MOONLIGHT FIRE RESTORATION STRATEGY

USDA Forest Service
Plumas National Forest

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Executive Summary

In July of 2012, the U.S. Forest Service received a settlement for the 2007 Moonlight Fire that included the collective sum of 55 million dollars and the transfer of 22,500 acres of private land. Fire settlement funds received by the Forest Service for restoration of the affected area provide a unique opportunity to restore ecosystem health, function and resilience. This Fire Restoration Strategy outlines current and desired conditions to provide both a framework and target for restoration efforts; it also defines specific goals and objectives to focus restoration activities on resources affected by the Moonlight Fire.

The Moonlight Fire burned approximately 65,000 acres of National Forest System and private lands; over half of these acres burned at high severity. This had both direct and indirect impacts on a broad suite of ecological and cultural resources. As a result, the restoration goals, objectives, and activities proposed in this strategy are equally as broad; proposals range from maintaining and enhancing late seral forest habitat conditions for wildlife to restoring degraded stream conditions and engaging local communities and schools in fire restoration.

Restoration strategies for many of the resources focus on areas or values directly impacted by the Moonlight Fire; for others it is necessary to consider the effects of the Moonlight Fire in the context of the broader landscape. The spatial and temporal effects of the Moonlight Fire provide the appropriate ecological context to assess the direct, indirect and cumulative impacts on ecological values and services. The process to restore lost resources is proposed, as are measures to preserve the nearest adjacent values as a surrogate until the original area is restored. It is ecologically appropriate to identify and link restoration opportunities both inside and outside of the Moonlight Fire, but within the affected area.

This Fire Restoration strategy does not initiate, authorize, or implement any site-specific project activities. Rather, it provides a framework for restoration of natural resources, ecological processes, and human values affected by the Moonlight Fire. The overarching goal of restoration in the Moonlight Fire area is to maintain, create, and promote healthy and resilient systems, which are better prepared for changing climates and human use patterns.

This strategy resembles a Landscape Assessment with a focus on a single event, the Moonlight Fire, and its effects. The affected area is tailored within each scientific discipline to natural features as defined by natural processes. The desired conditions, goals, and objectives show the needed restoration foci while proposed projects for the upcoming Fiscal Year are described in Appendix B. Proposals will be developed and submitted annually using the template provided in Appendix A to define specific projects for the following year.

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LOCATION MAP

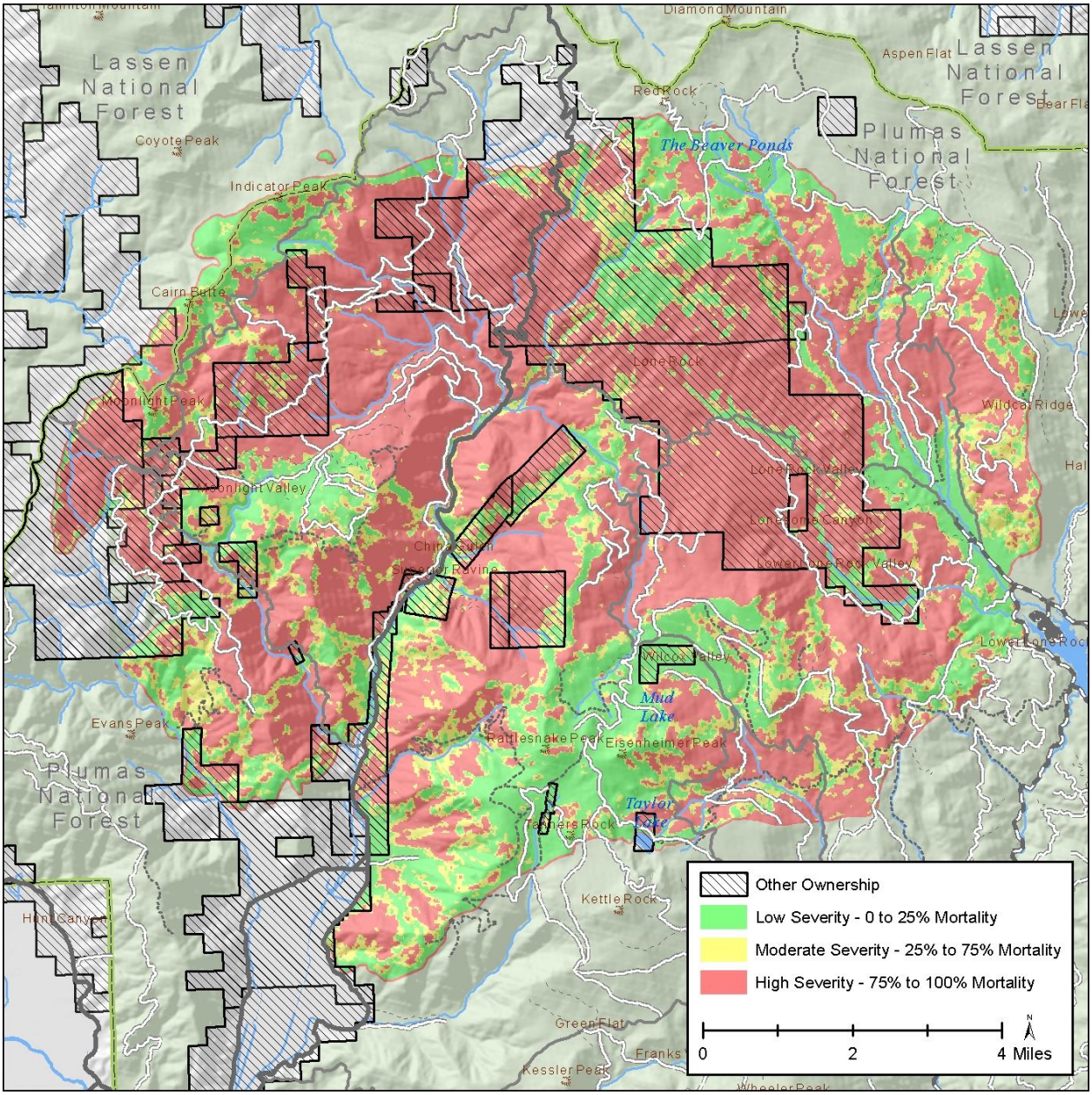


Figure 1. Map of the 2007 Moonlight Fire showing burn severity and land ownership.

1.0 Introduction

The Moonlight Fire ignited on September 3, 2007 in the northeastern portion of the Plumas National Forest (NF), just east of the main crest of the Sierra Nevada (Figure 2). Before it was contained on September 15, 2007 the fire burned approximately 65,000 acres of Sierra mixed conifer and true fir forest, hardwood stands, shrublands, meadows, and riparian areas; it also impacted roads, trails, cultural sites, rangeland infrastructure, and recreation sites. The watersheds affected by the Moonlight Fire, which range in elevation from 3,520 feet in Indian Valley to 7,820 feet at Kettle Rock, are drained by two main perennial streams, Lights Creek and Indian Creek; both eventually flow into the East Branch of the North Fork of the Feather River, an important water source for California.

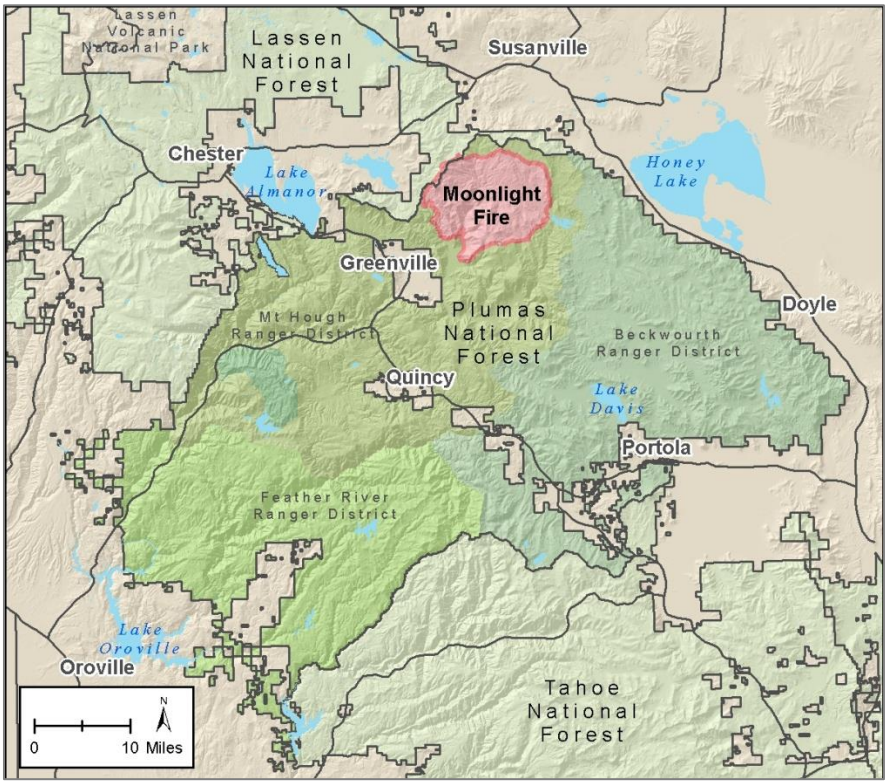


Figure 2. General vicinity map showing the location of the 2007 Moonlight Fire.

The Moonlight Fire burned through a mosaic of land ownerships, which included approximately 45,514 acres on the Plumas NF and 562 acres on the Lassen NF; it also burned large parcels of private timber land in the northeastern part of the fire and up to the Wildland Urban Interface (WUI) surrounding Indian Valley (Table 1, Figure 1). The Moonlight Fire burned over 80 percent of the Mud Lake Research Natural Area (RNA), which was established to maintain the rare fire-adapted conifer, Baker cypress (*Hesperocyparis bakeri*). The Antelope Lake Recreation Area, a popular destination for forest visitors, is situated directly adjacent to and east of the fire perimeter.

Table 1. Ownership of lands burned in the 2007 Moonlight Fire.

Land ownership	**Approximate acreage**	**Percentage of total area burned**
Plumas NF (Mt Hough Ranger District)	45,514	70%
Mud Lake Research Natural Area	*300*	
Lassen NF (Eagle Lake Ranger District)	562	1%
Private	18,920	29%

Prior to the fire, the Moonlight area landscape encompassed:

- previously treated areas, such as hazardous fuel reduction zones, plantations established over the last 40 years, and clear-cut units;
- recently burned areas (Figure 3);
- areas that had been protected from treatments, including 25 areas set aside as habitat for two sensitive wildlife species, the California spotted owl (*Strix occidentalis*) and Northern goshawk (*Accipiter gentilis*);
- six grazing allotments;
- more than 500 mining claims;
- over 200 cultural sites;
- more than 300 invasive plant species infestations;
- an estimated 475 miles of perennial, intermittent, and ephemeral streams;
- approximately 160 miles of National Forest System (NFS) roads;
- 25 miles of designated motorized (4WD vehicles) trails; and
- 18 miles of non-motorized trails.

1.1 Landscape Condition

The landscape burned by the Moonlight Fire was historically a mosaic of yellow pine forest, Sierra mixed conifer stands, true fir forest, oak woodlands, shrublands, meadows, aspen stands, and riparian corridors. Prior to European American settlement of the area in the mid-1800s, vegetation patterns and successional stages were created and maintained by historic disturbance processes, such as fire, insect and disease outbreaks, and drought. Historic fire regimes varied in response to topography and vegetation type, but were generally characterized by frequent, low to moderate intensity fires. Larger fires exhibited spatial heterogeneity in both fire intensity and patch size (Skinner and Chang 1996).

By the time the Moonlight Fire occurred in 2007, the effects of over a century of management were evident on the landscape. Past timber harvest activities, fire suppression, mining, and historic livestock grazing created areas with dense forest stands dominated by shade-tolerant

species, large accumulations of fuels, degraded meadows and riparian areas, and invasive species. Heavy fuel loads and dense forest conditions, combined with high wind speeds, dry conditions, and steep terrain, increased both the size and severity of the Moonlight Fire (Daley et al. 2008). By the time it was contained, the Moonlight Fire burned almost 38,000 acres at high severity, or 58 percent of the fire area (Figure 1, Table 2). Patches of high severity in the Moonlight Fire were uncharacteristically large compared to most historic fires, with many patches exceeding 2,500 acres (Collins and Stephens 2012). Riparian areas and protected activity centers (PACs) for spotted owl had some of the greatest percentage of high severity fire effects of any area within the fire perimeter, probably as a result of the lack of fuel treatments in these areas (Dailey et al. 2008, North, Collins, and Stephens 2012). Approximately 16,034 acres (25 percent) experienced low severity fire or were left unburned (Table 2).

Table 2. Acres and percentage of vegetation burn severity within the 2007 Moonlight Fire; calculated from the USDA Rapid Assessment of Vegetation Condition after Wildfire (RAVG) data

Severity	Definition	Acres	Percentage
Unburned	0% basal area mortality	6,206	10%
Low	0% < basal area mortality < 25%	9,828	15%
Moderate	25% ≤ basal area mortality < 75%	10,969	17%
High	basal area mortality ≥ 75%	37,970	58%

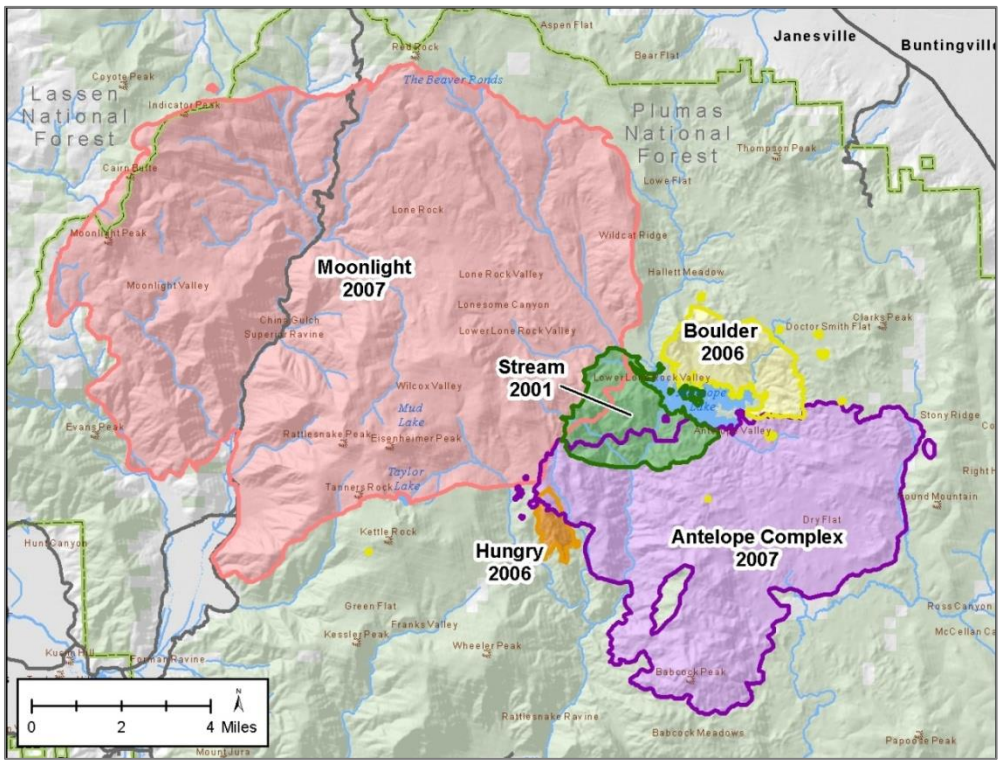


Figure 3. Large recent fires adjacent to and overlapping the 2007 Moonlight Fire

2.0 Restoration Strategy Framework

2.1 Ecological Restoration: Guiding Principles

Ecological restoration is defined by the Forest Service as:

> *"The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. Restoration focuses on establishing the composition, structure, pattern, and ecological processes necessary to make terrestrial and aquatic ecosystems sustainable, resilient, and healthy under current and future conditions" (Day et al. 2006, USDA 2013).*

In the Pacific Southwest Region, as stated in the Ecological Restoration Regional Leadership Intent (USDA 2011a), the Forest Service's fundamental goal is to "retain and restore ecological resilience of the National Forest lands to achieve sustainable ecosystems that provide a broad range of services to humans and other organisms." According to the Leadership Intent, "from this point forward, ecological restoration will be the central driver of wildland and forest stewardship in the Pacific Southwest Region" (USDA 2011a).

The Forest Service's Ecosystem Restoration Framework (Day et al. 2006) noted that:

> *"The nation's forests and grasslands face serious threats to their long term health, productivity, and diversity. Foremost are non-native invasive species, altered disturbance regimes, and climate change… Agency and public concern about some of these threats has led to (various efforts) to help facilitate restoration actions. Nevertheless, the magnitude of ecosystem restoration needs greatly exceeds the organizational and financial capacity of the agency. Many forest and grassland ecosystems continue to degrade at a preventable rate."*

2.2 Fire Settlement Funds

In July of 2012, the Forest Service received a settlement that included the collective sum of 55 million dollars and the transfer of 22,500 acres of private land (Mueller 2012). Fire settlement funds received by the Forest Service for the restoration of the area affected by the Moonlight Fire provide a unique opportunity to reverse ecosystem degradation, restore ecosystem health and resilience, rehabilitate damaged infrastructure, and prepare the impacted landscape for the effects of changing climates and human use patterns.

According to US Code 16 USC 579c:

> *" Any moneys received by the United States…as a result of a judgment, compromise, or settlement of any claim, involving present or potential damage to lands or improvements…are hereby appropriated and made available until expended to cover the cost to the United States of any improvement, protection, or rehabilitation work*

on lands under the administration of the Forest Service rendered necessary by the action which led to the forfeiture, judgment, compromise, or settlement."

Settlement funds spent under this Restoration Strategy must meet the following three key criteria from 16 USC 579c:

1. To conduct improvement, protection, or rehabilitation work;
2. On lands administered by the Forest Service;
3. For purposes rendered necessary by the Moonlight Fire.

2.3 Strategy Goals and Objectives

The purpose of this strategy is to provide a framework for restoration of natural resources, ecological processes, and human values affected by the Moonlight Fire. The overarching goal of restoration in the Moonlight Fire area is to maintain, create, and promote healthy and resilient systems, which may resemble the past, but are also better prepared for changing climates and human use patterns. Specific restoration goals and objectives are provided for individual resources in Sections 5.0 and 6.0 of this strategy.

This strategy does not initiate, authorize, or implement any site-specific project activities. All restoration activities that are implemented as a result of this strategy will be designed to protect National Forest resources and will comply with all applicable laws, regulations, and directives.

Restoration work carried out under the Moonlight Fire Restoration Strategy will:

- Assist the recovery of ecosystems that were degraded, damaged or destroyed by the Moonlight Fire;
- Result in more sustainable, resilient, and healthy ecosystems, with a focus on probable future conditions and climates in the restoration area;
- Consider the spatial and temporal relationship of fires on the landscape;
- Adopt an interdisciplinary landscape approach to accelerate the scale and pace of ecosystem restoration;
- Engage local communities to increase awareness and understanding of ecological restoration and fire-adapted ecosystems;
- Ensure the strategy and any subsequent proposed actions are linked to the restoration objectives laid out in the *Plumas NF Land and Resource Management Plan* (USDA 1988a), *Sierra Nevada Forest Plan Amendment* (USDA 2004), and other amendments;
- Ensure alignment of the strategy and proposed actions with the Forest Service Ecological Restoration Framework, the Region 5 Ecological Restoration Leadership

Intent (USDA 2011a), and Forest Service Handbook (FSH) Chapter 2020 (Ecological Restoration, in prep.);

- Utilize current scientific knowledge for landscape restoration, including – where appropriate – information synthesized in PSW-GTR-220, *An Ecosystem Strategy for Mixed Conifer Forests* (North et al. 2009), and PSW-GTR-237, *Managing Sierra Nevada Forests* (North et al. 2012);
- Coordinate with the Lassen NF, which was also affected by the Moonlight Fire, to develop landscape-scale restoration activities;
- Monitor the success of restoration efforts in the Moonlight Fire landscape and adapt the strategy when appropriate.

2.4 Strategy Framework

The following framework was used to develop restoration strategies for resources affected by the Moonlight Fire. First, **PAST AND PRESENT CONDITIONS** were analyzed for each resource (Sections 3.0 and 4.0). The analysis of past and present conditions drew heavily from past planning documents, such as the *Moonlight and Wheeler Fires Recovery and Restoration Project Final Environmental Impact Statement* (USDA 2008); *Diamond Vegetation Management Project Draft Environmental Impact Statement* (USDA 2006a); Moonlight Fire incident reports; Burned Area Emergency Response (BAER) reports; litigation and settlement documents; GIS datasets; and monitoring reports.

For most resources, it was necessary to consider fire impacts in the context of the broader landscape. For example, the impact of the Moonlight Fire on hydrologic resources, wildlife habitat connectivity, recreation opportunities, and forest vegetation extended to an area larger than the fire perimeter. In all of these cases, rationale was provided to make a clear link between the resource, the Moonlight Fire event, and the area analyzed for restoration opportunities.

Second, **DESIRED CONDITIONS** (Sections 5.0 and 6.0) were developed based on: analyses of past and present conditions; Forest Service guidance documents, such as the *Sierra Nevada Framework* (USDA 2004) and the *Plumas National Forest Land and Resource Management Plan* (USDA 1988); and evaluations of historic and reference ecosystems. The discrepancy between current and desired conditions was then used to identify restoration needs and to provide a target for management **GOALS AND OBJECTIVES** (Sections 5.0 and 6.0). Resource-specific goals were developed to provide a general strategy for achieving the desired conditions, whereas objectives were developed to define measurable statements of intent. Whenever possible, restoration projects were identified and described as objectives. Additional restoration projects will be developed as data are gathered and analyzed, resource specialists become more familiar with the Moonlight Fire landscape, and conditions on the ground change. In all of these cases, future restoration projects will link to the desired conditions, goals, and objectives provided in

this strategy. Specific project proposals for fiscal year 2014 are described in detail in Appendix B.

Finally, **MONITORING ACTIVITIES AND OPPORTUNITIES** were identified. The purpose of monitoring resources within the Moonlight Fire is to determine if restoration desired conditions, goals, and objectives are being achieved; if they are not being met, managers will use monitoring data to determine the appropriate course of action to restore or maintain conditions. Monitoring data will also be used to evaluate post-fire impacts, establish baseline conditions, and identify changes and trends over time.

3.0 Past and Present Ecological Conditions

3.1 Current and Probable Future Climate Trends

Changes in climate and climate-driven processes present new challenges for long-term restoration of any landscape, including the Moonlight Fire area. Climate models predict that future climates will likely be characterized by shifting weather patterns, increasing mean temperatures, changing precipitation patterns, and increasing incidence of extreme climatic events (Hayhoe et al. 2004, Harris et al. 2006, Safford et al. 2012). Studies of Sierra Nevada ecosystems have also shown that species ranges and ecological processes are already responding to recent climate shifts (e.g. Moritz et al. 2008, Forister et al. 2010, Miller et al. 2009).

This strategy includes discussions of past resource conditions that may provide one target for planning and implementation of restoration projects in the Moonlight Fire area; however it is also important to consider future climatic and biophysical conditions when defining desired conditions, setting restoration goals and objectives, and selecting reference systems. The following section summarizes current and probable future trends in climate and climate-driven processes across the northeastern climate region, which encompasses the area affected by the Moonlight Fire. Climate regions were developed for California by Abatzoglou et al. (2009), with each region encompassing weather stations that experience similar large-scale weather and climate patterns. Much of the following information was taken from a climate change trend summary, prepared by the Regional Ecology Program (Merriam and Safford 2011), which analyzed weather station data and spatial climate grid (Parameter-elevation Regressions on Independent Slopes Model-PRISM) data to identify regional and local climate trends.

3.1.1 Temperature

Across the northeast climate region, there have been significant increases in temperature over the last century, with mean annual temperatures increasing by approximately 1.7 degrees Fahrenheit (Figure 4). This trend is influenced by significant increases in mean minimum (nighttime) and mean maximum (daytime) temperatures. At the local scale, changes in temperature are much more variable, most likely as a result of complex weather patterns driven by topography and geography. This variability is evident in the Moonlight Fire area, where changes in temperature since the 1930s have ranged from negative to positive (Figure

5). Areas where these trends have been negative could provide important future refugia for climate-sensitive species.

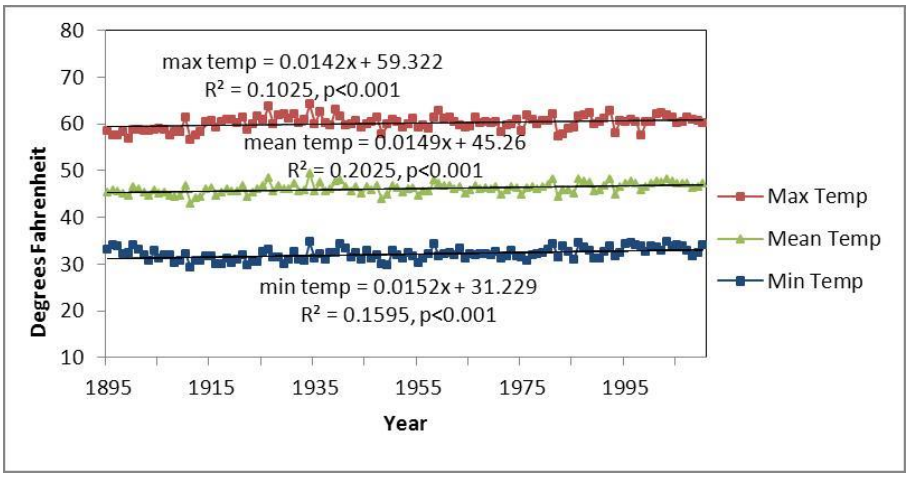


Figure 4. Trends in maximum, mean, and minimum temperatures recorded at weather stations across the northeast climate region between 1895 and 2010. Trend lines fit with simple linear regression, no transformations employed. Data from Western Regional Climate Center (WRCC 2010); figure reproduced from Merriam and Safford (2011).

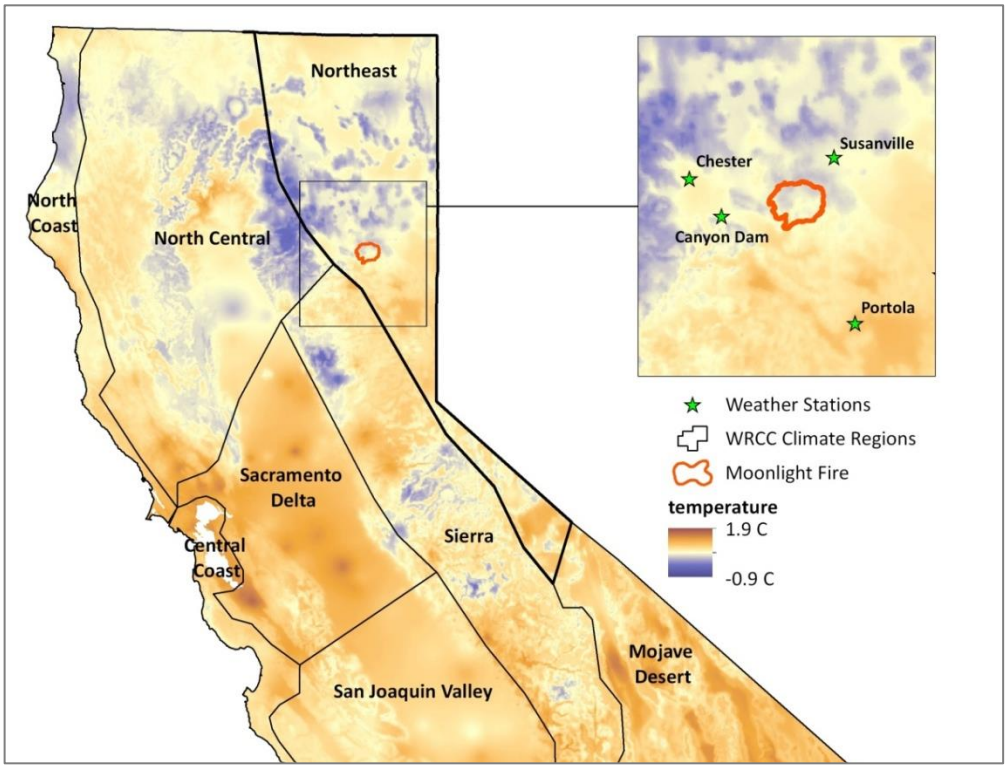


Figure 5. Mean annual temperature change between the 1930's and 2000's in central and northern California,, including the northeast climate region and the Moonlight Fire area, as derived from the PRISM climate model. Blue areas have experienced decreased mean temperatures, orange and red areas have experienced increased mean temperatures.

3.1.2 Precipitation

Regional precipitation trends have varied widely, ranging from negative to positive, even between neighboring weather stations (WRCC 2010). As a result, there has been no significant change in precipitation across the northeast climate region over the past century (Merriam and Safford 2011). The Moonlight Fire area shows similar variability in precipitation trends; however the PRISM models and data from local weather stations also suggest a general pattern of increasing precipitation in the western portion of the fire and decreasing precipitation in the eastern portion of the fire (Figure 6). Of the five weather stations evaluated in the northeast climate region, the Susanville weather station, located northeast of the Moonlight Fire, was the only station to report a significant trend in precipitation. Total annual rainfall at the Susanville station has decreased by almost nine inches since 1893 (Figure 7).

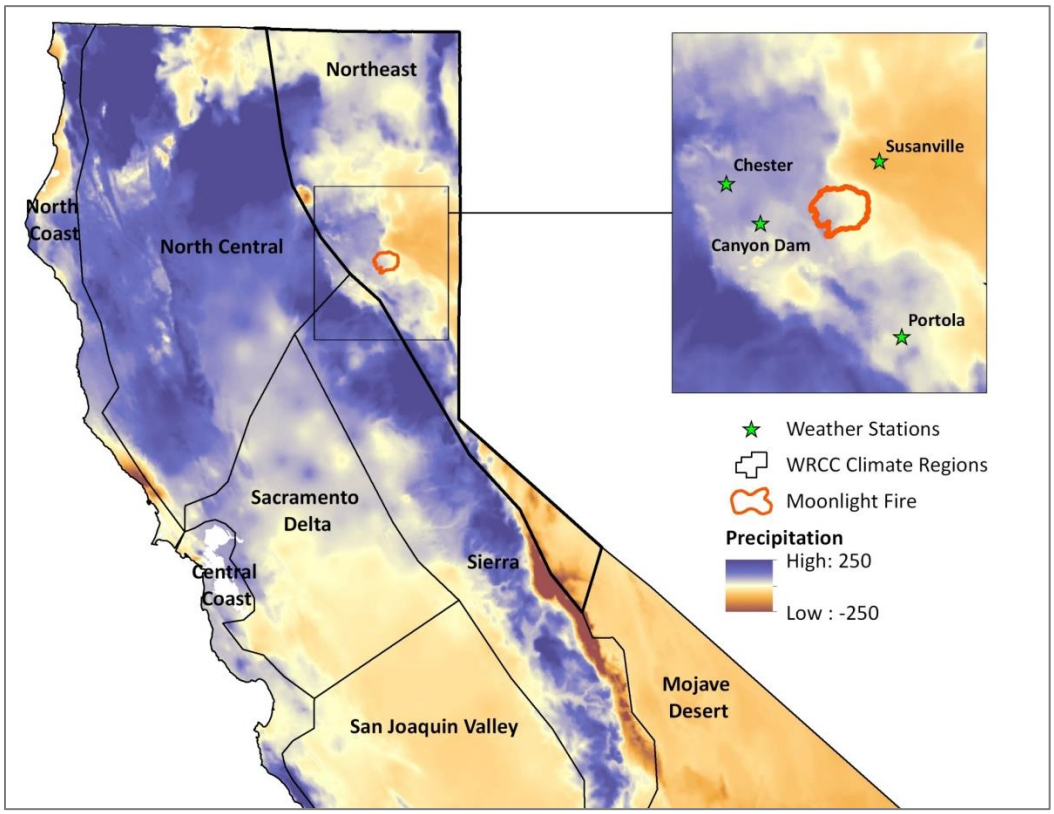


Figure 6. Mean annual precipitation change between the 1930's and 2000's in central and northern California, including the northeast climate region and the Moonlight Fire area, as derived from the PRISM climate model. Blue areas have experienced increased precipitation, orange and red areas have experienced decreased precipitation.

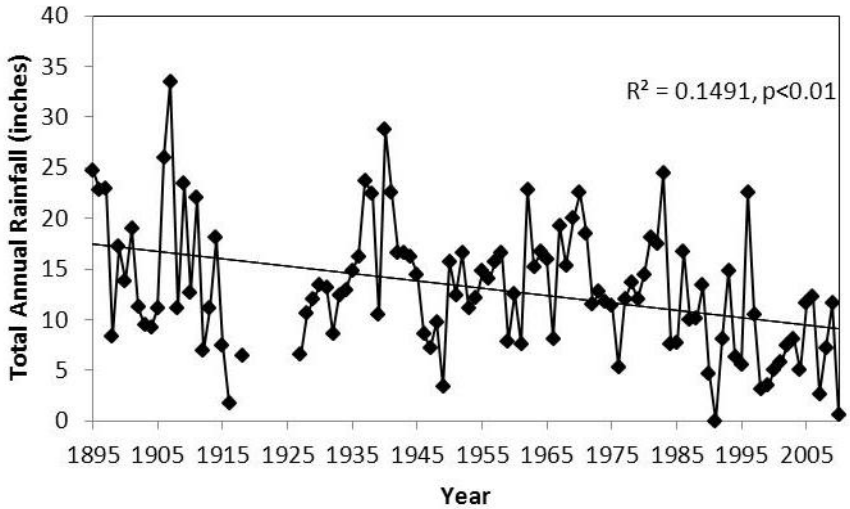


Figure 7. Total annual rainfall has significantly declined at the Susanville station, 1893-2010. Trend lines fit with simple linear regression. Data from WRCC (2010); figure from Merriam and Safford (2011).

3.1.3 Snowfall

Four of the five weather stations evaluated in the northeast climate region, including the two closest to the Moonlight Fire area, have documented significant declines in snowfall over the past century (Table 3). At several of the stations, the relationship between snowfall and year is much stronger than that observed for temperature or precipitation. For example, at the Susanville station over 40 percent of the variation in snowfall was a result of year and total annual snowfall declined from 66 inches in 1894 to four inches in 2009 (Merriam and Safford 2011). At the regional scale, spring snowpack has decreased by as much as 70 to 120 percent across most of the northern Sierra Nevada (Safford et al. 2012). Moser and others (2005) also reported decreases in early spring (April 1) snowpack and snow-water equivalents between 1950 and 1997 for most of the stations they surveyed in northeastern California.

Table 3. Direction and magnitude of significant shifts in total annual snowfall recorded at individual weather stations across the northeast climate region. Numerical values indicate the difference between the earliest and most recent years of each station's total annual snowfall in inches, as calculated using regression equation. Statistical significance of trends indicated as follows: 'NS' = not significant, '*' = p<0.05, '**' = p<0.01, '***' = p<0.001. Regression coefficients are also presented to indicate the strength of the relationship between snowfall and year.

Station	Total Annual Snowfall (inches)
Alturas	NS
Cedarville	-48***, R^2=0.42
Hat Creek	-38***, R^2=0.26
Susanville	-62***, R^2=0.41
Portola	-31*, R^2=0.08

3.1.4 Observed Trends

3.1.4.1 Hydrologic

As a result of decreasing snow packs, most of the western United States is experiencing a decline in total runoff occurring in the spring (Moser et al. 2009). Over the past 100 years, the fraction of annual runoff that occurs between April and July has decreased by 23 percent in the Sacramento basin and by 19 percent in the San Joaquin basin in California (Moser et al. 2009). Stewart and others (2005) showed that the onset of spring thaw in most major streams in the Sierra Nevada occurred 5 to 30 days earlier in 2002 than in 1948, and peak stream flow (measured as the center of mass annual flow) occurred 5 to 15 days earlier. In northeastern California, the timing of spring snowmelt driven stream flow is now about 10 to 15 days earlier than in the mid-1900s (Baldwin et al. 2003).

3.1.4.2 Wildfires

Wildfire frequency, size, and severity have increased across northern California over the past few hundred years (Miller et al. 2009). Westerling and others (2006) showed that the increased frequency of large fires (> 1000 acres) across the western United States since the 1980's is strongly linked to increasing temperatures and earlier spring snowmelt. Northern California, which includes the Moonlight Fire area, was one of two geographic areas with especially increased fire activity, which Westerling and others (2006) ascribed to an interaction between climate and increased fuels due to fire suppression. The authors identified northern California as being one of the geographic regions most likely to see further increases in fire activity due to projected future shifts in temperature. Northern California forests have already had substantially increased wildfire activity, with most wildfires occurring in years with early springs (Westerling et al. 2006).

Miller and others (2009) showed that mean and maximum fire size and total burned area across the Sierra Nevada, significantly increased between the early 1980's and 2007. Although climatic variables explained very little of the pattern in fire size and area in the early 20th century, 35 to 50 percent of the pattern could be explained by spring climate variables (e.g. spring precipitation and minimum temperature) in the last 25 years. The mean size of fires that escaped suppression efforts in the Sierra Nevada was about 750 acres until the late 1970's; the most recent ten-year average has climbed to about 1100 acres. Miller and others (2009) also showed that forest fire severity (a measure of the effect of fire on vegetation) rose strongly during the period between 1984 and 2007, with the pattern most evident in middle elevation conifer forests. Fires at the beginning of the record burned at an average of about 17 percent high severity, while the average for the last ten-year period was 30 percent. Approximately 58 percent of the Moonlight Fire burned at high severity. Miller and others (2009) suggest that both climate change and increasing forest fuels may explain this pattern of increasing fire severity.

3.1.4.3 Forest Structure and Composition

The role of climate in observed changes in forest structure over the past century is confounded by land use practices such as fire suppression and timber harvest, particularly in low and mid-elevation forests where these activities have been prevalent. However, a number of trends in forest structure and composition can be attributed, at least in part, to changes in climate. Regional trends that may be relevant to restoration of the Moonlight Fire area include: (a) increased tree regeneration and recruitment in response to increases in both temperature and precipitation (Bouldin 1999); (b) increased tree mortality associated with regional climate warming and drought stress (Bouldin 1999, Van Mantgem et al. 2009); and (c) increased frequency and severity of insect outbreaks, such as the mountain pine beetle (Mitton and Ferrenberg 2012). Comparisons of vegetation inventory data from the 1930s (Wieslander 1935) with modern vegetation maps and inventories show large changes in the distribution of many Sierra Nevada vegetation types over the last 70-80 years (Bouldin 1999, Moser et al. 2009). Two of these large-scale changes have been documented in the Moonlight Fire landscape: (a) the loss of yellow pine dominated forest and (b) the increase in the area of forest dominated by shade-tolerant conifers (especially fir species). These trends, which have been attributed more to human management choices than changes in climate, are described in Section 3.2 (Past and Present Vegetation Conditions: Conifer Forest).

3.1.4.4 Wildlife

A changing climate could have direct and indirect effects on the distribution and abundance of wildlife in the Moonlight Fire area. Recent work comparing historic (1914-1920) and contemporary small mammal surveys in Yosemite National Park (Moritz et al. 2008) documented range contractions in several high elevation species, as well as upward geographic range shifts in several lower elevation species. Similar patterns have also been observed for butterfly (Forister et al. 2010) and bird species (Tingley et al. 2009) in the Sierra Nevada. These studies suggest that wildlife species are moving in response to changing climates in order to maintain the environmental conditions to which they are adapted. Species with a high degree of habitat specialization and a smaller natural thermal range are more sensitive to changes in climate and may be under more pressure to move as climates warm (Gardali et al. 2012; Jiguet et al. 2006). As species shift their range, they will encounter new competition and predation pressures (Stralberg et al. 2009).

One major indirect impact of climate change on wildlife populations is the loss of synchrony between reproductive or migratory phenology and resource availability (Seavy et al. 2009, MacMyonowski and Root 2007). For example, the breeding dates of birds like tree swallows have advanced during the last century (Dunn and Winkler 1999), which may lead to a mismatch in timing of egg lying and the availability of food. In other areas, decreasing songbird diversity and abundance has been indirectly attributed to decreasing snowfall patterns (Martin and Maron 2012). Climate-related changes in parasitism, disease, and disturbance processes can also indirectly impact wildlife species.

3.1.5 Projected Future Trends

A review of projected future trends in climate by Safford and others (2012) described that over the next century, average temperatures across the Sierra Nevada are predicted to increase by as much as 2-4 °F in the winter and 4-8 °F in the summer. Although future changes in precipitation are more difficult to predict, most models are in agreement that summers will be drier than they are currently, primarily as a result of declining snow pack, regardless of annual precipitation levels. Snowpack across the Sierra Nevada has also been projected to decrease by 20 to 90 percent. Increased temperatures and lower snowpack in the Moonlight Fire area could result in (1) substantial increases in flood risk due to higher peak runoff; (2) increased wildfire size and extent; (3) increased drought stress; (4) expansion of invasive species; (5) higher frequency of insect and disease outbreaks; and (6) range contraction of wildlife species.

3.1.6 Considering Climate in Restoration

Future changes in climate will have direct and indirect impacts on plant and animal populations, forest structure, hydrologic processes, and disturbance regimes both within the Moonlight Fire area and in the surrounding landscape. To address climate change, restoration strategies in the Moonlight Fire area will incorporate management strategies that focus on resistance, resilience, response, and realignment by:

- Enhancing resilience and sustainability by removing or reducing non-climatic stressors; examples may include decreasing the density of forested stands, reducing fuel loads, restoring hydrologic systems, enhancing riparian vegetation, and protecting wildlife corridors to reduce fragmentation.
- Focusing on promoting heterogeneity in ecological structure, function, and composition. Homogeneous conditions promote low resilience to disturbances and projected changes in climate. Altering forest conditions so that disturbance processes can act to increase, rather than reduce, forest heterogeneity will provide ecosystems with the ecological flexibility (Holling 1973) to withstand and persist through future changes in climate and climate-related processes (Safford et al. 2012).

3.2 Past and Present Vegetation Conditions: Conifer Forest

Vegetation and fire and fuels are inherently linked because vegetation type, structure, and development have a profound effect on fuel accumulations and fire behavior, and conversely, fuel accumulations and fire behavior can have a profound effect on vegetation establishment, development, and structure.

In July 2007, the Antelope Complex Fire burned approximately 23,000 acres, over 13,000 acres of which burned with high fire severity. Two months later in September of 2007, the Moonlight Fire burned into the Antelope Complex Fire resulting in an additional 65,000 acres burned, with over 37,000 acres burning under high severity. Consequently, the direct, indirect, and cumulative effects of these fires, including size, severity, and adjacency converted a landscape

previously characterized by extensively forested stands into a landscape now characterized by vast areas of standing dead trees and montane chaparral (USDA 2009).

For the purpose of this restoration strategy, the ten watersheds containing the Moonlight Fire and the Antelope Complex Fire were used as the analysis area for conifer forest vegetation (Figure 8); this area was selected because:

1) It utilizes the watershed boundaries, which are a widely recognized ecological unit for analyzing forest vegetation on the landscape scale;
2) It considers the spatial and temporal relationship of fires on the landscape, which provides the ecological context and scale appropriate to assess the direct, indirect, and cumulative effects of the Moonlight Fire on loss of conifer forest vegetation.
    a. Spatial Effects: Limiting the scope of the analysis to the Moonlight fire watersheds substantially underestimates the loss of mid and late seral forest vegetation across the landscape. In 2007, the Moonlight Fire burned into the 2007 Antelope Complex fire, spatially connecting large areas of deforested conditions and expanding the loss of conifer forest vegetation by a factor of three (Figure 8, Figure 11, Figure 16). The analysis area accounts for the cumulative effects to conifer forest vegetation from the Moonlight Fire which fundamentally altered the spatial occurrence and distribution of mid to late seral conifer forest vegetation on the landscape (Figure 16);
    b. Temporal Effects: As described above, the Moonlight Fire resulted in large scale loss of mid to late seral conifer forest (Figure 16). Development of mid to later seral forest types will take a century, if not more (Figure 17). During this time, conifer forests will remain highly susceptible to future fires (including re-burns) and changing climatic conditions – which further hinder the establishment and development of conifer forest vegetation and increase the risk of long term loss of conifer forest due to vegetation type conversion. Consequently, an effective restoration strategy must include efforts to protect existing mid and late seral stands from stand replacing fire in order to insure the occurrence of these stands in the interim century. Limiting the analysis to the Moonlight Fire watersheds would not address the temporal loss of mid to late seral forests and the uncertainty associated with their development because the vast majority of these stands were already lost in the fire. The ten watershed analysis area provides the appropriate context and scale for the long term restoration of the temporal occurrence and distribution of mid to late seral conifer forests on the landscape.
3) It allows for a landscape level analysis of both on site and off site restoration opportunities as part of a comprehensive long term restoration strategy for conifer forest vegetation affected by the Moonlight Fire.

Refer to Section 5.1 (Conifer Forest Vegetation Desired Conditions, Goals, and Objectives) for additional discussion about the ecological context and scale chosen to analyze and identify conifer forest vegetation restoration opportunities.

Figure 8 shows the affected watersheds and the spatial relationship in fire severity between the 2007 Moonlight Fire, 2007 Antelope Complex Fire, 2006 Boulder Fire, and 2001 Stream Fire, all of which cumulatively impacted forest vegetation across the landscape. It is widely recognized that the size and scale of these fires may be within the ecological range of natural variation; however the primary issue of concern in the Moonlight Fire is that uncharacteristically large patches of high severity fire have had an effect on landscape-level vegetation within a relatively short time period (2001-2007) This increases the long term risk of widespread type conversion of conifer forest vegetation to montane chaparral.

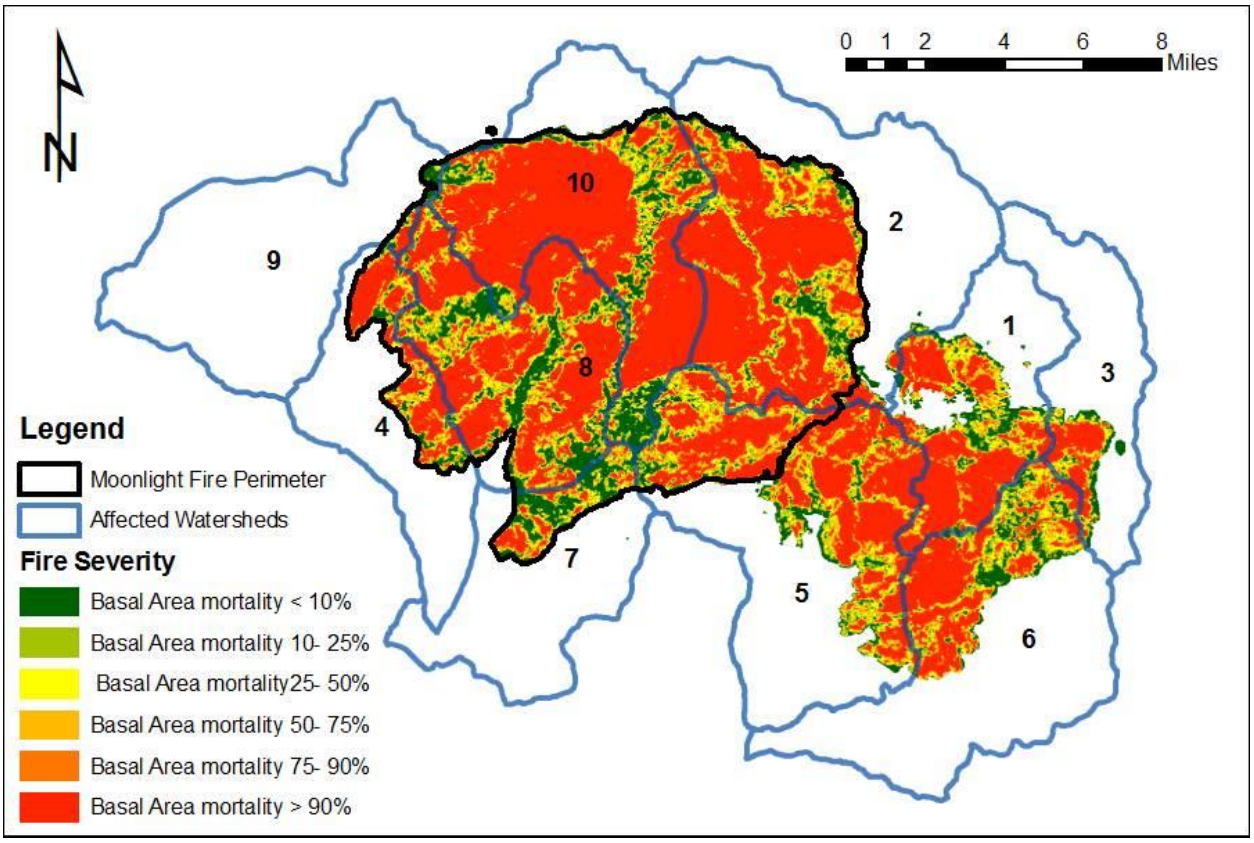


Figure 8. Area analyzed for conifer forest conditions; map displays the affected watersheds and the spatial relationship and severity of the 2007 Moonlight Fire and adjacent wildfires. The affected watersheds are numbered respective to Table 4.

Table 4 displays the affected watersheds, the percent burned, and the percent changed to a deforested vegetation condition as a result of high fire severity. Upper Lights Creek, Middle Lights Creek, Antelope Creek, Antelope Lake, and Genesee Valley all have uncharacteristically high amounts of high severity fire resulting in large proportions of deforested conditions.

Table 4. Affected Watersheds, percent of the watershed burned, and percent of the landscape in a "Deforested Condition"

Map ID	Watershed Name	Acres[1]	Percent burned	Percent in a Deforested Condition
1	Antelope Creek	13,220	61%	43%
2	Antelope Lake	32,389	53%	41%
3	Clarks Creek	11,730	17%	11%
4	Cooks Creek	13,488	31%	21%
5	Genesee Valley	27,110	58%	42%
6	Lower Last Chance Creek	23,585	33%	21%
7	Lower Lights Creek	14,522	20%	7%
8	Middle Lights Creek	16,694	97%	66%
9	Mountain Meadows (Lassen NF)	20,490	3%	1%
10	Upper Lights Creek	22,813	83%	62%
	TOTAL	**196,041**	**48%**	**34%**

[1] Reported acres and percentages include private land within the affected watersheds.

Forests within the eastside of the Sierra Nevada tend to be drier and occur on less productive sites characterized by poorly developed soils. The Forest Survey Site Class (FSSC) in the Moonlight and Antelope Complex fires range from five to seven, based on an index where FSSC seven represents the least productive site class (USDA 2006a). These relative lower site quality conditions exacerbate the temporal recovery of areas currently classified as deforested by delaying establishment, growth, and development of forest vegetation within the affected watersheds.

3.2.1 Historic Conditions

Historic vegetation data is somewhat scant for this area as it was not included in Lieberg's (1902) survey of forest conditions in the northern Sierra, or the recently digitized 1930s Wieslander Maps (Thorne et al. 2008). However, both historical sources do describe vegetative conditions in the Downieville and Sierraville quadrants just south of the Moonlight Fire area. We used these data, along with general patterns of precipitation across the region, to develop general inferences about forest vegetation types within the analysis area. This approach, using variables such as annual precipitation, evapotranspiration, and available water budget, is frequently used to classify ecological zones and describe ranges of dominant species types (Stephenson 1998, Van Wagtendonk and Fites-Kaufman 2006, Safford 2013).

The nearest Wieslander vegetation map completed in the 1930's lies between three and 20 miles south of the affected watersheds (Figure 9). Wieslander's map indicates that yellow pine forests generally dominate landscapes that receive less than 1000 mm of annual precipitation; this is congruent with descriptions of yellow pine and dry yellow pine dominated mixed conifer, also known as dry mixed conifer forests (Safford 2013). This trend also roughly corresponds with elevation, though it should be noted that within the affected watersheds, yellow pine forests range much higher in elevation due to lower annual precipitation levels and the

proximity to the eastern escarpment of the Sierra. Van Wagtendonk and Fites-Kaufman (2006) describe the eastside pine dominated forest type as being more than 20 miles wide from the eastern edge of the Sierra, particularly in the area north of Lake Tahoe where the affected watersheds are located.

Consequently, it is a reasonable assumption that much of the area affected by the fire was historically yellow pine dominated forest along with dry mixed conifer forest (Moody 2002, Taylor 2008). While transition to the more mesic Sierra mixed conifer forest likely occurred in areas with higher annual precipitation, this was likely restricted to the very western portion of the affected watersheds, and true fir forests were likely limited to the highest of elevations and mesic northern aspects.

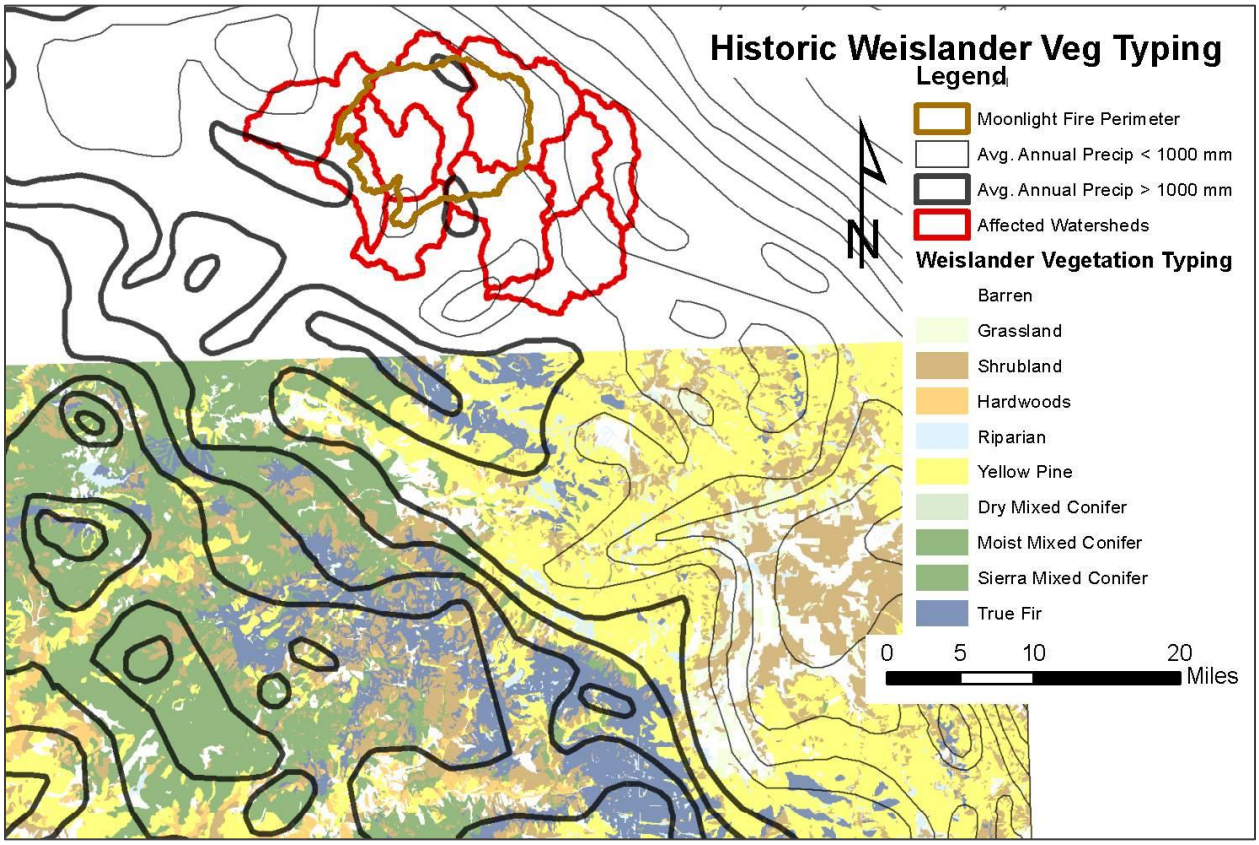


Figure 9. Historic 1930's Wieslander Vegetation Typing and Average Annual Precipitation. While these maps don't cover the Moonlight Fire area directly, Weislander did classify the historic vegetation immediately south of the affected watersheds. Wieslander's map indicates that yellow pine forests generally dominate landscapes that receive less than 1000 mm of annual precipitation, and this trend can reasonably be extrapolated to the north.

Modeling by Safford (2013) indicates that for yellow pine, dry mixed conifer, and moist mixed conifer forest types, as much as 45 to 50 percent of these forest types would be in a later seral stage under a natural fire disturbance regime (Figure 10). The modeling also suggests that for yellow pine and dry mixed conifer forest types, the majority of both the mid and later seral stages would have open canopy structure, which is characteristic of a more active fire regime

typified by frequent, low to mixed severity fire. Within the analysis area, both the 1945 California Timberlands Map and the 1941 aerial photos (Figure 10) confirm the trends noted by Safford (2013), suggesting that a majority of the area was dominated by later seral stand conditions.

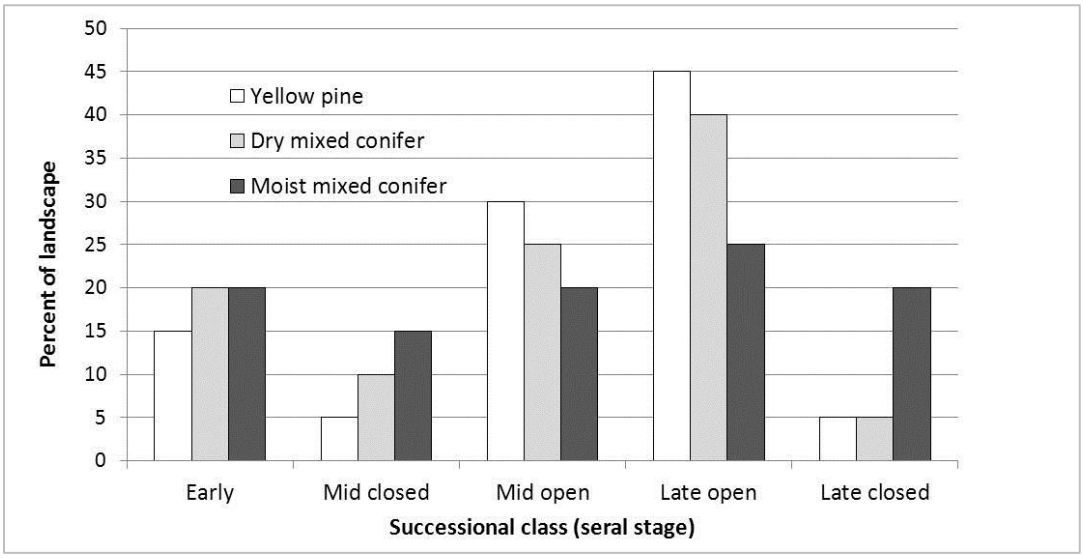


Figure 10. Seral Stage Distribution by Forest Type as modeled by Safford (2013)

Figure 11 displays a comparison of aerial photographs of the lower Lone Rock Valley and the upper reach of the Cold Stream drainage from 1941 (Photo A), 1998 (Photo B), 2005 (Photo C), and 2009 (Photo D). These photos show departure from historic landscape conditions, as well as the cumulative spatial and temporal effects of the 2007 Moonlight Fire and the 2001 Stream Fire. In the historic 1941 aerial photograph (Figure 11A), fire suppression policies had been in effect for approximately 30 years and there was little infrastructure or active forest management evident on the landscape. Considering this, these 1941 photos may depict the closest representation of a forest condition that is likely not too far departed from historical reference conditions – namely a forest that developed under a natural fire regime. Of particular note, the 1941 photo shows forest conditions dominated by later seral stages with landscape heterogeneity in canopy structure driven by aspect; more specifically the prevalence of open canopy conditions along drier south and west facing slopes, and more mesic closed canopy conditions on north-northeast facing aspects. These patterns reflect restoration framework objectives currently being employed across the Sierra Nevada (North et al. 2009 and North 2012).

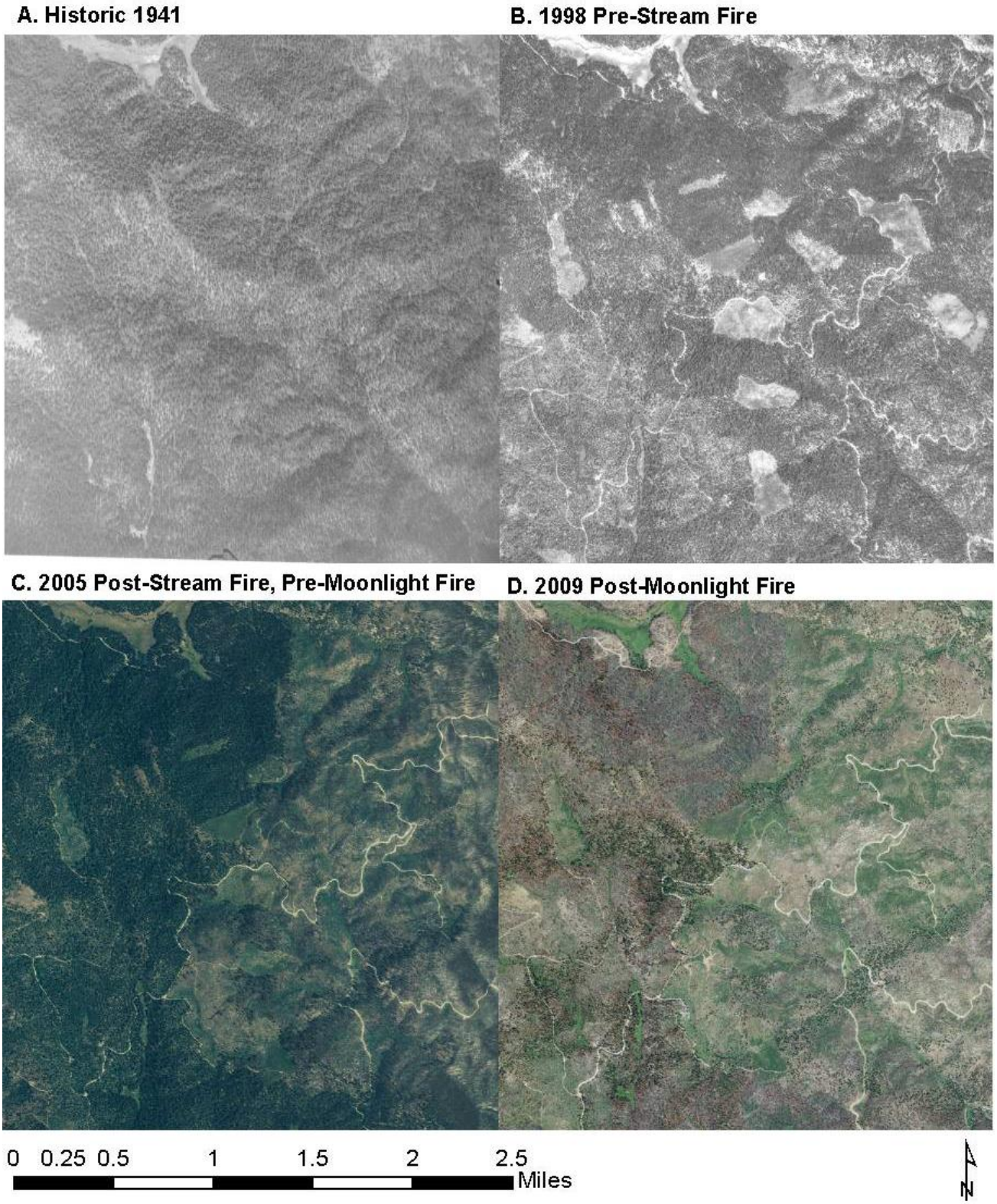


Figure 11. Comparison of Aerial Photographs of the Lower Lone Rock Valley and upper reach of the Cold Stream Drainage from 1941, 1998, 2005, and 2009. (T 27N. R 12E. Section 20 is the approximate center of the photos)

By 1998 (Figure 11B) and 2005 (Figure 11C), the effect of past management practices is evident on the landscape, including the construction of logging road infrastructure, fragmentation from clear-cutting, preferential removal of large diameter overstory trees, and increasing stand densities of mid seral closed canopy stands.

The 2005 photo (Figure 11C) also shows the effect of the Stream Fire that burned approximately 3,000 acres in July of 2001. Finally, the 2009 photo (Figure 11D) shows the cumulative effects of the 2007 Moonlight Fire on mid and later seral stands and the large scale type conversion within this landscape from forested conditions to one dominated by snags and montane chaparral (USDA 2009).

3.2.2 Contemporary Pre-fire conditions

Prior to the Moonlight and Antelope Complex fires, the landscape in the analysis area consisted primarily of pine-dominated Sierra mixed conifer forests, true fir forests at the highest elevations, and plantations established over the last 40 years in burned areas and clear-cut units.

Past harvest activities resulted in: 1) the reduction of large dominant and codominant overstory trees; 2) the retention and ingrowth of smaller diameter trees; and 3) a shift in species composition from shade-intolerant pine dominated stands to shade-tolerant, white fir dominated stands. In addition, a near absence of landscape level, low-intensity surface fires contributed to increased stand densities in smaller diameter classes and large accumulations of ground fuels, ladder fuels, and canopy fuels which increase the potential for stand-replacing, high-severity fire events (Skinner and Chang 1996, Weatherspoon and Skinner 1996). These high-density stands are also more susceptible to density-dependent mortality, driven by drought and insect and disease infestations (Ferrell 1996, Cochran 1998, Guarin and Taylor 2005, Macomber and Woodcock 1994). The Moonlight landscape was affected by widespread drought in the late 1980s and early 1990s, which resulted in extensive tree mortality. Much of this material has become dead and down fuel further contributing to surface fuel loads and stand replacing fire risk in remaining mid to late seral forests. All of these factors largely decreased landscape level forest heterogeneity (McKelvey and Johnston 1992).

Because such stand structure has increased vulnerability to high-severity fires, insect outbreaks, and drought-induced mortality, a homogenous occurrence of this seral stage across the landscape is unstable and more susceptible to large-scale high severity fire events such as the Moonlight and Antelope Complex fires (McKelvey and Johnston 1992, Millar et al. 2007). The result was an uncharacteristically rapid and large shift in forest vegetation types across the landscape (Figure 12). Conifer forests (yellow pine, Sierra mixed conifer, and true fir forests) dominated by long lived conifer tree species and characterized by frequent low severity fire regimes were converted to shrublands dominated by montane chaparral species (i.e. relatively short lived *Ceanothus* and *Arctostaphylos* species) with infrequent high severity fire regimes.

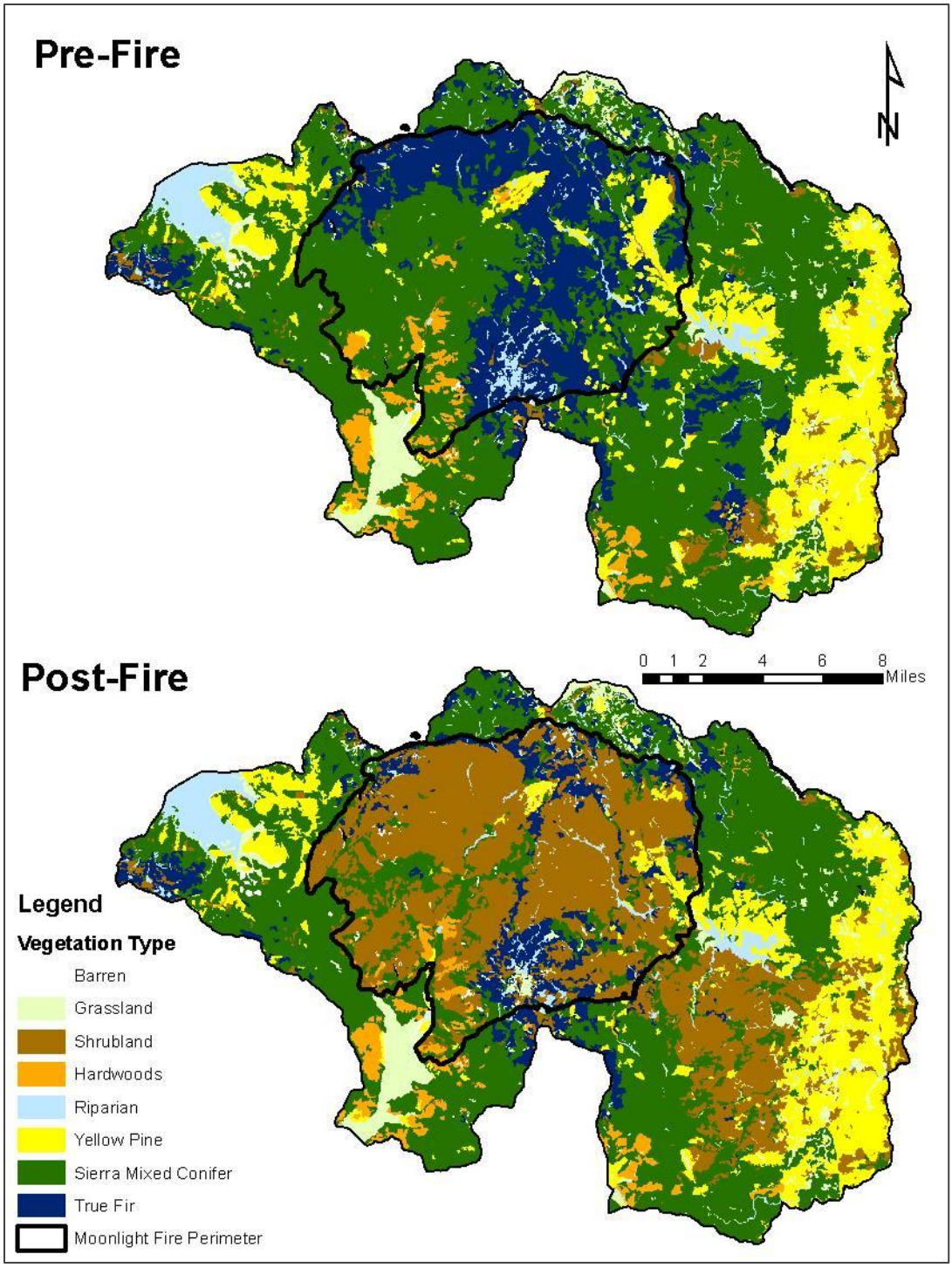
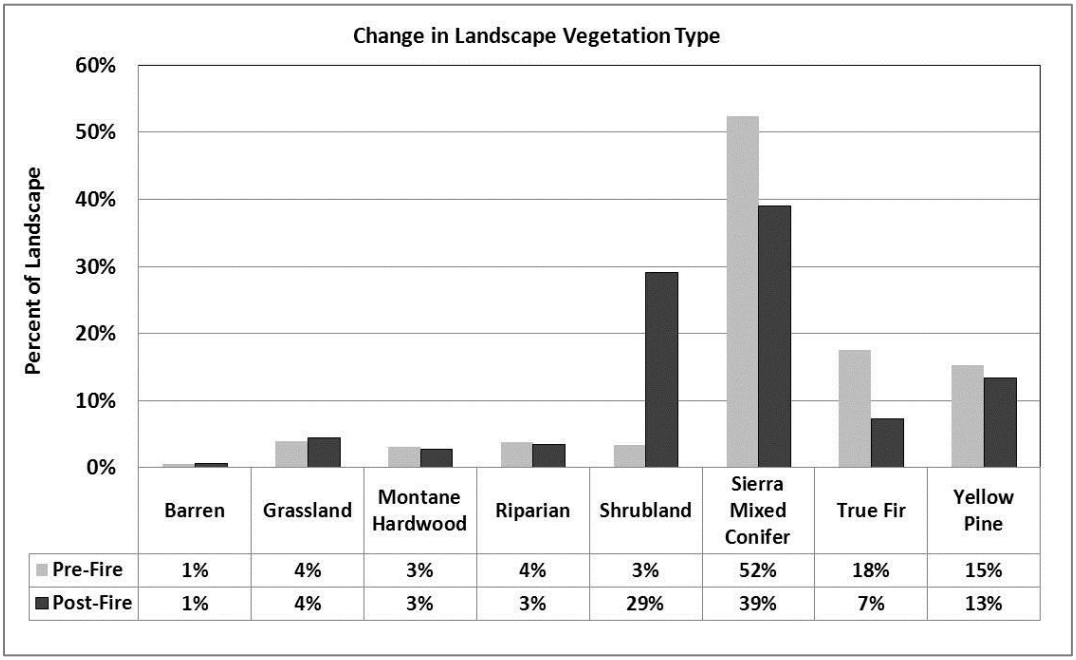


Figure 12. Pre and post-fire vegetation types across the landscape

3.2.3 Post-fire conditions

Between 2001 and 2007 approximately 48 percent of the landscape in the analysis area burned. In these fires, 70 percent of the area burned at high severity, resulting in uncharacteristically

large areas of standing dead trees, which are now dominated by shrubs. These large areas may adversely affect and/or delay the regeneration, establishment, and growth of conifer forest types due to factors such as reduced seed sources, increased distances to seed sources, and the effect of competing vegetation. Montane chaparral is an ecologically important early seral stage in conifer forest; however, the large patch size, and homogenous distribution of these areas across the landscape effectively increases the risk of vegetation type conversion from forest to shrubland for decades, if not permanently, while reducing the diversity of vegetation across the landscape. This presents a concern for the long term viability of forest vegetation within the affected watersheds (USDA 2009, USDA 1988a). Figure 12 displays the spatial changes in vegetation types across the landscape; Figure 13 quantifies this change in terms of the percent of the landscape occupied by each vegetation type prior to and after the fires.



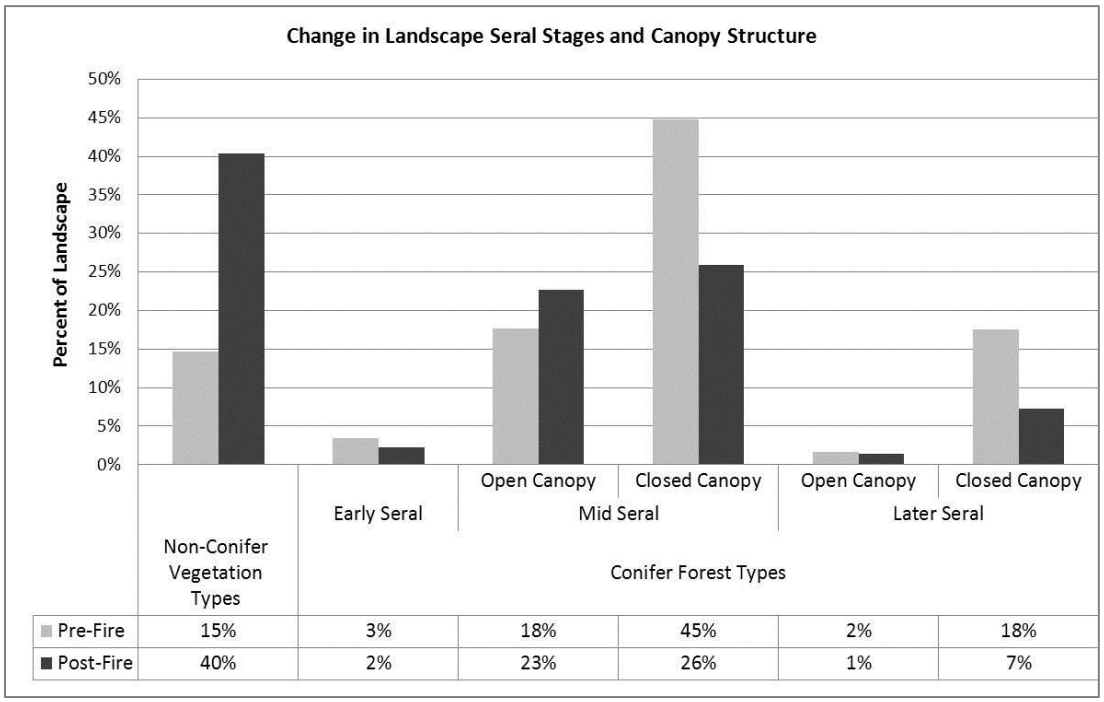
	Barren	Grassland	Montane Hardwood	Riparian	Shrubland	Sierra Mixed Conifer	True Fir	Yellow Pine
Pre-Fire	1%	4%	3%	4%	3%	52%	18%	15%
Post-Fire	1%	4%	3%	3%	29%	39%	7%	13%

Figure 13. Post-fire change in Vegetation types across the affected watersheds

Additional environmental stressors such as climate change, increase the risk of high severity fire and the potential for re-burn within these watersheds, which could further delay or alter the recovery of forest vegetation (Westerling and Bryant 2008, Thompson et al. 2007). The 2008 BTU Complex fires and the 2012 Chips Fire, both of which started within the footprint of the 2000 Storrie Fire, serve as a recent, local, and apropos example of this potential risk. In addition, the Moonlight Fire burned several plantations, which had been established after earlier fires further hindering the recovery of forest vegetation.

These trends highlight the importance of maintaining existing mid and late seral conifer forest on the landscape. The remaining unburned stands in the affected watersheds are also vulnerable to future high severity fire events; this increases the risk of losing values such as later seral forest habitat, desired seed sources, biological legacy structure, and landscape

heterogeneity. Consequently, restoration efforts to improve existing mid and late seral conifer forest and enhance their resistance to stand replacing fire should be a high restoration priority.

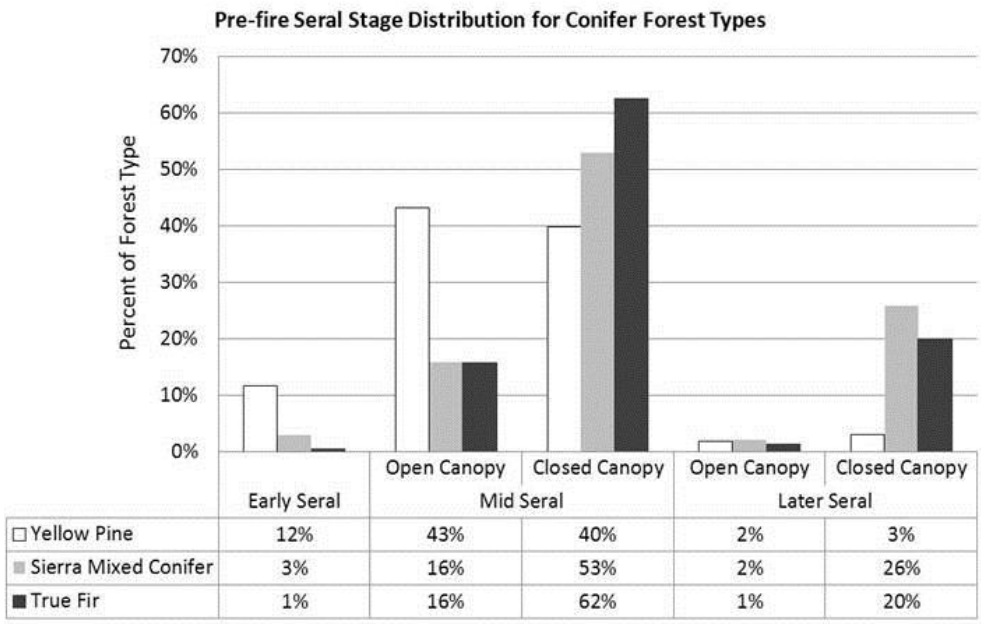


	Non-Conifer Vegetation Types	Early Seral	Mid Seral: Open Canopy	Mid Seral: Closed Canopy	Later Seral: Open Canopy	Later Seral: Closed Canopy
Pre-Fire	15%	3%	18%	45%	2%	18%
Post-Fire	40%	2%	23%	26%	1%	7%

Figure 14. Changes in Landscape Seral Stages and Canopy Structure[1]

Figure 14 displays the change in seral stage and canopy structure for vegetation types in the analysis area. Over 60 percent of the pre-fire landscape was dominated by closed canopy mid and later seral stands; this homogeneous spatial distribution makes the landscape particularly unstable and vulnerable to large scale high severity disturbance events, such as those that occurred during the 2007 fire season. As a result, many mid and later seral closed canopy conifer forests were converted to non-conifer forest vegetation due to high fire severities caused by high concentration and continuity of surface, ladder, and canopy fuels. These large homogenous and expansive areas of closed canopy forests experienced the largest vegetation type conversion. As shown in Figure 14, the relative amount of open canopy forest did not notably change. In general, many of the open canopy stands were more resilient to fire effects and had lower fire severities due to the relative lack of ladder fuels and continuity of surface, ladder, and canopy fuels. The increase in mid-seral open canopy stands post-fire is the result of low to moderate severity fire in closed canopy stands.

[1] Note: Conifer forest types that burned with high fire severity and experienced stand replacement were considered to be in a "Deforested Condition" per Region 5 post-fire assessment guidelines and were categorized as non-conifer forest vegetation. Conifer stands with certified establishment and stocking were classified as early seral conifer forest types.



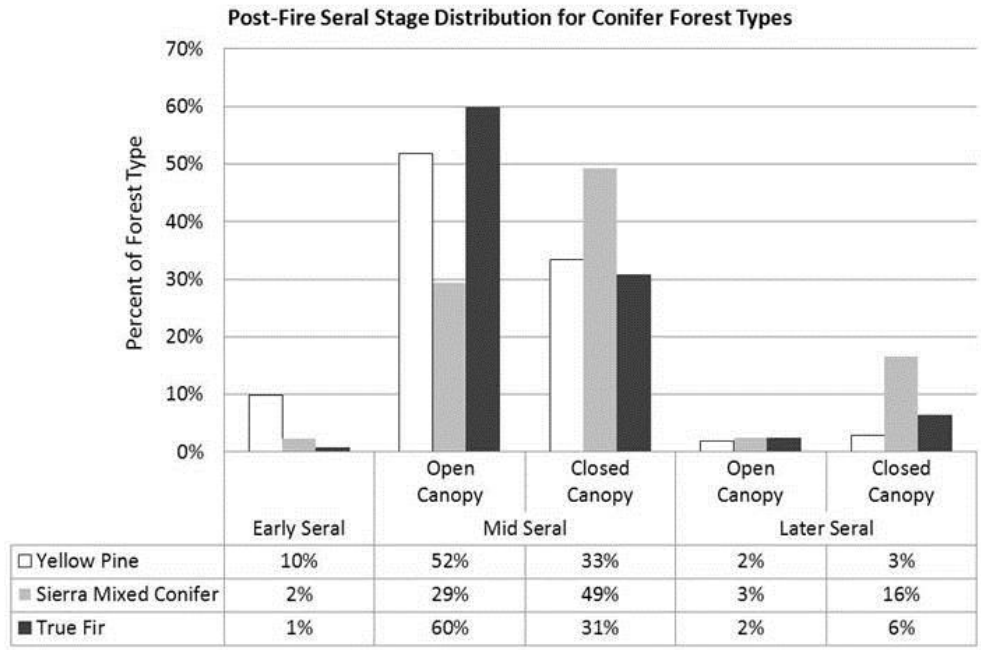


Figure 15. Pre (top) and post-fire (bottom) seral stage distribution for conifer forest types.

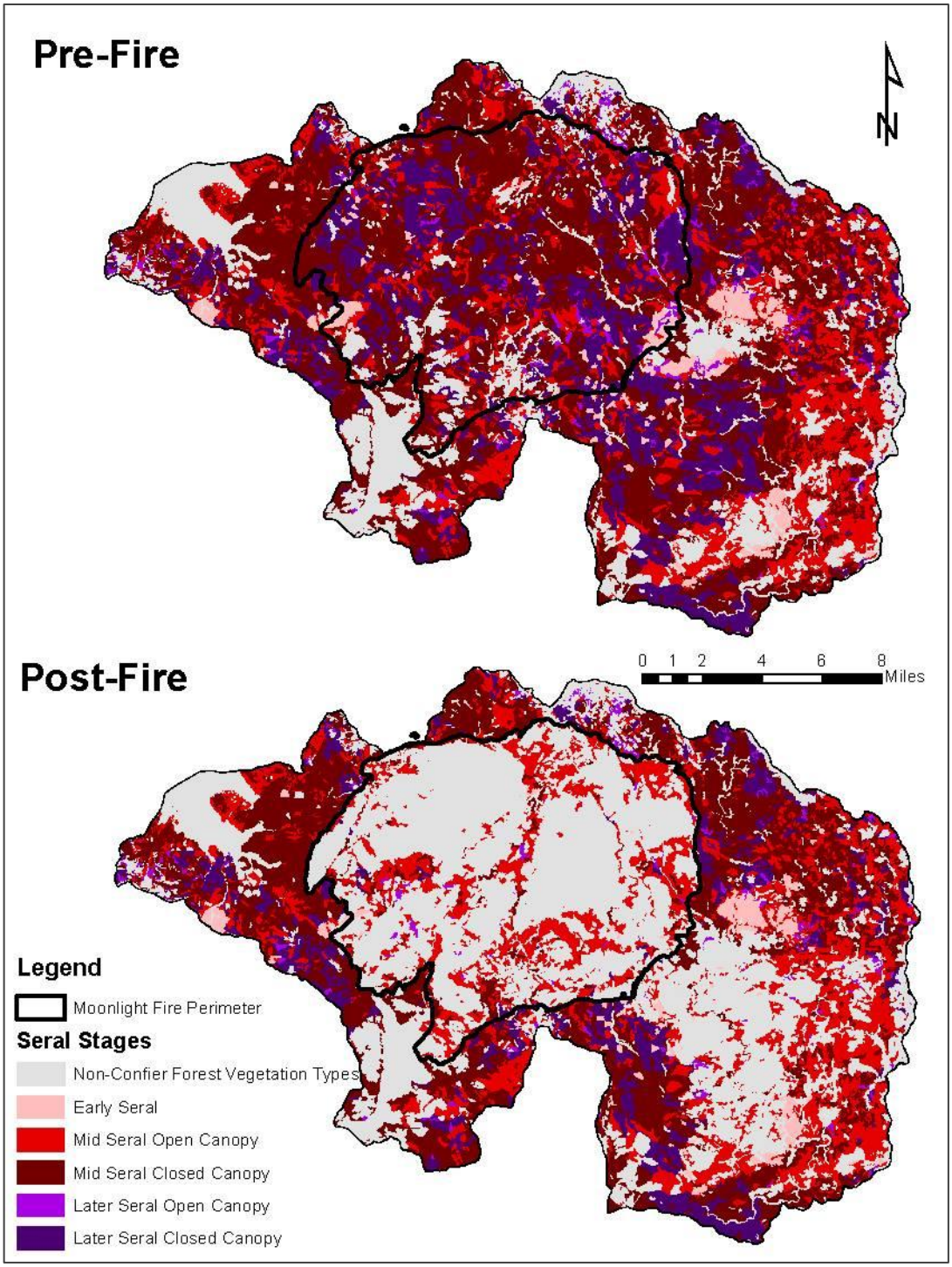


Figure 16. Pre and post-fire spatial distribution of conifer forest seral stages

Figure 15 displays the pre and post-fire distribution of seral stages for yellow pine, Sierra mixed conifer and true fir forest types. The direct and cumulative effect of the Moonlight Fire converted closed canopy mid and later seral stands to non-forest chaparral vegetation types

due to high severity fire. Figure 16 shows that large contiguous patches of closed canopy mid to later seral conifer forest still exist within the affected watersheds. These remaining green stands still have homogenous conditions with heavy accumulations of surface, ladder, and canopy fuels, increasing their susceptibility to future high severity fire. Such potential fire events would only compound the adverse cumulative effects to mid and later seral forest stands within the affected watersheds.

3.2.4 Post-fire development of forest vegetation: observations from past fires within the affected landscape

Post-fire landscapes are dynamic, and temporal development of forest vegetation may vary depending on factors such as soils, topography, site quality, past management, and existing seed sources. Observations from past fires on the Plumas NF serve as a useful reference for understanding potential trajectories of vegetation development over time. The conversion from conifer forest type to montane chaparral (shrub dominated non-forest vegetation), the longevity of these effects, and the development rates of forest vegetation in planted and naturally regenerated areas are evident from observations of past fires on the Plumas NF[2].

- The Morton Creek Fire in the Lights Creek drainage of the Moonlight Fire originally burned in 1959. Fifty years after the fire, plantations were characterized by early seral pole-sized stands (CWHR 3) with small areas of trees greater than 11 inches diameter at breast height (DBH) in favorable microsites. Within these small areas, the dominant trees in the plantation had reached capacity to produce a limited cone crop, but a substantial portion of this plantation was lost in the Moonlight Fire and was converted to montane chaparral.
- The Cooks fire of 1964 was planted in 1965 and prior to the Moonlight Fire was characterized by early seral pole-sized stands (CWHR 3) with a dense component of shrubs. A portion of this area burned in the 1996 Cooks Fire and converted back to montane chaparral. The remaining area burned with high severity in the 2007 Moonlight Fire and subsequently converted back to montane chaparral.
- The Big Burn of 1966 burned in the northeast corner of the Moonlight Fire. The area was planted circa 1967. Forty four years after planting, pine plantations were best characterized by early seral pole-sized stands (CWHR 3) with a prolific shrub component. Hotter and drier sites had noticeably reduced tree growth and denser shrub cover. A substantial portion of this plantation re-burned in the Moonlight fire and was converted to montane chaparral.

[2] It should be noted that plantations established within the affected landscape prior to circa 1990 likely had herbicide treatments implemented to reduce shrub competition and enhance tree survival and growth. Plantations established without the use of herbicide would likely have lower survival rates and longer developmental periods due to the effect of competing vegetation on tree survival and growth.

- The Elephant Fire burned in 1981 in the lower Last Chance Creek watershed of the 2007 Antelope Complex fire. Thirty years after the fire, areas that were left to naturally regenerate were dominated by shrub species. Pine plantations established circa 1983 and 1984 were early seral pole-sized stands (CWHR 3) with a dense component of shrubs. Substantial portions of this fire re-burned in the 2007 Antelope Complex, which converted pine plantation back to shrub dominated areas.

The effects of these fires likely varied in response to site productivity, fire severity, and subsequent post-fire salvage, site prep, and reforestation treatments. Nevertheless, observations indicate common trends in post-fire development of forest vegetation, including:

- Areas of high severity fire that are left to naturally regenerate within the Moonlight Fire will likely be dominated by shrub species for decades and, as is the case in the oldest fire observations, may persist for 85 years or more.
- Pine plantations established after past fires were typically established through intensive site preparation, planting, and follow-up herbicide treatments designed to maximize the growth of planted trees. The majority of these pine plantations have not yet matured past the pole-sized stage (CWHR 3) after 40 to 50 years of growth; however, small areas on more productive sites have developed trees greater than 11 inches DBH and have reached maturity and produced a limited cone crop.
- All of the previously established plantations re-burned further setting back restoration of mid and late seral forests. These early seral pole-sized forest types will remain highly vulnerable to potential re-burns for decades as observed in the Cooks, Morton Creek, Big Burn, and Storrie fires and described by Thompson et al. (2007), particularly with climate-driven changes in fire regimes (Westerling and Bryant 2008).

Past fire trends indicate that these landscapes will likely be dominated by shrubs for decades. They also indicate that large areas of high severity fire, low site quality, poor soils, hot and dry microclimates on south facing slopes, or areas that experience multiple re-burns will likely experience a delay in the return to forested conditions. Those areas left to regenerate naturally are often dominated by shrubs that are susceptible to re-burn, for decades. These conditions exist on NFS lands within the Moonlight Fire area.

Natural Conifer Regeneration. Post-fire natural regeneration is highly variable due to fire severity, patch size, local seed source, competing vegetation, and site quality (Tappenier 2007, USDA 2009). Table 5 displays summarized results from 186 natural regeneration plots measured within the Moonlight Fire area (Welch 2012). Post-fire natural regeneration surveys indicate that 33 to 37 percent of plots sampled within areas that burned under higher fire severity (fire severity codes 4 and 5) had natural regeneration. Of the 92 plots located in high fire severity, 38 percent had no visible seed source, which presents a concern for regeneration in large patches of high fire severity.

Table 5. Seedling density by fire severity[1]

Fire Severity	total # of plots	# plots w regen	% plots w regen	density conifer seedling per plot		density of conifer seedlings per acre	
				mean	s.d.	mean	s.d.
0	10	6	60	3.4	5.4	238.0	380.8
1	29	11	38	1.8	3.8	127.9	269.2
2	22	8	36	2.7	4.9	190.9	345.8
3	14	6	43	1.8	2.9	125.0	202.1
4	18	6	33	1.0	1.8	70.0	129.3
5	92	34	37	1.5	5.5	102.0	382.3

[1] This table is a summary of Kevin Welch's 2012 study and annual report. Kevin Welch's summary uses the National Park Service Fire Monitoring Handbook protocol to categorize and report by Fire severity. For reference, Fire Severity 3 is approximate to 50-75% BA mortality, Fire Severity 4 is approximate to 75-100% BA mortality where trees retain dead needles, and Fire Severity 5 is approximate to 100% BA mortality with full consumption of crowns and needles.

While natural regeneration is occurring within the Moonlight Fire, particularly within the lower fire severities, one large concern is the composition of regenerating species. Natural regeneration in the lower fire severities was skewed toward shade tolerant species such as white fir, Douglas-fir, and incense cedar. The higher fire severities had larger proportions of shade intolerant natural regeneration. In Welch's (2012) study, larger patch sizes of high severity fire with farther distances to remnant seed trees may be a limiting factor in meeting desired stocking levels, particularly with pine species (also suggested by Collins and Roller 2013).

3.2.5 Post-fire development of forest vegetation: site quality and projected development of forest vegetation

Site quality is used to describe the relative productivity of a site and is usually measured in terms of the capacity for forest or tree growth. Site classifications and site indices provide useful metrics in measuring the potential growth and development of forest vegetation on differing sites (Helms 1998) as well as quantifying the timeframes it would take to restore mid to late seral forest vegetation.

The Forest Survey Site Classes for the Moonlight Fire area are 5, 6, and 7; these are the least productive of the site classes This indicates that site quality in the Moonlight Fire area has relatively low potential in terms of forest growth and production. Forest Survey Site Classes 5, 6, and 7 are equivalent to the Region 5 site classes 3, 4, and 5.

Stand exam information collected in the Moonlight Fire area measured tree heights and tree ages for mid to late seral stands. Stand exam data[3] from the Moonlight Fire area indicate that

[3] Pre-fire stand exam information (collected in the Moonlight Fire area before the fire) measured tree heights and tree age in mid to late seral stands in the fire area. In addition post-fire stand exam information collected within

mid to late seral stands had maximum tree heights that ranged from approximately 70 to over 175 feet in height for predominant, dominant, and codominant trees; on average, maximum stand height of trees within these stands was approximately 125 feet.

As shown in Figure 17, Region 5 site index tables for site class 3 indicate that it could take over 300 years for 125 foot tall trees to develop on these sites. However, favorable microsites such as drainages and valley bottoms may be better represented by Region 5 site class 2, which suggests that it would require 180 years for a 125 foot tall tree to develop. Site trees sampled for age and height indicate that trees greater than 125 feet tall ranged in age from 145 to 400 years old and were approximately 330 years old on average. These data in conjunction with observations of development on past fires indicate that it could take nearly two to three centuries for late seral conditions to develop on the majority of the landscape.

	Site Class (Field 10)					
Age	0	1	2	3	4	5
40	95	81	66	49	43	35
50	106	90	75	56	49	39
60	115	98	82	63	53	43
70	122	105	88	68	58	45
80	129	111	93	73	61	48
90	135	116	98	77	64	50
100	140	121	102	81	67	54
110	145	125	106	84	70	54
120	149	129	109	87	72	55
130	153	133	112	90	74	57
140	157	136	115	93	76	58
150	160	139	118	95	78	60
160	163	142	120	98	80	61
170	166	144	123	100	81	62
180	169	147	125	102	83	63
190	172	149	127	104	84	64
200	175	152	129	106	86	65
220	179	156	133	109	88	67
240	184	160	136	112	90	68
260	188	163	139	115	93	70
280	191	166	142	117	95	71
300	195	169	145	120	96	73
320	198	172	147	122	98	74
340	201	175	150	124	100	75
360	204	177	152	126	101	76
380	206	180	154	128	103	77
400	209	182	156	130	104	78

Figure 17. Region 5 Site Classes show height by age and site class. The Region five site classes are based on ponderosa pine, Jeffrey pine, sugar pine, Douglas-fir, red fir, and white fir. Note: the yellow highlighted data displays that: For Site Class 2, it would take approx.180 years for the development of a 125 ft. tall tree. For Site Class 3, it would take approx. 340 years for the development of a 124 ft. tall tree.

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mid to late seral stands that burned with high and moderately high severity (>50 percent basal area mortality) in the Moonlight Fire measured tree heights in the fire area.

3.2.6 Post-fire Salvage and Reforestation Treatments on National Forest System Lands

Within the Moonlight Fire, post-fire harvest treatments were primarily focused on roadside hazard tree removal and post-fire salvage treatments to recover the value of fire-killed trees. Post-fire reforestation efforts were implemented annually between 2008 and 2011, with an emphasis on establishing a future seed source of desired species across the landscape, particularly in large areas of high severity fire where local seed sources were killed.

Roadside Hazard Tree Removal. Fire-killed and fire-injured trees were harvested within 150 feet of the road prisms along all the Level 2-5 roads (open NF System roads) within the Moonlight Fire perimeter (approximately 4,389 acres). Treatment units were determined by road location and included a variation of CWHR vegetation types, size classes, and densities. It is important to note that within this strip along the roads, only fire-killed or fire-injured trees capable of hitting the road were removed. Consequently, there was variable retention of dead and live forest cover depending on site specific local variables such as fire severity, mortality or damage to trees, and assessment of hazard/target proximity. All trees greater than 10 inches DBH were removed if the tree posed a hazard to the road.

Fire Salvage Harvest. Fire-killed trees were harvested across approximately 5,158 acres of conifer forest that burned with high fire severity. The salvage harvest was focused on conifer stands best characterized by CWHR size classes 4 and 5 of moderate (M) to dense (D) canopy cover. The majority of this occurred within ground based logging units; however, some skyline and helicopter harvest did occur on the Cairn Sale centered on the Lower Lights Creek drainage and Moonlight Valley. In all of these treatments, only larger merchantable trees were removed leaving approximately 275 to 400 trees less than 16 inches in diameter per acre on site. Approximately 1,720 acres were harvested using helicopter logging; due to the nature of helicopter logging, only large diameter high quality trees were harvested, and harvest did not occur on every acre, which maintained higher amounts of snags.

Reforestation. Between 2008 and 2011, approximately 13,000 acres of conifer forest that burned with high fire severity were planted. Approximately 100 to 210 trees per acre were planted in a wide-spaced cluster design to emulate the heterogeneity of a naturally occurring forest while allowing space for natural regeneration where available. Of these 13,000 acres, only eight percent or 2,000 acres received follow-up tree release and weed treatments, primarily due to safety concerns. Of the 2,000 acres that received release treatments, approximately half were in units that had been salvaged logged where snag hazards had been abated, and the other half were within the carbon demonstration plantation in the Pierce Creek Drainage. While release treatments increased plantation survival, overall, tree survival in plantations was highly variable and averaged approximately 33 percent due to: aggressive colonization of the site by shrub species; a two to three year delay in planting on some sites; poor site quality and/or droughty decomposed granitic soils; and competition for resources with competing vegetation.

3.2.7 Post-fire Salvage and Reforestation Treatments on Private Lands

Post-fire treatments on private lands within the Moonlight Fire included salvage harvest, herbicide applications, and plantation reforestation. These treatments were initiated rapidly. Salvage operations were intensive and extensive, covering all lands capable of timber production; reforestation treatments were focused on establishing conifer plantations and maximizing growth and yield through elimination of competing vegetation. Intensive herbicide treatments proved to be highly effective in reducing competing vegetation, and as a result, survival and growth rates of planted seedlings are much higher on private timberlands. It is a reasonable assumption that these lands will be intensively managed as conventionally spaced conifer plantations.

3.3 Past and Present Vegetation Conditions: Hardwood Forest

The effects of the Moonlight Fire on hardwood forest vegetation were evaluated using the conifer forest vegetation analysis area, encompassing the ten watersheds containing the Moonlight and Antelope Complex fires (Figure 8). Based on this evaluation, described below, the Moonlight Fire shifted the age class distribution of hardwoods across the landscape to sprouts and seedlings. Restoration efforts to protect this new cohort of hardwoods within the fire perimeter will be the first priority. However, additional efforts to protect and restore existing mature hardwood stands may also be important to maintain hardwoods on the landscape until the new cohort of hardwoods within the fire perimeter have matured.

Hardwoods addressed in this strategy include widespread lower montane species such as California black oak *(Quercus kelloggii*) and canyon live oak (*Quercus chrysolepis*). Hardwood species associated with riparian areas, including aspen, are addressed in Section 3.5 (Past and Present Vegetation Conditions: Meadow, Fen, Aspen and Riparian Vegetation).

Hardwood species have a number of adaptations that allow them to tolerate fire. Most species can sprout from epicormic buds following disturbances that kill the above ground stems (McDonald and Tappeiner 1996). Sprouting can be vigorous, with up to 100 sprouts observed emerging from a single stump. The growth rate of sprouts is high, allowing hardwood species to quickly reoccupy sites after fires.

Fire and other disturbances are critical to maintaining hardwood species in lower montane forests. California black oak, for example, is very well adapted to early seral conditions, requiring light for rapid growth in both the seedling and sapling stages (McDonald and Tappeiner 1996). Fire reduces canopy cover, creating openings for California black oak seedling establishment, growth and development, while also killing fire intolerant, late successional conifers (Plumb 1979). The absence of disturbance, such as fire, will eventually eliminate California black oak in lower montane forests by allowing it to be replaced by conifer forests.

Hardwood vegetation occupied approximately three percent of the analysis area both prior to and after the Moonlight Fire (Figure 13). However, the fire changed the structure of these stands by decreasing the number of acres of hardwood vegetation classified as closed stands

(40 percent or greater canopy closure) by almost 23 percent. The extent of hardwood vegetation classified as open stands (with less than 25 percent canopy closure), increased by over ten percent. The Moonlight Fire also shifted the size class distribution of hardwoods, causing a 16 percent decline in the extent of hardwoods over 11 inches DBH. There were no hardwoods in the seedling stage prior to the fire; almost 1,000 acres were mapped as hardwood seedlings after the fire. These data suggest the Moonlight Fire promoted sprouting of hardwoods and improved hardwood stand conditions by creating more open canopies and increasing light availability.

3.4 Past and Present Vegetation Conditions: Montane and Mixed Chaparral

The effects of the Moonlight Fire on montane and mixed chaparral vegetation were evaluated using the conifer forest vegetation analysis area, encompassing the ten watersheds containing the Moonlight and Antelope Complex fires (Figure 8). Based on this evaluation, described below, the Moonlight Fire did not appear to negatively affect chaparral vegetation in areas outside the fire perimeter, making potential restoration projects for montane and mixed chaparral within the Moonlight Fire perimeter the highest priority for restoration.

Montane and mixed chaparral in the analysis area can support a number of different shrub species, but often includes white-thorn (*Ceanothus cordulatus*), tobacco brush (*Ceanothus velutinus*), and green-leaf manzanita (*Arctostaphylos patula*).

Montane and mixed chaparral shrubs are fire adapted and establish rapidly after fire, either by sprouting or by germinating from a soil seed bank. For example, *Ceanothus* seeds can survive for over 200 years in the soil, allowing it to persist during long fire-free periods. Fire suppression has reduced the extent of montane and mixed chaparral as a result of succession to conifer dominated forests (Nagel and Taylor 2005). The fuel structure of montane and mixed chaparral often results in high severity crown fire, and chaparral is often more abundant on south facing upper slope positions where topography favors higher fire severity (Weatherspoon and Skinner 1995, Beaty and Taylor 2008). Large patches of montane and mixed chaparral may alter fire regimes by promoting longer fire return intervals and higher fire severity, which can effectively preclude the reestablishment of tree dominated vegetation.

The extent of montane and mixed chaparral vegetation in the analysis area increased dramatically after the Moonlight Fire (Figure 12). Shrubs occupied approximately three percent of the analysis area prior to the fire, and 29 percent of the analysis area after the fire (Figure 13). This 26 percent increase in the extent of montane and mixed chaparral as a result of the Moonlight Fire was associated with a 26 percent decrease in the extent of Sierra mixed conifer, true fir, and yellow pine forest types, as described in Section 3.2 (Past and Present Vegetation Conditions: Conifer Forest). Mature and decadent shrubs were entirely replaced by shrub seedlings as a result of the Moonlight Fire (Figure 18).

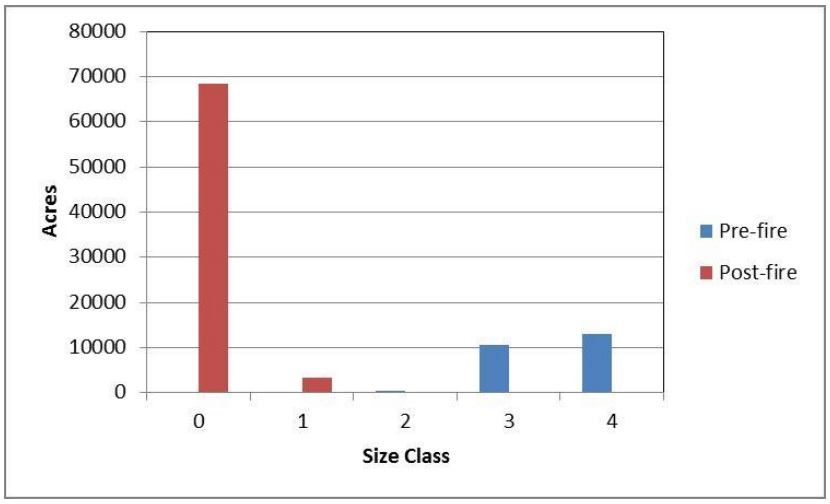

Figure 18. Size class distribution of montane and mixed chaparral prior to and after the Moonlight Fire. Size classes are: 1=Seedling Shrub, 2=Young Shrub, 3=Mature Shrub, and 4=Decadent Shrub. Data from USDA (2011b).

Prior to the Moonlight Fire, the mean patch size of montane and mixed chaparral was approximately 20 acres, ranging from less than one to over 1,000 acres in size. After the fire, patch sizes of montane and mixed chaparral ranged from 2,500 to 6,200 acres (Collins and Stephens 2012). This shift towards larger patch sizes is consistent with the large proportion of high severity fire effects resulting from Moonlight Fire (Figure 19).

Figure 19. Montane chaparral established in a former white fir stand after the Moonlight Fire.

3.5 Past and Present Vegetation Conditions: Meadow, Fen, Aspen and Riparian Vegetation

The analysis area used for other vegetation types, including hardwoods and conifers (Figure 8), was used to evaluate the effect of the Moonlight Fire on meadows, fens, and aspen. To

evaluate the effect of the Moonlight Fire on riparian vegetation, the area used to assess hydrologic resources, which includes the six hydrologic unit code (HUC) level six (approximately 20,000 acre) watersheds that contain the Moonlight Fire, was used (Figure 50).

Based on these evaluations, described below, the Moonlight Fire may have shifted the age class distribution of aspen across the landscape to sprouts and seedlings. Projects to protect this new cohort of aspen within the fire perimeter should be the first priority for restoration. However, additional efforts to protect and restore existing mature aspen stands both within and outside the fire perimeter may also be important to maintain aspen on the landscape until the new cohort of aspen within the fire perimeter has matured.

The Moonlight Fire resulted in shifts in livestock use as a result of altered forage availability and the closure of several grazing allotments within the fire perimeter. As a result, the Moonlight Fire led to degraded conditions in some of the fens and meadows outside of the fire perimeter, as described below. Therefore, projects to protect and restore meadows and fens both within and outside the fire perimeter will be necessary to reverse the negative effects of the Moonlight Fire.

The Moonlight Fire resulted in significant losses of riparian vegetation within the fire perimeter. Projects to restore these lost riparian resources should be the first priority for restoration. However, additional efforts to protect and restore existing riparian vegetation both within and outside the fire perimeter may also be important to maintain riparian resources on the landscape until riparian vegetation within the fire perimeter has been reestablished.

This analysis is based primarily on GIS data and a limited set of monitoring data available for the analysis area. No systematic surveys of meadows, aspen, or riparian vegetation have been conducted. Previous assessments of portions of the analysis area were also consulted for this analysis.

3.5.1 Past and present conditions

3.5.1.1 Meadows and Fens

There are 98 meadows mapped in the analysis area, occupying 1,775 acres (Fryjoff-Hung and Viers 2012). This is likely a conservative estimate; aerial photos show many stringer meadows that were not included in the GIS data used for this analysis. In addition to meadows, a complex of five fen wetlands occurs in the analysis area at Lowe Flat meadow (Figure 20). Fens are unique wetland ecosystems that support many rare and endemic plant and animal species. They depend on the presence of peat-forming vegetation, which can accumulate over thousands of years and serve as important carbon sinks. The 2004 Sierra Nevada Framework Plan Amendment (SNFPA) identified fen ecosystems as a key indicator habitat type. The five sloping, spring-fed fens at Lowe Flat are surrounded by mixed conifer forest along the north and west sides of Boulder Creek. The complex is entirely within the Antelope Grazing Allotment and is subject to livestock use.

Figure 20. Lowe Flat meadow containing a fen wetland.

Although the fens in Lowe Flat meadow were not directly affected by the Moonlight Fire, assessments indicate that they are at risk from dewatering, conifer encroachment, invasive species, and livestock use (Aitken et al. 2009). Grazing utilization standards established by the *Sierra Nevada Forest Plan Amendment* (USDA 2004), including less than 20 percent utilization of riparian shrubs and aspen, less than 20 percent altered banks, and less than 40 percent utilization of meadows, were exceeded in 2010 and 2012 at the Lowe Flat meadow (Lusk and Johnson 2012, Lusk et al. 2010). Previous efforts to restore the hydrology of one fen in the Lowe Flat complex included the construction of small wooden check dams; however channelization of this wetland area is still evident (Figure 21).

Figure 21. Channel incision in Lowe Flat meadow (2010).

Monitoring completed by the Region 5 Range Monitoring Program includes three meadows within the analysis area. A comparison of data collected in 2002 and 2003 with data collected five years later indicated that two of the meadows had experienced a downward trend in condition and did not meet desired conditions (see Table 6). Only one site was evaluated after the Moonlight Fire.

Table 6. Region 5 Range Monitoring data for three sites within the Moonlight Fire vegetation analysis area. Only one monitoring date occurred after the Moonlight Fire (*). Data from D. Weixelman, Regional Range Ecologist.

Meadow (type)	Date	Root depth (cm)	Bare soil (%)	Early seral plants (%)	Late seral plants (%)	Mid seral plants (%)	Condition
Lowe Flat (moist meadow)	7/4/2002	32	7	15	44	41	Upper moderate, meets desired condition
	8/22/2007	13	3	34	14	52	Moderate, does not meet desired condition
Wheeler Sheep Camp (moist meadow)	7/5/2002	27	10	34	40	26	Upper Moderate, meets desired condition
	8/22/2007	14	9	44	12	44	Moderate, does not meet desired condition
Little Antelope Creek (wet meadow)	7/29/2003	27	0	2	89	9	High, meets desired condition
	8/7/2008*	25	0	5	77	28	High, meets desired condition

Proper functioning condition assessments in grazing allotments have found that some areas are functional at risk with a downward trend and are in need of restoration. For example, Lone Rock Creek was found to be functional at risk with a downward trend due to cut banks, excessive sediment deposition, and dewatering due to a culvert (Cleland et al. 2006). Six locations were identified in the Diamond Project area with headcuts, excessive channel and bank erosion, and bank instability (USDA 2006a). Where headcut erosion has occurred in meadows, the meadow may no longer function as a floodplain during high flow events, and the water table of the meadow may be lowered, resulting in soil drying and loss of meadow vegetation.

Meadows and fens are characterized by moist soil conditions, which limit the spread of fire. The Lowe Flat fen complex and 80 percent of meadows found in the analysis area did not burn in the Moonlight Fire. However, of the 376 acres of meadows that did burn, 80 percent

experienced moderate to high fire severity (i.e. greater than 25 percent loss of vegetation). There are two range monitoring areas within the perimeter of the Moonlight Fire. One monitoring area is in the Lone Rock Creek grazing allotment, which burned with relatively high severity (Figure 22). This allotment was rested from grazing after the fire in 2008 and appeared to support dense vegetation the following year (Figure 22). The second range monitoring area in the Moonlight Fire perimeter is in the Lights Creek allotment. This area burned very lightly and was not rested from grazing after the fire (Figure 23).

Figure 22. Lone Rock Creek range monitoring area (from left to right): prior to the Moonlight Fire (2006), one month after the Moonlight Fire (2007), and one year after the Moonlight Fire (2008).

Figure 23 Lights Creek range monitoring area immediately after the Moonlight Fire (2007).

Fire can benefit meadows by killing encroaching conifers and upland shrubs species. Fire can also stimulate the production of herbaceous biomass in meadows in subsequent years (Wright and Chambers 2002). On the other hand, fire can negatively affect meadows. High severity fires that eliminate meadow vegetation and expose soil can increase rates of erosion, soil drying, and bank instability. The Moonlight Fire BAER report (USDA 2007a) identified numerous small meadows in the fire perimeter that had channel headcuts. Increased peak flows from the Moonlight Fire could have caused the headcuts to migrate at a faster rate, resulting in loss of meadow vegetation and increased sedimentation rates.

The Moonlight Fire may have affected livestock use in several ways. Immediately after the fire, areas that burned with moderate to high severity likely had reduced amounts of forage, which

may have caused livestock to move to unburned areas to graze. In the year following the fire, burned areas probably supported higher amounts of forage as a result of resprouting, which may have concentrated livestock in these areas. Only two allotments, Lone Rock and Antelope Lake, were rested from grazing in 2008; livestock numbers, season of use, and livestock distribution were not adjusted in the remaining seven active allotments within the fire perimeter (USDA 2008). The impact associated with grazing after the fire was described in the *Moonlight and Wheeler Fire Recovery and Restoration Project FEIS* (2008), which stated:

> *"It is expected that first year flush of grasses/forbs and riparian species would occur along wetter sites (stream courses, meadows) and this would attract livestock, leading to concentrated use along these sensitive areas. This would probably have a short-term effect on recovery of riparian vegetation, including willow, aspen, and wet meadow. Concentrated livestock use in these areas would delay and possibly impede stream bank recovery and increase compaction around wet sites. Thus it is anticipated that some short-term delay in recovery of riparian habitat would occur."*

3.5.1.2 Aspen Stands

Geospatial data indicate that there are 568 aspen stands, totaling 1,962 acres, in the analysis area. Many of these are associated with riparian vegetation or meadows, primarily in the southern and eastern portions of the analysis area. Prior to the Moonlight Fire, many aspen stands had been identified as being suppressed by encroaching conifers (USDA 2006a).

Although no comprehensive inventory of current aspen stand conditions have been made, fire generally promotes aspen sprouting. It is likely that the Moonlight Fire may have benefitted aspen. High severity fire, in particular, may have maintained aspen stands during pre-settlement times (Sheppard et al. 2006). Photo monitoring indicates that aspen stands have responded favorably to other fires in the analysis area, such as the Stream Fire in 2001 (Figure 24).

Figure 24. Aspen stand in the Stream Fire (from left to right): immediately after the fire (September 2001), one year after the fire (September 2002); and five years after the Stream Fire (September 2006).

Fire can benefit aspen by promoting sprouting and killing competing conifers that can suppress aspen growth. However, aspen sprouts are very vulnerable to browsing by cattle or native ungulates until they are able to grow above the browse line. Repeated grazing of aspen suckers can cause aspen to grow in a bushy, multi-stemmed form that is more susceptible to browsing.

Repeated browsing will eventually eliminate aspen by exhausting the underground resources of the stand (Kay 1997).

3.5.1.3 Riparian areas

Prior to the Moonlight Fire, riparian vegetation occupied approximately four percent of the analysis area; after the fire, riparian vegetation was reduced to approximately three percent of the analysis area. Although a reduction in the extent of riparian areas may have been an artifact of mapping error, it may also be attributed to loss of riparian vegetation as a result of high severity fire effects. Of the riparian vegetation within the Moonlight Fire perimeter, over 60 percent burned at moderate to high severity (i.e. greater than 25 percent basal area mortality).

As discussed in Section 3.13 (Past and Present Hydrological Conditions), mining and grazing had large impacts on riparian environments in the analysis area beginning in the late 19th century. For example, large-scale placer mining in Lights Creek likely wiped out large areas of riparian floodplain in the area downstream of the confluence of the East and West Branches (K. Roby, personal communication, 2013).

Riparian areas in the analysis area may be detrimentally affected by roads. Within the analysis area, there is approximately one mile of road in each square mile of riparian habitat conservation area, with approximately 10 stream crossings per square mile (USDA 2005). As mentioned in Section 3.13 (Past and Present Hydrological Conditions), streams such as Lone Rock Creek, Boulder Creek, and others in the Upper Antelope watershed exhibit both elevated sediment loads and headcuts.

Many headwater stream channels experienced very high severity fire effects in the Moonlight Fire, which eliminated much of the existing riparian vegetation (USDA 2007a) (Figure 25). The *Moonlight and Wheeler Fire Recovery and Restoration Project FEIS* (USDA 2008) noted that the post-fire condition for the drainages evaluated was moderate to poor due to loss of riparian vegetation. The amount of shade present in riparian areas was rated as poor and the amount of sediment in pool tail fines was high enough to rate as poor to very poor (USDA 2008). The authors also concluded that current and historic grazing in the area may have contributed to high sedimentation, low shade, and unstable banks within the drainages evaluated.

Figure 25. High severity fire effects in a riparian area in the Moonlight Fire

3.6 Past and Present Vegetation Conditions: Unique Botanical Resources

3.6.1 Rare plant species

The analysis area used to assess the condition of rare plants in the Moonlight Fire area includes the six HUC6 watersheds that contain the Moonlight Fire (Figure 50). This area was chosen to capture all rare plants that: (a) occur within the fire footprint; (b) were impacted by fire suppression activities adjacent to the fire footprint (Figure 26); or (c) have suitable habitat within the fire as well as a "source" (potential for seed dispersal) population located within close proximity.

In comparison to many other areas on the Plumas NF, relatively few rare plant species occur within the area affected by the Moonlight Fire (Table 7). Two notable exceptions to this generalization are: (a) the extensive stands (about 160 acres) of Baker cypress (*Hesperocyparis bakeri*) within the Mud Lake RNA and (b) the rocky ridges and outcrops within the analysis area, which support the rare adobe lomatium (*Lomatium roseanum*), Susanville beardtongue (*Penstemon sudans*), and Janish's beardtongue (*Penstemon janishiae*). Although most of the rocky ridges and outcrops were minimally impacted by the fire itself, some sites were directly impacted by bulldozer-constructed fire line as well as subsequent post-fire rehabilitation efforts (Figure 26).

Historical trends for many of the rare species that occur within the Moonlight Fire area are unknown because they have only been documented and tracked by the Forest Service for about 15 to 20 years.

Figure 26. Photo of Diamond Mountain dozer line going through populations of *Lomatium roseanum* and *Penstemon janishiae*.

Table 7. Occurrences of Forest Service Sensitive and Plumas NF Special Interest species known within the Moonlight analysis area.

Species	Common Name	Listing Status[1]	# of Occurrences		Notes
			Within the fire	Outside fire	
Antennaria umbrinella	brown everlasting	Category 1		1	Occurrence within 200 m of fire
Astragalus pulsiferae var. pulsiferae	Suksdorf's milkvetch	Sensitive		3	Greater than 4.5 miles from fire
Carex inops ssp. inops	long-stoloned sedge	Category 2	1		
Carex pentasta	Liddon's sedge	Category 1		1	Occurrence within 250 m of fire
Carex sheldonii	Sheldon's sedge	Category 2	2	7	Outside occurrences range from 300 m to > 4 miles from fire
Hesperocyparis bakeri	Baker cypress	Category 1	1	1	
Lomatium roseanum	Adobe lomatium	Sensitive		1	1.7 miles from fire; BUT directly impacted by suppression activities
Penstemon janishiae	Janish's beardtongue	Category 2		1	1.7 miles from fire; BUT directly impacted by suppression activities
Penstemon sudans	Susanville beardtongue	Sensitive	2	1	0.6 mile from fire
Rhamnus alnifolia	alderleaf buckthorn	Proposed		1	0.7 mile from fire boundary
Trichodon cylindricus	trichodon moss	Category 2	1		

[1] Listing Status: "Sensitive": Forest Service Region 5 Sensitive Species; "Proposed": proposed for Sensitive Species designation; "Category 1": Plumas NF special interest species that are globally rare enough to be considered for sensitive status but have been excluded because there is not enough information to determine the species' status or the taxonomy of the species is unclear. "Category 2" Plumas NF special interest species that are not globally rare enough to be considered for sensitive status but are locally rare, of public interest, or are a range extension of a more widespread species.

3.6.2 Baker cypress (Hesperocyparis bakeri)

Baker cypress (*Hesperocyparis bakeri*) is a rare fire-adapted conifer known from only 11 widely scattered locations in northern California and southern Oregon. Baker cypress is a California Native Plant Society list 4 species (species of limited distribution) and a Special Target Element in Region 5 of the Forest Service. This species bears closed (serotinous) cones that depend on fire for seed dispersal and require post-fire conditions, such as bare mineral soil and direct sunlight, to germinate (Vogl et al. 1977). Fire has been successfully excluded from most Baker cypress populations for almost a century. Cypress groves at many sites are densely crowded with shade-tolerant species and adult cypresses are dying with almost no evidence of regeneration. The Moonlight Fire triggered regeneration of the Baker cypress population on the Plumas NF, creating a unique opportunity to protect a young population of a species that is otherwise characterized primarily by old and decadent stands.

The analysis area for Baker cypress in this restoration strategy is the Mud Lake Research Natural Area (MLRNA), established in 1989 to preserve the two populations of Baker cypress found on the Plumas NF (Figure 27). The MLRNA is comprised of two separate units, the Wheeler Peak unit occupying 73 acres, and the Mud Lake unit, which is 307 acres in size.

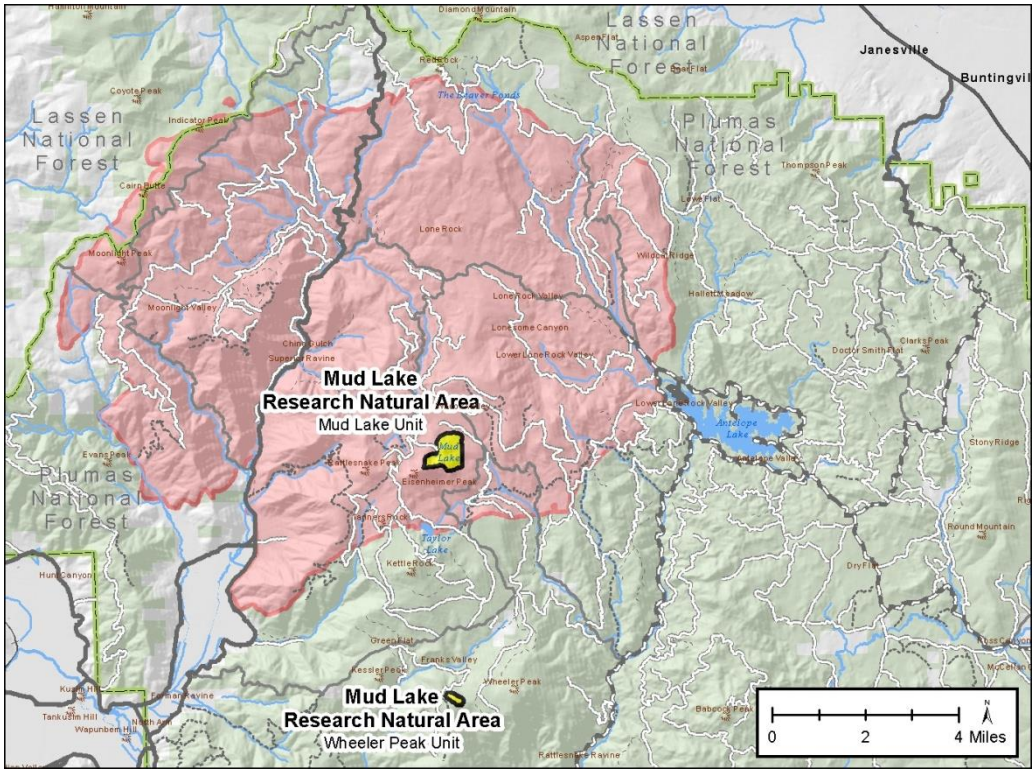

Figure 27. The Mud Lake and Wheeler Peak units of the MLRNA, the analysis area for Baker cypress.

Baker cypress stands are widely scattered throughout the two units of the MLRNA, representing the highest elevation, and furthest inland, occurrences of this species; no other cypress species in California has been documented above 6,000 feet in elevation and further

than 150 miles inland from the Pacific Ocean (Keeler-Wolf 1989). As a result, the two populations of Baker cypress within the MLRNA are likely subjected to lower temperatures and more snowfall than any other population of cypress in California or the world (Peattie 1953).

The effect of the Moonlight Fire on Baker cypress, as described below, included stimulating cypress regeneration at the Mud Lake Unit. Baker cypress in the Wheeler Peak unit now represents the only reproductively mature population in this portion of the species' range. Projects to protect this new cohort of cypress within the fire perimeter should be the first priority for restoration. However, additional efforts to protect and restore the existing mature Baker cypress stands at the Wheeler Peak Unit are also important to maintain this rare species on the landscape until the new cohort of cypress within the fire perimeter has matured.

This analysis is based primarily on data collected during a three-year study to evaluate Baker cypress across its range. The results of this larger study are described in Rentz and Merriam (2011a, 2011b) and Frame (2011).

3.6.2.1 Past and present conditions

Wheeler Peak Unit

The Wheeler Peak unit contains the world's largest Baker cypress, with a DBH of 56 inches and a height of 71 feet. In addition to this champion tree, several other Baker cypress trees within the Wheeler Peak unit are over 36 inches DBH (Figure 28). These large trees occur on a largely unvegetated, rocky ridgetop. The Wheeler Peak population of Baker cypress is younger than the Mud Lake population. The average age of trees in our plots at Wheeler Peak was 95 years, with a range of between 46 and 158 years. Keeler-Wolf (1985) suggested that this unit is in an earlier successional stage than the Mud Lake population.

The Wheeler Peak population is relatively healthy compared to other populations of Baker cypress across the species' range. Average crown condition of trees at Wheeler Peak was less than 50 percent dead or dying, just slightly over the range-wide average of 44 percent. Baker cypress trees at the Wheeler Peak unit were among the largest in DBH across the range of the species, averaging 9.8 inches. Much of the unit is characterized by small, dense groves of Baker cypress isolated from one another by open, rocky soil. However, there are some areas where competition from white fir may threaten Baker cypress trees, particularly on the lower slopes of the unit where there is evidence of suppression by conifers. Overtopping conifers can reduce Baker cypress cone production, tree health, and eventually cause tree mortality (Rentz and Merriam 2011a, 2011b). No seedlings were observed at the Wheeler Peak unit.

Figure 28. Baker cypress champion tree (left) and another larger Baker cypress (right) in the Wheeler Peak unit.

Mud Lake Unit

Prior to the 2007 Moonlight Fire, no fires had been recorded in either the Wheeler Peak or the Mud Lake unit of the MLRNA since 1910. Baker cypress averaged 135 years of age, ranging in age from 101 to 167 years. No seedlings were found in any of the study plots prior to the Moonlight Fire, and the Baker cypress stand was very unhealthy (Figure 29). Cypress trees were 87 percent dead or dying and represented only 28 percent of total stand density. Fire suppression at the MLRNA had allowed dense thickets of shade-tolerant white fir to dominate the stand, resulting in high levels of cypress mortality (Wagener and Quick 1963, Keeler-Wolf 1985). Other species averaged nine feet taller than Baker cypress in plots. This competition for light produced some of the tallest known Baker cypress, measuring up to 100 feet in height. The decline of Baker cypress at the Mud Lake unit due to competition was first noted by Wagener and Quick (1963) and had been recognized repeatedly since that time (Keeler-Wolf 1985). Prior to the 2007 Moonlight Fire, there was concern that without immediate action to reintroduce fire to this population, it would be extirpated.

Figure 29. Dead and dying cypress in the Mud Lake unit prior to the Moonlight Fire.

After the 2007 Moonlight Fire, substantial Baker cypress regeneration was observed at the Mud Lake unit (Figure 30). Despite low densities of living mature cypress in the stand prior to the fire, these residual trees had sufficient canopy seed storage to produce numerous seedlings. Seedling densities of up to 85 seedlings/m^2 occurred in plots with only three living cypress prior to the fire. Pre-fire data indicated that even plots with only three Baker cypress adult trees prior to the fire could have dispersed an average of 15,000 viable seeds after the fire. Fire severity was the strongest predictor of post-fire seedling density. Plots with higher scorch and char heights, and more percent crown scorch volume, had greater numbers of seedlings. Plots with higher soil burn severity also had significantly higher seedling density. The high severity fire effects caused by the Moonlight Fire were very beneficial to this population of Baker cypress.

Currently there is a high density of snags throughout most of the stand, and potential fire hazard may increase over time as these snags decay. The population in the Mud Lake unit is currently at significant risk of extirpation until the population can produce cones and accumulate sufficient seeds to regenerate the population after a fire. Cypress trees do not begin producing cones until around 15 years of age, and our research suggests that it takes a population between 35 and 50 years to accumulate enough cones in the canopy to regenerate the population after a fire. This range of fire return intervals is typical of the mixed fir forests where Baker cypress occurs.

Figure 30. Cypress seedling densities were high after the Moonlight Fire.

3.7 Past and Present Invasive Species Conditions

Invasive plant species pose a serious threat to biological diversity because of their ability to displace native species, alter nutrient and fire cycles, decrease the availability of forage for wildlife, and degrade soil structure (Bossard, Randall and Hoshovsky 2000). Disturbance, whether it is natural (such as the Moonlight Fire) or associated with management activities, often creates ideal conditions for the introduction and establishment of invasive species. Colonization into disturbed sites is often facilitated by the removal of natural barriers that frequently keep invasive species in check, such as unsuitable light, soil, or moisture conditions (Parendes and Jones 2000). Wildfires can expose soil surfaces, reduce shade, decrease competition from native species, and flush the soil of nutrients; all of these factors can create conditions favorable to invasion (Turner 1997, Sheley 2002). Refer to Section 3.10 (Past and Present Aquatic Conditions and Aquatic Invasive Species) for details on aquatic invasive species.

In order to assess the risk of invasive plant introduction, establishment, and spread within the Moonlight Fire area, a geographic area was selected for analysis based on the watershed boundaries (Figure 31). This area encompasses the Moonlight Fire, as well as the primary access roads, adjacent high-use recreation sites, and areas used during the fire suppression effort; these areas represent potential seed sources or vectors for invasive plant introduction and spread.

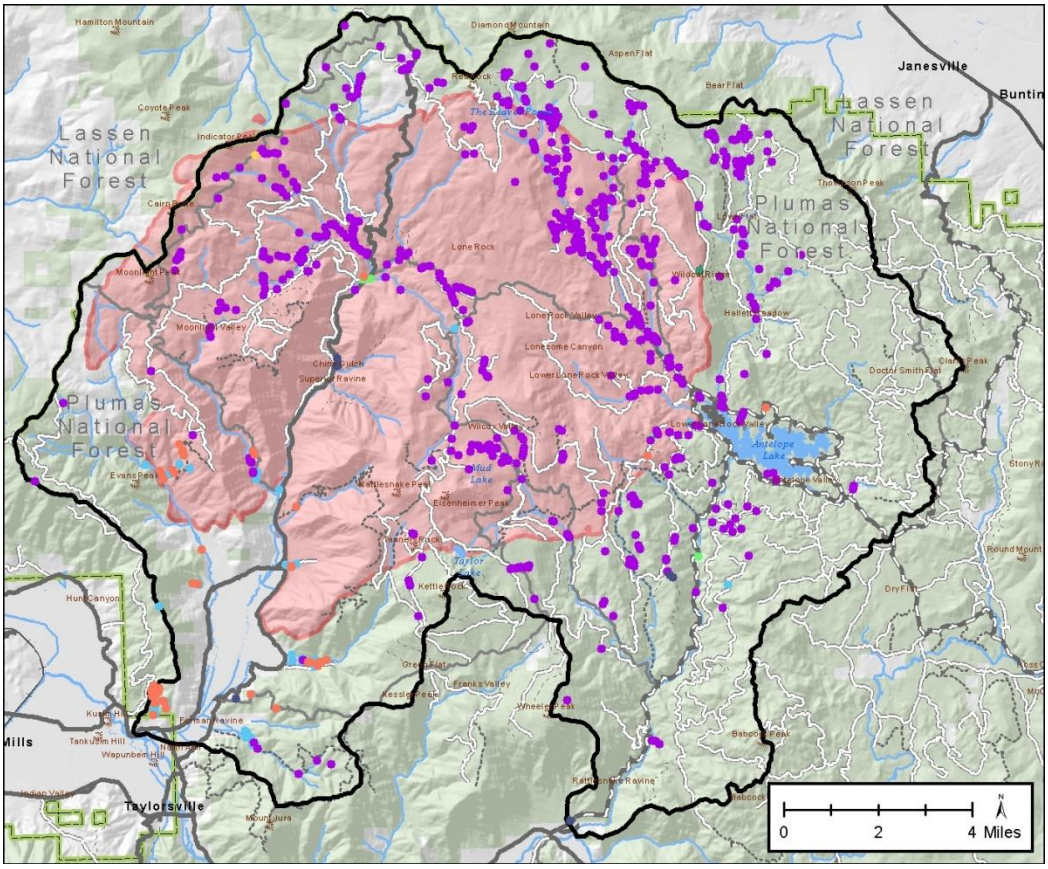

Figure 31. The area analyzed for invasive plant species. The most abundant species is Canada thistle (dark pink); other species in include barbed goatgrass (brown), spotted knapweed (green), yellow starthistle (light blue), Scotch broom (dark blue), dyer's woad (yellow), Russian thistle (teal), and medusahead (salmon pink).

3.7.1 Moonlight Invasive Species

Eight priority invasive plant species have been documented within the analysis area (Table 8). These species are known from 756 locations and about 240 acres; just over half (444 sites, 125 acres) occur within the Moonlight Fire boundary (Table 8). At present, most infestations are small, with 73 percent of the known locations occupying less than 0.1 acre. Approximately 74 percent of infestations occur within 500 feet of roads or trails. These infested areas can act as source populations for introduction and spread into less-invaded portions of the Moonlight Fire area. The highest concentration of invasive plants is presently in the northern portion of the Moonlight Fire (Figure 31).

Table 8. Invasive species documented in the Moonlight Fire analysis area

Species	Common Name	CDFA rating[1]	Cal-IPC rating[2]	Number of infestations (approximate acreage)	
				Within fire footprint	Within analysis area; outside fire
Aegilops triuncialis	barb goatgrass	B	High		1(0.7 ac)
Centaurea maculosa	spotted knapweed	A	High	6 (0.03 ac)	1 (< 0.1 ac)
Centaurea solstitialis	yellow starthistle	C	High	14 (9.4 ac)	38 (38.5 ac)
Cirsium arvense	Canada thistle	B	Moderate	400 (110 ac)	243 (36.4 ac)
Cytisus scoparius	Scotch broom	C	High	3 (1.6 ac)	4 (0.4 ac)
Isatis tinctoria	dyer's woad	B	Moderate	2 (3.7 ac)	
Salsola tragus	Russian thistle	C	Limited	2 (0.07 ac)	
Taeniatherum caput-medusae	medusahead	C	High	17 (0.3 ac)	25 (38.7 ac)

[1] CDFA ratings - A listed weeds: eradication or containment is required at the state or county level; B-listed weeds: eradication or containment is at the discretion of the County Agricultural Commissioner; C-listed weeds: eradication or containment required only when found in a nursery or at the discretion of the County Agricultural Commissioner.

[2] CalIPC ratings- High: attributes conducive to moderate to high rates of dispersal and establishment; usually widely distributed among and within ecosystems. Moderate: impacts substantial and apparent, but not severe; attributes conducive to moderate to high rates of dispersal; distribution may range from limited to widespread. Limited : ecological impacts are minor or information is insufficient to justify a higher rating, although they may cause significant problems in specific regions or habitats; attributes result in low to moderate rates of invasion; distribution generally limited, but may be locally persistent and problematic.

The most prevalent invasive species in the analysis area is Canada thistle (*Cirsium arvense*). This perennial thistle is most abundant in moist, riparian habitats within the fire, but is also found in drier sites such as old landings, skid trails, and roadsides. Canada thistle spreads rapidly either by seed or vegetatively (Bossard et al. 2000); documented rates of spread range from less than two feet to over 40 feet per year (Donald 1990, Nuzzo 1997, Bond and Turner 2004, USGS 2005). Like many of the invasive species in the Moonlight Fire, Canada thistle is considered particularly difficult to eradicate.

3.7.2 Effect of the Moonlight Fire on invasive species

About 72 percent (550 locations) of the infestations within the analysis area were discovered prior to the Moonlight Fire. Many of these were documented during project-level field surveys that were conducted on approximately 60,628 acres within the analysis area between 2000 and 2007. The remainder of the area had not been recently surveyed before the fire; therefore it is highly possible that a number of weed infestations were present in the un-surveyed areas prior to the fire and suppression activities.

Post-fire monitoring activities and surveys within the analysis area have documented 206 infestations that are either new or have expanded in size since the Moonlight Fire. It is often difficult to determine whether these new infestations became established after the fire

because accurate pre-fire information is generally lacking; however there are some situations where inferences can be made. In 2008, weed detection surveys were conducted on approximately 20 miles of fire line and 122 miles of NFS roads within the fire perimeter (USDA 2008). These areas were identified in the 2007 BAER report as important potential corridors for noxious weed dispersal, introduction, and spread (USDA 2007b). As a result of this effort, 35 new infestations were documented. Of these, 13 were discovered within previously surveyed areas and a large majority of the remaining infestations were found along NFS roads where they would likely have been visible and documented prior to the fire (USDA 2008). These findings suggest that some of these infestations were introduced after, and possibly as a result of, the Moonlight Fire.

Figure 32. New infestation of Dyer's woad discovered during post-fire BAER monitoring

Fire suppression activities during the Moonlight Fire likely increased the number of invasive species both within and adjacent to the fire. Dozer lines, drop points, and safety zones can all serve as invasive plant dispersal areas or corridors and suppression equipment can act as vectors for spread. Movement of fire suppression and rehab equipment can also facilitate the spread of invasive plants to and from areas within the fire. To prevent the introduction of noxious weeds into the burned area during suppression activities, Forest Service policy requires washing of all equipment mobilizing onto wildfires; however, the Moonlight Fire increased in size rapidly during the first several days due to extreme fire behavior, and some vehicles and equipment were not washed during mobilization (USDA 2007b). In addition, equipment such as tankers, engines, dozers, and excavators were not washed, inspected, or cleaned for dirt/plant parts on the way into the fire during suppression and rehabilitation efforts (USDA 2007b).

One infestation of spotted knapweed was disturbed by heavy equipment during the fire. The site was plowed for use as a safety zone and it is likely that fire suppression vehicles either parked in the site or passed through (USDA 2007b). Although post-fire monitoring did not detect an increase in knapweed individuals at the site (USDA 2008), future monitoring may detect new infestations within the fire footprint.

The effect of the Moonlight Fire on the existing invasive plant infestations was highly variable and was largely dependent on the species' ecology, location of the infestation relative to suppression activities, fire severity, and the effectiveness of pre-fire weed control efforts (USDA 2008). In 2008, 59 previously known weed infestations were re-visited and evaluated to determine the impact of the fire and suppression activities (USDA 2008). Of these, three previously known infestations of Canada thistle were encountered that had significantly increased in size (USDA 2008). General observations also noted that some lower priority invasive species, primarily cheat grass (*Bromus tectorum*) and bull thistle (*Cirsium vulgare*), were more abundant in some of the fire lines compared to the surrounding area (C. Rowe personal observation 2008). In 2012, eight Canada thistle locations within the Moonlight Fire were revisited; although the estimated acreage of these infestations decreased slightly, the density of stems five years after the fire had tripled compared to the density two years prior to the fire (J. Belsher-Howe, personal communication).

3.7.3 Weed control efforts

Weed control efforts within the analysis area have been conducted on an annual basis since 2002. The total acreage treated each year is less than five percent of the total present due to a lack of funding and completed environmental analysis for herbicide treatment. Although treatments have been limited in scope, they have been successful in eradicating a few small populations and reducing the size or preventing the spread of several others. In contrast, some infestations continue to spread despite dedicated treatment efforts. Many of the infestations documented prior to the Moonlight Fire were proposed for treatment under the Diamond Project DEIS (USDA 2006a), which was never implemented. Approximately 100 locations of Canada thistle have also been proposed for treatment under the proposed Wildcat Project.

3.7.4 Risk to the Moonlight Landscape

The location, severity, and management of the Moonlight and adjacent fires have created a high risk for invasive plant introduction and spread within the analysis area watersheds. Fire suppression activities, combined with large areas of high burn severity, resulted in considerable ground disturbance and the creation of favorable conditions for invasion. This level of past disturbance, combined with the large number of invasive species concentrated along roads where the risk of spread is high, greatly increases the vulnerability of the Moonlight Fire landscape.

Invasive plants migrate, establish, and spread rapidly and unpredictably. New infestations have been discovered within the analysis area every year since the Moonlight Fire. Without effective and timely treatment, invasive plants may spread rapidly within the watersheds affected by the Moonlight Fire.

3.8 Past and Present Fire and Fuels Conditions

Fire continues to be a major management challenge for National Forests of the Sierra Nevada. More and more frequently, fire suppression forces are overwhelmed by extreme fire behavior

largely driven by past forest management practices and a century of fire suppression (see Section 3.2, Past and Present Vegetation Conditions: Conifer Forest). Fire suppression has always been applied with the greatest intentions, however; it has also resulted in a number of unintended consequences including high fuel load accumulations and high tree stem densities particularly in small diameter shade tolerant trees (Beaty and Taylor 2001, Taylor and Skinner 2003, Beaty and Taylor 2007). In the most general terms, past management strategies have shifted systems from frequent low severity fire to infrequent high severity fire.

For analysis purposes a landscape approach has been adopted to help quantify impacts and trends within the Central Fire Management Zone of the Plumas NF. Both historically and currently, fire acts on a scale from 10's to 100's of thousands of acres moving wherever there are consumable fuels (Norman and Taylor 2003). Adding a temporal component of at least a century, only large landscapes can provide any insight into ecosystem trends and resource management goals and objective. Within these landscapes it will be important to balance and sustain resources such as timber and wildlife habitat for current and future generations.

3.8.1 Pre-Suppression Fire < 1900

Prior to European settlement, these landscapes experienced frequent and predictable fire cycles that functioned as a fundamental ecosystem process. Pre-suppression era fires were not only primarily frequent, low to moderate-intensity fires, but were also quite large, frequently covering 10's to 100's of thousands of acres (Norman and Taylor 2003). Landscapes with active fire regimes included open park-like multi-aged stands as well as relatively dense even-aged stands and shrub patches. Past fire cycles created complex mosaics of vegetation and successional stages capable of supporting old forest species such as the California spotted owl as well as disturbance dependent species such as the Black Backed Woodpecker. Effective fire suppression over the past century has considerably altered these ecosystems. Prior to European settlement, frequent fire dominated this analysis area as well as the Moonlight Fire footprint (Figure 33 and Figure 34). Based on fire return interval departure data compiled by Safford and others (2011), there is very little difference in fire regimes on the District compared to the Moonlight Fire area with 90 and 96 percent of these areas respectively dominated by fire return intervals in the range of 10 to 20 years.

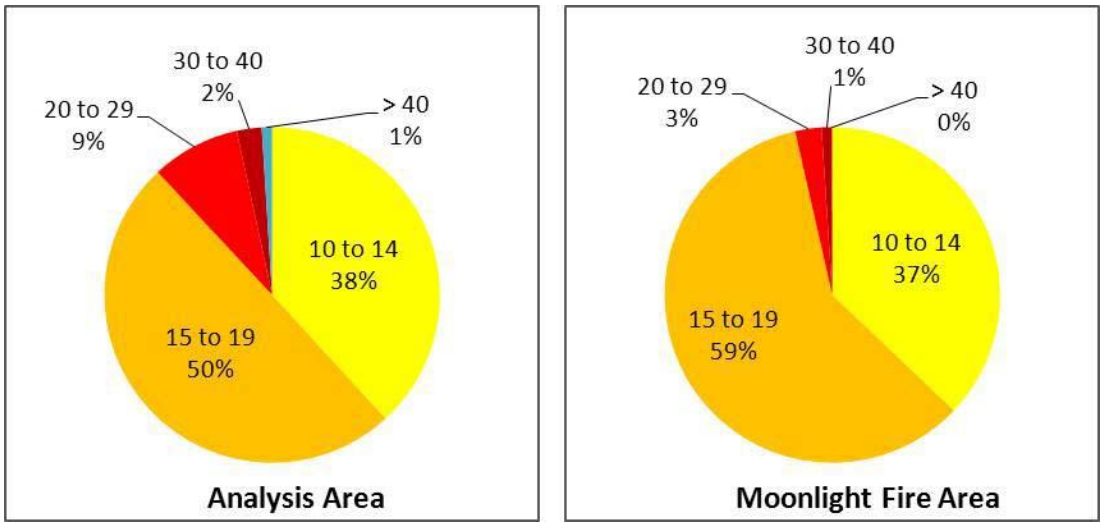

Figure 33. Graph showing the percent within Pre European mean fire return intervals within the analysis area and the Moonlight Fire area. Based on fire return interval departure data compile by Safford and Van De Water (2011).

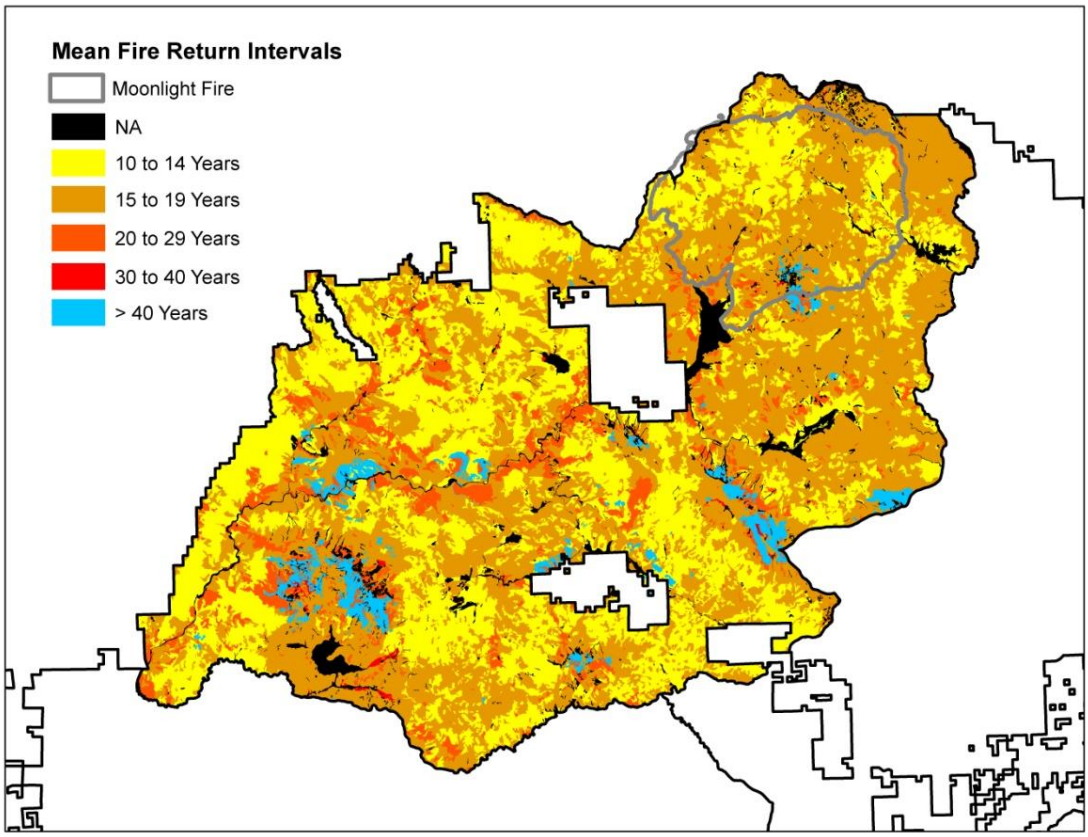

Figure 34. Map showing the distribution of Pre European mean fire return intervals on the Mt. Hough Ranger District and within the Moonlight Fire area (Safford and Van De Water 2011).

3.8.2 Fire Starts

Within the analysis area, the annual average number of fire starts recorded was 66 from 1970 to 2009 (Figure 35). The majority of recorded fire starts, 67 percent, are from lightning strikes. On average, the analysis area receives 427 lightning strikes per year with a general trend of fewer strikes in the west, with gradually increasing strike density as you move to the east (Table 9).

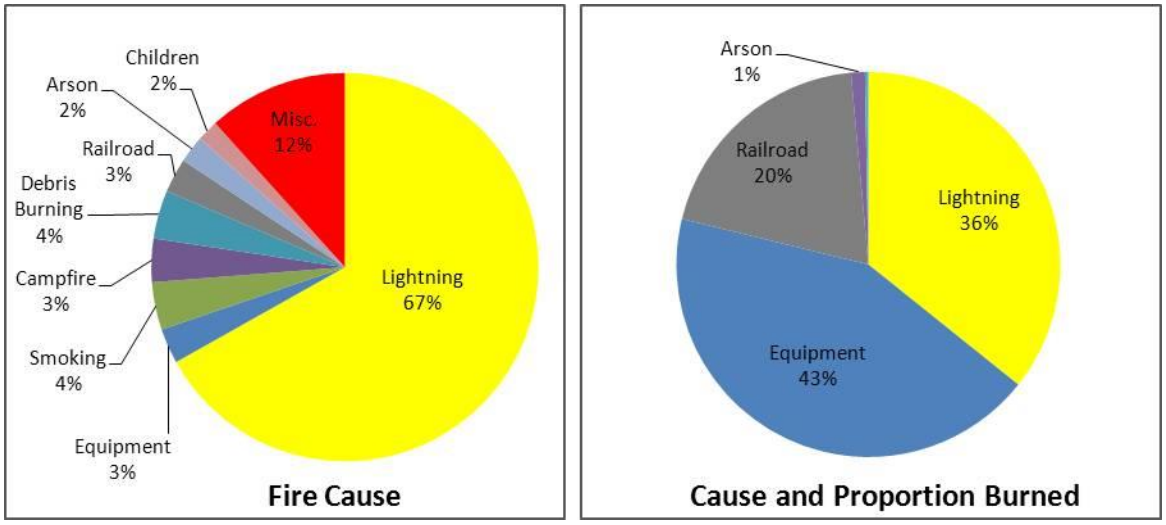

Figure 35. Left: historic fire starts from 1970 to 2009. Right: Proportion of area burned and their associated cause for large fires (>100 acres) from 1980 to 2011

Table 9. Average annual lightning strikes by Ranger District from 1995 through 2009.

Ranger District	Annual Strikes	Annual Strikes per Mile
Feather River	208	0.340
Mt. Hough	427	0.499
Beckwourth	624	0.813

Seasonally, the distribution of lightning strikes is in close alignment with the fire season (Figure 36). The arrival of spring weather systems triggers a sharp increase in lighting activity in May and June. The spring and summer months, from May through August, accounted for 81 percent of the lightning strikes throughout the year. Although lightning strikes account for the majority of fire starts, human caused fire has accounted for the majority of the area burned in recent decades. Fires associated with the railroad and equipment combined account for only six percent of the fire starts, however they are responsible for nearly two thirds of the area burned in recent large fires. It is unclear why this disparity exists. One of the largest contributing factors was the Moonlight Fire itself, which started as the result of heavy equipment use. Another contributing factor may be that in recent years the Forest Service has become exceedingly efficient at hunting down lightning strike fires with the ability to precisely map strike locations almost in real time as weather systems are moving through an area. This combined with aerial

scouting has resulted in a 98 percent success rate in keeping lightning fires less than 10 acres in size.

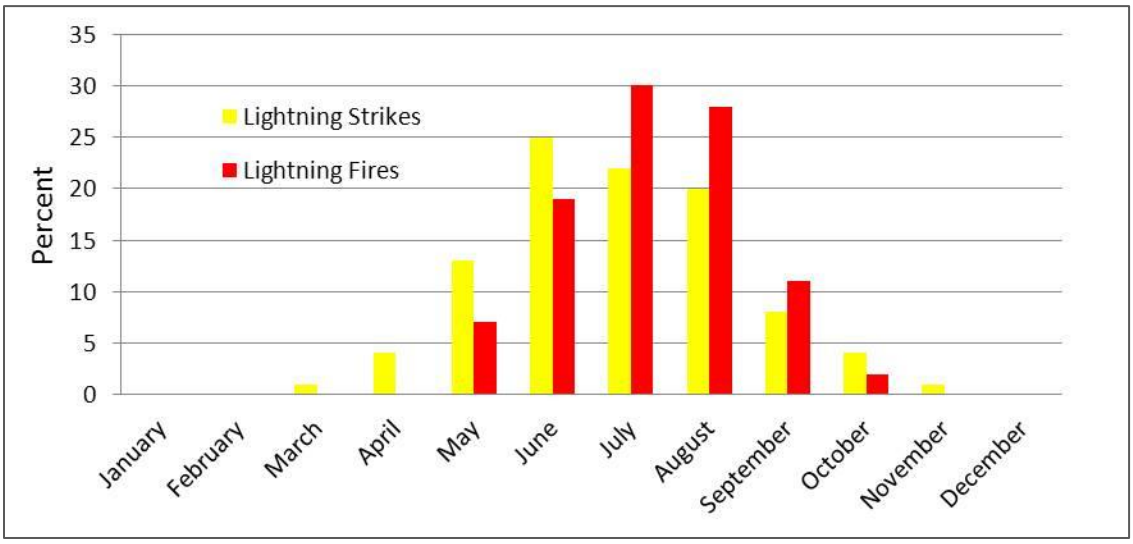

Figure 36. Seasonal distribution of lightning strikes and lightning fires on the Plumas NF from 1995 through 2009

It is unknown if these trends in fire starts and resulting burned areas will continue. However, it is clear that the Moonlight Fire area will be susceptible to reburning due to both lighting and human caused fires in the future.

3.8.3 Historic Fire 1910 to Present

Excluding the large fire complexes of 2007 including the Moonlight Fire, very little fire was historically seen in the vicinity of the Moonlight Fire. Some recent increases in fire activity were seen to the southeast with the 2001 Stream Fire (3,524 acres) and 2006 Boulder Fire (2,919 acres). Taken together, these fires generally coincide with the increases in fire activity of the 2000s, with the strongest concentrations in the North Fork of the Feather River Canyon and to a lesser degree the Middle Fork of the Feather River near Lake Oroville Forest wide.

Prior to the Moonlight Fire, the Moonlight Fire footprint had 15 recorded fires from 1917 to 2001 covering a total area of 7,216 acres. Most of these fires were relatively small with an average size of 481 acres. The largest historic fire occurred in 1966 and burned 2,181 acres. Overall, this level of fire activity represents a major departure from pre-settlement fire regimes with 89 percent of the area experiencing no recorded fire for about 100 years prior to the Moonlight Fire.

Although historic fire area data prior to about 1950 may be questionable (Lorrie Peltz-Lewis personal communication 2012), fire size and cumulative area burned has clearly been increasing in recent decades (Figure 37 and Figure 38). In the past decade the analysis area experienced the greatest number of acres burned in recorded history dating back to about 1910, with a cumulative total of 193,914 acres or about 35 percent of the area within the

administrative boundary. As large as this number seems, it is important to put it in perspective with what would be expected to burn within a decade prior to fire suppression. This equates to about 366,900 acres burned per decade. This disparity between what would be expected to burn and what has burned creates a vast fire deficit. In the dry forest types of the Sierra Nevada, decomposition via fungus and bacteria is frequently out paced by biomass production. Frequent, low severity fire was the primary ecological process that historically balanced out this equation.

Exacerbating this problem is the fact that by default, management dominated by fire suppression actively manages for high severity wildfire. It is only under the worst case scenarios, when fuels, weather, and topography come into alignment, that fire escapes initial attack. Shoulder season fires, and those occurring in better topography or fuel conditions, may provide ecological benefits, however by the same token they are more easily suppressed. In addition, notable increases in fire activity are predicted for California, driven largely by projected increases in temperature, decreases in snow pack, and to a lesser extent, increased fuel production from CO2 "fertilization" (Flannigan et al. 2000, Lenihan et al. 2003, Lenihan et al. 2008, Westerling et al. 2011).

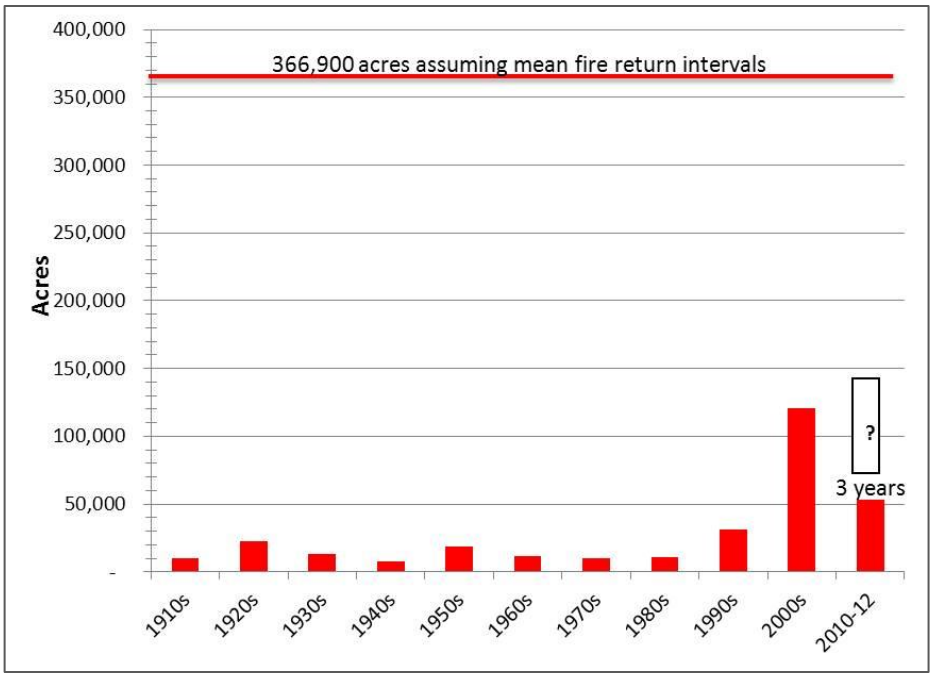

Figure 37. Cumulative acres burned by decade. Last bar only includes the past 3 years and is largely represented by the 2012 Chips fire with question mark above representing the uncertainty about cumulative fire over the rest of the current decade. Line above represents the number of acres that would be expected to burn prior to fire suppression.

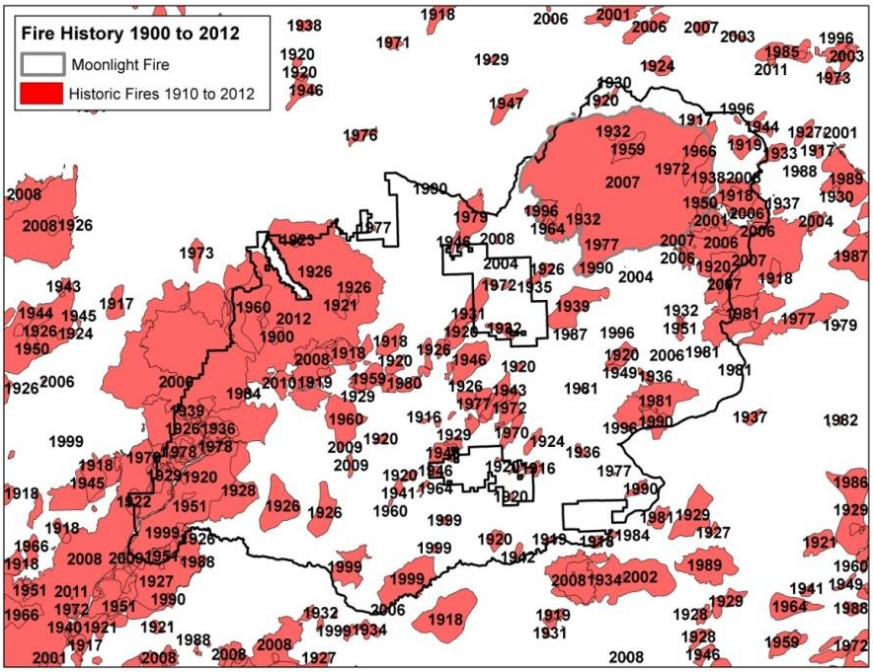

Figure 38. Fire history from 1910 to 2012

3.8.4 Trends and Impacts of Fire Severity

As mentioned above, fire size is not the major concern as we are only now beginning to approach fire areas that are within the pre-settlement natural range of variability (Collins and Stephens, 2010; Collins and Stephens, 2012). The patch size of high severity wildfire is the major concern as this has had a major impact on values such as timber and wildlife habitat (Skinner and Chang, 1996; Scholl and Taylor, 2010). The Moonlight Fire was dominated by large patches of high severity wildfire. Collins and Stephens (2012) found high severity patch sizes ranging from 2,500 to 6,200 acres. In addition, when compared to other recent large fires in the analysis area, the Moonlight and Antelope fires were particularly severe with an unprecedented 62 percent of the fire area considered high severity (Table 10).

Table 10. Basal Area (BA) mortality for recent high severity wildfires within the analysis area.

Fire	BA Mortality Acres (Percent)				Total Acres
	<25%	25-50%	50-75%	>75%	
Storrie [2000]	8,466 (34%)	2,475 (10%)	2,125 (9%)	11,605 (47%)	24,670
Moonlight-Antelope [2007]	15,609 (19%)	7,509 (9%)	7,117 (9%)	50,301 (62%)	80,537
Chips [2012]	19,984 (39%)	11,969 (23%)	6,434 (12%)	13,102 (25%)	51,488

For an overview of severity trends, data from the Monitoring Trends in Burn Severity Project (http://www.mtbs.gov) was combined with severity data for the recent 2012 Chips Fire. Large fires from 1990 to 2012 were analyzed. Where fires overlap, the highest severity polygons

trumped or were “floated to the top” such that no acres were double counted. The resulting dataset shows the greatest impacts of recent fires on the landscape (Figure 39 and Table 11).

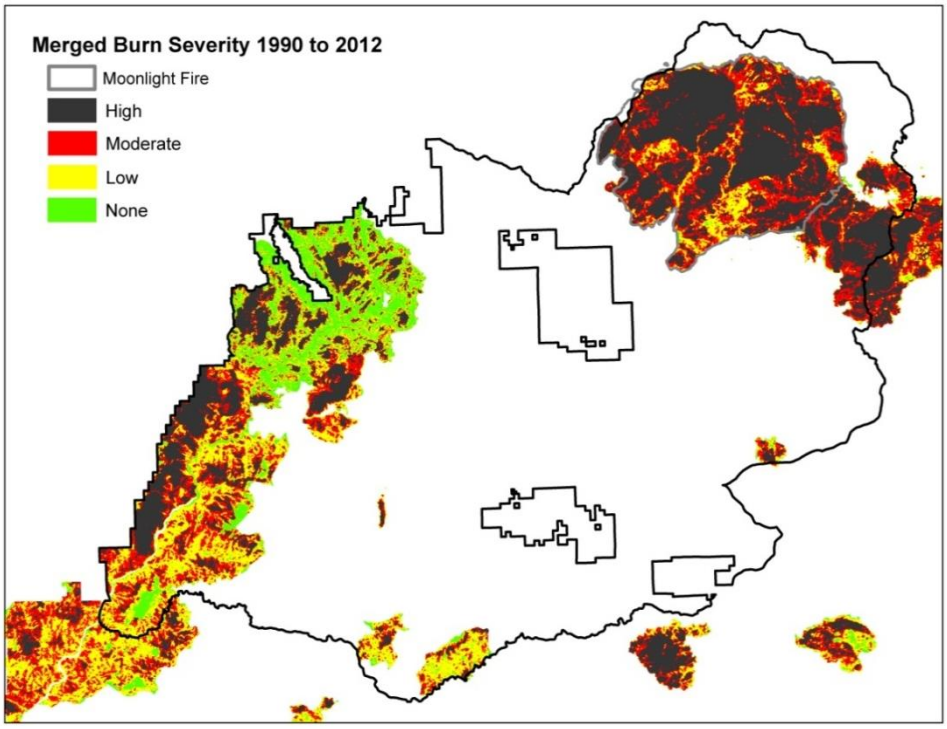

Figure 39. Merged fire severity for fires from 1990 to 2012 on the Mt. Hough Ranger District and within the Moonlight Fire area

Table 11. Merged fire severity from 1990 to 2012; where fires overlapped in area, higher severity trumped.

Ranger District	High	Moderate	Low	No Impact	Total
Beckwourth	26,959	25,581	12,739	3,497	68,776
Feather River	10,110	20,802	36,474	4,706	72,091
Mt. Hough	76,048	45,358	41,122	21,739	184,267
Total	**113,116**	**91,741**	**90,335**	**29,942**	**325,134**

Intersecting this severity data set with other resource allocations also yields interesting results. For example, when intersected with Old Forest Emphasis areas, about 57,685 acres of this land allocation has been lost or degraded by wildfire on the Mt. Hough Ranger District. This represents nearly one third of this land designation and a significant decline in habitat for old forest dependent species such as the pine marten, California spotted owl, and the Northern Goshawk.

3.8.5 Current Fire Risk

In addition to the impact of recent fires, wildfire danger and the risk of future damage to resources remains high, especially in unburned areas outside of the Moonlight Fire footprint

(Figure 40 and Figure 41). FlamMap 5 was used to predict fire behavior and movement across the landscape under high fire danger conditions. Model inputs included fuel model and topography data from Land Fire Refresh 2008. District Fire Management Staff also provided expert opinions on fire weather and fuel moisture content parameters (Table 12). Overall, fire danger within the District remains extremely high, with 52 percent of the area susceptible to flame lengths greater than 12 feet high. Under these conditions crowning, spotting and major fire runs are probable and control efforts are largely ineffective (Table 13).

Table 12. High fire danger FlamMap 5.0 inputs

1hr	10hr	100hr	Herbaceous	Woody	20 foot wind speed (MPH)	Direction (degrees)
2%	3%	6%	30%	70%	15	225

Table 13. Fire Behavior Hauling Chart; tactical interpretation for flame length

Flame Length	Interpretation
Less than 4 feet	Fires can generally be attacked at the head or flanks by firefighters using hand tools. Handline should hold fire.
4 to 8 feet	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied on to hold the fire. Dozers, tractors-plows, engines and retardant drops can be effective.
8 to 11 feet	Fires may present serious control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Over 11 feet	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

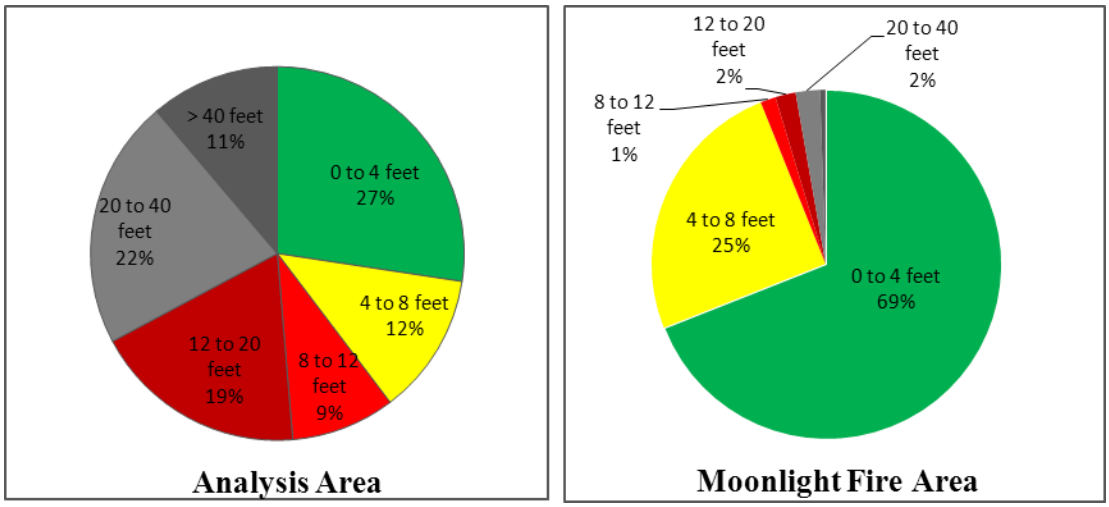

Figure 40. Graph showing FlamMap 5.0 predicted flame lengths under high fire danger conditions

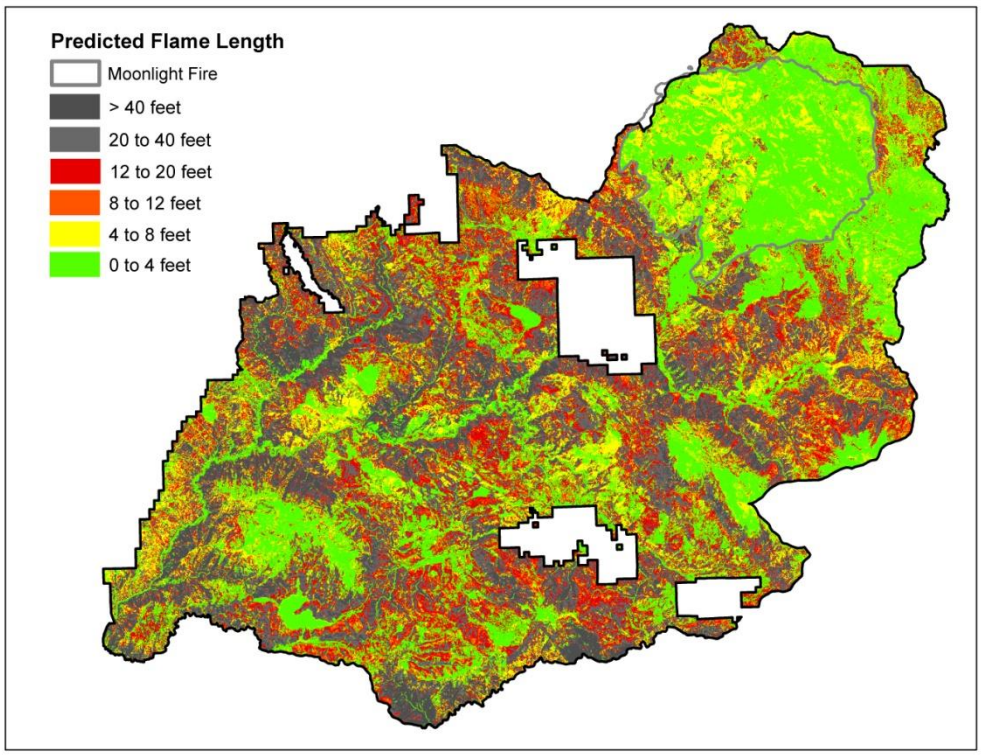

Figure 41. Map showing FlamMap 5.0 predicted flame lengths under high fire danger conditions on the Mt. Hough Ranger District and within the Moonlight Fire area

In contrast, fire danger within the Moonlight Fire footprint is considerably reduced (Figure 41). This result may be misleading as Land Fire Data used was only one year post-fire. In terms of the risk of re-burning, some lessons may be learned by looking at the overlap between the 2000 Storrie Fire and the 2012 Chips Fire (Table 14). Even though these fires were only 12 years apart, the proportion of high severity within this overlap was still relatively high at 32 percent. In fact, many remnant conifer stands that persisted after the Storrie Fire were subsequently lost in the Chips Fire, widening forest gaps and eliminating conifer seed sources.

Table 14. 2012 Chips Fire Basal Area mortality within the overlap of the 2000 Storrie Fire.

BA Mortality Acres (Percent)				Total Acres
<25%	**25-50%**	**50-75%**	**>75%**	
12,767 (52%)	1,898 (8%)	1,864 (8%)	7,812 (32%)	24,340

In part, some of the re-burn severity in Chips may be a result of the large accumulation of surface fuels and woody debris that resulted from the first fire event. In many high severity areas 12 years after the Storrie Fire, fuel loads were represented by high snag densities, thick shrubs as high as 5 feet tall, and a complex arrangement of fallen trees, broken tops and branches intermixed and suspended within a heavy shrub component (Figure 42). It is estimated that overall fuel loading could be as high as 200 tons per acre (Powers et al. 2013).

These elevated fuel loads and associated risk may persist for more than half a century (Figure 43). Currently, no fuel model exists to describe this complex arrangement of fuels and this condition is becoming ever more common as the size and severity of fires continues to increase within the region.

Figure 42. Left: Post 2000 Storrie Fire conditions captured 12 years after the fire. Right: Same frame taken 22 days after the Chips Fire passed through this site on August 1st 2012

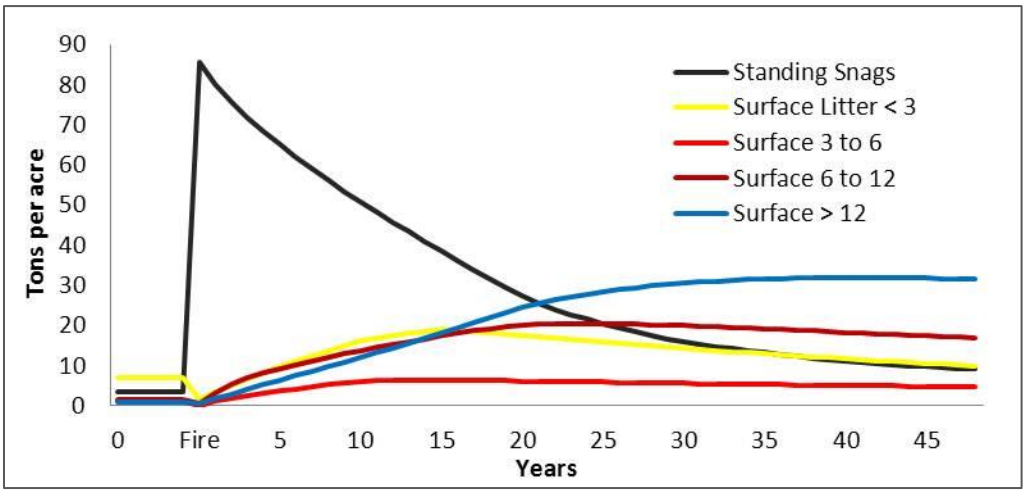

Figure 43. Fuel loading over time after stand replacing wildfire with no treatment. Representative mixed conifer stand chosen for Forest Vegetation Simulation was well to over stocked with a dense understory. Trees per acre = 450, basal area = 275, merchantable board feet = 30,000, quadratic mean diameter = 10.5

Much of the Moonlight Fire area may be susceptible to similar secondary fire events particularly in areas where no salvage or fuels work has been implemented. About 10,300 acres (16 percent) of the Moonlight Fire area was salvaged and these salvaged areas typically left logging slash and smaller snags 12 to 14 inches in diameter.

3.9 Past and Present Wildlife Habitat Conditions

The wildlife section of this restoration strategy is both a compilation of existing information, as well as some new analysis. Much of the following information was taken from a report written

by Rotta (2011) titled *Assessment of Impacts of the Moonlight Fire on Sensitive Wildlife Species Habitat*. In addition, data and narratives were borrowed from: the *Diamond Landscape Assessment* (USDA 2005), the *Biological Evaluation for the Moonlight-Salvage FEIS* (Collins 2009a), and the *Management Indicator Species report for the Moonlight-Salvage FEIS* (Collins 2009b).

The wildlife analysis area for the Moonlight Restoration Strategy includes all of the HUC 12 watershed boundaries that overlap with the Moonlight Fire and the adjacent Antelope Complex Fire (Figure 44); it excludes the watershed falls on the Lassen NF. In many cases, information borrowed from existing reports used either the Moonlight Fire footprint (Rotta 2011) or the Moonlight and Antelope Complex fire footprints combined (Collins 2009a, Collins 2009b, Keane et al. 2011). When these different analysis areas are used, they are noted.

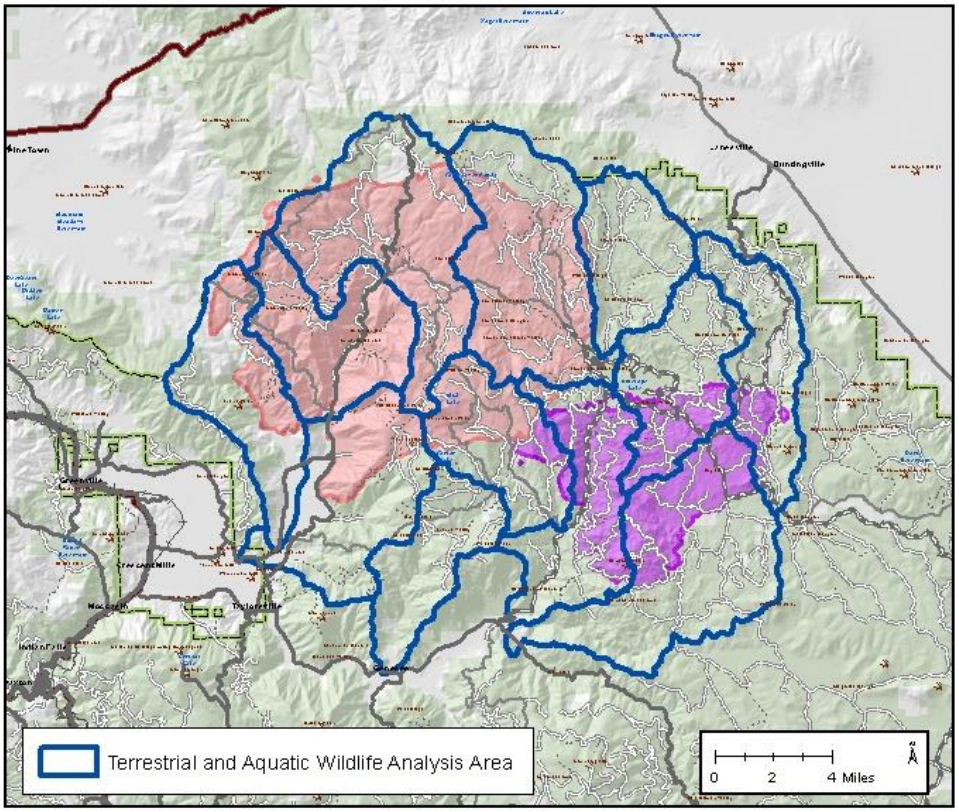

Figure 44. Analysis area for wildlife habitat restoration; maps displays the affected watersheds (analysis area) and the spatial relationship between the 2007 Moonlight Fire (pink) and Antelope Complex (purple).

Although historic vegetation data from the analysis area is limited, vegetative conditions for adjacent areas are available (varying between 3-20 miles from the analysis area; see Section 3.2.1 for details). Based on the congruence of historical vegetation data, precipitation patterns, and prior modeling efforts, it is assumed that much of the area affected by the fire was historically yellow pine dominated forest along with dry mixed conifer forest (Moody 2002,

Taylor 2008, see Section 3.2.1 for details). Yellow pine forest in the analysis area likely transitioned to Sierra mixed conifer forest in areas with higher annual precipitation (i.e. in the western portion of the analysis area); true fir forests likely occurred at higher elevations and along more mesic northern aspects. Under a natural fire regime, it is estimated that roughly half of forests in the analysis area would have been in relatively later seral stages (Figure 10, see Section 3.2.1 for details). Modeling efforts also predict that both mid and late seral stages would have had an open canopy structure (Figure 10, Safford 2013).

Forest management during the preceding century decreased landscape level forest heterogeneity compared to historic levels by reducing dominant and co-dominant overstory trees and retaining smaller diameter trees via selective harvest and fire suppression; this resulted in a shift in forest species composition to a greater representation of shade tolerant species (i.e., white fir). Compared to historic conditions, pre-fire forests within the analysis area contained denser stands of smaller diameter trees (primarily Sierra mixed conifer rather than historic yellow pine forests) and copious amounts of ground and ladder fuels (see Section 3.2.1 for details).

The Moonlight and Antelope Complex fires resulted in a rapid shift in forest vegetation types within the analysis area. Conifer forests dominated by long lived tree species and characterized by frequent low severity fire regimes were converted to shrublands dominated by montane chaparral species (relatively short lived) with infrequent high severity fire regimes (Figure 12). Although montane chaparral is an ecologically important early seral habitat type in this area, wildlife that previously utilized mid and late seral conifer forest habitat (Sierra mixed conifer, true fir, yellow pine) in the area experienced considerable habitat loss (Figure 13). Further, the level of fuels that exist within conifer forests that were not converted to shrublands post-fire (i.e. forests that did not burn at high severity, approximately 30 percent of the area that burned), coupled with the high-severity fire regime associated with shrublands, increases the risk of high severity fire returning to the analysis area and further reducing conifer forest habitat for wildlife species (Westerling and Bryant 2008, Thompson et al. 2007). Thus, remaining conifer forest stands in the analysis area are vulnerable to future high severity fire events. Aside from additional reductions to wildlife habitat for mid and late seral forest species, further loss of conifer forest to fire would reduce seed source availability near shrublands (limiting forest regeneration), reduce forest heterogeneity, and increase mid and late seral habitat fragmentation. Although high and moderate-high severity fire (basal area mortality greater than 50 percent) reduced habitat availability for wildlife associated with mid and late seral conifer forests, low to moderate-low severity fire (basal area mortality less than 50 percent) also modified these forest types by increasing snag recruitment over time (which in the future would lead to more downed logs) and encouraging understory growth (a key habitat component for many species) by opening up overly dense forest stands.

The availability of snags and large down woody debris on the landscape is critical for numerous wildlife species (i.e., availability of cavity and den sites). The average tonnage of woody debris within the analysis area will fluctuate over time as trees killed in the Moonlight Fire perimeter

fall over. Further, live green trees isolated by the fire could also be more susceptible to wind throw. The rate of snag fall varies with DBH and species and the rate of downed log decay varies with size species (Lyon 1977, Raphael and Morrison 1987, Cluck and Smith 2007). Snag fall rates are highest the first ten years within the smaller diameter classes, while larger snags persist for relatively longer time periods (Cluck and Smith 2007). The majority of snags resulting from the Moonlight and Antelope Complex fires are expected to fall within approximately 20 years post-fire. Additional snag recruitment would be expected through delayed mortality from live trees that initially survived the fire.

Due to habitat changes as a result of the fire, wildlife occupying habitat that was lost during the fires was displaced into adjacent areas that may be of lower quality habitat or currently occupied. This may cause stress to both the individuals occupying the current areas and the individuals being displaced. Competition for available resources may lead to the death of individuals, reduction in the health of individuals, and/or reduction in reproductive success of individuals. Such displacement effects may have already occurred and continue to occur within the analysis area.

3.9.1 Late Seral Forests and Associated Species

The large scale and high severity of the Moonlight and Antelope Complex fires resulted in long-term harmful effects to late seral forest species (i.e. California spotted owl, northern goshawk, and American marten). Forest stands containing large trees and multiple canopy layers that were lost to fire will not be replaced for over a century.

3.9.1.1 California Spotted Owl (Strix occidentalis)

The California spotted owl occurs in mixed-conifer and hardwood forests throughout the Sierra Nevada and the mountain ranges of southern California (Verner et al. 1992). Spotted owls nest in tree cavities, generally in conifer and mixed conifer-hardwood forests with the following characteristics: dominant and co-dominant trees in the canopy averaging at least 24 inches in DBH; at least 70 percent total canopy cover; higher than average levels of very large old trees; and higher than average levels of snags and downed woody material. These features provide habitat for California spotted owl nesting, and roosting, in the Sierra Nevada (USDA 2001). Definitions of suitable habitat are derived from those listed in Verner et al. (1992), SNFPA (USDA 2004), and the Federal Register (Volume 70, June 21, 2005).

The Moonlight Fire resulted in habitat loss and large scale openings that fragmented suitable nesting, foraging and dispersal habitat for spotted owls. Conversely, in some low burn severity areas that support live trees and forested canopy there likely would have been a short-term increase in snag availability that could provide additional nesting structures of owls. Further, increases in forest down wood component will benefit owl prey species. Increased habitat edge, between non-burned middle to late seral forest and burned early seral habitat may provide excellent foraging opportunities for spotted owls. Although California spotted owls require late-seral forest habitat, owls do exploit resources on post-fire landscapes. Recent studies have reported that California spotted owls may select forest patches that burned at

high severity for foraging over adjacent green forest habitat (Bond et al. 2009), and that high severity fire may burn over 30 percent of suitable habitat in a spotted owl breeding site without reducing the probability of site occupancy (Lee et al. 2012). The only edge habitat available for late seral species, such as spotted owls, to exploit is on the fire perimeter where high, medium and low severity patches occur adjacent to unburned habitat outside the fire perimeter.

As a result of the high severity burn within the Moonlight Fire, late seral closed canopy habitat (spotted owl nesting habitat) decreased 96 percent from pre-fire conditions, and total available spotted owl habitat (nesting and foraging) was reduced by 91 percent (Table 15).

Table 15. Effects of Moonlight Fire on Spotted Owl Suitable Habitat within the Moonlight Fire landscape (all acres approximate and all are NF)

Habitat*	**Pre-Fire Acres**	**Post-Fire Acres**	**Reduction in Suitable Acres**	**Reduction in Suitable Habitat (%)**
Suitable Nesting Habitat (5M, 5D, 6)	13,876	501	13,375	96%
Suitable Foraging Habitat (4M, 4D)	18,029	2,517	15,512	86%
Total	31,905	2,018	28,887	91%

*CWHR tree habitat: SMC, PPN, WFR, RFR. 5M = trees >24 inch DBH, 40-59% canopy cover; 5D = trees >24 inch DBH, >60% canopy cover; 6 = size class 5 trees over a distinct layer of size class 4 or 3 trees, total tree canopy exceeds 60% closure; 4M = trees 11-24 inches DBH, 40-59% canopy cover and 4D = trees 11-24 inches DBH, >60% canopy cover.

The SNFPA Record of Decision (USDA 2004) provides direction for spotted owl management, including Protected Activity Center (PAC) and Home Range Core Area (HRCA) delineation. California spotted owl PACs are delineated surrounding each territorial owl activity center detected on NFS lands since 1986. PACs are delineated to include known and suspected nest stands and to encompass the best available 300 acres of habitat in as compact a unit as possible. Home Range Core Areas (HRCAs) are established to surround each spotted owl PAC. On the Plumas NF, each HRCA is to be 1000 acres, which includes the 300 acre PAC. These HRCAs encompass the best available owl habitat in the closest proximity to the owl activity center; HRCAs are delineated within 1.5 miles of the activity center.

All or a portion of nineteen spotted owl PACs and their associated HRCAs were located within the perimeter of the Moonlight Fire (USDA 2008). As noted earlier, recent studies have reported California spotted owls may select forest patches that burned at high severity for foraging over adjacent green forest habitat (Bond et al. 2009), and that high severity fire may burn over 30 percent of suitable habitat in a spotted owl breeding site without reducing the probability of site occupancy (Lee et al. 2012). However, 17 of the 19 spotted owl PACs affected by the Moonlight and Antelope Complex fires have been rendered unsuitable due to high severity wildfire effects and have been removed from the Plumas NF PAC distributional network (USDA 2008). Narrow corridors of dispersal habitat, primarily provided by riparian habitat along creeks, within the fire area may still allow for owl dispersal across the area, but the combination of the Moonlight and Antelope Complex fires may have significantly reduced

owl dispersal across the landscape in northeastern Plumas County. Based on the evidence above, the Moonlight Fire resulted in long-term habitat loss and fragmentation that will impede dispersal into, use of, and occupancy of, this area by California spotted owl and creates a potential barrier to habitat connectivity.

Future risk to spotted owl habitat

To investigate the risk of wildfire impacting spotted owl habitat in the future (i.e., loss of existing habitat to future wildfires) we modeled fire within the analysis area (and Mt Hough RD) to predict potential fire behavior and movement across the landscape (see Section 3.8.5, Current Fire Risk, for details). A modeled fire burning during moderate weather conditions would be expected to burn 56 percent of PACs at high severity (flame length greater than 12 feet), and 25 percent of PACs at low severity (4-8 foot flame length) (Table 17). For context, another analysis at a larger scale was conducted across the Mt Hough Ranger District; this analysis found that 77 percent of the acres within PACs would likely burn at high severity under moderate weather conditions, an additional seven percent would burn at moderate-high severity (8-12 foot flame length), and additional four percent would burn at moderate severity (Figure 45).

Table 16. Predicted burn severity of California spotted owl PACs within the wildlife analysis area. Spotted Owl PACs with less than 50 percent of the acres in low severity category are at high risk for loss during the next wildfire. Predicted burn severity was modeled using moderate fire weather conditions (see Section 3.8.5, Current Fire Risk, for model details).

	% by predicted burn severity (flame length)			
PAC #	**Low Severity (0 to 4 feet)**	**Moderate Severity (4 to 8 feet)**	**Mod-High Severity (8 to 12 feet)**	**High Severity (>12 feet)**
PLU0071	89	4	2	5
PLU0072	22	11	14	53
PLU0085	14	6	20	60
PLU0107	58	8	5	29
PLU0109	33	7	4	57
PLU0130	2	2	9	86
PLU0131	6	14	21	59
PLU0167	43	14	12	32
PLU0200	5	4	12	80
PLU0210	6	1	7	86
PLU0220	56	17	10	17
PLU0230	13	14	12	60
PLU0241	7	1	3	89
PLU0258	6	6	5	84
PLU0286	20	10	9	61
PLU0287	27	9	18	47
PLU0301	51	14	15	20

PLU0355	10	11	12	66
Grand Total	**25**	**8**	**10**	**56**

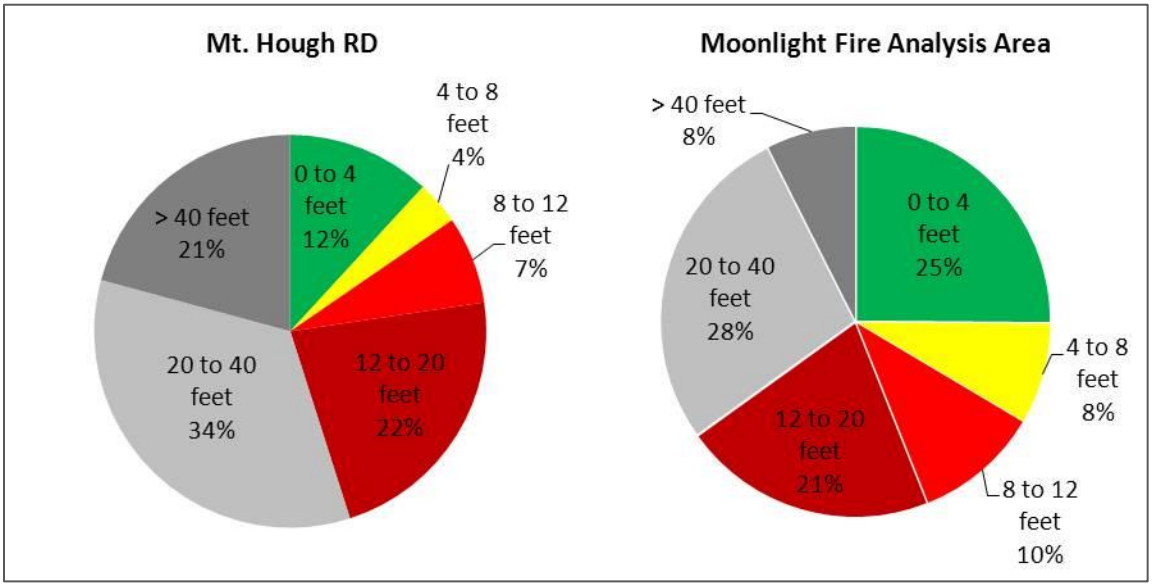

Figure 45. Predicted flame length within existing Spotted Owl PACs when wildfire was modeled across the analysis area and the entire Mt Hough Ranger District. Desired conditions are for at least 50 percent of the acreage to be in low fire severity condition (green) with no more than 25 percent of acres in moderate to high severity conditions (red and gray). See Section 3.8.5, Current Fire Risk, for model details.

To provide evidence to show that this modeling effort is valid, the following information shows that actual wildfires have burned spotted owl PACs at similar severity to the results of this modeling effort. In their assessment of the Moonlight Fire, Dailey and others (2008) found that 68 percent of the total spotted owl PAC and HRCA acreage had 75-100 percent canopy cover loss (high severity). This modeling effort found that 56 percent of PAC acres in adjacent unburned watersheds would likely burn at high severity. Dailey and others (2008) found that PAC and HRCA acres were burned at higher intensity than other untreated areas. They also found that areas treated with a combination of thinning and prescribed burning showed the greatest ability to reduce burn intensity. Dailey and others (2008) recommended treating in protected areas to enable these sites to withstand fire with lesser effects. Spotted owl PACs should be prioritized for treatment, with those with the highest percent predicted to burn at high severity ranking highest for treatment to reduce fire risk.

3.9.1.2 Northern Goshawk (Accipiter gentilis)

The Northern goshawk requires mature conifer and deciduous forest with large trees, snags, and downed logs, and dense canopy closure for nesting. Goshawks use forests with moderately open canopy and understory vegetation interspersed with meadows, brush patches, or other natural or artificial openings and riparian areas for foraging. Studies indicate that goshawks typically select for canopy closures greater than 60 percent for nesting (Hall 1984, Richter and

Callas 1996, Keane 1997). Goshawks usually nests on north slopes, near water, in the densest parts of stands, but close to openings (CDFG 2006). Goshawks construct stick nests generally located in live conifer or hardwood trees, although nests are sometimes placed in snags, and these nest trees are commonly among the largest trees in a stand (USDA 2001). The following forest types, typical of the restoration area prior to the fire, provide high nesting and feeding habitat capability when composed of medium (11-24 inches DBH) and large (greater than 24 inches DBH) trees with greater than 40 percent canopy cover: Sierra mixed conifer, white fir, red fir, ponderosa pine, lodgepole pine, and eastside pine (SNFPA FEIS Vo1.3, Chap.3, part 4.4 p. 116).

The Moonlight and Antelope Complex fires resulted in long-term harmful effects to goshawk habitat due to reduction in the existing large tree component and dense forested stand structure, as well as a short to long-term reduction in availability of structural diversity provided by mature conifer habitat. The foraging goshawk can take advantage of the short-term increase in prey availability resulting from the increase in snag and down wood component throughout the burn, especially on edges adjacent to low severity and unburned habitat. However, wildfires the size and severity of the Moonlight Fire usually result in habitat loss and large scale openings, fragmenting suitable nesting habitat. As a result of the high severity burn within the Moonlight Fire, potential goshawk habitat decreased 91 percent from pre-fire conditions (**Error! Reference source not found.**).

Table 17. Effects of Moonlight Fire on Goshawk Habitat (all acres approximate and all are NFS lands).

Habitat	**Pre-Fire Acres**	**Post-fire Acres**	***Reduction in suitable habitat***
*Suitable Habitat (5M, 5D,4M, 4D)**	*31,905*	*3,018*	*28,887 acres* *91% reduction*

**Sierra mixed conifer, ponderosa pine, white fir, red fir, lodgepole and eastside pine forest types. 5M = trees >24 inch DBH, 40-59% canopy cover; 5D = trees >24 inch DBH, >60% canopy cover; 6 = size class 5 trees over a distinct layer of size class 4 or 3 trees, total tree canopy exceeds 60% closure; 4M = trees 11-24 inches DBH, 40-59% canopy cover and 4D = trees 11-24 inches DBH, >60% canopy cover.

The SNFPA ROD (USDA 2004) provides direction for goshawk management and Protected Activity Center (PAC) delineation. Goshawk PACs are delineated surrounding all known and newly discovered breeding territories detected on NFS lands. PACs are delineated to include known and suspected nest stands and to encompass the best available 200 acres of habitat in the largest contiguous patches possible.

All six goshawk PACs located within the Moonlight Fire were severely impacted by the Moonlight Fire. Five of six goshawk PACs burned at moderate to high severity (greater than 50 percent basal area mortality) over 60 percent of the PAC. The fire rendered most potential habitat within each PAC unsuitable with high severity burn areas converted to brush fields and lower severity burn areas experiencing a reduction in canopy closure to 25-39 percent.

Although goshawks may take advantage of the short-term increase in prey availability resulting from the increase in snag and down wood component throughout the burn (especially on edges

adjacent to low severity and unburned habitat), all six PACs within the Moonlight Fire were rendered unsuitable due to high severity wildfire effects and have been removed from the Plumas NF PAC distributional network (USDA 2008). Within the Moonlight Fire perimeter, low quality habitat suitable for nesting goshawks may not be available for 80-100 years. High quality habitat with the stand structure and tree size capable of providing goshawk habitat that was present prior to the Moonlight Fire is not expected for 150+ years.

Future risk to goshawk habitat

To investigate the risk of wildfire impacting residual goshawk PACs in the analysis area (i.e., loss of existing PACs to future wildfires, N = 7) we modeled fire within the analysis area (and Mt Hough RD) to predict potential fire behavior and movement across the landscape (see Section 3.8.5, Current Fire Risk, for details). Despite not using severe fire weather conditions in these models, four of seven PACs were predicted to have had greater than 60 percent of the acreage burn at high fire severity during the next fire event (Table 18 and Figure 46).

Table 18. Predicted burn severity of northern goshawk PACs within the wildlife analysis area. Goshawk PACs with less than 50 percent of the acres in low severity category are at high risk for loss during the next wildfire. Predicted burn severity was modeled using moderate fire weather conditions (see Section 3.8.5, Current Fire Risk, for model details).

Goshawk PAC #	% by predicted burn severity			
	Low Severity (0 to 4 feet)	**Moderate Severity (4 to 8 feet)**	**Mod-High Severity (8 to 12 feet)**	**High Severity (> 12 feet)**
T02	13	1	6	80
T05	25	5	8	63
T30	70	6	15	9
T31	3	4	12	81
T45	49	21	12	17
T47	66	14	12	8
T50	10	10	11	69

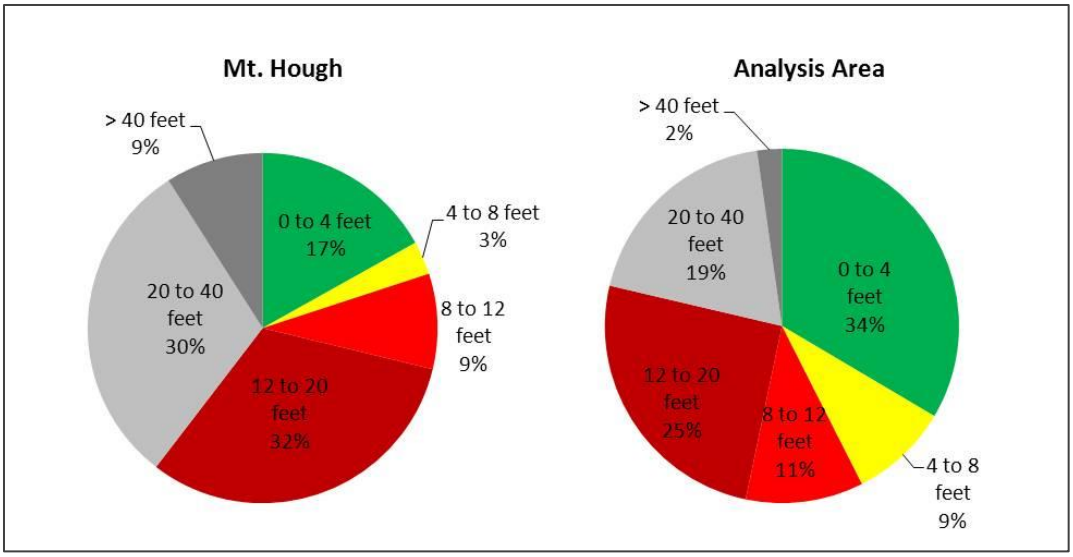

Figure 46. Predicted flame length within existing northern goshawk PACs when wildfire was modeled across the analysis area and the entire Mt Hough Ranger District. Desired conditions are for at least 50 percent of the acreage to be in low fire severity condition (green) with no more than 25 percent of acres in moderate to high severity conditions (red and gray). See Section 3.8.5, Current Fire Risk, for model details.

3.9.1.3 Mesocarnivores (American Marten and Pacific Fisher)

Habitat requirements for forest carnivores can be found in California Wildlife Habitat Requirements (Zeiner et al. 1990), habitat capability models (Freel 1991) and in Ruggerio et al. (1998). Large trees, large snags, large down wood and higher than average canopy cover are important habitat attributes for fisher, and a vegetated understory and large woody debris appear to be important for their prey species. Preferred fisher forest types include: aspen, Douglas-fir, eastside pine, Jeffrey pine, lodgepole pine, montane hardwood, montane hardwood-conifer, montane riparian, Ponderosa pine, red fir, Sierra mixed conifer, subalpine conifer and white fir. In the Sierra Nevada, marten are most often found above 7,200 feet, but the species core elevation range is from 5,500 to 10,000 feet (USDA 2001b). Martens prefer coniferous forest habitat with large diameter trees and snags, large down logs, moderate-to-high canopy cover, and in interspersion of riparian areas and meadows. Martens generally avoid habitats that lack overhead cover; they select stands with 40 percent canopy cover for both resting and foraging and usually avoid stands with less than 30 percent canopy cover. Foraging areas are generally in close proximity to both dense riparian corridors (used as travel ways), forest meadow edges, and includes an interspersion of small (less than 1 acre) openings with good ground cover used for foraging. Important forest types for marten include mature mesic forests of aspen, Douglas-fir, eastside pine, Jeffrey pine, lodgepole pine, montane riparian, Ponderosa pine, red fir, Sierra mixed conifer, subalpine conifer and white fir. The red fir zone forms the core of marten occurrence in the Sierra Nevada.

Approximately 65 percent of the Plumas NF has been systematically surveyed, by the Pacific Southwest Research Station (PSW), district biologists/wildlife technicians and contractors, to protocol for mesocarnivores using track plates and camera stations (American Marten, Fisher,

Lynx and Wolverine: Survey Methods for Their Detection; Zielinski and Kucera 1995). To date, there have been no fisher observations on the Plumas NF, but reintroduction efforts on adjacent private lands have used radio transmitters to track individuals making forays onto the forest. All confirmed sightings (photograph, tracks, hair sample, and sighting by reputable biologist) of American marten on the Plumas NF occur within three areas: the Lakes Basin-Haskell Peak area, Eureka Ridge area, or around Little Grass Valley Reservoir.

Open roads and improperly closed roads adversely affect mesocarnivores by: allowing access to areas and causing disturbance to these animals from human intrusion and removal of snags and downed logs through wood gathering activities; increasing vehicle/animal encounters resulting in road-kill; and fragmenting the habitat and affecting the ability of animals to use otherwise suitable habitat on opposing sides of the road (Duncan Furbearer Interagency Workgroup 1989). There may be a threshold value for road density (miles of open road per square mile) above which the habitat cannot sustain certain wildlife species but studies specifically addressing these effects on marten or fisher have not yet been addressed (USDA 2001a,b). Early habitat models (Freel 1991) indicated that to provide high habitat capability for marten, open road densities should be less than one mile/square mile; while one to two miles/square mile provided moderate habitat capability, more than two miles provided low to no habitat capability. Models indicate that open road densities should be less for pacific fisher. The approximate road density within the analysis area currently ranges between 1.25 and 2.94 miles of open road per square mile (see Section 3.13, Past and Present Hydrological Conditions, for additional details).

We previously discussed the extensive loss of late seral closed canopy forest, mesocarnivore habitat, within the analysis area during the Moonlight Fire. Hardwood and hardwood-conifer forest types (approximately three percent of the analysis area prior to the fire) also provided potential mesocarnivore habitat. However, the fire resulted in a reduction in the number of acres of hardwood vegetation classified as closed stands (40 percent or greater canopy closure) by almost 23 percent. Prior to the Moonlight Fire, there were no hardwoods in the seedling stage; however post fire vegetation mapping has identified nearly 1,000 acres of hardwood seedlings, suggesting the fire promoted hardwood sprouting (see Section 3.3, Past and Present Conditions: Hardwood Forest).

Although no comprehensive inventory of aspen distribution and condition has been made on the forest, the Plumas NF has identified 568 aspen stands in the analysis area, approximately 1,962 acres. Fire generally promotes aspen sprouting, and photo monitoring indicates that aspen stands have responded favorably to other fires in the analysis area, such as the Stream Fire in 2001. Although the Moonlight Fire may have promoted aspen sprouting and killed competing conifers that can suppress aspen growth (see Figure 24), aspen sprouts are very vulnerable to browsing by cattle or native ungulates until they are able to grow above the browse line. Repeated grazing of aspen suckers can cause aspen to grow in a bushy, multi-stemmed form that is more susceptible to browsing. Repeated browsing will eventually

eliminate aspen by exhausting the underground resources of the stand (Kay 1997, see Section 3.5.1.2, Aspen Stands).

Although the analysis area did not appear to provide habitat needed to sustain resident fisher or marten populations prior to the Moonlight and Antelope Complex fires, the presence of other late seral forest species (e.g., spotted owl and goshawk) implies that the habitat may have developed into suitable mesocarnivore habitat in the future. Further, we manage the forest to perpetuate those attributes that are important to fisher and marten to provide suitable travel corridors between resident populations and grow forest habitat to promote establishment of future populations.

Three species of bat (*Corynorhinus townsendii, Antrozous pallidus, Myotis thysanodes*) on the Regional Forester's Sensitive Species List (Region 5) occur within the analysis area in a variety of habitat types including late seral forest, grasslands, shrublands, woodlands, riparian zones, mixed conifer and true fir forests. There is scant information on the distribution of these species across the forest and within the analysis area, and information on habitat selection within the analysis area is rarer.

3.9.2 Shrubland, Early and Mid Seral and Burned Forests and Associated Species

The black-backed woodpecker (*Picoides arcticus*) is a Forest Service Management Indicator Species (MIS) for the ecosystem component of snags in burned forests. MIS are animal species identified in the Sierra Nevada Forests MIS Amendment Record of Decision (USDA 2007a). Guidance regarding MIS is set forth in the 1988 Plumas NF LRMP (USDA 1988a) as amended by the 2007 MIS Amendment (USDA 2007a) and directs Forest Service resource managers to: (1) at the project scale, analyze the effects of proposed projects on the habitat of each MIS affected by such projects, and (2) at the bioregional scale, monitor populations and/or habitat trends of MIS, as identified in the 1988 Plumas NF LRMP, as amended. Black-backed woodpeckers are dependent on snags created by moderate and high severity fires (greater than 25 percent basal area mortality; Hutto 1995, Kotliar et al. 2002, Smucker et al. 2005, Dudley 2012). Severely burned forests provide abundant snags that benefit prey (by providing food for the specialized beetle larvae that serve as prey) and ample nesting sites (Hutto and Gallo 2006). Areas where vegetation burn severity is low (i.e. less than 25 percent basal area mortality) are not considered to provide suitable black-backed woodpecker habitat but may contribute future snag habitat for black-backed woodpecker foraging and nesting near moderate and high burn severity areas (Hutto 1995).

Recent studies have confirmed and better delineated key habitat features (e.g., the importance of snag density) for black-backed woodpeckers (Siegel et. al 2013), and the recently developed *Black-backed Woodpecker Conservation Strategy* (Bond et al. 2012) provides numerous management recommendations that may be employed to benefit the species. Burned forest habitat suitability for black-backed woodpecker's declines over time as snags fall and decomposing trees gradually decline in foraging quality (Dudley and Saab 2007, Siegel et al. 2013). Over 30,000 acres of potentially suitable black-backed woodpecker habitat was created

during the Moonlight and Antelope Complex fires (USDA 2008). Over 50 percent of this habitat was not treated during the Moonlight and Wheeler Fires Recovery and Restoration Project and provides suitable habitat for black-backed woodpeckers (USDA 2008).

The fox sparrow (*Passerella iliaca*) is the US Forest Service Management Indicator Species (MIS) for shrubland (chaparral) habitat on the west-slope of the Sierra Nevada, comprised of montane chaparral (MCP), mixed chaparral (MCH), and chamise-redshank chaparral (CRC) as defined by the California Wildlife Habitat Relationships System (CWHR) (CDFG 2005). In the Sierra Nevada, the fox sparrow is dependent on open shrub-dominated habitats for breeding (Burnett and Humple 2003, Burnett et al. 2005, Sierra Nevada Research Center 2007). The Moonlight and Antelope Complex fires resulted in a rapid shift in forest vegetation types within the analysis area. Conifer forests dominated by long lived tree species and characterized by frequent low severity fire regimes were converted to shrublands dominated by montane chaparral species (relatively short lived) with infrequent high severity fire regimes (Figure 12). Seventy percent of the area burned during these fires burned at high severity, resulting in uncharacteristically vast areas of standing dead trees, which are now dominated by shrubs. The amount of the analysis area typed as shrubland increased after the fires from three to 29 percent (Figure 13). Surveys within the footprint of three fires on the Plumas and Lassen NF (Moonlight, Storrie and Cub) and green forest survey units on the Lassen NF found avian species richness and total bird abundance were significantly higher in green forest compared to any of the three fire areas (Burnett et al. 2009, 2010). fox sparrows were one of several species that exhibited greater abundance within the Moonlight Fire footprint compared to green forest habitat survey units (Burnett et al. 2009, 2010).

Mountain quail (*Oreortyx pictus*) is the US Forest Service Management Indicator Species (MIS) for early and mid seral coniferous forests (Douglas-fir, eastside pine, Jeffrey pine, ponderosa pine, red fir, Sierra mixed conifer, and white fir), but mountain quail also may serve as a good indicator of shrubland habitat quality in the Moonlight Restoration analysis area. The Mountain quail is routinely found on steep slopes, in open, brushy stands of conifer and deciduous forest and woodland, and chaparral; it may gather at water sources in the summer, and broods are seldom found more than 0.8 km (0.5 mi) from water (CDFG 2005). Aside from their use of shrubland habitat, mountain quail typically use early seral coniferous forest composed primarily of seedlings (less than one inch dbh), saplings (one to 5.9 inches dbh), and pole-sized trees (6 to 10.9 inches dbh), and mid seral coniferous forest comprised primarily of small-sized trees (11 - 23.9 inches dbh). Although shrubland habitat is utilized by mountain quail, and the proportion of the analysis area supporting shrublands increased by 26 percent after the Moonlight and Antelope Complex fires (Figure 13), there were negligible differences in the amount of early seral and mid seral open canopy habitat available to quail within the analysis area pre and post fire (Figure 14). There was a 19 percent reduction in the amount of mid seral closed canopy habitat within the analysis area post fire compared to pre fire conditions (Figure 14).

The Moonlight and Antelope Complex fires created large patches of shrubland habitat (25 percent increase over pre fire acreage levels), some of which will develop into early seral conifer forest habitat. Shrublands and early seral forests provide excellent foraging opportunities for mule deer (*Odocoileus hemionus*), the US Forest Service Management Indicator Species (MIS) for hardwood and hardwood-conifer forests. Early seral and shrubland habitats provide forage for deer in their summer, migration and winter ranges. However, important winter thermal cover was lost when mid- and late-seral habitats burned during fires. Prior to the Moonlight and Antelope Complex fires there was a network of 13 water catchment devices (termed guzzlers) in the analysis area. Guzzlers were placed to increase water distribution for wildlife species, specifically deer, quail and grouse. Numerous other species of wildlife also took advantage of increased water availability. Monitoring of wildlife guzzlers found that deer, bear, gray fox, squirrels, songbirds, quail and striped skunks were frequent users of the additional water available. Twelve of the 13 guzzlers burned in the Moonlight (N = 9) and Antelope Complex (N = 3) fires.

3.9.3 Golden Eagle and Other Cliff Nesting Raptors

Although golden eagles (*Aquila chrysaetos*) forage in grasslands and early successional stages of forest and shrub habitats, they construct stick nests on cliff ledges and in large trees within mature conifer forest. Golden eagles were known in the fire area before the Moonlight Fire, with nest sites ringing the fire area. Most (12 of 16) historic golden eagle nest sites on the Plumas NF were located within late seral forest with moderate (greater than 40 percent) to dense (greater than 60 percent) canopy cover; four other nests were on cliff ledges. Golden eagle home ranges vary across the landscape with nesting densities ranging from one pair per 36 square miles to one pair per 48 square miles in California (Zeiner et al. 1990). Given adequate resources (i.e. food and nesting sites), the analysis area could support two to three nesting pair of golden eagles. Two falcon species (*Falco peregrinus* and *F. mexicanus*) also have been observed in the analysis area.

The Moonlight Fire resulted in a long-term decrease in the number of large trees available for eagle nesting, and concomitantly increased open foraging habitats. Golden eagles can take advantage of the increase in prey availability resulting from the increase in open foraging conditions throughout the burn area, but only with sufficient nesting locations. Table 19 displays the effects of the Moonlight Fire on suitable golden eagle nesting habitat on FS lands within the analysis area. Approximately 28,887 acres of suitable nesting habitat was rendered unsuitable on NFS lands as a result of stand replacing fire.

Table 19. Effects of Moonlight Fire on tree-nesting habitat for golden eagles (all acres approximate and all are NFS lands).

Habitat	**Pre-Fire Acres**	**Post-fire Acres**	***Reduction in suitable habitat***
*Suitable Habitat (5M, 5D,4M, 4D)**	*31,905*	*3,018*	*28,887 acres - 91% reduction*

* * Sierra mixed conifer, ponderosa pine, white fir, red fir, lodgepole and eastside pine forest types (trees >24 inch DBH, 40-59% canopy cover; 5D = trees >24 inch DBH, >60% canopy cover; 6 = size class 5 trees over a distinct layer

of size class 4 or 3 trees, total tree canopy exceeds 60% closure; 4M = trees 11-24 inches DBH, 40-59% canopy cover and 4D = trees 11-24 inches DBH, >60% canopy cover.

3.9.4 Meadow Habitat and Associated Species

Ninety eight meadows have been mapped in the analysis area (1,775 acres, Fryjoff-Hung and Viers 2012); however, this is a conservative estimate as aerial photos show many stringer meadows that have not yet been georeferenced. A complex of five fen wetlands also occurs in the analysis area (Lowe Flat meadow, Figure 20). Fens are unique wetland ecosystems that support many rare and endemic plant and animal species. Fens depend on the presence of peat-forming vegetation, which can accumulate over thousands of years and serve as important carbon sinks (see Section 3.5.1.1, Meadows and Fens, for additional details). Meadows and fens are characterized by moist soil conditions, which limit the spread of fire. The Lowe Flat fen complex and 80 percent of meadows found in the analysis area did not burn in the Moonlight Fire. However, of the 376 acres of meadows that did burn, 80 percent experienced moderate to high fire severity (greater than 25 percent loss of vegetation). Fire can benefit meadows by killing encroaching conifers and upland shrubs species. Fire can also stimulate the production of herbaceous biomass in meadows in subsequent years (Wright and Chambers 2002). On the other hand, fire can negatively affect meadows. High severity fires that eliminate meadow vegetation and expose soil can increase rates of erosion, soil drying, and bank instability.

There are two range monitoring areas in meadow habitat within the perimeter of the Moonlight Fire. One monitoring area is in the Lone Rock Creek grazing allotment, which burned with relatively high severity. This allotment was rested from grazing after the fire in 2008 and appeared to support dense vegetation the following year (see Section 3.5.1.1, Meadows and Fens, for additional details). The second range monitoring area in the Moonlight Fire perimeter is in the Lights Creek allotment. This area burned very lightly and was not rested from grazing after the fire (Figure 23). Monitoring completed by the Region 5 Range Monitoring Program includes three meadows within the analysis area. A comparison of data collected in 2002 and 2003 with data collected five years later indicated that two of the meadows had experienced a downward trend in condition and did not meet desired conditions (see Section 3.5.1.1, Meadows and Fens, for additional details). Further, proper functioning condition assessments in grazing allotments have found that some areas are functional at risk with a downward trend and are in need of restoration. For example, Lone Rock Creek was found to be functional at risk with a downward trend due to cut banks, excessive sediment deposition, and dewatering due to a culvert (Cleland et al. 2006). Six locations were identified in the Diamond Project area with headcuts, excessive channel and bank erosion, and bank instability (USDA 2006a). Where headcut erosion has occurred in meadows, the meadow may no longer function as a floodplain during high flow events, and the water table of the meadow may be lowered, resulting in soil drying and loss of meadow vegetation.

The willow flycatcher (*Empidonax trailii brewsteri*) is a neotropical migrant that breeds in riparian and mesic upland thickets in the United States and southern Canada. Willow flycatchers typically inhabit moist meadows with perennial streams and smaller spring fed or

boggy areas with willow (*Salix* spp.) or alders (*Alnus* spp.) on the Plumas NF. The willow flycatcher is a US Forest Service Sensitive Species (Region 5) and has been detected at 25 distinct sites across the Plumas NF. Approximately 600 acres of potentially suitable willow flycatcher habitat has been identified within the analysis area, ranging in size from a couple acres to over 45 acres. Two statewide surveys found most (more than 80 percent) willow flycatchers on meadows greater than 19.8 acres in size (Serena 1982, Harris et al. 1988). Although use of meadows less than 0.5 ha (1 ac) have been documented (Stafford and Valentine 1985, USDA FS 1991), more than 95 percent of Willow Flycatcher breeding meadows are greater than 10 acres, and the most successful meadows (i.e., those in which >1 territory fledged young) are greater than 15 acres (Green et al. 2003).

3.10 Past and Present Aquatic Conditions

The aquatic analysis area covers over 184,000 acres ranging in elevation between 3,520 and 7,820 feet (Figure 44). The area contains approximately 1,015 acres of lacustrine habitat, 1,963 miles of stream habitat, and six mapped springs. Antelope Lake is by far the largest lake in the restoration analysis area at approximately 948 acres. Taylor Lake (approximately 26 acres) is considerably smaller in size, but is much larger compared to the 60+ small lakes (mean = 0.7 acres, range =0.03 – 5.5 acres) scattered across the analysis area. 201 miles of stream channel in the analysis area miles are perennial streams, 432 miles are intermittent and 1,329 miles are ephemeral streams. The average slope of streams in the area is 20 percent. The number of springs reported in the analysis area is certainly an underestimate as data on the distribution of springs across the forest is limited, at best. Additional surveys are necessary to determine an accurate estimate of the number of springs in the analysis area.

3.10.1 Aquatic Habitat Condition

Managers expressed concern for the condition of streams in the Moonlight Fire area prior to the fire (USDA 2005, USDA 2008, also see Section 3.13 for additional details). Several streams within the aquatic analysis area were surveyed prior to the Moonlight Fire (Stream Condition Inventory, SCI). Examination of overall stream condition (based on physical characteristics including bank full width: depth ratio, bank angle, shade, pool tail fines, particle count less than two millimeters, and unstable banks) found that less than a third of streams surveyed in the analysis area were in good condition; whereas, the remaining streams were in moderate to poor condition (see Section 3.13, Past and Present Hydrological Conditions, for details). Relatively fine sediment in pool tails were found in lower gradient reaches, and historic grazing regimes were suggested as one possible cause of poor pre-fire stream condition in the area; however, two years prior to the Moonlight Fire, stream conditions were generally improving in the area (USDA 2007a).

Aside from SCI surveys, 37 additional stream miles were examined for general condition prior to the Moonlight Fire. These were relatively longer stream lengths compared to the SCI reach surveys, and they revealed that approximately 22 percent of stream lengths had noticeable bank erosion, six percent had prevalent bank erosion, and one percent had extensive bank

erosion. Further, 13 headcuts were identified in the Antelope Lake HUC 6 watershed (USDA 2007a). In general, large woody debris (LWD) was rated good or fair in the area (90 percent of streams rated good). Streams with less than optimal LWD were concentrated in the Antelope Lake area.

Forest roads that are not properly maintained may have severe and catastrophic impacts to streams. Most roads surveyed in the analysis area were found to be in good condition prior to the Moonlight Fire; however, approximately six percent of roads were identified as requiring some level of reconstruction and roughly three percent of roads were causing resource damage and should likely have been decommissioned (USDA 2007a).

Prior to the fire, large cut banks and deposition resulted in classification of Lone Rock Creek as functioning-at-risk. Some of this habitat degradation was apparently due to a misaligned culvert on a NFS road. However, there has been concern with grazing impacts to stream banks along Lone Rock Creek coupled with herbivory on willows (*Salix*) that have consistently resulted in the areas being rated below thresholds of concern (for more details see Section 3.13- Past and Present Hydrological Conditions).

Mining activities have disturbed riparian areas and stream channels in several creeks in the area (e.g., Cooks, Moonlight, Lights and Indian Creeks), creating over-steepened and unstable stream banks at a minimum. There is little information available on mining related contaminant threats to aquatic organisms in the analysis area; however, knowledge of contaminant threats is necessary for effective aquatic restoration.

The effects of the Moonlight Fire on riparian vegetation were previously presented (Section 3.5, Past and Present Vegetation Conditions: Meadow, Fen, Aspen and Riparian Vegetation). Over 60 percent of riparian vegetation in the Moonlight fire perimeter burned at moderate to high severity (greater than 25% basal area mortality), and many first order streams experienced high severity fire (great than 75% basal area mortality; USDA 2007a). Most drainages evaluated post fire experienced significant loss of riparian vegetation, and the amount of shade present in riparian areas was rated as poor (USDA 2008).

In general, LWD was only partially consumed in larger channels; however, the Moonlight Fire burned out LWD in most first and second order streams, releasing sediment stored by LWD (USDA 2007a, USDA 2008). Reaches within meadow areas were relatively untouched, and burn severity was light on the meadow floodplain. Reaches in gorges such as Lower Lights Creek, with large areas of rock out cropping, also experienced a relatively less severe burn (USDA 2007e, USDA 2008).

Post-fire surveys reported that the main channel and tributaries of Pierce and Indian Creeks (composed mostly of cobbles and boulders) appeared stable; however, intermittent and ephemeral streams in Pierce and Upper Indian Creek drainages did exhibit prevalent or extensive bank instability (USDA 2008). Sections of Pierce and Boulder Creeks also contained high sediment in pool tail fines. Historic grazing activity around both reaches may have

contributed to bank instability. Further, Middle and Upper Indian Creek Drainages were found to contain inadequate amounts of LWD.

The confluence of numerous streams forms the main stem of Lights Creek (West Branch Lights Creek, upper Lights Creek, Bear Valley Creek, Morton Creek, Smith Creek, Fant Creek and East Branch Lights Creek). Channels in this area are broad and mobile with cobble/boulder dominated beds (USDA 2008). Channels upslope of the confluence with Lights Creek are steep with unstable banks. Prominent terraces have developed along Morton Creek immediately upstream of its confluence with East Branch Lights Creek. These features indicate that accelerated post-fire erosion and sedimentation are likely to increase channel instability and bank erosion in this area. The main channel of Lights Creek (braided cobble-dominated channel) also is unstable with high sediment loading for approximately one mile downstream of the confluence area. Abundant mine tailings and debris are present in the channel and on the banks of Middle Lights Creek and placer mining activities also have caused the channel to degrade (USDA 2007a).

The level of aquatic habitat fragmentation in the analysis area is unknown. There are anthropogenic barriers to aquatic organism passage (AOP) between both Lone Rock and Boulder Creeks and Antelope Lake. However, these AOP barriers likely reduce the risk that introduced fish species will negatively impact upstream Sierra Nevada yellow-legged frog (*Rana sierrae*) populations. Yellow-legged frogs also occur along Pierce Creek, but it is unknown whether there are anthropogenic or natural barriers to AOP between Antelope Lake and the creek. Additional information on AOP in the analysis area is needed.

3.10.2 Aquatic Species

Aside from both native (*Oncorhynchus mykiss, Catostomus platyrhynchus, Rhinichthys osculus*) and introduced (*Salmo trutta, Salvelinus fontinalis*) fish, salamanders (*Ambystoma macrodactylum*) and multiple species of frog (*Pseudacris regilla, Rana boylli, R. sierrae*), the Moonlight Fire restoration analysis area contains numerous semiaquatic (cranes, Gruiformes) and aquatic (herons, Ardeidae), birds, mammals (beaver) and a reptile (western pond turtle, *Actinemys marmorata*). Prior to construction of Oroville Dam, the analysis area historically provided breeding habitat for salmon (*Oncorhynchus*). Aquatic species of concern in or near the analysis area are listed in Table 20; these include Federally Threatened, Endangered, Proposed, and USDA Management Indicator Species (MIS) and Regional Forester's (Region 5) Sensitive Aquatic Species.

Aquatic invasive species include both aquatic plant and aquatic animal species. Invasive aquatic plants are introduced plants that have adapted to living in, on, or next to water, and they can grow either submerged or partially submerged in water. Invasive aquatic animals require a watery habitat, but do not necessarily have to live entirely in water. There are excellent resources for aquatic invasive species management at the USDA National Invasive Species Information Center (http://www.invasivespeciesinfo.gov/aquatics/main.shtml) and California Department of Fish and Wildlife (http://www.dfg.ca.gov/invasives/) websites.

Although signal crayfish (*Pacifastacus leniusculus*) are native to the northwestern U.S., it is an introduced species in California, and currently occurs in the analysis area. The American bullfrog (*Rana catesbeiana*) is native to the eastern half of the U.S.; however, this species also was introduced in California and occupies aquatic habitats in the analysis area. There are several aquatic invasive species that have not been detected in the analysis or adjacent areas, but are quite likely being dispersed through adjacent habitats, and possibly through the analysis area (i.e., *Dreissena polymorpha, D. bugensis, Potamopyrgus antipodarium, Corbicula fluminea*). For example, recreational boaters are a vector for many aquatic invasive species and Antelope Lake attracts both anglers and water sport enthusiasts to its waters, often after previously utilizing other water bodies which may contain aquatic invasive species. Similar to aquatic invasive species that have not been detected in the analysis area, but post a serious threat to aquatic communities, whirling disease, caused by a myxozoan parasite (*Myxobolus cerebralis*) occurs within Yellow Creek on the Plumas and Lassen NFs (Weber 2013). It is unknown whether whirling disease occurs within the analysis area.

In April 2013, the U.S. Fish and Wildlife Service (FWS) issued a proposed rule to list the Sierra Nevada yellow-legged frog (*Rana sierra*) as an endangered species under the Endangered Species Act (ESA) (http://www.gpo.gov/fdsys/pkg/FR-2013-04-25/pdf/2013-09600.pdf), and also proposed Critical Habitat for the species (http://www.gpo.gov/fdsys/pkg/FR-2013-04-25/pdf/2013-09598.pdf). Over 9,700 acres of habitat on Forest Service lands in the analysis area are proposed as critical habitat for the Sierra Nevada yellow-legged frog (Subunit 2A: Boulder/Lone Rock Creeks).

Potential habitat for Sierra Nevada yellow-legged frog (SNYLF) in the analysis area is along perennial and intermittent streams and water bodies above 3,500 foot elevation. SNYLF's occur in the Meadow Valley area and on the Feather River Ranger District as low 3,500 feet in elevation. Yellow-legged frogs are highly aquatic, typically utilizing only the immediate bank and emergent rocks and logs. Frogs appear to be more common in well illuminated, sloping banks of meadow streams, riverbanks, isolated pools, and lake borders with vegetation that is continuous to the water's edge (Martin 1992, Zeiner et al. 1988). Historically streams with a bank of less than 10 inches in vertical height with a moderately rocky, sparsely vegetated bank harbored the densest populations (Mullally and Cunningham 1956).

Frog space use patterns involve three main sites: overwintering, breeding and foraging. Tadpoles and adults overwinter in deep pools with undercut banks that provide cover (Martin 1992). Suitable breeding habitat is considered to be low gradient (up to four percent) perennial streams and lakes. Frogs usually lay their eggs in clusters, submerged along stream banks or on vegetation. Tadpoles require at least one year before metamorphosis to the adult stage, and some high elevation populations may require up to three years before metamorphosis (Knapp 1996).

Table 20. Threatened, Endangered, Proposed, and USDA Management Indicator and Regional Forester's (Region 5) Sensitive Aquatic Species and their habitats in the Moonlight Restoration analysis area.

Species Name	Elevation (feet)	Habitat	Potential Threats	PNF Status	Analysis Area		
					Suitable Habitat	Detection	Restoration Synopsis
Amphibians							
Rana boylii FOOTHILL YELLOW-LEGGED FROG Forest Service R5 Sensitive Federal Species of Concern	< 6,400	Breed in shallow, slow flowing water with at least some pebble and cobble substrate. Found in riffles and pools with some shading (>20%) in riparian habitats, and moderately vegetated backwaters, isolated pools, and slow moving rivers with mud substrate. Rarely found far from permanent water	Disease (chitrid fungus), Introduced exotic predators (fish stocking), contaminants, recreation, and grazing	>50 site detections on PNF	Yes	Yes	Multiple detections in one area (North Arm of Indian Valley)
Rana sierrae SIERRA NEVADA YELLOW-LEGGED FROG Federal Proposed	3,500 - 12000	Found in ponds, tarns, lakes and streams with sufficient depth and adequate refuge for over wintering. On the Plumas, most are in stream habitat	Disease (chitrid fungus), Introduced exotic predators (fish stocking), contaminants, recreation, and grazing	Greater than 50 site detections on PNF	Yes	Yes	Multiple detections at several sites
Fish							
Mylopharodon conocephalus HARDHEAD USDA Regional Forester (Region 5) Sensitive Species,	< 6,000	Widely distributed in undisturbed reaches of low to mid elevation streams from the Kern River in the south to the Pit River in the north	Population isolation, hydro-electric power, predation by smallmouth bass	Known distribution is 135 miles; suspected in 80 additional miles	No	No.	Suspected to occur downstream of analysis area (Indian Creek)

Reptiles							
Actinemys marmorata WESTERN POND TURTLE USDA Regional Forester (Region 5) Sensitive Species, Federal Species of Concern	< 4,700	Aquatic habitat in spring and summer. Adjacent upland habitat fall and winter. In rivers, needs slow flowing areas with deep underwater refugia and emergent basking sites. Migration, hibernation, and nesting occur on land up to 330 feet from riparian area	Non-native fauna, non-native turtles through competition and disease, bullfrogs and predatory fish, vehicles, timber harvest, mining, fire, grazing, water alteration and diversion	Greater than 50 detections from about 25 sites across the PNF (Butte & Plumas County)	Yes	Yes	One detection
Invertebrates							
AQUATIC MACROINVERTEBRATES USDA Management Indicator Species (Region 5) Aquatic Macroinvertebrates include: insects in their larval or nymph form, crayfish, clams, snails, and worms.	NA	Riverine and Lacustrine	Changes in: water chemistry, temperature, physical features, and flow. Increased sedimentation and changes in vegetative cover	Across PNF	Yes	Yes	throughout area

Adults primarily feed on aquatic and terrestrial invertebrates favoring terrestrial insects such as beetles, flies, ants, bees, and true bugs (Jennings and Hayes 1994). They are also known to feed on pacific treefrog (*Hyla regilla*) tadpoles (Zeiner et al. 1988). SNYLF tadpoles graze on algae and diatoms along rocky bottoms in streams, lakes and ponds. Garter snakes and introduced trout prey upon SNYLF tadpoles (Zeiner et al. 1988). As adults overwinter underwater and tadpoles exhibit an extended metamorphosis period, the species is very vulnerable to introduced fish (Knapp 1996). Female frogs can have live 13-14 years with a male maximum recorded life span of 11-12 years (Matthews and Miaud 2007).

Preliminary survey effort in the southwestern portion of the analysis area reported both foothill yellow-legged frog (*Rana boylii*, FYLF) and SNYLF in the North Arm of Indian Valley. Further survey efforts are necessary to elucidate whether these data are accurate (i.e., whether both species occur in the watershed, or misidentification may have occurred). The SNYLF is known to occupy habitat upstream of the North Arm of Indian Valley (West Branch Lights Creek), to the northwest of Antelope Lake (Boulder, Pierce, and Lone Rock Creeks), and along the eastern edge of Plumas County (Clarks Creek) in the restoration analysis area. Additional considerations may be appropriate for FYLFs if future surveys confirm that they occur (or co-occur with SNYLFs) along Cooks and Lights Creeks in the North Arm of Indian Valley.

Managers expressed concern for the condition of aquatic habitats in the Moonlight Fire area prior to the fire; and although some areas appear to be recovering quickly (e.g., Moonlight Creek), riparian zones across much of the restoration analysis area (e.g., Lone Rock, Upper Indian and its tributaries, Boulder, and Lights creeks) have and will continue to merit attention from land managers (USDA 2008, for additional details see Section 3.13, Past and Present Hydrological Conditions). Many streams were impacted through accelerated erosion and sedimentation post-fire, and the eastern part of the analysis area contained headcuts and monitoring results indicated less than desirable conditions both before and after the Moonlight Fire (USDA 2008).

3.11 Past and Present Range Conditions

Range resources in the Moonlight restoration area include the understory vegetation in timbered areas, meadows and fens, and riparian areas, creeks, and springs. Range resources also include the permittee and the permitted livestock that graze within an allotment. An allotment is the area of land designated for livestock grazing in the Plumas NF LRMP (USDA 1988a) and is authorized under a grazing permit. Grazing permits are issued to permittees for individual allotments; some permittees are authorized to graze on two or more allotments. The grazing permit defines the number, kind, and class of livestock, season of use, standards and guidelines, allowable use, monitoring areas, pasture rotation, range improvements, and areas of concerns.

The area analyzed for range resources includes the six allotments that were affected by the Moonlight Fire (Table 21). The watersheds in this analysis area were historically characterized by a mosaic of open eastside pine and mixed conifer forest types and a frequent low-severity

fire regime. The range resources within these watersheds have been cumulatively impacted by multiple recent fire events, which include the Moonlight Fire (2007), Antelope Complex (2007), Boulder Fire (2006), and Stream Fire (2001). Allotment boundaries were chosen for the analysis area because grazing is permitted and administered by allotment. The six allotments within the analysis area are listed in Table 21 (also see Figure 47). Two of the allotments, Hungry Creek and Taylor Lake, are currently vacant and were considered in this analysis for comparison and for potential restocking opportunities. Analyses of these allotments will enable the forest to meet Region 5 Range targets and make reductions in season and number and change grazing systems if need be.

Table 21. Range allotments within the analysis area

Allotment	**Total size[1]**	**Acres within analysis area (% of total)**	**Acres within Moonlight Fire (% of total)**
Antelope	24,447	24,277 (99%)	1,927 (8%)
Antelope Lake	4,401	4,401 (100%)	125 (3%)
Hungry Creek[2]	17,007	16,996 (100%)	2,974 (17%)
Lights Creek	29,930	29,882 (100%)	20,144 (67%)
Lone Rock	24,633	24,633 (100%)	24,288 (99%)
Taylor Lake[2]	26,922	20,014 (74%)	13,760 (51%)

[1]Acres are based on GIS information and may differ slightly from the permitted size; [2] currently vacant allotments

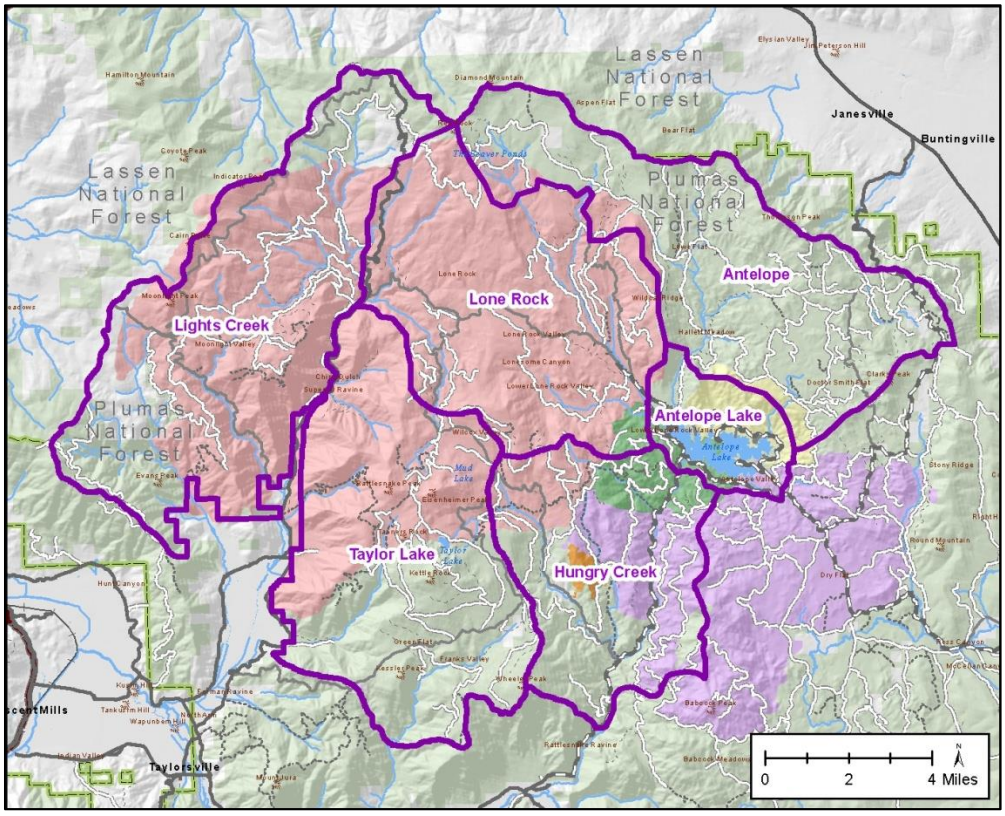

Figure 47. Area analyzed for range resources and restoration opportunities. Past fires are shown in purple (2007 Antelope Complex), yellow (2006 Boulder Complex), green (2001 Stream Fire), and orange (2006 Hungry Fire)

Livestock grazing has occurred on the Plumas NF since the mid-1800s. The early 1860s ushered in an era of intensive livestock use across the Sierra Nevada (Allen-Diaz 1991, McKelvey and Johnston 1992). Increasing human populations and market demands, combined with wide scale drought in the 1860s and 1870s, resulted in summer grazing of Sierra montane meadows where livestock could take advantage of abundant forage and water (Kosco and Bartolome 1981, Ratliff 1985). In the 1880s and early 1900's, an estimated 30,000 sheep grazed within the restoration area (S. Lusk personal communication). Grazing remained unregulated until the early 1900s, when regulations helped bring livestock numbers within reasonable bounds (Kosco and Bartolome 1981). Today, most allotments in the analysis area contain fewer than 500 calf/cow pairs (Table 22).

Table 22. Allotment management grazing strategy, numbers and season for 2013

Allotment	Permittee	Permitted Numbers and Season	Grazing Strategy
Antelope	CW Johnson	200 cattle pair; 6/15-9/15	Two pasture split herd
Antelope Lake	R.Egan	150 cattle pair; 9/3-10/2	Deferred till after Labor Day
Hungry Creek	Vacant	Vacant	Vacant
Lights Creek	Stroing	20 pair On, 16 pair Off; 6/1-9/1	Season long
Lone Rock	R.Egan	116 On, 180 Off; 6/16-9/15	Season long
Taylor Lake	Vacant	Vacant	Vacant

3.11.1 Fire effects on vegetation and forage

As discussed in the vegetation sections of this strategy (Sections 3.2 through 3.7), plant communities in the analysis area have been altered by past management activities, including fire suppression. Prior to European-American settlement in the mid-1800s, frequent, low intensity fires maintained a mosaic of open eastside pine and mixed conifer forest types with productive understory plant communities; however fire suppression, combined with past timber harvest, had decreased forest heterogeneity across the landscape, resulting in dense, overcrowded stands and closed forest canopies with sparse herbaceous understory. Prior to the Moonlight Fire, very little forage was available to cows in the forest understory (Fites 1993). As a result, grazing was concentrated in meadows, riparian stringers, and along roads (USDA 2007c).

As described in the discussion of montane and mixed chaparral vegetation (Section 3.4), the extent of shrubland in the analysis area increased dramatically after the Moonlight Fire (Figure 12); shrub types increased from approximately three percent of the analysis area prior to the fire to an estimated 29 percent after the fire (Figure 13). Increased shrub cover in post-fire landscapes can discourage the development of herbaceous vegetation, which is important foraging material for grazing animals.

In the short-term, the Moonlight Fire may have reduced forage within burned areas; however, many important forage species, such as grasses, sedges, willows, and aspen, were also likely encouraged by the fire (Figure 48). In some allotments, forage likely increased, creating transitory range. The number of cattle on allotments was not increased to optimize transitory forage created after the Moonlight or Antelope Complex fires.

Figure 48. Three Creeks South Pasture in the Clarks Creek Allotment before the Antelope Complex Fire (top) and after fall grazing in 2012 showing sedge meadow regrowth after fire (bottom).

The majority of primary livestock range did not burn at high severity in the Moonlight Fire (USDA 2007c). This left a mosaic of burned and unburned areas (Figure 49), with many of the primary grazing areas left unburned (USDA 2007c). The primary grazing areas in the Lights Creek Allotment, which include Indicator Meadow, Flemming Sheep Camp, and Snoring Spring, were not burned (USDA 2007c). The Antelope allotment was also relatively unaffected by the Moonlight Fire (USDA 2007c). The majority of forage in the Lone Rock allotment occurs on private lands. After the Moonlight Fire, private timber lands were harvested and replanted and the Lone Rock permittee was asked to run more cattle to reduce grass competition on planted conifer seedlings (S. Lusk personal communication)

Figure 49. Lone Rock allotment in September 2007 right after the Moonlight Fire, showing a mosaic of burned and unburned patches within the meadow.

There are two range monitoring areas within the perimeter of the Moonlight Fire. One monitoring area is in the Lone Rock Creek grazing allotment, which burned with relatively high severity. This allotment was rested from grazing after the fire in 2008 and appeared to support dense vegetation the following year (Figure 22). The other range monitoring area in the Moonlight Fire perimeter is in the Lights Creek allotment. This area burned very lightly and was not rested from grazing after the fire (Figure 23). These allotments are monitored annually to determine if standards and guidelines (outlined in Table 37) have been met or exceeded. Post-fire monitoring determined that the standards and guidelines have not been exceeded since the Moonlight Fire (S. Lusk personal communication).

Monitoring completed by the Region 5 Range Monitoring Program includes three meadows within the analysis area. A comparison of data collected in 2002 and 2003 with data collected five years later suggest that two of the meadows did not meet desired conditions prior to the fire (see Table 6); the remaining site, which was the only one evaluated after the Moonlight Fire, met desired conditions. In 2004, a rapid assessment transect was also established to determine meadow species vegetation composition in each pasture in the monitoring area. This monitoring needs to be repeated to determine the effects of the fire on meadow vegetation.

In 2006, Proper Functioning Condition (PFC) assessments were conducted on some of the streams within the allotments. These pre-fire assessments rated Lone Rock Creek as Functioning at Risk with a downward trend due to active cut banks and excessive deposition of sediments and recommended the removal of the culvert (Cleland et al. 2006). PFC ratings done on Antelope and Antelope Lake Allotments were at PFC, except for Lowe Unit, which was a wet meadow due to a beaver dam and was not assessed.

3.11.2 Fire Effects on the Permittees and Livestock

As a result of the Moonlight Fire, twelve head of cattle were burned and died and over 20 miles of fence was damaged or destroyed (S. Lusk personal communication). Five gates were burned and one cattle guard, on NFS road 28N03, was crushed due to heavy fire suppression traffic (USDA 2007c). The Lone Rock permittee also had to rent pasture outside of the fire in 2008 for his herd.

Two allotments, Lone Rock and Antelope Lake, were rested from grazing in 2008. Rotation changes were made in the adjacent Clarks Creek, Doyle, and Bass Allotment pastures to allow for seed set the first year following the fire. Livestock numbers, season of use, and livestock distribution were not adjusted in the remaining active allotments because stocking was light, the allotments had meadows or pastures that were not burned in the fire, or they were not grazed until after dormancy (S. Lusk personal communication). The impact associated with grazing after the fire was described in the *Moonlight and Wheeler Fire Recovery and Restoration Project FEIS* (2008) and is also described in this document under Section 3.5 (Past and Present Vegetation Conditions: Meadow, Fen, Aspen, and Riparian Vegetation).

Use of some of the pastures has changed after the fires. For example, the permittee on the Antelope allotment sold their cows and the new permittee turned all 219 pair into Lowe Flat Fen in 2010. The Antelope allotment was then changed from a three pasture rotation to a two pasture split herd with Lowe Flat being used as a pass through pasture for a maximum of 10 days.

3.12 Past and Present Soil Resources Conditions

The analysis area for soil conditions includes the six HUC 6 watersheds that contain the Moonlight Fire (Figure 50); these are Upper Lights Creek, Antelope Lake, Genesse Valley, Lower Lights Creek, Cooks Creek, and Middle Lights Creek. Prior to the Moonlight Fire, four of the watersheds, Antelope Lake, Genesse Valley, Middle Lights Creek, and Upper Lights Creek, were analyzed in the *Diamond Landscape Assessment* (USDA 2005) and then for the Diamond Project DEIS (USDA 2006a). This past analysis area represents 78 percent of the soil analysis area in this restoration strategy, or 99,000 out of 127,000 acres. The Moonlight Fire area was also analyzed for burned area emergency response (BAER) in 2007 (USDA 2007d) and then for the salvage effort in 2008 (USDA 2008). The unburned watersheds that were not analyzed under the Diamond Project were examined in the *Keddie Ridge Hazardous Fuels Reduction Project Final Environmental Impact Statement* (USDA 2011c).

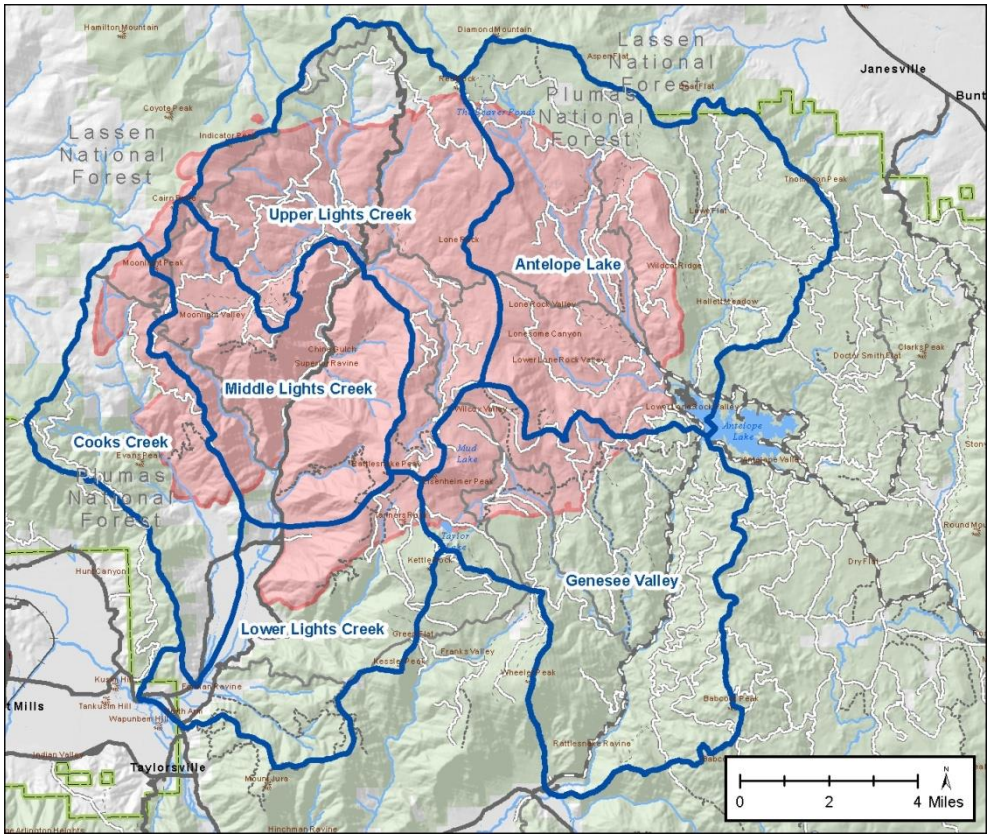

Figure 50. Area analyzed for soil and hydrological conditions; shows the six HUC6 watersheds that contain the Moonlight Fire.

3.12.1 Past Soil Conditions

Soils in the analysis area are predominantly derived from granitic parent material. There are also some areas where younger volcanic and metavolcanic parent rock form soil in the northern and western portions of the analysis area. These granitic soils are generally not very productive in their natural state and are prone to erosion when vegetation is removed. The *Diamond Landscape Assessment* included an analysis of the erosion hazard rating (EHR), which measures the tendency to erode once vegetative cover is removed (USDA 2005). For the four watersheds in the Diamond Project area, soils with high or very high EHR were estimated to exist over 81 to 98 percent of the watershed area (USDA 2005: pp. 2-3).

Despite the low productivity of these soils and high erosion potential, vegetative ground cover in pre-settlement conditions was likely high and erosion was low between exceptional fire and/or flood events. In a more natural fire regime these south-facing watersheds would burn frequently, but generally at lower severity. High severity burns would still occur but their aerial extent would be much less than modern fires (McKelvey et al. 1996). Other activities besides fire exclusion and high severity fire have detrimentally affected soils in the analysis area similarly to the rest of the Sierra Nevada; these include mining, grazing, and harvest activities (Young2003, McKelvey and Johnston 1992).

Site visits to evaluate soil condition were conducted for both the Diamond Project (pre-Moonlight Fire) and the Keddie Project. With a few exceptions, units surveyed for the Diamond Project met soil cover and compaction standards. The Forest Service Manual provides guidelines for soil cover, which range from 50 to 60 percent affective soil cover depending on the EHR (USDA 2012b). Within Diamond Project units, soil cover ranged from 72 to 85 percent (averaged by Defensible Fuel Profile Zone and area thinning units). The HFQLG project soil monitoring program set a desired condition of less than 15 percent of the area of treated units should be detrimentally compacted. Diamond Project units surveyed averaged from 6 to 15 percent; older clear-cut units were mentioned as being responsible for the higher numbers (Table 23). As presented in the Region 5 supplement to the national Forest Service Manual for Soil Management (USDA 2012), the desired condition for areal extent of fine organic matter on soil is greater than 50 percent. Diamond Project surveys found that the average in units ranged from 61 to 82 percent. The 2004 SNFPA ROD requires that desired levels of large down wood be established on a project-by-project basis, with 10 to 15 tons per acre being a common project standard for Plumas National Forest projects. The levels of large down wood observed in Diamond Project units ranged from 24 to 32 logs per acre, which amply exceeds 10 to 15 tons per acre (Table 23).

Table 23. Soil productivity results from Diamond Project field surveys (from USDA 2006a: pp. 3-11)

Unit type	Average % Soil Cover	Average % Detrimental Compaction	Average % Skid Trails and Landings	Average % Cover of Fine Organic Matter	Average Number of Down Logs (per acre)
Moonlight DFPZ	84	12	19	73	23
Cold DFPZ	86	6	15	72	32
Wild DFPZ	72	12	19	61	24
Area Thinning Units	85	15	17	82	26

Soil monitoring results were similar in the unburned portion of the analysis area covered by the Keddie Project FEIS. Soil cover ranged from 84 to 95 percent, detrimental compaction ranged from 15 to 20 percent, down logs ranged from 16 to 20 per acre, and cover of fine organic matter ranged from 74 to 81 percent (USDA 2011c). In units where the areal extent of detrimental compaction was shown to be near or over the HFQLG desired condition of 15 percent, it is important to note that surveys were conducted only in units where past logging practices likely impacted them and is not representative of the whole watershed (USDA 2011c, pp. 186). An analysis of past cumulative impacts from management was also conducted for the Diamond and Keddie projects using the Equivalent Roaded Acre (ERA) model. The results of this analysis are discussed under in Section 3.13 (Past and Present Hydrological Conditions) of this strategy.

In summary, soils in the Moonlight Fire analysis area are naturally not very productive and are prone to erosion. Management activities, including grazing, mining, and timber harvest, have had varying degrees of detrimental soil impacts; however where examined in the field, soil conditions generally met standards and guidelines.

3.12.2 Present Soil Conditions

Soil conditions in the analysis area were adversely affected by the Moonlight Fire. This fire was not only notable for its size, but also for the large proportion of high burn severity. Multiple fires have occurred in the recent past as well (Figure 3). The Antelope Complex burned a portion of the Genesee Valley watershed earlier in the summer of 2007. The Hungry Fire (2006) and Stream Fire (2001) also burned in this watershed adjacent to the footprint of the Moonlight Fire.

Soil burn severity is listed for the analysis watersheds in Table 24. Overall 75 percent of the fire area had moderate (37%) to high (38%) soil burn severity (USDA 2007e). Moderate burn severity was assigned to areas where much of the fine root structure was still intact, but little to no above ground soil cover remained. These areas were still likely to have increased runoff and erosion in the first two to three years after the fire, but may have recovered faster than the high severity areas where fine root structure was absent. It is important to note that soil burn severity is based first on reflectance observed from satellite data that is then field verified. It is not to be confused with the various vegetation burn severity metrics, although high soil burn severity areas are generally denuded of live vegetation as well.

Table 24. Soil burn severity by watershed (from USDA 2007e: pp. 3-11)

Watershed	Total Acres	Acres burned (% of watershed)	Acres burned at moderate to high soil severity (% of watershed)	Acres burned at low soil burn severity or not burned (% of watershed)
Genesse Valley	27,105	5,952 (22%)	4,432 (16%)	1,520(6%)[1]
Cooks Creek	13,488	4,078 (30%)	2,819 (21%)	1,259 (9%)
Antelope Lake	32,382	16,093 (50%)	12,679 (39%)	3,414 (11%)
Upper Lights Creek	22,811	18,709 (82%)	14,927 (63%)	3,782 (17%)
Middle Lights Creek	16,693	13,987 (84%)	12,235 (73%)	1,752 (10%)
Lower Lights Creek	14,521	5,101 (35%)	1,153 (8%)	3,948 (27%)

[1] Note that the Hungary Fire and Antelope Complex burned another 1,157 acres of this watershed in 2006 and 2007; the Stream Fire also burned here in 2001.

In the Moonlight BAER evaluation, erosion potential was predicted to increase greatly in the first few years after the fire. Using the Erosion Risk Management Tool (ERMIT) model, rates of 46 tons per acre per year were predicted; these were generally due to the removal of ground cover. Water repellency was only observed on 797 acres. Poor vegetative regrowth was observed in the adjacent fires by BAER personal as well (USDA 2007e).

In 2008, the Moonlight and Wheeler Fire Restoration Project was planned and salvage logging units monitored to determine soil condition. Even after some regrowth and needle fall from dead trees, post-fire soil conditions were quite different from the surveys conducted for the 2006 Diamond Project. In the 22 units monitored in 2008, soil cover ranged from 0 to 50 percent with an average of 20 percent. Down logs were mostly non-existent (USDA 2008: p. 101). Some of the post-fire salvage units overlapped with the previously planned Moonlight Defensible Fuel Profile Zone (DFPZ) in the Diamond Project (see Table 23). An analysis of pre and post-fire soil monitoring data in these units indicate that the percent soil cover went from

84 to 10 percent and downed logs went from 23 to less than one per acre. Interestingly detrimental compaction was shown to improve from 12 to seven percent post-fire; however this may be due to the larger extent of the salvage unit surveyed (USDA 2008: pg. 101).

Data on actual erosion and degraded soil conditions are limited and results of analyses mixed. In the monitoring reports for the BAER upland treatment areas, no substantial problems requiring follow-up field treatments were found. Figure 51 provides an example of re-vegetation after the fire. The lack of observed upland erosion after the fire may have been the due to the winter of 2007/2008, which lacked large rain events and was characterized by runoff dominated by slower snowmelt. Somewhat contrary to these results, several mass movement and erosion problems have been noted on roads in the fire area (USDA 2009); refer to the Transportation discussion (Section 4.5) in this strategy for more detailed information.

Figure 51. BAER monitoring of a potential helicopter-mulch unit along NFS road 28N19. Photographs taken in the same location in June 2008 (top) and July 2009 (bottom). Note vegetation recovery two years after the fire.

In one monitoring reach, established on Moonlight Creek for the Diamond Project, pre and post-fire sampling showed a large increase in fine sediment in the first year after the fire. This reach has proceeded to return to pre-fire conditions with regards to fine sediment (Mayes and

Roby 2013). Refer to Section 3.13 (Past and Present Hydrological Conditions) of this strategy for more details.

Another potential impact on soil condition is the risk of re-burn in areas where large numbers of snags remain after the fire. In a recent assessment of the Chips fire on the Plumas NF, Young and Gardiner (USDA 2012c) noted that the majority of the true high soil burn severity was located in areas where the Chips Fire re-burned the 2001 Storrie Fire. The long fire residence time in the down snag component was likely a contributing factor to the higher soil burn severity in these areas. The soils in these higher severity areas will take longer to recover (USDA 2012c: p. 2).

It is certain that the large areas of high soil burn severity have had lasting impacts in the Moonlight Fire area. Mass movements have been noted on the road system and should be re-examined. Fine sediment has been delivered to the stream network, and although vegetation is returning, soil coverage and organic content is likely to be lacking in areas. Some past mining areas, such as the Engel Mine tailings along Lights Creek, appear to lack vegetation and any topsoil development; these areas should be more closely examined and opportunities to accelerate restoration of these sites investigated.

3.13 Past and Present Hydrological Conditions

The analysis area used to assess hydrological conditions within the Moonlight Fire is identical to the area assessed for soil conditions (Figure 50); for a detailed description refer to Section 3.12 (Past and Present Soil Resources Conditions).

The Moonlight analysis area ranges in elevation from 7,820 feet at Kettle Rock to 3,520 feet in the North Arm of Indian Valley. The two main drainages are Lights Creek and Indian Creek. Both watersheds are generally oriented from north to south, and water flows from the crest of the Diamond Mountains in the north to Indian Valley in the south. Although mountainous, the area is east of the main crest of the Sierra Nevada, so storms coming off of the Pacific are relatively moisture-starved when they get to the Moonlight Fire area. Annual precipitation varies from around 40 inches along Keddie Ridge to within the 30 inch range across the rest of the analysis area. As with the rest of the Sierra Nevada, the majority of this precipitation comes in the winter months, mostly as snow above 6,500 feet and a mixture of snow and rain at lower elevations. According to the latest geographic data, there are 170 miles of perennial streams and 305 miles of intermittent and ephemeral streams in the analysis area. The average slope of these streams is 20 percent, which is quite steep.

3.13.1 Past Hydrological Conditions

3.13.1.1 Historic

It is assumed that in pre-settlement times these watersheds produced high quality water with similar runoff timing to the rest of the northern Sierra Nevada. This timing would include winter floods, spring and early summer snowmelt, and then a low flow period from later summer into

the fall. Background erosion rates have been shown to be very low for the Sierra Nevada in general (Kettleman 1997); however this area is geomorphologically active and there would have been episodic periods of high erosion after floods, natural wildfire, and landslides. There might have been some minor impacts to hydrology from the native Maidu tribes and their burning practices, but these were presumably minor.

Starting in the 1850s, placer mining began in the Lights Creek area (see Section 4.1, Past and Present Cultural Conditions for more details). Negative impacts to hydrologic conditions began at this time. A major dredging operation was located downstream of the confluence of the West and East Forks of Lights Creek. Gold mining declined but then a copper mining boom commenced in the early 1900s. The Engles Mine near China Gulch became a major operation (USDA 2006a: pp. 3-67 to 3-69). The mine operated until the 1930s. Today mine tailings are still largely not vegetated and are immediately adjacent to Lights Creek. Placer gold mining continues to be a potential impact to hydrologic conditions. Section 4.6 (Past and Present Mining Conditions) of this strategy provides an overview of present mining activity within the Moonlight Fire area.

Along with mining, logging and associated road and railroad building began in the 1900s. Impacts from these activities increased drastically through the early 20th century as steam power, chain saws, and tractors came on line. Lights Creek was a corridor for an early wagon road before the Indian Valley Railroad was laid up the Creek to the Engles Mine; this then became a county road. Ranching came with the mining in the 1850s. The higher terrain was used by Basque sheepherders in the 1900s. Markings are evident in this area (Figure 59). Historic grazing has likely impacted riparian areas in the Moonlight Fire area.

3.13.1.2 Pre and post-fire

Watershed Condition

In 1989, the *East Branch North Fork Feather River Erosion Inventory Report* was completed by the Soil Conservation Service (which later became the NRCS). This broad-scale reconnaissance report provided information on sources of erosion and watershed degradation in the East Branch North Fork Feather River (EBNFFR) watershed. According to this report, erosion rates in the EBNFFR are estimated to be 90 percent higher than natural background rates (USDA Soil Conservation Service 1989: p.20). The Antelope Lake sub-watershed, which contains Boulder and Upper Indian Creek, ranked as the highest sediment producing watershed. Hungary and Middle Creek in the Genesee Valley HUC 6 watershed also ranked high. Although still producing higher than natural background rates, the Lights/Cooks Creek sub-watershed ranked lower. Bank erosion in tributary watersheds and cut and fill over-steepened slopes associated with roads accounted for most of the erosion.

Another source of information about pre-fire hydrologic conditions is the Diamond Project DEIS (USDA 2006a) and Landscape Analysis (USDA 2005). Extensive work was done in the planning of this project and it covers the majority of the analysis area for the strategy. Watershed condition was analyzed using the Equivalent Roaded Acre (ERA) methodology. This is a common model

used in Region 5 of the Forest Service. It equates various management activities and existing infrastructure with the impacts of an impervious road surface. Soils such as those under roads lack hydrologic conductivity and water runs off quickly, therefore potentially causing erosion of uplands, stream banks, and delivery of sediment to streams. The model also assigns recovery to activities that occur at a point in the past such as logging activities and wildfires. A threshold of concern (TOC) of the percentage area in a modeled roaded condition of the sub-watershed is set based on watershed sensitivity factors. It was set at 12 percent for the sub-watersheds in the Diamond Project (USDA 2006a, p. 3-18). Although the ERA was computed for smaller watersheds they were summarized by the HUC 6 watersheds in which they lied.

Watershed sensitivity was also examined during HFQLG planning (described in USDA 2005: p. 25). Ratings were based on scores assigned to erosion potential, steepness, extent of alluvial channels, road densities, number of road stream crossings, conditions of channels, etc. All but two of the 14 HFQLG watersheds were listed as having a moderate risk of cumulative watershed effects. Two sub-watersheds in the Antelope Lake HUC 6 were listed as having very high risk of cumulative effects; these are Upper Indian and Boulder Creek. Boulder Creek is only on the periphery of the Moonlight Fire.

Watersheds were recently analyzed for the Watershed Condition Framework (USDA 2011d). This is a Forest Service wide effort to rate watershed condition and then prioritize watersheds for restoration. Nearly the entire Moonlight analysis area was rated as “functioning, at risk.” As of the writing of this document, none of the watersheds in the area have been designated as priority watersheds.

Post-fire ERA’s were computed for sub-watersheds during the analysis for the Moonlight Wheeler Recovery and Restoration Project (USDA 2008); these are summarized for the corresponding HUC 6 watershed in Table 25. Generally the numbers tripled due to the effects of the fire itself and salvage logging on private ground (USDA 2008, p. 115). This means that the TOC was exceeded and suggests that there were effects to stream channels and water quality. Road density was also calculated as part of the Diamond Landscape Assessment and is summarized in Table 25. Densities within the analysis area are about average for the Plumas NF.

Table 25. Pre and post Moonlight ERA and road densities.

HUC 6 Watershed	Average ERA (percent of watershed)				Road density (mi/sq mi)[1]
	pre-fire	Notes: Pre fire	post-fire	Notes: Post-fire	
Genesse Valley	6	Some larger values from public logging, Stream Fire, and roads	10-15	Mostly in the Hungary and Cold Creek Area	2.43
Cooks Creek	-	Not calculated pre-Moonlight	4-10	Calculated for Keddie Project; higher in Upper Cooks due to private salvage logging (USDA 2011c, p. 211)	1.25

HUC 6 Watershed	Average ERA (percent of watershed)				Road density (mi/sq mi)[1]
	pre-fire	Notes: Pre fire	post-fire	Notes: Post-fire	
Antelope Lake	6	Some high values from the past fires	16-20, 28	28 in Lonesome Canyon (highest on the fire) due to high severity fire effects and private salvage logging.	2.40
Upper Lights Creek	7	Private and public logging	18-21	Due to fire effects and private and public salvage	2.94
Middle Lights Creek	2	Low number, but mining impacts not taken into account	15-20		2.23
Lower Lights Creek	-	Not calculated pre-Moonlight	4	Calculated for Keddie Project (USDA 2011c, p. 211)	1.80

[1] the average for the Plumas NF is 2.9 miles/square mile

Stream Conditions

Flow conditions

Gage records for flow are available for the general area. USGS operated gages on Boulder Creek above Antelope Lake between 1966 and 1980, Indian Creek at Taylorsville (1957-1980), and Indian Creek at Indian Falls (1906-1993 and 2001 to present). The Feather River Coordinated Resource Management (CRM) Plumas Corporation also collected stream flow data on Indian Creek at Taylorsville, Flourney Bridge, and Lights Creek between 2001 and 2012 (Feather River CRM 2012). Of these, only the Lights Creek gage represents a high percentage of area burned by the Moonlight Fire. Assessment of this short monitoring record shows no evident effect of the fire.

Diamond (Pre-fire)

Several Stream Condition Inventory (SCI) sites were established as part of the Diamond Project planning effort. Several of the lower gradient response reaches were shown to have relatively high fine sediment in pool tails, which brought down their overall ratings (Table 26). Pierce Creek and Boulder Creek had the worst scores and the highest fine sediment in pool tail fines. Historic grazing was suggested as a possible cause for some of the poor conditions. Stream conditions were shown to be generally improving as of 2005 (USDA 2007a, pp. 3-15 to 3-16).

Table 26. Summary of stream condition inventory data for the Diamond Project Area (USDA 2007a).

Stream	Reach Type	Year Surveyed	Overall Rating[a]	Previous Survey Years	Change Since Previous Surveys[b]
Moonlight	Response	2005	Good	1998, 2000, 2001	Improvement
Boulder: Hawlett Meadow	Response	2004	Moderate-poor	2001	Improvement
Antelope	Response	2005	Poor	2000	NA
Little Antelope	Response	2005	Poor	2000, 2003	Improvement

Stream	Reach Type	Year Surveyed	Overall Rating[a]	Previous Survey Years	Change Since Previous Surveys[b]
Pierce: Wheeler Sheep Camp	Response	2003	Poor		NA
Hungry	Transport	2001	Good	1995, 1998	Improvement
Hungry: below Middle confluence	Transport	2004	Poor-moderate		NA

[a.] The overall condition rating is given for the most recent survey data. Ratings are based on physical characteristics including bank full width: depth ratio, bank angle, shade, pool tail fines, particle count less that 2 millimeters, and unstable banks. [b] Improvement indicates that the overall rating improved (for example, from moderate to good) compared to previous surveys. "NA" indicates that no previous rating was available for comparison.

Longer stream lengths were also surveyed where they crossed through DFPZ units. This added up to about 37 miles of stream. Approximately 70 percent of the stream miles had stable banks, 22 percent had noticeable bank erosion, six percent had prevalent bank erosion, and one percent had extensive bank erosion. Eleven headcuts were identified primarily in the Thompson and Boulder Creek sub-watersheds, and two more in the Upper Indian and Pierce Creek sub-watersheds; all of these are in the greater Antelope Lake HUC 6 watershed (USDA 2007a pg. 3-16). Large woody debris (LWD) rated as good or fair on 90 percent of the streams. The streams with less than optimal LWD conditions were located in the Antelope Lake HUC 6 area.

Forest roads can cause both chronic and catastrophic impacts to stream conditions and water quality. Although road surveys in the Diamond Project determined that most of the 400-plus mile road system was in good condition, 24.2 miles were proposed for reconstruction and 10 miles were shown to be causing substantial resource damage and were proposed for decommissioning (USDA 2007a pp. 2-23, 3-16).

Restoration Projects

The Feather River CRM Plumas Corporation has completed two stream enhancement projects in the Moonlight Fire area (Feather River CRM 2012). One project along Willow Creek was completed in 1996 and consisted of headcut controls and pond and plug meadow treatments; this project was apparently destroyed in the 1997 flood (CRM 2012). Another restoration project was constructed on Boulder Creek upstream of Antelope Lake in 1997. Vortex rock weirs, LWD jams, and check dams were constructed to trap sediment and raise the base level of the stream along a 3,000 foot reach and connect it with the floodplain (CRM 2012). Although the project met the objectives the first few years, the stream is now starting to erode around the structures (CRM 2012). The Forest Service plans to repair these structures as part of the recently planned Boulder Creek Watershed Improvement Project (USDA 2012d). The Boulder Creek Watershed Improvement Project also proposes to stabilize 17 headcuts, remove conifers from a small aspen stand, and improve drainage on several roads in this sub-watershed (USDA 2012d). Much of this work was identified previously in the Diamond Project.

Range

Range condition monitoring occurs on public grazing allotments within the Moonlight Fire area. In 2006 the Proper Functioning Condition (PFC) protocol (Prichard et al. 1988) was used at some

of the sites with riparian features. PFC is designed to be a simple assessment of the physical functioning of riparian –wetland areas. It considers hydrology, vegetation, and soil/landform attributes (Prichard et al. 1988). Prior to the fire, Lone Rock Creek (Antelope Lake watershed) was determined to be functioning-at-risk. This was due to large cut banks and deposition, some apparently due to a misaligned culvert on NFS road 28N00 (Lone Rock PFC 2006.) End-of-season use monitoring in 2007 shows some fire effects in the riparian area of Lone Rock Creek (Figure 52). This monitoring has been ongoing and impacts to the stream banks and willows are consistently below thresholds of concern (Figure 52).

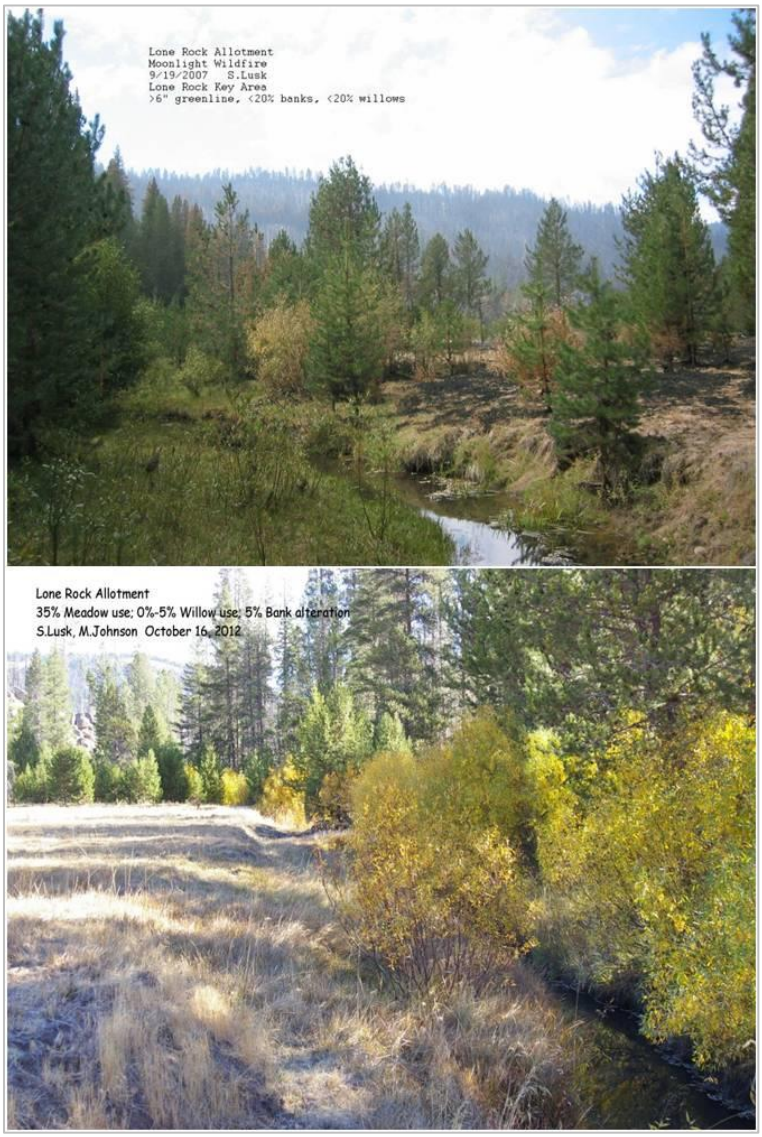

Figure 52. Lone Rock Creek immediately after Moonlight Fire in 2007 (top) and five years post-fire in 2012 (bottom)

Burned Area Emergency Response (BAER)

Post-fire stream conditions were first assessed by Faust and others as part of the BAER hydrology assessment (USDA 2007a). They noted that the smaller 1st and 2nd order streams generally lost most of the LWD to the fire. LWD was partially lost in the perennial streams, but was considered likely to increase over time as burned trees fell into the streams (USDA 2007a p. 1). Stream condition observations were grouped by the HUC 6 watersheds in the Moonlight BAER Hydrology report.

Table 27. Summary of stream condition by watershed in the 2007 BAER Report (USDA 2007a)

Watershed	Stream conditions immediately post-fire.
Genesse Valley	Hungry Creek appeared to have intact riparian vegetation. Cold and Middle were not looked at. Many of these sub-watersheds have seen multiple fires in the recent history.
Cooks Creek	Stream channels were not examined.
Antelope Lake	Many of the sub-watersheds burned. Willow Creek is incised in the meadow at the bottom, and most channels appear stable.
Upper Lights Creek	Steeper rocky channels here appear stable
Middle Lights Creek	Moonlight Creek appears to be degrading in Moonlight Valley, otherwise steeper transport reaches appear stable.
Lower Lights Creek	Lights Creek is braided here and appears dynamic and less stable. Fred's Creek appears at risk to debris flows. Peters Creek was not surveyed.

Stream Condition Index (SCI) Post-Fire

SCI was completed in 2008 on three streams in the Moonlight Fire area: West Branch Lights Creek, Lone Rock Creek, and Moonlight Creek. Moonlight Creek was selected for resampling in subsequent years and is the only SCI that has good pre-fire data. Results of the surveys were reported in the 2008 HFQLG Stream Monitoring Report (Foote et al. 2008). Percent pool tail fines and the percent of particles less than two millimeters were high relative to other similar gradient streams in the HFQLG area. Lone Rock Creek had particularly high pool tail fines at 56 percent; this was the second highest value for the 24 streams monitored that year (Foote et al. 2008). Percent shade cover was low compared to similar streams that were sampled (Foote et al. 2008, pp. 12-13).

Excessive fine sediment can be detrimental to many native aquatic species. Lack of shade can lead to higher water temperatures, which is also a concern for native trout species. This is especially a concern approximately 45 miles downstream of the Moonlight Fire area in the North Fork Feather River; this area is listed by the State Water Board as impaired (303d under the Clean Water Act) due to temperature impairment in the area of the hydroelectric projects.

Figure 53. Lone Rock Creek monitoring reach (Plumas NF)

Moonlight Creek had the most pre-fire data and was selected to be sampled annually; monitoring of benthic macroinvertebrates (BMIs) was also added. The following is quoted directly from the 2013 SCI monitoring report (Mayes and Roby 2013):

> *The Moonlight Creek SCI reach is located approximately 1.5 miles upstream of Moonlight Creek's confluence with Lights Creek (see Appendix B20). Most of the watershed upstream of the reach was burned by the Moonlight Fire in the summer of 2007. The fire burned nearly 99% of the watershed, approximately 5,579 acres. Of these acres, approximately 1,100 acres burned at low severity (1-25% vegetation mortality), 613 acres burned at moderate severity (26-50% vegetation mortality), and 3,866 acres burned at high severity (>50% vegetation mortality). The majority of streamside areas in the upper watershed experienced high-severity burning. Part of the upper watershed is on private land, and is located approximately 5 miles upstream of the reach. The private land portion was where the majority of high intensity fire occurred and was extensively salvage logged using a combination of high-lead and ground-based systems from the winter of 2007 through the summer of 2008.*
>
> *In 2009, approximately 1,490 acres of tractor salvage occurred on federal lands. Monitoring completed in 2010 and 2011 is intended to assess the post-fire and fire salvage conditions.*

Table 28. Summarized data for Moonlight Creek. An unpaired, unequal variance student's t-test ($\alpha = 0.10$) was used to compare data between combined pre-fire and each post-fire stream survey. Values in **bold** indicate a significant difference between pre-fire and post-fire data for that given year.

Year	Pool Tail Fines (%)	p-value	% particles <2mm	Res. Pool Depth (m)	p-value	Shade %	p-value
1998 (pre-fire)	9.36		3.0	0.46		64.1	
2000 (pre-fire)	2.76		3.0	0.45		70.3	

Year	Pool Tail Fines (%)	p-value	% particles <2mm	Res. Pool Depth (m)	p-value	Shade %	p-value
2001 (pre-fire	6.73		10.0	0.48		96.3	
2005 (pre-fire)	4.12		9.5	0.45		77.8	
2008	15.70	**<0.001**	15.2	0.40	**0.076**	57.7	**<0.001**
2009	4.50	0.264	0	0.43	0.436	28.8	**<0.001**
2010	4.07	0.138	8.0	0.50	0.291	27.6	**<0.001**
2011	4.96	0.413	0.8	0.50	0.219	42.2	**<0.001**

A significant increase in pool tail fines and a substantial increase in fines in the particle count were found the first year after the fire. Residual pool depths significantly declined in 2008 following the Moonlight Fire, before returning to pre-fire conditions in 2009. Stream shade was also significantly less than in pre-fire conditions. The increase in sediment appeared to be short-lived, as pool tail fines and particle counts less than 2mm in diameter in riffles returned to near pre-fire conditions in 2009 and remained near those levels through 2011.

Stream channel shade for 2011 remained significantly reduced from pre-fire conditions; however, channel shade has significantly increased between 2010 and 2011 (p-value = 0.0002). This trend in channel shade is attributable to a resurgence of riparian vegetation along the stream corridor, particularly willows. The decrease in stream shade between 2008 and 2009 post-fire surveys is likely the result of falling dead timber between the survey dates. This theory is supported by the fact that large woody debris counts dramatically increased between 2008 and 2010. In 2008, a total of 66 pieces of LWD were counted. The following two years saw LWD counts increase to 122 pieces in 2009, and 213 pieces in 2010 (Attachment 1). No adverse effects were observed resulting from tractor salvage operations in 2009. While it appears Moonlight Creek is returning to pre-fire conditions pertaining to sediment deposition, future monitoring will be required to track recovery of stream channel canopy cover.

Results from ANCOVA for Moonlight Creek temperatures did not show a significant difference in the y-intercepts of the regression lines (p = 0.842). Thus, it cannot be said that water temperatures were significantly affected by the reduction of channel shade over Moonlight Creek. This finding was unexpected due to the relatively dramatic reduction in stream channel shade over Moonlight Creek following the Moonlight Fire. However, it indicates that factors other than air temperature, such as groundwater input, may be having greater influence on Moonlight Creek water temperatures than do ambient air temperatures.

Macroinvertebrate sampling conducted during SCI surveys took place from 2000 to 2010 within the Moonlight Creek monitoring reach. Biologic indices and O/E scores calculated from this sampling are presented in [Table 29] below.

Table 29. Biotic Index (BI) and Observed/Expected (O/E) scores for the Moonlight Creek SCI monitoring reach. BI scores range from a minimum of 4 to a maximum of 20, with 4 considered "very degraded" and 20 considered "very healthy." O/E scores closer to 1 are considered "healthy."

Year	Biotic Index score	O/E score
2000 (pre-fire)	7	0.75
2001 (pre-fire)	10	0.82
2005 (pre-fire)	4	0.89
2008 (post-fire)	10	1.03
2010 (post-fire)	14	0.75

Interestingly, there appears to have been no decline in macroinvertebrate indices collected from the Moonlight Creek monitoring reach, despite increases in fine sediment observed in 2008 [Table 28 and Table 29]. Biologic indices and O/E scores were higher following the 2007 Moonlight Fire than they were pre-fire, despite the significant increase in fine sediment post-fire. One possible explanation for the increases in BI and O/E scores following the Moonlight Fire is increased productivity within the riparian area. Field notes collected in 2010 indicated a significant increase in the abundance of riparian hardwood species (particularly willow), as the Moonlight Fire burned the vast majority of conifers within the watershed and allowed increased sunlight penetration into the Moonlight Creek riparian zone. Many macroinvertebrate species feed upon the leaves of deciduous hardwoods such as willows. Thus, an increase in the abundance of riparian hardwoods may have led to an increase in macroinvertebrate species richness and abundance as well.

Other Sources

According to former Greenville District Hydrologist and retired Fish Biologist, Ken Roby, Upper Indian Creek above Antelope Lake is a "head scratcher." He notes that aquatic habitat is lacking, particularly considering the gradient and size of the stream. As for a cause, he postulated that it may have never recovered from a 1964 flood event. He has observed the East Branch of Lights Creek as being in poor condition. This may be due to an old road template degrading the stream. He has also observed that Lights Creek downstream of the confluence of the West and East Branches is braided and unstable, probably due to the impacts of extensive dredging and copper mining in the area (K. Roby, personal communication, 2013).

3.13.1.3 Summary

In summary, the stream information gathered for the Diamond Project and other sources indicates that the streams in the Moonlight Fire area were not pristine prior to the fire and that concerns were documented. The eastern part of the analysis area contained headcuts and monitoring results indicated less than desirable conditions both before and after the Moonlight Fire. It appears that Lone Rock Creek, Upper Indian Creek and its tributaries, and Boulder Creek will continue to merit attention from land managers.

The Moonlight Fire impacted streams in the area through accelerated erosion and sedimentation. Moonlight Creek appears to have recovered quickly. Some attributes of this watershed that may explain the quick recovery include: (a) the area is more volcanic and lacks the more erodible granitic soils of the eastern areas and (b) the SCI reach appears to be quite steep and boulder and bedrock controlled, this type of channel may transport the finer sized particles that are associated with detrimental erosion (Figure 54).

Figure 54. Moonlight Creek SCI reach, 2006

4.0 Past and Present Human Resource Conditions

4.1 Past and Present Cultural Conditions

Archaeological sites, features, objects, historic buildings and structures and even cultural landscapes are the fabric of our national heritage. Collectively known as historic properties or cultural resources, they are the tangible links with our past. Cultural resources are non-renewable assets and the Plumas NF is responsible for, and committed to, protecting and managing significant cultural properties in a spirit of stewardship for future generations to understand and enjoy. The following assessment of cultural resource conditions is focused on properties within or directly adjacent to the Moonlight Fire perimeter. Yet, prehistoric, ethnographic and historic era events reflected by cultural resource properties within this area are linked to broader local and regional contexts which must be taken into account when assessing cultural resource significance.

The Plumas NF manages an array of cultural resource properties in compliance with Sections 106 and 110 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470) and the Pacific Southwest Region's (Region 5) Programmatic Agreement addressing the

management of cultural and historic properties.[4] Further guidance is found in Forest Service Manual part 2360 (USDA 2008).

The Forest Service acknowledges that important contemporary Native American interests are also present. Traditional Cultural Properties, sacred places, cultural landscapes, resource procurement areas, archaeological sites, as well as the natural environment can all be of significance to Native American interests. The Plumas NF works closely with both federally recognized and non-recognized tribes, organizations and individuals to identify and manage significant cultural properties. See Section 4.2 for a discussion of tribal relations.

4.1.1 Cultural Context of Moonlight Fire Area

The following narrative is a brief overview of past cultural activity that has influenced the Moonlight Fire area. Ecosystem models based solely on biological and physical elements often disregard the complex interaction between humans and their environment. Defining the pattern and content of cultural phenomena within the Moonlight Fire area will potentially provide a rich opportunity to understand the effects humans have had on the environment.

Archaeological studies within and nearby the Moonlight Fire area have primarily been limited to cultural resource inventories for proposed Forest Service undertakings. Such inventories generally result in the identification and recording of cultural properties but often do not lead to further analysis. Existing data do allow for some degree of quantitative and qualitative assessment but it is very clear that there is much yet to be learned about the cultural past in this area.

4.1.1.1 Prehistoric Period

Because archaeological research accomplished in the northern Sierra Nevada is insufficient to define prehistoric complexes, no directly applicable cultural chronology for this region is yet available. Cultural resource assessments and interpretations specific to the Moonlight Fire area must rely upon extrapolations from other regional studies including models applied to the north-central Sierra Nevada mountains; in particular those devised for the Lake Tahoe vicinity.

Archeological investigations on the Plumas NF have revealed evidence of Native American occupation extending as far back as 9,000 years. Prehistoric cultural resources include flaked-stone artifact scatters reflecting resource procurement activities and seasonal campsites, permanent habitation sites with midden deposits and house pits, lithic quarry locations, bedrock mortar stations and occasional rock art sites. The primary cultural resource class that is present within the Moonlight Fire area is artifact scatters consisting of flaked-stone tools,

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[4] Full title: *Programmatic Agreement Among the U.S.D.A. Forest Service, Pacific Southwest Region (Region 5), California State Historic Preservation Officer, Nevada State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding the Processes for Compliance with Section 106 of the National Historic Preservation Act for Management of Historic Properties by the National Forests of the Pacific Southwest Region* (2013).

debitage, and occasional ground stone artifacts resulting from one or more occupational episodes. The distribution of prehistoric archeological sites within the fire area appears to have been influenced by the occurrence of perennial or reliable intermittent water sources with most sites found in close proximity to these natural features.

Only scant evidence exists of human use in the northern Sierra Nevada that dates to the Paleo-Indian period, between 9000–6000 B.C. (Kowta 1988; Nilsson et al. 1996:8). Cultural chronology dating post-6000 B.C. is generally defined under two comprehensive archaeological periods, the Archaic Period and Emergent Period. These two periods date between 6000 B.C.–A.D. 500 and A.D. 500–historic contact (A.D. 1850) respectively. The Archaic has also been divided into Lower (6000–3000 B.C.), Middle (3000–1000 B.C.), and Upper (1000 B.C.–A.D. 500) phases. Archaic populations in the northern Sierra Nevada are broadly characterized as highly mobile with a variable resource procurement strategy that emphasized short-term seasonal residency and lacked any permanent settlement. The Emergent phase of this cultural chronology (A.D. 500 – A.D. 1850) marks a rather dramatic shift in settlement pattern including permanent occupation of villages. In the Moonlight Fire area, this would represent pre-contact Northeastern Maidu populations.

Prehistoric material culture in the Sierra Nevada has been categorized according to more localized chronologies that define technological, economic, social and ideological elements (Kowta 1988). Primary among these is the Martis-Kings Beach, or Tahoe Reach chronological sequence that was first developed by Heizer and Elsasser (1953) after an extensive survey of cultural resource sites around Lake Tahoe. This highly utilized cultural sequence has been subsequently refined and revised by Elston et al. (1977) among others. It has frequently been applied to archaeological assemblages found within the northern Sierra Nevada although questions continue to be raised regarding its applicability in areas outside the Lake Tahoe vicinity.

This model represents a starting point from which more localized models should be developed; taking into account, for instance, pre-contact Northeastern Maidu in the northernmost Sierra Nevada area in addition to the Washoe (Table 30).

Table 30. Cultural Phases of the Tahoe Reach (after Elston et al. 1977)

Age	Phase	Characteristics	Climate
A.D. 1200–Historic Contact	Washoe-Late Kings Beach	Desert Side-notched and Cottonwood Series points, chert cores, utilized flakes, and other small chert tools.	Neoglacial; wet and cool but with little summer precipitation
A.D. 1200–500	Early Kings Beach	Eastgate and Rose Spring series points, chert cores, utilized flakes, and other small chert tools.	Nonglacial; dry, trees growing in former bogs; Tahoe may often not overflow
A.D. 500–500 B.C.	Late Martis	Corner-notched and eared points of the Martis and Elko series. Large side-notched	Neoglacial; wet but not necessarily cooler, increased summer precipitation

Age	Phase	Characteristics	Climate
		points. Large basalt bifaces and other basalt tools.	
500 B.C–1500 B.C.	Middle Martis	Steamboat points, other types in Elko-Martis series. Large basalt bifaces and other basalt tools.	Possible warm, dry interval centered on 1500 B.C.
1500–2000 B.C.	Early Martis	Contracting stem points of the Elko-Martis series. Large basalt bifaces and other tools. Light-colored basalt artifacts	Beginning of Meditherimal; Neoglacial, wet but not necessarily cooler, increased summer precipitation; Tahoe begins to overflow
2000–5000 B.C.	Spooner	Point in the Pinto and Humboldt series, light-colored basalt artifacts.	Altithermal; generally hot and dry; Tahoe does not overflow for long periods of time
6000 B.C.	Tahoe Reach	Parman points.	Anathermal; warming trend, climate similar to later Neoglacial intervals

Since, as noted above, little more than inventory level assessment of the prehistory of the Moonlight Fire area has been accomplished to date, conclusions regarding ancient human land use patterns in this area can only be postulated. Based on current data, it would seem most likely that the Moonlight Fire area would have been primarily utilized for seasonal resource procurement activities in association with hunting and gathering plant resources. There may also be an element of trade reflected in the archaeological record as the logical route of travel leading from the North Arm of Indian Valley (North Arm) following the Lights Creek drainage north over the Diamond Mountains to the Honey Lake Valley must have been a well-used corridor for thousands of years. These and other assumptions regarding the prehistoric use of the Moonlight Fire area await more formal study to assess their validity.

4.1.1.2 Ethnographic Period

The Moonlight Fire area is located within the ethnographic territory of the Maidu, also known as the Mountain or Northeastern Maidu (Dixon 1905:123-125; Kroeber 1925:391-392; Riddell 1978:370-371). The traditional Maidu homeland is bounded by Lassen Peak to the north, the Sierra Buttes to the south, extending west of American Valley (Bucks Lake vicinity), and east into the Honey Lake Valley. Neighboring groups included the Konkow on the lower reaches of the Feather River to the west, Yana to the northwest, Atsugewi and Achumawi to the north, Nisenan to the southwest, and Washoe and Northern Paiute to the east and northeast respectively.

The geography of Maidu territory was generally mountainous including numerous high mountain valleys and meadows. Maidu people resided in permanent villages within American, Butt, Genesee, and Indian Valleys, Big Meadows (now under Lake Almanor), and Mountain Meadows (Riddell 1968; 1978:370-372). Occupation was generally restricted to seasonal use in other valleys, including Humbug, Red Clover, Sierra and Mohawk while many temporary camps were utilized in the mountains and along the secondary drainages throughout their territory.

Political organization encompassed at least one if not several permanent autonomous village communities (Kroeber 1925:397-398; Riddell 1978:373). A central village housed a circular, semi-subterranean ceremonial assembly structure (roundhouse) and was usually the home of a community headman. A village population did not exceed 200 people. Houses were either semi-subterranean or conical bark structures.

The fundamental economy of the Maidu was one of subsistence hunting, fishing, and the collection of plant resources on a seasonal basis (Riddell 1978:373-374). Acorns were a dietary staple but the Maidu gathered and utilized a very wide range of vegetal resources. A variety of other animal resources (for food and many other applications) were also utilized. Salmon was a very important resource and specific seasonal encampments along the Feather River and its primary tributaries were associated with the annual salmon runs.

A wide variety of innovative technologies were employed to process food resources (Riddell 1978:373-379). This included the use of portable stone mortars and pestles, milling stones and a wide variety of basketry. Bedrock mortar stations were frequently used as well. Maidu basketry was a highly developed industry and were either coiled or twined. They also traded extensively with nearby groups for resources not readily available within their home territory.

Northeastern Maidu lifeways were little affected by the early expeditions of Spanish explorers and Euro-American trappers prior to 1848. A disastrous epidemic swept the Sacramento Valley in 1833 that decimated the neighboring Konkow but its effect on the Northeastern Maidu remains unclear (Riddell 1978:385). With the outset of the California Gold Rush even the remote territory of the Northeastern Maidu was overrun. The results were immediate and devastating including the loss of hunting and gathering locales, violence, malnutrition, and starvation. Estimates indicate the Northeastern Maidu population was reduced to a few hundred individuals compared to at least several thousand prior to contact (1978:386).

Riddell (1968:88-89) records the presence of two permanent villages that were either occupied at, or possibly even after Euro-American contact within the lower (southern portion) of the North Arm but both locations were well outside the Moonlight Fire area. Thus, while there is no documented post-contact Maidu occupation or use within the Moonlight Fire area during the late nineteenth or early twentieth centuries, it seems certain that, despite the cultural upheaval that was present during the post-contact period, some level of tribal use of the area would have been ongoing.

4.1.1.3 Historic Period

Early Settlement

The early history of Plumas County is firmly entwined with the California Gold Rush. By 1850 a number of rich placer gold locations had been discovered along the Feather River and settlements rapidly followed (Young 2003:25-30). James Beckwourth opened an emigrant trail over the lowest pass across the northern Sierra Nevada mountains (today's Beckwourth Pass) in 1851 and a steady flow of emigrants and miners began to arrive from the east. Ranching and

mercantile interests began to establish themselves in the area as well. By the time Plumas County was formed out of Butte County in 1854, a number of modest but active settlements had been well established.

The first Euro-American settlement in Indian Valley occurred when Peter Lassen established a trading post here in 1851 (Fariss and Smith 1988:295). While Lassen did not remain, Jobe Taylor settled on land at the southeast end of the valley in 1852 and the town of Taylorsville was soon established. The valley was soon claimed for ranches and farms (Farris and Smith 1988:296). Not surprisingly, many of the earliest settlers also prospected for gold which was located, among other areas, along what became known as Lights Creek.

Gold and Copper Mining

The early era of mining along Lights Creek is not well documented but it is known that significant placer mining was occurring here by the early 1850s (Clarke 1976: 86-87; Foote and Huberland 1998; Gudde 1975:194). This area soon became known as the Union Mining District (Lamb 1995). Placer mining intensified from stream and bank sluicing to include hydraulic mining as well (MacBoyle 1920:31-32). A great number of water ditches were constructed along Lights Creek and elsewhere in the Moonlight Fire area. Two prominent examples were the Fant and Ruffa ditches which were in use for decades (Foote 1991:15). Despite these early activities, the Lights Creek area never became a major placer mining locus during the second half of the nineteenth century. Substantial segments of these many water conveyance systems can still be easily traced within the Moonlight Fire area (Figure 55).

In the 1860s, quartz or hard rock mining began to be developed in areas surrounding Indian Valley. In the Greenville vicinity alone, up to 15 quartz mines were operating between 1860 and 1880 (Young 2003:35). The Lucky S Mine, a hard rock gold mine present within the Moonlight Fire area, had been located by 1882 (Lamb 1995:3) (see Figure 56). Quartz mining was ultimately the most economically important form of gold mining in Plumas County (Clark 1976:82-83).

From the late 1850s up through ca. 1900, Chinese miners comprised a significant portion of the population in Plumas County. Typically, they worked placer gold diggings that had been abandoned by Euro-American miners often making significant profits due to their diligent mining methods. China Gulch, a tributary of Lights Creek within the Moonlight Fire area, was certainly named for Chinese miners (Foote and Huberland 1998:9) (Figure 56). While very little information is available, the General Land Office (GLO) Plat for T27N, R11E dating to 1881, shows ditch segments and a mining cut at the upper end of China Gulch that were labeled as “old” at that time. While Chinese mining activities in this area are not well understood, their population levels in the Lights Creek vicinity were likely relatively limited.

Figure 55. The Cairn Ditch just above Lights Creek. One example of many old historic era mining ditches recorded within the Moonlight Fire area.

Despite the modest production in gold from this area, the real mineral wealth was realized in copper. A brief copper boom occurred in California during the Civil War years that resulted in a small amount of copper production from the Cosmopolitan Mine located in the Genesee Valley area (Lamb 1995). James Ford, a prominent rancher in the North Arm, may have first located copper deposits along Lights Creek at this same time but no significant development was forthcoming (Foote 1991:12). By 1868 copper prices had dropped, and there was only very limited work accomplished for the remainder of the nineteenth century.

Henry A. Engels and his family had settled on Lights Creek by 1880 in a location that soon became known as “Engels” (Lamb 1995:3). He recognized the potential of the copper resources in this area. By the end of the 1890s, with the maturing of the industrial revolution and the rise in demand for electrical power and products, copper prices improved dramatically. The Engels Copper Mining Company (ECMC) was organized in 1901 to gain the capital required to develop mining on a larger scale. Although other mining concerns were present around this time, only the ECMC evolved into a major operation in this area (Foote 1991:15-16; Young 2003:43-45).

Engels Mine was one of three major copper mines within the 18 mile long “Plumas Copper Belt” (Foote 1991:13-14). The Engels and Superior Mines, both part of the ECMC, were located within the Lights Creek drainage, at the north end of the belt, while Walker Mine was present at the southern end; south of Genesee Valley. Transportation was the greatest challenge for the ECMC during its early years. When the Western Pacific Railroad was completed through the Feather River Canyon in late 1909, the ECMC finally had an efficient means to ship concentrates to distant smelters for processing.

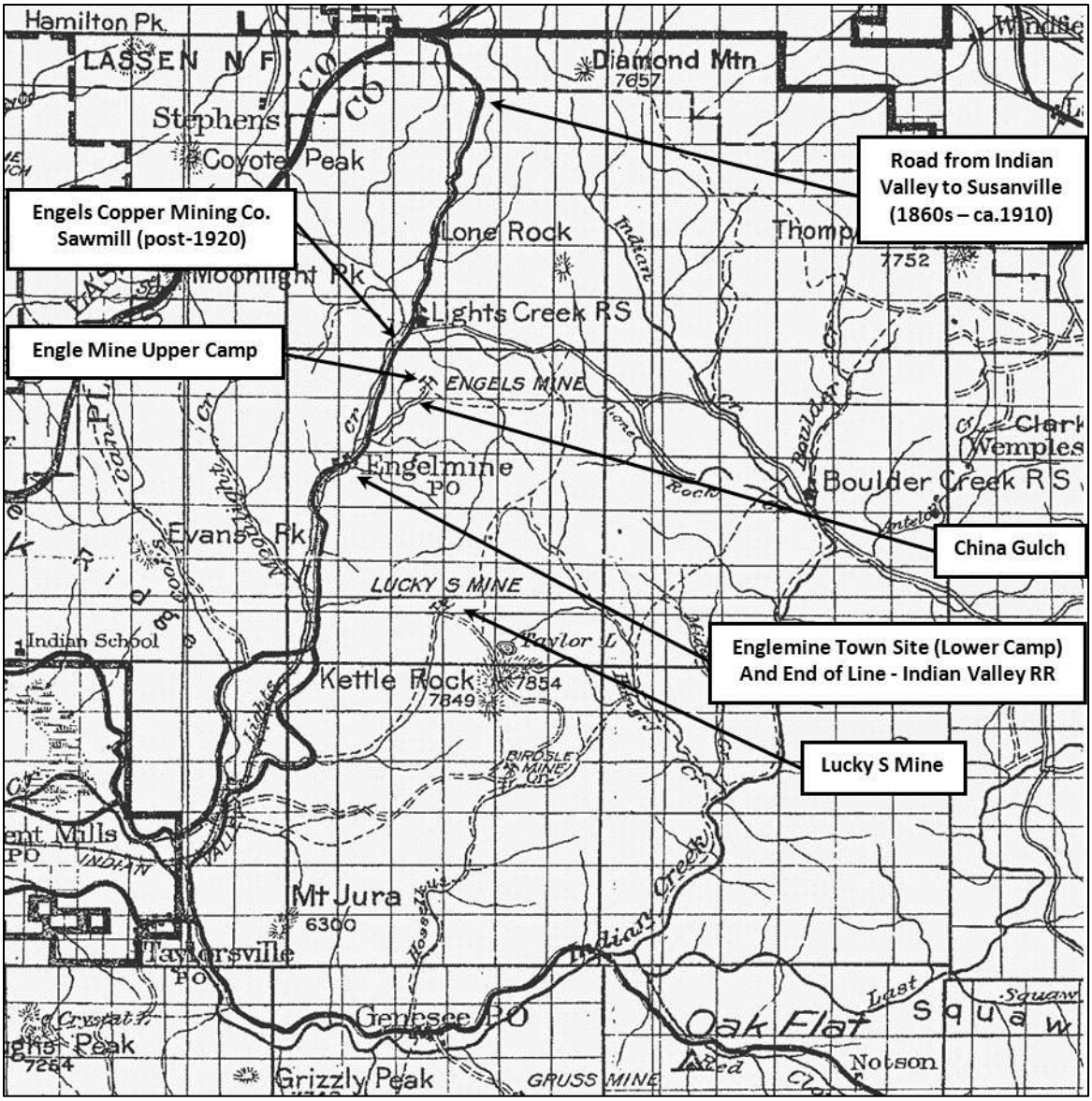

Figure 56. Excerpt of Plumas NF Map, 1925 showing the vicinity of the Moonlight Fire area. Note the Plumas NF's Boulder Creek and Lights Creek Guard Stations. Note also, at the far center left of the map, the old Greenville Indian Mission School. A portion of the primary wagon road between Indian Valley and Susanville is also highlighted.

In 1911, the ECMC built a smelter in China Gulch at significant cost (Foote and Huberland 1998:10-11). Shortly after its completion, however, the Forest Service prohibited its operation (MacBoyle 1920:57). Following this financial debacle, a flotation mill was constructed at Upper Camp in 1914 which was the first all floatation copper mill constructed in the United States. Upper Camp was located at the headwaters of China Gulch. A second mill, the Superior Mill, was constructed in 1917 and operated for the remainder of the life of the mine. This mill was located immediately south of the junction of the Superior Ravine with Lights Creek (Figure 57).

At the same time the new Superior Mill was completed, the ECMC constructed a broad gauge short-line railroad used to haul concentrates from the Superior Mill as well as freight and passengers. Completed in 1917, the Indian Valley Railroad ran daily from Lower Camp to a connection at Paxton with the Western Pacific mainline (Young 2003:44, 72-75) (Figure 57).

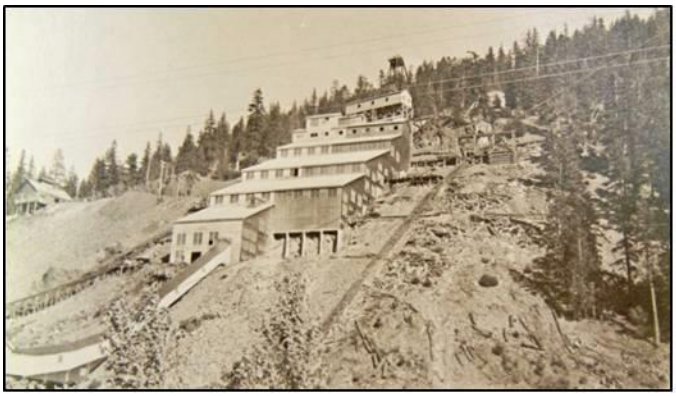

Figure 57. The Superior Mill (left) which operated between 1917 and 1930. The concrete footings for this impressive structure can still be readily observed on the hillside above Lights Creek. The Indian Valley Railroad Engine No. 1 at Englemine (Lower Camp) in the 1920s (right). Courtesy of the Plumas County Museum.

The town site of "Engelmine" was laid out in 1918 near Lower Camp on Lights Creek just north of the Superior Mill which included a dining hall, recreation hall, hospital, school, post office, store/hotel, large dormitories, and family housing (see Figure 56). Utilities included sewer, power, and water. By 1923 Upper Camp had been abandoned (Foote 1991:17-18). Two additional portions of Englemine, "Hollywood" and "Tijuana," were located to the north.

Along with the thriving timber industry, copper was a driving force in Plumas County's economy through the 1920s up until the Great Depression. Engels Mine was the largest copper producer in California during this period and yielded some 117 million pounds of copper over its lifetime (Young 2003:43-45). At least $25 million was realized at the Engels Mine before the ECMC closed it in 1930 when the price of copper dropped too low to maintain profitability. Operations continued at a reduced pace on the Indian Valley Railroad until 1937 (Young 2005:78). By 1940, all of the equipment at the mine had been sold and the railroad right-of-way abandoned. Houses from Englemine were either torn down or moved off-site (Foote 1991:18). With the closure of Walker Mine in 1941, all active copper mining in Plumas County ceased ending the county's short but lucrative copper mining era.

Placer mining continued well into the twentieth century along Lights Creek and there are still many active claims, particularly during the economic depression of the 1930s. Between 1939 and 1942, the confluence of Morton Creek, and the west and east branches of Lights Creek were subjected to dredge mining (Elliott and Weinberg 2011).

Agricultural Development

By the mid-1850s, most of Indian Valley had been claimed for raising hay and grain crops as well as for dairy and beef production. The first gristmill in Indian Valley was constructed in 1856 (Fariss and Smith 1988:295). The dairy industry, in particular, became very important and Indian Valley products were finding their way as far as Nevada's Comstock by the early 1870s. Farmers grew hay, oats, barley, potatoes, vegetables, and maintained fruit orchards. By 1880, Indian Valley had a population of nearly 2,000 individuals and its economic base was firmly agrarian.

Many of the high mountain valleys and meadows of the northernmost Sierra Nevada mountains were also being claimed for seasonal range and dairy operations. Antelope Valley, just east of the Moonlight Fire area, had at least two seasonal dairies active including the Torrey Ranch and Dairy present here by the mid-1870s (Elliott 2007). The 1879 GLO Plat for T28N, R11E (SE ¼ of Section 36) notes "Droge's Dairy House" just southeast of Lone Rock; well within the recent fire area. By the end of the 1890s, market conditions had declined and most of these small dairies were abandoned (Figure 58).

Figure 58. The Fisher Dairy house in Antelope Valley just east of the Moonlight Fire area. In an advanced state of decay when this photograph was taken in the 1930s; it represents a typical small-scale seasonal dairy of the northern Sierra Nevada. Note the water wheel which would have supplied power for cream separation. This location is now submerged beneath Antelope Lake.

Sheep grazing in the forests of the southern and central Sierra Nevada was by all accounts very extensive during the second half of the nineteenth century (see McKelvey and Johnston 1992:232). This does not appear to have been the case in the vicinity of the Moonlight Fire area prior to ca. 1900. At this time, however, flocks of sheep and their Basque shepherds became a routine, seasonal presence in the area (Young 2003:58). Originally from the Pyrenees Mountains in Spain and France, Basques initially arrived in California during the Gold Rush (Zubiri 1998). There was a large influx of Basque sheepherders between 1900 and 1930. Basque tenders and herders were still common as late as the 1970s (Tahoe NF 2005). They were well

known in the greater Sierra Nevada region for their unique tree carvings, referred to as "arborglyphs" or "dendroglyphs." Carvings were typically made on aspen trees and included names, dates, and messages along with various images. Examples of arborglyphs have been recorded within and adjacent to the Moonlight Fire area (Figure 59).

Figure 59. Example of an arborglyph in an aspen grove within the Moonlight Fire area.

Timber Production

Like early agricultural development in Plumas County, the initial growth of the timber industry in the region was a direct result of the Gold Rush and the booming mining industry of the time. Jobe Taylor constructed the first sawmill in Indian Valley in 1855 and powered it by diverting the water from Indian Creek (Young 2003:79-80). Logs were usually transported from nearby stands to sawmills using oxen, mules, or horses. Production was restricted to local markets and was used to develop the growing towns and ranches as well as in support of the many mining developments throughout the area.

The completion of the Western Pacific Railroad in late 1909 resulted in an immediate large scale intensification of the lumber industry in Plumas County. Many logging railroads were built from sawmills into the forest during the 1910s and 1920s but none were developed out of Indian Valley. The 1920s represented the heyday of steam power in the forests of Plumas County. Yet, by the end of the decade caterpillar tractors were rapidly replacing steam donkeys while motorized trucks became more efficient for hauling logs.

The Engels Mine maintained its own sawmill. It was first located near Lower Camp in the early 1910s, then moved to Upper Camp in 1914, then back to Lower Camp again shortly afterward (Foote and Huberland 1998:11). It was moved again nearly three miles upstream (north) along

Lights Creek. This latter sawmill had a capacity in 1920 of 30,000 board feet per day. It was sold to a private company about 1926 and operated until the late 1930s (Figure 60).

With the post-World War II housing boom and the advancement of logging technology, the forested slopes in and around the Moonlight Fire area experienced significant levels of timber harvesting (e.g. Figure 11). This included miles of new logging roads constructed throughout the area beginning in the 1940s. Conversely, in 1971 Lights Creek Canyon was the location of the nation's first helicopter timber sale (Young 2003:95). The use of helicopters to harvest the timber reduced the need for roads and helped preserve wildlife habitat and prevent erosion on the steep slopes.

Figure 60. Engel Copper Mining Company's sawmill on Lights Creek in the early 1920s. The site was later subjected to gold dredging around 1940 and no sign of it remains today. View is to the south. Courtesy of the California-Engels Mining Company.

Roads and Trails

The Maidu maintained a network of trails throughout their traditional homeland for generations. Many of these were later utilized by Euro-American populations and some were ultimately converted to wagon and automobile roads (see examples as shown in Figure 56). An excellent example within the Moonlight Fire area would be the old Indian Valley – Susanville Road (County Road 213) which served as a primary route of travel between the 1860s and the early twentieth century. Many other old roads and trails are present within the Moonlight Fire area including the southern end of the historically well-used Clarks Trail which once extended up China Gulch (see GLO Plat for T27N, R11E, 1881). Other early trails within or partially within the fire area include the Peters Trail and the Cold Stream Trail.

Forest Service Administration

The Plumas Forest Reserve was established in March of 1905. Among the very earliest guard stations established on the Forest were Boulder Creek and Lights Creek, both completed by 1908 (Barrett 1940:6-7). The former was a log cabin located near present day Antelope Lake while Lights Creek Station was a small frame building near the confluence of the main and east branches of Lights Creek (Figure 61). The Lights Creek Guard Station was removed in the 1950s after a long period of non-use. While none of the original Boulder Creek Guard Station buildings remain, it is still an active Forest Service facility (for more details on the Boulder Creek Station see Section 4.5.2).

Figure 61. The first Lights Creek Guard Station ca. 1910. A second, somewhat more substantial building replaced this one in the early 1920s which was itself removed in the 1950s. Only the concrete foundation from the second house remains along with some refuse to mark the site of the old station.

The Plumas NF began to develop fire detection lookout sites as early as 1908 (Barrett 1940:6). A lookout on Kettle Rock was present at least by 1915. Located just south of the Moonlight Fire area, a total of three lookout structures were constructed on this site over time. The final one was completed in 1953 and was abandoned in the 1980s. It was recently removed to erect a new radio relay facility. The lookout at Red Rock, immediately north of the Moonlight Fire area, was constructed much later in 1955. This lookout has only recently been un-staffed (2009) as a direct result of the Moonlight Fire and it is uncertain at what point it may see use again as part of the Forest's fire detection system.

4.1.2 Known Cultural Resources within the Moonlight Fire Area

A total of 263 cultural resource sites are currently recorded on Forest Service lands within or partially within the Moonlight Fire area. Additional sites are located on privately owned property; in particular on patented mineral lands of the California-Engels Mining Company. A total of 204 cultural resource sites are historic (78 percent); 51 are prehistoric (19 percent) and 8 are multi-component sites (3 percent) containing evidence of both historic era and prehistoric uses. There have been 81 past cultural resource inventories performed within or partially within the Moonlight Fire area.

Immediately following the 2007 Moonlight Fire, Plumas NF archaeologists were involved in Burned Area Emergency Rehabilitation (BAER) efforts (Padilla and Smith 2007). BAER team archaeologists monitored 84 sites in areas of moderate to high burn severity, however, few appeared to be at immediate risk from erosion, flooding, or slope degradation.

4.1.2.1 Existing Condition (Prehistoric Period)

The great majority of the 51 prehistoric cultural resource sites are classified as lithic scatters – i.e. occurrences of flaked stone tools, tool fragments and debitage from shaping and modifying such tools. Lithic material typically includes a high percentage of basalt and, to a lesser extent, crypto-crystalline silicates, usually referred to collectively as chert. Obsidian can also be present, but is comparatively rare.

The Moonlight Fire area lacks any occurrences of bedrock mortar sites. These features are common in many areas within the Sierra Nevada. Likewise, there is an absence of what is commonly referred to as rock art sites; i.e. petroglyphs (incised) and/or pictographs (applied pigment). The former are recorded to the south of the Moonlight Fire area but not with any significant frequency until the Lakes Basin area at the southern end of the Forest. Pictographs are exceedingly rare anywhere in the northern Sierra Nevada with but one occurrence recorded in the vicinity of Last Chance Creek on the east side of the Plumas NF.

Isolated prehistoric artifacts do occur within and adjacent to the Moonlight Fire area. These are documented but are not generally recorded as cultural resource sites. Isolated projectile points, for example, can provide at least a gross indicator of the period of use of a given area but typically provide little else in terms of understanding past human behavior.

The effects of intensive wildfire to prehistoric cultural resources can be very severe. Negative effects to both flake stone and ground stone artifact classes become more pronounced with increased fire intensity and duration of exposure (Deal 2012:110-111). Indeed, if the duration of fire exposure is long enough, even low intensity exposure can result in degrading effects. Flaked stone artifacts can not only be physically damaged and deformed but critical information potential can be lost. While considerable observation on post-fire site conditions was conducted during BAER efforts as well as during subsequent monitoring for fire salvage project(s) (see Padilla and Smith 2007; Padilla 2008), there is much work yet to be done to assess the full extent of the effects to cultural resource values within the Moonlight Fire area.

4.1.2.2 Existing Condition (Historic Period)

As noted above, the great majority of the 204 historic era cultural resource sites recorded in the Moonlight Fire area are mining related, and of these many are directly or indirectly associated with copper mining activity ca. 1910-1930. There is substantial evidence in the Lights Canyon area, and elsewhere in the Moonlight Fire area, reflective of past placer mining. Hard rock mining sites are also present. The Lucky S Mine was active later in time than most other historic mines and, as a result, a number of standing structures still remain. Yet, this is the exception rather than the rule. The majority of the machinery and recyclable metal (head frames, etc.) at most mining sites were removed long ago and what typically remains behind today are shafts and adits (sometimes still open), associated tailings piles, old road beds and track, structural debris, and refuse. Many standing structures that might have survived were likely lost to the fire while other historic features were certainly adversely affected.

Few, if any, cultural resources associated with the large historic ranches that were so important in the settlement of Indian Valley are located within the Moonlight Fire area. The fire did extend into the upper part of the old Ford Ranch in the North Arm but recent field monitoring indicates that only the Ford family cemetery, located on public lands above (east of) the old ranch site, was actually affected by the fire. Cultural resources associated with an agricultural theme would likely be in and around valleys or meadows where either dairy or beef cattle were being grazed or where sheep were being tended. Several arborglyph sites have been recorded within and adjacent to the fire area reflecting past Basque sheep herding activities. Already a fast disappearing resource, it is documented that at least some of these aspen stands were very negatively affected by the Moonlight Fire (Padilla 2008).

Early era logging was generally confined to local markets and the limited scope of cutting for the Engels Copper Mining Company likely did not extend significantly far afield from the mining operation. No logging railroads were ever used in this area nor are any woods camps known to have been present during the pre-World War II era. Thus, very little in the way of cultural resources associated with historic logging, at least prior to ca. 1950, are expected in this area.

The old Indian Valley – Susanville Road passes through the Moonlight Fire area and is still in use today. Dating to the 1860s, it is not known if any early era segments of this important historic route survive and, if so, to what extent these might have been affected by the fire. Early roads and trails, unless maintained, are susceptible to the effects of erosion over time. Such processes can be greatly accelerated in post-fire environments. The Plumas NF has recorded segments of several early trails in the Moonlight Fire area but many others depicted on historic maps are yet to be examined.

The Plumas NF's Lights Creek Guard Station was removed long ago and the still-active Boulder Creek Guard Station is located just outside the fire perimeter (see Section 4.5.2). The Kettle Rock Lookout to the south is now removed. The Red Rock Lookout directly to the north still remains but is currently un-staffed (see Section 4.3.2). No other cultural resources associated

with Forest Service administration have been recorded or are expected within the Moonlight Fire area.

In much the same manner as prehistoric cultural resources, historic era sites are prone to effects from wildfire (Haecker 2012). Structural remains of wood can, of course, be partially or entirely consumed. Even stone, brick and concrete features can be affected. Historic refuse deposits can contain an array of material types and diagnostic artifacts can be damaged beyond identification. In addition, suppression efforts can adversely affect nearly all cultural resource classes with mechanical (dozer) fire lines being especially detrimental. While the BAER monitoring and the examinations made during the post-fire cultural resource inventories have provided a starting point for damage assessments, a great deal of work remains to determine significance and levels of impacts to cultural resources within the Moonlight Fire area.

4.2 Past and Present Tribal Relations

4.2.1 Tribal Interests and Concerns for the Moonlight Fire Area

As noted in Section 4.1 (Past and Present Cultural Conditions), contemporary Native American interests include Traditional Cultural Properties (places associated with cultural practices or beliefs that are rooted in history and important in maintaining cultural identity), sacred places and cultural landscapes. Also of direct concern are ongoing Forest Service cultural and natural resource management practices. In particular, tribal organizations and individuals have clearly indicated a desire to affect Forest Service land management policies and actions by the application of Traditional Ecological Knowledge.

Approximately 2,500 Maidu tribal members currently live in and around Plumas County. Of the eight federally recognized Maidu tribes in northern California, two tribes, or “Rancherias”, are located in the direct vicinity of the Moonlight Fire area. These are the Greenville Rancheria and the Susanville Indian Rancheria. With its offices in Greenville and Red Bluff (Tehama County), there are approximately 150 enrolled members of the Greenville Rancheria; primarily of Maidu descent. The Susanville Indian Rancheria includes membership from traditional Maidu, Paiute, Pit River (Achumawi and Atsugewi), and Washoe tribal peoples. With nearly 700 members, the Susanville Indian Rancheria has its headquarters in Susanville and maintains tribal property not far to the east of the Moonlight Fire area (Cradle Valley). In addition, the Maidu Summit Consortium is an organization comprised of both federally recognized and un-recognized Maidu tribal interests. These tribal organizations all have direct and ongoing concern regarding Forest Service management within their traditional homeland. Their collective involvement in future land management direction, as well as any specific restoration measures that might be proposed within the Moonlight Fire area, will likely be very significant.

The Maidu name the North Arm of Indian Valley “Hopnom Koyo” and Lights Creek is known as “Hopnom Sewi” (Maidu Cultural and Development Group 1998). Despite the current paucity of data regarding tribal use of this particular area from the ethnographic period up to the present day, the fact that Maidu occupation of Indian Valley was by all accounts quite robust just prior

to Euro-American contact leads to the reasonable inference that cultural use and knowledge of the Moonlight Fire area was quite extensive.

To date, there are no Traditional Cultural Properties or sacred places on US Forest Service lands within or directly adjacent to the Moonlight Fire area that the Plumas NF is aware of. There is one instance, however, of a traditional gathering area that has been identified by Maidu informants since the 2007 Moonlight Fire. This area, located within Lights Creek Canyon, exhibited fresh examples of an array of medicinal plants apparently not seen by tribal members in many decades. These ethno-botanical resources had emerged as a direct result of the fire (a rare instance of a positive effect resulting from the Moonlight Fire). The botanical occurrence took in a large area (323 acres) and was sufficiently documented by the Plumas NF to ensure adequate protection during planned fire salvage undertakings. More work to better define these particular resources is certainly warranted as are efforts to identify, protect, and even enhance other important ethno-botanical resources within the Moonlight Fire area.

4.3 Past and Present Recreation Conditions

The Moonlight Fire restoration analysis boundary for recreation (hereafter called the recreation analysis area) incorporates such areas as the Antelope Lake Recreation Area, Indian Creek, Lights Creek, Taylor Lake, and the Antelope-Taylor Lakes Trail (Figure 62). Although the Moonlight Fire did not burn down to any of the recreation sites at Antelope Lake, the entire Antelope Lake Recreation Area is included in the analysis boundary since recreation sites and opportunities at Antelope Lake were substantially impacted by the Moonlight Fire. The recreation sites at Antelope Lake Recreation Area are all within the view shed impacted by the Moonlight Fire. Burned landscapes from the Moonlight Fire are visible from all of the recreation sites at Antelope where visitors recreate. Recreation sites and opportunities are all connected at Antelope Recreation Area since a recreation user may participate in more than one recreation activity; for example, a camper may bring a boat and use the boat launch, then travel to a picnic area, fishing site, or other day-use site. Visitors will view burned landscapes from all of the recreation sites and trails they visit while staying in the Antelope Lake area.

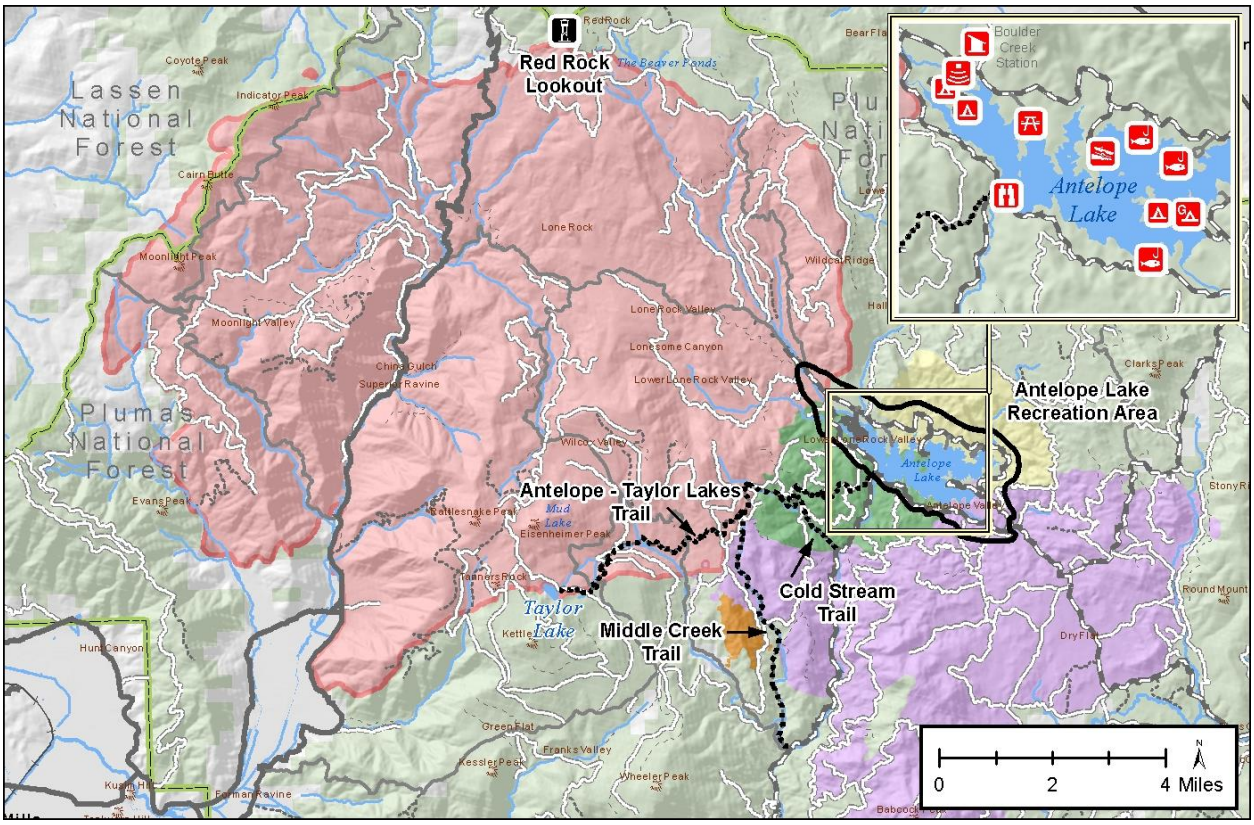

Figure 62. Area analyzed for recreation resources. Past fires are shown in purple (2007 Antelope Complex), yellow (2006 Boulder Complex), green (2001 Stream Fire), and orange (2006 Hungry Fire)

4.3.1 Developed Recreation

Antelope Lake Recreation Area is the primary location for developed recreation activities within the recreation analysis area. Developed recreation opportunities at Antelope Lake include: camping, picnicking, motorized boating, non-motorized boating, swimming, fishing, driving for pleasure, mountain biking and road biking. The analysis area includes three campgrounds at Antelope Lake (Lone Rock, Boulder Creek and Long Point Family and Group Campgrounds), a picnic area, a boat launch, two developed fishing sites (Guiney Point and Lunker Landing), an interpretive amphitheater, an information kiosk with a restroom, and a general store.

The three campgrounds at Antelope Lake have deteriorating infrastructure that has not been replaced or repaired since the 1960's, when the campgrounds were constructed. Pavement on interior roads and spurs within campgrounds is narrow and crumbling and is a safety hazard for recreational vehicles (see Figure 63). The camp spurs are narrow and do not accommodate modern recreational vehicles. There are no universally accessible recreation sites anywhere at Antelope Lake for persons with disabilities.

Prior to 2006, campgrounds were, on average, 75 percent full during busy summer months in July and August. The four campgrounds have a total capacity of 1,315 people (209 campsites). There is no camping allowed outside of developed campgrounds in the recreation area. The

developed campgrounds and general store were under a special use permit with a campground concessionaire, Northwest Park Management, prior to the Moonlight Fire; Royal Elk Park Management currently holds that special use permit. Campgrounds are typically open from early May to early October.

Figure 63. Example of deteriorated pavement typical in Lone Rock Campground

There were approximately 27,520 visitor days at campgrounds at Antelope Lake in 2005 (Dyer 2005). After the fire, in 2010, there were approximately 21,309 visitor days at campgrounds at Antelope Lake (Damm 2010). Recreation use decreased after the Moonlight and Antelope fires by approximately 22 percent, and has not yet come back to pre-fire levels. This is likely because visual quality at Antelope Lake was significantly diminished after the Moonlight and Antelope fires. Visitors now see predominantly burned landscapes around the lake. Although wildflowers and brush have begun to return in the landscapes around the lake, burned trees still dominate. Because of this, the recreation area likely no longer meets intended high visual quality objectives identified in the Plumas NF LRMP for Recreation Areas (Rx-5 Recreation Area Prescription).

Decreased recreation use at campgrounds could also result, in part, from the closing of the recreational vehicle dump station in 2008 after the Moonlight Fire. The dump station was not equipped to take large amounts of sewage at once, and was used beyond its capacity during Moonlight Fire logistical operations.

Due to the campground evacuations at Antelope Lake during the Antelope and Moonlight fires in 2006 and 2007, the campground concessionaire lost over $80,000 in income over those two years. Campground use levels have not increased to levels prior to 2006, affecting the economic viability for campground concession operations at Antelope Lake. The current special use permit with Royal Elk Park Management is valid through 2019. Only one bid was received on

the prospectus for campground operations in 2010. Feedback to recreation staff received from other potential bidders was that the remoteness and cost of doing business at Antelope versus gross income earned did not make the concession operation very viable.

An area orientation kiosk at Antelope Dam was destroyed during the Stream Fire of 2001 and was not replaced. Some interpretive signs along the Nature Trail adjacent to Lone Rock Campground existed prior to the Stream fire, but were not maintained post-fire. Additionally, evening campfire programs were provided by the concessionaire until 2010 at the amphitheater. An average of one program per year has been provided since that time due to the change in the concessionaires since Forest Service can no longer require interpretive services of concessionaires.

The Department of Water Resources, Northern Region Office (DWR), conducted a recreation survey of day use at Antelope Lake Recreation Area in 2009 to estimate the amounts and types of lakeside recreation use and angler success. No previous recreation day use surveys had been performed at Antelope Lake up until 2009. DWR survey results found an estimated total day use on Antelope Lake of 64,369 hours. These surveys estimated 23,253 hours of non-fishing related recreation and 41,116 hours of fishing on Antelope Lake between May 10 and September 30, 2009. The most frequently observed activities were beach use, swimming and wading, and fishing. More than 48 percent of the observed use occurred at Lunker Landing Fishing Area (Boyt 2011).

According to the DWR 2009 survey, the majority (nearly 83 percent) of recreational visitors to Antelope Lake originated in California. California residents came from 25 different counties, of which 71 percent were from adjacent northeast counties. Place of residence for anglers differed slightly from recreational visitors. About 18 percent of anglers came from Nevada, 72 percent from California's northeastern counties, and three percent came from Sacramento Valley counties (Boyt 2011).

4.3.2 Dispersed Recreation

Dispersed recreation activities within the recreation analysis area include camping, picnicking, swimming, boating, fishing, snowmobiling, hunting, rock hounding, driving for pleasure, Christmas tree cutting, and firewood cutting. Dispersed camping is very common along Indian Creek, and Taylor Lake is popular for day-use activities such as fishing. In 2005, the estimated number of visitor days along Indian Creek from Antelope Dam to Flournoy Bridge was 2,000 (Hinton 2005). It is estimated by recreation staff at the Mt. Hough Ranger District that the recreation analysis area receives approximately 10,000 recreation visitor days per year (excluding the Antelope Lake Recreation Area).

In the analysis area there are dispersed campsites accessed by routes that, due to resource impacts, are no longer authorized for motorized vehicles, as a result of the Plumas NF travel management process and EIS. If impacts can be mitigated, the Forest may be able to authorize some of these routes for motorized access.

Another popular visitor destination within the recreation analysis area is Taylor Lake, which is also considered sacred to the Mountain Maidu. There are currently negotiations underway for a possible land exchange in which Taylor Lake would become part of the public lands managed by the Plumas NF. The land exchange has been in process for several years; however if successful, there will be numerous opportunities to improve and restore recreational resources at Taylor Lake.

The Red Rock Lookout, which also lies within the recreation analysis boundary, was identified by the Plumas NF LRMP as an opportunity for remote developed recreation (USDA 1988a: p. 4-282). With appropriate funding, unused lookouts can be converted to recreation rentals; for example the Black Mountain Lookout on the Beckwourth Ranger District of the Plumas NF was successfully converted to a recreation rental in 2010 and is now reserved throughout the season. The Red Rock Lookout is currently unstaffed by fire personnel and is in a deteriorated condition since it has not been staffed since the Moonlight Fire in 2007.

Woodcutting for personal and commercial use is permitted throughout the recreation analysis area. Woodcutting opportunities have likely increased after the Moonlight Fire since there are an abundance of dead trees available for firewood removal.

There are several special use permits that occur within the analysis boundary including three fishing outfitters at Antelope Lake, and one recreation event, the Indian Valley Century Bike Ride.

4.3.3 Non-motorized Trails and Off-Highway Vehicle Recreation

There are approximately 18 miles of non-motorized trails in the recreation analysis area that have been used and are currently used by hikers, equestrians, and mountain bikers. These trails include Antelope-Taylor Lake Trail (10 miles), Cold Stream Trail (2 miles), Middle Creek Trail (5 miles) and Peters Creek Trail (1 mile). These trails did not receive a large amount of visitor use prior to the Moonlight Fire; however they currently receive even less visitor use since the Antelope Complex and Moonlight fires burned along the majority of these trails, making them inaccessible to mountain bikers and equestrians due to down trees (Figure 64). In addition, the safety of visitors and trail workers is at risk due to hazard trees along trails.

Figure 64. Antelope-Taylor Lakes Trail, between NFS roads 27N45A and 27N10 (April 2013)

Prior to the Moonlight Fire, the non-motorized trail system was maintained by recreation personnel on the Mount Hough Ranger District, primarily by getting logged out and receiving minor tread maintenance. Due to the Moonlight Fire, snags and overgrown brush have become major maintenance issues, and it is not possible for a district maintenance crew to maintain these trails to required maintenance standards. Between 2010 and 2013, the Mt. Hough Ranger District spent a significant amount of funding (approximately $150,000 in American Recovery and Re-investment Act funds) towards opening up burned trails; however, snags continually fall on burned sections of the trail and brush has overgrown trails that were maintained to standard in 2010. These trails are now inaccessible again three years later.

There are an abundance of motorized roads and trails available for off-highway vehicle (OHV) use within the analysis area; however, currently (pre and post-fire) there is a lack of single track motorized trail opportunities. The Plumas NF has been receiving state funds since 1989 to operate and maintain the OHV program on the Forest. OHV use was estimated at 35,000 visitor days per year on the roads and trails of the Plumas NF through 2005 National Visitor Use Monitoring (NVUM) Surveys. It is estimated that the Moonlight recreation analysis area receives approximately 2,000 visitor days per year by OHV users.

Many of the motorized roads and trails have hazard trees adjacent to them as a result of the Moonlight Fire, which pose a safety hazard to OHV users driving on trails. This risk increases as these burned trees stand longer each year. Motorized trails are maintained by district staff. Hazard trees on roads and trails also pose a risk to employees working on trails and roads.

The Diamond Mountain Limited Vehicular Access Area administratively closes roads within this designated area to any motorized vehicles during the zone X-6A rifle deer season.

4.4 Past and Present Education and Outreach Conditions

4.4.1 Past Conditions

Greenville High School (GHS) Natural Resources Academy Program initiated some of the first restoration field work to occur within the Moonlight Fire. With the support of a four-year California Specialized Secondary Program (SSP), a grant was awarded to GHS. Through this grant, the Natural Resources Academy was formed, which supported natural resources classes, curriculum development, fieldtrips, and tools. The Academy was also supported by the Sierra Institute for Community and Environment; a non-profit organization that promotes healthy and sustainable forests and watersheds by investing in the well-being of rural communities and strengthening their participation in natural resource decisions and programs. As part of their focus on connecting people to the landscape through education, Sierra Institute provided natural resource education for Greenville teachers and junior/senior high school students. Natural resource classes and students participated in tree planting and monitoring sites within the Moonlight Fire area. The SSP grant expired in 2011. A video was produced about the fire by the Natural Resource class (http://www.youtube.com/watch?v=lbHtyR6CF3w).

A Secure Rural Schools Title II RAC grant was applied for and awarded in November 2009 to Sierra Institute to continue support of the GHS Natural Resource Program. The RAC grant will be concluding this year in 2013. The following was accomplished through both grants: three separate tree plantings; riparian restoration of upper Indian Creek where a bottomless culvert was installed; monitoring that included: five years of photo point data, three vegetation plots, two snag plots, five to six photo points monitored annually, and a bird count.

The Moonlight Fire impacted the nearby Antelope Lake Recreation Area by altering natural vistas and aesthetics, creating smoke hazards, destroying trails, causing campground closures, and ultimately decreasing visitation and recreation opportunities. The Recreation Area had been previously impacted by the Stream Fire (2001), Boulder Fire (2006), and Antelope Complex (2007).

4.4.2 Present Conditions

Moonlight Fire Restoration efforts continued in 2013 with a tree planting fieldtrip with Greenville HS on April 19 and riparian restoration completed April 26. An additional fieldtrip occurred on May 21 to visit a rare Baker Cypress site. There are no additional restoration projects involving Plumas Unified School District (PUSD) students pending completion of the Moonlight Post-fire Restoration Strategy.

The target area for educational restoration opportunities encompasses the Plumas Unified School District (PUSD) schools in Chester, Greenville, Quincy, and Portola. A successful model for student participation exists. We are in the second full year of implementation of the Storrie

Fire Restoration Project collaboration between the Forest Service and PUSD. This comprehensive approach to conservation education includes all 3-12 grade classes in public schools in the communities of Chester, Greenville, Quincy and Portola. Activities include various educational restoration and stewardship activities in the Storrie and Rich Fire geographic areas, in-class pre-and post-fire curriculum, pre- and post-field study, and stewardship on school campuses and adjacent sites known as Learning Landscapes.

No interpretive programs are provided by the campground concessionaire at Antelope Lake Recreation Area. No area orientation is provided. There is no interpretation about the area's fire history or natural history.

4.5 Past and Present Conditions: Facilities and Infrastructure

4.5.1 Transportation

The analysis area used to assess transportation conditions within the Moonlight Fire is identical to the area assessed for soil conditions (Figure 50); for a detailed description refer to Section 3.12 (Past and Present Soil Resources Conditions).

4.5.1.1 Pre-Fire

A survey of road conditions conducted for the Diamond Project in May of 2006 determined that there were a total of 45.5 miles (out of a total of 369 miles) of roads that needed reconstruction prior to the Moonlight Fire (USDA 2006a). The total reconstruction cost was estimated to be approximately $60,327. The total mileage of reconstruction was estimated to be 18.1 miles based off of a rate of $3,330 per reconstructed mile. While the exact categorization of the actual reconstruction mileage is unknown, the 45.5 miles of road can be broken down as shown in Table 31 below.

Table 31. Categorization of roads in need of reconstruction; determined in May of 2006 (USDA 2006a)

By Maintenance Level		By Surface Type	
Maintenance Level 1	1 mile	Native Surface	29.4 miles
Maintenance Level 2	33.7 miles	Aggregate Surface	16.1 miles
Maintenance Level 3	10.8 miles	Paved Surface	0 miles

Additionally, there were 16 roads totaling 9.53 miles that were causing resource damage and were recommended for decommissioning. The basis by which these 16 roads were recommended for decommissioning were as follows: (1) ten roads were dead end spurs; (2) three roads were loop roads; and (3) three roads required relocation (USDA 2006a)

4.5.1.2 Post-Fire

As part of the BAER effort, the Plumas NF Engineering team surveyed some of the more heavily used roads in the Moonlight Fire perimeter. In the survey, five roads were identified with a need for significant reconstruction and/or relocation. The results of this survey are shown in

Table 32 below. It is important to note that there are approximately 160 miles of system roads within the Moonlight Fire perimeter, and nearly 400 miles in the HUC 6 analysis watersheds.

Table 32. Summary of the more extensive damage on heavily used roads in the Moonlight perimeter.

NFS Road	Road Name	Mitigation Recommended
27N09	Hungry Creek	Reconstruct and repair surface
28N03	Boulder	Relocate stream crossing and about 800’ of road slide area. Relocate additional 5,000’ east of slide area to minimize increased erosion and siltation due to increased run-off velocity and volume at current location.
28N19	Goat Rock	Decommission
28N30	West Branch Lights	Repair and relocate numerous small slide areas.
29N46	Ruby Mine	Relocate 1,000’ at major slide.

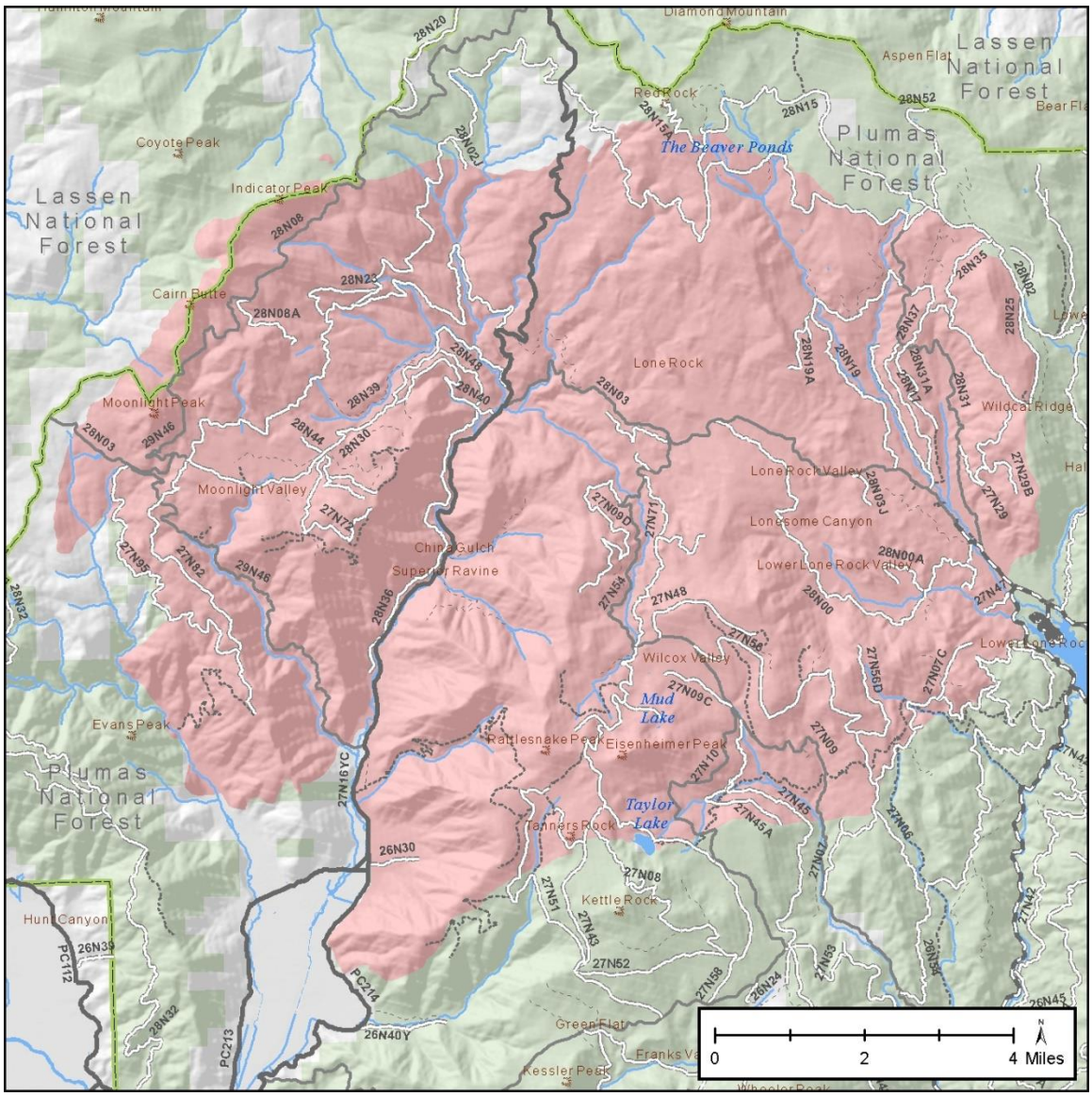

Figure 65. NFS roads within the Moonlight Fire area.

Monitoring of the BAER roads showed some slumps and landslide initiation. Figure 66 shows a road slump discovered in 2009 on NFS road 28N03. Other problems have been noted on NFS roads 28N30 in the West Branch of Lights Creek and 29N46 road near the Ruby Mine (USDA 2008). Additional field surveys in June and July of 2013 discovered that the following NFS roads are effectively closed as a result of extensive slides and slumps that have buried or obliterated the roadway: 27N45 (in section 25, T 27N, R 11E); and 28N03 (in sections 25 and 36, T 28N, R 10E); 28M39 (in section 31, T 28N, R 11E).

Figure 66. Road slump along NFS road 28N03 noted in BAER road monitoring (USDA 2009)

The Keddie Project covers the unburned portion of the Moonlight analysis area in the Lower Lights Creek and Cooks Creek HUC 6 watersheds. Specific information on roads is not listed in the FEIS, but NFS road 28N32 in the Cooks Creek watershed and NFS roads 27N10 and 26N02 in the Lower Lights Creek watershed are listed as needing some improvements along their length (USDA 2011c).

4.5.2 Boulder Creek Station

The Boulder Creek Station is situated 0.1 mile east of the Moonlight Fire perimeter and NFS road 28N03, one of the primary access routes to the fire (Figure 62). It is generally staffed between June and September by a Forest Service Fire Engine crew; however this is dependent upon available funding. Over the past few decades, fire crews stationed at Boulder Creek have played an important role in fuel reduction and fire suppression efforts. Crews have responded to and contained numerous small fires in the area, effectively reducing the number and size of escaped wildfires. Fire personnel stationed at Boulder Creek currently provide information, support, and assistance to visitors and Forest Service personnel in this remote part of the Plumas NF. In addition to these services, fire staff stationed at Boulder Creek could provide

support and staff for implementation of proposed restoration projects, such as thinning and prescribed burning.

Due to the remote location of the Moonlight Fire, the Boulder Creek Station could play a key role in the fire restoration effort by providing barracks space for restoration crews, secure storage for restoration project equipment and materials, diesel fuel for project vehicles, and internet access. The Boulder Creek Station currently has two barracks, which can accommodate 16 people, and an office building. A diesel generator powers the entire compound, including the well pump supplying the station and adjacent campgrounds, and six trailer hookups. The collective benefits of these features make Boulder Creek an effective and economical location for operations associated with the fire restoration effort.

4.6 Past and Present Mining Conditions

The Moonlight Fire area has a long history of mining activity (see Section 4.1, Past and Present Cultural Conditions). There are seven abandoned mine sites noted on the maps, plus three patented claims. There is also evidence of historic placer mining in several areas; gold and copper were the main commodities sought.

There are currently 550 mining claims filed within the Moonlight Fire area. Most of these are owned by one claimant, who has not proposed any activities thus far. The Forest Service currently administers two active Plan of Operations and two Notices of Intent. Three additional Plans have recently been active. However, the current state ban on dredging has reduced the number of active operations considerably. The Lights Creek drainage presently has the most active operations, where placer mining continues on a small scale. It is likely that the Moonlight Fire area will continue to be popular for small scale miners. If conditions become favorable, some of the larger companies, which own a substantial number of claims, may propose copper or gold mining on a larger scale.

5.0 Ecological Resources Desired Conditions, Goals, and Objectives

This section outlines the desired conditions, goals, and objectives for natural resources and human values affected by the Moonlight Fire. Desired conditions provide a target for management goals and objectives. Management goals are broad statements that outline a general strategy for achieving the desired conditions; they are not strictly measureable. Objectives are more specific statements of intentions based on facts, and are measureable. The goals and objectives presented in this section range from broad to specific. Many were derived from the standards and guidelines provided in forest-level planning documents (e.g. SNFPA, PNF LRMP) and objectives and goals developed for previous decision documents (i.e. Moonlight FEIS).

5.1 Conifer Forest Vegetation Desired Conditions, Goals, and Objectives

5.1.1 Historical Reference Conditions and Strategies for the Future

Historically, landscape and stand structure was driven by disturbance; primarily fire, but also disease, insect outbreaks, drought cycles, and their interactions. Numerous studies have examined historic forest structure and composition in an attempt to develop reference conditions for dry western mixed conifer forests. These types of forests are adapted to similar disturbance regimes, in terms of forest type, agents of change, frequency, and severity, and can be useful in determining forest structure, composition, and processes which may be best adapted to these disturbances in terms of both resistance and resilience. These reference conditions characterize forest conditions under intact disturbance regimes and are thought to represent resilient forests, which is a common management objective of dry western mixed conifer forests. This can be useful in characterizing desired conditions in the analysis area given the similarities in species composition and disturbance regimes (North et al. 2007, North et al. 2009, Stephens and Fule 2005, Stephens et al. 2010).

Historical reference conditions are not to be used to re-create strict or absolute structural targets. Rather, historical reference conditions are used as a benchmark for forest structure and function, which was shaped by ecological processes and is thought to be more resilient to natural disturbance regimes. It should be recognized that the development of present-day forests will be influenced by future trends, which contain unknowns and uncertainty, and restoration, based on a strict interpretation of historical pre-settlement conditions, may not be entirely appropriate (North et al. 2007, Millar et al. 2007). Appropriate reference conditions represent forests that are better adapted to disturbance, including drought, fire, and insect and disease outbreaks, which are projected to intensify with future climate change (Battles et al 2008, North et al. 2007, North et al 2009, Hurteau and North 2009, Millar et al. 2007 Stephens et al. 2010).

Stephens et al. (2010) present adaptive strategies for managing forests of the future considering changes in climate and disturbance regimes including fire. These strategies include, increasing resiliency, facilitating transitions, and re-alignment. The following are examples specific to the Moonlight Fire landscape where these strategies may be employed:

- For eastside yellow pine forests and yellow pine-dominated mixed-conifer forests in the Moonlight Fire area that have been significantly altered through past management (long-established fire suppression, overstory harvesting, and extensive grazing), reference conditions may be used to *increase resiliency* of disrupted forests by promoting and emulating spatial variability and heterogeneity of historical forests at multiple scales (tree neighborhood, stand, and landscape scales). This includes promoting more drought and fire resistant species (i.e. pine species) and maintaining lower density open canopy stands that are resistant to fire and have less competition for growing space resources.

- Another departure from historical conditions include landscape-wide accumulations of surface, ladder, and canopy fuels due to the lack of fire and resulting in-growth of shade tolerant species. Fuel treatments that reduce these live and dead fuel accumulations *increase resistance* of stands to high severity disturbances such as fire. In the Moonlight Fire area, treating fuels in "green" stands either within the fire footprint or outside the fire area within the affected watersheds would increase landscape resistance to the effects of future high severity fire.
- Reforestation treatments within areas of high severity fire must consider the long-term investment and viability of the species to be planted. A pine species planted in 2013 has the potential to live for 100-300 years, but that individual may likely have to tolerate unknown changing conditions and disturbances within that lifespan. Designing heterogeneity in reforestation treatments, planting spacing and arrangements, species mixes, and stock types (seed zones, elevations, and transfer rules) may help *facilitate transitions and responses* and increase forest resistance and resilience in a changing future environment.
- *Re-alignment* options for restoration within the Moonlight landscape can vary from using historic reference conditions to emulate forest structure best adapted to active-fire disturbance regimes to modifying present and future forest conditions, which are very different from historic conditions. For example, the Moonlight Fire landscape lies on the dry eastside of the Sierra Nevada range and under a changing climate this landscape could become substantially drier. Because of this, reference conditions from lower density pine dominated forests from the southern Sierra or Sierra San Pedro Martir may become increasingly more relevant (Taylor 2008). In addition, while mesic forest types such as true fir and moist mixed conifer stands with closed canopies do currently exist on the landscape, the range and proportional distribution of these forest types and canopy structures may potentially decrease in the future; a re-alignment option may be to emphasize more viable lower density open canopy pine dominated stands while managing vulnerable forest types in strategically placed refugia.

5.1.2 Overarching Strategic Restoration Goals for Forest Vegetation

Overarching restoration goals for forest vegetation are designed to move the current conditions of the affected landscape toward desired conditions considering: 1) the value of spatial and structural heterogeneity of historical conditions; 2) long-term viability of species and forest types; and 3) incorporating adaptive strategies to respond to changing climate and disturbance regimes within the context of landscape restoration of forest vegetation. These overarching restoration goals include:

1. Restore the long-term viability of appropriate forest types and reduce the potential for vegetation type conversion.
    a. Reforest high severity fire areas to establish appropriate proportions and cover of forest cover per the National Forest Management Act (1976).

   b. Provide for a long-term seed source of desired species
   c. Promote the establishment, growth, and development of early seral conditions into mid seral conditions.

2. Restore landscape heterogeneity in terms of spatial and temporal variability, forest type and species diversity, and forest seral stages and structure.
   a. Promote a diversity of forest types, seral stages, and canopy densities with a preference toward open canopy stands which may be better adapted to drier climates and more active fire regimes.
   b. Enhance the development of mid-seral forested stands into later seral stands
   c. Promote open canopy later seral stands dominated by shade intolerant and fire-resistant species in the yellow pine and yellow pine dominated dry mixed conifer forest types
   d. Promote forest structural characteristics that vary according to topographical position, aspect, and precipitation regimes
   e. Retain legacy structures, such as large snags and down woody debris, of ecologically appropriate types (Bull et al. 1997) and in ecologically diverse amounts and distributions across the landscape, rather than homogeneously on every acre.
   f. Account for prescribed fire and natural fire as an essential ecological process
3. Restore the forest landscape to one that is well-adapted to natural disturbance regimes and can respond to changes in climate and disturbance regimes
   a. Promote forested conditions that have increased resistance and resilience to active and potentially higher severity disturbance regimes
   b. Facilitate transitions in species distribution and forest structure so that forest vegetation can better respond to a changing future environments
   c. Re-align forest type, structure, and distribution as necessary and appropriate to increase landscape resilience to a changing future environment.
4. Restoration efforts in early, mid, and late seral forests should balance probability of success, levels of investment, and long term and short term risk to best address the spatial and temporal effects of the Moonlight Fire on the landscape. Prioritize restoration efforts treatments based on proximity to the Moonlight Fire, maximizing probability of success while minimizing risk, providing for long-term protection and maintenance of investments, and ensuring safety for the public, contractors, and Forest Service personnel.

5.1.3 Desired Conditions

A more diverse distribution of seral stages, characterized by heterogeneous stand structures, may be more resilient to disturbance events such as fire, drought, and insect and disease infestations – which have been projected to potentially intensify under a changing climate (Battles et al. 2008, Westerling and Bryant 2008). For pine-dominated mixed-conifer forests, such as those within the Moonlight Fire area, historic reference conditions may be used to "re-align" disrupted forests towards desired conditions (Stephens and Fule 2005, Millar et al. 2007, Collins and Stephens 2010, North et al. 2009, North et al. 2012).

A number of studies examining pre-fire suppression forest structure and subsequent change as a result of management practices and fire suppression have been completed throughout the dry fire-adapted mixed conifer forests of the Sierra Nevada, Southern Cascades, and San Pedro Martir forests of Baja California (summarized in Table 33). These studies have characterized late seral conditions and dynamics in stand structure and species composition through reconstruction analyses. These historic reference conditions of forest vegetation, as discussed in Section 3.2 (Past and Present Vegetation Conditions: Conifer Forest), serve as an appropriate "way-point" target for desired conditions; however, this needs to be adaptively tempered with resiliency, resistance, transition, and re-alignment strategies to increase resilience of the landscape so that the probability of future large scale high severity disturbance is minimized.

Table 33. Estimates of forest structure for pine dominated and mixed conifer forests in California and northern Mexico adapted to an active fire disturbance regime

Study	Study Site	Forest Type	Time period	Trees per Acre[1]	Basal Area (ft^2/acre)[1]	Diameter (in)[1]	Relative Density[2]
Taylor 2004, 2006, & 2007	N. Sierra: Lake Tahoe	JP - Mixed conifer	Pre-fire suppression (ca. 1870-1900)	28 (12 - 46)	111 (55- 166)	26.6 (21.5-33.6)	29%
Taylor (unpub data) in Taylor 2008	Central Sierra: Yosemite Valley	Ponderosa Pine - Black Oak	Pre-fire suppression (unknown)	36 (31 - 38)	95 (39 - 117)	21.9[A]	28%
North et al. 2007	S. Sierra: Teakettle Forest	JP - Mixed conifer	Pre-fire suppression (ca. 1865)	27[B]	225[B]	19.5[B]	18%
Taylor & Scholl 2006 in Taylor 2008	Central Sierra: Yosemite NP	JP - Mixed conifer	Pre-fire suppression (ca. 1899)	54 (4 - 210)	186 (21 - 452)	25.2[A]	53%
Scholl and Taylor 2010	Central Sierra: Yosemite NP	JP - Mixed conifer	Pre-fire suppression (ca. 1899)	65 (16 – 263)	130 (1 – 387)	20.7 (3.2 – 43.6)	46%
Stephens & Gill 2005	N. Mexico: Sierra San Pedro Martir	JP - Mixed conifer	Contemp. Forest with unaltered disturbance	59 (12 - 130)	87 (25 - 221)	12.8 (1.0 - 44.1)	20%

Study	Study Site	Forest Type	Time period	Trees per Acre[1]	Basal Area (ft^2/acre)[1]	Diameter (in)[1]	Relative Density[2]
			regime				
Taylor 2001, Taylor 2010	S. Cascades: Ishi Wilderness	Ponderosa Pine -Black Oak	Contemp. Forest with relatively unaltered disturbance regime [C]	47 (29 - 64)	108 (65 - 142)	20.6 (17.6 - 23.6)	33%

[1] Ranges are provided in parentheses
[2] Calculation of Relative Density is based on a Maximum SDI of 450 from Long and Shaw's Draft Density management diagram for Pine-dominated Sierra mixed conifer Forests. Using a maximum SDI of 450 provides a very liberal estimate of density because relative density = current SDI/ maximum SDI. Using higher values for maximum SDI would produce even lower relative densities.
[A] Mean Diameter was calculated using Trees per acre and Basal area per acre
[B] No range provided.
[C] Skinner and Taylor (2006) discuss the applicability of the Beavery Creek Pinery site in the Ishi Wilderness in Sidebar 10.2 (pages 207-209)

The common theme of nearly all these studies of historical forest conditions, with perhaps the slight exception of Taylor and Scholl (2006), is that the relative density of forested stands with active fire disturbance regimes is on average, very low (20 to 30 percent). It must be recognized that the pre-fire suppression data may not accurately capture the number of smaller trees as these stumps may have deteriorated and become undetectable when the study was performed. Consequently, historic stand densities (represented by measures such as trees per acre, basal area per acre, and relative density) may be slightly higher in these instances. However, it would take a large number of small trees to substantially affect these densities and such densities are not supported by data from historical observations (Lieberg 1902) or studies of contemporary forests adapted to active fire disturbance regimes (Stephens and Gill 2005, Taylor 2001, Taylor 2010).

While these reference forests are characterized by low relative densities and generally larger diameter trees, it should also be noted that these studies recognize and emphasize the heterogeneity of forest structure within active fire disturbance regimes (Stephens and Fule 2005, Stephens and Gill 2005, North et al. 2007, and Taylor 2007, Scholl and Taylor 2010). This is evidenced by the wide ranges reported in the abovementioned studies on reference conditions. It is important to incorporate this heterogeneity into silvicultural prescriptions that re-align forest structure with more active fire disturbance regimes, while recognizing that, on average, the densities were very low which indicates more open forest canopy structure relative to closed canopy structure. This structural heterogeneity, both at the stand and landscape scales, is thought to contribute to overall forest resilience (Stephens et al. 2010). In contrast, more conservative goals, which trend toward closed canopies in the name of "minimal impact", may not truly meet restoration goals (Fule et at. 2006).

While the 2004 SNFPA ROD provides general desired conditions for land allocations, the conceptual framework for managing and restoring Sierra Nevada forests in North et al. (2009 and 2012) provides tools that can be used to develop more site specific desired conditions. In addition, the bioregional assessments developed by the Region 5 Ecology program provide a useful description of appropriate natural range of variation for various ecological vegetation types. These tools were used to develop a landscape-level desired condition for distribution of Forest types as shown in Figure 39. This desired distribution considers increasing landscape resistance utilizing: historic vegetation types and ranges of dominant species given geographic precipitation and elevation patterns; increasing resiliency by promoting heterogeneity based on aspect and topography; and facilitating transitions and re-alignment strategies by considering anticipated trends from changing climates and increasingly more active fire regimes.

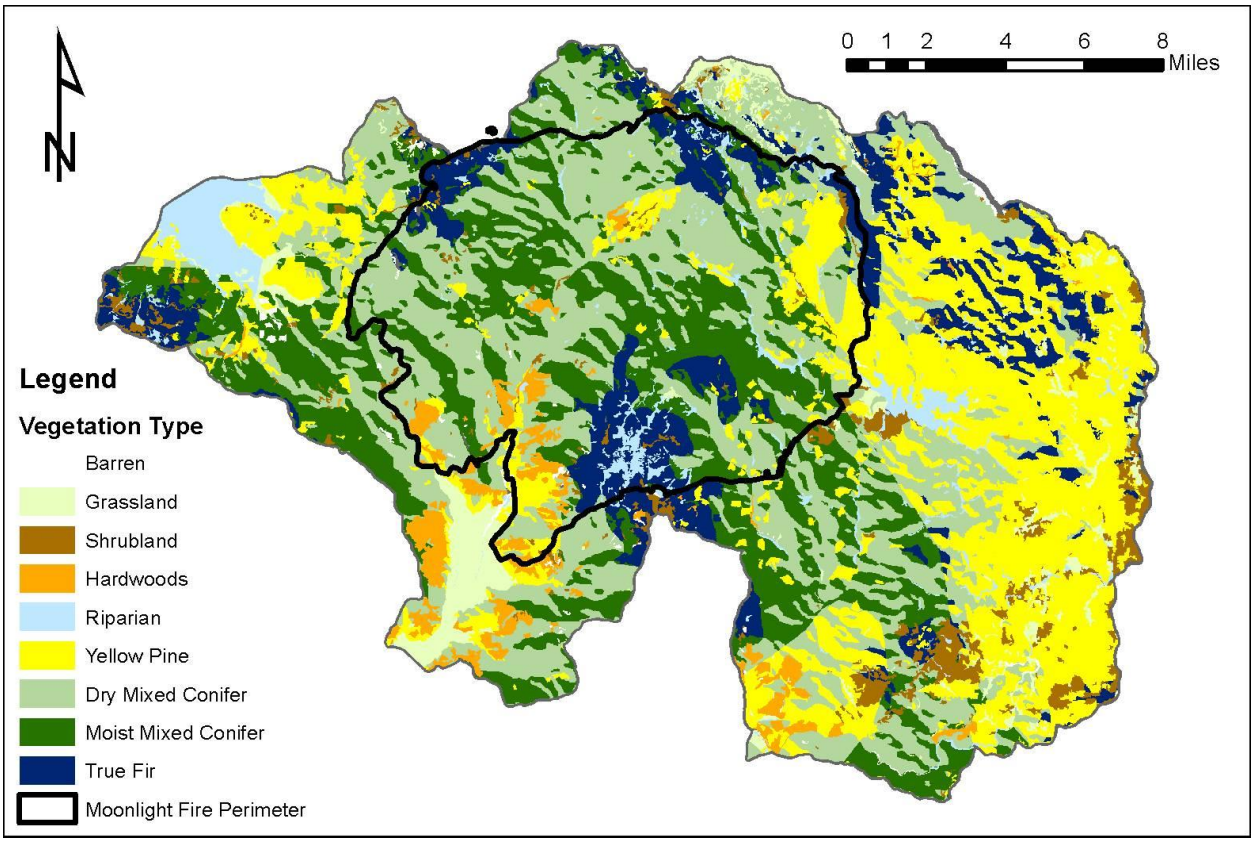

Figure 67. Spatial characterization of desired landscape-level distribution of forest vegetation types. Variables such as topography, aspect, elevation, precipitation, and historic reference conditions were utilized to develop a desired spatial distribution of forest vegetation based on the conceptual framework presented in North 2012. While these desired conditions are displayed as a map, it is intended to serve as a broad landscape-level condition rather than an exact site specific target.

When utilized in conjunction with the seral stage distribution for yellow pine mixed conifer forest types (yellow pine, dry mixed conifer, and moist mixed conifer) as shown in Figure 10 (Safford 2013), the landscape level desired condition is one dominated by later seral open canopy forests, particularly on the south and west facing slopes. Moist mixed conifer stands

with more closed canopies would occur primarily within north and eastern aspects and at generally higher elevations. True fir stands with more closed canopy forest structure would be primarily restricted to the highest elevations with a preference for more mesic northern and easterly aspects.

5.1.4 Restoration Opportunities

Table 34 provides both on-site and off-site restoration opportunities and design tactics by seral stage to move the affected watersheds toward desired condition.

On-site restoration strategies include passive restoration (relying on natural recovery), assisted restoration (assisting the establishment, growth, and development of natural regeneration through application of appropriate silvicultural techniques), and active restoration (through active reforestation and application of silvicultural techniques) (Moreira et al. 2012). For example:

- In early seral stands, active reforestation should be focused on high site quality and easily accessible sites that burned with high severity in order to maximize success in re-establishing forest vegetation and to accelerate growth and development into later seral stages. Access is particularly important because it ensures the efficiency of long-term follow-up cultural treatments such as release for survival and growth, pre-commercial thinning, and pruning which will: a) protect the reforestation investment, b) maximize the growth of the investment, and c) increase the investment resiliency to future disturbances such as fire. Site preparation, fuels reduction, and treatment of competing vegetation should be prioritized for these sites in order to best maximize success of reforestation efforts developing into mid and later seral stands and minimize longer term interim risk of loss to future disturbances.
- Incrementally more passive techniques should be employed on sites that burned with lower fire severity, are of lower quality, or are inaccessible. For example, moderately burned or lower quality sites may benefit from assisted restoration techniques, such as site preparation for natural regeneration or release and pre-commercial thinning techniques to increase growth and development of naturally occurring regeneration. Inaccessible sites may receive a less intensive long-term strategy wherein these sites are planted, then left to develop without the intensive release treatments designed to maximize growth. Due to the inherent challenges on these sites, these efforts may have relatively more uncertainty in success and have relatively more long term risk in terms of losses to future disturbance events – particularly in areas with higher fuel accumulations or slope and topography alignment.
- On-site restoration strategies also include treating mid seral stands to accelerate growth and development into later seral stands in order to replace those that were converted to non-forest vegetation as a result of the fire. These treatments should be designed to increase resistance and resiliency of these stands to future disturbances (such as fire,

insects, disease, and climate change) so as to not sustain any further losses within the landscape.

- Similarly, later seral stands within the fire perimeter should receive fuel reduction and timber stand improvement treatments; these would be designed to increase resistance and resilience to future disturbances in order to mitigate any future adverse cumulative effects to forest vegetation within the affected landscape. These restoration efforts are particularly important because very few mid to late seral stand remain within the fire perimeter.

Off-site restoration includes the same passive, assisted, and active restoration activities as on-site restoration but occurs outside of the Moonlight Fire within the affected watersheds. As discussed in Section 3.2 (Past and Present Vegetation Conditions: Conifer Forest), the Moonlight Fire contributed to both direct, indirect, and cumulative adverse effects, particularly with regards to loss of later seral forest vegetation within the affected landscape. While entirely appropriate, active reforestation and silvicultural techniques, designed to accelerate the establishment, growth, and development of forest vegetation within the fire, have limited capacity to mitigate the temporal and spatial cumulative effects of the fire. **Simply put, the trees that are planted today will take at least a century, if not more, to mature (Figure 17); during this time period, these early seral stages are susceptible to fire and changing climatic conditions. This significantly impedes restoration of the occurrence, distribution, and structure of mid to later seral forests on the landscape. In these cases, it is ecologically appropriate to substitute "space for time" and to identify off-site restoration opportunities outside of the Moonlight Fire, but within the affected watersheds (landscape).** For example:

- Active reforestation and silvicultural techniques to accelerate the establishment, growth, and development of forested stands on high quality sites with reasonable access outside the fire would facilitate, maximize, and protect long-term reforestation investments within the affected landscape. These treatments would offset the lower success and growth rates of reforestation on lower quality or inaccessible sites within the Moonlight Fire. In addition, since a homogenous distribution of plantations may likely be more susceptible to loss from large fire events, this tactic could effectively spread this risk by creating a mosaic of dispersed plantations across the landscape thereby promoting heterogeneity.
- Applying silvicultural techniques to accelerate growth and development of already established plantations and mid seral stands outside the fire would mitigate the length of time it would take to restore an ecologically appropriate component of later seral stands within the affected watersheds. For example, plantations such as those established after the 1981 Elephant fire already have a 30 year "head start" in terms of growth and development into mid and later seral stands. Release for growth and fuels treatments in existing plantation and mid seral stands increases their resistance to future disturbances and provide for faster recruitment of mid and late seral stands on the landscape.

- Applying silvicultural techniques to reduce stand density, restore appropriate forest structure, and improve forest health in mid to later seral stands outside the fire would increase resistance and resilience of these forested stands to further losses as a result of potential high severity disturbance within the affected watersheds. Due to the uncertainty of future change and disturbance, such off site restoration investments that protect/restore later seral forest within the affected watersheds would likely have much less risk and higher return in comparison to active reforestation within the fire which must withstand 100 years plus of uncertainty before nearing desired conditions. Such off site restoration investments would also mitigate the adverse temporal cumulative effects that the Moonlight Fire had, particularly on the occurrence and distribution of later seral forests within the affected watersheds.

To best address the spatial and temporal effects of the Moonlight fire on the landscape, on-site and off-site restoration efforts should balance the probability of success with the level of investment and short and long term risk. Efforts should be prioritized based on proximity to the Moonlight Fire, as well as effectiveness (i.e. maximizing probability of success while minimizing risk and providing for long-term protection and maintenance of investments), and ensuring safety for the public, contractors, and Forest Service personnel.

In terms of effectiveness, a comprehensive restoration strategy should consider a suite of treatments that diversifies risk and timely achievement of desired conditions. For example, reforestation efforts designed to establish early seral stands assume a higher risk given future environmental stressors and may have long range returns due to the time needed to meet mid to late seral desired conditions. Timber stand improvement efforts in existing plantations and mid seral stands assumes less risk and provides more mid and short range returns to accelerate the recruitment and development of mid to late seral forest stands. Fuels reduction and forest restoration efforts in late seral stands have the least amount of risk and the most immediate benefits in terms of maintaining, enhancing, and protecting remnant late seral stands on the landscape. Both on-site and off-site restoration efforts should balance these respective levels of risk and returns.

With regards to safety, many stands that burned with high severity were never salvaged. Existing conditions within these stands are dangerous to contractors and employees due to large amounts of snags in various stages of decay. Falling tops and limbs pose a serious safety hazard to field going personnel. Depending on the quantity, size, and decay state of these snags, abatement of this hazard may be both necessary and feasible using ground-based equipment or trained fallers. However, sites with steep slopes, >50 foot tall snags, and/or too many trees may not be realistically treated. Since these hazards cannot be readily abated on these sites, it may be best delay treatment until these snags naturally fall, at least in part. As with all activities, exposure to such hazards needs to be managed responsibly and therefore needs to be considered in prioritizing restoration efforts (Forest Service Manual 6714).

Table 34. On-Site and off-site restoration opportunities and design tactics to meet overarching restoration goals and desired conditions by seral stage.

		Design Tactics to achieve Strategic Overarching Restoration Goals and Desired Conditions for Forest Vegetation
On-site and Off-site Restoration Opportunities	**Early Seral**	Focus more active and intensive reforestation efforts on moderate to high site quality lands that 1) historically sustained forest vegetation, 2) burned with moderate to high severity, and 3) have reasonable access and infrastructure for long-term maintenance of investments. These areas should be prioritized for site preparation for both natural and artificial regeneration, reforestation, and follow-up cultural treatments such as release for survival and growth, and pre-commercial thinning. The size and scale of these treatments should vary from small patch sizes (i.e. "founder stands") to larger strategically placed plantations. Treatments should focus on successful establishment and enhanced growth of early seral stages of conifer forest. This should include treatments to enhance survival and maximize growth by reducing competing vegetation – this could include consideration of herbicide use. Focus release for survival and release for growth on existing plantations within and outside of the Moonlight Fire to accelerate the growth and development of early seral stands into mid seral stands. This should include treating fuels within these plantations to reduce their susceptibility to future fire effects within the affected watersheds.
		A combination of active and passive reforestation techniques on moderate to high site quality lands that 1) historically sustained ecologically appropriate forest types, 2) burned with moderate to high severity, and/or 3) are relatively inaccessible or lack infrastructure. The size, scale, and intensity of these treatments should be strategically designed in terms of location, proportion, and long-term maintenance utilizing tactics such as "founder stands" or site preparation for natural regeneration. Treatments should emphasize long-term development of seed sources for desired shade intolerant species
		Prioritize more passive management techniques on lower site quality lands that 1) are within the Moonlight Fire, 2) may not have historically sustained forest types (i.e. ridge top locations), 3) are relatively inaccessible and lack infrastructure, and/or 4) have relatively lower probability for success or higher risk (i.e. sites with very rocky or shallow soils, areas with high snag/safety issues). These passive management techniques could include site preparation for natural regeneration, certification of natural regeneration or designated natural recovery.
	Mid seral	Focus silvicultural efforts to improve forest health, reduce fuels, and accelerate growth and development into later seral stages in existing plantations and mid seral stands (best characterized by CWHR size classes 3 and 4) that either a) burned with low to moderate fire severity or b) were not burned. Prescriptions should be designed to reduce stand density (Blackwell 2004) and to promote open-canopy stands in order to a) reduce competition, b) increase resilience to disturbances (fire, insects and disease), and c) accelerate growth and development into subsequent size classes; for example, promoting CWHR 3 to CWHR4, or CWHR4 to CWHR 5. Appropriate management activities include release for growth, pre-commercial thinning, intermediate commercial thinning to reduce stand density and improve growth and yield. The size, scale, and intensity of these treatments should be strategically designed in terms of location, proportion, and long-term maintenance utilizing prescribed and natural fire. Off-site restoration treatments should be strategically designed to modify landscape level fire behavior, provide options for fire management tactics, and provide greater protection of restoration investments.
	Later Seral	Focus silvicultural efforts on intermediate treatments to improve/promote/enhance/maintain the growth, health, and long-term viability of surviving "green" stands that burned with low to moderate fire severity or those that did not burn at all. Treatments should promote the development/maintenance of later seral open canopy stands dominated by pine species (for example: CWHR 5P) that are resilient to fire. Prescriptions should be designed to maintain/enhance heterogeneity at multiple scales, reduce stand density (Blackwell 2004) and to promote open-canopy stands in order to a) reduce competition and b) increase resilience to disturbances (drought, fire, insects and disease).The size, scale, and intensity of these treatments should be strategically designed in terms of location, proportion, and long-term maintenance utilizing prescribed and natural fire.

5.2 Hardwood Forest Vegetation Desired Conditions, Goals, and Objectives

5.2.1 Desired Conditions

The desired condition for hardwood forests in the analysis area is to promote and maintain these important communities, including diverse understory species comprised of native perennial grasses, forbs and shrubs. Hardwoods provide important habitat for diverse communities of plants and animals, including over 300 vertebrate wildlife species, more than 2,000 plant species, and an estimated 5,000 species of insects (Allen-Diaz et al. 2007). California spotted owls depend on hardwood forests for nesting, foraging, and cover. The presence of California black oak and other hardwoods has been found to increase habitat quality for fishers in mixed-conifer forests (Zielinski et al. 2004). Hardwood forests also provide downed woody debris and snags critical for many other species of wildlife, including reptiles, amphibians, and insects. Oak species are susceptible to stem rot, which creates large cavities in the tree bole that are used for nesting by many bird and mammal species (Motroni et al. 1991). Hardwood tree cavities filled with rainwater or detritus provide habitat for unique invertebrate communities, some of which are entirely restricted to these cavities during a portion of their life cycle.

5.2.2 Goals

As described in the *Sierra Nevada Forest Plan Amendment* (SNFPA) *Record of Decision* (ROD, USDA 2004, p. 35), goals for hardwood forests include maintaining and restoring:

- A diversity of structural and seral conditions in landscapes in proportions that are ecologically sustainable at the watershed scale;
- Sufficient regeneration and recruitment of young hardwood trees to replace mortality of older trees over time; and
- Sufficient quality and quantity of hardwood ecosystems to provide important habitat elements for wildlife and native plant species.

5.2.3 Objectives

Objectives for montane hardwood forests described in the SNFPA ROD (USDA 2004, pp. 53-55) include:

- Where possible, create openings around existing California black oak and canyon live oak to stimulate natural regeneration;
- Manage hardwood ecosystems for a diversity of hardwood tree size classes within a stand such that seedlings, saplings, and pole-sized trees are sufficiently abundant to replace large trees that die;
- Retain the mix of mast-producing species where they exist within a stand;

- During mechanical vegetation treatments, prescribed fire, and salvage operations, retain all large hardwoods on the westside except where: (1) large trees pose an immediate threat to human life or property or (2) losses of large trees are incurred due to prescribed or wildland fire; large montane hardwoods are trees with a DBH of 12 inches or greater. Allow removal of larger hardwood trees (up to 20 inches DBH) if research supports the need to remove larger trees to maintain and enhance the hardwood stand;
- Prior to commercial and noncommercial hardwood and fuelwood removal in hardwood ecosystems, pre-mark or pre-cut hardwood trees to ensure that stand goals are met. Retain a diverse distribution of stand cover classes;
- During or prior to landscape analysis, spatially determine distributions of existing and potential natural hardwood ecosystems (Forest Service Handbook (FSH) 2090.11). Assume pre-1850 disturbance levels for potential natural community distribution. Work with province ecologists or other qualified personnel to map and/or model hardwood ecosystems at a landscape scale (approximately 30,000 to 50,000 acres). Include the following steps in the analysis: (1) compare distributions of potential natural hardwood ecosystems with existing hardwood ecosystems; (2) identify locations where existing hardwood ecosystems are outside the natural range of variability for potential natural hardwood ecosystem distribution; and (3) identify hardwood restoration and enhancement projects.
- Include hardwoods in stand examinations. Encourage hardwoods in plantations. Promote hardwoods after stand-replacing events. Retain buffers around existing hardwood trees by not planting conifers within 20 feet of the edge of hardwood tree crowns; and
- To protect hardwood regeneration in grazing allotments, allow livestock browse on no more than 20 percent of annual growth of hardwood seedlings and advanced regeneration. Modify grazing plans if hardwood regeneration and recruitment needs are not being met.

Additional objectives include:

- Implement treatments in hardwood communities that currently have excessive conifer or fuel loads to make them more resilient to future fires;
- Survey the analysis area to evaluate current conditions of hardwood stands and prioritize sites for restoration;
- Where necessary, implement treatments (i.e. prescribed fire, thinning) to promote and maintain hardwood species;
- Monitor the effectiveness of restoration treatments in hardwood stands; and
- Monitor selected hardwood stands to assess their status and trend over time.

5.3 Montane and Mixed Chaparral Desired Conditions, Goals, and Objectives

5.3.1 Desired Conditions

Desired conditions for montane and mixed chaparral are to maintain these important vegetation types on the landscape at the appropriate extent and patch size to contribute to landscape heterogeneity, biodiversity, and soil nutrients, without precluding succession to forest vegetation on appropriate sites. A number of wildlife species are also dependent on mixed and montane chaparral, particularly deer populations that rely on this vegetation type for their summer and winter range. Mixed and montane chaparral is also important for a number of shrub dependent Sierra Nevada birds (Humple and Burnett 2010). Many chaparral species fix nitrogen, providing critical inputs of a limiting nutrient to the soil.

5.3.2 Goals and Objectives

The following goals and objectives for montane and mixed chaparral were developed based on recommendations by North and others (2009) and Burnett and others (2011):

- Maintain montane and mixed chaparral on sites where edaphic conditions preclude the establishment of other species.
- Promote a range of size and age classes of montane and mixed chaparral, including young shrubs that provide high forage value to wildlife.
- Manage shrublands as a mosaic of species, seral stages, patch sizes, and densities based on natural topography and fire regimes. Utilize the principles behind both GTR-220 and GTR-237 (North et al. 2009, North 2012) to support the management of forested and montane and mixed chaparral communities using topographic variability. For example, retain higher cover of montane and mixed chaparral on sites where fire severity is typically high, including ridge lines and upper slope positions.
- Promote patch size distributions of montane and mixed chaparral that maximizes landscape heterogeneity, species diversity, wildlife habitat and nutrient cycling, while minimizing the likelihood of widespread, permanent type conversion on sites that would be in dynamic equilibrium with forest dominated vegetation under an active fire regime.
- Manage the Moonlight Fire landscape to create a diverse and abundant understory plant community that includes montane and mixed chaparral shrub species; wherever possible consider clustering thinning treatments to increase plant diversity and shrub cover in forest understories (North et al. 2005b).
- In unburned conifer stands, create gaps where a high-light environment will favor both regeneration of shade-intolerant trees and shrubs (North et al. 2009). Reduce competing shrubs around individual trees in plantations while still maintaining a shrub component across the larger landscape.
- In ecologically appropriate sites, consider retention of dense patches when mechanically treating shrub habitats. In highly decadent shrub habitats consider burning or masticating

half of the area (in patches) in one year and burning the rest in the following years once fuel loads have been reduced (Burnett el al. 2011).

- Where patches are retained, consider making them at least 10 acres in size; shrub cover should average over 50 percent across the area in order to support sensitive species such as the fox sparrow (Burnett el al. 2011).
- Maximize the use of prescribed fire to create and maintain chaparral habitat and consider a natural fire regime interval of 20 years as the targeted re-entry rotation for creating disturbance in these habitat types (Burnett el al. 2011).

5.4 Meadow, Fen, Aspen and Riparian Vegetation Desired Conditions, Goals, and Objectives

5.4.1 Desired conditions

5.4.1.1 Meadows and riparian areas

Desired conditions for meadows and riparian areas are described in the SNFPA Record of Decision (USDA 2004, pp. 42-43) as follows:

- Habitat supports viable populations of native and desired non-native plant, invertebrate, and vertebrate riparian and aquatic-dependent species.
- Species composition and structural diversity of plant and animal communities in riparian areas, wetlands, and meadows provide desired habitat conditions and ecological functions.
- The distribution and health of biotic communities in special aquatic habitats (such as springs, seeps, vernal pools, fens, bogs, and marshes) perpetuates their unique functions and biological diversity.
- Spatial and temporal connectivity for riparian and aquatic-dependent species within and between watersheds provides physically, chemically and biologically unobstructed movement for their survival, migration and reproduction.
- The connections of floodplains, channels, and water tables distribute flood flows and sustain diverse habitats.
- Soils with favorable infiltration characteristics and diverse vegetative cover absorb and filter precipitation and sustain favorable conditions of stream flows.
- In-stream flows are sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats and keep sediment regimes as close as possible to those with which aquatic and riparian biota evolved.
- The physical structure and condition of stream banks and shorelines minimizes erosion and sustains desired habitat diversity.

- The ecological status of meadow vegetation is 50 percent or more of the relative cover of the herbaceous layer with high similarity to the potential natural community. A diversity of age classes of hardwood shrubs is present and regeneration is occurring.
- Meadows are hydrologically functional. Sites of accelerated erosion, such as gullies and headcuts are stabilized or recovering. Vegetation roots occur throughout the available soil profile. Meadows with perennial and intermittent streams have the following characteristics: (1) stream energy from high flows is dissipated, reducing erosion and improving water quality, (2) streams filter sediment and capture bedload, aiding floodplain development, (3) meadow conditions enhance floodwater retention and groundwater recharge, and (4) root masses stabilize stream banks against cutting action.

5.4.1.2 Aspen

The following desired conditions for aspen were developed by Campbell and Bartos (2001). They describe that aspen stands in a properly functioning condition will generally have multi-aged stems in the stand, adequate regeneration to perpetuate the stand, age classes of mostly less than 100 years old, and diverse, productive understory plant communities. Healthy aspen stands will have both compositional and structural diversity. Specifically, desired conditions for most types of aspen stands will include:

- Conifer cover (understory and overstory) of less than 25 percent;
- Aspen canopy cover greater than 40 percent;
- Dominant aspen trees less than 100 years old;
- Aspen regeneration (stems 5 to 15 feet tall) of more than 500 stems per acre; and
- Sagebrush cover of less than 10 percent.

5.4.1.3 Fens

Desired conditions for fens were developed from Weixelman and Cooper (2008). Fens that are functioning properly have the following characteristics:

- Perennially high water table and saturated soils that limit decomposition rates;
- Natural surface and subsurface flow patterns that are not significantly affected by disturbance;
- Sufficiently low soil temperatures that limit microbial activity and low organic matter decomposition rates resulting in low CO^2 emissions;
- Good cover of native, non-invader vegetation over the peat body with little exposed peat;
- High proportion of peat-forming plant species; and

- Fen is in balance with the water and sediment being supplied by the watershed (i.e. no excessive erosion or deposition).

5.4.2 Goals

- Ensure that grazing management is contributing to desired conditions.
- Maintain and restore healthy riparian areas to protect water quality and protect stream banks from accelerated erosion (USDA 2004, p. 32).
- Maintain and restore habitat for riparian and meadow associated species, especially for rarer habitats such as springs and fens (USDA 2004, p.32).
- Promote fire resilience in riparian areas and aspen stands.
- Maintain meadows and fens in a properly functioning condition (Weixelman and Cooper 2008, Weixelman and Zamudio 2001).
- Protect aspen stands from conifer encroachment.
- Protect aspen sprouts from excessive browsing.

5.4.3 Objectives

- Conduct surveys to evaluate the current condition of meadows, fens, and aspen stands within the analysis area; this includes an assessment of grazing effects, hydrologic condition, and extent of conifer encroachment. Identify and prioritize sites for restoration.
- Evaluate riparian condition throughout the analysis area, including areas identified as potentially at-risk such as Upper Indian Creek, Boulder Creek, Lone Rock Creek, and parts of Lights Creek. Identify and prioritize sites for restoration.
- Conduct an assessment of the proper functioning condition of the Lowe Flat fen complex.
- Maintain and restore the hydrology of riparian areas, meadows, and fens. Potential restoration activities include headcut mitigation, culvert replacement, channel realignment, check dam installation, pond and plug type projects, and road improvement, decommissioning, or realignment.
- Implement stream and riparian restoration projects in areas that have been identified in the Hungry Creek, West Branch Lights Creek, and East Branch Lights Creek watersheds. Identify additional restoration opportunities through surveys.
- Determine if management practices such as water source construction or fencing is needed to protect sensitive areas from grazing impacts. For example, fencing may be needed to successfully recruit the next cohort of aspen or to restore fen or meadow hydrology.

- Remove encroaching conifers to restore and enhance riparian areas, meadows, fens, and aspen stands. Treatments may include commercial or hand-thinning of conifers greater than 12”DBH, and hand-piling and burning of surface fuels. Implement projects to remove conifers from aspen stands identified at Peters Creek, Taylor Lake, Hungry Creek, upper Middle Creek, upper Cold Stream, Lower Lone Rock Valley, Willow Creek, Upper Indian Creek, and West Branch Lights Creek (K. Gardiner, personal communication). Conduct surveys to identify additional opportunities for conifer removal in the analysis area.
- Treat fuels in riparian areas and aspen stands to increase their resilience to future fires.
- Implement best management practices during all restoration activities. Special design features may be required in some areas.
- Monitor restoration treatments to evaluate their success.
- Monitor meadow, fen, aspen and riparian areas to assess the status and trend of these habitats.

5.5 Unique Botanical Resources Desired Conditions, Goals, and Objectives

5.5.1 Rare plant species

5.5.1.1 Desired conditions

The desired condition for the Moonlight Fire area is to have large, genetically diverse populations of rare plant species that are capable of withstanding impacts from future disturbance events. At a broad scale, rare plants occur within resilient, robust, and diverse native plant communities.

5.5.1.2 Goals and Objectives

The Plumas NF LRMP (USDA 1988a) and *Sierra Nevada Forest Plan Amendment* (2004) outline standards and guidelines for rare plant species that include:

- protect Sensitive and Special Interest plant species as needed to maintain viability;
- inventory and monitor Sensitive plant populations on an individual project basis; and
- develop species management guidelines to identify population goals and compatible management activities / prescriptions that will maintain viability.

In addition to these, the following goals and objectives were developed for rare species and native plant communities within the Moonlight Fire:

- Consider the ecological requirements of existing or potentially occurring rare plant species when designing and implementing habitat restoration activities, such as vegetation manipulation or removal of invasive species;

- Develop and implement restoration projects that improve the resilience of rare plant habitats and native plant communities.
- Where appropriate, encourage the natural expansion of rare plant populations; for example, eradicate or control invasive species to reduce negative impacts to native vegetation.
- Continue to build the native plant materials program so that local native seed and plants are available for restoration projects

5.5.2 Baker cypress

5.5.2.1 Desired conditions

Desired conditions, goals, and objectives for Baker cypress are described in the *Plumas NF Land and Resource Management Plan* (USDA 1988a, page 4-289) and the Mud Lake Research Natural Area Management Plan (USDA 2006b, page 2). These documents emphasize the need to protect, enhance, and maintain the long-term viability of Baker cypress. A secondary objective listed in the Plumas NF LRMP is to provide interpretation services for the public within the MLRNA.

The short-term desired condition for Baker cypress at the Mud Lake unit of the MLRNA is a population that is allowed to mature in an environment where the risk of subsequent fires is minimized. The long-term desired condition for Baker cypress in the Mud Lake unit is a mature, healthy population with sufficient seed storage to regenerate after a fire. Once the stand is mature, the desired condition is to allow high severity fire to regenerate the population before shade tolerant conifers can dominate the stand.

The desired condition for the Wheeler Peak unit is a healthy population that is free from competition from other conifer species and available to benefit from high severity fire without the threat of fire suppression.

5.5.2.2 Goals and Objectives

In order to preserve the Baker cypress populations within the analysis area, the following goals and objectives have been developed for this restoration strategy:

1. Fire suppression is recommended at the Mud Lake unit until Baker cypress trees are able to mature and develop a canopy seed bank. Sufficient canopy seed storage will not likely occur until the stand is between 35 and 50 years old.
2. To reduce the risk of fire eliminating the Mud Lake stand, strategic fuel treatments should be implemented around the population.
3. Seed banking of cones from remaining adult trees in the MLRNA should be conducted to preserve the genetic composition of these populations and to provide a source of seed

for reintroduction efforts should one or both of the populations be extirpated by another fire.

4. Fire suppression is not recommended for the Wheeler Peak unit, where older trees likely have sufficient seed storage to regenerate the population.
5. Selective thinning of the Wheeler Peak population, particularly on lower slopes where Baker cypress is suppressed by other conifer species, could help promote the health and cone production of this stand. Although outside of the Moonlight Fire, the Wheeler Peak unit contains the only other Baker cypress population in this geographically isolated portion of the species range.
6. Continued monitoring of these populations is necessary to identify the need for and/or opportunities for additional management and restoration activities.
7. Create interpretive materials to educate the public about the ecology and importance of Baker cypress.

5.6 Invasive Species Desired Conditions, Goals, and Objectives

The desired condition for the Moonlight Fire area is a diverse and resilient native plant community free of invasive plant species. Within and adjacent to the fire, new introductions of invasive plants are prevented, new infestations are rapidly treated, and established infestations are contained and controlled where they threaten wildland values or pose a high risk of spread to uninfested areas. To achieve this desired condition, the Forest Service must develop the flexibility to adapt to changing conditions and respond rapidly to invasive plant threats that may be currently unknown. Aquatic invasive species desired conditions, goals and objectives are presented in Section 5.9.2.

5.6.1 Goals and Objectives

The primary goal is to mitigate the potential impacts of invasive plant species in the Moonlight Fire area by providing an integrated approach to management. This approach has five areas of emphasis: (1) education and collaboration; (2) prevention of conditions that favor invasive plant introduction and spread; (3) early detection of new infestations; (4) implementation of site-specific treatments to eradicate, contain, or control infestations; and (5) monitoring and adaptive management to continually improve treatment effectiveness. Detailed goals and objectives are as follows:

1. <u>Education and Collaboration</u>
    - Educate the workforce and the public to help identify, report, and prevent the introduction and spread of invasive species.
    - Collaborate with the County Noxious Weed Working Group, adjacent landowners, forest user groups, and other external partners to coordinate invasive species prevention and control efforts within and adjacent to the Moonlight Fire area.

- Encourage research and monitoring activities that address invasive species control and management.

2. Prevention

   - Implement appropriate prevention practices to help reduce the introduction, establishment, and spread of invasive species within the Moonlight Fire area.
   - Prevent new weed infestations and the spread of existing weeds by avoiding or removing sources of weed seed and propagules.
   - Improve the effectiveness of prevention practices through weed awareness and education.

3. Early Detection

   - Detect new infestations of invasive species promptly by creating and maintaining complete, up-to-date inventories of infested areas, and proactively identifying and inspecting susceptible areas that are not infested.

4. Treatment

   - Establish treatment protocols that will allow for adaptive management of known infestations and evaluation and prioritization of expanding and newly introduced invasive plant infestations for treatment
   - Prioritize known invasive plant infestations for treatment using the criteria provided in Table 35.
   - Use an integrated approach to treat invasive plant infestations. Use the best available information to select the most effective combination of treatment methods, including manual, cultural, chemical, and biological controls.
   - Control new infestations promptly. Where control is not feasible, suppress or contain expansion of infestations. Refer to Table 36 for species-specific management goals.
   - Protect human health and critical ecosystem functions, such as water quality and threatened, endangered, and sensitive species during invasive plant treatment.
   - Build the capacity to treat currently unidentified invasive plant infestations.

5. Monitoring

   - Assess the efficacy of control treatments. Conduct follow-up inspection of treated sites to prevent reestablishment.
   - If prevention and treatment strategies are failing to meet objectives, re-evaluate these strategies and alternatives to better meet objectives in a cost-effective manner.

Table 35. Prioritization for treating invasive plant infestations in the Moonlight Fire analysis area

Priority	Description
1	Eradicate: • Newly discovered species • Species with very few isolated infestations • Any infestations that occur in the Mud Lake Research Natural Area

2	Control or eradicate:
	• Fast-growing species that:
	  ○ Impact high value resources
	  ○ Are relatively isolated from other infestations; OR
	  ○ Occur along spread vectors, such as roads, campgrounds, trailheads, administrative facilities, gravel pits, parking lots

3	Eradicate: small, isolated infestations of slow-growing species Control: fast-growing species that are rapidly expanding

4	Control:
	• Large infestations that:
	  ○ Are adjacent to other large infestations
	  ○ Occur in highly disturbed areas
	  ○ Do not occur along spread vectors
	  ○ Are not rapidly spreading
	• Species for which available technology has not proven effective

5	Contain: species of very wide distribution where control or eradication is not deemed feasible

Table 36. Current management goals for known infestations on NFS lands within the analysis area

Species	Management Goal[1]	Total # of locations	Total Acres
barbed goatgrass	eradicate	1	0.74
Canada thistle	contain	643	146.18
Dyer's woad	eradicate	2	3.73
medusahead	control	42	38.94
Russian thistle	eradicate	2	0.07
Scotch broom	eradicate	7	2.03
spotted knapweed	eradicate	7	0.03
yellow starthistle	control	52	47.84

[1] This strategy uses the following definitions (taken from USDA 2005): *Eradicate*: Attempt to totally eliminate an invasive plant species, recognizing that this may not actually be achieved in the short-term since re-establishment/re-invasion may take place initially; *Control*: Reduce the infestation over time; some level of infestation may be acceptable; *Contain*: Prevent spread of the weed beyond the current perimeter of infested areas.

5.7 Fire and Fuels Desired Conditions, Goals, and Objectives

5.7.1 Desired Conditions

- Establish a landscape-scale system of fuels treatments that function to slow fire spread and reduce fire intensity with an emphasis on protecting plantation investments.
- Establish fuel treatments in remnant conifer stand and historic plantations that reduce surface and ladder fuels and maintain large fire resilient trees.
- Establish fuel treatments that are integrated with protecting and promoting the development of old forest ecosystems.

5.7.2 Goals and Objectives

- Establish baseline current conditions of fuels and vegetation by collecting data from inside the Moonlight Fire perimeter.
- Restore frequent low to moderate severity fire as an ecological process within the Moonlight Fire footprint in appropriate vegetation types.
- Reduce dead fuel loading and ladder fuels to a level that would not sustain a crown fire during 90 percent weather conditions (an average flame length less than four feet) in order to reduce the threat of wildland fire (except for types that require crown fires, i.e., cypress, and aspen).
- Identify fuels reduction opportunities within the 12,750 acres of plantations established after the Moonlight Fire. Protect plantation trees from future wildfire through the use of herbicide, mechanical or hand treatments, and prescribed burning such that some form of replacement habitat may develop over the next two to four hundred years.
- Identify fuels reduction opportunities within the 23,118 acres that burned with less than 50 percent basal area mortality in order to protect remnant conifer stands.
- Identify fuels reduction opportunities within the 57,418 acres that burned with greater than 50 percent basal area mortality in order reduce heavy dead and down fuel accumulations associated with many post-fire environments.
- Identify fuels reduction opportunities that would protect Backer cypress until trees are mature enough to produce serotinous cones.

5.8 Wildlife Habitat Desired Conditions, Goals, and Objectives

5.8.1 Late Seral Forest and Associated Species (spotted owl, northern goshawk and mesocarnivores)

5.8.1.1 Desired Conditions

Create a more fire resilient forest both within the fire footprints, as well as in adjacent habitat. Desired conditions for old forest and general forest areas (SNFPA, USDA 2004, p. 48) include

high levels of horizontal and vertical diversity; trees of varied sizes, ages, and species composition; and enough dead trees, standing and fallen, to meet habitat needs of old forest associated species, while allowing for successful establishment of early-seral stage vegetation.

Areas treated with thinning and surface fuel and ladder fuel treatments have been shown to experience the lower vegetation mortality and retain more forest habitat ecologically suitable for wildlife post fire compared to areas that were not treated. Desired conditions are for at least 50 percent of the late-successional habitat acreage to be in low fire severity condition and no more than 25 percent to be in the moderate to high severity conditions.

Restoration efforts should identify resource selection by sensitive bat species (in late seral habitats and others) and use this information to direct restoration activities within the fire footprints and across the analysis area.

5.8.1.2 Goals

- Maintain an abundance of late seral forest habitat types to provide for viable wildlife populations.
- In late seral forests, maintain: vertical and horizontal structural diversity; at least two tree canopy layers with dominant and co-dominant trees in the canopy averaging at least 24 inches in DBH with at least 70 percent total canopy cover; higher than average levels of very large old trees; and higher than average levels of snags and downed woody material (USDA 2001).

Copious amounts of late seral habitat were lost during the Moonlight and Antelope Complex fires. Restoring late seral habitat on the scale at which it was lost is not feasible within the Moonlight Fire footprint in a reasonable period of time. Due to the length of time necessary for late seral forests to develop, it makes sense to protect and restore similar habitats on lands adjacent to the fire footprint. Further, it is prudent to facilitate development of late seral forest habitats in adjacent areas, as many mid seral forest patches within fire footprints will not develop late seral habitat conditions within a 50, or even 100, year time span. Because management actions taken to restore late seral forests within the fire footprints would take 80 – 150 years, areas with potential to develop late seral habitat that are adjacent to the fire footprint should be managed to compensate for the losses suffered within the fire footprint. Dense forests adjacent to the Moonlight and Antelope complex fire footprints offer tremendous opportunities to invest in stand development for the protection and production of wildlife habitat. Managing for late seral forest development in adjacent lands would help compensate for the tremendous amount of late seral habitat loss that occurred during the Moonlight and Antelope Complex fires.

Due to substantial loss of late successional habitat within the fire footprints, it is critical to maintain the sparse late seral forest habitat remaining within the fire footprints, as well as improve fire resiliency within late seral forest stands to improve the likelihood of short- (next decade) and long-term (into the next century) persistence. Concomitantly, and equally

important, late seral forests in watersheds impacted by the fires (i.e., analysis area), but falling outside fire footprints, should be treated to increase stand resiliency to future wildfires.

5.8.1.3 Objectives

The Moonlight and Antelope Complex fires resulted in long-term habitat loss and fragmentation that will impede dispersal into, use, and occupancy of this area by late seral forest species (e.g., spotted owls, goshawks, mesocarnivores). It is critical to maintain remaining late seral forest habitats adjacent to the fire footprint, and improve late seral forest resiliency to future wildlife events.

Currently only 25 percent of the acres within spotted owl habitat would burn at low severity fire under moderate fire weather conditions within the analysis area (see Table 16,Figure 45). Treat this habitat to achieve a minimum of 50 percent of acres within PACs and HRCAs to withstand wildfires (i.e., burn at low to moderate severity). Monitoring of indirect effects of these treatments will be critical to understand how owls are able to withstand short- and long-term effects of treatments.

Spotted owl PACs should be prioritized for treatment, with those with the highest percentage of area predicted to burn at high severity during future wildlife events ranking highest for treatment. Those with greater than 50 percent of the acreage predicted to burn at high severity should be prioritized for fuel reduction activities (e.g., underburn and hand thin, pile and burn. This includes Spotted Owl PACs PLU-072, 085, 109, 130, 131, 200, 210, 230, 258, 241, 286, 287, and 355. Associated acres within the Home Range Core Area (HRCA) should also receive fuel treatments to ameliorate the negative impacts of future wildfires on late seral forest habitat. Response by spotted owls from fuels management is not well studied. Monitoring of spotted owl PACs is necessary to determine occupancy and productivity both before and after treatments.

Northern Goshawk PACs should be prioritized for treatment, those with the highest percentage of area predicted to burn at high severity during future wildlife events ranking highest for treatment. Four of the goshawk PACs in the analysis area are at extreme risk for loss if they experience wildfire unless management is implemented (goshawk PACs T02, 05, 31 and 50). Portions of these PACs would benefit from fuels reduction treatments. Management should prioritize goshawk PACs with the highest proportion of acres in high fire severity threat categories. Response by goshawks from fuels management is not well studied. Monitoring of goshawk PACs is necessary to determine occupancy and productivity both before and after treatments.

5.8.2 Shrubland, Early and Mid Seral and Burned Forests and Associated Species

5.8.2.1 Desired Conditions

Maintain an abundance of shrubland, early and mid seral forest, and burned forest habitats to provide for viable wildlife populations.

Desired conditions for shrubland, early and mid seral forest, and burned forest habitats, is to contribute to the stability of species inhabiting these forest types and maintaining or improving habitat and population trends across the Sierra Nevada bioregion. Maintain a diversity of shrub species in patch sizes at or exceeding 10 acres, with greater than 50 percent shrub cover, ensuring remnant trees, snags and downed material are available to maintain wildlife populations.

Prior studies in the region suggest that the use of prescribed fire has far more positive effects on the avian community compared to the use of mechanical mastication in early seral habitats (Burnett et al. 2009). If mechanical mastication is used, especially in high quality shrublands, retaining leave islands of very dense shrubs will help provide nesting habitat and reduce potential negative impacts to shrubland species.

5.8.2.2 Goals

- Provide a diversity of vegetation types and habitat to support viable populations of all wildlife species (PNF LRMP 4-29).
- Maintain viability of snag-dependent wildlife (PNF LRMP 4-30).
- Maintain viability of species dependent upon dead and down material (PNF LRMP 4-31).
- Maintain viability of wildlife species dependent on hardwoods (PNF LRMP 4-31).
- Maintain viability of state-listed species, such as the willow flycatcher (PNF LRMP 4-33).
- Maintain burned forest habitat as an ecological component of the forest.
- Protect and improve habitat for harvest species (PNF LRMP 4-34).

5.8.2.3 Objectives

Consider the landscape context (e.g., watershed, ecosystem,) and relative availability of different habitat types when planning post-fire management actions. The large patches of dense shrub cover that are developing in high severity burn patches will support numerous shrub specialists, and species diversity at the landscape scale may be maximized when these large shrubland patches are interspersed, in a mosaic of forest types (burned, early, mid and late seral green forest) across the landscape. Time management activities (e.g., in relation to the length of time since the area last burned) such that areas are treated during seral stages that will minimize impacts to wildlife using the habitat.

<u>Snags</u>

- Manage a substantial portion of burned forest habitat as large patches (minimum of 50 acres, preferably larger) of high severity burned forest habitat. Consider that post-fire habitats are still being used by a diverse and abundant wildlife community.
- Delineate burned forest habitat patches in locations with relatively higher densities of larger diameter trees. Retain burned forest patches in areas where pre-fire snags are abundant as these are the trees most readily used by avian species during the first five

years post fire. Retain snags in salvaged areas in the largest and densest clumps possible, exceeding green forest standards. Retain smaller snags in heavily salvaged areas as well, as a full size range of snags are necessary to accommodate the suite of species utilizing these resources.

- Snag retention immediately following a fire should aim to achieve a range of snag conditions from heavily decayed to recently dead in order to ensure a longer lasting source of snags for wildlife.
- When reducing snags in areas more than five years post fire, snag retention should favor large pine and Douglas-fir but decayed snags of all species with broken tops should be retained in burned areas when feasible.
- Retain snags (especially large pines) in areas being re-vegetated as these may be the only source of snags in those forest patches for decades to come.

Burned, Early and Mid Seral Forests

- Manage burned areas for diverse and abundant understory plant communities, including shrubs, grasses, and forbs. Understory plant communities provide a unique and important resource for a number of species in conifer dominated ecosystems.
- Most shrub patches should be at least 10 acres and shrub cover should average over 50 percent across the area in order to support shrubland specialist (e.g. fox sparrow).
- Retain natural oak regeneration with multiple stems (avoid thinning clumps) as these dense clumps may serve as understory bird habitat in post-fire areas. Manage for a mosaic when treating shrub habitats to ensure some dense patches are retained. In highly decadent shrub habitat consider burning or masticating half the area (in patches) in one year and burning the rest in the following years, after fuel loads have been reduced.
- Maximize the use of prescribed fire to create and maintain shrublands and early seral forest habitat, and consider the appropriate natural fire regime interval as the targeted re-entry rotation for creating disturbance in these habitat types.
- Ensure that remaining burned forest habitat is accessible to California spotted owls

Deer Habitat

- Contribute to the stability of deer populations and/or habitat status and trend across the Sierra Nevada bioregion. Maintain a diversity of forage habitat, hiding cover, and thermal cover.
- Implement deer herd plans (PNF LRMP 4-34), which provide habitat elements to improve forage and cover for both the Doyle and Sloat deer herds.
- Return frequent fire to critical habitat elements to maintain key forage areas.
- Restore habitat enhancement structures and features on landscape.

- Provide resources where gaps exist in habitat (e.g., water).
- Provide for varied habitat conditions to sustain deer herds following Plumas NF LRMP guidelines (page 4-34) to implement cooperative Forest Service/California Department of Fish and Wildlife deer herd plans for the Sloat and Doyle deer herds.
- Protect winter thermal cover areas.
- Manage aspen groves to provide key deer fawning and foraging habitat. See aspen habitat assessment described in Section 5.4 of this document.
- Conduct stand exams on the aspen stands within fire area following the protocols in the Aspen Delineation project protocol (Burton 2002). Rejuvenate aspen stands in need of management.
- Provide additional black oak in addition to the "Oak and Other Hardwoods" standards where needed to achieve habitat objectives of deer-herd plans; for example up to 35 square feet basal area on summer range, intermediate range, and fall holding areas, and up to 30 percent canopy on winter range (PNF LRMP 4-34).
- Conduct burning, thinning and mastication treatments within shrub dominated areas to rejuvenate forage for deer. Maintain deer habitat enhancement structures, such as water catchment guzzlers, in working condition.
- Replace guzzlers lost to wildfires.

Shaping Future Forests

- Limit replanting of dense stands of conifers in areas with significant oak or aspen regeneration.
- When replanting hardwood areas, use conifer plantings in clumps to promote a mosaicked mixed conifer hardwood stand.
- Retain patches of burned forest adjacent to intact green forest.
- Incorporate fine and coarse scale heterogeneity when re-vegetating areas, by clumping trees with unplanted areas in mosaics in order to invigorate understory plant communities and encourage natural recruitment of shade intolerant tree species.
- Plant a diversity of tree species where appropriate.
- Consider staggering plantings across decades and leaving areas to naturally regenerate to promote uneven-aged habitat mosaics at the landscape scale.

5.8.3 Golden eagles and cliff nesting raptors

5.8.3.1 Desired Conditions

Desired conditions for golden eagles includes adequate levels of open foraging habitat and suitable nesting structures, which may be either late-seral forests or tall cliffs with suitable ledges or platforms for nests. Other raptors (e.g., *F. mexicanus* and *F. sparverius, Buteo jamaicensis* and *B. lagopus*) also would benefit by managing for open foraging habitat and sympatric cliff nesting raptors (e.g., *F. mexicanus*) would benefit from increased availability or suitability of nesting cliffs in the area.

5.8.3.2 Goals

- Maintain species viability of golden eagles and prairie falcons (PNF LRMP 4-33).
- Maintain suitability of prairie falcon and golden eagle territories.
- Provide suitable nesting structure to allow continued nesting of golden eagles.

5.8.3.3 Objectives

- Maintain and restore golden eagle foraging habitat and improve availability or suitability of nesting habitat for eagles. Identify two to three cliff sites within the analysis area that may support nesting eagles and create a suitable ledge inaccessible by predators to compensate for habitat lost in the Moonlight Fire.

5.8.4 Meadow Habitat and Associated Species

5.8.4.1 Desired Condition

Desired conditions, goals, and objectives for meadow habitat mirror those outlined in Section 5.4 (Meadow, Fen, Aspen and Riparian Vegetation Desired Conditions, Goals, and Objectives). In addition, restoration efforts should be directed at identifying and increasing the amount or condition of willow flycatcher habitat in the analysis area. Desired conditions include moist meadows with perennial water and large expanses (over 10 acres if feasible) of willow (*Salix* spp.) or alders (*Alnus* spp.).

5.8.4.2 Goals

Goals for meadow habitat restoration, in relation to wildlife, include mitigating ongoing resource damage (e.g. livestock grazing), improving meadow community diversity (flora and fauna), and maintaining or improving habitat suitability for willow flycatchers.

5.8.4.3 Objectives

Objectives for meadow habitat restoration, in relation to wildlife, include:

1. Inventory of all identified willow flycatcher habitat within the analysis area to determining habitat occupancy and restoration need;

2. Management of livestock grazing to prevent excessive grazing on regenerating willows;
3. Mitigation or elimination of resource damage to streams and meadows from livestock grazing.

5.9 Aquatic Species Desired Conditions, Goals, and Objectives

5.9.1 Aquatic Native Species

Desired conditions, goals, and objectives for aquatic species mirror those outlined in Section 5.4 (Meadow, Fen, Aspen and Riparian Vegetation Desired Conditions, Goals, and Objectives). In addition, restoration efforts directed at aquatic species should focus on:

- Identifying potential impacts of grazing on riparian habitats and mitigating negative impacts;
- Determining the distribution and abundance of SNYLFs across the restoration analysis area, in and outside of proposed critical habitat;
- Assessing habitat condition for SNYLF across the restoration analysis area and restoring degraded habitat;
- Identifying sedimentation, channel degradation, and contamination issues resulting from mining activities that occurred across the analysis area and implementing reasonable mitigations;
- Identifying first and second order streams most deficit in LWD and restoring this habitat component when feasible;
- Determining the number and location of improperly maintained forest roads, prioritizing reconstruction or decommission for those roads causing relatively higher resource damage, and coordinating road restoration work with AOP assessment and mitigation measures;
- Assessing the effectiveness, and non-target effects of herbicide application during restoration activities; the application of herbicides has the potential to affect most aquatic species either through direct poisoning of individuals if toxicants enter streams or indirectly by reducing food availability or suitability (e.g. contaminating food, poisoning prey);
- Documenting the distribution of springs across the restoration analysis area, wildlife use of springs, and improving spring condition where possible.

5.9.2 Aquatic Invasive Species

5.9.2.1 Desired Conditions

Manage aquatic invasive species and pathogens to protect, restore, and sustain aquatic ecosystems, ecological functions and values; protect and improve biodiversity; improve and

protect public recreational opportunities; prevent negative impacts to human health and the economy, and protect and restore fish and wildlife populations and habitats. Three sets of invasive species activities are desirable within the analysis area: (1) invasive species control (treatments and treatment monitoring); (2) invasive species detection (surveys, inventories, and mapping), and (3) invasive species prevention (all prevention activities, including outreach and education).

5.9.2.2 Goals

Management activities for aquatic invasive species (including vertebrates, invertebrates, plants, and pathogens) will be based upon an integrated pest management approach on all areas within the National Forest System, and on areas managed outside of the National Forest System under the authority of the Wyden Amendment (P.L. 109-54, Section 434), prioritizing prevention and early detection and rapid response actions as necessary. All National Forest System invasive species management activities will be conducted within the following strategic objectives: Prevention, Early Detection and Rapid Response, Control and Management, Restoration, and Organizational Collaboration.

5.9.2.3 Objectives

- Identify and assess aquatic invasive species (e.g., *Pacifastacus leniusculus, Rana catesbeiana*) and disease threats (e.g., whirling disease, caused by a myxozoan parasite, *Myxobolus cerebralis*) across the restoration analysis area.
- Coordinate rapid responses to aquatic invasive species and pathogens.
- Control aquatic invasive outbreaks; manage activities and habitat to prevent the spread of invasive species.
- Restore community composition and habitat features altered by invasive species.
- Collaborate with Federal, State and non-government partners to protect, restore, and sustain aquatic ecosystems in the face of ever changing invasive species threats.

5.10 Range Desired Conditions, Goals, and Objectives

5.10.1 Desired Conditions

Restoration of more frequent, low intensity fires and a mosaic of open eastside pine and mixed conifer forest types will promote productive understory plant communities; this is an essential component of sustainable range systems. Development of understory forage will help to draw livestock away from riparian areas and disperse use across the landscape. A mosaic of habitats that include forest, shrubland, forest openings, meadows, and riparian areas will create a heterogeneous and diverse landscape that can support livestock and reduce future fire risk (Calvo et al. 2012). The hydrology and vegetation sections of this strategy describe specific goals and objectives to restore the proper functionality of riparian areas and meadows. The

goals and objectives listed below are in addition to these and were developed to improve, protect, and restore the range resource on NFS system lands within the analysis area.

5.10.2 Standards and Guidelines

The Plumas NF LRMP (USDA 1988a) contains general direction and forest-wide standards and guidelines for range management. The following is the general direction outlined in the Forest Plan for range management (USDA 1988a, pages 4-35 and 4-36):

- maintain or increase grazing and range productivity on a sustained yield basis as demand and economy warrant; and
- implement a system to protect riparian areas

A forest-wide *Range NEPA Strategy and Implementation Plan* was signed by the Forest Supervisor on December 16, 2005. The intent of this plan is to document the analyses performed (in accordance with the National Environmental Policy Act [NEPA]) on all 65 allotments on the Plumas NF, which include the eleven allotments described above that occur within the analysis area.

5.10.3 Annual Operating Instructions (AOI)

The Plumas NF has developed annual operating instructions (AOI) for each allotment in the analysis area. The management direction for AOIs comes from the *Sierra Nevada Forest Plan Amendment Final Supplemental EIS* (USDA 2004b). The standards and guidelines for range management are listed in Table 37.

Table 37. AOI use standards for range allotments on the Plumas NF

Meadow Use	Shrub Use	Bank Alteration
Less than 40%	Less than 20%	Less than 20%

5.10.4 Goals and Objectives

Range conditions within the analysis area were altered by the 2007 Moonlight and Antelope Complex fires. Analyses need to be completed to determine carrying capacity and whether livestock use should continue to be authorized within the analysis area allotments according to the 2004 *Sierra Nevada Forest Plan Amendment* standards and guidelines. To do this, the following objectives need to be met:

- Collect data on meadow ecological seral stage; range condition (using Parker Three Step methods and Region 5 Range Monitoring plots); stream, spring, and fen proper functioning condition (PFC); and wildlife and heritage resources for the six allotments affected by the Moonlight Fire.
- Conduct rangeland monitoring in order to document change over time in vegetation or other rangeland resources and to determine the impact of wildfire on range resources.

- Monitor permit use compliance in accordance with the standards listed in Table 37. Utilize this information to develop recommendations for livestock number, season, and grazing system, which will be used in the NEPA analysis.
- Use inventory and monitoring data to assess environmental impacts in a NEPA analysis and decision for the six allotments affected by the Moonlight Fire.
- Install fence line and repair or restore other rangeland infrastructure impacted by the Moonlight Fire to protect resources from negative impacts.
- Provide public education on rangeland restoration activities by installing a multiple use educational kiosk.
- Remove whitethorn (*Ceanothus cordulatus*) from approximately 140 acres in the Lone Rock allotment and seed; montane and mixed chaparral vegetation in the analysis area increased dramatically after the Moonlight Fire.

5.11 Soil Resource Desired Conditions, Goals, and Objectives

5.11.1 Desired Conditions

The latest summary of Forest Service management direction for soils in Region 5 comes from the recently approved Forest Service Manual Chapter 2550 on soil management (USDA 2012b). In general, proper functioning soil should store water and nutrients, provide favorable habitat for soil organisms and plant growth, and provide protective cover to prevent erosion and water quality degradation (USDA 2012b: pg. 3). Within Riparian Conservation Areas (RCAs), the SNFPA states that "soils with favorable infiltration characteristics and diverse vegetative cover absorb and filter precipitation and sustain favorable conditions of stream flows" (USDA 2004: p. 43).

Soils can be drastically impacted by high severity wildfire, resulting in large areas not meeting desired conditions. Some attributes such as soil cover may recover in a few years, but micro-structure and topsoil creation may take longer.

5.11.2 Goals, Objectives, and Potential Projects

Goals for soil restoration in the Moonlight Fire area are as follows:

- Maintain and restore soils with favorable infiltration characteristics and diverse vegetative cover to adsorb and filter precipitation and to sustain favorable conditions of stream flows (SNFPA ROD 2004, pg.32).
- Protect soil resources and natural recovery processes from being impacted by any post-fire management activities.
- Balance the need for fuels reduction work with protection of soil resources. Take into account the risk and impact of re-burn on soil resources.

The HUC 6 watersheds that contain the Moonlight Fire will be used to identify opportunities for restoration. This area allows for the evaluation of soil resources both inside and outside the perimeter of the fire, but within the same watershed. Soils with high quality characteristics that may have been lost or degraded in the fire area may exist within the watershed, but adjacent to the fire boundary; therefore, it may be possible to protect or restore some soil resources that are impractical or impossible to restore within the fire area at less than decadal time scales.

Objectives for future projects related to these goals include:

- Take indicators of soil condition into account when conducting inventories of streams, roads, and other resources; record sub-optimal conditions.
- Identify areas where soil indicators (such as compaction or soil cover) are in poor condition and work to improve them. Priorities for this goal would be determined by locating areas where poor soil condition is having a negative impact on other resources such as water quality, roads, and aquatic and terrestrial habitat, and initiating activities to move these soils toward desired conditions.
- Investigate mine tailings, especially where there is a lack of vegetation. Soil samples may be needed to analyze contamination. There may be opportunities to restore these sites, especially near streams and within riparian areas.
- Evaluate active landslides; stabilize these sites or re-align roads away from these areas if possible.
- Re-vegetation, including planting, seeding, mulching or possible soil augmentation, should be considered for restoration projects, especially in granitic areas where soil cover is still lacking. The Plumas NF has had promising results replanting the fill and cut-slopes along reconstructed OHV trails in granitic soils (see Figure 68).

Figure 68. After OHV trail reconstruction, granitic soils are mulched and planted. In this Storrie Fire restoration project, native grasses persist 1.5 years after treatment.

5.12 Hydrology Desired Conditions, Goals, and Objectives

5.12.1 Desired Conditions

Desired conditions specific to hydrologic function and pertinent to the Moonlight Fire area are quoted or paraphrased from the SNFPA ROD (USDA 2004, pp. 42-42):

- Water quality meets the goals of pertinent laws such as the Clean Water Act.
- The connections of floodplains, channels, and water tables distribute flood flows and sustain diverse habitats.
- Sediment regimes are kept as close as possible to those in which aquatic and riparian biota evolved.
- The physical structure and condition of stream banks and shorelines minimizes erosion and sustains desired habitat diversity.

5.12.2 Goals

The 2004 SNFPA lists goals for riparian ecosystems; they are paraphrased or quoted below (USDA 2004: p. 32):

- Maintain and restore water quality and comply with the Clean Water Act.
- Maintain and restore watershed connectivity both for aquatic species, and sediment regimes.
- Maintain and restore the connections of floodplains, channels and water tables.
- Maintain and restore the physical structure and condition of stream banks and shoreline to minimize erosion and sustain desired habitat diversity.

There are also three additional goals specific to the restoration of the Moonlight Fire area:

1. Protect the desirable hydrologic characteristics that exist, or that are recovering from the fire, from management actions.
2. Evaluate known problem areas to see if they represent a cost effective opportunity to enhance or restore hydrologic function.
3. Locate new opportunities for enhancement or restoration. Collect robust data across the entire analysis area to ensure that the sites causing the most substantial resource damage are located and that priorities for enhancement and restoration are cost effective and make sense at a watershed scale.

The HUC 6 watersheds that contain the Moonlight Fire will be used to identify opportunities for restoration. This area allows for the evaluation of hydrologic or watershed resources both inside and outside the perimeter of the fire, but within the same watershed. Due to the connectivity of riparian habitats, some stream restoration projects adjacent to the Moonlight Fire could have direct impacts on hydrologic conditions within the fire footprint. In addition, areas with high quality characteristics that may have been lost or degraded in the fire area may exist within the watershed, but adjacent to the fire boundary; therefore, it may be possible to protect or restore some hydrologic resources that are impractical or impossible to restore within the fire area at less than decadal or greater time scales.

5.12.3 Objectives and Potential Projects

- Conduct an inventory of roads and OHV trails in the analysis area. Limited data exists; however a comprehensive inventory utilizing modern data gathering techniques is needed to evaluate risks to water quality from:
    - Stream crossings; evaluate risk of catastrophic failure, connection to roads, ability to pass aquatic species and sediment, diversion potential from plugged culverts, etc.
    - Chronic erosion features related to poorly placed, designed, or maintained roads

    - Water drafting sites; identify opportunities to relocate out of the active channel and bring up to best management standards.

- Conduct a travel analysis for the analysis area using the inventory data described above. Designate roads and OHV trails for maintenance, reconstruction, realignment and/or decommissioning. Use a watershed perspective to prioritize this work. Implement projects starting with best value, high priority sites.
- As described in the present condition discussion (Section 3.13), data sources identify less-than desirable conditions in several sub-watersheds in the eastern portion of the analysis area; these include Lone Rock, Upper Indian, Willow, and Boulder. Past and future data should be evaluated to target potential sites of degradation and accelerated erosion in these particular watersheds.
- The area near the confluence of the East and West Branch of Lights Creek is mentioned as still recovering from past mining and road impacts. This area should be evaluated for opportunities for restoration or enhancement.
- The grazing allotments in the Moonlight Fire analysis area are entering into NEPA for reauthorization. During this process, data should be gathered on riparian and stream conditions.
- A reconnaissance of stream conditions should be completed on the lower gradient perennial streams in the analysis area. Prioritize the potential "problem" sub-watersheds mentioned above. Evaluations of sediment sources, channel conditions, large woody debris, riparian vegetation, and aquatic habitat should be included. This will also help prioritize restoration and enhancement projects.
- Work with engineering to develop quarries or other rock sources to both produce aggregate surfacing to decrease erosion from native surface roads, and larger rock types for potential meadow-stream stabilization projects, and aquatic passage projects.

6.0 Human Resources Desired Conditions, Goals, and Objectives

6.1 Cultural Resource Desired Conditions, Goals, and Objectives

6.1.1 Desired Conditions for Cultural Resource Management

The desired condition for Cultural Resource Management within and adjacent to the Moonlight Fire area includes formal archaeological and historical inquiry to enhance our understanding of past human use of the area as well as providing public outreach and interpretative opportunities. Cultural resource surveys are completed and significant properties are identified and documented. Properties that lack importance, as per National Register of Historic Places criteria for significance, are released from active management. In partnership with interested public and tribal partners, the Forest identifies cultural properties where interpretative developments, either on-site or off-site, are appropriate. Forest visitors are informed about the cultural history of the area as well as the importance of historic preservation by utilizing

interpretive signage, programs, brochures, on-line information, and other social media venues as appropriate.

6.1.2 Cultural Resource Management Goals and Objectives

1. Complete cultural resource surveys within and adjacent to the Moonlight Fire area that are sensitive for prehistoric, ethnographic and historic era properties.
2. As per Section 110 of the National Historic Preservation Act and Region 5's Programmatic Agreement for Managing Historic Properties, determine the significance of cultural properties for potential eligibility for inclusion in the National Register of Historic Places. Release from management non-significant properties where appropriate while preserving and actively managing eligible cultural resources.
3. Work in partnership with the California-Engels Mining Company specifically to interpret the history of the Engels Copper Mine; the archaeological remains of which lie both on private and public lands.
4. Consult and collaborate with tribal interests to enhance our understanding of past lifeways within and surrounding the Moonlight Fire area.
5. Work in partnership with the Ford family and other interested parties to restore and enhance the Ford Cemetery which was affected by the Moonlight Fire.
6. Collaborate with recreational interests to meet the goals of enhanced visitor experience through heritage tourism by rehabilitating historic trails, creating walking or driving tours that include cultural resource elements, or providing signage at developed recreation sites.
7. Potentially rehabilitate the Red Rock Fire Lookout as a recreation rental.

6.2 Tribal Relations Desired Conditions, Goals, and Objectives

6.2.1 Desired Conditions for Tribal Relations

The desired condition for Tribal Relations begins with an ongoing and positive collaborative relationship between the Plumas NF and both federally recognized and non-recognized tribal organizations, groups and individuals in regard to Forest Service management of both natural and cultural resources. Opportunities for the application of Traditional Ecological Knowledge are realized that are of benefit to both tribal interests and to the American public. Traditional Cultural Properties, sacred places, cultural landscapes and important resource procurement areas are identified, as appropriate, and are actively managed to preserve and enhance cultural traditions. Tribal history is conveyed to forest visitors providing educational and interpretive opportunities. Programs are developed for local schools in partnership with tribal interests to educate youth concerning Native American lifeways. Economic benefits are realized for the tribal community through job opportunities within and adjacent to the Moonlight Fire area.

6.2.2 Tribal Relations Goals and Objectives

1. Consult with Native American organizations, groups and individuals to identify (as appropriate), protect, and enhance Traditional Cultural Properties, sacred places, cultural landscapes, archaeological resources and important resource procurement areas.
2. Collaborate with Native American interests to incorporate Traditional Ecological Knowledge in the identification, planning and implementation of restoration projects within and adjacent to the Moonlight Fire area.
3. Maintain continuous and meaningful government to government consultation with federally recognized tribes.
4. Interpret tribal history as reflected within the Moonlight Fire area in collaboration with Native American organizations, groups and individuals to convey the values and lifeways of tribal culture to forest visitors.
5. Provide opportunities for educational advancement for both tribal and non-tribal youth as it pertains to Native American lifeways through field trips, class projects and direct hands-on involvement in restoration activities.
6. Realize economic benefits for tribal organizations and individuals through employment as cultural monitors, trail restoration crew, vegetation treatment or other opportunities as they are identified.

6.3 Recreation Desired Conditions, Goals, and Objectives

6.3.1 Developed and Dispersed Recreation

6.3.1.1 Desired Conditions

The desired conditions for developed recreation in the Antelope Lake Recreation Area would be enhanced developed recreation opportunities so that visitor use returns at Antelope Lake to pre-fire levels documented prior to 2006. Visual quality desired conditions would be improved visual quality around the lake from restoration activities, resulting in improved vistas from recreation sites at Antelope Lake.

Desired conditions for dispersed recreation would be improved and enhanced recreational fisheries and dispersed recreation with the remote nature of the analysis area maintained consistent with Forest Plan direction. The existing roads designated for public use would provide a quality dispersed recreation experience, including dispersed camping, fishing, and hunting. A stable, safe road system would also provide opportunities to better manage dispersed camping opportunities, including developing low impact campsites.

Desired conditions for conservation education would be the availability of education for the public and schools on fire history and other natural resource related topics.

6.3.1.2 Goals and Objectives:

- Provide and enhance developed recreation opportunities at Antelope Lake to replace opportunities lost by the Moonlight Fire by improving facilities, infrastructure, and conservation education within recreation sites and around the lake. Specific types of projects that would enhance developed recreation opportunities include:
    - Replacing the water distribution systems for Lone Rock/Boulder Creek and Long Point Campgrounds to improve health and safety.
    - Replacing wooden picnic tables with concrete tables, replacing fire rings at Boulder Creek Campground, and adding amenities such as lantern posts and bear proof food lockers to enhance visitor satisfaction.
    - Replacing signs and bulletin boards at all three campgrounds and all recreation sites at Antelope Lake.
    - Constructing a shower facility at Boulder Creek Campground to enhance visitor satisfaction.
    - Providing solar power to run the general store to improve visitor experiences so that visitors don't hear a generator running.
    - Repaving and widening all three campground roads and spurs to improve visitor safety and satisfaction at recreation sites.
    - Developing an education and interpretive plan for the Moonlight Fire and adjacent Antelope Lake Recreation Area.
    - Implementing interpretive programs on fire history and natural history to improve and enhance education opportunities.
    - Developing and placing interpretive panels on fire history and natural resource topics around the Lake (specifically, Antelope Dam).
    - Providing and enhancing remote developed recreation opportunities consistent with the standards and guidelines in the PNF LRMP (USDA 1988a, 4-282, Management Area #28), by developing Red Rock Lookout into a recreation rental to be run by a private concessionaire.
    - Additional host sites at Boulder Creek and Long Point Campgrounds to include sewage vault.
    - Upgrading road surfaces to day use recreation sites: Lunker Landing, Antelope Picnic Area, Eagle's Landing, Guiney Point, and Little Lunker.
    - Thinning and improving forest health in and around recreation sites to protect recreation sites from future catastrophic fire.
    - Hazard tree removal at all recreation sites to improve public safety

- Specific projects to improve and enhance dispersed recreation opportunities and to replace opportunities lost to the Moonlight Fire include:
    - Providing and enhancing dispersed recreation opportunities by ensuring safe access along roads and trails to dispersed recreation opportunities such as hunting, camping, fishing, and off-highway vehicle driving.
    - Designating routes to certain dispersed campsites not designated through Plumas NF Travel Management EIS to allow authorized access to these campsites.

6.3.2 Non-motorized and Motorized Trails

6.3.2.1 Desired Conditions

The desired condition for motorized and non-motorized trail systems is to accommodate the predicted type of use (mountain bike, equestrian, hiker, and OHV) and capacity while providing a safe and enjoyable experience consistent with the general directions and management objectives outlined in the Plumas NF LRMP.

Desired conditions for non-motorized and motorized trails would be that trails are open and maintained to design and maintenance standards identified in Forest Service Handbook 2309.18 Section 23.12. Hazard trees along trails would not pose a safety risk to trail users and trail workers, and other vegetation would be maintained to safely accommodate hikers, bicycles, and equestrians. Trail tread would exhibit proper width, drainage, stabilization, and slope.

6.3.2.2 Goals and Objectives

- Restoring burned trail segments through brushing and removing and trimming vegetation along the trails to safely accommodate hikers, equestrians, and bicyclists.
- Implement herbicide treatments or manual removal of brush from roots to keep trails open and maintained. An alternative option to herbicide or manual removal could be allowing motorbike use on non-motorized trails to help keep trails open.
- Restoring and repairing trail tread for proper width, drainage, stabilization, and slope.
- Restoring and improving trail safety by removing hazard trees along trails.
- Repairing and replacing all fire damaged structures to support the trail system such as bridges, turnpikes and culverts.
- Improving and enhancing motorized trail opportunities for single track users by adding single track motorized trails. Specific trail opportunity projects include:
    - Honey Lake Plumas to Lassen Trail planning and development
- Restoring and enhancing damaged trail route markers, directional, regulative and interpretive signs.

- Attracting visitor use back to the trail system through education and marketing which would in turn assist in keeping trails open.

6.4 Education and Outreach Desired Conditions, Goals, and Objectives

6.4.1 Desired Conditions

Enhance Moonlight Fire restoration efforts by supporting student participation and promoting critical thinking skills while establishing links to the California State Content Standards, Curriculum, and new Core Standards. Student participation engenders public participation from adults and incorporates public ownership into the restoration efforts. Well-educated students who participate in restoration efforts become ambassadors/stewards and educate our local communities. Visitors and our local communities are knowledgeable about fire-adapted ecosystems via interpretive signage, brochures, website, podcasts, and other social media venues.

6.4.2 Goals for community integration into fire restoration

1. Integrate PUSD students in restoration activities while supporting the California State Content Standards, Curriculum, new Core Standards, and advancing critical thinking skills.
2. Build upon and expand the successful partnership agreement between the Plumas National Forest and PUSD for fire restoration; utilize the existing model of the PUSD/Storrie Fire Restoration Project.
3. Build on the successful partnership for the monitoring and restoration program in the Moonlight Fire area among Greenville High School, Sierra Institute, and the Plumas NF. Utilize the pilot work on the Moonlight Fire done by the Greenville High School Natural Resource Academy at Greenville High School as a model.
4. Increase local community understanding of fire ecology concepts and fire-adapted ecosystems; awareness provides support for fuel treatments, fuels reduction projects, and prescribed burn projects.
5. Expand opportunities for fire restoration partnerships with local organizations (Oakland Camp/Camps in Common and Sierra Institute), tribes (Maidu Summit Consortium, and urban schools (Oakland Unified School District).

6.4.3 Objectives for education and outreach

1. Incorporate student participation in appropriate restoration activities such as monitoring of restoration efforts, planting of trees and plants, native plant propagation, and recreation projects.

2. Engage the public in restoration efforts by developing partnerships with urban schools, local organizations, and tribes for student exchange of knowledge/restoration practices and Traditional Ecological Knowledge (TEK).
3. Incorporate youth employment into restoration efforts utilizing Youth Conservation Corps (YCC) or other model. Youth crew to be comprised of local and urban youth.
4. Demonstrate student role in restoration by developing a Moonlight Fire Restoration Project section on the Plumas NF webpage. Ensure project status and successes are updated.
5. Expand restoration by developing a PUSD/Moonlight Strategic Plan for related budget, curriculum support, and learning opportunities for local students.
6. To support Moonlight Fire Restoration efforts, develop an education, outreach, and interpretive plan for the Moonlight Fire and adjacent Antelope Lake Recreation Area.

6.5 Facilities and Infrastructure Desired Conditions, Goals, and Objectives

6.5.1 Transportation Desired Conditions, Goals, and Objectives

6.5.1.1 Desired Conditions

The Forest Service is obligated to provide a transportation system that is safe, protects the forest's natural and cultural resources, and spends the public's tax dollars wisely. An ideal transportation system would be both efficient and sustainable. It would be manageable in size to assure routine operation and maintenance. An ideal transportation system would only consist of roads that have known value or benefit; this would minimize excess surface water runoff and related drainage features from causing accelerated rates of erosion. The desired transportation system would provide economic value by providing access to dispersed campsites, overlooks, staging areas, motorized or non-motorized trails, viewpoints, swimming holes, and hunting. It would also provide access to areas in need of administrative and fire management. An efficient and sustainable transportation system will help maximize tax dollars while providing proper hydrologic function, storm proofing, maintenance, and reconstruction.

6.5.1.2 Goals and Objectives

Long term management and restoration of the Moonlight Fire area is dependent on access. The primary transportation goal is to provide reasonable access through a passable, stable, minimal, and safe transportation system with functioning hydrologic drainage features and structures.

Specific objectives include:

- Completing road surveys, with specific data gathered on road drainage and stream crossings. Comprehensive road surveys have not been done since the early 2000s. Past survey efforts, such as those conducted for the Diamond Project and Moonlight Fire

BAER, should be used to set priorities. Other tools, such as the Geomorphic Road Analysis and Inventory Package (GRAIP), should also be used to assess Moonlight roads.

  - Complete a GRAIP assessment of the roads in the analysis area. The GRAIP uses a computer model coupled with field data to estimate what road drainage is associated with the greatest sediment production and connectivity with water bodies (http://www.fs.fed.us/GRAIP/). Data gathered in the GRAIP inventory can be used to prioritize road rehabilitation, stream crossing upgrades, and decommissioning with a watershed and best value perspective.

- Road maintenance and some reconstruction will begin immediately on roads that are certain to be needed in the future; these include NFS roads 27N09, 28N03, and 29N46.
- Rock sources have been identified that will be reopened and reprocessed to provide materials for road and watershed restoration work.
- Existing data should be reviewed and a plan developed to assess opportunities to upgrade or remove stream crossings for both aquatic passages and hydrologic function.
- Non-system routes mapped during the sub-part B Travel analysis will be checked to see if physical obliteration is warranted.
- Water drafting sites will be identified and inventoried to see if they meet best management practices. A plan to reconstruct, construct new, and/or decommission these will be the ultimate objective.

6.5.2 Boulder Creek Station Desired Conditions, Goals, and Objectives

6.5.2.1 Desired Conditions

Forest Service personnel stationed at the Boulder Creek Station continue to play an important role in restoration, fuel reduction, and fire suppression activities in the Moonlight Fire area. Due to the remote location of the Moonlight Fire, the Boulder Creek Station plays a key support role in the fire restoration effort by providing barracks space for restoration crews, secure storage for restoration project equipment and materials, diesel fuel for project vehicles, and internet access.

6.5.2.2 Goals

- Maintain the Boulder Creek Station so that it can provide support for restoration activities in the Moonlight Fire area; this includes providing adequate lodging and remote office facilities for restoration crews, secure areas for equipment storage, and diesel fuel for project vehicles.
- Implement upgrades to facilities and equipment where necessary, considering energy efficient options whenever possible.
- Provide support and assistance to visitors and Forest Service crews working in and adjacent to the Moonlight Fire.

6.5.2.3 Objectives

- Conduct an assessment of the Boulder Creek Station to determine whether facility or equipment upgrades and/or maintenance are needed to adequately support restoration crews working within the Moonlight Fire area.
- Implement projects identified during the assessment to maintain and improve the Boulder Creek facilities. Examples of projects may include:
    - Increasing the efficiency of the power generation system at Boulder Creek by considering an alternative power source for the existing generator. The station currently operates off of a 25 kilowatt diesel generator. While the output capability of the generator is necessary in some cases (i.e. during an incident to provide power for an ICP) it far exceeds the general needs of the station.
    - Construction of an enclosed storage building to house a Forest Service Engine and serve as a storage area for restoration materials (i.e. seed, herbicides, erosion control products, etc.).

6.6 Mining Desired Conditions, Goals, and Objectives

The desired condition for the mining community would be safe, well maintained roads. The mining community relies on Forest Service roads for safe access to their claims. The loss of slope vegetation and trees can lead to washed out or damaged roads. In addition, burned trees pose a falling hazard to road travel and to occupancy of the claims for conducting mining activities.

Another desired condition would be closure of abandoned mines within the Moonlight Fire area. Abandoned mines pose a safety hazard to forest visitors, Forest Service employees, and contractors working in the area. With the surrounding vegetation burned off, abandoned mine sites become more visible, creating an attractive nuisance for an unsafe situation. Mine closure requires inventory field work and NEPA documentation, as well as the actual closure work; the estimated average cost for this, from inventory to closure, is about $10,000 per site.

6.6.1 Mining Post-fire Restoration Goals

- Provide safe access to mining claims by maintaining and improving roads and removing hazard trees along routes.
- Close abandoned mine sites where they pose a safety hazard to forest visitors, Forest Service employees, and contractors working within the Moonlight Fire area.

7.0 Monitoring and Inventory

The following section summarizes some of the monitoring and inventory activities that will be associated with the Moonlight Fire restoration effort. This list of activities is not comprehensive; modifications and additions will very likely be necessary as data are gathered and analyzed and monitoring questions become more apparent.

Monitoring is emphasized in the 2012 Planning Rule, as well as the *USDA Forest Service Ecosystem Restoration Framework* (Day et al. 2006) and the *Region 5 Ecological Restoration Leadership Intent* (USDA 2011a). These documents emphasize the importance of monitoring and inventory efforts for effective restoration and management. Other reasons for monitoring and establishing baseline conditions within the Moonlight Fire restoration area include:

- There are indications that fire size, frequency, and severity are rising in Sierra Nevada forests (Westerling et al. 2006, Miller et al. 2009). Monitoring post-fire conditions, rates, and trajectory of recovery after fire is fundamental to understanding future forest conditions and the effect of vegetation and fire management practices.
- Development of goals and objectives for ecological restoration of any site or ecosystem requires sufficient information regarding the state of the site/ecosystem to be able to identify departures from desired conditions or trends. This information is attained via resource inventories in the area of interest.
- The effects of restoration projects must be monitored to document restoration success and adopt a strategy of adaptive management.

In general, monitoring within the Moonlight Fire will fall under two broad categories:

- **Baseline monitoring** - to document changes in community structure, plant and animal species composition, population dynamics (recruitment, survival, etc.), and changes in the condition of resources. This information may be used to determine the need for treatment as well as the frequency, intensity, and method. Baseline inventories will be used to compare with future conditions.
- **Effectiveness monitoring** - to assess the effectiveness of management activities at meeting the goals and objectives outlined in Sections 5.0 and 6.0. This type of monitoring will also evaluate the response of key resources to management activities. More specifically, was the restoration project successful in achieving or leading toward desired conditions?

Data collected and evaluated from these efforts will allow managers to identify post-fire impacts, establish baseline conditions, and identify changes and trends over time. Monitoring results will be used to determine if restoration desired conditions, goals, and objectives are being achieved. If they are not being met, managers will use monitoring data to determine the appropriate course of action to restore or maintain conditions within the Moonlight Fire area.

7.1 Integrated Vegetation Monitoring Goals

1. Develop a database of baseline information (inventory) to understand actual on-the-ground conditions within the Moonlight Fire in a statistically definable and defensible way
2. Measure temporal and spatial trends in vegetation response after the Moonlight fire, including assessment of the effects of different vegetation management scenarios

3. Install a permanent grid of plot-based common stand exams and regeneration plots to permit monitoring of forest condition and management effects far into the future

Among other things, inventory and monitoring data collected in the Moonlight Fire will provide the Plumas NF with:

- A quantitative assessment of current vegetation conditions in the Moonlight Fire area, including unburned controls along the fire perimeter
- An evaluation of snag retention, fuels accumulation, and downed wood decomposition rates
- A characterization of tree mortality rates
- An examination of patterns of shrub and understory species composition and succession
- An assessment of natural regeneration of trees, both conifers and hardwoods
- An examination of the occurrence of noxious weeds and sensitive native plant species
- An independent comparison of post-fire treated (e.g., planted, salvage logged) versus untreated areas in all variables

7.2 Conifer Forest Monitoring

1. Conduct survival exams for reforestation per the Reforestation Handbook (FSH 2409.26b)
2. Conduct natural regeneration exams and certify natural regeneration where stocking and species composition meet desired conditions (FSH 2409.26b).
3. Monitor existing plantations for survival, growth, and competing vegetation.
4. Conduct post thinning stand exams
5. Conduct an inventory of post-salvage snags to determine the quantity, longevity and distribution.
6. Improve mapping of conifer forest stands using remote sensing datasets, such as LiDAR, aerial imagery, and field surveys.

7.3 Hardwood Forest Monitoring

7. Improve mapping of hardwood stands using remote sensing datasets, such as LiDAR, aerial imagery, and field surveys.
8. Conduct baseline surveys within the analysis area to evaluate the current condition of hardwood stands and prioritize sites for restoration.
9. Monitor hardwood stands to assess status and trend.

7.4 Meadow, Fen, Aspen and Riparian Vegetation Monitoring

1. Improve mapping of aspen stands, meadows, stream corridors, and riparian vegetation using remote sensing datasets, such as LiDAR, aerial imagery, and field surveys.
2. Conduct baseline surveys to evaluate the current condition of meadows, fens, and aspen stands within the analysis area; this includes an assessment of grazing effects, hydrologic condition, and the extent of conifer encroachment.
3. Evaluate riparian condition throughout the analysis area, including areas identified as potentially at-risk such as Upper Indian Creek, Boulder Creek, Lone Rock Creek, and parts of Lights Creek.
4. Conduct an assessment of the proper functioning condition of the Lowe Flat fen complex.
5. Monitor meadow, fen, aspen, and riparian areas to assess the status and trend of these habitats.

7.5 Unique Botanical Resources Monitoring

1. Monitor Baker cypress stands to determine changes in population status and trend, community structure, species composition, population dynamics (recruitment, survival, etc.), and changes in the physical condition (i.e. fuels) within the Mud Lake RNA (USDA 2006b).
2. Establish a baseline dataset that allows for analysis and comparison with future conditions and identification of additional management and restoration needs.
3. Collect baseline information on post-fire fuels, both within and adjacent to the RNA; utilize data to evaluate landscape level future fire potential and to develop long-term conservation strategies for Baker cypress.

7.6 Invasive Species Monitoring

1. Conduct baseline surveys to document changes in the size of infestations, number of individuals, and any existing or potential threats to native plant communities or sensitive resources. This information will be used to prioritize treatment of weed sites across the Moonlight Fire area and to develop a large-scale weed treatment project.
2. Monitor treated sites on an annual basis to assess treatment effectiveness, facilitate adaptive management, and identify potential revegetation needs.
3. Assess the effect of larger-scale restoration activities, including prescribed fire and seeding, on invasive species infestations. Examples may include the following:
    a. Canada thistle (*Cirsium arvense*) has been documented at numerous locations within the Moonlight Fire area and is a high management concern. At present, the effect of natural and prescribed fire on established infestations is unclear; it's response to fire has ranged from positive to negative and appears to be

dependent upon season, burn severity, site conditions, and plant community composition and phenology. Monitoring will be conducted to evaluate the effects of prescribed fire treatments on Canada thistle spread or control. Findings will be integrated into future restoration activities.

b. Seeding with native grasses after herbicide treatment is currently being tested as a potential post-fire control method for yellow starthistle on the El Dorado NF (USDA 2012e). Implementation and monitoring of native grass establishment and starthistle density will help determine the efficacy of this type of treatment at meeting restoration goals.

4. Assess and monitor the distribution and size of aquatic invasive species populations.

7.7 Fire and Fuels Monitoring

Inventory and monitoring of fire and fuels should be strategic and site specific such that it focuses on management issues and challenges and should be prioritized such that it does not duplicate information or trends already well documented in the scientific literature. However, a number of inventory exercises could be implemented with the goal of identifying future treatment acres.

- Inventory of green conifer forest within the Moonlight Fire that may be targeted for treatment.
- Inventory and establish stand exam plots in adjacent old-forest habitat that may be targeted for fuels reduction and forest restoration treatments.
- Inventory and establish stand exam plots in adjacent early successional forest stands that may provide replacement old forest habitat in the future with applied treatments.

7.8 Wildlife Monitoring

- Late seral forests - Survey for California spotted owl occupancy in existing territories. Determine if proposed spotted owl PAC treatments negatively impact owls or habitat suitability; Survey for northern goshawk occupancy in existing territories. Determine if proposed goshawk PAC treatments negatively impact owls or habitat suitability.
- Burned forests – Survey for black-backed woodpeckers in burned forest habitats and plan restoration activities to maximize woodpecker productivity.
- Monitor California spotted owl use of burned forests to retain key remnant burned forest patches within the analysis area. Monitoring directed at improving our understanding of owl use of burned forest habitat would benefit from sampling owl behavior in recently burned patches on the forest (i.e., Chips Fire landscape) as well as within the Moonlight and Antelope Complex fire footprints to better inform post fire restoration activities.

- Monitor habitat occupancy by bats to determine habitat selection throughout the annual cycle to direct restoration activities within the analysis area and promote viable bat communities.
- Shrublands and early and mid seral forests – Conduct avian and mammalian surveys prior to and post restoration to quantify impacts of activities (e.g., thinning, mastication, and prescribed fire) on avian and mammalian communities.
- Golden eagle and other cliff nesting raptors - Determine presence and absence of cliff nesting raptors on existing cliffs in the analysis area, and evaluate cliff suitability for raptor nesting, and improve cliff suitability for raptors where feasible.
- Meadow habitat - Survey meadows to determine use by willow flycatcher. Evaluate habitat quality and investigate opportunities for restoration.

7.9 Aquatic Species Monitoring

- Monitor restoration activities within aquatic habitats to assess their effectiveness; for example when barriers to aquatic organism passage (AOP) are removed or mitigated, assess aquatic community composition and species abundance above and below barriers before and after restoration activity.
- Couple ongoing survey efforts within range allotments (proper functioning condition and end of season use surveys) with additional riparian monitoring to evaluate grazing impacts on riparian communities and to develop appropriate management priorities and projects to address any negative impacts from grazing.
- Conduct surveys to determine the distribution and size of Sierra Nevada yellow-legged frog (SNYLF) populations and assess habitat condition for SNYLF across the restoration analysis area.
- Monitor SNYLF populations with sufficient frequency to identify significant changes in population size.
- Quantify sedimentation, channel degradation, and contamination issues resulting from mining activities before and after restoration activity.
- Monitor retention of LWD in first and second order streams after restoration activities.
- Monitor for non-target effects on riparian systems when herbicides are used during restoration activities.
- Monitor wildlife use of springs and surrounding habitat before and after spring restoration or improvement activities are accomplished.

7.10 Range Monitoring

The following four types of monitoring have been, and will continue to be, conducted in range allotments in the analysis area. Additional monitoring activities will be conducted as needs are identified.

1. *Allowable Use*. Allowable use standards are monitored annually and reported to Congress through the Regional Range Office. The use standards are described in Table 37.
2. *Meadow species vegetation composition*. A Rapid Meadow Assessment (developed by T. Frolli) transect was established in 2004 to determine meadow species vegetation composition in each monitoring area pasture. These will be reread as part of the analysis for Range NEPA.
3. *Proper Function Condition* (PFC) assessment of riparian areas was completed in 2006 and will be reassessed during the Range NEPA analysis if funding is available.
4. *Meadow Composition and Trend*. Long term plots were established at several monitoring areas in 2000-2003 as part of the Region 5 Meadow Monitoring program. These were reread after five and ten years to determine trend (see Table 6).

7.11 Soils Monitoring

- Soil inventory and monitoring will generally occur contemporaneously with other management actions and inventory efforts in the analysis area. Special attention will be paid to areas of disturbance that were further exacerbated by the Moonlight Fire, such as those associated with grazing, mining, and the transportation network.
- Excessive erosion impacting streams will be identified during inventories of aquatic conditions, and near stream roads and trails. Mining impacts will be assessed on their own as well. Vegetation management actions will be inventoried adhering to protocols identified in the Forest Service Manual 2500, Chapter 2550 Soil Management (2012)

7.12 Hydrology Monitoring

- Hydrology monitoring will first focus on a highly detailed survey of the transportation network in the analysis area. The Geomorphic Road Analysis and Inventory Package (GRAIP) will be used to predict road sediment production and delivery, mass wasting risk, and road connectivity to water bodies. This product will then be used to prioritize watershed enhancement projects and to evaluate project efficacy into the future.
- Past inventory information on stream and riparian condition will be used to prioritize areas for follow up surveys. These efforts will likely be a joint effort, with aquatic and range resources also evaluated.
- Stream crossing will be evaluated for capacity, risk of failure, and aquatic passage. This will be a joint effort with engineering and aquatics.

- Improve mapping stream corridors using remote sensing datasets, such as LiDAR, aerial imagery, and field surveys.
- Conduct quantitative monitoring, using methods such as the Multiple Indicator Monitoring (MIM) protocol, in streams that are at identified to be at risk, contain sensitive or listed species, or have potential conflicts with livestock grazing.
- All projects will be monitored for best management practices to ensure compliance under the Clean Water Act (R5 FSH 2509.22, Chapter 10, Water Quality Management Handbook, 2011).

7.13 Recreation Monitoring

- Establish baseline surveys for recreation use at Antelope Lake and trailheads by installing traffic counters and trail counters at trailheads and Antelope Lake entry portals. Monitoring would continue at three to five year intervals.
- Monitor visitor use and campground occupancy to assess the effectiveness of post-fire restoration activities at returning use in the area to pre-fire levels.
- Monitor visitor satisfaction by conducting surveys at campgrounds, recreation sites, and trail heads.
- Monitor trail hazards on motorized and non-motorized trails to ensure visitor and worker safety.
- Establish the most efficient trail treatment in burned areas by monitoring effectiveness after testing different methods of brush removal.
- Monitor trails to ensure trails are maintained to standard and open without being impacted by overgrown brush or fallen logs.

7.14 Education and Outreach Monitoring

- Establish baseline survey of new/additional students' participation in fire restoration projects.
- Determine pre- and post-fire restoration and fire ecology knowledge.

7.15 Transportation Monitoring

- Conduct a baseline inventory of roads in the analysis area. Limited data exists; however a comprehensive inventory utilizing modern data gathering techniques is needed to evaluate risks to water quality from:
    - Stream crossings; evaluate risk of catastrophic failure, connection to roads, ability to pass aquatic species and sediment, diversion potential from plugged culverts, etc.
    - Chronic erosion features related to poorly placed, designed, or maintained roads

    - Water drafting sites; identify opportunities to relocate out of the active channel and bring up to best management standards.

- The GRAIP inventory described in Section 7.12 will be used to inventory the transportation network, along with further evaluation by transportation engineers.
- Annual inspection of road drainage function, surface erosion, and stabilization will be used to determine needs for reconstruction, repair, maintenance, and hazard tree removal.

8.0 Project Development and Prioritization

8.1 Project Development

The project proposal template, provided in Appendix A, will be used to document all proposed restoration projects within the Moonlight Fire area. Appendix B includes project proposals for Fiscal Year 2014 restoration projects. Future projects will be developed as data are gathered and analyzed, resource specialists become more familiar with the Moonlight Fire landscape, and conditions on the ground change. In all of these cases, future restoration projects will link to the desired conditions, goals, and objectives outlined in this strategy. Funding requests for new and ongoing projects for the following fiscal year will be submitted to the Regional Office for approval by November 1, together with the annual report.

The template in Appendix A outlines the types of information required in the project proposal. The following provides some additional information on two important sections.

Link to Desired Conditions, Goals, and Objectives

Moonlight Fire Restoration projects must be directly linked to the desired conditions, goals, and objectives described in Sections 5.0 and 6.0 of this strategy. Objectives may be missing from the strategy; for example in some cases inventory information may be required before meaningful objectives can be developed. In these situations, the project proposal must include a clearly worded objective that is (a) directly tied to a desired condition and goal from the strategy, and (b) written so that progress toward the objective can be evaluated, preferably quantitatively, through monitoring.

Project Justification

Project proposals must include a justification that states:

1. how the project meets 16 USC 579c criteria and any criteria set by the court decision;
2. how the project meets the need identified in the Moonlight Fire Restoration Strategy (linkage to a significant fire impact identified in the strategy is important); and
3. if work is proposed outside of the fire perimeter, a clear description of why this is necessary.

8.2 Project Prioritization

Prior to submission of the annual funding request, projects within the Moonlight Fire area will be assessed and prioritized using some of the following criteria:

1. Desired Conditions, Goals, and Objectives
    a. What desired conditions, goals, and objectives does the project address?
    b. Will more than one resource area benefit from implementation of the project?
    c. Is the connection to the fire clearly articulated?
2. What is the status of the project and the planning effort required?
    a. Has NEPA been completed?
    b. Will it require a CE, EA, or EIS?
    c. Are specialists available to work on the project?
3. What is the timeframe for the project? Do other projects depend on it being completed?
4. Is the project within a priority watershed? Does it benefit federally listed or Sensitive species?
5. Are external partners involved or matching funds?

9.0 Reporting

A report, which may be made public, will be submitted to the Regional Office every year by November 1. This report will accompany funding requests for new and ongoing projects for the following fiscal year. The report (508 compliant) will document results of baseline surveys, implementation of restoration projects, results of monitoring, and an evaluation of progress toward desired conditions and objectives. The evaluation will be meaningful, so that mid-course adjustments can be made whenever appropriate. If mid-course adjustments are warranted, they will be fully developed in the report, in a manner analogous to this original Restoration Strategy. In this way, we ensure that the adaptive management cycle continues throughout the fire restoration process.

10.0 Contributors

The following individuals, listed in alphabetical order, contributed to the Moonlight Restoration Strategy. The restoration team leader is indicated by an asterisk (*).

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Appendix A: Moonlight Fire Restoration Project Proposal Template

Moonlight Fire Restoration Project Proposal (Fiscal Year)

Project Name

Project Leader Name (Job Title)**:** _____

Link to Restoration Strategy desired condition and goal: (state specific desired condition and goal from Strategy)

Objective: (either link to an objective from the Restoration Strategy, or develop a clearly stated objective that links to a desired condition and goal in the Strategy. Objectives are specific, narrowed statements of intentions that are measurable. Progress toward an objective can be evaluated through monitoring)

Project justification: (state how project meets 16 USC 579c criteria and criteria set by court decision; state how project meets need identified in the Fire Restoration Strategy; if project proposes work beyond the fire perimeter, clearly describe why this is necessary)

Project description: (what is being proposed, identify whether assessment, planning, implementation or monitoring. If implementation, describe how progress toward overarching objective will be measured)

Monitoring and evaluation: (State monitoring objective, methods, data to be collected and how they will address the monitoring objective, statistical design for quantitative monitoring, how frequently monitoring will be conducted, frequency of evaluation, standards used in evaluation, trigger points for success or adjustment of project)

Estimated cost: (Provide cost estimate for project, separated out by year if known; complete workplan for the project)

Timeline and associated accomplishments: (Identify whether the project will span multiple years and if so specify tasks, accomplishments, and targets by year)

Year	***Task***	***Product / Accomplishment***[1]

[1] Identify the anticipated level of NEPA documentation (i.e. CE, EA, or EIS) and target accomplishment

Appendix B – Moonlight Fire Restoration 2014 Project Proposals

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Moonlight Fire Restoration Project Proposal (2014)

Moonlight Reforestation and Release for Survival Planning

Project Leader Name: Maurice Huynh (District Silviculturist)

Link to Restoration Strategy desired condition and goal:

- Restore the long-term viability of appropriate forest types and reduce the potential for vegetation type conversion.
- Restore landscape heterogeneity in terms of spatial and temporal variability, forest type and species diversity, and forest seral stages and structure.

Objective: Through proper site preparation and planting, forested areas that were converted to chaparral vegetation types by the Moonlight Fire can be restored to conifer stands. Between 2009 and 2010, large areas were planted without any site preparation or release. Subsequent survival did not meet objectives on many sites. This project would evaluate plantations and plan additional site prep, planting, and release for survival treatments within these plantations. Planting conifers would provide for seed sources of desired species lost during the fire. Site preparation would help ensure success, long term viability of plantations and help prevent conversion of previously burned areas to montane chaparral. Plantations with suitable tree survival and stocking would receive consideration for release for survival treatments.

Project justification: Please refer to Section **Error! Reference source not found.** (**Error! ference source not found.**) and section **Error! Reference source not found.** (**Error! Reference source not found.**). This project meets all criteria set forth by 16 USC 579c because it:

- Rehabilitates lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service; and
- Replacement of fire-killed conifer forest was rendered necessary by the Moonlight Fire.

The few treatments outside the fire are focused in the immediately adjacent Antelope Complex and include the highest quality site which provides greater potential for tree establishment and survival.

Project description: Refer to Map 1 (below) for the approximate location of proposed activities. This is the first phase of a multi-year project and colored map polygons display only the priority locations for evaluation in the first year. Part of this project would include additional reconnaissance of future FY locations (colored in grey) with a prioritization on high quality sites within the Moonlight Fire. The reforestation area outside the Moonlight fire is the highest quality site within the adjacent Antelope complex. In FY14, project planning and NEPA analysis would be completed. This would be followed by site prep of planted areas in FY15 through a combination of mastication, hand thin and pile, or hand thin and grapple pile to reduce fuels, mitigate safety hazards and reduce competitive brush vegetation to seedlings. After site prep activities, conifer seedlings would be planted (target FY16) using a wide-space cluster design.

Desired seedling density would be approximately 100 to 300 seedlings per acre. Manual release ("grubbing") may occur within five years after planting. Manual release would involve the use of a tool to remove competing vegetation in a five foot radius around seedlings. FY15 targets would include fuels reduction (FUELS-ALL) and some forest vegetation improvement (FOR-VEG-IMP) acres. FY16 targets would include forest vegetation establishment (FOR-VEG-EST) acres..

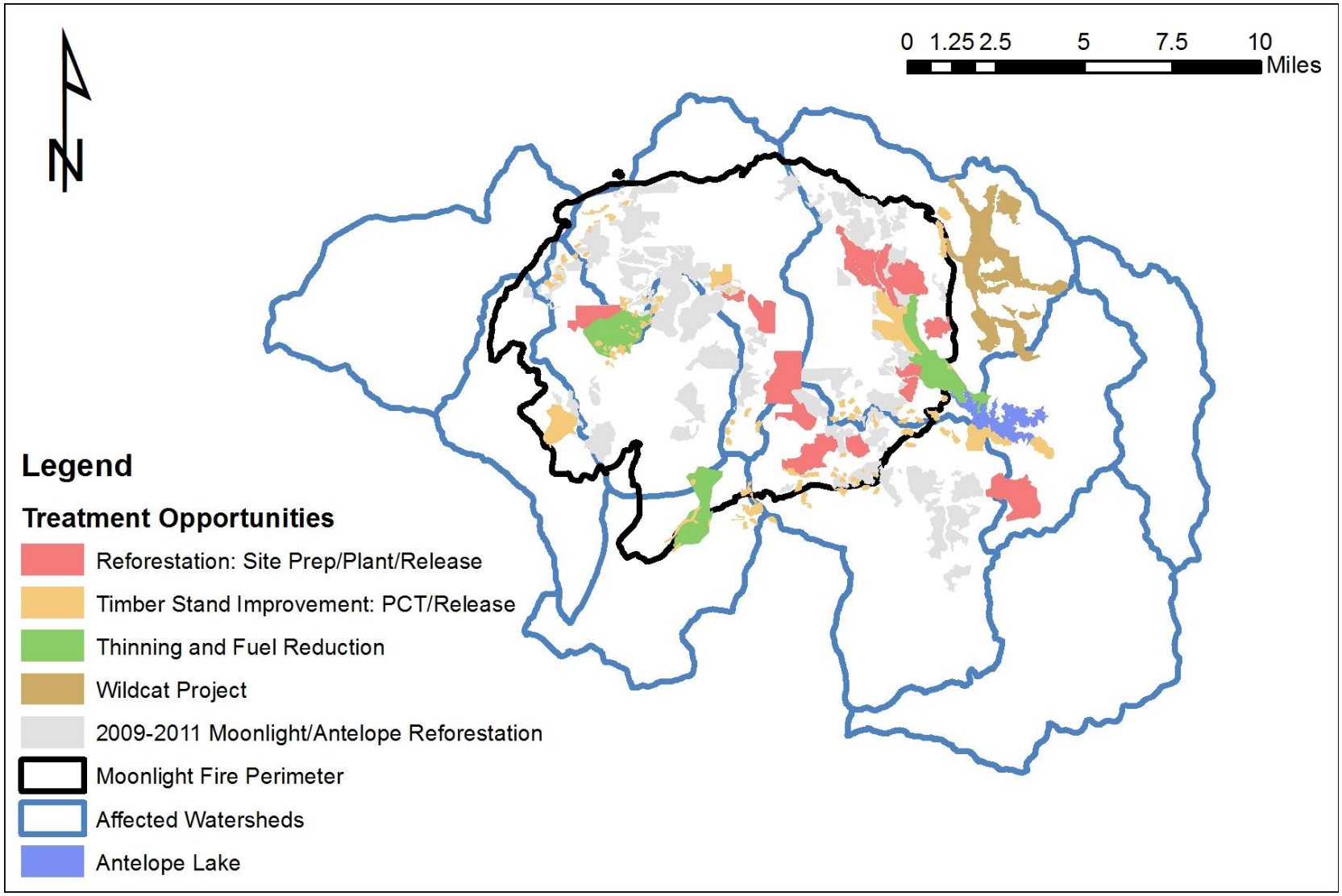
Monitoring and evaluation: Standard plantation survival exams would be used to monitor and evaluate the success of planting. Survival exams would occur on the first, third and fifth year after planting.

Estimated cost: The estimated cost of project planning and NEPA analysis (FY14 activities): $43,807.

Timeline

Year	Task[1]	Product / Accomplishment
FY14	project planning and NEPA analysis	Categorical Exclusion (CE) completed
FY15*	Site preparation	Fuel reduction (FUELS-ALL) and Forest Vegetation Improvement (FOR-VEG-IMP) accomplishment
FY16*	Tree planting	Forest Vegetation Establishment (FOR-VEG-EST) accomplishment
FY17-FY21*	Manual release and survival exams	Forest Vegetation Improvement (FOR-VEG-IMP) accomplishment

* Estimated project cost does not cover these out-year tasks



Map 1. Approximate locations of commercial thinning, precommercial thinning, and planting units.

Moonlight Fire Restoration Project Proposal (2014)

Moonlight Precommercial Thinning, Release for Growth, and Fuel Reduction Planning

Project Leader: Maurice Huynh (District Silviculturist)

Link to Restoration Strategy desired condition and goal:

- Restore the long-term viability of appropriate forest types and reduce the potential for vegetation type conversion.
- Restore landscape heterogeneity in terms of spatial and temporal variability, forest type and species diversity, and forest seral stages and structure.
- Restore the forest landscape to one that is well-adapted to natural disturbance regimes and can respond to changes in climate and disturbance regimes

Objective: The Moonlight Fire effectively converted many forested mid to later seral stands to chaparral vegetation types. However, there are older plantations that survived the fire. Thinning these plantations would increase long-term viability. In older plantations, thinning would also accelerate growth towards larger size classes and later seral stages.

Precommercial thinning of plantations can also increase stand heterogeneity. The Moonlight Fire left a fair amount of the landscape in homogenous patches of either early seral or brush vegetation types. Diversifying the forest types through proper selection of species, diameters and heights will increase stand and hence, landscape heterogeneity.

Reduction in stand density would increase stand vigor and reduce the amount of ladder fuels. This would increase a stand's ability to respond to natural disturbances including insects, disease and fire. A healthy stand would be better adapted to respond to changes in climate as well.

Project justification: Please refer to Section 5.1.2 (Overarching Strategic Restoration Goals for Forest Vegetation) and Section 5.1.4 (Restoration Opportunities). This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service; and
- Improvement of existing, residual green stands is rendered necessary to retain remnant mid seral conifer stands within Moonlight Fire and to accelerate the development of proximate mid seral stands that were lost in the Moonlight Fire. The few treatments outside the fire are focused on plantations on the highest quality sites immediately adjacent to the Moonlight fire. These already established plantations would be considered to accelerate

the development of mid seral stand conditions and provide a localized seed source for the Moonlight Fire.

Project description: Refer to Map 1 (above) for the approximate location of proposed activities. This is the first phase of a multi-year project. FY14 will involve reconnaissance and NEPA planning for timber stand improvement of surviving plantations within the Moonlight Fire; implementation is anticipated in FY15. FY 15 targets include FOR-VEG-IMP and FUELS-ALL.

In older plantations, most thinning would be considered precommercial with no sawlog product being removed. Depending upon the average stand diameter, removal of trees would likely be through use of a masticator. Plantations with larger trees may have some commercial product removal.

Monitoring and evaluation: Depending upon the contract, either sale administrators or contracting representatives (COR's) would monitor to ensure successful implementation.

Estimated cost: The estimated cost of project planning and NEPA analysis (FY14 activities) is $72,219

Timeline

Year	Task[1]	Product / Accomplishment
FY14	project planning and NEPA analysis	Categorical Exclusion (CE) completed
FY15*	Project implementation	Fuel reduction (FUELS-ALL) and Forest Vegetation Improvement (FOR-VEG-IMP) accomplishment

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Moonlight Thinning and Fuel Reduction Planning

Project Leader: Maurice Huynh (District Silviculturist)

Link to Restoration Strategy desired condition and goal:

- Restore the long-term viability of appropriate forest types and reduce the potential for vegetation type conversion.
- Restore landscape heterogeneity in terms of spatial and temporal variability, forest type and species diversity, and forest seral stages and structure.
- Restore the forest landscape to one that is well-adapted to natural disturbance regimes and can respond to changes in climate and disturbance regimes

Objective: The Moonlight Fire effectively converted many forested mid to later seral stands to chaparral vegetation types. However, there are residual mid to later seral stage conifer stands that survived the fire. Mature stands comprising of larger trees usually typify later seral stages.

Thinning these stands would increase long-term viability and generally increase vigor and improve resiliency to disturbances such as insects, disease and fire. In addition, removing trees in a stand can increase stand heterogeneity. The Moonlight Fire left a fair amount of the landscape in homogenous patches of either early seral or brush vegetation types. Diversifying the forest types through proper selection of species, diameters and heights will increase stand and hence, landscape heterogeneity.

A proper reduction in stand density would also increase stand vigor reduce the amount of ladder fuels. This would increase a stand's ability to respond to natural disturbances including insects, disease and fire. A healthy stand would be better adapted to respond to changes in climate as well.

Project justification: Please refer to Section 5.1.2 (Overarching Strategic Restoration Goals for Forest Vegetation) and Section 5.1.4 (Restoration Opportunities). This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service;
- Improvement of existing, residual green stands is rendered necessary to retain what is left after the Moonlight Fire burned a fair amount of forested areas

Project description: Refer to Map 1 (above) for the approximate location of proposed activities. This is the first phase of a multi-year project. FY14 will involve reconnaissance and NEPA planning for commercial thinning within the Moonlight Fire; implementation is anticipated in

FY15. FY15-FY16 targets would include FUELS-ALL, FOR-VEG-IMP, and with a potential component of TMBR-VOL-SOLD.

The project area is comprised of more mature stands that would most likely be commercially thinned with an emphasis on restoring and maintaining later seral stage components. Smaller ladder fuels and non-desired species such as true fir would also be removed. Additional considerations such as safety and aesthetics will also be highlighted.

Monitoring and evaluation: Depending upon the contract, either sale administrators or contracting representatives (COR's) would monitor to ensure successful implementation.

Estimated cost: The estimated cost of project planning and NEPA analysis (FY14 activities) is $71,508.

Timeline

Year	Task[1]	Product / Accomplishment
FY14	project planning and NEPA analysis	Categorical Exclusion (CE) completed
FY15-FY16*	Project implementation	Fuel reduction (FUELS-ALL), Forest Vegetation Improvement (FOR-VEG-IMP), and possibly Timber Volume Sold (TIMB-VOL-SOLD) acres accomplished

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Wildcat Fuel Reduction and Forest Health Thinning Project

Project Leader: Maurice Huynh (District Silviculturist)

Link to Restoration Strategy desired condition and goal:

- Restore the long-term viability of appropriate forest types and reduce the potential for vegetation type conversion.
- Restore landscape heterogeneity in terms of spatial and temporal variability, forest type and species diversity, and forest seral stages and structure.
- Restore the forest landscape to one that is well-adapted to natural disturbance regimes and can respond to changes in climate and disturbance regimes

Objective: The Moonlight Fire had an indelible effect on forested vegetation within its fire perimeter, effectively converting many forested mid to later seral stands to chaparral vegetation types. However, on the external fringes of the fire perimeter, many stands experienced low fire severity. Nonetheless, as evidenced by the recent Chips Fire, these residual green stands are still at risk to vegetation conversion from fires starting inside the Moonlight Fire perimeter. The Chips Fire started within the Storrie Fire footprint. Due to the presence of heavy ground fuels, the fire grew and burned outside the original Storrie Fire footprint into green stands. Arguably, this situation could occur with Moonlight and adjacent green stands.

The Wildcat Project area is adjacent to the eastern edge of the Moonlight Fire perimeter. Thinning these stands would decrease ladders fuels, increase crown separation and generally reduce fuel loading. In the event of a future fire starting in the Moonlight Fire perimeter and burning out of it, Wildcat would serve as an effective buffer in limiting the spread of the fire toward the community of Janesville. Conversely, the Wildcat project would provide protection to plantation investments and surviving green stands within the Moonlight Fire perimeter from external fires. The Wildcat Project and its surrounding area have been referred to by Mt. Hough District fire personnel as “lightning alley”. The Boulder (2006) and Antelope (2007) Complex is evidence to the potential fire hazard in the area. Due to the extent of high severity fires during the Moonlight Fire, it is imperative to protect the recently established plantations and surviving remnant stands from future fires. These stands are at risk of loss to fire, both from within and outside the Moonlight Fire perimeter. Increasing fire resiliency in Wildcat would help protect reforestation efforts and investments within the Moonlight Fire area.

In addition, a proper reduction in stand density would increase stand vigor. Many stands within the Wildcat project area are considered mid seral. Thinning these stands would increase stand growth and accelerate their development into larger size classes and their ability to respond to other natural disturbances such as insects and disease – such conditions would be better adapted to respond to climate change. Diversifying the forest types through proper selection of species, diameters and heights will increase stand and hence, landscape heterogeneity; heterogeneity that was lost in the Moonlight Fire as many acres were effectively converted to shrub vegetation types or early seral stands.

Project justification: Please refer to Section 5.1.2 (Overarching Strategic Restoration Goals for Forest Vegetation) and Section 5.1.4 (Restoration Opportunities). This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire
- Is on lands administered by the Forest Service
- Improvement of existing, residual green stands is rendered necessary to retain mid to late seral stands on the landscape to prevent any further cumulative losses from the Moonlight Fire, and to mitigate the temporal effects of the Moonlight fire on development of mid to late seral conditions.

Project description: The proposed project area is lies between Wildcat Ridge on the east and on the west by the Mt. Hough/Beckwourth Ranger District boundary; see Map 1 above. This is the first phase of a multi-year project. FY14 will involve reconnaissance and NEPA planning for commercial and non-commercial thinning; implementation is anticipated in FY15. FY15 –FY16 targets would include FUELS-ALL, FOR-VEG-IMP, and TMBR-VOL-SOLD.

The project area is comprised of more mature stands that would most likely be commercially thinned with an emphasis on restoring and maintaining later seral stage components. Part of the area has experienced a vegetation shift away from "east side pine" which historically had much lower tree densities dominated by shade intolerant pines. Smaller ladder fuels and non-desired species such as true fir would also be removed in order to help return the area to a more east side pine condition. There is a limited amount of aspen stands within the Wildcat project area that are being proposed for treatment. Prescriptions in aspen stands will be to protect and restore vigor. Additional considerations such as safety and aesthetics will also be highlighted.

Monitoring and evaluation: Depending upon the contract, either sale administrators or contracting representatives (COR's) would monitor to ensure successful implementation. In addition, aspen stands would most likely be monitored for prescription and treatment efficacy.

Estimated cost: The estimated cost of project planning and NEPA analysis (FY14 activities): $161,594

Timeline

Year	Task[1]	Product / Accomplishment
FY14	project planning; NEPA analysis	Environmental Assessment (EA) completed
FY15-FY16*	Project implementation	Fuel reduction (FUELS-ALL) acres in both the WUI and non-WUI; Forest Vegetation Improvement (FOR-VEG-IMP) acres; Timber Volume Sold (TIMB-VOL-SOLD); Terrestrial Habitat Enhancement (HBT-ENH-TERR)

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Aspen and Meadow Inventory

Project Leader: Kyle Merriam (Sierra Cascade Province Ecologist)

Link to Restoration Strategy desired condition and goal: This project will inventory aspen stands and meadows ***within*** the Moonlight Fire area to determine if they meet desired conditions for meadows and aspen. Desired conditions from the restoration strategy (Section 5.4) for meadows include:

- Habitat supports viable populations of native and desired non-native plant, invertebrate, and vertebrate riparian and aquatic-dependent species.
- Species composition and structural diversity of plant and animal communities in riparian areas, wetlands, and meadows provide desired habitat conditions and ecological functions.
- The connections of floodplains, channels, and water tables distribute flood flows and sustain diverse habitats.
- In-stream flows are sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats and keep sediment regimes as close as possible to those with which aquatic and riparian biota evolved.
- The ecological status of meadow vegetation is late seral, meaning that 50 percent or more of the relative cover of the herbaceous layer is late seral with high similarity to the potential natural community. A diversity of age classes of hardwood shrubs is present and regeneration is occurring.
- Meadows are hydrologically functional. Sites of accelerated erosion, such as gullies and headcuts are stabilized or recovering. Vegetation roots occur throughout the available soil profile. Meadows with perennial and intermittent streams have the following characteristics: (1) stream energy from high flows is dissipated, reducing erosion and improving water quality, (2) streams filter sediment and capture bedload, aiding floodplain development, (3) meadow conditions enhance floodwater retention and groundwater recharge, and (4) root masses stabilize stream banks against cutting action.

Desired conditions for aspen include:

- Conifer cover (understory and overstory) of less than 25 percent;
- Aspen canopy cover greater than 40 percent;
- Dominant aspen trees less than 100 years old;
- Aspen regeneration (stems 5 to 15 feet tall) of more than 500 stems per acre; and
- Sagebrush cover of less than 10 percent.

This project addresses restoration goals, including: a) ensure that grazing management is contributing to desired conditions; b) maintain and restore habitat for riparian and meadow associated species, c) promote fire resilience aspen stands; d) protect aspen stands from conifer encroachment, and e) protect aspen sprouts from excessive browsing.

Objective: This project implements restoration objective (Section 5.4.3): "Conduct surveys to evaluate the current condition of meadows, fens, and aspen stands within the analysis area; this includes an assessment of grazing effects, hydrologic condition, and extent of conifer encroachment. Identify and prioritize sites for restoration."

Maintenance of aspen stands will also meet objectives of the cooperative Forest Service and California Department of Fish and Wildlife Deer Herd management plans. Two important deer populations, the Sloat and Doyle herds, are present in the Moonlight Fire area.

Project justification: This project meets the three key criteria from 16 USC 579c: 1) To conduct improvement, protection, or rehabilitation work; 2) On lands administered by the Forest Service; and 3) For purposes rendered necessary by the Moonlight Fire by conducting inventories of aspen and meadow condition required to prioritize and develop improvement and rehabilitation work on the Plumas NF in areas that were burned by the Moonlight Fire.

Project description: This project will inventory aspen stands and meadows that were burned during the Moonlight Fire to identify and prioritize sites for restoration as part of the Moonlight Fire Restoration Plan. This project will result in accomplishments for forest vegetation improvement, fuels reduction and terrestrial habitat enhancement. These surveys would be conducted in coordination with monitoring proposed for the Mt. Hough Range allotments. Many aspen stands that burned in the Moonlight Fire responded with prolific sprouting. Although sprouting can rejuvenate aging aspen stands, these sprouts are now highly vulnerable to excessive livestock browsing, which can eventually eliminate aspen. Meadow ecosystems may have been damaged by the Moonlight Fire in areas where high severity fire effects altered meadow hydrology or damaged meadow vegetation. The results of this inventory will be used to develop restoration projects for aspen and meadows during FY15, with project implementation in FY15 and FY16.

Monitoring and evaluation: This project will complete a baseline inventory of current aspen and meadow conditions to identify and prioritize sites for restoration. Effectiveness monitoring will begin in FY15.

Estimated cost: FY14 cost is $39,043, including personnel and fleet costs. See workplan for budget details.

Timeline

Year	Task	Product / Accomplishment

FY14	Complete inventory and assessment	(1) Accurate GIS layer (currently not available, but necessary for future restoration efforts) (2) Assessment and prioritization of meadow and aspen habitats for restoration
FY15*	Develop and analyze aspen and meadow restoration projects	NEPA document (most likely a CE)
FY15-FY16*	Project implementation	Accomplishments would include: acres of terrestrial habitat improved (TER-HAB-IMP); Forest Vegetation Improvement (FOR-VEG-IMP); potentially stream habitat improvement (HBT-ENH-STRM)

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Mud Lake Baker Cypress Fuel Treatment Planning

Project Leader Name: Kyle Merriam (Sierra Cascade Province Ecologist)

Link to Restoration Strategy desired condition and goal: This project will occur in the Mud Lake unit of the Mud Lake Research Natural Area (MLRNA), an area that was burned during the Moonlight Fire. The project will address the following desired condition from the restoration strategy (Section 5.5.2): "The short-term desired condition for Baker cypress at the Mud Lake unit of the MLRNA is a population that is allowed to mature in an environment where the risk of subsequent fires is minimized."

Objective: This project would implement the following goals and objectives described in the Section 5.5.2 of the restoration strategy:

- Fire suppression is recommended at the Mud Lake unit of the MLRNA until Baker cypress trees are able to mature and develop a canopy seed bank. Sufficient canopy seed storage will not likely occur until the stand is between 35 and 50 years old.
- To reduce the risk of fire eliminating the Mud Lake stand, strategic fuel treatments should be implemented around the population.

Project justification: This project meets the three key criteria described in 16 USC 579c by implementing fuel treatments to protect the Baker cypress stand burned in the Moonlight Fire from subsequent fires before the population has become reproductively mature. This project would occur on lands administered by the Forest Service within the Moonlight Fire perimeter. This project is necessary because the Moonlight Fire stimulated the regeneration of a new cohort of Baker cypress by killing the senescent adult population previously found at the site.

Project description: The Mud Lake Unit of the MLRNA, containing one of only two populations of Baker cypress found on the Plumas National Forest, burned in the Moonlight Fire (Figure 27). Baker cypress is a serotinous species, requiring fire to regenerate. The Moonlight Fire was very successful in stimulating regeneration of this very decadent and dying stand. However, the population is now extremely vulnerable to subsequent fires, which would kill young cypress before they have matured and produced cones. A second fire would likely extirpate this population of Baker cypress. This project would plan an approximately 200 acre fuel treatment, building upon fuel treatments designed for the Diamond project, to be constructed around the 307 acre Mud Lake Unit of the MLRNA. This fuel treatment is critically needed to protect the tens of thousands of Baker cypress seedlings that currently occupy the site. Work completed in FY14 would include surveys, project planning, and development of the NEPA decision document. Implementation of this project would be planned for FY15. This project will result in accomplishments for forest vegetation improvement and fuels reduction.

Monitoring and evaluation: This project will complete a baseline inventory of conditions within and adjacent to the Mud Lake Unit of the MLRNA for use in project planning. Future monitoring to evaluate the success of this project will be conducted beginning in FY15.

Estimated cost: FY14 cost $22,126 for surveys and NEPA analysis. See workplan for additional budget details.

Timeline

Year	Task	Product / Accomplishment
FY14	project planning; NEPA analysis	Categorical Exclusion (CE) completed
FY15-FY16*	Project implementation	Acres treated will count toward Fuel reduction (FUELS-ALL) and Forest Vegetation Improvement (FOR-VEG-IMP) target accomplishments.

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Informing landscape-scale forest restoration using site specific historical reference conditions

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Project Leaders:
Brandon Collins, Research Forester, Pacific Southwest Research Station
Michelle Coppoletta, Associate Province Ecologist, Region 5 Ecology Program
Ryan Tompkins, Forest Silviculturist, Plumas National Forest

Link to Restoration Strategy desired condition and goal:

<u>From Conifer Forest Vegetation (Section 5.1):</u>

Desired Condition – Landscape dominated by later seral open canopy forests, particularly on the south and west facing slopes. Moist mixed conifer stands with more closed canopies would occur primarily within north and eastern aspects and at generally higher elevations. True fir stands with more closed canopy forest structure would be primarily restricted to the highest elevations with a preference for more mesic northern and easterly aspects.

Goal 2 – Restore landscape heterogeneity in terms of spatial and temporal variability, forest type and species diversity, and forest seral stages and structure.

Goal 3 – Restore the forest landscape to one that is well-adapted to natural disturbance regimes and can respond to changes in climate and disturbance regimes.

<u>From Hardwood Forest section (Section 5.2)</u>

Goal 1 – [Restore] a diversity of structural and seral conditions in proportions that are ecologically sustainable at the watershed scale;

Goal 1 – [Maintain] sufficient quality and quantity of hardwood ecosystems to provide important habitat elements for wildlife and native plant species.

<u>From Montane and Mixed Chaparral (Section 5.3)</u>

Desired condition – Maintain montane and mixed chaparral on the landscape at the appropriate extent and patch sizes to contribute to landscape heterogeneity, biodiversity, and soil nutrients, without precluding succession to forest vegetation on appropriate sites.

Goal 1 – Maintain montane and mixed chaparral on sites where edaphic conditions preclude the establishment of other species.

Goal 4 – Promote patch size distributions of montane and mixed chaparral that maximizes landscape heterogeneity, species diversity, wildlife habitat and nutrient cycling, while minimizing the likelihood of widespread, permanent type conversion on sites that would be in dynamic equilibrium with forest dominated vegetation under an active fire regime.

Objective: Describe the distribution of vegetation types and structures in the 1941 landscape and compare that to the contemporary landscape, both prior to and following the suite of recent fires (Boulder Complex, Antelope Complex, and Moonlight fire).

Project justification: The Moonlight Fire Restoration Strategy outlines a landscape-scale approach for restoring vegetation patterns that are more consistent with what occurred in these areas historically under an intact fire regime. Based on a number of studies that have reconstructed historical forest conditions, it appears that landscapes with intact fire regimes included relatively dense, even-aged stands and shrub patches, as well as the often referenced open, park-like, multi-aged stands. Actual proportions in each vegetation type/structure are largely unknown due to the limitations of historical reconstruction studies. The proposed study would provide this information using the 1941 aerial photographs. While 1941 certainly does not capture an unperturbed forest condition, it does predate heavily mechanized fire suppression and timber harvesting.

Project description: A full set of 1:24,000 exits in hard copy for the Plumas NF. Work is underway to digitally scan and orthorectify a subset of these photos to allow for GIS analysis. This subset comprises the Moonlight and Antelope Complex fires, along with the surrounding landscape. In total, the area of interest is approximately 200,000 acres, including the ten watersheds containing the Moonlight Fire and the Antelope Complex. This is the same analysis area used in Moonlight Fire Restoration Strategy (Figure 8). Using aerial photo interpretation techniques, including both supervised and unsupervised image classification, we will quantify patch sizes of the different vegetation types/structures (e.g., shrub-dominated, open canopy forest, dense canopy forest). We will also explore the extent to which topography and soil type control the vegetation patterns observed in 1941. We will then assess change in vegetation patterns both prior to and following the recent large fires (Boulder, Antelope, and Moonlight). Contemporary vegetation will be determined both from CalVEG and from 2005/2009 NAIP images. This comparison to both pre- and post-fire vegetation will examine whether recent fires moved landscape vegetation patterns closer to or further away from historical patterns. ***The intent is to provide guidance to restoration efforts aimed at creating vegetation conditions consistent with those existing under a more intact fire regime*.** These conditions are often assumed to reflect more resilient landscapes that can withstand external stressors, namely fire and changing climate (Fulé 2008; Stephens et al. 2010).

This project would inform project level, site-specific planning for restoration projects, as well larger forest-level and bio-regional planning efforts. The project timelines and product development would be coordinated as best as possible to meet the Forest FY14 planning needs of ID Teams for specific restoration projects. The Wildcat Fuel Reduction project, Range NEPA, and Heritage Projects are a few that would directly use information generated from the proposed research project. The research would contribute to partnerships between the Plumas NF, PSW, and Region 5 Ecology Program and would produce a publication which would contribute to PSW fire research accomplishments (RES-PUBL, RES-FIRE-NDX, RES-FIRE-QUAL-NDX).

Archaeological and Other Cross Disciplinary Benefits: The 1941 aerial photographs of the Plumas NF have been a valuable tool for historians and archaeologists for many years. On occasion, single prints have been digitally scanned for interpretive uses in conjunction with historic and modern maps, and more recently with ortho-photography. Up to this point, however, there has been no means to utilize these images directly in GIS analysis. The 1941 aerial photo collection, the oldest complete over-flight photo set of the Forest, often shows historic era features such as settlements, past mining developments, past logging patterns and methods, and transportation systems. These images are particularly useful for tracing historic linear features such as ditches, trails, roads and railroads; many of which can date decades prior to the date of the aerial photos themselves. An overlay of the 1941 photo set with cultural resource data could prove exceedingly useful for predictive modeling and sensitivity assessments for site locations and understanding past human influence on the landscape. Finally, on perhaps a more practical level, digitizing would allow for enhanced preservation the photos themselves with copies being readily available for use from a digital library without having to rely on an aging, and largely irreplaceable, set of hard copy prints.

In addition to heritage resources, we anticipate the GIS products from this project proposal would have cross disciplinary benefits for Interdisciplinary teams planning restoration projects for vegetation, wildlife, watershed, and range resources.

Monitoring and evaluation: The fact that staff from both the R5 Ecology Program and the Plumas NF is co-principal investigators will insure a direct communication link between the researchers and the end-users, Plumas NF resource staff. This will provide an accessible and efficient process for updating forest staff on progress and review of draft products (see products below).

Estimated cost and timeline: The proposed project will be a collaborative effort between the Plumas NF, R5 Ecology Program, and PSW. The majority of the image analysis and write-up of the final report will be conducted by Collins and other PSW staff. The contribution from the Plumas NF and the Ecology Program will consist of local expertise in developing vegetation classes and evaluating draft vegetation maps, in addition to writing the final report. ***Deliverables will be***: 1) final report detailing vegetation patterns in 1941, 2005, and 2009; 2) vector maps available in GIS format of the classified vegetation in 1941, 2005, 2009, and 3) a journal publication.

The duration of the project is 1.5 years. We anticipate the processing of the aerial photography and the vegetation classification will take approximately 10 months. Analysis of landscape vegetation patterns and comparison among the three time periods will take approximately 4 months. The write-up of the final report and preparation of a journal manuscript will take an additional 4 months. Funding requested includes: 12 months of salary plus benefits for a GS-9/3 Biological Science Technician at PSW ($72k), 1.5 months of salary plus benefits for the associate province ecologist - Coppoletta ($9k), use of computer facilities for image processing at UC Davis Information Center for the Environment ($2k), and travel ($2k). The total funding requested is $85,000. Contributed funds include salary plus benefits for Collins (3 months -

$29k), Coppoletta (3 weeks - $4.5k), Tompkins (2 weeks - $4k), and Dan Elliot, Plumas NF Heritage Program Manager (1 week - $2K).

Timeline

Year	Task	Product / Accomplishment
FY14	Data analysis (image processing and vegetation classification)	• Georeferenced historic 1941 photos; • GIS classification (GIS layer) of historic (1941); pre-fire (2005); and post-fire (2009) vegetation; • Support to IDT in development of desired conditions and prescriptions for proposed vegetation (i.e. Wildcat) and heritage projects
FY15	Completion of final report and publication	Final report and publication; associated targets include: RES-PUBL, RES-FIRE-NDX, RES-FIRE-QUAL-NDX
FY16	Ongoing IDT support	Products from this project would have cross disciplinary benefits for IDTs planning restoration projects for vegetation, wildlife, watershed, and range resources.

Moonlight Fire Restoration Project Proposal (2014)

Invasive Plant Treatments and Inventory

Project Leader Name: Jim Belsher-Howe (Botanist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goal: The desired condition for the Moonlight Fire area is a diverse and resilient native plant community free of invasive plant species. Within and adjacent to the fire, new introductions of invasive plants are prevented, new infestations are rapidly treated, and established infestations are contained and controlled where they threaten wildland values or pose a high risk of spread to uninfested areas.

Objective: This project will contribute to the following goals and objectives, which were identified in the Moonlight Fire Restoration Strategy (Section 5.6):

- Detect new infestations of invasive species promptly by creating and maintaining complete, up-to-date inventories of infested areas, and proactively identifying and inspecting susceptible areas that are not infested.
- Use an integrated approach to treat invasive plant infestations. Use the best available information to select the most effective combination of treatment methods, including manual, cultural, chemical, and biological controls.
- Control new infestations promptly. Where control is not feasible, suppress or contain expansion of infestations. Refer to Table 36 (in the strategy) for species-specific management goals.
- Assess the efficacy of control treatments. Conduct follow-up inspection of treated sites to prevent reestablishment.

Project justification: Invasive plant management is an important component of restoration in the Moonlight Fire area. Increased activity from restoration activities, as well as the large number (~ 74%) of infestations situated in close proximity to roads or trails, increases the risk of introduction and spread into less-invaded portions of the Moonlight fire area. At present, over 750 infestations, covering about 240 acres, have been documented within and adjacent to the fire; 444 sites (~125 acres) occur within the boundary of the Moonlight fire. Although some post-fire surveys have been conducted, the majority of these sites have not been accurately assessed since prior to the fire.

Manual control treatments of some infestations have occurred on an annual basis since 2002. The total acreage treated each year is less than five percent of the total present due to a lack of funding and completed environmental analysis for herbicide treatment. Although treatments have been limited in scope, they have been successful in eradicating a few small populations and reducing the size or preventing the spread of several others.

Project description: In 2014, manual eradication and control efforts will continue on approximately 7.5 acres of invasive plant infestations. In addition, an inventory of weed sites

will be conducted to document changes in the size of infestations, number of individuals, and any existing or potential threats to native plant communities or sensitive resources. Many of the weed sites in the Moonlight Fire area have not been revisited since they were first documented prior to the fire; over 200 new infestations were discovered after the fire. This baseline information will be used to prioritize treatment of weed sites across the Moonlight Fire area and to develop a large-scale weed treatment project (target FY15).

Future invasive plant projects that are tied to this:

- Treatment of invasive plants in the Moonlight Fire area using an integrated approach
- Identification of weed-free locations for future fire camps. These will be mapped and resurveyed annually.

Monitoring and evaluation: Invasive plant monitoring within the Moonlight Fire area will focus on the effectiveness of treatment activities. Managers will use monitoring results to evaluate changing conditions and new information on an ongoing basis and then assess the need to refine site-specific treatment strategies. The length of time for monitoring and the level of intensity needed will vary depending on the species; for example, a plant that reproduces vegetatively may need to be monitored longer than an annual that reproduces exclusively from seed. In the short-term, control efforts will be evaluated with follow-ups approximately one to two months following treatment to assess the efficacy of controls and to check for the presence of seedlings. In the long-term, a site should be monitored annually for at least the first three to five years following treatment. If no plants are found, the monitoring frequency can decrease to every other year for the next five to ten years or until the seed bank has been exhausted and no new germination is taking place.

Estimated cost and timeline: Cost of inventory and limited treatment in FY14: $26,231

Year	Task	Product / Accomplishment
FY14	manual eradication and control; inventory and assessment	Approximately 7.5 acres treated (INVPLT-NXWD-FED-AC)
FY15*	Continued manual treatment; treatment prioritization; potential development large-scale weed treatment project (based on FY14 assessment)	Acres treated (INVPLT-NXWD-FED-AC) Potential proposed action
FY16*	Continued manual treatment; NEPA analysis	Acres treated (INVPLT-NXWD-FED-AC) NEPA document; level of analysis (CE vs. EA) will be dependent upon proposed action
FY17*	Treatment implementation	Acres treated (INVPLT-NXWD-FED-AC)

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Cliff Nesting Raptor Habitat Enhancement

Project Leader Name: Colin Dillingham (Wildlife Biologist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goal: Desired conditions for golden eagles and prairie falcons include adequate levels of open foraging habitat as well as suitable nesting structure, which may be either late-seral forests or tall cliff sites with suitable platforms for nests. Goals are to maintain species viability of golden eagles and prairie falcons (PNF LRMP 4-33). Maintain suitability of prairie falcon and golden eagle territories. Provide suitable nesting structure to allow continued nesting of golden eagles.

Objective: Restore nesting habitat for golden eagle habitat as replacement habitat lost when the Moonlight Fire destroyed late-seral nesting habitat for golden eagles. Identify 2-3 cliff sites within the Moonlight Fire area that may support nesting eagles and create a suitable ledge inaccessible by predators to compensate for habitat lost in the Moonlight Fire.

Project justification: This project meets all criteria set forth by 16 USC 579c because it: 1) Improves and restores lands affected by the Moonlight Fire; 2) Is on lands administered by the Forest Service; and 3) Replace habitat lost during Moonlight Fire burned majority of suitable nesting habitat.

Project description: Plan project and award contract for two cliff site enhancement sites. The Moonlight Fire destroyed thousands of acres of suitable raptor habitat, including habitat for Golden Eagles, which also nest on cliffs. As compensation for lost nesting habitat, find and develop two cliff sites to sustain long term nesting capability through eyrie development (potentially blasting to create cliff platform and install pea gravel for nesting substrate through contract). This would require surveys for project development, NEPA planning to clear project through environmental process, and contract development.

Monitoring and evaluation: Monitoring of project development would be through surveys of cliff enhancement sites and determining occupancy. Data would be collected 1-2 times annually to determine if cliff enhancement sites are being using by raptors. If cliff sites are used within 10 years, site will be considered a success.

Estimated cost and timeline: Total cost for project: $23,479, including personnel and fleet costs. See work plan for budget details.

Year	Task	Product / Accomplishment
FY14	Fall 2013 – conduct surveys to locate potential cliff nesting sites Winter 2013 – complete NEPA and write contract Spring 2013 – award contract Summer 2013 – Implement contract	Categorical Exclusion (CE) Accomplishment target: terrestrial habitat improved (TER-HAB-IMP)

Moonlight Fire Restoration Project Proposal (2014)

Wildlife Habitat Improvement (Guzzler) Replacement

Project Leader Name: Colin Dillingham (Wildlife Biologist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goal: Desired condition for deer habitat is to contribute to the stability of deer populations and/or habitat status trend for these habitats across the Sierra Nevada bioregion. Maintain a diversity of available water, forage habitat, hiding cover, and thermal cover. Goals are to protect and improve habitat for harvest species (PNF LRMP 4-34). Provide resources where gaps exist in habitat (such as provide water in wildlife guzzlers).

Objective: Replace deer habitat enhancement structures, such as water catchment guzzlers, that were ***lost during Moonlight Fire***. Prior to the fires, guzzlers were placed to increase water distribution for wildlife species, specifically deer, quail and grouse. Numerous other species of wildlife also took advantage of increased water availability. Monitoring of wildlife guzzlers found that deer, bear, gray fox, squirrels, songbirds, quail and striped skunks were frequent users of the additional water available. Twelve of the 13 guzzlers burned in the Moonlight (N = 9) and Antelope Complex (N = 3) fires. Eight of the nine guzzlers destroyed by the Moonlight Fire should be replaced.

Project justification: Prior to the Moonlight and Antelope Complex fires there was a network of 13 water catchment devices (termed guzzlers) in the analysis area. Guzzlers were originally placed in the area to increase water availability for wildlife species (e.g., deer, quail and grouse) in areas with limited access to water. The eleven guzzlers destroyed by the Moonlight and Antelope fires should be replaced. This project meets all criteria set forth by 16 USC 579c because it: 1) Improves and restores lands affected by the Moonlight Fire; 2) Is on lands administered by the Forest Service; and 3) Replaces habitat improvement structures lost during Moonlight Fire.

Project description: The Moonlight Fire burned nine wildlife guzzlers. The objective of the project proposal is to gradually replace these deer habitat structures. Past wildlife habitat investments were lost when the Moonlight Fire destroyed the guzzlers. A cooperative agreement with the Mule Deer Foundation would be used to implement this project using volunteer labor.

Monitoring and evaluation: Monitoring of guzzlers would be done using remote wildlife cameras on two survey periods per guzzler. Data would be reviewed to determine if deer and other species of wildlife are using guzzlers and to determine if they are functional. If guzzlers are being used by wildlife, project will be considered a success.

Estimated cost and timeline: Total cost for project: $15000, including personnel and fleet costs for 2014. See work plan for budget details. Cost estimate includes plan to use volunteer effort from Mule Deer Foundation for guzzler installation.

Year	Task	Product / Accomplishment
FY14	Replace 2 guzzlers and monitor success	500 acres per guzzler of Terrestrial habitat improved (TER-HAB-IMP); no NEPA required
FY15*	Replace 2 guzzlers and monitor success	500 acres per guzzler of Terrestrial habitat improved (TER-HAB-IMP); no NEPA required
FY16-17*	consider replacing 4 additional guzzlers pending monitoring results	500 acres per guzzler of Terrestrial habitat improved (TER-HAB-IMP); no NEPA required

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Moonlight Fire California Spotted Owl Monitoring

Project Leader Name: Colin Dillingham (Wildlife Biologist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goals:

- Maintain an abundance of late seral forest habitat types to provide for viable wildlife populations.
- Response by spotted owls from fuels management is not well studied. Monitoring of spotted owl PACs is necessary to determine occupancy and productivity both before and after treatments.
- Provide a diversity of vegetation types and habitat to support viable populations of all wildlife species.
- Maintain viability of snag-dependent wildlife.
- Maintain viability of species dependent upon dead and down material.
- Maintain burned forest habitat as an ecological component of the forest.
- Remaining burned forest habitat is accessible to California spotted owls

Objective: This study will monitor California spotted owl nesting activity in existing territories and determine if proposed spotted owl PAC treatments negatively impact owls or habitat suitability. This project also will estimate post-fire habitat use (wild and prescribed fire) by nesting owls in and outside the moonlight fire footprint (e.g. Chips Fire area) to adequately direct restoration activities in burned forests (retention of key remnant burned forest patches in the analysis are) and estimate how owl use of burned forests varies over time. For example, is burned forest adjacent to owl nesting habitat primarily used by owls immediately after the fire, or do owls utilize burned forests for many years?

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service; and
- Will determine if proposed spotted owl PAC treatments negatively impact owls or habitat suitability, and direct restoration activities to avoid burned forest habitats utilized by owls and quantify burned forest characteristics associated with owl use..

Project description: Collaborative study with USDA Pacific Southwest Research Station to monitor California spotted owl nesting activity in existing territories and determine if proposed spotted owl PAC treatments negatively impact owls or habitat suitability. Project also will monitor California spotted owl use of burned forests, in and out of the moonlight fire footprint

(e.g., Chips Fire area) to understand owl use of burned forests and retain key remnant burned forest patches within the analysis area during restoration activities.

Monitoring and evaluation:

1. Late seral forests - Survey for California spotted owl occupancy in existing territories. Determine if proposed spotted owl PAC treatments negatively impact owls or habitat suitability; Survey for northern goshawk occupancy in existing territories. Determine if proposed goshawk PAC treatments negatively impact owls or habitat suitability.
2. Monitor California spotted owl use of burned forests to retain key remnant burned forest patches within the analysis area. Monitoring directed at improving our understanding of owl use of burned forest habitat would benefit from sampling owl behavior in recently burned patches on the forest (i.e., Chips Fire landscape) as well as within the Moonlight and Antelope Complex fire footprints to better inform post fire restoration activities.
3. Shrublands and Early and Mid Seral Forests – Conduct avian and mammalian surveys prior to and post restoration to quantify impacts of activities (e.g., thinning, mastication, and prescribed fire) on avian and mammalian communities.

Estimated cost and timeline: This project will be initiated in FY14 at an estimated cost $60,000 (personnel time, vehicles, telemetry equipment). We anticipate requesting three additional years of field support and one year for analyses and report preparation.

Year	Task	Products (NEPA required)
2014	Monitor owl reproductive success and habitat use prior to restoration activities: evaluate owl use of burned forest habitat.	Habitat use results used to direct restoration activities within PACs. Collect baseline measures to evaluate management success (no NEPA required, but these surveys area required to develop EA for PAC treatments).
2015*	Monitor owl reproductive success and habitat use prior to, and during, restoration activities: evaluate owl use of burned forest habitat.	Habitat use results used to direct restoration activities within PACs. Baseline measures to evaluate management success (no NEPA required, but these surveys area required to develop EA for PAC treatments). Restoration activities that this project will monitor and evaluate will enhance terrestrial and stream habitats (HBT-ENH-TERR, HBT-ENH-STRM).
2016*	Monitor owl reproductive success and habitat use prior to, during, and after restoration activities: evaluate owl use of burned forest habitat.	Post restoration monitoring to evaluate if proposed spotted owl PAC treatments negatively impact owls or habitat suitability. Restoration activities that this project will monitor and evaluate will enhance terrestrial and stream habitats (HBT-ENH-TERR, HBT-ENH-STRM).

Year	Task	Products (NEPA required)
2017*	Monitor owl reproductive success and habitat use post restoration activities: evaluate owl use of burned forest habitat.	Post restoration monitoring to evaluate if proposed spotted owl PAC treatments negatively impact owls or habitat suitability. Restoration activities that this project will monitor and evaluate will enhance terrestrial and stream habitats (HBT-ENH-TERR, HBT-ENH-STRM).
2018*	Analyze results and prepare final report.	Final report on: owl responses to restoration activities, identification key habitat patches where future restoration efforts may be directed, identification of any remnant burned forest patches within the analysis area used by owls, management direction on managing burned forest habitat for spotted owl use during restoration activities.

Moonlight Fire Restoration Project Proposal (2014)

Moonlight Fire Black-backed Woodpecker Monitoring

Project Leader Name: Matthew Johnson (WFRP program manager, PNF)

Link to Restoration Strategy desired condition and goal:

- Provide a diversity of vegetation types and habitat to support viable populations of all wildlife species (PNF LRMP 4-29).
- Maintain viability of snag-dependent wildlife (PNF LRMP 4-30).
- Maintain viability of species dependent upon dead and down material (PNF LRMP 4-31).
- Maintain burned forest habitat as an ecological component of the forest.
- Retain patches of burned forest adjacent to intact green forest.
- Manage a substantial portion of burned forest habitat as large patches (minimum of 50 acres, preferably larger) of high severity burned forest habitat. Consider that post-fire habitats are still being used by a diverse and abundant wildlife community.
- Delineate burned forest habitat patched in locations with relatively higher densities of larger diameter trees. Retain burned forest patches in areas where pre-fire snags are abundant as these are the trees most readily used by avian species during the first five years post fire. Retain snags in salvaged areas in the largest and densest clumps possible, exceeding green forest standards. Retain smaller snags in heavily salvaged areas as well, as a full size range of snags are necessary to accommodate the suite of species utilizing these resources.
- Snag retention immediately following a fire should aim to achieve a range of snag conditions from heavily decayed to recently dead in order to ensure a longer lasting source of snags for wildlife.
- When reducing snags in areas more than five years post fire, snag retention should favor large pine and Douglas-fir but decayed snags of all species with broken tops should be retained in burned areas when feasible.
- Retain snags (especially large pines) in areas being re-vegetated as these may be the only source of snags in those forest patches for decades to come.

Objective: Monitor Black-backed woodpeckers (collaborative study with Institute for Bird Populations) to evaluate restoration opportunities and activities, quantify the effects of restoration activities (i.e. disturbance) to nesting woodpeckers, and evaluate mitigation buffers

as a management tool to ameliorate disturbance to nesting birds. This project will identify areas to avoid modifying burned forest habitat (i.e. removing habitat occupied by black-backed woodpeckers), as well as areas not utilized by woodpeckers prior to implementing ground disturbing activities. Black-backed woodpecker densities in six year old burned forests on the Plumas NF (Wheeler and Antelope Complex fires) were similar to the highest densities observed in the Sierra Nevada within burned forest of any age, and woodpeckers were abundant during 2012 in the Moonlight Fire footprint; however, it is unknown how long the analysis area will support woodpecker occupancy. Although it appears that black-backed woodpecker occupancy begins to decline between 5-8 years post fire in the Sierra Nevada, but it is unclear what factors most influence persistence. This project also will quantify forest attributes in relation to occupancy to evaluate factors import for woodpecker occupancy in burned forests of varying age, and direct restoration activities to promote or retain those factors.

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service; and
- will identify areas currently occupied by black-backed woodpeckers and areas not utilized by woodpeckers prior to implementing ground disturbing activities, quantify the effects of restoration activities (i.e., disturbance) to nesting woodpeckers, and evaluate mitigation buffers as a management tool to ameliorate disturbance to nesting birds.

Project description: Results from this project will indicate where restoration activities in burned forest habitats should be directed to avoid destroying black-backed woodpecker habitat, and evaluate disturbance to nesting birds caused by restoration activities and the use of mitigation buffers as a tool to ameliorate adverse effects to nesting birds. Further, the project will quantify forest attributes in relation to occupancy to evaluate factors import for woodpecker occupancy in burned forests of varying age, and direct restoration activities to promote or retain those factors.

This is a collaborative study with the Institute for Bird Populations (IBP) to identify and evaluate restoration activities and assess habitat suitability and persistence for black-backed woodpeckers. IBP is a USDA FS partner and conducts black-backed woodpecker MIS monitoring at the regional level. This project also will identify areas to avoid modifying burned forest habitat (i.e., occupied habitat), and areas not utilized by woodpeckers prior to implementing ground disturbing activities. Further, this project will quantify disturbance to nesting woodpeckers during restoration activities and evaluate the effectiveness of mitigation buffers at ameliorating disturbance to breeding birds.

Systematic searches, broadcast surveys, and radio-transmitters will be used to locate black-backed woodpecker nests. After discovery, nests will be monitored at least every 4 days until the nest fails or fledges young. When nests are discovered in proximity to restoration activities,

each of these nests will be assigned to one of three experimental treatments. Experimental treatments will consist of centering a mitigation buffer (measuring 1, 12, or 24 acres) on each nest, and curtaining all restoration activities within the mitigation buffer until the nest fails or fledges young. Space use, nest attendance and parental behaviors will be monitored at nests treated with a mitigation buffer and at nests not exposed to disturbance to evaluate mitigation buffer effectiveness.

Black-backed woodpecker space use appears to be highly variable (home range size ranged between 59 and 168 acres in the Wheeler Fire footprint, Siegel et al. 2013), and habitat occupancy varies with burned forest habitat age. To adequately assess mitigation measures, evaluate factors import for woodpecker occupancy in burned forests of varying age, and direct restoration activities to promote or retain those factors woodpecker nest monitoring will need to occur in burned forest habitats of varying age and disturbance regimes. Therefore, nest monitoring will occur within the Moonlight fire footprint, and burned forests outside the footprint (e.g., Wheeler and Chips Fire).

Results will indicate how restoration activities near nesting woodpeckers impact nesting behavior and success, and whether restoration buffers may be employed to reduce negative impacts to nesting woodpeckers.

Monitoring and evaluation:

- Burned forests – Survey for black-backed woodpeckers in burned forest habitats and plan restoration activities to maximize woodpecker productivity.
- Evaluate factors, temporal and spatial, are influencing black-backed woodpecker occupancy dynamics in post fire landscapes, how do we manage and restore burned forest habitats in the short- and long-term, for burned forest specialists (e.g., black-backed woodpeckers)?

Estimated cost and timeline: This project will be initiated in FY14 at an estimated cost $40,000 (2-person field crew, analyses and management recommendations). We anticipate requesting additional support (FY15, FY16) for this project (additional field work) and one year for analyses and report preparation (FY17).

Year	Task	Products (NEPA required)
2014	Survey black-backed woodpecker habitat within moonlight fire perimeter. Quantify reproductive success and parental behavior. Implement mitigation buffer study where feasible.	Preliminary report identifying areas to avoid modifying burned forest habitat (i.e., removing habitat occupied by black-backed woodpeckers), as well as areas not utilized by woodpeckers prior to implementing ground disturbing activities. Baseline and experimental data on breeding behavior and success. Preliminary measures of mitigation treatment success (no NEPA required, but these surveys area required to develop CEs, EAs or EISs for projects occurring in burned forest habitat suitable for black-backed woodpeckers.
2015*	Survey black-backed	Preliminary report identifying areas to avoid modifying burned forest

Year	Task	Products (NEPA required)
	woodpecker habitat within moonlight fire perimeter. Quantify reproductive success and parental behavior. Implement mitigation buffer study where feasible.	habitat (i.e., removing habitat occupied by black-backed woodpeckers), as well as areas not utilized by woodpeckers prior to implementing ground disturbing activities. Baseline and experimental data on breeding behavior and success. Preliminary measures of mitigation treatment success (no NEPA required, but these surveys area required to develop CEs, EAs or EISs for projects occurring in burned forest habitat suitable for black-backed woodpeckers.
2016*	Survey black-backed woodpecker habitat within moonlight fire perimeter. Quantify reproductive success and parental behavior. Implement mitigation buffer study where feasible.	Identify where restoration activities in burn forest habitats should be directed to avoid destroying black-backed woodpecker habitat. Baseline and experimental data on breeding behavior and success. Preliminary measures of mitigation treatment success (no NEPA required, but these surveys area required to develop CEs, EAs or EISs for projects occurring in burned forest habitat suitable for black-backed woodpeckers.
2017*	Analyze results and prepare final report.	Final report that evaluates restoration opportunities and activities in the analysis area, quantifies effects of restoration activities (i.e., disturbance) to nesting woodpeckers, and evaluates mitigation buffers as a management tool to ameliorate disturbance to nesting birds. Further, the report will quantify forest attributes in relation to occupancy to evaluate factors import for woodpecker occupancy in burned forests of varying age, and direct restoration activities to promote or retain those factors.

Moonlight Fire Restoration Project Proposal (2014)

Aquatic Organism Passage, 27N09 at East Branch Lights Creek

Project Leader Name: Ryan Nupen

Link to Restoration Strategy desired condition and goal:

Stabilize and maintain the identified transportation system needed to support the general Moonlight Fire Restoration effort.

To provide viable and sustainable aquatic organism passages as part of the Moonlight Fire Restoration, Wildlife Recovery, strategy and goals.

Objective: : To correct and mitigate for the adverse effects of accelerated run-off and debris collection that has effectively blocked passage of many aquatic organisms past the 27N09 crossing of East Branch Lights Creek

Project justification: This project is within the Moonlight Fire perimeter. The damage to the stream channel at, and adjacent to, the 27N09 crossing has effectively blocked passage of many AOs, particularly fish, due to debris and stream-bed degradation. Construction of a bottomless arch will allow the reestablishment of a more natural stream channel at the crossing. Surveys will be completed in FY13; it is expected that a moderate amount NEPA work will be required in FY14.

Project description: Construct a bottomless arch structure to carry the road over the stream.

Monitoring and Evaluation: Monitoring and evaluation will be accomplished by the hydrology and biology specialists as part of their continued activities within the recovery area.

Estimated cost and timeline: Cost projection is estimated to be $127,000. Cost for design, solicitation, preparation, and administration is estimated to be $19,500.

The project will be completed in FY 2014 under the condition that surveys and NEPA are completed.

Moonlight Fire Restoration Project Proposal (2014)

Lone Rock Creek Cattle Exclosure (TES, Sierra Nevada Yellow-legged Frog)

Project Leader Name: Tina Hopkins (Fisheries Biologist, PNF)

Link to Restoration Strategy desired condition and goal:

- Identifying potential impacts of grazing on riparian habitats and mitigating negative impacts;
- Determining the distribution and abundance of SNYLFs across the restoration analysis area, in and outside of proposed critical habitat;
- Assessing habitat condition for SNYLF across the restoration analysis area and restoring degraded habitat;

Objectives: This project will reconstitute a temporary electric fence along Lone Rock Creek to facilitate riparian habitat restoration within proposed critical habitat for Sierra Nevada yellow-legged frogs. Prior to the Moonlight fire, large cut banks and deposition resulted in classification of Lone Rock Creek as functioning-at-risk. There has been concern with grazing impacts to stream banks along Lone Rock Creek coupled with herbivory on willows (Salix) that have consistently resulted in the areas being rated below thresholds of concern. Post fire recovery of riparian vegetation growing along Lone Rock Creek attracts cattle grazing in this area. This fence will restrict cattle use of this riparian area of concern in the Moonlight Fire footprint while it recovers, and protect Sierra Nevada yellow-legged frog populations from potential adverse impacts of cattle grazing (e.g., trampling and increased siltation). Further, the project will plant native riparian vegetation to provide shade and bank stabilization to trampled banks.

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire
- Is on lands administered by the Forest Service
- Facilitates post fire vegetation recovery within proposed critical habitat for the Sierra Nevada yellow-legged frog.

Project description: Plant native riparian vegetation to provide shade and bank stabilization to trampled banks and construct a temporary cattle exclosure. Exclosure will consist of two sections of electric fence along Lone Rock Creek with known population of Sierra Nevada yellow-legged frogs.

Monitoring and evaluation:

- Couple ongoing survey efforts within range allotments (proper functioning condition and end of season use surveys) with additional riparian monitoring to evaluate grazing impacts

on riparian communities and to develop appropriate management priorities and projects to address any negative impacts from grazing.

- Conduct surveys to determine the distribution and size of SNYLF populations and assess habitat condition for SNYLF across the restoration analysis area.
- Monitor SNYLF populations with sufficient frequency to identify significant changes in population size.

Estimated cost and timeline: The project will be implemented in FY14 at an estimated cost $14,000 (personnel time and propagation and fencing materials).

Year	Task	Products (NEPA required)
2014	Reconstitute a temporary electric fence along Lone Rock Creek and plant native riparian vegetation to provide shade and bank stabilization to trampled banks.	Target accomplishments include acres of terrestrial (HBT-ENH-TERR) and stream (HBT-ENH-STRM) habitat restored Watershed and Range improvement (No NEPA required, reconstituting seasonal temporary fence)

Moonlight Fire Restoration Project Proposal (2014)

Aquatic Organism Passage (AOP) Surveys, Database, Project Prioritization, Report

Project Leader Name: Tina Hopkins (Fisheries Biologist, PNF)

Link to Restoration Strategy desired condition and goal:

- Quantify the level of aquatic habitat connectivity within the restoration analysis area and reducing fragmentation where appropriate (e.g., avoid increasing aquatic organism passage where non-native species may negatively impact native species);
- Identifying sedimentation, channel degradation, and contamination issues resulting from mining activities that occurred across the analysis area and implementing reasonable mitigations;
- Identifying first and second order streams most deficit in LWD and restoring this habitat component when feasible;
- Determining the number and location of improperly maintained forest roads, prioritizing reconstruction or decommission for those roads causing relatively higher resource damage, and coordinating road restoration work with AOP assessment and mitigation measures;

Objective: The Moonlight Fire resulted in channel degradation and sedimentation issues across the analysis area. To alleviate these issues, watershed and wildlife restoration activities are assessing culvert and low water crossing conditions and evaluating their effects on watershed and wildlife habitat condition. This project will collate, standardize and QA/QC existing AOP data in the Natural Resource Manager database, prioritize additional AOP surveys, conduct AOP surveys, and prioritize NEPA and implementation for AOP projects in a report to the District Ranger.

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire
- Is on lands administered by the Forest Service
- Corrects and mitigates adverse effects of accelerated run-off and debris collection that has effectively blocked passage of many aquatic organisms.

Project description: Collate, standardize and QA/QC existing AOP data in the Natural Resource Manager database, prioritize additional AOP surveys, conduct necessary AOP surveys, and prioritize NEPA and implementation for AOP projects in a report to the District Ranger.

Monitoring and evaluation:

- Conduct AOP surveys to assess aquatic habitat connectivity. When barriers to AOP are removed or mitigated, assess aquatic community composition and species abundance above and below barriers before and after restoration activity. Populate and maintain USDA corporate AOP database.
- Quantify sedimentation, channel degradation, and contamination issues resulting from mining activities before and after restoration activity.
- Monitor retention of LWD in first and second order streams after restoration activities.

Estimated cost and timeline: This project will be completed in FY14 at an estimated cost $34,000 (personnel time and vehicles).

Year	Task	Products (NEPA required)
2014	Collate, standardize and QA/QC existing AOP data in the Natural Resource Manager database. Prioritize additional AOP surveys. Conduct AOP surveys. Work with District Staff to prioritize NEPA and implementation for AOP projects.	All known AOP related data entered and reviewed in the Natural Resource Manager database. Final report to the District Ranger summarizing AOP work completed thus far, identifying opportunities, and prioritizing those opportunities in a Moonlight AOP strategy. No NEPA required for this project, but this project will prioritize out-year NEPA projects (CEs). Although habitat restoration will not be accomplished during the planning process, projects prioritized in the AOP restoration strategy will produce both stream and watershed accomplishments.

Moonlight Fire Restoration Project Proposal (2014)

Aquatic Organism Passage (AOP) NEPA

Project Leader Name: Tina Hopkins (Fisheries Biologist, PNF)

Link to Restoration Strategy desired condition and goal:

- Quantify the level of aquatic habitat connectivity within the restoration analysis area and reducing fragmentation where appropriate (e.g., avoid increasing aquatic organism passage where non-native species may negatively impact native species);
- Identifying sedimentation, channel degradation, and contamination issues resulting from mining activities that occurred across the analysis area and implementing reasonable mitigations;
- Identifying first and second order streams most deficit in LWD and restoring this habitat component when feasible;
- Determining the number and location of improperly maintained forest roads, prioritizing reconstruction or decommission for those roads causing relatively higher resource damage, and coordinating road restoration work with AOP assessment and mitigation measures;

Objective: Complete NEPA process (categorical exclusions) for two AOP projects within the Moonlight Fire footprint. One project, along Moonlight Creek, has already been identified. Ongoing survey efforts in 2013 will prioritize a second project within the fire footprint.

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire
- Is on lands administered by the Forest Service
- Corrects and mitigates adverse effects of accelerated run-off and debris collection that has effectively blocked passage of many aquatic organisms.

Project description: The NEPA process (categorical exclusions) for two AOP projects within the Moonlight Fire footprint will be completed. One project, along Moonlight Creek, has already been identified. Ongoing survey efforts in 2013 will prioritize a second project within the fire footprint.

Monitoring and evaluation:

- Conduct AOP surveys to assess aquatic habitat connectivity. When barriers to AOP are removed or mitigated, assess aquatic community composition and species abundance above and below barriers before and after restoration activity. Populate and maintain USDA corporate AOP database.

- Quantify sedimentation, channel degradation, and contamination issues resulting from mining activities before and after restoration activity.
- Monitor retention of LWD in first and second order streams after restoration activities

Estimated cost and timeline: The NEPA process will be completed in FY14 at an estimated cost $19,000 (personnel time and vehicles).

Year	Task	Products (NEPA required)
2014	Complete NEPA process for two AOP projects within the Moonlight Fire footprint. One project, along Moonlight Creek, has already been identified. Ongoing survey efforts in 2013 will prioritize a second project within the fire footprint.	Two CEs completed for AOP projects to be implemented when funding becomes available. Although habitat restoration will not be accomplished during the planning process, these projects will produce stream and watershed accomplishments, when implemented.

Moonlight Fire Restoration Project Proposal (2014)

Amphibian and Aquatic Invasive Species Surveys

Project Leader Name: Colin Dillingham (Wildlife Biologist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goal:

- Identifying potential impacts of grazing on riparian habitats and mitigating negative impacts;
- Determining the distribution and abundance of Sierra Nevada yellow-legged frogs across the restoration analysis area, in and outside of proposed critical habitat;
- Assessing habitat condition for Sierra Nevada yellow-legged frogs across the restoration analysis area and restoring degraded habitat;
- Identifying sedimentation, channel degradation, and contamination issues resulting from mining activities that occurred across the analysis area and implementing reasonable mitigations;
- Identifying first and second order streams most deficit in LWD and restoring this habitat component when feasible;
- Manage aquatic invasive species and pathogens to protect, restore, and sustain aquatic ecosystems, ecological functions and values; protect and improve the biodiversity; improve and protect public recreational opportunities and wilderness integrity; prevent negative impacts to human health and the economy, and protect and restore fish and wildlife populations and habitats. Three sets invasive species activities are desirable within the analysis area: Invasive Species Control (Treatments and Treatment Monitoring), Invasive Species Detection (Surveys, Inventories, and Mapping), Invasive Species Prevention (All Prevention Activities, including outreach and education).

Objective: These surveys will directly inform restoration activities in the Moonlight Fire footprint that overlap with riparian habitat and are necessary to develop aquatic species centric projects in FY15, and beyond. Post fire, Sierra Nevada yellow-legged frog habitat across the analysis area is recovering from riparian vegetation loss and other forms of habitat degradation (e.g., increased sedimentation rates). This project will survey priority perennial and intermittent streams and waterbodies for Sierra Nevada yellow-legged frogs (proposed endangered species) and foothill yellow-legged frogs and Western Pond Turtles (FS Sensitive Species) following Regional Protocols, and assess aquatic invasive species (e.g., *Pacifastacus leniusculus*, *Rana catesbeiana*) across the restoration analysis area.

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service; and

- will determine the distribution and abundance of Sierra Nevada yellow-legged frogs and FS Sensitive Species across the restoration analysis area to direct and prioritize restoration activities.

Project description: Survey priority perennial and intermittent streams and waterbodies for Foothill and Sierra Nevada yellow-legged frogs and the Western Pond Turtle following to Regional Protocols, and assess aquatic invasive species (e.g., *Pacifastacus leniusculus*, *Rana catesbeiana*) across the restoration analysis area. These surveys also will directly inform other riparian restoration activities in the Moonlight Fire footprint and is necessary to develop Sierra Nevada yellow-legged frogs centric projects in FY15, and beyond.

Monitoring and evaluation:

- Assess aquatic invasive species (e.g., Pacifastacus leniusculus, Rana catesbeiana) and disease threats (e.g., whirling disease, caused by a myxozoan parasite, Myxobolus cerebralis) across the restoration analysis area.
- Coordinate with governmental and non-government organizations to develop and implement aquatic invasive species education and prevention programs.
- Couple ongoing survey efforts within range allotments (proper functioning condition and end of season use surveys) with additional riparian monitoring to evaluate grazing impacts on riparian communities and to develop appropriate management priorities and projects to address any negative impacts from grazing.
- Conduct surveys to determine the distribution and size of SNYLF populations and assess habitat condition for SNYLF across the restoration analysis area.
- Monitor SNYLF populations with sufficient frequency to identify significant changes in population size.
- Quantify sedimentation, channel degradation, and contamination issues resulting from mining activities before and after restoration activity.
- Monitor retention of LWD in first and second order streams after restoration activities.
- Monitor for non-target effects on riparian systems when herbicides are used during restoration activities.
- Monitor wildlife use of springs and surrounding habitat before and after spring restoration or improvement activities are accomplished.

Estimated cost and timeline: This project will be completed in FY14 at an estimated cost $41,000 (personnel time and vehicles).

Year	Task	Products (NEPA required)
2014	Complete aquatic wildlife and invasive species surveys in priority Sierra Nevada yellow-legged frog habitat.	Occurrence data for aquatic species (proposed endangered species, FS Sensitive and invasive species) entered and reviewed in the Natural Resource Manager database. These data are necessary for restoration planning when proposed activities overlap perennial and intermittent streams providing suitable yellow-legged frog habitat.

Moonlight Fire Restoration Project Proposal (2014)

Moonlight Fire Bat Monitoring

Project Leader Name: Colin Dillingham (Wildlife Biologist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goal: Restoration efforts should identify resource selection by sensitive bat species and use this information to direct restoration activities within the fire footprints and across the analysis area.

Objective: Bat habitat occupancy across the restoration analysis area in unknown, but snags produced by the Moonlight Fire and within the restoration analysis area provides key habitat features (roost and nursery sites) for Forest Service Sensitive bat species. This project will survey habitat occupancy by bats to determine habitat selection throughout the annual cycle to direct restoration activities within the analysis area and promote viable bat communities. Further, forest biologists will work with the Greenville Junior/Senior High School Natural Resources Program students in the classroom and field to pass along the knowledge we gain through this effort, educating students to the importance of burned forest habitats for bat communities and the role bats play the ecosystems where they live.

Project justification: This project meets all criteria set forth by 16 USC 579c because it:

- Improves and protects lands affected by the Moonlight Fire;
- Is on lands administered by the Forest Service; and
- will determine the distribution and abundance of FS sensitive species within the Moonlight Fire footprint, inform restoration across the restoration analysis area, and educate students in the Greenville Junior/Senior High School Natural Resources Program on the importance of burned forest habitat and bat communities in the forest.

Project description: This project will determine habitat occupancy by three FS sensitive bat species in the restoration analysis area. Recently acquired remote bat monitoring stations will be deployed throughout the Moonlight Fire restoration analysis area to determine habitat selection throughout the annual cycle and direct restoration activities within the analysis area and promote viable bat communities. Further, forest biologists will work with the Greenville Junior/Senior High School Natural Resources Program students in the classroom and field to pass along the knowledge we gain through this effort, educating students to the importance of burned forest habitats for bat communities and the role bats play the ecosystems where they live.

Monitoring and evaluation: Monitor habitat occupancy by bats to determine habitat selection throughout the annual cycle to direct restoration activities within the analysis area and promote viable bat communities.

Estimated cost and timeline: This project will be completed in FY14 at an estimated cost $29,000 (personnel time, vehicles, software).

Year	Task	Products (NEPA required)
2014	Survey for FS sensitive bat species across the restoration analysis area.	Presence /Absence point data for bat species in the restoration analysis area entered and reviewed in the Natural Resource Manager database. Identify areas containing relatively high densities of bats. Data collected in FY14 will be used to evaluate restoration impacts on bat occupancy throughout the restoration analysis area. These data are necessary to identify and then maintain or promote habitat suitable for FS sensitive bat species.

Moonlight Fire Restoration Project Proposal (2014)

Range Allotment Analysis

Project Leader Name: Scott Lusk (Plumas NF Range Specialist)

Link to Restoration Strategy desired condition and goal: Desired conditions and goals relevant to this project can be found in Sections 5.10 (Range), 5.4 (Fens, Meadows, Aspen, and Riparian habitats), 5.9 (Aquatic Species), and 5.12 (Hydrology). The desired condition for this project is to develop an ecologically and economically appropriate livestock management strategy for the allotments within the watersheds affected by the Moonlight Fire.

Objective: This project includes the following objectives from Section 5.10 (Range Desired Conditions, Goals, and Objectives):

- Collect data on meadow ecological seral stage; range condition (using Parker Three Step methods and Region 5 Range Monitoring plots); stream, spring, and fen proper functioning condition (PFC); and wildlife and heritage resources for the six allotments affected by the Moonlight Fire.
- Conduct rangeland monitoring in order to document change over time in vegetation or other rangeland resources and to determine the impact of wildfire on range resources.
- Monitor permit use compliance in accordance with the standards listed in Table 37. Utilize this information to develop recommendations for livestock number, season, and grazing system, which will be used in the NEPA analysis.
- Use inventory and monitoring data to assess environmental impacts in a NEPA analysis and decision for the six allotments affected by the Moonlight Fire.

Project justification: Range conditions were altered by the 2007 Moonlight Fire. As a result of the fire, twelve head of cattle were burned and died and over 20 miles of fence was damaged or destroyed. Five gates were burned and one cattleguard, on NFS road 28N03, was crushed due to heavy fire suppression traffic (USDA 2007c). The Lone Rock permittee also had to rent pasture outside of the fire in 2008 for his herd.

The Moonlight Fire may have affected livestock use patterns in several ways. Immediately after the fire, areas that burned with moderate to high severity likely had reduced amounts of forage, which may have caused livestock to move to unburned areas to graze. In the year following the fire, burned areas probably supported higher amounts of forage as a result of resprouting, which may have concentrated livestock in these areas. While the long-term effect of the fire on forage may have been positive for livestock, altered use patterns also likely impacted other habitats (i.e. riparian areas or meadows) and species. The purpose of this project is to conduct a comprehensive environmental analysis to analyze the effect of altered livestock patterns and use on a suite of resources after the Moonlight Fire. This project will ultimately determine the most ecologically and economically appropriate livestock

management strategy for the allotments within the affected watersheds. These analyses are needed to determine carrying capacity and whether livestock use should continue to be authorized within the analysis area allotments according to the 2004 *Sierra Nevada Forest Plan Amendment* standards and guidelines.

Project description: The 1995 Recessions Act says no changes to grazing, that is, reducing number, season, or changing grazing system, can be made with expiring permits until NEPA analysis is completed. This project consists of an analysis of condition and trend of meadows, fens, creek, springs, upper and understory vegetation. The decision will be made on number, kind, class of livestock, season of use, use standards and guides, allowable use, monitoring areas, pasture rotation, range improvements, and areas of concerns.

Monitoring and evaluation: Meadow monitoring will use Region 5 Long Term Meadow and Rapid Meadow Assessment protocols and plots. The National Riparian Team's 'Proper Function Condition' assessment guide will be used on creeks (TR 1737-9 1993), springs (TR 1737-16 2003), and fens (R5-TP-028). Multiple Indicator Monitoring (MIMs) TR 1737-23 2011) protocols will be used to assess stream channels and streamside vegetation.

Estimated cost and timeline: Allotment NEPA is a two year process. The first year (FY14) data is collected. The second year the environmental analysis, including scoping and the Decision, is completed. The following is an outline of the tasks associated with allotment analysis as well as their estimated costs and timeline.

Year	Task	Estimated Cost	Product / Accomplishment
FY14	Data collection (meadow ecological seral stage; Parker Three Step Rereads, and Wiexleman Plots; stream, spring and fen PFC; wildlife and heritage surveys) on **Lights Creek, Lone Rock, Antelope, and Antelope Lake Allotments**	$ 90,500	Data collection and analysis
FY15	Write NEPA analysis and decision on **Lights Creek, Lone Rock, Antelope, Antelope Lake**	$120,000	4 Environmental Assessments (EAs) completed
	Permit Use compliance with <20% bank alteration, <20% riparian shrub use, and <40% meadow use: **Lights Creek, Lone Rock, Antelope, Antelope Lake**	$35,000	Target: acres administered to standard
FY16	Permit Use compliance with <20% bank alteration, <20% riparian shrub use, and <40% meadow use on **Lights Creek, Lone Rock, Antelope, Antelope Lake**	$35,000	Target: acres administered to standard
FY17	Data collection (meadow ecological seral stage; Parker Three Step Rereads, and Wiexleman Plots; stream, spring and fen PFC; wildlife and heritage surveys) on Hungry Creek and Taylor Lake Allotments	$110,000	Data collection and analysis
	Permit Use compliance with <20% bank alteration, <20% riparian shrub use, and <40% meadow use: **Lights Creek, Lone Rock, Antelope, Antelope Lake**	$35,000	Target: acres administered to standard

FY18	Write NEPA analysis and decision on **Hungry Creek and Taylor Lake Allotments**	$120,000	Two EAs completed
	Permit Use compliance with <20% bank alteration, <20% riparian shrub use, and <40% meadow use: Lights Creek, Lone Rock, Antelope, Antelope Lake, Hungry Creek, and Taylor Allotments		Target: acres administered to standard

Moonlight Fire Restoration Project Proposal (2014)

Geomorphic Road Assessment and Inventory Package (GRAIP) Road Inventory

Project Leader Name: Kurt Sable (Hydrologist, Mt Hough Ranger District)

Link to Restoration Strategy desired condition and goal: Desired conditions from the Hydrology and Transportation Sections (5.12 and 6.5.1) include: (a) meeting water quality goals of the Clean Water Act; (b) keeping sediment regimes as close as possible to those which aquatic and riparian biota evolved; and (c) having a sustainable transportation network that has minimal impact to water quality and aquatic resources.

Goals from the Hydrology and Transportation Sections (5.12 and 6.5.1) include:

- Protect the desirable hydrologic characteristics that exist, or that are recovering from the fire, from management actions.
- Evaluate known problem areas to see if they represent a cost effective opportunity to enhance or restore hydrologic function.
- Locate new opportunities for enhancement or restoration. Collect robust data across the entire analysis area to ensure that the most egregious sites are located and that priorities for enhancement and restoration are cost effective and make sense at a watershed scale.
- Long term management and restoration of the Moonlight Fire area is dependent on access. The primary transportation goal is to provide reasonable access through a passable, stable, minimal, and safe transportation system with functioning hydrologic drainage features and structures.

Objective: The objective is to inventory and evaluate the existing transportation system in the Moonlight Analysis area for impacts to water quality and aquatic resources. An added benefit will be an inventory of the condition and drivability of the transportation system.

Project justification: To meet objectives for both hydrology and transportation an analysis of the transportation system is needed to prioritize and plan restoration projects in the analysis area.

The HUC 6 watersheds that contain the Moonlight Fire will be used to identify opportunities for restoration. This area allows for the evaluation of hydrologic or watershed resources both inside and outside the perimeter of the fire, but within the same watershed. Areas with high quality characteristics that may have been lost or degraded in the fire area may exist within the watershed, but adjacent to the fire boundary; therefore, it may be possible to protect or restore some hydrologic resources that are impractical or impossible to restore within the fire area at less than decadal or greater time scales. Also roads located outside the perimeter that impact resources may be needed to access the fire area. These roads should be brought up to BMP standards.

Project description: Geomorphic road analysis to cover ~400 miles of roads and motorized trails in the Moonlight Analysis Area. The Geomorphic Road Assessment and Inventory Package (GRAIP) is a process and a set of tools for analyzing the impacts of roads on forested watersheds. GRAIP combines a detailed road inventory with a powerful GIS analysis tool set to predict road sediment production and delivery, mass wasting risk from gullies and landslides, and road hydrologic connectivity.

Monitoring and evaluation: This project is in itself a baseline monitoring effort. It will be used to examine the efficacy of future watershed enhancement and road storm proofing, and decommissioning projects.

Estimated cost and timeline: Cost projection is based on estimates from the Rocky Mountain Research Station specialists who will be brought in to do the GRAIP survey. It is $150,500 and the work is expected to be completed during the 2014 fiscal year.

Year	**Task**	**Product / Accomplishment**
FY14	GRAIP analysis	detailed road inventory; GIS analysis tool
FY15	*Phase I:* Moonlight Watershed and Transportation Enhancement (EA): GRAIP analysis will be used to prioritize work. Possibly in conjunction with cypress and aspen restoration and meadow enhancement project.	Completion of project EA; 10-20 miles level 2 and 3 road maintenance, water drafting sites constructed. Road decommissioning and rerouting will lead to 10-30 acres of soil/watershed improved and stream miles improved.
FY15-16	*Phase II*: expand project to include OHV trails.	10-20 miles of road, OHV Trail, and stream improvements.

Moonlight Fire Restoration Project Proposal (2014)

Annual National Register of Historic Places (NRHP) of Five Cultural Resource Sites

Project Leader Name: Cristina Weinberg, Mt. Hough Ranger District Archaeologist

Link to Restoration Strategy desired condition and goal: Over 250 cultural resource sites are located within the Moonlight Fire footprint. Five cultural resource sites will be evaluated annually for National Register of Historic Places (NRHP) eligibility in accordance with the PA (2013). Those cultural resource sites that are categorically determined not eligible as outlined in the PA can be released from cultural resource management. Interpretation of NRHP eligible sites will be accomplished in partnership with the MHRD Recreation Staff, local Native American parties & Plumas County Museum as appropriate. As noted in Section 6.1.1 of this strategy, this project links to the following desired conditions:

- Enhance our understanding of past human use of the area as well as providing public outreach and interpretative opportunities;
- Properties that lack importance, as per National Register of Historic Places criteria for significance, are released from active management;
- In partnership with interested public and tribal partners, the Forest identifies cultural properties where interpretative developments, either on-site or off-site, are appropriate.

Objective: This project meets the following goals and objectives (as described in Section 6.1.2 of this Restoration Strategy):

1. Complete cultural resource surveys within and adjacent to the Moonlight Fire area that are sensitive for prehistoric, ethnographic and historic era properties.
2. As per Section 110 of the National Historic Preservation Act and Region 5's Programmatic Agreement for Managing Historic Properties, determine the significance of cultural properties for potential eligibility for inclusion in the National Register of Historic Places. Release from management non-significant properties where appropriate while preserving and actively managing eligible cultural resources.
3. Consult and collaborate with tribal interests to enhance our understanding of past lifeways within and surrounding the Moonlight Fire area.

Project justification: Recommendation to evaluate cultural resource sites for NRHP eligibility within the Moonlight Fire footprint was recommended in the 2010 Moonlight Fire Valuation. Over 250 cultural resource sites are located within the Moonlight Fire footprint. Of the 250 sites located in the Moonlight Fire footprint, 154 cultural resource sites were assessed for fire effects during the 2007 BAER Assessment. 103 sites were burned over. 45 sites were located in the severe burn, 41 were located in the moderate burn, and 17 were located in the light burn. Section 110 of the National Historic Preservation Act and Region 5's Programmatic Agreement for Managing Historic Properties the Agency is required to determine the significance of

cultural properties for potential eligibility for inclusion in the National Register of Historic Places. Those properties determined not significant can then be released specifically from cultural resource management as appropriate and can then be managed for other restoration projects.

Project description: Five cultural resource sites will be evaluated annually for National Register of Historic Places (NRHP) eligibility in accordance with the PA (2013). Those cultural resource sites that are categorically determined not eligible as outlined in the PA can be released from cultural resource management. Interpretation of NRHP eligible sites will be accomplished in partnership with the MHRD Recreation Staff, local Native American parties & Plumas County Museum as appropriate.

Monitoring and evaluation: Sites will be evaluated for National Register of Historic Places (NRHP) eligibility in accordance with the PA (2013).

Estimated cost and timeline: Personnel days = 36. Total cost of project = $10,771.00. Accomplishment planned for 09/30/2014.

Year	Task	Product / Accomplishment
FY14	NRHP evaluation of 5 sites	Annual NRHP Evaluation Report. Sites determined eligible for NRHP can be potentially interpreted and enhanced for public education and enjoyment. Sites determined not eligible can be released from cultural resource management as appropriate.
FY15*	NRHP Evaluation of additional 5 sites	Annual NRHP Evaluation Report. Sites determined eligible for NRHP can be potentially interpreted and enhanced for public education and enjoyment. Sites determined not eligible can be released from cultural resource management as appropriate.
FY16-FY25*	NRHP Evaluation of 5 sites per year	Final product is NRHP Evaluation of total of 20 sites within the Moonlight Fire footprint.

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Cold Stream Historic Trail Enhancement

Project Leader Name: Cristina Weinberg, Mt. Hough Ranger District Archaeologist

Link to Restoration Strategy desired condition and goal: This project would meet the following desired conditions and goals listed in Section 6.1.1 of the Moonlight Fire Restoration Strategy:

- Enhance our understanding of past human use of the area as well as providing public outreach and interpretative opportunities;
- Forest visitors are informed about the cultural history of the area as well as the importance of historic preservation by utilizing interpretive signage, programs, brochures, on-line information, and other social media venues as appropriate.

Objective: This project was listed as a specific objective in Section 6.1.2 of the Moonlight Restoration Strategy.

- Collaborate with recreational interests to meet the goals of enhanced visitor experience through heritage tourism by rehabilitating historic trails, creating walking or driving tours that include cultural resource elements, or providing signage at developed recreation sites.

Project justification: Although the Cold Stream Trail was not assessed in the 2007 BAER Assessment, it is located within the Moonlight Fire footprint. This project will provide public outreach and interpretive opportunities as well as inform the public about local cultural history of the area and the importance of historic preservation.

Project description: FS Site #05-11-52-338 (Cold Stream Trail) consists of a Forest Service system trail that was blazed and mapped by the CCC as early as the 1930s. This trail was affected by the 2001 Stream Fire and sections of the trail were heavily brushed in during monitoring for the Antelope Hazard Tree Removal (2007). This trail was brushed and tread work was done on this trail by Sierra Buttes Trail Stewardship. However, trees continue to fall on the trail obstructing access and whitethorn grows annually. Proposal is to install interpretive signage at the beginning and end of the trail. Any interpretation and signing of cultural resources will be accomplished in partnership with the Mt. Hough Recreation Staff and local Native American parties as appropriate. This proposal is for development and installation of signs at both ends in 2014.

Monitoring and evaluation: Monitor annually to determine whether signs require replacement.

Estimated cost and timeline: Cost of two signs = $2,000.00. Personnel days = 13; Cost of personnel = $3,994.00. Grand total cost of proposal = $5,994.00. Accomplishment planned by 09/30/2014.

Year	Task	Product / Accomplishment
FY14	Development of 2 interpretive signs for the Cold Stream Trail	Installation of interpretive signage at the beginning and end of the Cold Stream Trail
FY15*	Monitoring of visitor use and feedback in conjunction with Recreation Staff.	Assess effectiveness of signage relating to public education and enjoyment in conjunction with Recreation Staff.
FY16+*	Annual monitoring as appropriate	Annual assessment appropriate

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Peters Creek Historic Trail Enhancement

Project Leader Name: Cristina Weinberg, Mt. Hough Ranger District Archaeologist

Link to Restoration Strategy desired condition and goal: This project would meet the following desired conditions and goals listed in Section 6.1.1 of the Moonlight Fire Restoration Strategy:

- Enhance our understanding of past human use of the area as well as providing public outreach and interpretative opportunities;
- Forest visitors are informed about the cultural history of the area as well as the importance of historic preservation by utilizing interpretive signage, programs, brochures, on-line information, and other social media venues as appropriate.

Objective: This project was listed as a specific objective in Section 6.1.2 of the Moonlight Restoration Strategy.

- Collaborate with recreational interests to meet the goals of enhanced visitor experience through heritage tourism by rehabilitating historic trails, creating walking or driving tours that include cultural resource elements, or providing signage at developed recreation sites.

Project justification: Although the Peters Creek Trail was not assessed in the 2007 BAER Assessment, it is located within the Moonlight Fire footprint. Through rehabilitation of this trail, the trail will be more easily accessed and defined. This project will ultimately provide public outreach and interpretive opportunities as well as inform the public about local cultural history of the area and the importance of historic preservation.

Project description: Project description: FS site #05-11-52-341 (Peters Creek Trail) consists of a historic trail linking 4 miles long linking the Peters Ranch to the south to the Lucky S Mine to the north. Rehabilitation was done for about a mile under a RAC grant in 2008. The section of trail approximately 0.5 miles below NFS Rd. 27N51 and section above NFS Rd. 27N51 leading to the Lucky S Mine is no longer visible. Proposal is to reconstruct approximately 3-3.5 miles of trail (section that has not been reconstructed).

Monitoring and evaluation: Monitor annually to determine whether trail requires further maintenance.

Estimated cost and timeline: Personnel days planned = 45. Proposal includes a Staff Archaeologist (for 4 days) and 4 Recreation Crew members (for 10days) for grand total of $6,375. Project completion planned by 09/30/2014.

Year	Task	Product / Accomplishment
FY14	Reconstruct approximately 3-3.5 miles of trail	Once reconstruction is accomplished, the entire trail will be visible and more easily followed.
FY15*	Install interpretive signs at both ends of the trail	Visitor enjoyment, education, and public outreach.
FY16+*	Monitoring of visitor use and feedback in conjunction with Recreation Staff.	Assess effectiveness of signage relating to public education and enjoyment in conjunction with Recreation Staff.

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Installation of Five Interpretive/Information/Protection Signs

Project Leader Name: Cristina Weinberg, Mt. Hough Ranger District Archaeologist

Link to Restoration Strategy desired condition and goal: This project would meet the following desired conditions and goals listed in Section 6.1.1 of the Moonlight Fire Restoration Strategy:

- Enhance our understanding of past human use of the area as well as providing public outreach and interpretative opportunities;
- Forest visitors are informed about the cultural history of the area as well as the importance of historic preservation by utilizing interpretive signage, programs, brochures, on-line information, and other social media venues as appropriate.

Objective: This project was listed as a specific objective in Section 6.1.2 of the Moonlight Restoration Strategy.

- Collaborate with recreational interests to meet the goals of enhanced visitor experience through heritage tourism by rehabilitating historic trails, creating walking or driving tours that include cultural resource elements, or providing signage at developed recreation sites.

Project justification: The 2007 BAER Assessment revealed that the Lucky S Mine was located in low and light burn severity. This project will provide public outreach and interpretive opportunities as well as inform the public about local cultural history of the area and the importance of historic preservation.

Project description: Interpretive/Information/Protection Signing for 6 Sites: The Lucky S Mine consists of 5 recorded sites: FS Site #s 05115200248, 05115200255, 05115200318, 05115200349, & 05115200350. FS Site #05115200351 consists of a historic mining site with structures. A member of the Mt. Hough Ranger District Staff will develop the interpretive signs

Monitoring and evaluation: Monitor the four sites annually in the fall to determine whether signs were effective in preventing vandalism and looting and whether signs require replacement.

Estimated cost and timeline: Personnel Days = 25. Total cost of personnel: $7, 626.00. Cost of 5 signs at $1,000.00 each = $5,000.00. Total cost of project = $12,626.00. Installation of signs planned by 09/30/2014.

Year	Task	Product / Accomplishment
FY14	Development of 5 interpretive signs at Lucky S Mine Complex	Installation of 5 interpretive signs at Lucky S Mine Complex for public enjoyment and education.

Year	Task	Product / Accomplishment
FY15*	Monitoring of visitor use and feedback in conjunction with Recreation Staff.	Assess effectiveness of signage relating to public education and enjoyment in conjunction with Recreation Staff. Assess effectiveness of signs relating to vandalism
FY16+*	Annual monitoring	Annual assessment

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Moonlight Fire Restoration Conservation Education

Project Leader Name: Michele Jimenez-Holtz (Education Liaison)

Link to Restoration Strategy desired condition and goal: Enhance Moonlight Fire restoration efforts by supporting student participation and promoting critical thinking skills while establishing links to the California State Content Standards and Curriculum. Well-educated students become ambassadors/stewards and educate our local communities. Visitors and our local communities are knowledgeable about fire-adapted ecosystems via interpretive signage, brochures, website, podcasts, and other social media venues.

Goals for community integration into fire restoration:

1. Create additional opportunities for PUSD students to participate in restoration activities while supporting the California State Content Standards and Curriculum and advance critical thinking skills.
2. Build upon and expand the successful partnership agreement between the Plumas National Forest and PUSD; utilize the existing model of the PUSD/Storrie Fire Restoration Project.
3. Build on the successful partnership among Greenville High School, Sierra Institute, and the Plumas NF for the monitoring and restoration program in the Moonlight Fire area. Utilize the pilot work on the Moonlight Fire done by the Greenville High School Natural Resource Academy at Greenville High School as a model.
4. Increase local communities understanding of concepts of fire ecology and fire-adapted ecosystems; awareness provides support for fuel treatments, fuels reduction projects, and prescribed burn projects.
5. Expand opportunities for fire restoration partnerships with local organizations (Oakland Camp/Camps in Common and Sierra Institute), tribes (Maidu Summit Consortium, and urban schools (Oakland Unified School District).

Objectives:

1. Incorporate student participation in appropriate restoration activities such as monitoring, planting of trees and plants, native plant propagation, and recreation projects.
2. Engage the public in restoration efforts by developing partnerships with urban schools, local organizations, and tribes for student exchange of knowledge/restoration practices and Traditional Ecological Knowledge (TEK).

3. Incorporate youth employment into restoration efforts utilizing Youth Conservation Corps (YCC) or other model. Youth crew to be comprised of local and urban youth.
4. Demonstrate student role in restoration by developing a Moonlight Fire Restoration Project section on the Plumas NF webpage. Ensure project status and successes are updated.
5. To support Moonlight Fire Restoration efforts, develop an education, outreach, and interpretive plan for the Moonlight Fire and adjacent Antelope Lake Recreation Area.
6. Expand restoration by developing a PUSD/Moonlight Strategic Plan for related budget, curriculum support, and learning opportunities for local students.

Project justification: This project will provide student participation and support for restoration and rehabilitation projects. Community and youth participation will engender ownership of restoration projects by future generations. This project also enhances and improves upon the progress of existing partnership agreements to complete on-the-ground restoration work.

Project description: Planning and pre-implementation. Project funds fire ecology education and student projects to include wildlife and vegetation monitoring, tree planting, native plant propagation, trail improvements, and expansion/operation of Greenville HS greenhouse (native and rare plants for restoration).

Monitoring and evaluation: Determine student and community understanding of fire ecology, fuel treatments/fuels reduction projects, restoration efforts and success of student restoration projects by obtaining a baseline online survey at beginning and end of the school year. Students, teachers, and parents are to be surveyed.

Estimated cost and timeline: FY14 $57,178; $10,000 for GHS greenhouse expansion; $40,000 for Moonlight/PUSD Partnership Agreement (planning and pre-implementation to include initial school fieldtrips into fire area, teacher education and preparation). A multi-year partnership agreement cost is to be determined pending approval of this restoration strategy and appropriate project proposals to involve student participation.

Moonlight Fire Restoration Project Proposal (2014)

Off-Channel Water Sources

Project Leader Name: Ryan Nupen

Link to Restoration Strategy desired condition and goal: The primary goal is stabilizing and maintaining the identified transportation system needed to support the general Moonlight Fire Restoration effort. The secondary goal is supporting the specific re-construction or construction of identified wildlife, hydrologic and recreation facilities and structures.

Objective: Water sources are needed for restoration activities (e.g. road work). The objective of this project is to ensure adequate and appropriate water source primarily for use in the maintenance or re-construction of system roads and trails. A secondary use will be for the construction of identified features such as aquatic organism passages (AOP) and recreational facilities. This project consists of the installation of the first of several planned closed, seasonal water storage units. This first one will provide a limited supply of water for mid-term (2-4 years) work.

Project justification: Currently, within the Moonlight Fire Recovery area, there is a scattered collection of in-channel and off-channel water sources in varying conditions of accessibility. In anticipation of restrictions on the continued use of existing in-channel water sources or the use or construction of traditional off-channel ponds due to threatened and/or endangered wildlife issues, we plan to install several off-channel closed water storage units.

Project description: Installation of the first of several closed, off-channel, water sources. We are examining several types and designs. The first is to be an enclosed, partially buried 3,500 gallon tank with controlled inlet and drain and drafting access. As the work is near to, but not within, the stream channel, it is expected that minimal review for a CE will be required.

Monitoring and evaluation: Maintenance requirements will be monitored to evaluate the long-term viability of the design and system.

Estimated cost and timeline: Cost projection is estimated to be $41,600. It is expected this will adequately substitute for a traditional open drafting pond. Cost for design, solicitation preparation, and administration is estimated to be $8,200

The project will be completed in FY 2014 under the condition that minimal review for a CE will be required.

Year	Task	Product / Accomplishment
FY14	Project planning and implementation	Categorical Exclusion (CE) completed Installation of off-channel, water source

Moonlight Fire Restoration Project Proposal (2014)

Aggregate Material Source Development

Project Leader Name: Jonathan Berry

Link to Restoration Strategy desired condition and goal: The primary goal is stabilizing and maintaining the identified transportation system needed to support the general Moonlight Fire Restoration effort. The secondary goal is supporting the specific re-construction or construction of identified wildlife, hydrologic and recreation facilities and structures.

Objective: Aggregate material will be needed for Moonlight restoration activities. This project will ensure an adequate and appropriate aggregate material for use in the maintenance or re-construction of system roads and trails, and the construction of identified features such as aquatic organism passages (AOP) and recreational facilities. This project will provide material for mid-term (2-6 years) work.

Project justification: Current local non-government sources appear adequate for the near-term needs; however their ability to supply the quantity and quality of material for mid and long-term requirements is not assured. Other sources, both private and government, are located a considerable distance away, thus incurring significant transportation costs. This project (and another to follow) will insure an adequate supplemental supply of aggregate material available as needed during the recovery process.

Project description: Additional development of an existing Forest Service aggregate source within the currently approved development plan. As the work is to remain within the scope of the existing Approved Development Plan, it is expected that minimal review for a CE will be required.

Monitoring and evaluation: Maintenance of records and allocation of material to insure that priority of use is directed to Moonlight Fire Recovery needs.

Estimated cost and timeline: Cost projection is estimated to be $120,000. It is expected this will produce a minimum of 10,000 cubic yards (15,500 tons) of aggregate material. Cost for design, solicitation preparation, and administration is estimated to be $11,500.

The project will be completed in FY 2014 under the condition that minimal review for a CE will be required.

Year	Task	Product / Accomplishment
FY14	Project planning and implementation	Categorical Exclusion (CE) completed Development of existing USFS aggregate source

Moonlight Fire Restoration Project Proposal (2014)

Cadastral Surveys

Project Leader Name: Forest Engineer

Link to Restoration Strategy desired condition and goal: The primary goal is stabilizing and maintaining the identified transportation system needed to support the general Moonlight Fire Restoration effort. The secondary goal is to support the specific re-construction or construction of identified wildlife (AOPs) and hydrologic structures.

Objective: To obtain the necessary data and other information required to identify and adequately mark the forest boundaries in areas where preexisting markers and other demarcations are compromised or missing. Work will be done in areas where roads or trails are to be re-located, re-constructed, decommissioned, or whose designated use is to be significantly changed.

Project justification: The Moonlight Fire destroyed many of the Forest Boundary markers. Accurate surveys are needed to ensure that actual boundaries and land ownership are identified before projects are designed or site work commences.

Project description: Contract cadastral (boundary) surveys within the Moonlight Fire area.

Monitoring and evaluation: Monitoring and/or evaluation will be in accordance with contract or agreement provisions.

Estimated cost and timeline: Cost projection is estimated to be $30,000 to $40,000. It is expected this work will continue through FY 2014 as needed.

Year	Task	Product / Accomplishment
FY14	Project planning and implementation	Categorical Exclusion (CE) completed Survey boundaries marked

Moonlight Fire Restoration Project Proposal (2014)

Aggregate Material Source and Delivery Contract

Project Leader Name: Craig Kusener

Link to Restoration Strategy desired condition and goal: The primary goal is stabilizing and maintaining the identified transportation system needed to support the general Moonlight Fire Restoration effort. The secondary goal is to support the specific re-construction or construction of identified wildlife (AOPs), hydrologic, and recreation facilities and structures.

Objective: To insure adequate and appropriate aggregate material for use in the maintenance or re-construction of system roads and trails, and the construction of identified features such as AOPs and Recreational Facilities. This project will provide material for early-term (1-2 years) work.

Project justification: This contract is for local non-government aggregate sources for the short term while government owned sources are further developed. This contract will insure an adequate supply of aggregate material available as needed during the recovery process.

Project description: Purchase and delivery of aggregates materials for maintenance and construction projects in the Moonlight area

Monitoring and evaluation: Maintenance of records and allocation of material to insure that priority of use is directed to Moonlight Fire Recovery needs.

Estimated cost and timeline: Cost projection is estimated to be $66,000. It is expected this will produce supply 1,200 tons of aggregate material. Additional funding need for contract preparation and administration: $6,800. As the work is to remain within the scope of the existing Approved Development Plan, it is expected that minimal review for a CE will be required. Under that condition, the project will be completed in FY 2014.

Year	Task	Product / Accomplishment
FY14	Project planning and implementation	Categorical Exclusion (CE) completed

Moonlight Fire Restoration Project Proposal (2014)

Road Maintenance and Repair

Project Leader Name: Craig Kusener

Link to Restoration Strategy desired condition and goal: The primary goal is stabilizing and maintaining the identified transportation system needed to support the general Moonlight Fire Restoration effort. The secondary goal is to support the specific re-construction or construction of identified wildlife (AOPs), hydrologic, and recreation facilities and structures.

Objective: To restore and maintain passability on key roads for public and administrative use. To prevent and alleviate watershed impacts to and from roads.

Project justification: Fallen snags and movement of rocks and soil due to the Moonlight fire have reduced access on roads in the fire area. Specialists need to access the area to assess and implement future projects. Unmaintained roads in the area also have the potential to aggravate runoff, erosion, slope failure, and stream sedimentation.

Project description: Repair and maintenance of:

- 25 miles of level 3 roads (grading, culvert cleaning/repair)
- 100 miles of level 2 roads (removing hazard trees and debris, culvert cleaning/repair)
- 3 miles of level 5 roads (asphalt surface repair)

Monitoring and evaluation: Road condition surveys would be conducted by engineers each year after completion of work.

Estimated cost and timeline: Cost estimate is $60,000. Work would be completed in FY14.

Moonlight Fire Restoration Project Proposal (2014)

Non-motorized Trail Restoration and Hazard Tree Removal

Project Leader Name: Erika Brenzovich (Public Service Staff Officer)

Link to Restoration Strategy desired condition and goal: Desired conditions for non-motorized and motorized trails would be that trails are open and maintained to design and maintenance standards identified in Forest Service Handbook 2309.18 Section 23.12. Hazard trees along trails would not pose a safety risk to trail users and trail workers, and other vegetation would be maintained to safely accommodate hikers, bicycles, and equestrians. Trail tread would exhibit proper width, drainage, stabilization, and slope.

Objectives:

- Begin restoring burned trail segments within the fire area through removing hazard trees, brushing, and removing and trimming vegetation along the trails to safely accommodate hikers, equestrians, and bicyclists.
- Begin manual removal of brush from roots to keep trails open and maintained. Monitor whether manual removal of root wads is an effective means to maintain brush and keep trail open. Target accomplishment would be ¼ mile of root wad removal within the Moonlight Fire perimeter.
- Survey and reconnaissance for future repair and replacement of fire damaged structures to support the trail system such as bridges, turnpikes and culverts.
- Survey and reconnaissance for future trail maintenance on burned trails within the Moonlight Fire perimeter.

Project justification: The Moonlight Fire burned approximately eight miles of non-motorized trails, making them currently inaccessible to mountain bikers and equestrians due to down trees caused by the fire. These trails could be restored with Moonlight Restoration funds to allow access for mountain bikers and equestrians. Additionally, the safety of visitors and trail workers is at risk due to hazard trees along trails.

Project description: Hazard tree removal would be implemented on 8 miles of burned trails within the fire area through either force account crews or a tree contractor. Restoration activities are proposed on approximately 1-3 miles of trails within the fire area for trail restoration and tread stabilization. A combination of survey and assessment is also being proposed to assess future maintenance and restoration needs on trails within the fire area. Work would include restoring burned trail segments within the fire area through hazard tree removal, brushing and removing and trimming vegetation along the trails. Trails include Cold Stream, Middle Creek, and Antelope Target accomplishments for FY 14 would be approximately 1-3 miles of burned trails within the fire area.

FY 14 work would also include beginning manual removal of brush from roots to keep trails open and maintained. Target accomplishment would be ¼ mile of root wad removal within the Moonlight Fire perimeter.

Engineering surveys and district staff reconnaissance would be needed to assess needs for future repair and replacement of fire damaged structures to support the trail system such as bridges, turnpikes and culverts. The Hungry Creek Bridge was damaged in the Moonlight Fire and is in need of replacement. Engineering surveys and reconnaissance would also occur to assess needs for future trail maintenance on burned trails within the Moonlight Fire perimeter.

Monitoring and evaluation: Monitor whether manual removal of root wads is an effective means to maintain brush and keep trails open. Monitor effectiveness of trail restoration and tread stabilization.

Estimated cost and timeline: Hazard tree removal would occur in FY 14, trail maintenance and restoration would occur over a five year period from FY 14-FY 18.

Estimated cost for FY 14: $95,487

- Hazard Tree Removal Contract: $75000
- Engineering salaries for trail survey: $4119
- Brush/root wad removal, trail restoration, and trail monitoring: $12,368
- Vehicles: $3000
- Trail maintenance supplies: $1000

Year	Task	Product / Accomplishment
FY14	Hazard tree removal	Hazard tree removal along 8 miles of burned trails
FY14-FY18	Trail maintenance and restoration	Miles of trail maintained

Moonlight Fire Restoration Project Proposal (2014)

Antelope Lake Recreation Site Engineering Surveys and Recreation Assessment

Project Leader Name (Public Service Staff) Erika Brenzovich

Link to Restoration Strategy desired condition and goal: The desired conditions for developed recreation in the Antelope Lake Recreation Area would be enhanced developed recreation opportunities so that visitor use returns at Antelope Lake to pre-fire levels documented prior to 2006. Visual quality desired conditions would be improved visual quality around the lake from restoration activities, resulting in improved vistas from recreation sites at Antelope Lake.

Objectives: Provide and enhance developed recreation opportunities at Antelope Lake to replace opportunities lost by the Moonlight Fire by improving facilities, infrastructure, and conservation education within recreation sites and around the lake. Specific types of projects that would enhance developed recreation opportunities are included under Section 6.3 (Recreation Desired Conditions, Goals, and Objectives) in the Moonlight Restoration Strategy. Work proposed in FY 14 includes engineering surveys and recreation planning for future improvements.

Project justification: The Moonlight Fire Restoration recreation analysis boundary includes the Antelope Lake Recreation Area and developed recreation sites at the lake. This Recreation Area extends outside of the Moonlight Fire perimeter; however, recreation sites and opportunities at Antelope Lake were substantially impacted by the Moonlight Fire since the recreation sites at Antelope Lake are all within the view shed impacted by the Moonlight Fire. Burned landscapes from the Moonlight Fire are visible from all of the recreation sites at Antelope where visitors recreate. As described in the Moonlight Fire Restoration Strategy under Section 4.3 (Past and Present Recreation Conditions), use at Antelope Lake has decreased since the Moonlight Fire. Moonlight Restoration funds could help restore recreation opportunities and view sheds lost to the Moonlight Fire by enhancing recreation sites and opportunities within the Antelope Lake Area.

The three campgrounds at Antelope Lake have deteriorating infrastructure that has not been replaced or repaired since the 1960's, when the campgrounds were constructed. Pavement on interior roads and spurs within campgrounds is narrow and crumbling and is a safety hazard for recreational vehicles. The camp spurs are narrow and do not accommodate modern recreational vehicles. There are no universally accessible recreation sites anywhere at Antelope Lake for persons with disabilities. Water systems are dated and in need of upgrades and repair. Moonlight Restoration funds could be utilized to enhance all of these recreation site components and restore recreation opportunities lost to the Moonlight Fire.

Project description: FY 14 funds would be used to implement engineering surveys for recreation sites and allow recreation staff to assess recreation site needs for future planning at recreation sites

Monitoring and evaluation: No monitoring needed for surveys and assessments in FY 14. Monitoring eventually would include traffic counters on roads and trails to monitor use at Antelope.

Estimated cost and timeline: $24,085

- Engineering salaries for surveys: $17,867
- Public Service salaries for recreation planning: $6218

This project would be part of a multi-year project

Year	Task	Product / Accomplishment
FY14	planning for surveys and designs	Engineering surveys and cost estimates completed for campground and recreation site improvement/restoration projects completed
FY15	NEPA and engineering design production for recreation enhancements at facilities	Categorical Exclusion (CE) completed
FY 16	implement recreation improvements/restoration	1 recreation site improvement/restoration completed
FY 17	implement recreation improvements/restoration	2 recreation site improvement/restoration completed
FY 18	implement recreation improvements/restoration	1 recreation site improvement/restoration completed

* Estimated project cost does not cover these out-year tasks

Moonlight Fire Restoration Project Proposal (2014)

Red Rock Lookout Stabilization and Planning Project

Project Leader Name (Public Service Staff) Erika Brenzovich

Link to Restoration Strategy desired condition and goal: The Red Rock Lookout was identified by the Plumas NF LRMP as an opportunity for remote developed recreation (USDA 1988a: p. 4-282). With appropriate funding, unused lookouts can be converted to recreation rentals; for example the Black Mountain Lookout on the Beckwourth Ranger District of the Plumas NF was successfully converted to a recreation rental in 2010 and is now reserved throughout the season. The Red Rock Lookout is currently unstaffed by fire personnel and is in a deteriorated condition since it has not been staffed since the Moonlight Fire in 2007. The ultimate goal for the Red Rock Lookout would be to stabilize the facility, conduct NEPA and surveys, and convert it to a recreation rental.

Objective: The Red Rock Lookout, which lies within the recreation analysis boundary, was identified by the PNF LRMP as an opportunity for remote developed recreation (USDA 1988a: p. 4-282). Converting the Red Rock Lookout to a recreation rental would provide and enhance remote developed recreation opportunities in the Moonlight Fire recreation analysis boundary by replacing opportunities lost by the Moonlight Fire.

Project justification: The Moonlight Fire Restoration recreation analysis boundary includes the existing Red Rock Lookout facility, which is currently unstaffed as an operational lookout. The Red Rock Lookout extends outside of the Moonlight Fire Perimeter; however, recreation sites and opportunities within the Moonlight Fire area were substantially impacted by the Moonlight Fire, and the Red Rock Lookout lies on the border of the fire area. Burned landscapes from the Moonlight Fire are visible from recreation sites and trails adjacent to the fire area. Moonlight Restoration funds could help restore recreation opportunities and view sheds lost to the Moonlight Fire by enhancing recreation sites and opportunities such as development of the Red Rock Lookout. There are also opportunities to do interpretation and conservation education at the Red Rock Lookout to educate the public on fire ecology.

Project description: Stabilization of Red Rock Lookout would occur in FY14 to keep the lookout from deteriorating and prevent further vandalism. Stabilization would include sealing and patching the concrete foundation and other annual maintenance activities. NEPA and archaeology surveys would be completed in FY 14 in preparation to designate the lookout as a recreation rental in FY 15-FY16. Cost estimates would be provided by engineering and recreation personnel to convert the facility into a recreation rental. Restoration activities to restore Red Rock Lookout would help provide high quality recreation opportunities that were lost to the Moonlight Fire.

Monitoring and evaluation: Monitoring the Lookout would be required in FY14 to FY16 to prevent vandalism and further deterioration of the lookout.

Estimated cost and timeline:

This project would be part of a multi-year project:

Year	Task	Product / Accomplishment
FY14	Conduct NEPA and contract out archaeology evaluation and surveys, implement stabilization activities at lookout to prevent further deterioration and vandalism to include patching and re-sealing concrete foundation	Complete archaelogical evaluation of the lookout, Categorical Exclusion (CE) completed, engineering cost estimates
FY15	Implement restoration of lookout	Contract awarded to convert to recreation rental
FY 16	Process fee proposal through Recreation Advisory Council to implement fees at lookout, finish conversion to recreation rental	Recreation Advisory Council approves fees at Red Rock Restoration activities completed to convert to a recreation rental
FY 17	Annual maintenance and operations of the lookout	Recreation rental available for rental by the public

Estimated cost for FY 14: $18,310

Estimated cost for FY 15: $100,000

Estimated cost for FY 16: $10,000

Estimated cost for FY 17: $5,000

Appendix C – Moonlight Fire Potential Research Questions

The Moonlight Fire landscape has already proven to be an important resource for scientific research (see the list of recent studies below). In turn, forest managers continue to rely on science to inform ecological restoration and management activities. For studies to be most effective to the Moonlight Fire restoration effort, researchers must work closely with Forest Service managers to foster communication and collaboration, ensure relevance and applicability, and incorporate findings into project design and implementation. Proposed research must be directly linked to the desired conditions, goals, and objectives described in this strategy. Studies should focus on identifying or improving management actions; they should also lead directly to the design and implementation of on-the-ground restoration projects.

The most applicable research studies will be those that are driven by the needs of forest managers. In recognition of this, the Moonlight Fire restoration team has developed the following preliminary list of research questions to help guide potential research and monitoring activities.

<u>Vegetation</u>

- Are the treatments described by North et al. (2009) in PSW-GTR-220, such as clustering thinning treatments, effective at increasing plant diversity and shrub cover in forest understories?
- What are the differences in effectiveness between cluster planting and natural revegetation in a post-fire environment? Treatments considered should include:
    - Site prep and planting
    - Site prep for natural regeneration
    - Planting without site prep
    - Natural regeneration without site prep
- How is the spread rate of annosus (*Heterobasidion* root disease) affected by post-fire salvage where no fungicide (i.e. Sporax®) is applied?
- What is the post-fire vegetation response in low to moderately low fire severity areas in terms of growth rates, understory regeneration, species composition, and fuels
- How can historical reference conditions better quantify landscape heterogeneity and resilience as described by North et al. (2009) in terms of vegetation patch size, canopy conditions, slope position, aspect? Does the conceptual framework in North et al. (2009) hold true?
    - What were the canopy conditions and seral stage distributions under more active fire regimes?
    - How has the landscape changed in terms of heterogeneity and patch size, and how can management be designed to emphasize heterogeneity over time?

    - What was the historic range of patch sizes for chaparral and other vegetation types across the landscape encompassing the Moonlight Fire?
    - In low to moderately low fire severity areas, does the stand more closely resemble the desired condition, including structural heterogeneity, and at what scale(s)?
    - How might historical reference conditions and concepts of heterogeneity be implemented in post-fire restoration strategies to build resilience particualry under a changing climate and future fire regimes?

- As described in the SNFPA ROD (USDA 2004, page 53): "…spatially determine distributions of existing and potential natural hardwood ecosystems (Forest Service Handbook (FSH) 2090.11). Map and/or model hardwood ecosystems at a landscape scale (approximately 30,000 to 50,000 acres). Include the following steps in the analysis: (1) compare distributions of potential natural hardwood ecosystems with existing hardwood ecosystems; (2) identify locations where existing hardwood ecosystems are outside the natural range of variability for potential natural hardwood ecosystem distribution; and (3) identify hardwood restoration and enhancement projects."

- Were the resource mitigation and protection measures integrated into the design features of the fire salvage effective and truly necessary?

<u>Fire and Fuels</u>

- Currently there is no accurate fuel model for post-fire landscapes. What are the post-fire fuel dynamics in salvaged and un-salvaged stands? What is the post-fire fuel pulse (broken into various size/hour class ranges) in these areas?

<u>Unique Botanical Resources</u>

- What is the genetic structure of the remaining Baker cypress populations? How closely related are the Mud Lake and Wheeler Peak populations?

<u>Wildlife</u>

- Post fire restoration activities require more detailed knowledge of the spatial and temporal variation in California spotted owl use of burned forests. Although California spotted owls require late-seral forest habitat, owls do exploit resources on post-fire landscapes. Recent studies have reported California spotted owls may select forest patches that burned at high severity for foraging over adjacent green forest habitat (Bond et al. 2009), and that high severity fire may burn over 30% of suitable habitat in a spotted owl breeding site without reducing the probability of site occupancy (Lee et al. 2012). Future research directed at improving our understanding of owl use of burned forest habitat would benefit from sampling owl behavior in recently burned patches on the forest (i.e., Chips Fire landscape) as well as within the Moonlight and Antelope Complex fire footprints to better inform post fire restoration activities.

- Can we manage post fire landscapes to promote biotic and abiotic seed dispersal, and thereby facilitate natural re-vegetation of burned habitats? Restoration activities within

the Moonlight and Antelope Complex fires would benefit from a greater understanding of factors limiting seed dispersal into burned forest patches. For example: What is the relative contribution of small mammal and avian communities to natural regeneration within post fire landscapes (i.e., seed dispersal and predation)? Does relative abundance of specific seed dispersing species significantly impact natural post fire re-vegetation? If we effectively manage post fire landscapes to promote seed disperser populations, will natural regeneration increase in response? Can we manage green forest patches within or adjacent to burned forest to increase wind dispersal distance from source trees?

- What effect are aquatic invasive species having on native communities?
- What is the size of and factors limiting populations of Sierra Nevada yellow-legged frogs in the analysis area?
- What species of bats occur within the analysis area, what habitats are they utilizing throughout the annual cycle, and how may restoration activities be directed to best promote native bat populations.
- Can we vary grazing regimes on allotments to improve terrestrial and aquatic wildlife habitat and promote viable wildlife populations.
- What effect does increasing aquatic connectivity have on populations of native and introduced species?

Hydrology and Soils

- Roads and motorized trails have long been shown to be a factor in degraded forested watersheds throughout the western United States.
    - What is the current state of the road system in the Moonlight Analysis Area? Which roads are quantifiably degrading water quality and aquatic conditions?
    - How does the current observed impacts from roads relate to the fire?
    - How do the relative impacts of roads to water quality and aquatic conditions differ when comparing different geologic areas in the Moonlight Analysis Area?
    - How effective are our treatments of known problem roads?
- What is the risk of re-burn of wildfires to soil conditions? How does time since last fire and severity factor in?

Recent published studies of the Moonlight Fire area:

Bond, M. L., D. E. Lee, R. B. Siegel, J. P Ward, Jr. 2009. Habitat use and selection by California Spotted Owls in a post-fire landscape. Journal of Wildlife Management 73:1116-1124. http://onlinelibrary.wiley.com/doi/10.2193/2008-248/abstract

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