 feet and extensive grassy parks surrounded by lodgepole pine and limber pine. Douglas-fir and ponderosa pine occur on the east end of the range. The east side of the range drains to the Musselshell River, and the west drains to the Smith River.

Crazies Geographic Area

This island range, located between the Musselshell and Yellowstone rivers, has sharp bald peaks and ridges covered with slide rock, and are among the more rugged ranges in Montana. This range was formed by igneous intrusions in sedimentary rock. The isolated igneous peaks and ridges protrude through Cretaceous shale and sandstone that have been elevated by volcanic forces. Due to the eastern location, these mountains are drier and less densely forested than other mountain ranges in Montana. The highest point is Crazy Peak at 11,214 feet, which is on the Gallatin NF. Loco Mountain, 9,239 feet, is the highest point on the Lewis and Clark NF portion of the Crazy Mountains.

Divide Geographic Area

The Divide Geographic Area encompasses the area south and west of Helena. East of the Continental Divide, it includes the Tenmile drainage as well as the headwaters of Prickly Pear and Little Prickly Pear Creek. West of the Continental Divide, it includes the Little Blackfoot drainage. The river's canyon and the valleys were formed by the Missoula Floods, cataclysmic glacial lake outburst floods which occurred at the end of the last ice age. The range is predominantly sedimentary, with some volcanic intrusions. The area has been heavily mined since the late 1800s.

Elkhorns Geographic Area

This range is formed by a massive igneous intrusion knows as the Boulder Batholith, characterized by serrated ridges and bald peaks. The volcanic Elkhorn Mountains are a large mass of forested lava associated with the batholith. Mineral deposits associated with the Elkhorn Mountains Volcanics include silver, which was mined at Elkhorn, Montana, now a ghost town, and gold at the Golden Sunlight Mine near Whitehall, which is associated with a breccia pipe in the volcanics. The highest point is Crow Peak at 9,414 ft. The 1988 Warm Springs Creek fire burned 47,000 acres in the Elkhorn Mountains, most of which are now covered with regenerated lodgepole pine. Most of this geographic area drains to the Missouri River, including Beaver Creek, Crow Creek, and Prickly Pear Creek. The southwestern section drains to the Boulder River, via Elkhorn Creek and Dry Creek.

Highwoods Geographic Area

The Highwood Mountains are a small island mountain range. The range is a group of rhyolitic volcanic intrusions. High elevation grassy parks are skirted by lodgepole pine slopes. The highest point is Highwood Baldy at 7,670 feet. The majority of the area drains north to the Missouri River; drainages include Thain and Highwood Creeks. Recreation and grazing are the primary uses of the area.

Little Belts Geographic Area

This range is similar to the Big Belts, but their peaks and ridges are somewhat more rounded and their average elevation is a few hundred feet lower. The highest point is Big Baldy Mountain at 9,175 feet.This area includes the Middle and Lost Forks of the Judith River, which cut deep canyons through multicolored limestone cliffs. Other notable streams include Belt, Sheep, and Tenderfoot Creeks. The Middle Fork-Judith Wilderness Study Area (WSA) contains over 29 miles of streams containing small reaches of genetically pure westlope cutthroat trout, hybridized populations, and rainbow trout (*Oncorynchus mykiss*). Silver mining has affected the central part of the range. Higher elevations are covered in lodgepole pine and whitebark pine, while lower elevations contain ponderosa pine and Douglas-fir intermixed with grassy parks and meadows.

Rocky Mountain Range Geographic Area

This range is composed of metamorphosed shale, sandstone, and limestone. It is characterized by steep slopes and is heavily deformed geologically by faulting, folding, and overthrusting. Some oil and natural gas exploration has occurred along the Rocky Mountain Front, but the majority of NFS lands are within the Bob Marshall Wilderness Area or roadless area and were withdrawn from mineral development in 2006. The section of the Rocky Mountain Range within the planning area is all east of the continental divide, which forms the western boundary of the Geographic Area. High peaks, several above 8,000 and 9,000 feet are located along the divide. Primary drainages flow east to the Missouri River, including the Sun River, Teton River, and Dearborn River. Recreation is the primary activity.

Snowies Geographic Area

This range is a sinuous limestone ridge and consists of a high ridge from which steep dissected southern slopes extend eastward. These mountains are two of Montana's island ranges. About 112,000 acres of the Big Snowy Mountain Range are for the most part roadless, the bulk of this on NFS lands, as well as 6,870 acres in the Twin Coulees Wilderness Study Area on adjacent BLM land. Ninety-eight thousand acres of the NFS lands are also a Wilderness Study Area. The Big Snowy Mountains feature a long, relatively level east-west summit, rising above timberline, and they culminate in Greathouse Peak, the highest point in the range. The dominant tree species include ponderosa pine, Douglas-fir, and subalpine fir on the heavily forested north slope, while the south slope is drier. The Little Snowy Mountains are a continuation of the Big Snowy Mountains to the west. The South Fork Flatwillow Creek runs from the north side of the pass near Red Hill and east along the north side of the range. Willow Creek and various tributaries drain most of the range to the south and flows into the Musselshell River on to the southeast.

Upper Blackfoot Geographic Area

The majority of this geographic area encompasses the headwaters of the Blackfoot River extending west from the continental divide extending from the Rocky Mountain Front to the Nevada and Arrastra Creek drainages. The river's canyon and the valleys were formed by the Missoula Floods, cataclysmic glacial lake outburst floods which occurred at the end of the last ice age. The range is predominantly sedimentary, with some volcanic intrusions. The mineralized areas have been heavily mined since the late 1800s, including the Mike Horse Mine, a historic zinc and lead mine that is now in remediation and clean-up. Another primary use of this geographic area is recreation.

Broad Scale Context and Key Ecosystem Components

An ecosystem is defined as a spatially explicit, relatively homogeneous unit of the earth that includes all interacting organisms and elements of the abiotic environment within its boundaries. Ecosystem integrity is the condition where natural ecological composition, structure, and processes are essentially intact and self-sustaining. This indicates that the ecosystem is able to evolve naturally with its capacity for self-renewal and biodiversity maintained. Ecosystems are described in terms of structure, composition, function, and connectivity (CFR 219.8). Composition refers to the types and variety of living things. Structure is the physical distribution and character of components of the ecosystem. Function is the processes or interactions that occur between the living elements of the ecosystem; and connectivity as the spatial linkage between them. The analysis for terrestrial vegetation uses a variety of classifications and metrics to assess these elements.

Key ecosystem characteristics are identified based on the dominant ecological characteristics that describe the four elements of ecosystems. The terrestrial ecosystems chapter describes the key ecosystem characteristics of vegetation. Key ecosystem characteristics that pertain to soil water or aquatic ecosystems are listed here (See Table 3.1). Some or all of these characteristics may be carried forward to inform Forest Plan components and/or long term monitoring plans depending on their relevancy to coarse and fine filter ecosystem diversity.

Table 3.1 Key Ecosystem characteristics

Key Ecosystem Characteristic		Indicator(s)	Measure(s)
Watershed and water quality	Watershed condition and function attributes	WCF indicator and attribute ratings, changes in overall watershed rating	Number of watersheds in each class
	Water Quality	Streams listed on State 303(d) list	Number of streams listed, TMDLs written
	Groundwater Dependent Ecosystems	Springs, riparian areas, wetlands, fens	Acres
	Wetlands/Riparian areas	Changes to and maintenance of conditions	PFC condition ratings
Aquatic Ecosystems	Native Species: including Bull Trout, Westslope Cutthroat Trout	Species diversity, distribution and abundance	Fish surveys, miles of habitat, patch size
	Aquatic Habitat	Water Temperature, Sediment, Pool habitat, Barriers, diverse species and age compositions of native, riparian vegetation	Stream surveys, monitoring data, trend data
Soils	Soil Stability	Soil Site Stability and Hydrologic Function	% Bare Ground
	Mollic Soil Characteristics	Trees on mollic soils are an indicator of ingrowth. These are sites that should be converted back to primary range.	Acres
	Soil moisture deficit	Measure of changes due to warming climate	Acres experiencing drought
Air	Visibility	Interagency Monitoring of Protected Visual Environments (IMPROVE) Program monitoring network including GAMO1 (Gates of the Mountains) and MONT1 (Bob Marshall and Scapegoat Wilderness Areas)	Standard Visibility Range (miles)

Watersheds

Introduction

A watershed is a ‘region or land area drained by a single stream, river, or drainage network; a drainage basin’ (36 CFR 219.19). These drainage areas are defined by the highest elevations surrounding a selected location on a stream so that a drop of water falling inside the boundary will drain to the stream while a drop of rain falling outside of the boundary will drain to another watershed. Watersheds encompass all of the ecosystem elements – water, soils, vegetation, and animals. Watersheds also span the landscape at many different scales. Watershed boundaries cross ownership boundaries since they are based on topography. A systematic method of delineating watershed boundaries and giving them a number code was developed by the USGS (Seaber et al. 1987). The number code is called the hydrologic unit code (HUC). The HUC system is used to divide and subdivide the watersheds into successively smaller nested “levels”, with level one being the broadest and level six being the smallest used in this assessment.

Analysis Area Watershed Scale

The Helena and Lewis & Clark Forest Plan area is located within two HUC Regions:

- **The Missouri Region** (HUC = 10) is on the eastern side of the Continental Divide. Within this region, the plan area is located in 3 subregions: Missouri Headwaters (HUC=1002), Missouri-Marias (HUC=1003), and Missouri-Musselshell (HUC=1004). Within these subregions, the plan area is located in 14 fourth level watersheds. Within these fourth level watersheds the plan area is located within 88 fifth level watersheds which are further broken down into 301 sixth level watersheds.

- **The Pacific Northwest Region** (HUC = 17) drains to the west. Within this region, the plan area is located in one subregion, the Kootenai-Pend Oreille- Spokane (HUC=1701). Within this subregion, the plan area is located in two fourth level watersheds: Upper Clark Fork and Blackfoot River. Within these fourth level watersheds, the plan area is within 16 fifth level watersheds which are further broken down into 72 sixth level watersheds.

This analysis uses the fourth, fifth and sixth level watershed scales to assess current conditions across the Helena and Lewis & Clark NFs.

Current Forest Plan Direction

Originally adopted in 1986, the Helena and Lewis & Clark NF Land Resource Management Plans (LRMPs) are the primary documents that establish management standards and guidelines governing activity on NFS lands within the boundaries of the Helena and Lewis & Clark NF. The forest plan provides a variety of management direction related to aquatic resources. Much of this direction is based on the Clean Water Act (CWA), National Forest Management Act (NFMA), the Endangered Species Act (ESA), and Forest Service policy. The LRMPs direct the Forests to maintain long term water quality to meet or exceed state water quality standards. To ensure meeting these standards, the Forests are to: monitor surface-disturbing activities where this need is identified; refer to forestwide standards under water and soils for BMPs, landtype guidelines and standards applicable to projects or activities within this management area; and analyze and evaluate all project proposals to determine the potential water quantity and quality impacts; and develop mitigation measures to minimize adverse impacts.

Existing Information

Information regarding management and condition of watersheds within the plan area includes the following:

- Forest Service watershed condition classification
- Montana Department of Environmental Quality (MT DEQ) 303(d) information
- Montana forestry best management practices (BMP) monitoring
- MT DEQ public water supply program
- R1/R4 BMP Handbook FSH 2509.22
- Helena and Lewis & Clark Forests Monitoring data and reports

For the watershed assessment, the best available science was used to inform the assessment. The data and reports provide background information on the current and historic water quality conditions across the Forests.

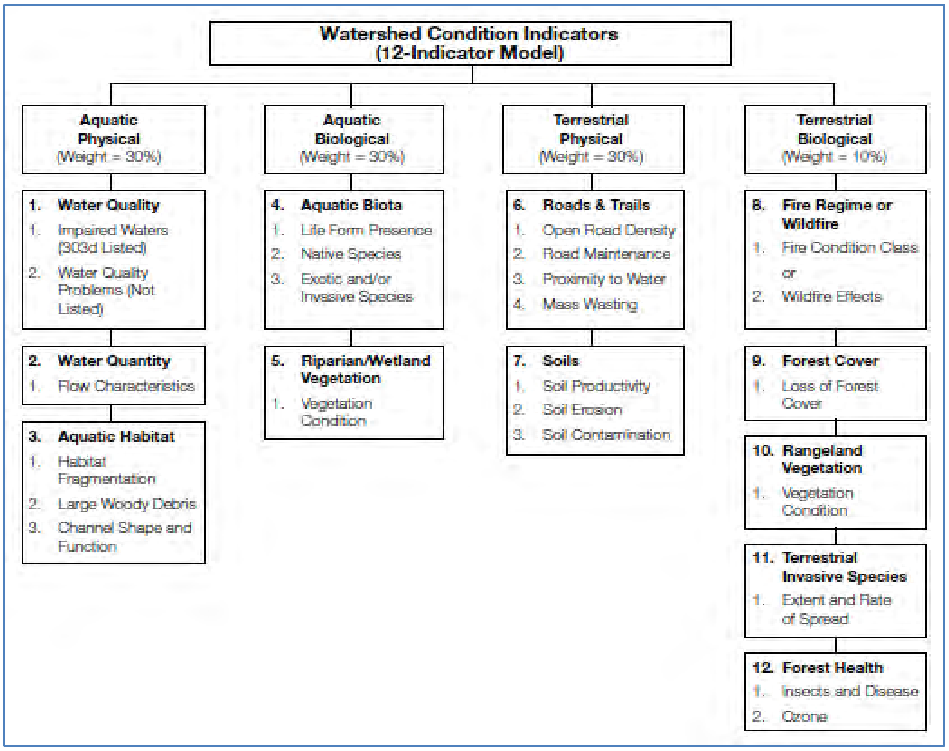
Existing Condition

Watershed condition is the state of the physical and biological characteristics and processes within a watershed that affect the soil and hydrologic functions supporting aquatic ecosystems. Watershed condition can range from natural pristine (functioning properly) to degraded (impaired). The Forest Service Manual (FSM) defines watershed condition in terms of ‘geomorphic, hydrologic, and biotic integrity’ relative to ‘potential natural condition.’ In this context, integrity relates directly to functionality.

In 2011, sixth-level watersheds (typically 10,000 to 40,000 acres) across all NFS lands were classified using the national Watershed Condition Framework (WCF) (USDA Forest Service 2011). A watershed condition was assigned following an assessment of existing data, knowledge of the land, and professional judgment. The three watershed condition classes are directly related to the degree or level of watershed functionality or integrity: Class 1 – Functioning Properly, Class 2 – Functioning at Risk, and Class 3 – Impaired Function (USDA Forest Service 2011). A watershed is considered to be functioning properly (Class 1) if the physical attributes are suitable to maintain or improve biological integrity. By contrast, a Class 3 watershed has impaired function because some physical, hydrological, or biological threshold has been exceeded. Substantial changes to the factors that caused the degraded state are commonly needed to improve conditions that sustain physical, hydrological, and biological integrity (USDA Forest Service 2010).

The WCF uses 12 indicators, which are further refined using 24 attributes in four categories to assess watershed condition (Figure 3.1). The 24 attributes are surrogate variables representing the underlying ecological functions and processes that affect soil and hydrologic function. Each attribute was given a rating of 1 (good), 2 (fair), or 3 (poor). The 24 ratings were then put through an algorithm to identify a watershed condition class score. Aggregate class scores of 1, 2, and 3 directly correspond to final class rankings of Class 1, Class 2, and Class 3. The attribute ratings and the watershed class scores are stored in the Watershed Condition and Tracking Tool (WCATT) database by sixth level watersheds, using the Watershed Condition Classification Technical Guide (Potyondy and Geier 2011).

Figure 3.1 Core national watershed condition indicators and attributes



Watershed conditions vary across the plan area with conditions ranging from those unaffected by direct human disturbance to those exhibiting various degrees of modification and impairment. According to the model, 40 percent of watersheds within the plan area are in watershed condition Class 1 and “exhibit high geomorphic, hydrologic and biotic integrity relative to their natural potential condition” (Potyondy and Geier 2011). These conditions will be re-assessed in the future to assess change. The results are displayed in Table 3.2 and on map14 of appendix A, Watershed Condition Class Framework. In summary, 103 were rated as functioning properly, 159 were rated as functioning at risk, and 34 were rated as impaired. The most significant drivers of the ratings in the plan area were roads, grazing, and mining.

Table 3.2 Number of sixth level watersheds by geographic area rated in each category under the WCF

Geographic Area	Class 1 Functioning Properly	Class 2 Functioning at Risk	Class 3 Impaired Function	Grand Total
Big Belts	3	35	7	45
Castles	2	9	1	12
Crazies	5	5		10
Divide	1	13	14	28

Geographic Area	Class 1 Functioning Properly	Class 2 Functioning at Risk	Class 3 Impaired Function	Grand Total
Elkhorns	1	18	2	21
Highwoods	3	4		7
Little Belts	21	39	4	64
Rocky Mountain Range	40	13	1	54
Snowies	15	3		18
Upper Blackfoot	12	20	5	37
Grand Total	103	159	34	296*

*8 watersheds are within 2 GAs, making the total 296 rather than 288.

Across the Plan area, watersheds were most commonly rated as impaired for the indicators: aquatic biota, roads and trails, and water quality. Of the 24 attributes, watersheds were most commonly rated impaired for aquatic invasive species, proximity to water, and insects and disease. Table 3.3 breaks shows the indicators and attributes most commonly rated impaired for watersheds by geographic area.

Table 3.3 Indicators and attributes most commonly rated Impaired for watersheds by GA

GA	Indicators		Attributes		
	Most common	Second	Most common	Second	Third
Big Belts	Roads & Trails	Water Quality	Aquatic Invasive Species	Road MTC	
Castles	Water Quantity	Roads & Trails	Insects & Disease	Proximity to water	
Crazies	Water Quantity	Roads & Trails	Insects & Disease	Proximity to water	
Divide	Roads & Trails	Water Quality	Insects & Disease	Road MTC	Impaired Waters
Elkhorns	Roads & Trails	Aquatic Biota	Insects & Disease	Proximity to water	Aquatic Invasive Species
Highwoods	Aquatic Biota	Invasive Species	Native Species	Aquatic Invasive Species	
Little Belts	Aquatic Biota	Invasive Species	Insects & Disease	Proximity to water	Aquatic Invasive species
Rocky Mountain Range	Aquatic Biota	Soils/ Invasive Species	Aquatic Invasive Species	Soil Erosion	Soil Productivity/ proximity to water
Snowies	Fire	Invasive Species/ Water Quantity	Proximity to water	Aquatic Invasive Species	
Upper Blackfoot	Roads & Trails	Fire/ Water Quality	Road MTC	Insects & disease	Proximity to water

As part of the initial rating process, four watersheds were designated as priority watersheds. Headwaters Sheep Creek in the Little Belts GA, Upper Tenmile Creek in the Divide GA, Lower South Fork Two Medicine Creek in the Rocky Mountain GA, and Copper Creek in the Upper Blackfoot GA were all identified as priorities in 2011. Issues in these watersheds include past mining impacts, riparian structure and function, invasive species, and water quality. In road-accessible areas, projects have been identified that would help to minimize the potential for soil erosion and mass wasting to aid in restoring water flow patterns and re-establishes native plant species. The main efforts have included the following: restoration of vegetation to natural species, age, and opening patterns; soil decompaction of skid trail and log landings; restoration of soil productivity; and reduction of impacts of forest roads by road reconstruction, maintenance, and decommissioning. Watershed Restoration Action Plans are attached to the priority watersheds within the interactive map at http://www.fs.fed.us/publications/watershed/.

Work is in process in two of the priority watersheds: Lower South Fork Two Medicine Creek and Copper Creek. Work in Two Medicine has included 20.5 miles of road obliteration, culvert removal, stream channel reconstruction, and noxious weed treatment. Work in Copper Creek has included culvert replacement, road surfacing and stabilization, and road obliteration.

Two additional watersheds were identified as priorities in 2014. Cabin Gulch in the Big Belts GA was identified for road and mining impacts to stream channels as well as mountain pine beetle impacts to forest fuel loads, and Lower Dry Fork Belt Creek in the Little Belts GA was identified in 2014 for past mining activity, road density, water quantity, water quality and species habitat concerns.

Trends and Drivers

Trends in Class 1 watersheds are relatively static. The primary drivers of change in these areas are wildfires, climate, and insect/disease infestations. Changing climate may have contributed to and possibly exacerbated the magnitude and extent of effects from these drivers. Forest management direction over the past 10 years has been to allow natural processes to dictate variations in watershed conditions in these areas. Several Class 1 watersheds have the potential to degrade to Class 2 with only moderate climate changes, due to the influence of multiple stressors.

In Class 2 and Class 3 watersheds, the trends are mixed: while some watersheds are declining, most watersheds are showing slow, continual improvement as restoration activities are implemented or natural recovery occurs. In road-accessible areas, projects have been designed to incorporate a soil and water improvement component to minimize the potential for soil erosion and mass wasting to aid in restoring water flow patterns and re-establishment of native plant species. The main efforts have included the following: restoration of vegetation to natural species, age, and opening patterns; restoration of soil productivity; and reduction of impacts of forest roads by road reconstruction, maintenance, and decommissioning. In these areas, timber harvest, wildfire, mining, livestock grazing, recreation activities, road location, and management have combined with natural disturbances to either accentuate or lessen the intensity or duration of watershed processes. Changing climate may have either exacerbated or contributed to the magnitude and extent of the effects of these drivers.

Every year, the Forests accomplish up to 800 acres of watershed improvement work. Much of this is in conjunction with other projects, including timber, road, and fire projects, but also includes stream restoration and riparian projects. These projects will contribute to improving conditions and ratings across the watersheds.

Information Needs

There are no information needs at this time.

Water Resources and Water Quality

Introduction

The Montana Department of Environmental Quality (MT DEQ) is responsible for ensuring that Montana's surface, ground, and drinking water resources meet state water quality standards. MT DEQ's website (http://www.deq.mt.gov/wqinfo/default.mcpx) has numerous water quality–related reports, documents, maps, peer-reviewed literature, and brochures and links to regulations. The Montana Department of Natural Resources and Conservation (DNRC) is responsible for overseeing the implementation of the Montana Natural Streambed and Land Preservation Act, and the Montana Fish, Wildlife and Parks (MTFWP) Department implements the Stream Protection Act.

The Helena and Lewis & Clark NFs implement State of Montana water quality BMPs as well as federal BMPs, and other requirements of the Clean Water Act (CWA) and the Montana Stream Protection Act (SPA 124), along with numerous other project design features and resource protection measures when implementing silvicultural projects. Use of the water quality BMPs ensures compliance with the CWA. The State of Montana Forestry Practices Program leads a biennial audit of the application and effectiveness of BMPs on selected sites. Summaries of these audits are available from the state website at https://dnrc.mt.gov/Forestry/Assistance/Practices/bmp.asp.

The Forest Service is initiating implementation of a National BMP Program, which integrates water resource protection into management activities conducted across the landscape. The goal of the National BMP Program is to improve agency performance, accountability, consistency, and efficiency in protecting water quality, and is a significant component of the Agency's water strategy. The National BMP Program will enable the Agency to readily document compliance with the management of nonpoint source pollution at local, regional, and national scales and address the new planning rule requirement for national BMPs (36 CFR 219.8(a)(4)) (see http://www.fs.fed.us/biology/watershed/BMP.html).

Existing Information

The main surface water quality report prepared by MT DEQ is the biennial Clean Water Act (CWA) 303(d)/305(b) Integrated Report, the most recent of which was prepared in 2012 (MT DEQ 2012). For waters that have pollutant impairments, the MT DEQ or its contractors prepare a sub-basin assessment and total maximum daily load (TMDL) assessment. Impaired waters without a completed TMDL are assigned to Category 5 of the CWA Section 303(d) list. Waters with impairments that have approved TMDLs are listed in Category 4a of the CWA Section 303(d) list. The following assessments have been prepared for watersheds on the Forests:

- Water Quality Restoration Plan for Metals in the Blackfoot Headwaters TMDL Planning Area (2003)
- Blackfoot Headwaters Water Quality and Habitat Restoration Plan and TMDL for Sediment (2004)
- Boulder-Elkhorn Metals TMDLs and Framework Water Quality Improvement Plan (2012)
- Sediment, Nutrients, and Temperature TMDLs and Water Quality Improvement Plans for the Boulder-Elkhorn Planning Area (2013)
- Development of a TMDL to Reduce Nonpoint Source Sediment Pollution in Deep Creek, Montana (1996)
- Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area: Volume 1-Watershed Characterization and Water quality Status Review. (2004)
- Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area: Volume II – Final Report (2006)
- Lake Helena Planning Area Metals Total Maximum Daily Load (TMDL) Addendum (2013)

- The Missouri-Cascade and Belt TMDL Planning Area Metals Total Maximum Daily Loads and Framework Water Quality Improvement Plan (2011)
- Little Blackfoot 2011 & 2014 (http://deq.mt.gov/wqinfo/tmdl/finalreports.mcpx)
- Middle Blackfoot-Nevada Creek
- Other data sources: streamflow gages, other monitoring including FS, State, EPA, CERCLA, and USGS.
- Comments from the public and stakeholders will also be used to inform the assessment and the analysis during the revision process.

For the water resource and quality, the best available science was used to inform the assessment. The data and reports provide background information on the current and historic water quality conditions across the Forests.

Existing Condition

Water Quality

According to the State 303(d) list, 55 stream segments within the plan area are not meeting water quality standards (MT DEQ, 2014) (Table 3.4 and also see map 15 in appendix A, Montana State 303(d) Listed Water Quality Impaired Streams). Thirty-five of these are listed for mining related impacts, and the remaining 20 are listed for grazing or habitat quality issues. Total Maximum Daily Load assessments (TMDLs) have been prepared and are being implemented for several sub-basins in the plan area, including those in the Divide, Elkhorns, and Upper Blackfoot GAs. The streams with mining related issues are also discussed in the minerals and geology section of this assessment.

Table 3.4 Number of 303(d) listed streams and causes by GA

Geographic Area	Number of Stream segments	Miles	Sources	TMDL
Big Belts	7	36	Mostly grazing, road impacts, mining in confederate gulch	Deep Creek, Canyon Ferry
Divide	14	54	Primarily mining impacts, road impacts	Little Blackfoot, Lake Helena Boulder-Elkhorn
Elkhorns	11	40	Abandoned mines, road impacts, water diversions	Boulder-Elkhorn Lake Helena
Little Belts	8	99	Mining, road and grazing impacts	Missouri-Cascade/Belt Creek,
Rocky Mountain Range	1	4	Grazing and flow alterations, road impacts	Sun River (completed)
Snowies	1	2	Grazing and road impacts	no
Upper Blackfoot	13	54	Abandoned mines, road impacts	Blackfoot Headwaters Middle Blackfoot – Nevada Creek

Across the planning area, water quality monitoring in conjunction with forest project activities have been occurring since the last Forest Plan was developed. Both the Helena and Lewis & Clark NFs have extensive watershed monitoring programs. For more than three decades, data have been collected at 55 water quality monitoring sites on the Helena National Forest (HNF) to monitor the majority of HNF timber sales and other major projects. The number of years of data collection at each site has varied based on project needs. In Fiscal Year (FY) 2013, 22 water quality monitoring stations were maintained, three rain gauge monitoring sites were installed, 5 roadside hazard tree units were monitored, and 133 decommissioned roads were evaluated for closure effectiveness. In addition to HNF data collection, other data collection efforts on the Forest have included various

TMDL inventory and monitoring programs, the HNF Youth Forest Monitoring Program, which included 12 water quality sites, and monitoring done by other governmental agencies (e.g. MT DEQ, US EPA).

On the Lewis & Clark NF, monitoring has been more focused around grazing allotments. Ten exclosures have benchmarked monitoring reaches where monitoring has included: up to 10 cross-sections (both inside and outside the exclosure), photo points, sinuosity, pebble counts, and slope measurements. Other monitoring is focused on road obliteration project monitoring, which includes documentation of vegetative recovery, weeds, stream crossings, and erosion along obliterated roads.

The Helena NF has been applying for obtaining instream flow water rights on several streams across the Forest. Applications to obtain in-stream flow water rights were submitted for Kady Gulch, Mike Renig Gulch and South Fork Quartz Creek in the Divide GA, and Cotter Creek, Snowbank Creek and Willow Creek in the Upper Blackfoot GA. In 2013, water rights were obtained for in-stream flows on Camas Creek (Big Belts GA), Nevada Creek (Upper Blackfoot GA), and Ontario Creek (Divide GA).

Municipal Water Supply

The 1986 Forest Plans identified portions of three sixth level watersheds as Municipal Water Supplies: Tenmile Creek, Belt Creek-Carpenter Creek, and North Fork Smith River-Trout Creek. These watersheds and one not identified in the 1986 LRMPs provide drinking water to four cities or towns by either a reservoir or water diversion. Please see map 16 in appendix A, Municipal Water Supply Watersheds.

The City of Helena uses Tenmile Creek in the Divide GA and its tributaries as its main source of municipal water. Streams in the lower portion of the Tenmile watershed do not meet drinking water quality standards, but above the diversions, water quality does generally meet standards. Diversions are located on Tenmile Creek above Rimini and near the mouths of Beaver Creek, Minnehaha Creek, Moose Creek, and Walker Creek. Water from all diversions is carried to the Tenmile Water Treatment Plant in a common buried pipeline. In addition, the City of Helena stores water from several tributaries in Scott and Chessman Reservoirs (in the upper part of the watershed) when streamflow is high. The Red Mountain Flume carries water from some of these tributaries to Chessman reservoir. Vegetation treatment efforts are occurring in the watershed under the Red Mountain Flume Chessman Reservoir Project. This project treats the areas around the flume and reservoir. Further treatments in the rest of the watershed are in the planning process for the Tenmile South Helena Project. The primary objective of this project is to reduce the risk for a high intensity wildfire and associated adverse post-fire watershed effects in the watershed.

The City of East Helena uses McClellan Creek (which was not identified in 1986 FP) in the Elkhorn GA for one source of municipal water. This source is an infiltration gallery located approximately five miles south of East Helena, in the McClellan Creek drainage, downstream of the planning area. The infiltration gallery draws water into two collection systems installed into alluvium near the creek. Recharge to McClellan Creek occurs in the Elkhorn Mountains on FS lands.

The town of White Sulphur Springs uses Willow Creek (part of NF Smith River-Trout Creek sixth level watershed). The Willow Creek municipal watershed is located in the Castles GA. The Castle Mountains landscape assessment of 2012 described conditions within the municipal watershed as good. Specifically, the watershed is fenced out and with the exception of few trespassers, livestock access is nonexistent. It has a healthy riparian area with a great diversity of plants including cottonwood, aspen, dogwood, alder, and willow. Mixed conifers adjacent to the channel provide an excellent source of large woody debris which forms numerous log jams along the profile. A boulder dominated channel bed, less-prone to degradation when compared to other project area channels, dissipates the 500 year flood energy efficiently and shows no detrimental effects from the natural event. The overall condition of the watershed is excellent but hillslopes surrounding the creek have high fuel loading (dead lodgepole pine) which could potentially trigger a wildfire. Treatments proposed for the watershed include thinning and prescribed burning.

The town of Neihart uses O'Brien Creek and Shorty Creek (both within Belt Creek-Carpenter Creek sixth level watershed in the Little Belts GA). Neihart has had some issues with turbidity in O'Brien Creek not meeting EPA Safe Drinking Water Standards, so it uses Shorty Creek during those times. The City received a State TSEP (Treasure State Endowment Program) planning grant in 2015 and has applied for a project grant to implement this plan to improve their overall system.

Ground Water Dependent Ecosystems

Ground water-dependent ecosystems are communities of plants, animals, and other organisms whose extent and life processes depend on ground water (USDA Forest Service 2007). The following are examples of some ecosystems that may depend on ground water:

- Wetlands in areas of ground water discharge or shallow water table
- Terrestrial vegetation and fauna, in areas with a shallow water table or in riparian zones
- Aquatic ecosystems in ground water-fed streams and lakes
- Caves and Karst systems
- Aquifer systems, and
- Springs and seeps

These areas contain ecological resources that potentially are highly susceptible to permanent or long-term environmental damage from contaminated or depleted ground water. Ground water extraction by humans modifies the pre-existing hydrologic cycle. It can lower ground water levels and alter the natural variability of these levels. The result can alter the timing, availability, and volume of ground water flow to dependent ecosystems. Ground water-dependent ecosystems vary in how extensively they depend on ground water, from being wholly dependent to having occasional dependence. Unique ecosystems that depend on ground water, fens or bogs for example, can be entirely dependent on ground water, which makes them very susceptible to local changes in ground water conditions (USDA Forest Service 2007). Particular threats in the plan area include facility and road development, grazing impacts, contamination from roads, and clearing of vegetation.

Riparian and wetland areas are described for the overall planning area in the Terrestrial Vegetation Chapter (chapter 2, see Table 2.19 and Figure 2.31, as well as map 10 in appendix A). Riparian and wetland vegetation types are mapped on over 70,000 acres of the HLC NFs administrative area, less than 3%. These types are more extensive on private lands.

The best information about riparian/wetland vegetation conditions across the planning area is the riparian vegetation condition indicator ratings in the Watershed Condition Framework analysis. Within the planning area, the majority of watersheds were rated "Fair" for this attribute (Table 3.5). The Divide GA had the most watersheds rated "poor" for this attribute (16 of 28 watersheds).

Table 3.5 Number of 6th level watersheds rated in each category using the WCF Riparian Vegetation Indicator ratings

GA	1	2	3	Total	% rated 3
Big Belts	3	33	9	45	20
Castles		10	2	12	17
Crazies	2	8		10	0
Divide	2	10	16	28	57

GA	1	2	3	Total	% rated 3
Elkhorns	2	16	3	21	14
Highwoods		5	2	7	29
Little Belts	16	44	4	64	6
Rocky Mountain Range	36	17	1	54	2
Snowies	11	5	2	18	11
Upper Blackfoot	3	33	1	37	3
Grand Total	75	181	40	296	14

Trends and Drivers

See below, *Trends and Drivers* under Aquatic Ecosystems.

Information Needs

There are no information needs at this time.

Aquatic Ecosystems

Introduction

Aquatic conditions within the plan area have been summarized in monitoring reports, viability assessments, watershed analyses, including the WCF, landscape assessments, a sub-basin document, westslope cutthroat trout *(Oncorynchus clarki lewisi)* MOU/Conservation agreement, the bull trout *(Salvelinus confluentus)* conservation strategy, recovery plans, and environmental baselines assessments associated with Endangered Species Act (ESA) consultations for bull trout.

For all areas, except the Blackfoot river sub-basin, this aquatic habitat assessment area is comprised of fifth level watersheds that contain Helena or Lewis and Clark NFS lands. This extent encompasses watersheds on the east side of the continental divide and those in the Little Blackfoot River drainage, which is west of the continental divide. This includes the streams in these two areas where NF planning or management efforts could be expected to affect habitat parameters in magnitudes that would either be measurable or have a potential to affect beneficial water or aquatic habitat related uses. Increasing the assessment boundaries in these areas, to include entire sub-basins containing NF lands, would add vast watershed areas with very different characteristics. In this portion of the two NF's, administrative boundaries tend to occur in close proximity to the mountain/prairie interface. This change in elevation and landform creates dynamic differences in aquatic habitat parameters. The affected environmental characteristics include; increased water temperatures, reduced summer stream-flows, lower stream gradients, increased sediment deposition, finer textured substrates, increased width to depth ratios, and reduced levels of shading by near-bank vegetation. These habitat gradients frequently determined historical changes in native aquatic wildlife species assemblages. With the prevalence of irrigation withdrawals and the conversion of prairie lands into agricultural uses, changes to these environmental parameters and processes have typically become more amplified.

This assessment will include the entire Blackfoot River sub-basin as downstream gradients in the aforementioned habitat parameters do not limit species distribution and potential effects within this extent. There are some inter-mountain prairie areas within the Blackfoot River sub-basin, but most tributaries drain higher elevation, montane areas. Connectivity also allows for migration and/or connected populations of bull trout and westslope cutthroat trout throughout much of this sub-basin.

There are multiple sources of information that are unique in this assessment for the Blackfoot River Sub-basin. The upper Blackfoot River is within the Southwestern Crown of the Continent Collaborative. This is one of ten landscape-scale restoration projects selected nationally under the Collaborative Forest Landscape Restoration Program (CFLRP). This program was established by the United States Congress in the 2009 Omnibus Public Land Management Act. Analyses within this project have yielded additional assessment datasets. Sub-basin wide bull trout assessments are available for this sub-basin and the watersheds within the Little Blackfoot River drainage, which is also within the range of this species.

West of the continental divide, fisheries are managed primarily for inland native species with an emphasis on bull trout because of their listing status under the Endangered Species Act. Also, current Forest Plans have been amended by the Inland Native Fish Strategy or INFISH (USDA 1995) to provide interim direction to protect habitat and populations of resident native fish outside of anadromous fish habitat. Inland native fishes within the scope of the INFISH strategy have been identified by private, state, and federal agencies as being at risk due to habitat degradation, introduction of nonnative species, over-fishing, and loss of migratory forms.

Since 1999 three separate draft bull trout recovery plans were developed by the US Fish and Wildlife Service (USFWS), but none were finalized. However, these draft recovery plans served to identify recovery actions across the range of bull trout and provide a framework for implementing numerous recovery actions. Then in 2014 the USFWS issued a new Revised Draft Recovery Plan for bull trout (USFWS 2014) that supersedes and replaces all previous recovery plans. This revised draft recovery plan: 1) incorporates and builds upon new information and studies regarding bull trout, and 2) revises recovery criteria proposed in earlier draft recovery plans to focus on effective management of threats to bull trout at the *core area* level. The 2014 Revised Draft Recovery Plan reorganized the recovery unit structure for the coterminous United States bull trout population by combining the previous 27 Recovery Units (RUs) into 6 newly defined Recovery Units consistent with Distinct Population Segment (DPS) policy. Drainages west of the Divide on the Helena portion of the Helena-Lewis & Clark NF fall within the Columbia Headwaters RU.

Recovery Units are further broken down into bull trout *core areas*. Core areas are defined as a combination of core habitat (habitat that could supply all elements for long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat). A *local population* is considered to be the smallest group of fish representing an interacting reproductive unit, which may occupy a single headwater tributary or complex of headwater tributaries. Therefore, core areas represent the functional equivalent of a metapopulation structure for bull trout, and the local populations within these core areas are interconnected by occasional dispersal amongst them thereby potentially sharing some genetic characteristics. Core areas constitute the basic unit on which to gauge bull trout recovery within a recovery unit. Within the Columbia Headwaters Recovery Unit there are 35 bull trout core areas of which two encompass drainages west of the Divide on the Helena and Lewis & Clark NF: 1) the Blackfoot River Core Area, and 2) Upper Clark Fork River Core Area (formerly Clark Fork River Section 1).

Within the Blackfoot River Core Area there are two local populations of bull trout on the HLC NFs—Landers Fork and Poorman Creek. Other groups of streams that are not designated local populations with this core area but are considered together as peripheral or other important populations include Arrastra Creek, Lower Alice Creek, Hogum Creek, and Sauerkraut Creek. Within the Upper Clark Fork River Core Area there are there are no local populations of bull trout within the boundaries of the HLC NFs. The Little Blackfoot River is the weakest bull trout local population in the Upper Clark Fork River Core Area, but it’s no longer designated as a local population under the revised draft recovery plan for bull trout. Extensive sampling from 2008-2010 indicates bull trout are nearly extinct in the Little Blackfoot River drainage. Although it is not designated as a local population, the drainage is significant to help maintain geographic distribution of bull trout across the Upper Clark Fork River Core Area.

In support of the draft USFWS Bull Trout Recovery Plan for the Montana portion of the proposed Columbia Headwaters, the Bull Trout Conservation Strategy on NFS lands in western Montana (USDA Forest Service 2013) was developed. The USDA Bull Trout Conservation Strategy helps the FS address Forest Plan Amendment requirements under INFISH and provides a framework for planning and implementing actions to improve local bull trout habitat and populations. Importantly, this strategy forms the basis for an aquatic conservation approach during Forest Plan revisions (USDA Forest Service 2013, page 4).

Westslope cutthroat trout conservation and recovery is a management concern in all plan area drainages that occur west of the divide. This is also a concern in much of the drainages east of the divide. This area includes Judith River drainages and all those that lie upstream in the Missouri River system. This only excludes the portions of the plan area that occur within the Musselshell River drainage. The westslope cutthroat trout is a sub-species that is afforded sensitive species status as approximately 95 percent of populations have been lost. Since these fish form genetically discrete populations within individual streams (Leary et al. 1987, Allendorf and Leary 1988), this corresponds to losing populations within 95% of historically occupied streams. Hybridization with introduced fishes is one of the primary agents responsible for this loss. The threshold is 90 percent genetic purity for a population being considered a conservation population under the Upper Missouri River Westslope Cutthroat Trout Status and Recovery Plan (Tews et al 2000).

Existing Information

Helena and Lewis and Clark NF's Watershed Condition Framework (WCF) analyses – These comprehensive and interdisciplinary assessments were conducted in 201l through 2012. Most of the status determinations accurately reflect current conditions. These are appropriate in scale and detail to function as the primary data source for this assessment. To not use this similar assessment effort as a primary data source would result in a redundant process containing less interdisciplinary expertise. More recent information will incorporated where management activities or existing condition changes have occurred. The WCF effort included the following sources of existing information. These same sources will be used in instances where developments have occurred since 2012:

- Helena and Lewis and Clark NF's Aquatic Species Viability reports
- INFISH priority and key watersheds
- Helena and Lewis and Clark NF's and Montana Fish, Wildlife and Parks (MTFWP) fish population monitoring
- Montana Fish Wildlife and Parks (MTFWP) Upper Missouri River Westslope Cutthroat Trout Recovery Plan annual monitoring reports
- PACFISH/INFISH Biological Opinion (PIBO) Monitoring Reports
- Inland Native Fish Strategy (INFISH) (USDA 1995)
- Helena NF McNeil Core sediment sampling
- Bull Trout Conservation Strategy (USDA 2013)
- Forest Service Northern Region road-stream crossing surveys (Hendrickson et al. 2008)
- Helena and Lewis and Clark NF's evaluations and monitoring reports
- Helena and Lewis and Clark NF's fish population status calls at sixth level watersheds
- Montana Natural Heritage Program (MTNHP): Species field guides, population surveys, species range maps, and status reports
- National Wetlands Inventory (USFWS), and

- Montana Department of Environmental Quality: water quality data and mapping

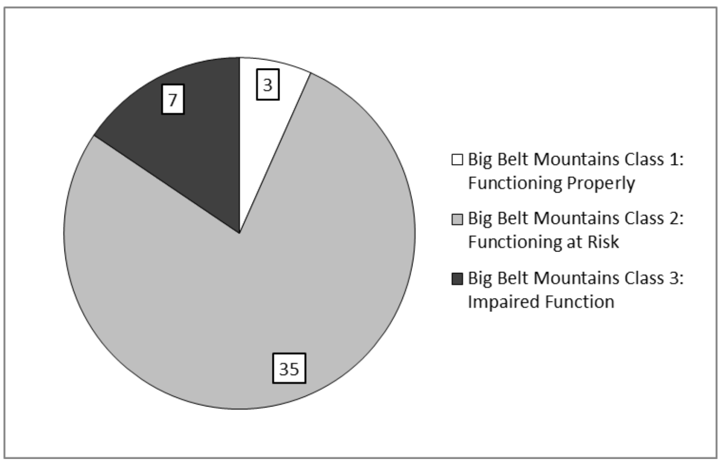
Existing Condition

Big Belt Mountains Geographic Area

The majority of the watersheds in the Big Belts GA were rated as Class 2 (functioning at risk), but there were three rated as Class 1 (functioning properly) and seven rated as Class 3 (impaired) (Figure 3.2). The GA is split between the Missouri and Smith River watersheds, with the majority of the impaired watersheds draining into the Missouri River. Grazing and the existing road and trail network are the most wide-spread management activities that influence aquatic habitat conditions in this mountain range. The Confederate Gulch watershed has also been impacted by mining activities.

There are ten conservation populations of westslope cutthroat trout in this GA with nine of these occurring on USFS lands. There is occupied western toad habitat within this geographic area. Western pearlshell mussel habitat is present, with tributaries of the Smith River being more likely to contain remnant populations. Surveys for this species are incomplete and very low population levels make it difficult to conclusively determine presence and absence.

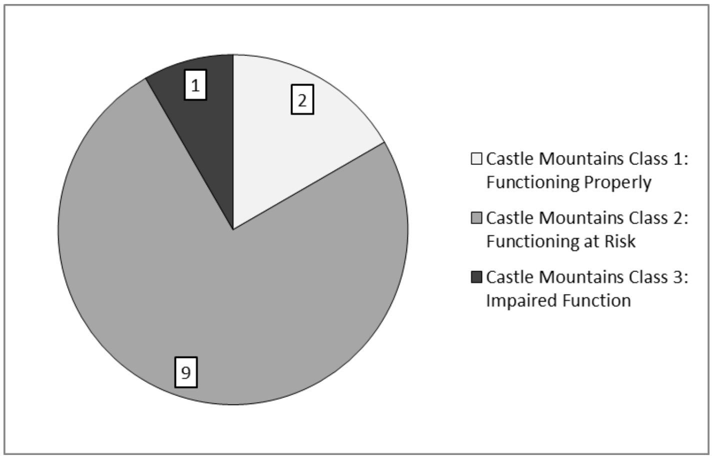
Figure 3.2 Big Belts GA: watershed condition framework—functioning classes



Castles Geographic Area

The watersheds in the Castles Geographic Area were mostly placed in the Class 2 (functioning at risk) category within Watershed Condition Framework rating process (Figure 3.3). Grazing and the existing road and trail network are the most wide-spread management activities that influence aquatic habitat conditions in this mountain range. Moderate impacts levels are generally present along streams within livestock allotment areas. Some higher impact stream segments are now protected by fencing exclosures. Road and trail related impacts are related more to maintenance conditions than to density and proximity issues. Drainage features were found to be lacking along several major road crossings during recent survey efforts related to the Castle Mountains Restoration Project Environmental Assessment. A network of motorized routes was converted into “Jeep trails” in the Travel Management Plan. These are primarily in upland areas, but most lack recent maintenance and erosion reducing improvements. Legacy mining activities are also present. Effects from this activity are present but at low enough levels to have not extirpated aquatic life-forms from stream reaches.

Figure 3.3 Castles GA: watershed condition framework – functioning classes



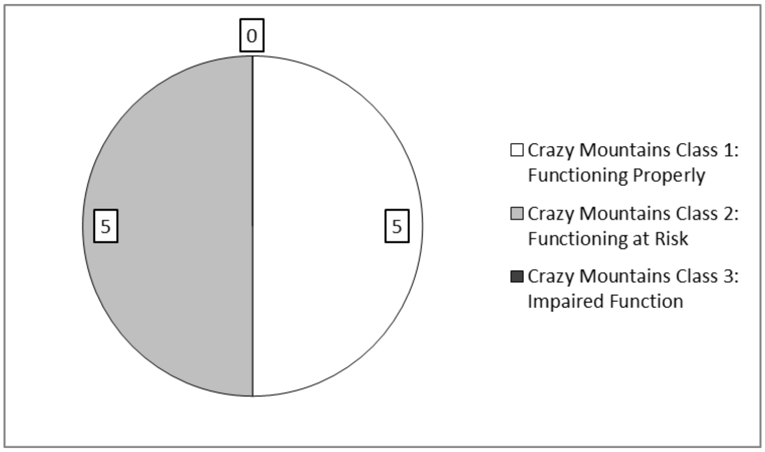
The northwest portion of this geographic area drains into the Smith River. The remaining approximately three-quarters of this area drains into tributaries of the Musselshell River. Westslope cutthroat trout are native to the Smith River drainage watersheds, but not those within the Musselshell River. Four remnant westslope cutthroat trout populations exist in this geographic area. These represent much of the highest genetic purity cutthroat trout stocks that remain in the Smith River system. Grazing occurs along three of these populations with exclosures protecting some of the more prone to damage reaches. The fourth occurs in the municipal watershed for the city of White Sulphur Springs. This is outside of a permitted livestock allotment area. Sites where it would be practical to construct barriers to prevent upstream hybridization are limited. Recent genetic tests confirm that purity is being lost in the Richardson Creek population. Habitat conditions downstream of the exclosure can't be completely ruled out as a contributing factor. However, the size of the hybrid swarm below this population coupled with the lack of a physical barrier would be a large risk factor regardless of the presence of grazing.

Western pearlshell mussels were not modeled to be likely present in this geographic area, with the exception of one reach of Fourmile Creek (Stagliano 2011). There are no recorded occurrences for this species in this reach, and surveys conducted by the Montana Natural Heritage Program were negative. Surveys of downstream habitat areas were also negative through the North Fork and upper main-stem of the Smith River. This species colonizes upstream slowly, thus it isn't likely for this area to become suitable or occupied habitat within the predictable future. Western toads are present in this geographic area, which is part of their native range. There are some likely breeding pond areas, but these are somewhat rare across the mountain range. Adults may also disperse into this area from ponds that lie below forest boundaries.

Crazies Geographic Area

The Crazies Geographic Area is evenly split between Class 1 (functioning properly) and Class 2 (functioning at risk) watersheds under the Watershed Condition Framework process (Figure 3.4). There are not any Class 3 (impaired) watersheds present. The area doesn't contain a fish species of special concern. The portion of the Crazy Mountains within this assessment is outside of the native range of all trout and chars. This geographic area is within the range of western toads. A few breeding ponds exist but much of this area would be limited in supporting populations of western toads. Northern leopard frogs are not known to occupy USFS lands within this mountain range. This area is outside of the range of western pearlshell mussels (Montana Department of Fish, Wildlife and Parks, Natural Heritage Program 2014a, Montana Department of Fish, Wildlife and Parks, Natural Heritage Program 201d).

Figure 3.4 Crazies GA: watershed condition framework – functioning classes

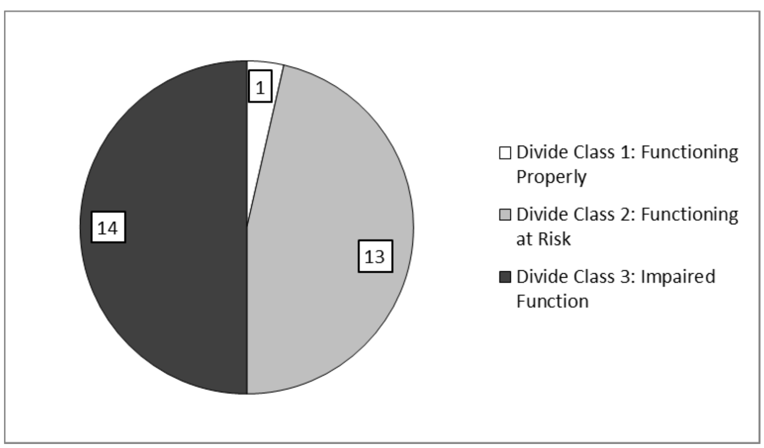


Road densities are low in this geographic area and mostly confined to two watersheds. Timber activities have been sparse throughout the Geographic Area with the exception of some parcels acquired in land exchanges. Grazing impacts are highest in the Cottonwood Creek drainage. There are some "non-functioning" stream segments under the PFC rating system in this drainage with the West Fork of Cottonwood Creek appearing to be most impacted. "Functioning at risk" segments are prevalent along the main-stem. Other drainages, such as Comb Butte, contain grazing impaired stream segments. These occur at lower densities than in Cottonwood Creek and often correlate to site-specific features such as nearby water tanks or flat, shady areas. Grazing and nonnative fishes are the primary risk impacts in watersheds in the five Class 2 watersheds within the GA.

Divide Geographic Area

The Divide GA straddles the Continental Divide west of Helena, MT. The west portion is within the Little Blackfoot watershed, which drains to the Clark Fork River. The East portion is within the Tenmile, Prickly Pear and Little Prickly Pear watersheds, which drain to the Missouri River. The Divide GA has the greatest proportion of at risk and impaired watersheds of any GA in the plan area (Figure 3.5). This is primarily due to the impacts of legacy mining and mining related activities.

Figure 3.5 Divide GA: watershed condition framework – functioning classes



Bull trout in the Little Blackfoot River population are believed to be nearly extinct based on extensive sampling efforts by MFWP personnel during 2007 and 2008 and sampling by Forest Service fishery personnel in 2010. Currently bull trout are known to exist in only three of the 16, sixth level watersheds influenced by Helena Forest lands in this local population. The decline of bull trout in the drainage is most likely due to hybridization and competition with brook trout *(Salvelinus fontinalis)* in the headwater reaches of the Little Blackfoot River (hybrids have been documented); sport harvest due to miss-identification of bull trout as brook trout; competition and possibly predation by brown trout *(Salmo trutta)* in the mid and lower reaches of the Little Blackfoot River; and less than optimum water temperatures for bull trout throughout the river, but especially below the Forest boundary. In the reaches of the Little Blackfoot (nonfederal lands) below the confluence of Dog Creek, brown trout are the dominant species in the river and are likely a factor that limits potential for bull trout due to the potential for competition and predation. Additionally, downstream of the Forest there are multiple water diversions on the main stem river between Elliston and Garrison. The low flows resulting from water diversion result in increased water temperature during the summer months that are far from optimum for bull trout. The low flows in the river below the Forest boundary inhibit fish movements, but do not present complete barriers to fish movements in most years. Channel and habitat alterations from past highway and railroad construction have affected stream morphology and reduced the quality of fish habitat in addition to agricultural practices in some reaches. In addition to the main stem of the Little Blackfoot River, many of the tributaries below the Forest also suffer from water diversion and elevated water temperatures. Regarding portions of tributaries below the Forest, there currently is a lack of connectivity from the river to the upper reaches of most tributaries during times when any remaining bull trout would be migrating to spawning areas. Within the forest there are no barriers on the main stem river and few barriers remaining on tributaries.

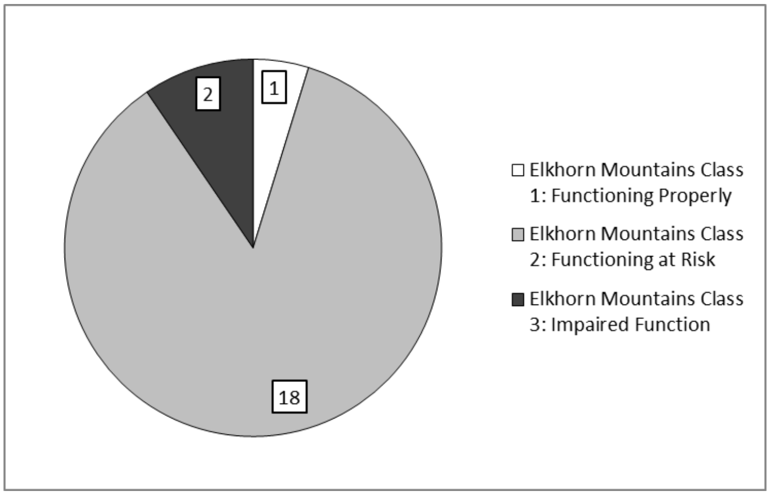
Any effort to recover bull trout in the Little Blackfoot River drainage would require extensive efforts at nonnative fish control since nonnative fish are believed to be the primary factor on the Forests limiting bull trout. These include brown trout, rainbow trout, and brook trout. Brown trout are becoming an increasing concern in interactions with bull trout. This species becomes more predacious as they grow in size and they compete for deep-pool and run habitat. Water temperatures, although not optimum for bull trout, appear adequate. There are additional opportunities to reduce sediment delivery to streams via improved road maintenance efforts as well as obliteration of some roads. Several barriers to fish movement remain on tributaries and cutthroat trout and brook trout are more likely to respond to removal of barriers than bull trout. Below the Forest nonnative fish as well as low flows and elevated water temperatures associated with water diversions are the most important limiting factors.

East of the continental divide, the Tenmile Creek drainage is the principal source of municipal drinking water for the City of Helena. Numerous diversions associated with the water supply system and dewatering of stream reaches limit fish passage. Additionally, mining impacts have had adverse impacts on water quality. Sediment levels are elevated in some reaches of the watershed. There are no conservations populations of westslope cutthroat trout in the Tenmile Creek drainage. There are ten conservation populations in the remainder of the Missouri River drainage portion of this GA, with nine of these occurring on USFS lands.

Elkhorns Geographic Area

The Elkhorn Mountains are split between the Boulder River watershed and the Missouri River watershed on the east side of the Continental Divide. The majority of the watersheds were rated Class 2 (functioning at risk) (Figure 3.6). There are several streams on the State 303(d) list, primarily listed for mining impacts.

Figure 3.6 Elkhorn Mountains GA: watershed condition framework—functioning classes



The majority of this geographic area drains into the Missouri River. The southwest portion of this area drains into the Boulder River. Westslope cutthroat trout are native to the both of these watersheds. Eleven westslope cutthroat trout populations exist in this geographic area. Seven of these are endemic remnants and four are established replicates of populations from outside the area.

Highwoods Geographic Area

The Highwoods Geographic Area has 4 sixth level watersheds that were rated Class 2 (functioning at risk) and 3 that were rated Class 1(functioning properly) (Figure 3.7). The amount of land area in Class 2 is greater than this proportion as some of the Class 2 watersheds are larger in area. The national formula for determining WCF category appears to somewhat de-emphasize existing impairments in two of the three Class 1 watersheds. The prevalence of “functioning at risk” and “non-functioning monitoring reaches under the PFC assessment are perhaps more reflective of current conditions within near-stream areas. The presence of six small native fish populations and the absence of roads and other classes of impairments in the national, weighted formula appears to somewhat over-ride the existing impairments related to livestock grazing and nonnative fishes.

Figure 3.7 Highwoods GA: watershed condition framework – functioning classes

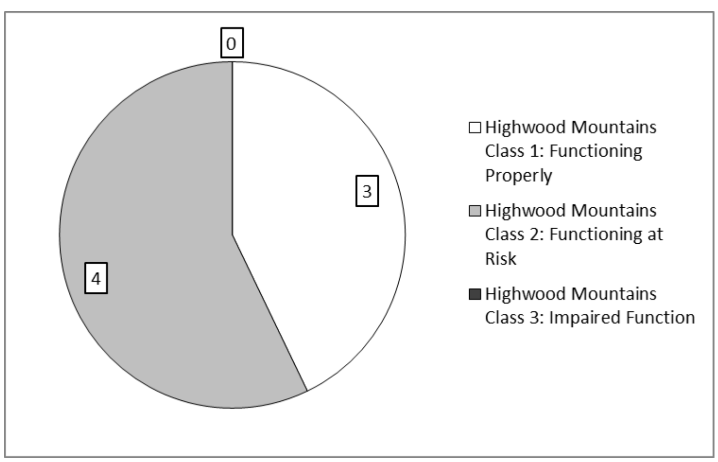
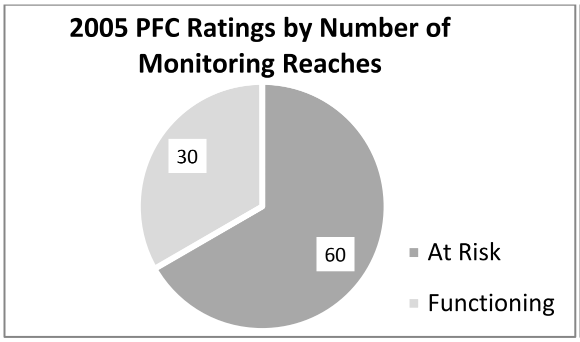
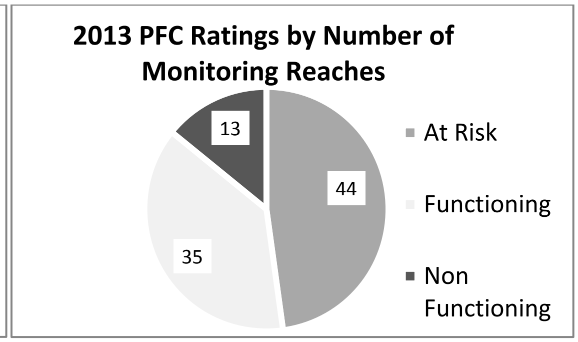


Figure 3.8 shows charts of PFC condition classes, which are provided to illustrate this anomaly between measured conditions at the stream segment level and the integrated WCF calls made after averaging in impairment types that are rare or not present in some watersheds at a more landscape level. These charts show that impairments

related to the immediate vicinity of stream channels and riparian areas are at fairly high levels. The trend also demonstrates a downward direction between 2005 and 2013. Impairments in the Highwood Mountain Range are usually related to livestock grazing and spatially focused to riparian areas with upland areas receiving far less concentration of use. The WCF calls correctly describe the overall conditions in the watersheds, as the methodology is designed to perform. In doing so for this geographic area, the heavier levels of impacts on a small portion of the landscape are under-emphasized. This portion of the landscape is small, but it represents much of the aquatic wildlife habitat in the mountain range.

Figure 3.8 Distribution of monitored stream reaches in the Highwoods GA across properly functioning channel (PFC) condition classes, showing changes between 2005 and 2013





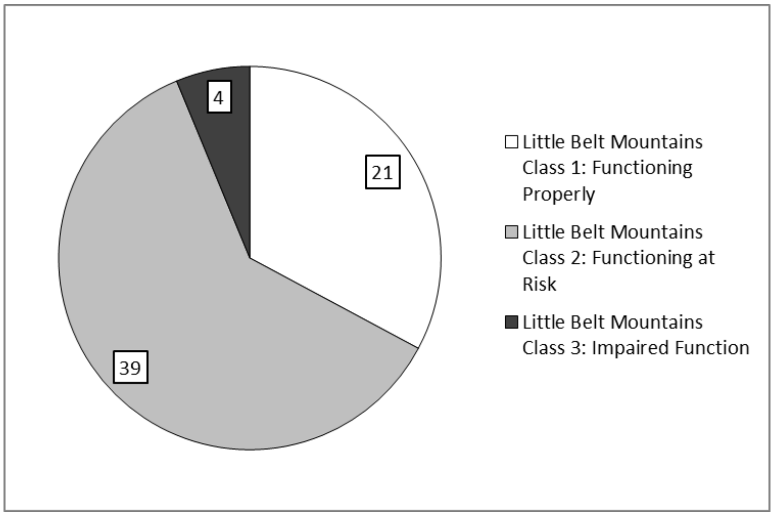
Most of this geographic area is under a season-long grazing regime that averages about 90 days. This is an "island mountain range" surrounded by the prairie. It has warmer summer flows than other mountain ranges in the plan area that are within the native range of westslope cutthroat trout. Resiliency is naturally low to channel and riparian area impairments that increase water temperatures. Cumulative effects from road, timber harvest and other land management activities are relatively low. Some activities, such as timber harvesting, haven't occurred during the last several decades. Fine sediment concentrations are typically high in the existing condition in areas that are roadless, but under season-long grazing. Big Coulee Creek and the North Fork of Little Belt Creek are exceptions to this. These drainages also contain less cattle frequenting near stream-bank areas.

Nonnative fishes are common throughout this mountain range. Five of the 6 remaining westslope cutthroat trout populations are protected by constructed or waterfall migration barriers. Boyd Creek contains the unprotected population and there isn't a feasible site to install a barrier for its protection. A drift fence was installed to limit cattle access to Big Coulee Creek about 10 years ago. The recovery of shade canopy along big Coulee Creek is very apparent in comparison to other similar stream reaches in this geographic area. Passive restoration, which involves lessening or removing the disturbance without implementing reconstruction projects (Kauffman et al. 1997), appears to have potential for greater success in this mountain range. The ongoing Highwood Mountains Range Management Environmental Assessment analyzed adaptive management tools as part of the proposed action. Additional use of these tools could lead to more passive restoration if this alternative was implemented.

Little Belts Geographic Area

The Little Belts GA has a majority of sixth level watersheds rated Class 2 (functioning at risk) (Figure 3.9). Several cumulative effects contribute to the prominence of this rating in the Little Belts GA. The most widespread management activity contributing to the Class 2 ratings is livestock grazing. Bank alteration monitoring efforts consistently found that thresholds were being exceeded (Enk et al. 2009, Cikanek et al. 2011). Some allotment management adjustments have led to improving conditions in recent grazing seasons in some watersheds (USDA Forest Service 2012, USDA Forest Service 2013b). Sediment inputs from forest roads, the winter-sanding of US Highway 89, and the Showdown Ski Area are not as geographically widespread as grazing related impacts. However, these can combine to form a similar or higher risk factor in some watersheds. Effects from legacy forest roads are being lessened through decommissioning in some watersheds. Impacts from timber harvest activities occur but are limited in distribution and intensity in this geographic area. The supporting temporary road system forms much of the aforementioned legacy road network that is being decommissioned.

Figure 3.9 Little Belts GA: watershed condition framework – functioning classes



A biological based effect across all watersheds is the historical stocking of nonnative trout and char species. This contributes to the Class 2 classifications. There are over 20 known populations of westslope cutthroat trout in this geographic area. This is a higher density than in most areas of the native range east of the Continental Divide. The effects of management related impacts on these populations vary. Grazing and road related impacts typically lessen habitat quality for all species. While these effects are usually below levels that threaten the viability of individual populations, they can have dramatic effects when the impacts coincide with native populations and other perturbations. Mining impacts have ranged from completely eliminating habitat to protecting small populations from hybridization by creating chemical barriers to the upstream movement of nonnative fish.

The four Class 3 watersheds are influenced heavily by historical mining and restoration efforts are underway in these. It will likely take multiple decades for conditions to improve enough for WCF classifications to change. Impairments are at high levels and recovery to important habitat parameters, such as water acidity, can lag behind cleanup activities or become permanent problems.

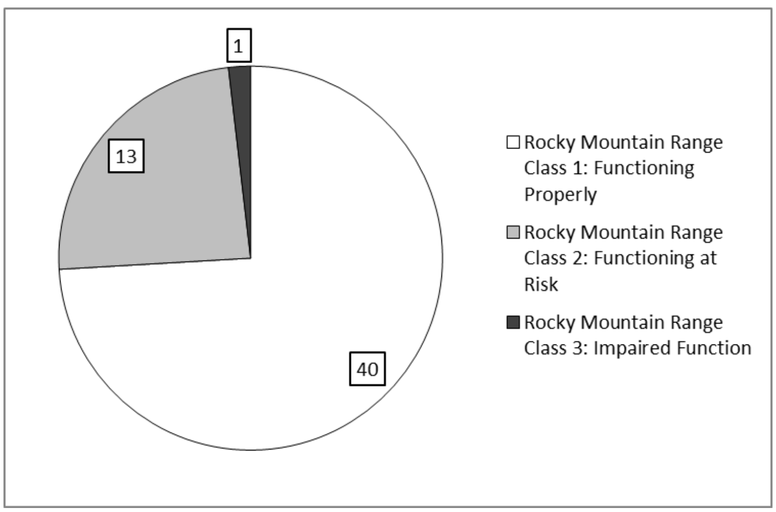
The 21 Class 1 watersheds all contain nonnative fishes in some habitat areas, but low-levels of management related impairments or risks. Many of these are on the western portion of the mountain range. Much of this area has low-to-zero densities of roads and limited-to-no occurrence of livestock grazing. Conservation populations of westslope cutthroat trout exist in many of these watersheds. This is both a factor in allowing for these watersheds to achieve this classification as well as being reflective of the generally high quality habitat in the current condition.

Western pearlshell mussels are modeled or predicted to be present in some watersheds within the Smith River drainage portion of this geographic area. Pearlshells have been found in limited survey efforts of the most likely habitat areas (Stagliano 2011), at two sites in the Smith River drainage where their population viability for the next 25 years was rated as poor (Stagliano 2010). One of these sites is on or immediately adjacent to Forest lands (Stagliano 2010). Much of this predicted habitat area for this species corresponds to road-less and research natural areas (RNA's). There are no apparent impairments which would prevent current occupation or have eliminated this species from this habitat. Western toads are present in this geographic area. Population trends aren't well established, but appear to be stable. Breeding pond areas are limited but present. Fire suppression over the last century is likely the activity most affecting this species within this geographic area. This species is known to increase in numbers after wildfire in forested, montane habitat areas (Guscio et al. 2008). Conditions with higher levels of light penetration and less on-ground impediments to mobility appear to favor western toads.

Rocky Mountain Range Geographic Area

The majority of the watersheds in the Rocky Mountain Range GA are rated as Class 1 (Figure 3.10). The most widespread impact to aquatic habitats in the Rocky Mountain Range Geographic Area is the stocking of nonnative fish. This has eliminated westslope cutthroat trout of conservation-level purity from most of the historically populated stream reaches. The few isolated populations that still persist represent unique genetic diversity from the range east of the continental divide (Leary et al. 1987, Allendorf and Leary 1988). Survey work jointly conducted by the USFS and Montana Fish, Wildlife and Parks recently led to the discovery of a previously unknown remnant population. This is the last known genetically pure population in the entire Sun River drainage. The lack of detection represents a great risk for all unprotected remnant populations since hybridization, replacement, competition, and predation by nonnative trout and char continue to drive local populations closer to extirpation. Areas yet to be surveyed are mostly in vast backcountry areas, where complex logistics require a considerable investment of time and other resources to sample. The highly intact and well-connected condition of this geographic area appears to be more conducive to a more complete upward spread of nonnative fishes than in areas that are more fragmented. Historically, fish were unable to colonize the Sun River above the falls at Diversion Dam located approximately 1.5 miles downstream from Gibson Dam. Although fish are not native to this portion of the Sun River drainage, this area has been stocked with both natives and nonnative fish species and is dominated by nonnative trout.

Figure 3.10 Rocky Mountain Range GA: watershed condition framework – functioning classes



Several other river and large stream networks occur within this geographic area. These include headwater portions of the Two Medicine River, Badger Creek, the Teton River, Deep Creek, and the Dearborn River. Thirty-four conservation populations of westslope cutthroat trout are known to occur in this geographic area. Headwater tributaries of Badger Creek contain five of the eight tested populations with 100 percent genetic purity. There are not any genetically pure populations known in Dearborn River drainages. There is one in each of the Two Medicine River and Teton River systems. Preliminary testing indicates that Deep Creek contains genetically pure fish from west of the continental divide. These are likely the result of an unauthorized transplant from west of the continental divide to an area above a waterfall that is a natural fish barrier.

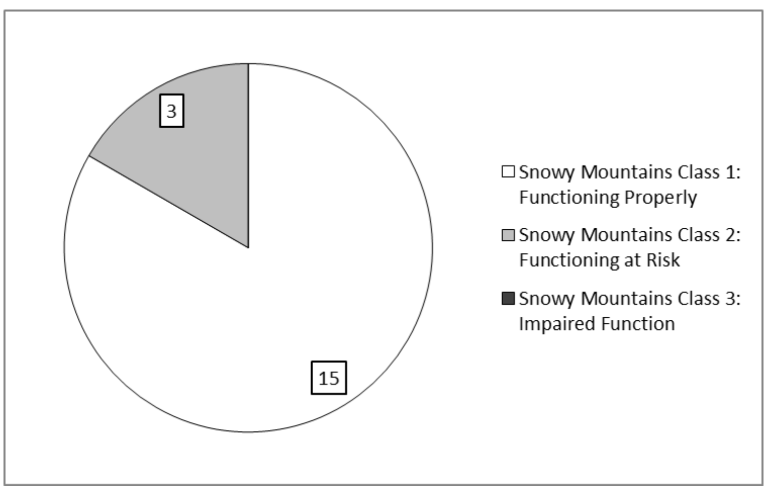
Much of this geographic area is roadless or in designated wilderness so management related impacts are very light. Grazing related impacts occur in allotment areas. These are generally more confined to areas where site-specific features congregate cattle along stream banks than in other geographic areas in the plan area. Cooler summer temperatures, some upland plateaus, confined stream bottoms, and increased downfall in riparian areas appear to encourage cattle to less frequent valley bottom areas. Gibson and Swift are the main reservoirs that occur in the plan area. Several other reservoirs exist as infrastructure for irrigation projects and districts, but are located downstream of forest boundaries. Several forest roads occur outside of the designated wilderness. Although densities are low, some stream segments, including portions of the North and South Forks of the Teton River are encroached upon by the adjacent roads, which have generated substantial inputs of road sediments in the past. These site or segment-specific impacts fall below the sub-watershed scale. Fire and floods have historic and dynamic roles in this geographic area. The scale and intensity of wildfires may have been influenced by previous decades of fire suppression. These include the Canyon Creek and Gates Park fires in 1988, and the Skyland and Ahorn fires in 2007. However, large, stand replacement wildfires are part of this landscape that contains vast areas of lodgepole pine and a windy climate with drought cycles.

A few stream segments were modeled as being predicted habitat areas for western pearlshell mussels (Stagliano 2011). Surveys have been negative in these areas. Bed-load scour regimes were not considered in this model. This is likely limiting to this species in the predicted streams as these run-off related events are more frequent and intense than the species tends to tolerate. Frequent and heavy scouring likely limit western toad breeding in many of the near-channel ponds in this geographic area. Cold water temperatures can also be limiting to fish and other types of aquatic wildlife and have been observed in a limited number of streams in this geographic area. This geographic area is mostly in a properly functioning condition. However, natural conditions are relatively harsh and can create limited resiliency to stressors that exceed historical parameters.

Snowies Geographic Area

This geographic area is comprised of the Big Snowy and Little Snowy Mountain Ranges. There weren’t any Class 3 (impaired) watersheds identified during the WCF rating process. Most were considered Class 2 (functioning at risk) with three rated as Class 1 (functioning properly) (Figure 3.11). Grazing is the most wide-spread management activity that influences aquatic habitat conditions in these mountain ranges. Moderate impact levels are generally present along streams within allotment areas. Road related impacts occur at a very limited scale.

Figure 3.11 Snowies GA: watershed condition framework – functioning classes



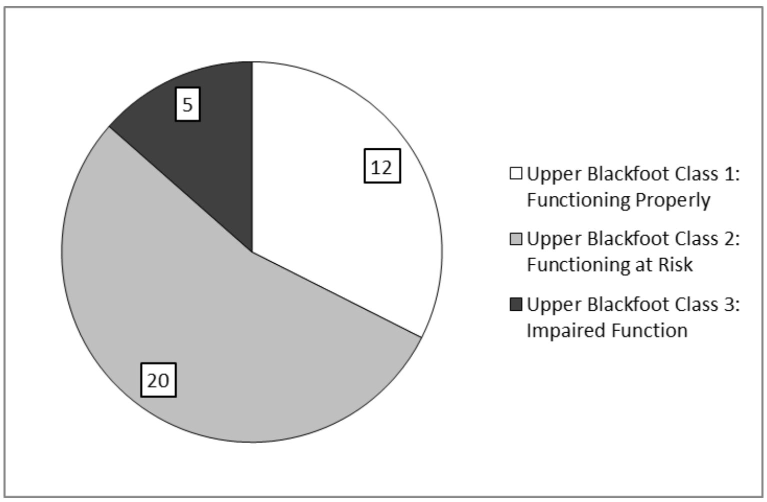
There are no fish species of special concern native to this geographic area. Three westslope cutthroat trout populations occur in the Big Snowy Mountain Range. These are believed through preliminary genetic testing to have originated from undocumented trans-basin transfers. These are outside of recovery plan objective areas and coverage by the interagency memorandum of understanding. Viability is still a management concern with Regional Forester sensitive species status.

Sensitive or amphibian species of special concern have not been found in these two mountain ranges. This area is outside of the range of western toads (Montana Department of Fish, Wildlife and Parks, Natural Heritage Program 2014c). This area is within the range of northern leopard frogs (Montana Department of Fish, Wildlife and Parks, Natural Heritage Program 2014b) but appears to lack the combination of suitable habitat and connectivity to source populations that is necessary for colonization. This geographic area is well away from the species range for western pearlshell mussels. Several introduced populations of nonnative trout are locally popular for recreational fishing. Crystal Lake is a put-and-take fishery as it lacks suitable depth to overwinter fish. Several streams have trout fisheries that are relatively small. However, these provide for the closest access to this type of recreational experience for people living across a vast portion of Northeastern Montana.

Upper Blackfoot Geographic Area

Within the Upper Blackfoot GA, 12 watersheds were rated as functioning properly, 20 were rated as Class 2 (functioning at risk), and five were rated as Class 3 (impaired) (Figure 3.12). The majority of the GA is located west of the continental divide and is habitat for bull trout. Mining impacts are noteworthy in this GA.

Figure 3.12 Upper Blackfoot GA: watershed Condition framework—functioning classes



There have been two bull trout local populations within the Blackfoot River core area on the Helena National Forest – Landers Fork and Poorman Creek, identified by the 2002 Draft Bull Trout recovery Plan and the Conservation Strategy for Bull Trout on NFS lands in Western Montana.

Historically, bull trout populations were well distributed throughout the core area and were likely in much higher densities than they are today. It is thought that up to 1,000 bull trout redds may have been historically present in the Blackfoot River Core Area. As with most bull trout populations, overall numbers were likely highly variable from year to year, based on natural climatic and disturbance patterns. These redd numbers were generated from estimating the potential in each of the 16 major spawning tributaries to the Blackfoot River (Union, Gold, Belmont, Cottonwood, Monture, Chamberlain, North Fork Blackfoot, Nevada, Arrastra, Beaver, Willow, Poorman, Upper Willow, Landers, Alice, and the upper Blackfoot).

Bull trout populations in the Blackfoot River were likely first exposed to mining -caused impacts in the late 1800’s in the form of small scale mining. This mining was focused mainly south of the Blackfoot River in the Lincoln area (eastern Nevada Creek tributaries to Anaconda Cr.) and in the northern Garnet mountain range (Ashby to Chamberlain Creek). The mining method was often an instream “placer” type operation that directly disrupted fish habitat and stream functions. Once disturbed in this fashion, streams rarely have the ability to naturally recover to their predisturbance level.

In the early 1900's small scale ranching and homesteading moved into the Ovando and Helmville area. Substantial impacts to the population were likely related to water rights, water diversions, and overgrazing or clearing of stream riparian areas. Use of surface waters required diversions, which were not usually screened, leading to the entrainment of most age classes of aquatic species. In addition to unscreened diversions, the dewatering of the stream channel diminished or eliminated adequate habitat to maintain aquatic species. Clearing of riparian shrubs and damage to streambanks by over-grazing and other agricultural practices also caused impacts to stream's geomorphology (streams channels becoming wider, shallower, and warmer). Eroding banks introduced high amounts of anthropomorphic sediment into streams which exacerbated stream morphology problems and reduced fish habitat spawning success.

Early in the logging era, log drives down the mainstem of the Blackfoot River and its major tributaries were common. These log drives effectively removed important log jams that created adult bull trout habitat in the mainstem Blackfoot and also impacted pools and spawning habitats in the larger tributaries. In addition, droughts (1930's and 2000's) undoubtedly played a role along with other negative effects by reduced access to spawning areas and increased stress and mortality.

Many of the past impacts have been mitigated, reduced, or eliminated so some stressors on the population no longer play as large of a role as they did historically. For instance, fish barriers have been identified as a major impact; consequently, multiple agencies and partners have focused on removing culverts, upgrading culverts to allow fish passage, removing mainstem dams (Milltown) and removing or modifying additional barriers such as irrigation diversion structures to provide connectivity. In addition, regulation changes no longer allow harvest or intentional fishing for bull trout. Another recent positive attribute within this core populations is the implementation of the Montana Legacy Lands Projects. This project successfully transferred thousands of acres of Plum Creek Timber Company land ownership to that of the Forest Service and Montana Fish Wildlife and Parks, via The Nature Conservancy. This land transfer now allows for large scale restoration efforts in the form of decommissioning roads that are negatively impacting aquatic resources, relocating roads out of valley bottoms, removing and upgrading undersized culverts, and allowing stream side management areas to recover without industrial timber harvest or the threat of subdivision.

Trends and Drivers: Water Resources, Water Quality, and Aquatic Ecosystems

Consideration of system drivers

Habitat quality is the main system driver throughout this plan area for the abundance and viability of aquatic wildlife species. This is being defined for the purpose of this assessment by "the integration of conditions where sediment regimes, thermal regimes, stream width to depth ratios, aquatic habitat complexity, and the species composition and age structure of associated riparian habitat areas, as well as controlling natural processes such as wildfire, climatic regimes and events, competitive balances between species, and flood-flow regimes are within natural parameters". Thus, there are important abiotic, biotic, and ecosystem factors. Abiotic factors would include parameters such as residual pool depths, stream temperatures throughout the year, and concentrations of find sediments in spawning gravels. Biotic factors would include the presence of nonnative species and concentrations/assemblages of forage species. Flood and bankfull flows flush away sediments from higher gradient reaches and habitat areas. This process is important in cleaning and maintaining spawning gravels. These materials are then deposited in lower gradient reaches and along stream margins. This helps to support sediment dependent forage species and is also the primary mechanism for building stream banks.

The concept of these drivers being within the range of natural conditions or parameters is important. Streams form in size and structure to transport and store the natural sediment and water yields that are typical to these specific basins. Native aquatic species are typically matched to these conditions. The exceptions are when environmental conditions are so harsh as to make it difficult to thrive in an area. Native species may persist in these areas but be low and cyclical in density. Chronic increases in water or sediment yields, or catastrophic events that are beyond historical levels, surpass these formative processes and balances. This usually disrupts the dynamic equilibrium, making the area less suitable for native species than were the historic conditions. For example, some fine sediment is necessary for aquatic ecosystem health and function. This sediment not only builds banks and supports riparian vegetation communities, but it also contains some nutrients that would otherwise be almost completely unavailable. Native fish are well suited to persist under natural sediment regimes. Natural high water cycles flush systems in regular enough intervals to prevent fine sediments from increasing to concentrations that would be limiting. Either the chronic increase of sediment yields or the limiting of channel forming flows would disturb this process and the resulting sediment balance. Increasing flood flows and frequencies to levels beyond natural parameters may clean sediments, but could scour away streambanks and more reproductive year-classes than can be compensated for by populations and their inherent life-cycles.

There are other parameters and ecosystem processes that are present in the aquatic habitats within this plan area, but those specifically mentioned in this section are the primary drivers and/or those that show the greatest response to stressors (Al Chockhachy et al. 2010). Beavers are a biotic factor that influence sediment transport from other processes by spatially concentrating the storage of sediment, increasing aquatic habitat complexity, assisting in the building fine-textured banks, and storing water in floodplains and groundwater which increases late-summer flows. When present, these factors normally increase the resiliency of aquatic habitats to environmental stressors and changes. Overwintering habitat can be a critical habitat component that may even control the size of fish populations that a stream can support. Beaver generally add to this by increasing the quantity, depth, and volume of pools. The increase in habitat complexity afforded by beaver activity often allows for more spawning and juvenile rearing habitat. There are situations, however, where beaver activity may be a negative impact on particular fish populations. Summer water temperatures can be increased by the entrainment of water in dam pools. Brook trout appear to have a competitive advantage over westslope cutthroat trout in dam influenced pools (Shepard et al. 1998, Shepard 2004).

Beaver populations have declined across much of this plan area due reductions in woody forage species from livestock grazing impacts, road construction, and access related activities. Fire suppression is also a factor as riparian areas can convert from the cottonwood, poplar, and willow species preferred by beavers towards coniferous tree species under the prolonged absence of fire. This reduction in beaver populations and activities creates an altered system that is less able to absorb or compensate for factors that add stress to aquatic systems. Trapping may also have been a factor in beaver decline along individual streams, but habitat degradation would often need to be addressed before recolonization would occur.

Consideration of system stressors

Nonnative fish

As previously mentioned, nonnative fish species are system stressors that are prominent across the plan area. These affect native fish by interbreeding with them, preying upon them, and dominating desirable habitat areas such as overwintering pools. Nonnative fish species typically benefit from environmental stressors that exceed natural habitat or historical parameters to the detriment of native species. Rainbow trout are more tolerant of increases in summer water temperatures than are westslope cutthroat trout or bull trout. Reduced survivability has been documented for westslope cutthroat trout at 20 degrees Celsius in laboratory studies, with the same response occurring for rainbow trout at 24.3 degrees Celsius (Bear et al. 2007). Bull trout were not involved in this study and citation with a parallel response-point wasn't found. The native range greatly overlaps with westslope cutthroat trout and many studies show, as expected, similar to slightly cooler temperature preferences and requirements (Dunham et al. 2003). The distribution and colonizing success of rainbow trout is positively correlated with temperature in areas where westslope cutthroat trout are native (Muhlfeld et al. 2009a, Muhlfeld et al. 2009b). Brook trout tolerate increased sediment levels (Shepard et al. 1998, Shepard 2004) better than cutthroat trout. Thus, the negative effects of nonnative fish on native species can be expected to amplify with increases in other system stressors. Since nonnative fish are considered the primary factory in the loss of 95% of westslope cutthroat trout populations across this portions of the planning area east of the divide, an increase in the intensity of this effect is of concern. Cumulative effects from diversions, dewatering, and habitat degradations are larger factors in bull trout and cutthroat declines west of the divide. However, nonnative fish are still an important factor in continuing to suppress these already impacted populations.

Aquatic Invasive species

Nonnative invasive species are a serious threat to all aquatic habitats in the United States. The severity of this threat is difficult to assess or predict in this plan area, or in any other specific locality. Virtually every biological lifeform has been a documented agent in disruptive outbreaks in North America. These lifeforms cover the range from viruses to mammals. Included in documented losses to ecologic integrity and beneficial uses are vegetative lifeforms that range from single-cell algae to vascular plants such as nonnative trees.

The ecological and economic impacts of invasions vary greatly in scale. Effects from invasive species also vary with local environmental dynamics and complexity of the ecosystem. Whirling disease *(Myxobolus cerebralis)* appears to have produced major changes in the assemblage of fish species in some Montana rivers but not in others. Where ecological disruptions have been noted, there were lost recreational opportunities and revenues for the tourism, outfitting, and related industries. However, the spread and the intensity of effects have been less pervasive across most of this planning unit, suggesting the conditions to complete the life cycle requiring two hosts have so far proven to be less suitable.

When a new aquatic invasive species invasion occurs in a locality, it often requires research and observation time before reliable inferences can be made regarding spread patterns, specific effects, and potential containment strategies. A baseline often is lacking to predict how an invasive species from another region or continent will respond when introduced into a new environment. Since a local environment contains a unique assemblage of thousands of interconnected components and processes, the results in one area can vary slightly or significantly from previously infected areas.

If an aquatic invasive species becomes established, elimination may be nearly impossible and efforts for containment can be very difficult, time consuming, and expensive. Thus, prevention of invasions is of paramount importance in land and natural resource management. This involves recognizing the vectors for infection and spread and implementing safeguards, or resource protection measures, to minimize and prevent the transmission of invasive organisms through these pathways. An example of a transmission vector would be pumps and other mineral exploration equipment that come into contact with water. This equipment is increasingly used and transported globally between exploration projects. Microbes, spores, planktonic larval and adult stages, and plant materials can easily be spread on this and other equipment. Requiring effective sanitation and inspection measures would be appropriate resource protection measures.

Spread and introduction vectors are inherent to most projects and types of forest use. Thus, components of the Land and Resource Management Plan require mechanisms for addressing aquatic invasive species. More general or universal objectives and procedures, such as using current best practices for equipment washing before and after entering an area, are recommended for inclusion in the fish and aquatic wildlife sections of the document. High risk activities within individual resource areas are likely best addressed in the resource-specific sections. This better assures that these components are included as resource protection measures at the project level. These activities would include, but aren't limited to; transporting water across drainage boundaries for fire suppression, constructing stream fords, operating equipment in a riparian area and near a water course, and the use of pumps and sumps for mineral exploration, fire suppression, or construction related dewatering activities.

Localized Effects from Global Climate Change

Westslope cutthroat trout and bull trout populations are sensitive to increased water temperatures (Bear et al. 2007, Selong et al. 2001, Dunham et al. 2003). The latest science and modeling results for predicting localized climatic changes were reviewed to assess possible changes in summer water temperatures. Outputs from models which accurately back-predict historical temperatures were used in this assessment for analyzing climatic effects on aquatic wildlife populations. It appears that these are relatively consistent in predicting that local, average summer air temperatures are predicted to increase between 2 to 4 degrees Celsius by 2050 (Luce 2011, Barsugli 2009).

The year 2050 was chosen for this analysis for multiple reasons. Complex model runs and local predictions that provide predictions for this time period are available. Carbon dioxide emission is an assumption built into these models which greatly impacts outputs. The accuracy of emission predictions for time periods further out into the future become questionable as technological advances and economic growth trends are important drivers. The typical lifespan of a forest plan is between fifteen and thirty years. This would cover much of the time increment in which management actions could affect conditions in the plan area for the mid-21st century.

Water temperatures in montane stream systems do not respond directly in magnitude to changes in maximum and average air temperatures. For instance, a one degree increase in average air temperature parameters will almost universally result in less than a one degree increase in either average or maximum water temperatures. Buffering influences from factors such as groundwater, and the role of direct solar radiation in heating stream water, prevent this from occurring. In the plan's geographical area, for every degrees Celsius increase in air temperature, a 0.44 degrees Celsius increase in average water temperature is predicted (Isaak et al. 2010, Mohseni and Stefan 1999, Mohseni et al. 2003). This would indicate that under constant catchment basin characteristics, an increase in summer water temperatures ranging from 0.88 to 1.76 degrees Celsius could be expected between now and 2050. This extrapolated prediction is consistent with trends measured in recent decades of approximately 0.24 degrees Celsius per decade (Isaak et al. 2012). Extending this rate out to 2050 would match the low-end of this range without considering or adjusting for rate changes due to emission patterns or other influencing trends. This extrapolated range is also consistent with predictions found in a recently published paper (Isaak and Rieman 2013). This article provides more of an accuracy check than an independent collaboration of the results brought forward in this assessment. Both efforts use similar citations and are primarily based on the same source data and modeling runs.

This assessment recognizes that decade long averages of summer temperatures naturally vary across the North American continent. There is a pattern of warmer and cooler decades. Any future decade could fall at the margins of the historic variation before modeled increases are put into consideration.

One of the climate change related viability concerns for aquatic wildlife populations in this plan area is whether adding the predicted 0.88 to 1.76 degree Celsius increase to current maximum summer temperatures would lead to mortality concerns. The term “mortality concerns” in this context addresses temperature related fish-kill events that could reasonably be expected to occur during prolonged, extreme heat/drought events in the warmer sections of a stream. A fish-kill does not necessarily occur when temperatures exceed the critical thermal maximum for a species. The magnitude, duration, frequency of these events as well as the local microhabitat conditions are important factors. A weather event in which water temperatures slightly exceed a “reduced survivability threshold” for a few-minutes on only one day of the summer would be much less likely to create a fish-kill than a heat/drought event in which temperatures exceed the same threshold by a higher magnitude, across multiple hours each day and persisting over the span of several days.

There are climatic factors in addition to maximum summer water temperatures that affect survival and lifecycle completion for fish and mussel species. Thermal regimes in other seasons can affect the timing of spawning and the success of egg incubation. Earlier snowmelt run-off could increase scour during critical time periods in the lifecycles of trout, char, and mussels (Isaak et al. 2012). Earlier loss of snowpack also leads to lower summer flows which have been correlated within this plan area with decreased densities of westslope cutthroat trout (Moser 2011). Receding summer flows can lead to lower winter flows depending on fall precipitation events and effects of drought cycles on groundwater levels. Low winter flows are a concern as the critical over-wintering habitat is restricted.

Groundwater influence and entry into surface water has been shown to both moderate temperature and be positively correlated with salmonid abundance (Ebersole et al. 2003). Perennial stream reaches in higher-elevation areas that have well-timbered valley bottoms and ground-water entry will be most resilient to warming conditions and changing weather patterns promoting earlier run-off. Lower elevation stream reaches, lacking riparian shade, containing high sediment loads, with impaired width-depth ratios, and losing flows to groundwater will be the least resilient reaches to changing conditions.

Livestock grazing related impacts

This class of impacts often correlates spatially across the plan area with the stream reaches identified in the previous sentence as being least resilient to changing climatic conditions. The primary grazing areas that have low enough precipitation and high enough evaporation rates to support grass communities, instead of coniferous stands, tend to occur in the warmer, lower elevation areas that may also include losing stream reaches. Although the losing flows in these areas tend to be principally geologically controlled, grazing related impairments can also contribute to stream-flow loss. Mechanisms include reductions in shade canopy, disruption of beaver created water storage in flood-plains, and altering width-depth ratios. These same impairment related mechanisms often lead to an increase in water temperatures in the stream. An additional grazing related impairment is increased yields and in-channel storage of fine sediments, which also impact stream channel form and fish habitat. Across the plan area, fine sediments are almost always darker in color than native gravels and larger sized substrates. That combined with the higher width-depth ratio and a reduced shade canopy results in higher solar radiation absorption increasing water temperatures and decreasing food production and the quality of aquatic habitat.

Grazing frequently damages springs and other types of groundwater dependent wetland habitats. These off-channel aquatic features have high biodiversity and serve important ecosystem functions. They are attractive to livestock as they offer palatable browse and flat and cool resting spots. This can lead to water quality issues, damaged organic soils, and reduced wildlife habitat. Impacts to these areas are commonly noticeable earlier in the grazing season than most other types of sites within pastures. The response to this use pattern has often been to fence-off these features when damage has been repeatedly noted. This is effective as long as fences are consistently maintained. Maintenance failure can cause higher levels of damage as cattle tend to remain in longer as they move further away from the point of entry.

The severity of the effects of livestock grazing related impairments on aquatic wildlife populations can be expected to increase under warmer climatic conditions with lower summer flows. Within current conditions, these impairments impact population sizes and recruitment success at levels of occurrence and effect that seem to require consideration in plan revision efforts. These impacts can accelerate the replacement of native species with nonnative populations. However, effects are not limited solely to native trout and char species. Several recreational fisheries are limited by habitat loss and lower recruitment rates. One known leopard frog population is in a habitat area where the lack of browse species necessary to retain beavers is causing pond areas to recede.

The scale of livestock effects in this planning area is difficult to quantitatively assess. Habitat quality monitoring methodologies, such as PFC assessments, have been conducted where greatest needs have been identified. This helps to address site-specific issues, but it would greatly bias any effort to expand trends upward in geographic extent.

Chronic sediment inputs from roads and other infrastructure related activities

Most of the more serious impacts to aquatic wildlife from road-stream interactions, including those affecting species of special concern and listed species, are or have been addressed with mitigation steps such as relocating road segments. One notable exception is the road that often fords across the Middle Fork of the Judith River. This is on the Lewis and Clark National Forest within the Little Belt Mountains. The scale of chronic sediment delivery from the road system is discussed further in the "Identifying the Need for Change" section of this assessment. Most of this effect can be mitigated by bringing and keeping road segments into adherence with Best Management Practice (BMP) standards. Additionally, culverts or bridges that provide for aquatic organism passage are still being planned for replacement in some areas where native species would benefit. Recent inventory efforts have found road segments needing additional drainage features, such as rolling dips and lead-outs, to more-fully meet BMP standards. More frequent maintenance is also necessary in some areas as this addresses rutting and other conditions that increase sediment yields.

Legacy mining effects

Legacy mining effects are more limited in spatial distribution than the other effects analyzed in this assessment, but they tend to be the very highest in severity in the areas where they occur. High levels of physical habitat impairments such as a complete, mechanical deconstruction of natural stream channels and valley-bottom structure are present. Extreme chemical changes impairing water quality are also present. These effects range from completely removing all invertebrate and vertebrate life-forms or reducing the population levels to forming a chemical barrier that protects native fishes in upper portions of a watershed. Remediation and restoration is always desirable, but mitigation efforts have to consider how to prevent mobilizing toxic sediments or allowing for nonnative species to invade the area inhabited by native species, resulting in hybridization, competition and/or replacement.

Trends and reasonably foreseeable future conditions

The trends for the viability of individual populations of species of concern are mixed. Several populations of westslope cutthroat trout are at imminent risk of hybridization and/or extirpation through predation or replacement by nonnative species. These tend to be in stream reaches where protective mechanisms such as constructed barriers or removal of nonnative species aren't feasible. Replication efforts are underway to reduce risk, but these efforts do not completely remove risk as hybridization can occur and be detected before suitable locations are found and prepared to be more secure. Very small populations may not contain adequate population numbers or genetic variation for relocation to be successful. The reaches found for replication may also not be long enough reaches to provide long-term persistence of the duplicated population. Other populations have been secured with efforts such as barrier construction and nonnative fish suppression. Since recovery efforts started, the number of known westslope cutthroat trout populations has remained constant; populations added through recovery projects have roughly equaled those lost in areas where greater protection wasn't feasible. Populations are mostly small isolates with meta-population sized objectives, as outlined in the recovery plan, yet to be achieved. Efforts underway in the Dry Fork of Belt Creek will create over 20 miles of connected habitat over the next three to five years and move towards partial achievement of meta-population objectives. This opportunity exists because several somewhat rare basin characteristics combine to allow for a probability of success that isn't readily available in other locations.

Bull trout express two life histories within this plan area. Resident populations in tributaries are mostly known to be displaying stable trends based on monitoring survey efforts. There are long-term concerns with smaller, isolated populations as habitat patch-size is known to be a determining factor in viability under stable and disturbance conditions including wildfire and climatic change (Eby et al. 2014, Reiman et al. 2007). Bull trout express a fluvial life history in the Blackfoot River and historically in the Little Blackfoot River drainages. The US Fish and Wildlife service now considers the fluvial life-form to be extirpated from the Little Blackfoot River. Surveys conducted by MTFWP personnel have been negative for occurrence. Personnel from the HNF located a few fluvial-sized fish in tributaries about ten years ago and observed one angler catch more recently. The most recent genetic test of remnant fluvial-sized fish documented hybridization (Harper 2014). Additional sampling is planned in the Little Blackfoot to determine if any bull trout persist in the drainage utilizing a new technique involving environmental DNA.

The viability of the fluvial life-history form of bull trout in the upper Blackfoot River basin, which correlates well with the boundaries of the HNF, is believed to be at low risk under current and forecasted climatic change conditions (Young 2014). The same survey and assessment efforts put the viability of fluvial populations at high risk lower in the Blackfoot River drainage. Tributaries on the HNF are known to contribute fluvial fish to lower portions of the Blackfoot River.

Information Needs

Aquatic ecosystems are extremely complex. They contain a large number of known and also many unknown living and non-living factors. These interact with each other in ways that produce both predictable and unpredictable outcomes. There is recognition within this assessment effort of gaps in available information on aquatic ecosystem components and functioning. These gaps include; population level and trend data for many individual streams, existing condition and trend data for habitat parameters on many individual streams, and monitoring data for quantifying the effects of various management activities on some individual streams or stream-reaches. Pool depths, bank angles, fine sediment concentrations, and the health and regeneration status of streamside woody vegetation are common parameters that both show response to management effects and determine habitat quality. The availability and completeness of data tends to be better on streams or wetland areas containing sensitive or threatened aquatic species.

Even with attempts to use the best available science, the methodology and understanding available has limitations in using current and additional information to predict aquatic ecosystem responses to natural and management related events. The gaps in available information may lessen over time as new information and analysis methodologies to add value to having additional data become available. The complexity of aquatic habitats and ecosystem processes also means that descriptions of existing conditions and management related issues are simplified by necessity. There is continual effort to collect new information and to improve analysis methodologies. Any near-term advances in these areas will be evaluated for potential use in later phases of the revision effort.

Soil

Introduction

Soil provides many ecosystem services on which other life forms (including humans) depend. Soil yields supporting ecosystem services by providing a substrate and nutrients from plants. Soil provides regulating ecosystem services through thermoregulation, nutrient cycling, and water purification and storage. Soil contributes to provisioning ecosystem services by providing wildlife habitat, plant-growth media, and fill (construction). Especially important to humans are the cultural ecosystems services that soil provides to society.

Existing Information

For the soil resources, the best available science was used to inform the assessment. Information regarding management and condition of the soil resource within the plan area includes the following:

- Soil Survey of Helena NF Area, Montana (USDA Forest Service & NRCS 2001)
- Soil Survey of the Lewis and Clark NF Area, Montana (USDA Forest Service & NRCS, 2014)
- Soil Resource Inventory, Lewis & Clark National Forest (Holdorf 1981)
- Land System Inventory of the Bob Marshall Wilderness (USDA FS 1980)

The Helena NF Soil Survey is complete and has been correlated and entered into the National Soil Information System (NASIS), however the Lewis & Clark Soil Survey has not been completed, but it is expected to be complete in the next several months. In addition, correlation is needed between the Helena and Lewis & Clark Soil Surveys so that they can be used together for the plan area.

Existing Condition

The diverse and productive soils of the Helena and Lewis & Clark National Forest are described, characterized, and classified in the Soil Survey of Helena National Forest Area, Montana and Soil Survey of Lewis and Clark Forest Area, Montana, respectively. Soil formation is a function of the climate, organic material, relief, parent material, and time as developed by Han's Jenny (1941).

Soil is a natural, three-dimensional body on the earth's surface. Soil has properties that result from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over a period of time. Although there are many different soils, each soil is the result of the interaction of the same five factors. These factors are the effect of climate on the parent material, the kinds of plants and organisms living in the soil, the relief of the land, the physical and chemical composition of the parent material, and the length of time it took for the soil to form. Within short distances, the combination of these factors varies, and, consequently, the soils that form differ in fertility, productivity, and physical and chemical characteristics.

The WCF has one indicator for soils, which is comprised of three attributes that were rated across the plan area by watershed. These are soil productivity, soil erosion, and soil contamination. The results are summarized by GA in Table 3.6. The Rocky Mountain Range GA has the most watersheds rated 3 (impaired) for soil productivity and erosion, primarily due to natural characteristics of the soil, and the Divide and Little Belts had the most watersheds rated 3 (impaired) for soil contamination, primarily due to mining impacts.

Table 3.6 WCF soils attribute ratings: number of watersheds by geographic area

Geographic Area	Soil Productivity			Soil Erosion			Soil Contamination		
	1	2	3	1	2	3	1	2	3
Big Belts		45		11	34		31	12	2
Castles	10	2		10	2		7		5
Crazies	8	2		9	1		6	4	
Divide	1	27		8	19	1	12	6	10
Elkhorns	3	18		8	13		8	9	4
Highwoods	5	2		6	1		5	2	
Little Belts	42	17	5	47	13	4	27	11	26
Rocky Mountain Range	23	10	21	23	8	23	53	1	
Snowies	18			17	1		10	4	4
Upper Blackfoot	9	28		24	13		23	11	3
Totals:	119	151	26	163	105	28	182	60	54

Once the soils surveys are completed, the following maps will be produced as part of the planning process.

- Post fire erosion hazard (k-factor)
- Mollic soils
- Available water
- Lithic contact

These maps will be useful to developing management objectives and plan components for fuels management, silvicultural objectives, range management, and identifying the inherent capacity of a site to support desired wildlife habitat. Soil carbon will also be assessed.

Hydric Soils

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile (59 Federal Register 35680, 7/13/94). These soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation. Hydric soils occur across the landscape in areas along stream channels, on floodplains, and in isolated springs and seeps. Hydric soils are a primary indicator of wetlands and are used in the assessment of Forest Service compliance with Executive Orders 11988 and 11990, directives relative to the management and disposition of floodplains and wetlands.

Sensitive Soils

Certain attributes associated with soils on forest make them sensitive or susceptible to management caused impairment of soil quality and productivity. Sensitive soil properties on the forest are the organic surface horizons, mass wasting events, and thin-lithic soils.

Land use practices, such as grazing, logging, and mining, have been occurring on the Helena and Lewis & Clark NFs since their inception. Activity impacts are evident on the soil landscape today. Dynamic soil characteristics may be indicators of impaired productivity. Compaction may restrict plant rooting, may lower water-holding capacity and may decrease infiltration. Loss of surface soil through displacement and mixing may decrease soil productivity. Displacement occurs during temporary road construction, excavation of skid trails and landings, and displacement of soils during ground-based harvest. Areas with ground disturbance may become more favorable for weed invasion, which can reduce overall soil productivity.

The soil organic layer is extremely important to all soils on the forest. Soil organic matter is fundamentally important to sustaining long-term soil productivity and is influenced by fire, harvest activities, and decomposition and accumulation rates. The organic component of soil is a large reserve of nutrients and carbon and is the primary site for microbial activity. Forest soil organic matter influences many critical ecosystem processes, including the formation of soil structure. Soil organic matter is also the primary location for nutrient recycling and humus formation, which enhances nutrient and water storage and overall fertility. Soil organic matter depends on inputs of biomass (e.g., vegetative litter, fine woody debris) to build and maintain the surface soil horizons, support soil biota, enhance water-holding capacity, and prevent surface erosion. A review of the soil data and interpretations from the NRCS Web Soil Survey shows that a majority of the plan area has soils sensitive to erosion should the surface organic layer be removed.

Woody debris in the form of slash can provide a practical and effective mitigation for reducing harvest impacts on soil physical function and processes. Some controversy has emerged in recent years over the role of coarse woody debris in maintaining long-term soil productivity. The controversy involves the fact that coarse wood contains very little in the way of nutrients. Regardless, recent research still recommends leaving enough of this material on the ground after treatment to encourage biodiversity and ecological function (e.g., microbial action, mushroom production) (Page-Dumroese et al. 2010).

Soils formed from granitics comprise another group of sensitive soils on the forests. These soils are typically noncohesive and coarse textured and are susceptible to erosion and mass wasting. These soils are droughty with low water and nutrient holding capacities; therefore, keeping the thin surface organic layer intact is extremely important.

Soils with an ash cap are another group of sensitive soils on the Helena NF (approximately 220,000 acres (7%), which are spread across the Upper Blackfoot, Divide, Elkhorn, and the central section of the Big Belts GAs of the Helena NF). These soils are characterized by a low bulk density, high water holding capacity, and high cation exchange capacity that can lead to a concentration of nutrients. Ash caps are extremely susceptible to decreased soil quality due to compaction, erosion, and soil mixing. Ashy soils do not recover from compaction as quickly as other soil types. Since volcanic ash is not replaced, the effects of erosional losses of the ash cap would be permanent.

Mollic soils are another group of sensitive soils in the plan area. These are dark black soils with a large amount of organic matter (not wetlands). They are very productive for growing grass and are soils that should support primary grazing. These soils don't develop under conifer stands, but they possibly could under aspen. Areas with these soil types will be overlaid on a map with vegetation, and anything that shows as transitory grazing will become priority lands to be restored to primary grazing. These soils will also be used as an indicator in areas that have conifer encroachment, but that should be restored to meadow or rangeland. This is thought to be occurring over 10s of thousands of acres across the plan area. This analysis will be undertaken when the soil maps are completed.

The final group of sensitive soils is the fine-textured, shallow soils (defined as soils less than 20 inches deep). These soils are sensitive because they are susceptible to erosion and detrimental effects from management actions. They are generally weakly developed, have relatively little organic matter, and therefore have low nutrient levels. Any soil displacement or loss can greatly affect their productivity because there is little nutrient-rich soil left when even a small amount is removed. Further, when soil is shallow, runoff can infiltrate to the bedrock layer and run along that layer, carrying the overlying shallow soil with it.

Current Forest Plan Direction

Originally adopted in 1986, the Helena and Lewis & Clark Land Resource Management Plans (LRMP) are the primary documents that establish management standards and guidelines governing activities on NFS lands within the boundaries of the Helena and Lewis & Clark NFs. The forest plans provide a variety of management direction related to the soil resource. Much of this direction is based on the NFMA and Forest Service policy (manual and handbook direction). The LRMP directs the forest to ensure all resource management activities will maintain soil productivity and minimize erosion and design or modify all management practices as necessary to protect land productivity.

The National Forest Management Act states that management activities on National Forest System lands will not produce substantial and permanent impairment of productivity. The agency assures that productivity is maintained by establishing soil quality standards. Since 1999, physical soil disturbance has been the focus of soil management on NFS lands. FSM Chapter 2550 Region 1 Soil Management Supplement provides a benchmark that indicates when changes in soil properties and conditions may result in a notable change or impairment of soil quality. Not all soil disturbance results in substantial or permanent impairment of productivity. The R1 FSM defines levels of soil disturbance (compaction, displacement, rutting, severe burning, surface erosion, loss of surface organic matter, and soil mass movement) that are considered detrimental (of a great enough magnitude to potentially cause substantial impairment). Because soil disturbance recovers toward natural conditions either naturally or through restoration activities, no more than 15% of an activity area may have detrimental soil disturbance. This low level of detrimental soil disturbance allows recovery to occur between management activities.

In 2010, FSM Chapter 2550 Soil Management was revised at the national level. The emphasis of soil management was changed to include long-term soil quality and ecological function. The FSM defines six soil functions: soil biology, soil hydrology, nutrient cycling, carbon storage, soil stability and support, and filtering and buffering. The objectives of the national direction on NFS lands are 1) to maintain or restore soil quality, and 2) to manage resource uses and soil resources to sustain ecological processes and function so that desired ecosystem services are provided in perpetuity.

Trends and Drivers

Ability of Soil to Maintain Ecological Functions

FSM Chapter 2550 Soil Management identifies six soil functions: soil biology, soil hydrology, nutrient cycling, carbon storage, soil stability and support, and filtering and buffering. Soil is the foundation of the ecosystem; in order to provide multiple uses and ecosystem services in perpetuity, these 6 soil functions need to be active.

Soil biology is the presence of roots, fungi, and microorganisms in the upper sections of the soil. Diversity of soil biology is beneficial for several reasons:

- The complex process of decomposition and nutrient cycling requires a varied set of microorganisms.
- An intricate group of soil organisms can compete with disease-causing organisms and prevent a problem-causing species from becoming dominant.
- Several organisms are involved in creating and maintaining the soil structure important to water dynamics in soil.
- Most soil organisms cannot grow outside of soil, so it is necessary to preserve healthy and diverse soil ecosystems to preserve beneficial microorganisms.

The soil biology attributes of note on the Forests are roots and aeration, plant community potential, and thermodynamics. Little information currently exists on the trends of soil biology. It is likely that severe or frequent burns (natural or prescribed) reduce the diversity of the soil biota by reducing the soil organic matter required to support the biota. Similarly, erosion may reduce soil biota diversity. Climate change will likely change the soil biota due to increased accumulation and decomposition of organic matter and changes in soil temperature and moisture. The climate change effects are site specific. Invasive species cover may also reduce soil biota diversity.

Soil hydrology is the ability of the soil to absorb, store, and transmit water both vertically and horizontally. Soil hydrology is extremely important on the Forests because the ecosystem productivity is typically limited by water. Soil can regulate the drainage, flow, and storage of water and solutes, including nitrogen, phosphorus, pesticides and other nutrients and compounds dissolved in water. When properly functioning, soil partitions water for groundwater recharge and use by plants and animals. Changes in soil bulk density, soil chemistry, soil structure, soil pores, and ground cover can alter soil hydrology. The main impacts to soil hydrology on the Forests are compaction, erosion, loss of vegetation cover, and hydrophobicity from severe burns. Interception by roads also affects soil hydrology. The historic soil impacts from past activities have affected soil hydrology especially in areas where road densities are high.

Nutrient cycling is the movement and exchange of organic and inorganic matter back into the production of living matter. Soil stores, moderates the release of, and cycles nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant available forms, held in the soil, or even lost to the atmosphere or water bodies. Soil is the major ‘switching yard’ for the global cycles or carbon, water, and nutrients. Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled through the soil. Decomposition by soil organisms is at the center of the transformation and cycling of nutrients through the environment. Decomposition liberates carbon and nutrients from the complex material making up life forms and puts them back into biological circulation so they are available to plants and other organisms. Decomposition also degrades compounds in soil that would be pollutants if they entered ground or surface water. Nutrient cycling can be assessed by considering organic matter composition on a site and the nutrient availability. The major impacts to nutrient cycling are compaction and loss of organic matter and topsoil.

Nearly all nitrogen (N) in forest systems is bound to organic matter. Very little of the total pool of N is available to plants; only about 2.5percent of total organic N is released annually (Grigal and Vance 2000). The rate of N release from organic matter (a process called mineralization) is controlled by microbial decomposition, which in turn is controlled by environmental factors as well as the amount and chemical composition of organic matter (Drury et al. 1991, Grigal and Vance 2000). Rates of mineralization are highly spatially variable within stands (Campbell and Gower 2000). The availability of N from organic matter has been said to 'most often limit the productivity of temperate forests' (Hasseett and Zak 2005). Logging residues are a source of N during early periods of stand growth after harvest (Malkonen 1976, Hyvonen et al 2000). Dead woody material left after logging provides carbon-rich material for microbes to feed upon; and typically microbial populations increase after forest harvests due to the input of logging residues. When logging residue is removed for fuels management and/or site prep microbial populations may decrease.

Carbon storage is the ability of the soil to store carbon. The carbon cycle illustrates the role of soil in cycling nutrients through the environment. More carbon is stored in soil than in the atmosphere and above-ground biomass combined. Compaction and loss of organic matter and topsoil can be assumed to affect carbon storage.

Existing Impairments and Disturbances

Land-use forest practices have affected soil functions, and these functions are intertwined, making it difficult to discuss them separately. Management action such as timber activities, road management, fuels management, recreation, and grazing can all have effects such as compaction, erosion, and loss of organic matter, and can impair the majority of soil functions. While these effects have not been eliminated in current practices, the Forest Service has decreased these types of effects substantially. This reduction of effects, coupled with soil restoration activities, should result in a sustainable or possibly even increased capacity of the soils to support multiple uses and ecosystem services.

The relationship between soil and anthropogenic climate change is twofold. First, anthropogenic climate change may affect the soil resource. Second, soil has the ability to either store or release greenhouse gases; thereby, potentially influencing climate change.

The potential impacts of anthropogenic climate change on the forest soil resource are not well known at this time. Warmer, wetter winters may result in large areas of reduced trafficability for winter harvest operations; a common soil protection practice on the HLC NFs. Increased frequency and severity of summer droughts could threaten effective vegetation cover through increased wildfire, and pathogen and insect activity. Literature suggests that opportunities may exist to manage the soil carbon pool (Harmon and Marks 2002, Johnson and Curtis 2001, Yanni et al. 2003). However, predicted soil carbon response to anthropogenic climate change is extremely uncertain at this time (Friedlingstein et al. 2006, Todd-Brown et al. 2013).

More carbon is stored in soil than in the atmosphere and above-ground biomass combined (Yanni et al. 2003). Soil carbon is in the form of organic compounds created through photosynthesis in which plants convert atmospheric carbon dioxide (CO_2) into organic carbon compounds. The organic compounds enter the soil system when plants and animals die. Immediately, soil organisms begin consuming the organic matter, releasing water, heat, and CO_2 back to the atmosphere. Thus, if no new plant residue is added to the soil, soil organic matter will gradually disappear. If plant residue is added to the soil at a faster rate than soil organisms convert it to CO_2, carbon will gradually be removed from the atmosphere and stored (sequestered) in the soil. Some forms of soil carbon are very stable and will persist for long periods. It is unknown at this time as to how forest practices affect soil carbon storage. Research is looking into these questions.

Information Needs

Soil carbon effects from management activities are not well known at this time and most carbon sequestration modeling research assumes soil carbon is static. The assumption that soil carbon is static has been proven untrue (Jandle et al. 2007; Lal 2005; Nave et al. 2010; Talbot and Treseder 2011). Research is ongoing.

Climate change effects on soil temperature and moisture regimes and soil biology are unknown at this time. Research into the potential likely changes would be beneficial.

The following analysis needs have been identified:

- Identify important attributes or characteristics of soils and sites that make them susceptible to loss of integrity resulting from specific uses, disturbances or environmental change.
- Identify existing impairments, such as critical loads, acidification, or invasive species impacts.

Air Quality

Introduction

Clean air is an important environmental benefit provided by forests. Clean air is necessary for all life on Earth, and air pollution has been associated with a range of adverse health and environmental effects. Trees absorb and sequester air pollutants such as carbon dioxide (CO_2) through photosynthesis and produce oxygen for people and animals to breathe. Trees also play an important role in capturing air pollutants deemed hazardous to human health: ground-level ozone (O_3), particulate matter (PM), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) as documented by Nowak et al. (2014). The pollutants come from dust, pollen, smoke, ash, motor vehicles, and industrial sources such as power plants.

The Environmental Protection Agency (EPA) establishes national ambient air quality standards and the Montana Department of Environmental Quality (MT DEQ) manages these standards within the state of Montana. MT DEQ, along with select counties, monitors for air pollution and provides reports summarizing air quality data.

Existing information

For the air resources, the best available science was used to inform the assessment. Numerous federal laws directly relate to air quality within the plan area:

- Clean Air Act (1963, 1970, 1977, 1990)
- Wilderness Act (1964)
- National Environmental Policy Act (1969, 1975, 1982)
- National Forest Management Act (1976)

The EPA sets standards for air pollutants as directed by the Clean Air Act. These standards are established to protect human health and the environment from air pollution; it is believed that exposure to pollutants at levels below these thresholds will not have detrimental effects. The National Ambient Air Quality Standards (NAAQS) established by the EPA focus on six criteria pollutants including: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM) including both PM_{10} and $PM_{2.5}$ as defined by the aerodynamic diameter of the particulate in microns.

In Montana, air quality is regulated in part by the Clean Air Act of Montana (MT DEQ 2009). MT DEQ has an EPA-approved State Implementation Plan (SIP) that defines how the state will attain and maintain the NAAQS. Protection of air quality standards forms the basis of the SIP. In some instances, MT DEQ has developed air quality control plans (also known as SIPs) that are specific to individual air quality standards for a given area. These control plans provide a framework, in part, summarizing how forest management activities may occur while staying within the established air quality standards. These control plans also explain and outline more site-specific concerns, such as cumulative effects and impacts to local entities and how all effects will be taken into account to comply with regulations and laws. Table 3.7 lists the active air quality monitoring sites within the plan area.

Table 3.7 Monitoring sites for principal air pollutants

Principal Air Pollutant		Location	Available Data
Ozone (O_3)		Lewistown Sieben Flats	2012-2014 2011-2014
Carbon monoxide (CO)		Sieben Flats	2011-2014
Nitrogen dioxide (NO_2)		Lewistown	2012-2014
Sulfur dioxide (SO_2)		Sieben Flats	2011-2014
Lead (Pb)		-	-
Particulate matter (PM)	PM_{10}	Lewistown	2012-2014
	$PM_{2.5}$	Lewistown Sieben Flats Rossiter Pump House	2012-2014 2011-2014 2009-2014

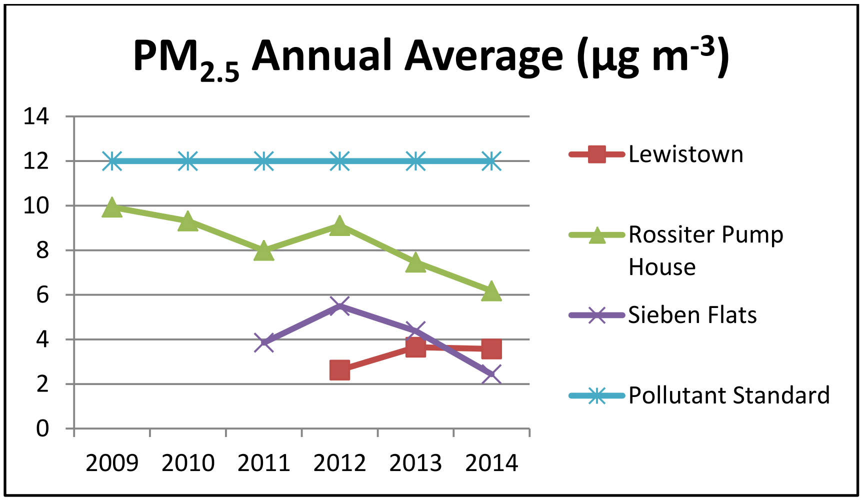
There are other documents that guide specific actions in the plan area:

- Montana/Idaho Airshed Group Operations Guide (Montana/Idaho Airshed Group 2010)
- Helena NF Fire Management Plan (HNF FMP 2014)
- Lewis and Clark NF Fire Management Plan (LCF FMP 2014)

Existing condition

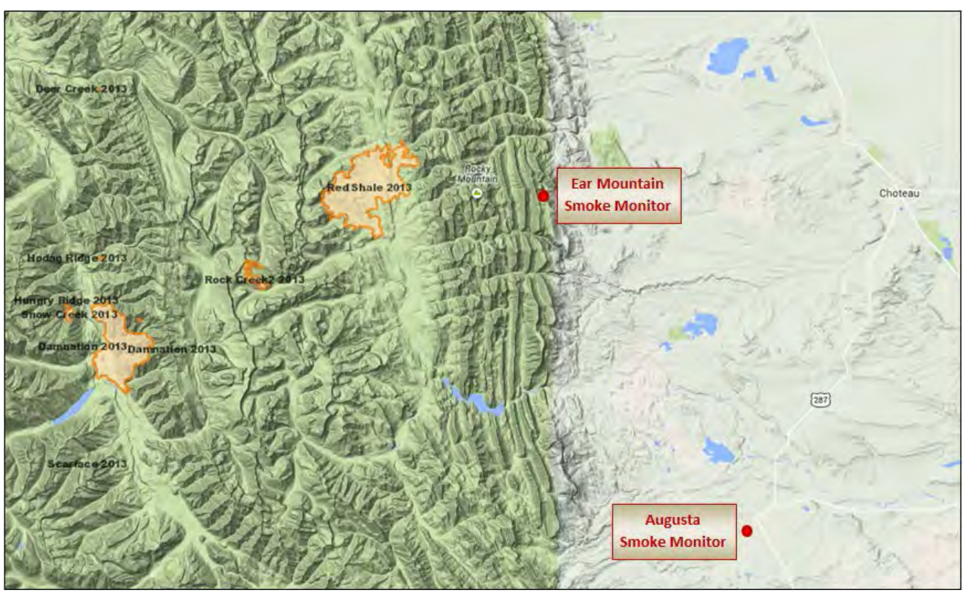
The HLC NFs typically have good air quality across the entire plan area. Annual data from the air quality monitoring sites listed in Table 3.7 were evaluated for all available years. Average values for each measured air pollutant remained below applicable NAAQS standards, although the Rossiter Pump House consistently measured short-term spikes of $PM_{2.5}$ that did not tend to occur at Lewistown or Sieben Flats (Figure 3.13). The major sources of $PM_{2.5}$ emissions in the plan area include: 1) fires (including wildfires, prescribed fires, and agricultural field burning), 2) dust (road dust and construction dust), and 3) agriculture (crop and livestock dust). Fires tend to contribute a higher proportion of total $PM_{2.5}$ emissions in the western part of the plan area while agriculture contributes a higher proportion in the eastern part of the plan area (EPA Air Emission Sources 2014). Fires also release other pollutants such as CO, CH_4, NO_x, volatile organic compounds, and SO_2 (Urbanski 2014).

Figure 3.13 Annual average values for $PM_{2.5}$ in the plan area



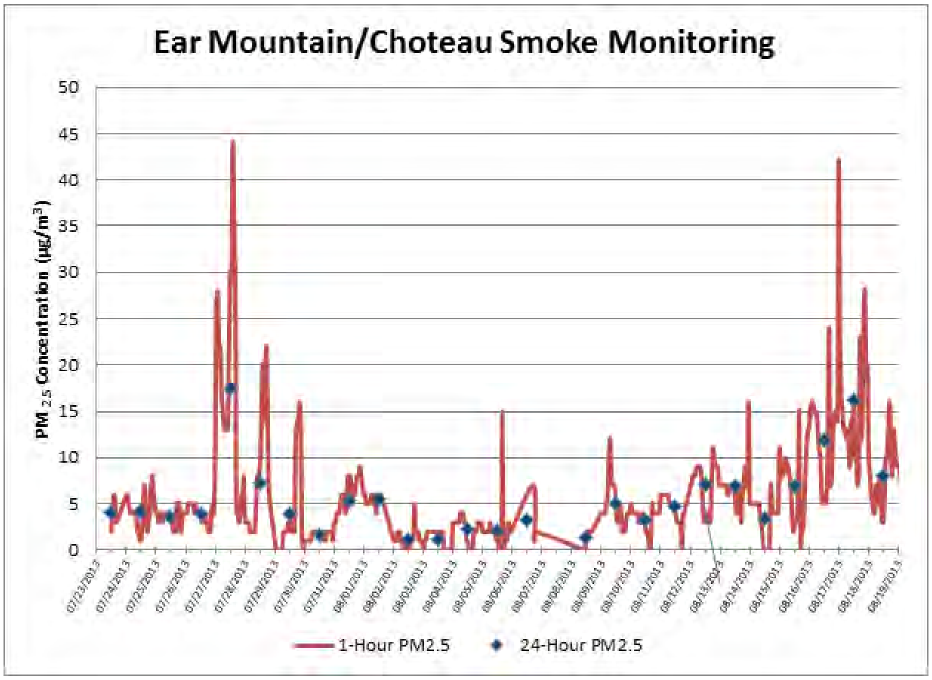
In July of 2013, a strategy was approved by the Northern Rockies Coordinating Group to deploy smoke particulate monitors in strategic locations to provide MT DEQ with real-time data to inform the public about emissions from wildfires. Smoke from the Red Shale Fire in the Bob Marshall Wilderness as well as other active wildfires were tracked by smoke particulate monitors placed at Ear Mountain and the Augusta Work Center (Figure 3.14). The Red Shale Fire burned approximately 12,379 acres over a two month period in 2013 and was managed for point/zone protection, meaning that suppression actions were directed towards protecting identified values rather than containing the entire fire perimeter. The Red Shale Fire burned almost entirely within the footprint of the Gates Park Fire of 1988; dominant fuels included large, downed logs and lodgepole pine regeneration. Other wildfires in the area included the Rock Creek Fire on the LCF that started on August 20 and burned approximately 600 acres and the Damnation Fire on the Flathead NF that started on August 11 and burned about 8,246 acres.

Figure 3.14 Location of wildfires in the Bob Marshall Wilderness in the summer of 2013 and temporary smoke particulate monitor sites



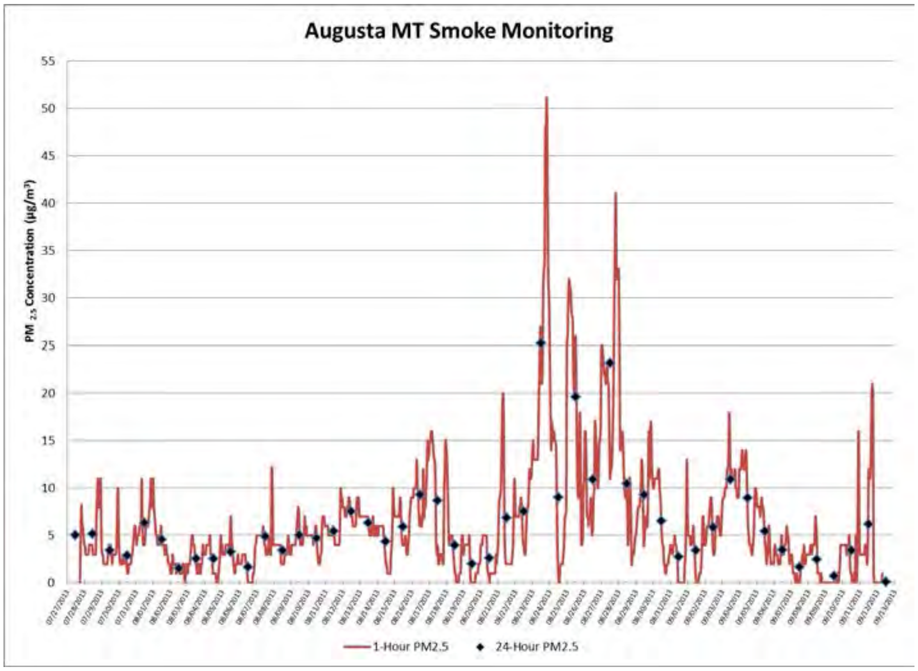
The smoke particulate monitor at Ear Mountain collected data from July 23 through August 21 of 2013 (Figure 3.15). Hourly concentrations of $PM_{2.5}$ were typically less than 10 µg m^{-3} with a maximum value of 44 µg m^{-3} on July 27 (Dzomba 2013). The highest 24-hr average concentration for $PM_{2.5}$ was 17 µg m^{-3}, which also occurred on July 27 (Dzomba 2013). There was substantial growth on the Red Shale Fire during this time, as the fire area grew from 2,351 acres on July 23 to 7,618 acres on July 28.

Figure 3.15 Hourly and 24-hr average values of $PM_{2.5}$ at Ear Mountain in 2013



The smoke monitor at the Augusta Work Center collected data from July 27 until September 12, when rain was received throughout the active fire area that diminished fire activity (Figure 3.16). Hourly concentrations of $PM_{2.5}$ typically remained below 15 µg m^{-3}, except for the period from August 23 through August 29 when hourly concentrations frequently exceeded 15 µg m^{-3} with a maximum of 51 µg m^{-3} on August 23 (Dzomba 2013). Average 24-hr concentrations of $PM_{2.5}$ were typically below 10 µg m^{-3} but reached 25 µg m^{-3} on August 23 (Dzomba 2013). Based on concentrations displayed in Figures 3.15 and 3.16, 24-hr average concentrations of $PM_{2.5}$ did not exceed the NAAQS standard of 35 µ g^{-3} at either smoke particulate monitor location.

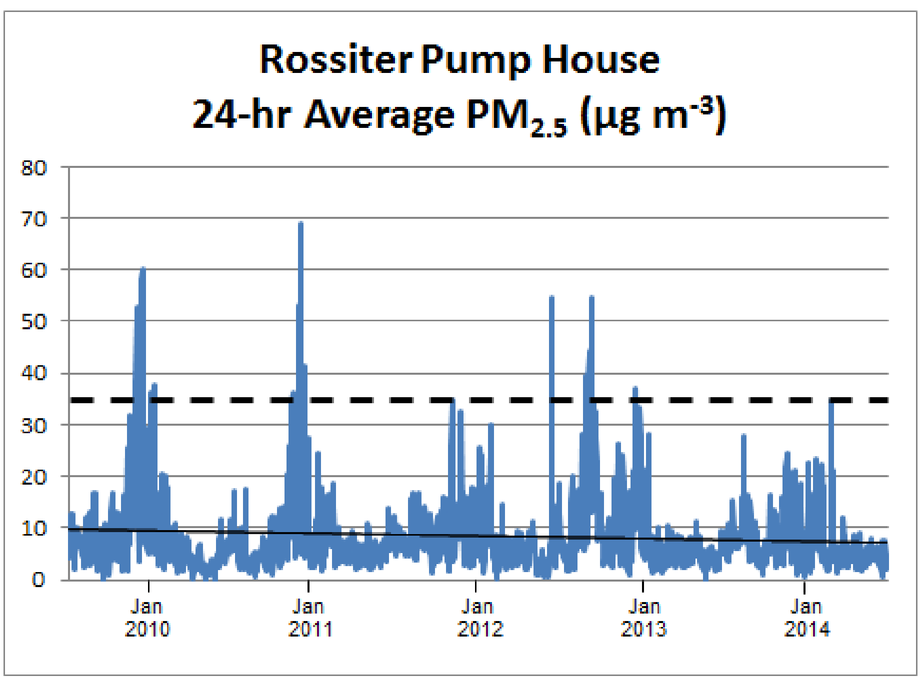
Figure 3.16 Hourly and 24-hr average values of $PM_{2.5}$ at the Augusta Work Center in 2013



The highest average daily values for $PM_{2.5}$ typically occur during the winter months at the Rossiter Pump House in the Helena valley although there were also spikes in the summer of 2012, most likely due to numerous wildfires in the area (Figure 3.17). There are numerous sources in the Helena valley that contribute to levels of $PM_{2.5}$ throughout the year, but the wintertime spikes are likely due to inversions that trap pollutants such as dust and residential wood smoke.

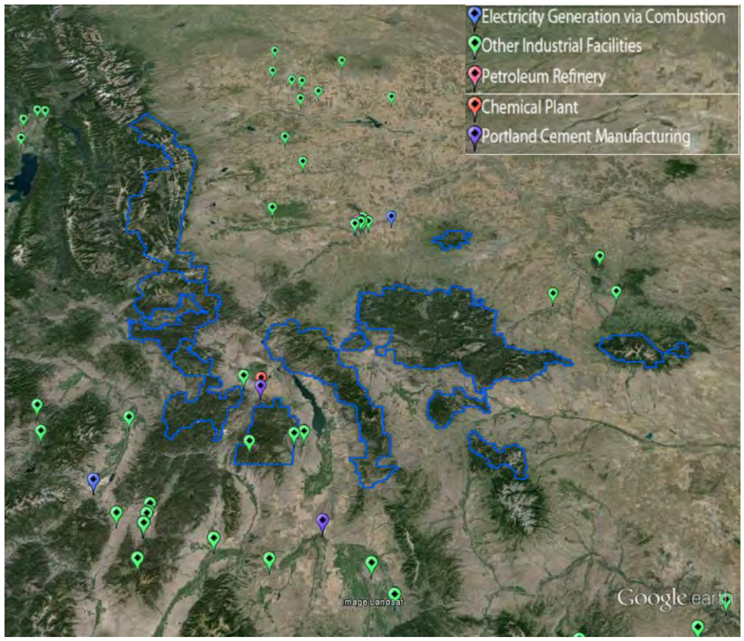
Figure 3.17 Daily average values for $PM_{2.5}$ at the Rossiter pump house in the Helena valley.

The solid line displays the arithmetic mean while the dashed line indicates the NAAQS standard for $PM_{2.5}$ based on the 24-hr average. Average values for $PM_{2.5}$ occasionally exceed the standard of 35 µg m^{-3}



In addition to the major non-point sources of $PM_{2.5}$ emissions including fires, dust, and agriculture, there are also five sources of point pollution contributing to $PM_{2.5}$ emissions in the plan area (Figure 3.19). The HLC NFs are also subject to long-distance transport of emissions from sources to the west in Idaho, Oregon, Washington, and California, most notably wildfire smoke as it tends to be the most visible.

Figure 3.18 Sources of point source air pollutants in the plan area (EPA AirData 2014)



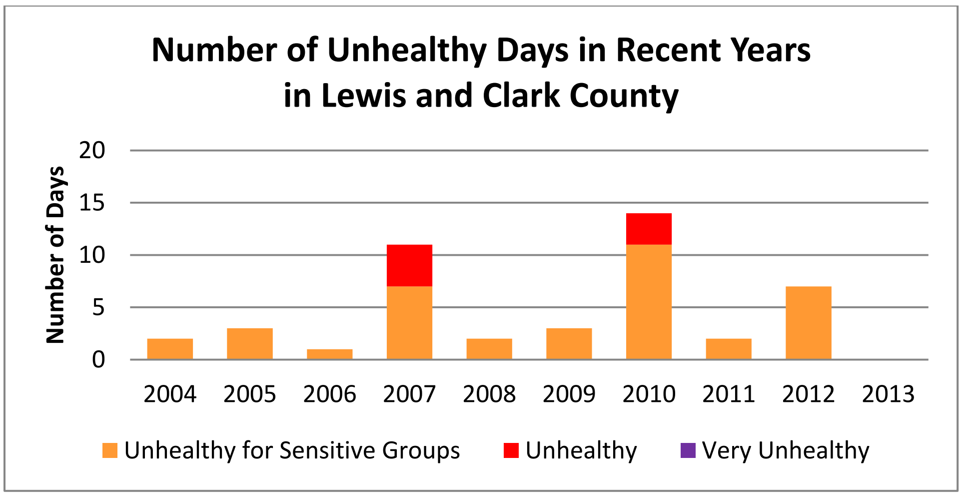
Air pollution is constantly monitored based on data from monitoring sites and the EPA then classifies local air quality using the Air Quality Index (AQI). The AQI is calculated using five of the six principal air pollutants and provides information on air quality to the general public as well as people with health concerns or target age groups (Table 3.8).

Table 3.8 AQI ranges and explanations

Air Quality Index	Numerical Value	$PM_{2.5}$ Concentration ($\mu g\ m^{-3}$)	Description
Good	0 – 50	0 – 12	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 – 100	12.1 – 35.4	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	35.5 – 55.4	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 – 200	55.5 – 150.4	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	150.5 – 250.4	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 – 500	250.5 – 500.4	Health alert: everyone may experience more serious health effects.

The historical profile for Lewis and Clark County indicates periods in 2007 and 2010 when the AQI was rated as unhealthy (red) for the general population. However, there are periods almost every year when the AQI is rated as unhealthy for sensitive groups (orange) as shown in Figure 3.19 (EPA Air Emission Sources 2014). The majority of days rated as unhealthy and unhealthy for sensitive groups occur in December and January with a small occurrence in September (EPA Air Emission Sources 2014). Most of the counties within the plan area do not have historical profiles for the AQI, except Cascade County which indicates the AQI was rated as unhealthy for sensitive groups for one to three days per year in 2004, 2007, and 2012 (EPA Air Emission Sources 2014). In Cascade County, days classified as unhealthy for sensitive groups occur in August and September (EPA Air Emission Sources 2014). For both Lewis and Clark and Cascade Counties, prescribed fire or wildfire smoke could contribute to ratings of unhealthy or unhealthy for sensitive groups in September but would not contribute emissions in December or January.

Figure 3.19 AQI data from 2004 to 2013 for Lewis and Clark County



MT DEQ evaluates air quality using only $PM_{2.5}$ concentrations and displays this information daily via Today's Air website (MT DEQ 2015). MT DEQ uses different breakpoints in Today's Air for $PM_{2.5}$ concentrations than the EPA uses for the Air Quality Index; note the different values in Table 3.7 and Table 3.8. Table 3.9 displays the $PM_{2.5}$ concentration breakpoints; MT DEQ uses the same color ramp and category names that the EPA uses for the AQI.

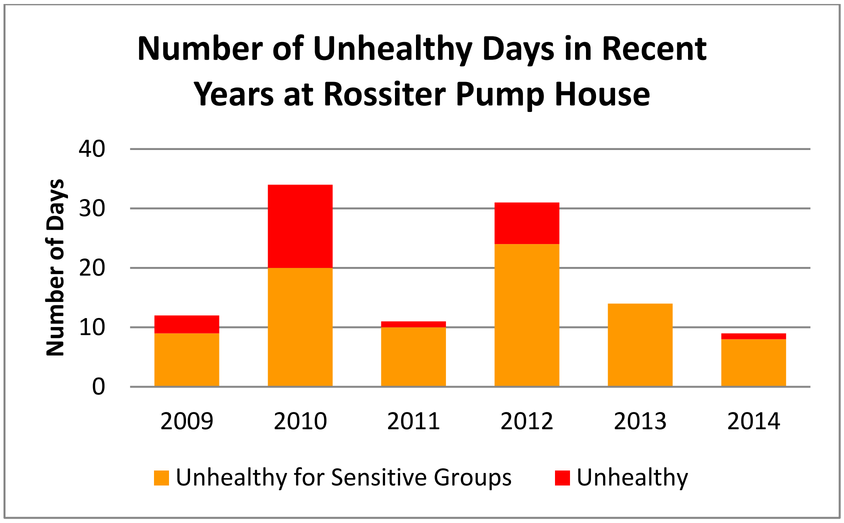
Table 3.9 Categories, associated concentrations of $PM_{2.5}$, and visibility used by the MT DEQ in Today's Air

Health Effect Categories	Visibility (miles)3	24-Hour BAM (ug/m3) 1	8-Hour BAM (ug/m3) 2	1-Hour BAM (ug/m3) 3
Hazardous	< 1.3	>135.4	> 193.4	> 338.5
Very Unhealthy	2.1 - 1.3	80.5 - 135.4	115.0 - 193.4	201.1 - 338.5
Unhealthy	5.0 - 2.2	35.5 - 80.4	50.7 - 114.9	88.6 - 201.0
Unhealthy for Sensitive Groups	8.7 - 5.1	20.5 - 35.4	29.2- 50.6	51.1 - 88.5
Moderate	13.3 - 8.8	13.5 - 20.4	19.2 - 29.1	33.6 - 51.0
Good	> 13.4 +	0.0 - 13.4	0.0 - 19.1	0.0 - 33.5

BAM=Beta Attenuation Monitor: used to monitor particulates in air.

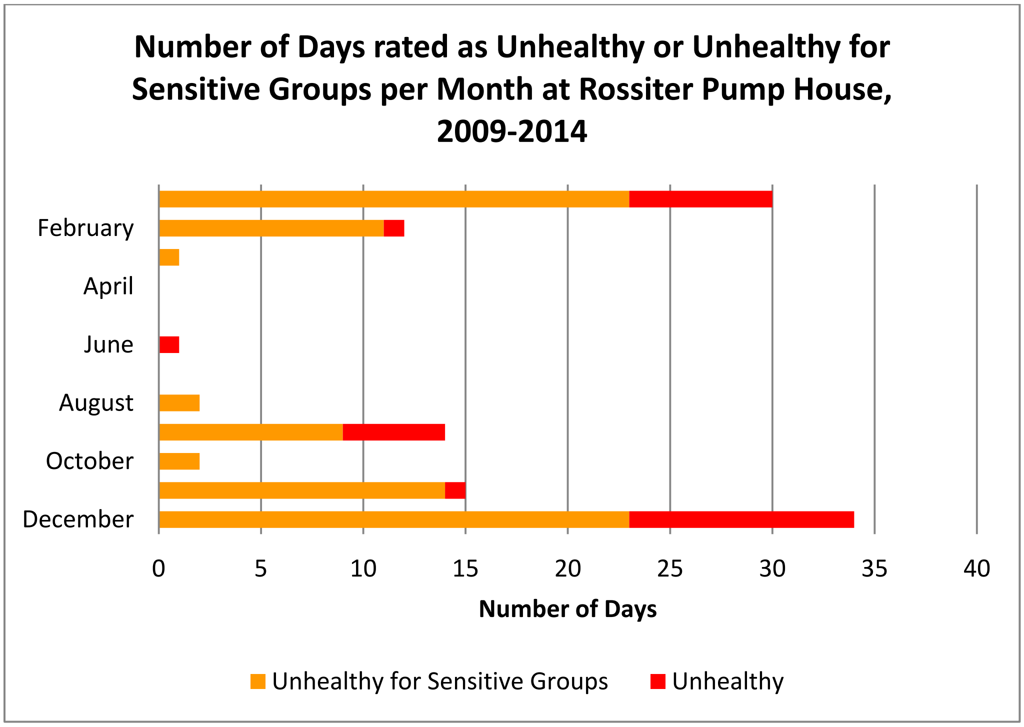
More days are classified as unhealthy and unhealthy for sensitive groups over the period from 2009-2014 using the breakpoints for 24-hr $PM_{2.5}$ concentrations established by MT DEQ as compared to the AQI (Figure 3.20).

Figure 3.20 : Today's Air health effect categories for 2009 through 2014 at Rossiter Pump House



Most of the days classified as being unhealthy or unhealthy for sensitive groups occur in colder months from November through February (Figure 3.21); inversions are common during winter and trap residential wood smoke. Smoke from wildfires or prescribed fires may contribute to $PM_{2.5}$ concentrations from August through October (Figure 3.21); it is probable most of the smoke contributing to spikes in $PM_{2.5}$ comes from wildfires as prescribed fires are highly regulated.

Figure 3.21 : Number of days rated as Unhealthy or Unhealthy for Sensitive Groups at Rossiter Pump House for the entire period of 2009-2014



Forest Service air quality policy directs coordination of National Forest activities with state and federal air quality control efforts. This is done by properly managing and/or mitigating the sources of air pollution created by Forest Service activities, such as prescribed burning, the construction and use of roads, and the operation of various facilities. Mandatory Class I federal areas enjoy special protection afforded by amendments to the Clean Air Act in 1977. The EPA has designated mandatory Class I federal areas, including the three wilderness areas within the plan area wholly or partially managed by the HLC NFS - the Bob Marshall, Scapegoat, and Gates of the Mountains Wilderness Areas. The Forest Service has the responsibility to protect the Air Quality Related Values (AQRVs) of Class I areas as directed by the Wilderness Act and Clean Air Act. Table 3.10 lists AQRVs associated with the wilderness areas managed by the HLC NFs.

Table 3.10 Air quality related values associated with wilderness areas in the HLC NFs

Wilderness Area	AQRV
Bob Marshall	Visibility, aquatic ecosystems, wildlife
Gates of the Mountains	Visibility, water, wildlife, flora
Scapegoat	Visibility and scenery, water quality, wildlife, vegetation, odor, climate

Within wilderness areas of the Northern Region, the following values are monitored over time: 1) lake chemistry, 2) visibility, 3) lichens, 4) precipitation chemistry as part of the National Atmospheric Deposition Program, and 5) snow chemistry. Visibility has generally improved since 2001 at the Gates of the Mountains Wilderness Area (GAMO1) IMPROVE (Interagency Monitoring of Protected Visual Environments) site as well as the MONT1 IMPROVE site on the Lolo NF that monitors air quality for the Bob Marshall Wilderness Complex and Scapegoat Wilderness Area (Grenon and Story 2009). Air quality affects the visibility and the visual aesthetics of an area. Many forest users visit these areas solely for the scenic beauty and solitude. There are many other destinations on the HLC NFs where users travel to enjoy the sheer scenic beauty of the landscape. High mountain lakes, lookouts, river corridors, and ridgeline roads and trails provide many scenic overlooks throughout the HLC NFs. For visitors willing to hike or ride, there are endless opportunities to discover the scenic beauty.

Snow chemistry is monitored at three sites within the planning area as part of the Rocky Mountain Regional Snowpack Chemistry Monitoring Project (Figure 3.22). This monitoring program provides information of deposition of airborne pollutants by monitoring the chemistry of snowpack at upper elevations; fifty high elevation sites in the Rocky Mountains are monitored through the winter which provides the ability to evaluate long-term trends based on approximately twenty years of data (USGS 2015). This project aims to identify the sources of acid deposition that may affect mountain watersheds (USGS 2015).

The trend for sulfate (SO_4) shows a general decrease in concentrations over time at King's Hill (Figure 3.23) and Spring Gulch (Figure 3.24) whereas measurements at Mount Belmont have remained fairly steady (Figure 3.25). The trends for ammonium (NH_4) and nitrate (NO_3) have been highly variable since snowpack chemistry monitoring began (Figures 3.23-3.25).

Figure 3.22 Rocky Mountain regional snowpack chemistry sites in the planning area (USGS 2015)

Figure 3.23 Chemical concentrations in snowpack at King's Hill from 1993 to 2013 (USGS 2015)

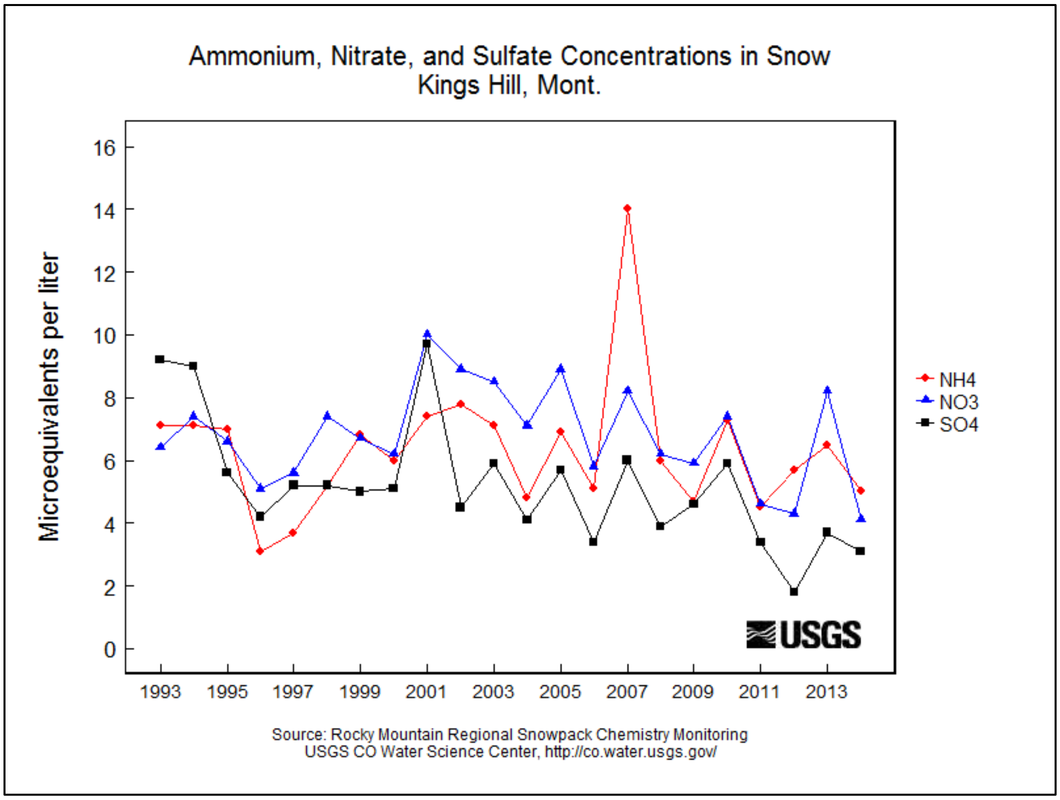


Figure 3.24 Chemical concentrations in snowpack at Spring Gulch from 1997 to 2013 (USGS 2015)

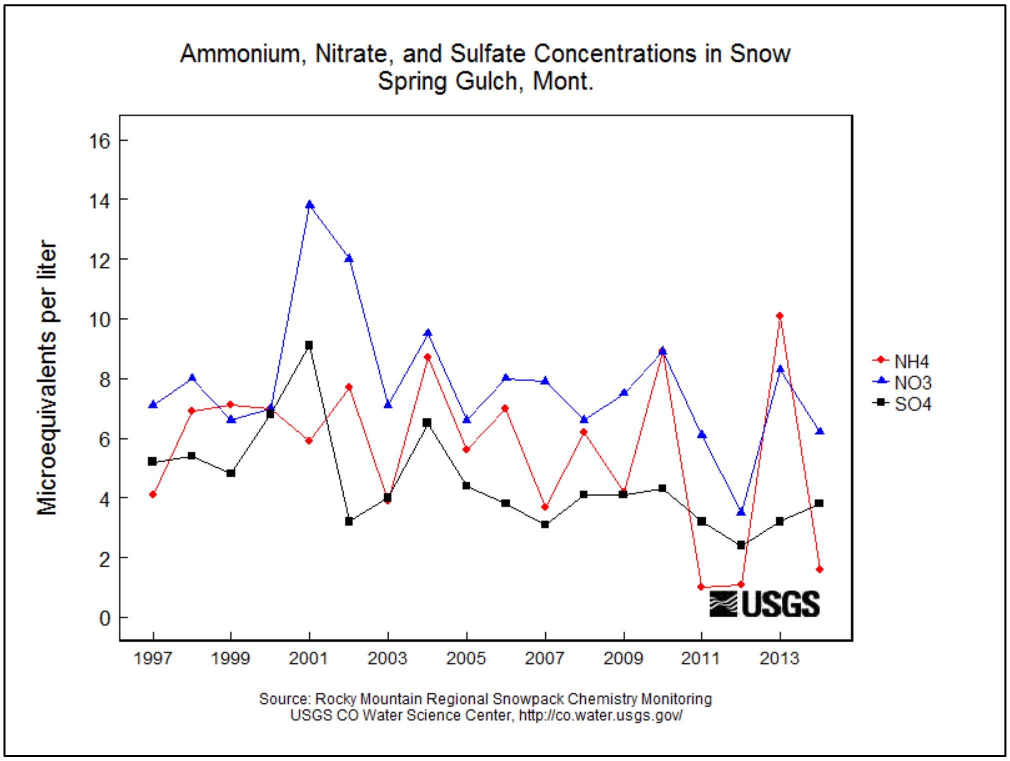
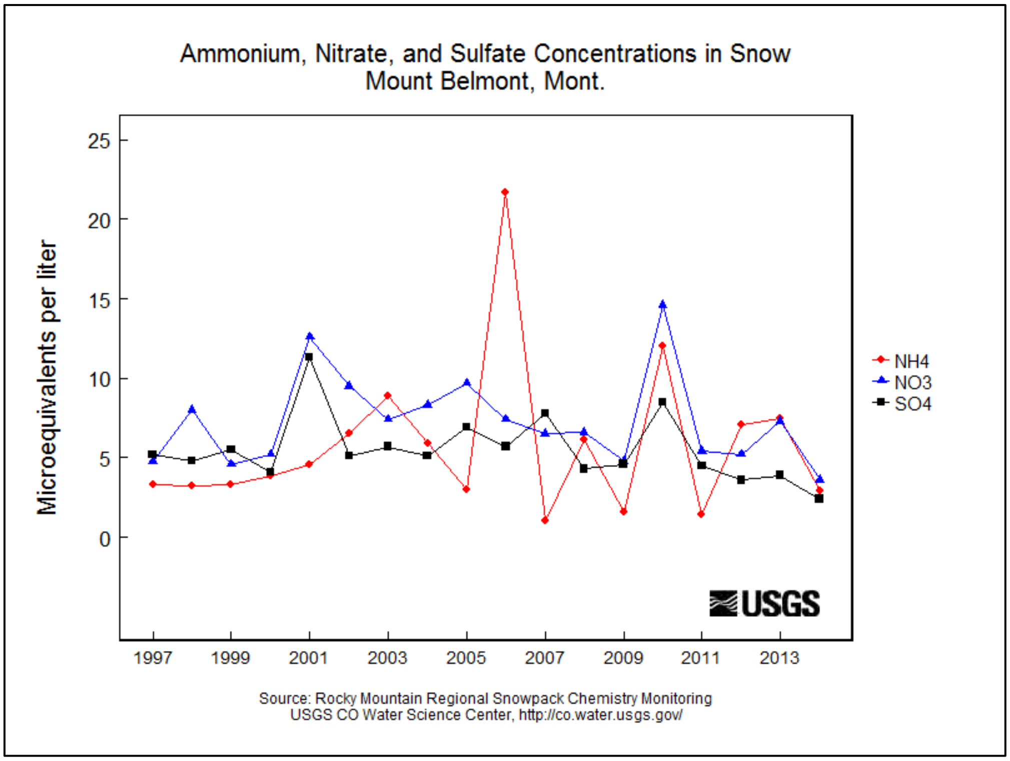


Figure 3.25 Chemical concentrations in snowpack at Mount Belmont from 1997 to 2013 (USGS 2015)



The potential effects of activities proposed on NFS lands must be assessed as directed by the National Environmental Policy Act, including effects to air quality. Montana DEQ often works collaboratively to measure air pollutants associated with activities such as prescribed burning using mobile air quality sensors. The National Forest Management Act directs agencies to protect and improve the quality of air resources, in addition to soil and water.

The Montana/Idaho Airshed Group includes multiple stakeholders committed to protecting air quality while accomplishing prescribed burning objectives. All prescribed burning activities are coordinated by the Smoke Management Unit in Missoula, Montana that makes decisions based on unit size and location, fuel type, and forecast weather conditions. This airshed group maintains an operating guide that provides specific details about managing prescribed fire smoke so as not to exceed air pollutant standards (Montana/Idaho Airshed Group 2010). The Helena NF Fire Management Plan (HNF FMP 2014) and Lewis and Clark NF Fire Management Plan (LCF FMP 2014) are revised annually and provide guidance for implementing interagency federal fire policy, Forest Service Manual direction, and Forest Plan direction. The Fire Management Plans (FMPs) incorporate existing interagency plans and assessments and considers the best available science to assess and plan on a landscape scale. Starting in 2015, FMPs will be spatially based and closely tied to forest plans.

Trends and reasonably foreseeable future conditions

Clean air will continue to be produced and filtered through the Forests. The major impact to air quality in the plan area is fine particulate matter ($PM_{2.5}$), from agriculture, wildfires and prescribed fires, dust, and residential wood smoke. Agricultural burning and prescribed burning are highly regulated throughout the plan area and residential wood smoke is regulated in certain areas including Lewis and Clark County (Lewis and Clark County 2011); guidelines governing these sources may become even more stringent in the future.

The HLC NFs and adjacent communities generally have very good air quality. In Lewis and Clark County, December and January tend to register the highest $PM_{2.5}$ concentrations. In the remainder of the plan area, the months of July, August, and September are likely to register increases in $PM_{2.5}$. During these months, wildfires, prescribed fires, agricultural burning, and agriculture dust can adversely impact air quality, although pollutants do not generally reach unhealthy levels based on the air quality sensors. Much of the plan area is sparsely populated and subject to transport winds that serve to disperse pollutant emissions but high pressure systems common in the summer can stall dispersion and impact air quality. Smoke from agricultural, personal debris burning, prescribed burning, or wildfires can settle for days, producing unhealthy conditions in valley bottoms. Usually, these conditions only occur for a few days at a time. However, the fine particles associated with smoke from wildland fires can be especially problematic for those with ongoing health problems, such as lung disease or asthma, and for the elderly and children, increasing their risk of hospital and emergency room visits or even the risk of death (EPA 2003). Montana DEQ and counties regulate open burning throughout the year while working with the Montana/Idaho Airshed Group to coordinate projects and potential air quality impacts from each prescribed burn.

Air quality impacts from wildfires may intensify in the future if these fires occur with greater frequency or the amount of burned area increases. Many climate projection scenarios indicate warmer temperatures in the plan area (Wear et al. 2013) which could lengthen the wildfire season. If warmer temperatures indeed occur, the window for available burning by wildfires may broaden which would affect fire frequency in mid to upper elevation areas where fuel moisture and burning conditions during summer months currently inhibit fire spread in many years. Spracklen et al. (2009) indicate that increases in emissions from wildfires may increase organic carbon concentrations by 40 percent and elemental carbon concentrations by 20 percent over the western U.S. by 2050. Large fires will continue to occur on the HLC NFs, driven by climate, weather, and fuel conditions, including the influence of the Pacific Decadal Oscillation (PDO), El Niño Southern Oscillation (ENSO), and the Atlantic Multidecadal Oscillation (AMO; Kitzberger et al. 2007, Morgan et al. 2008, Schoennagel et al. 2005).

National direction for Forest Service management actions will continue to have a profound effect on how wildfires and fuels are managed across the HLC NFs. Variable fire budgets will impact suppression efforts, prescribed fire implementation, hazardous fuels planning, and wildland fire implementation. National direction will also continue to provide forests with guidance in the management of wildland fires and fuels on the landscape. National direction will likely continue to focus on increasing the occurrence of fires managed for restoration, resiliency and resource benefit objectives (formerly wildland fire use); hazardous fuels reduction; and accelerated restoration and resiliency objectives.

Information Needs

There are no information needs at this time.

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