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 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.

Two allotments, Lone Rock and Antelope Lake, were rested from grazing in 2008. Rotation changes were made in 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).

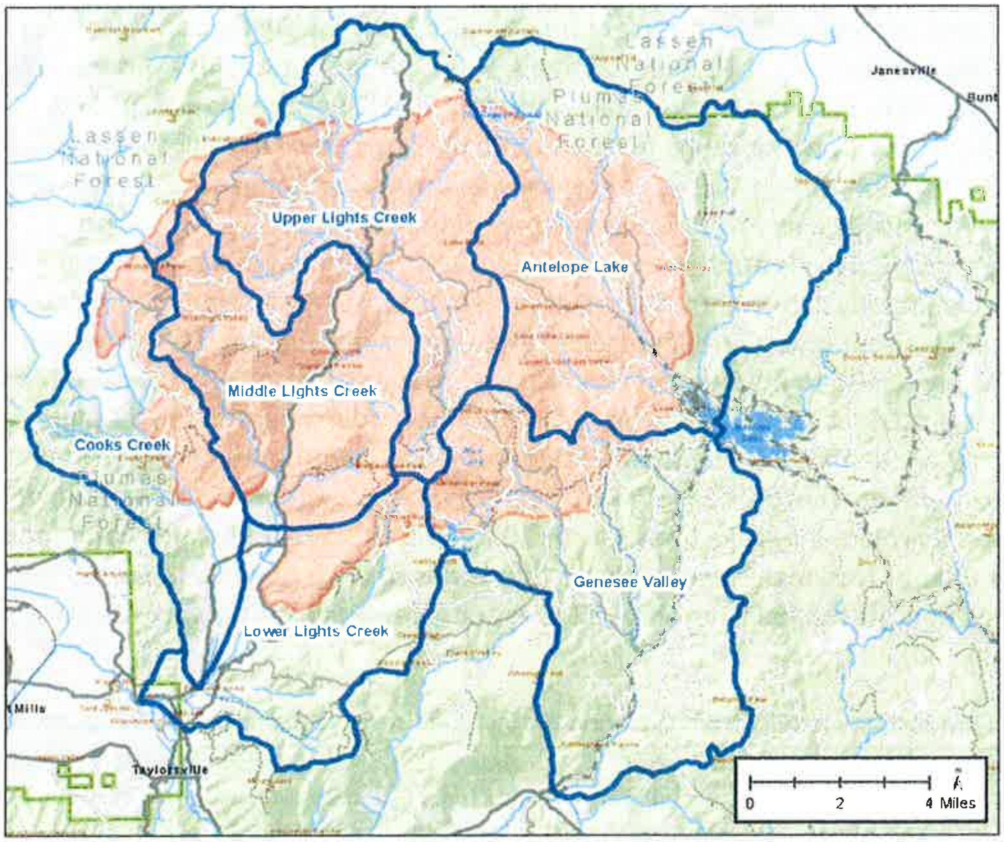

Figure 50. Area analyzed for soil and hydrological conditions; shows the six HUC6 watersheds that contain the Moonlight Fire.

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 24). 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 24).

Table 24. 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 extend 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 the Hydrology section 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. The Antelope-Wheeler 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 25. 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 25. 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 24). 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 the Hydrology section 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. In 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. 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. The Mining section 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 2are evident in this area. Historic grazing has likely impacted riparian areas in the Moonlight Fire area.

3.13.1.2Pre 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 3. 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 32. Densities within the analysis area are about average for the Plumas NF.

Table 26. 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 27). 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 27. 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

Stream	Reach Type	Year Surveyed	Overall Rating[a]	Previous Survey Years	Change Since Previous Surveys[b]
Little Antelope	Response	2005	Poor	2000, 2003	Improvement
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)

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 28. 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 29. 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	

Year	Pool Tail Fines (%)	p-value	% particles <2mm	Res. Pool Depth (m)	p-value	Shade %	p-value
2000 (pre-fire)	2.76		3.0	0.45		70.3	
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 30] below.

Table 30. 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 29 and Table 30]. 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).

3.13.1.3Summary

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 (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.

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,

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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).

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, 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 Northern Sierra Nevada although questions continued 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 31).

Table 31. 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

Age	Phase	Characteristics	Climate
A.D. 500–500 B.C.	Late Martis	Corner-notched and eared points of the Martis and Elko series. Large side-notched points. Large basalt bifaces and other basalt tools.	Neoglacial; wet but not necessarily cooler, increased summer precipitation
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 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 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 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 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.

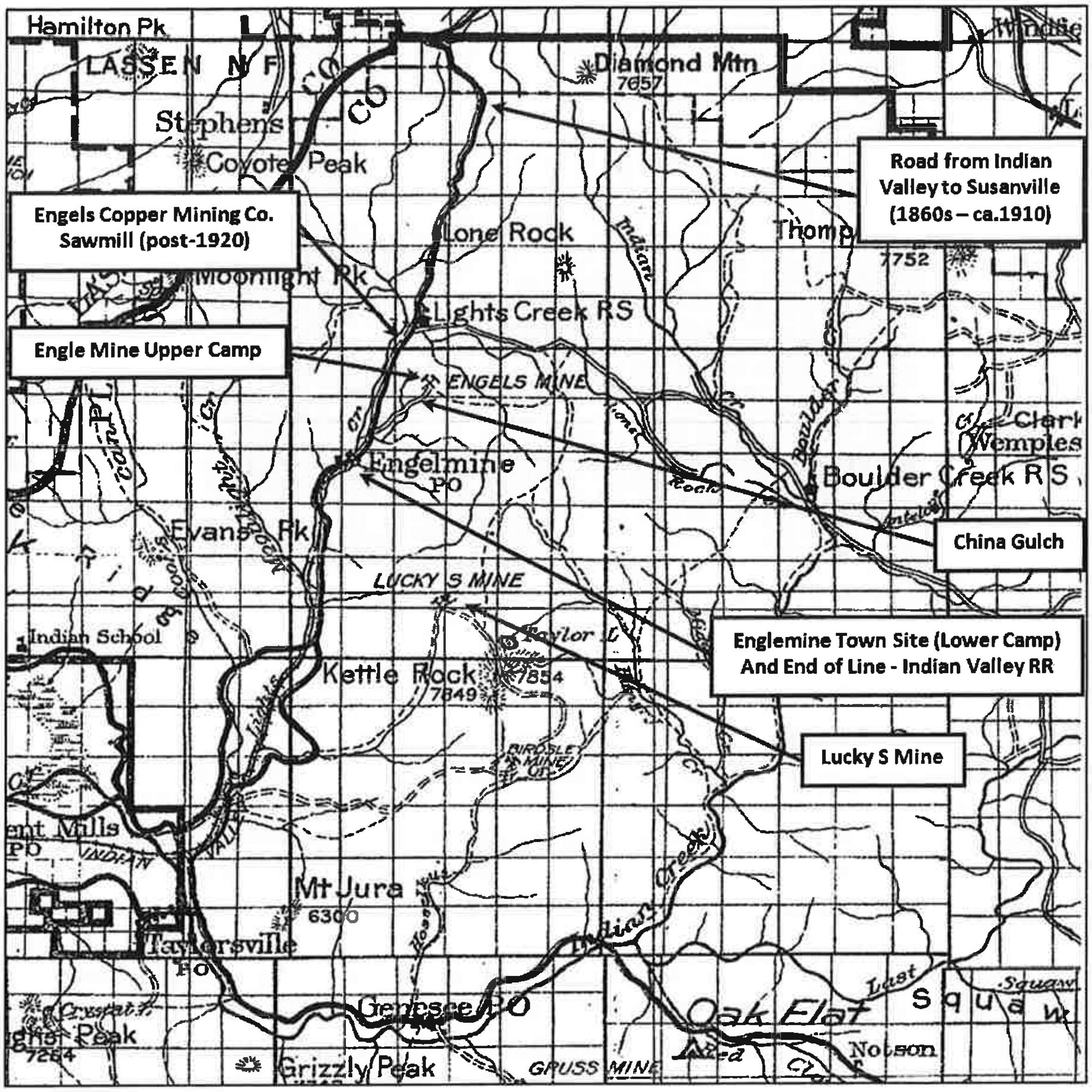
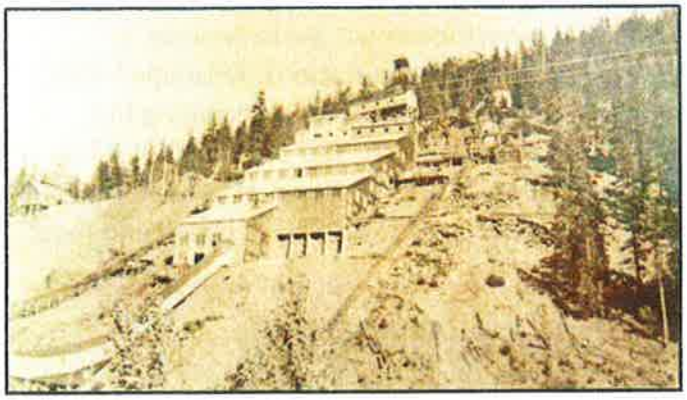


Figure 56. Excerpt of Plumas NF Map, 1925 showing the vicinity of the Moonlight Fire area. Note the Plumas NF's Boulder Creek and Lights Creek Guard Stations. Note also, at the far center left of the map, the old Greenville Indian Mission School. A portion of the primary wagon road between Indian Valley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



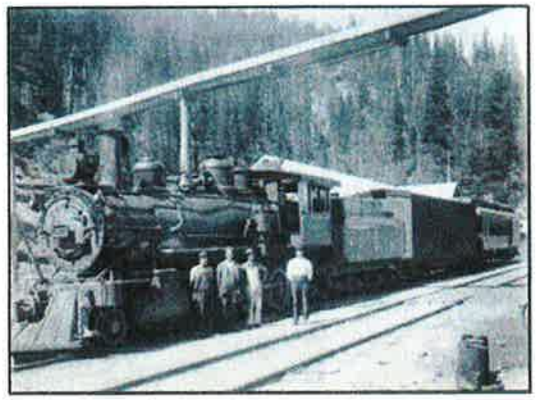


Figure 57. The Superior Mill (left) which operated between 1917 and 1930. The concrete footings for this impressive structure can still be readily observed on the hillside above Lights Creek. The Indian Valley Railroad Engine No. 1 at Englemine (Lower Camp) in the 1920s (right). Courtesy of the Plumas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

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 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 an 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. 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. 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 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 the recreation sites and trails they visit while staying in the Antelope Lake area.

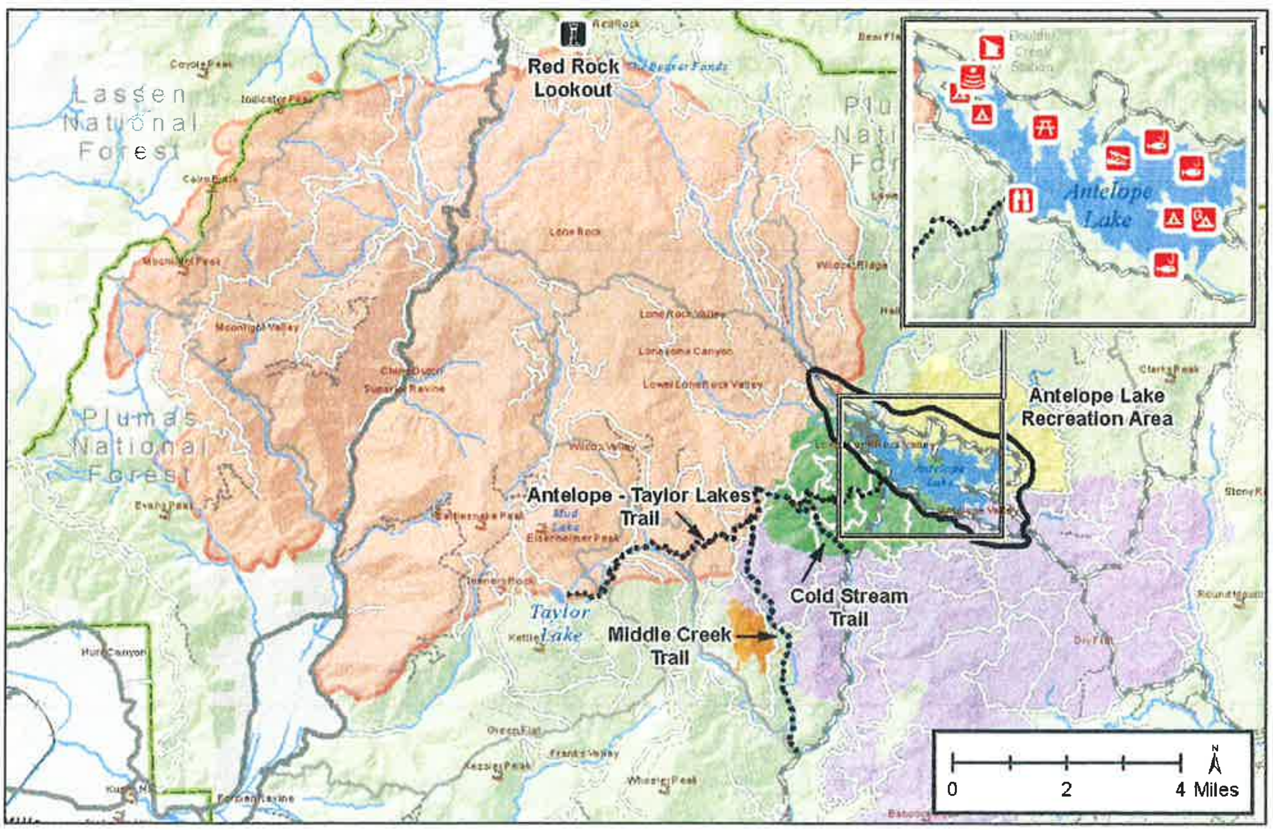


Figure 62. Area analyzed for recreation resources. Past fires are shown in purple (2007 Antelope Complex), yellow (2006 Boulder Complex), green (2001 Stream Fire), and orange (2006 Hungry Fire)

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 PNF 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 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 PNF 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 PNF 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. 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=IbHtyR6CF3w).

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 bottom-less culvert was installed; monitoring: 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, 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.

Analysis area: Plumas Unified School District (PUSD) schools (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 32 below.

Table 32. 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

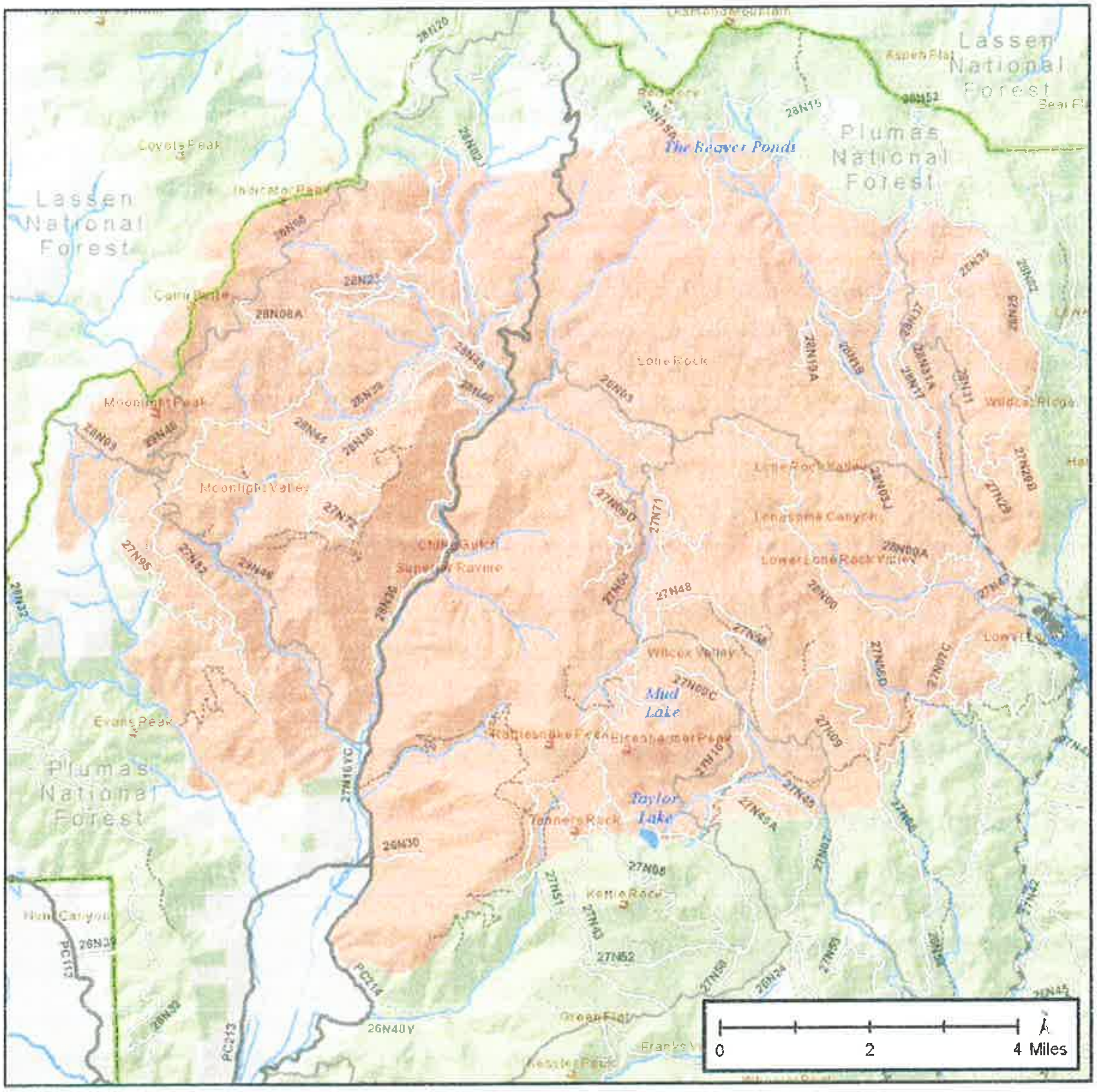


Figure 65. NFS roads within the Moonlight Fire area.

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 33 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 33. Summary of the more extensive damage on heavily used roads in the moonlight perimeter.

Road Number	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.

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)
- 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. 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 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 may 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 FS 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 34). 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) section of this document, serves 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 34. 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 (inches)[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 (unpublished 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 and 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:	JP - Mixed	Pre-fire suppression	65 (16 –263)	130 (1 – 387)	20.7 (3.2 – 43.6)	46%

Study	Study Site	Forest Type	Time period	Trees per Acre[1]	Basal Area (ft^2/acre)[1]	Diameter (inches)[1]	Relative Density[2]
	Yosemite NP	conifer	(ca. 1899)				
Stephens & Gill 2005	N. Mexico: Sierra San Pedro Martir	JP - Mixed conifer	Contemporary Forest with unaltered disturbance regime	59 (12 -130)	87 (25 - 221)	12.8 (1.0 - 44.1)	20%
Taylor 2001, Taylor 2010	S. Cascades: Ishi Wildernes s	Ponderos a Pine - Black Oak	Contemporary 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 Sierran 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 stands 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.

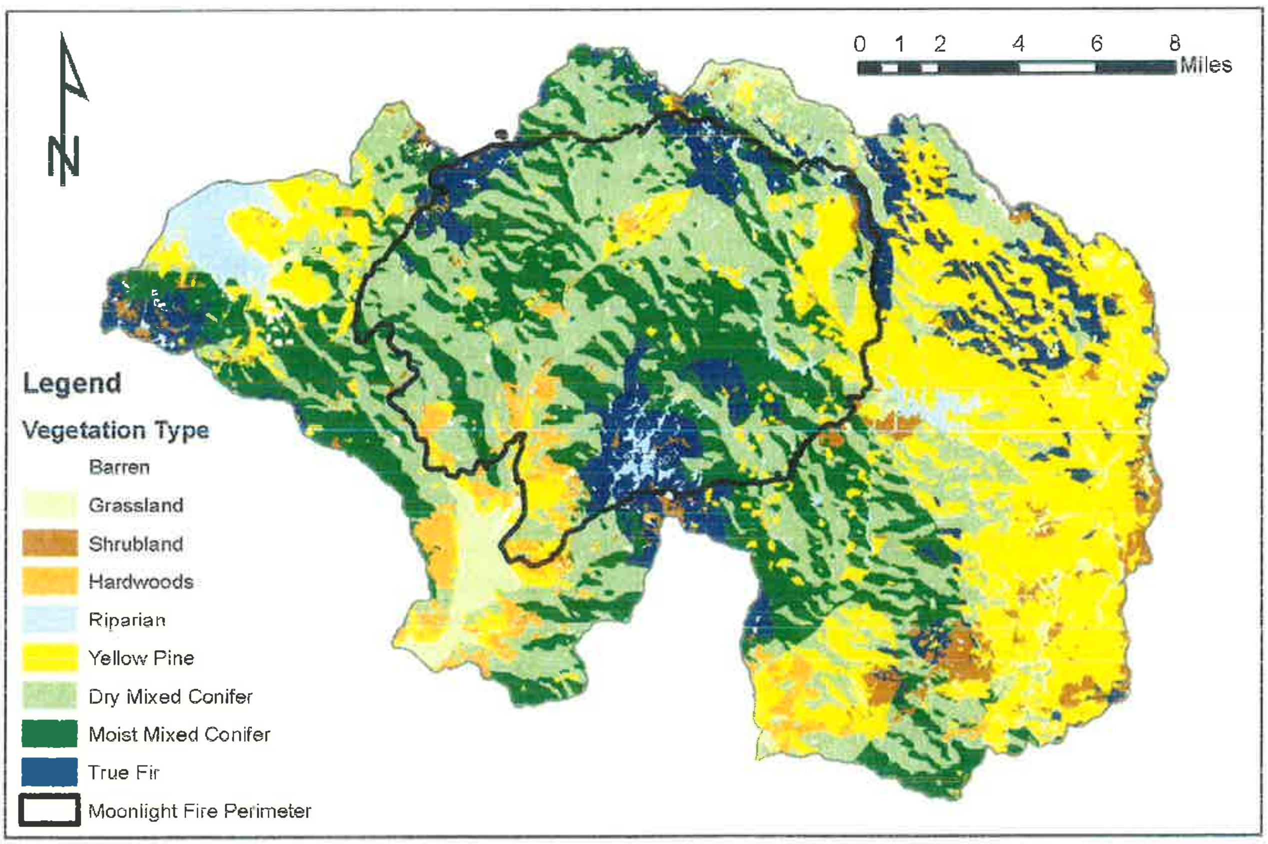


Figure 67. Spatial characterization of desired landscape-level distribution of forest vegetation types. Variables such as topography, aspect, elevation, precipitation, and historic reference conditions were utilized to develop a desired spatial distribution of forest vegetation based on the conceptual 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 35 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.

Table 35. 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 size,such as "founder stands" to larger strategically placed plantations. Treatments should focus on successful establishment and enhanced growth of early seral stagesof conifer forest. This should include treatments to enhance survival and maximize growth by reducing competing vegetation – this could include judicious proposals considering 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. ridgetop locations), 2) are relatively inaccessible and lack infrastructure, and/or 3) 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.

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 shown in the Past and Present Conifer Forest Vegetation section of this document, 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 may be 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 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 sooner 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.

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 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 described in the Sierra Nevada Forest Plan Amendment (SNFPA) Record of Decision (ROD, USDA 2004, page 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 for future fires;
- Survey the analysis area to evaluate current conditions of hardwood stands and prioritize sites for restoration;
- 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 sizes 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 Sierran 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 et al (2009) and Burnett et al (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-200 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. Education and Collaboration
    - 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 36.
   - 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 37 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 36. 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:
	  o Impact high value resources
	  o Are relatively isolated from other infestations; OR
	  o 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:
	  o Are adjacent to other large infestations
	  o Occur in highly disturbed areas
	  o Do not occur along spread vectors
	  o 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 37. Current management goals for known infestations on NFS lands within the analysis area

Species	Management Goal1	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, ie, 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, surface fuel and ladder fuel treatments have been shown to experience the lower vegetation mortality and retained 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 was 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 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 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 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 fire footprints, it is critical to maintain the sparse late seral forest habitat remaining within 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 acres would burn at low severity fire under moderate fire weather conditions within the analysis area. 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 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 is available to maintain wildlife populations.

Prior studies in the region suggests 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 (LRMP 4-29).
- Maintain viability of snag-dependent wildlife (LRMP 4-30).
- Maintain viability of species dependent upon dead and down material (LRMP 4-31).
- Maintain viability of wildlife species dependent on hardwoods (LRMP 4-31).
- Maintain viability of state-listed species, such as the willow flycatcher (LRMP 4-33).
- Maintain burned forest habitat as an ecological component of the forest.
- Protect and improve habitat for harvest species (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 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.

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% 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.
- Remaining burned forest habitat is accessible to California spotted owls

Deer Habitat

- Desired conditions for fire-created early seral habitat (including both montane chaparral and early seral coniferous 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 forage habitat, hiding cover, and thermal cover.
- Implement deer herd plans (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 were gaps exist in habitat (e.g., water).
- Provide for varied habitat conditions to sustain deer herds following 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.
- See aspen habitat assessment described elsewhere in this document. Manage aspen groves to provide key deer fawning and foraging habitat.
- Provide additional black oak in addition to the "Oak and Other Hardwoods" standards where needed to achieve habitat objectives of deer-herd plans: up to 35 sq. ft. basal area on summer range, intermediate range, and fall holding areas, and up to 30% canopy on winter range (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.
- Conduct stand exams on aspen stands within fire area following the protocols in the Aspen Delineation project protocol (Burton 2002). Rejuvenate aspen stands in need of management.
- 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 interspersed to mosaics and invigorate understory plant communities and 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 (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 with 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 inventorying all identified willow flycatcher habitat within the analysis area to determining habitat occupancy and restoration need, manage livestock grazing to prevent excessive grazing on regenerating willows and mitigate or eliminate 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 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).

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

- Identifying 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 38.

Table 38. 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 following allotments:
    - Lights Creek, Lone Rock, Antelope, and Antelope Lake Allotments (target: FY2014)
    - Clarks Creek and Doyle Allotments (target: FY2015)
    - Bass and Jenkins Allotments (target: FY2016)
    - Hungry Creek and Taylor Lake Allotments (target: FY2017)

- 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 38. 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 following allotments:
    - Lights Creek, Lone Rock, Antelope, Antelope Lake (target: FY2015)
    - Clark's Creek and Doyle Allotment (target: FY2016)
    - Bass and Jenkins Allotment (target: 2017)
    - Hungry Creek and Taylor Lake Allotment (target: FY2018)
- Install fence line and repair or restore other rangeland infrastructure impacted by the Moonlight Fire to protect resources from negative impacts.
    - Install drift fence to tie in with NRCS private land drift fence
    - Replace eight miles of fence that was burned off during the Antelope Complex on the Clark's Creek allotment
    - Install off-site water developments in the Clark's Creek and Jenkins allotments
- 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.

5.13 Aquatic Species Desired Conditions, Goals, and Objectives

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 PNF 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 PNF 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 advance 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. 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. 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) are expanded.

6.4.3 Objectives for education and outreach

1. 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.
2. Expand restoration by developing a PUSD/Moonlight Strategic Plan for related budget, curriculum support, and learning opportunities for local students.

3. Couple restoration work with employment opportunities for local youth utilizing Youth Conservation Corps (YCC) or other model. Youth crew to be comprised of local and urban youth.
4. Further restoration by developing partnerships with urban schools, local organizations, and tribes for student exchange of knowledge/restoration practices and Traditional Ecological Knowledge (TEK).
5. Incorporate student participation in appropriate restoration activities such as monitoring of restoration efforts, planting of trees and plants, native plant propagation, and recreation projects.
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 check 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 (USDA citation), 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 National Forest 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 determine 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

- 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.
- 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.

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 38.
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 these projects 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 aquatics 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 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, management guidance shifts, 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 October 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 the project proposes work beyond 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 October 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 (*).

Jim Belsher-Howe (District Botanist, Mt Hough Ranger District, PNF)
Erika Brenzovich (Public Service Staff Officer, Mt Hough Ranger District, PNF)
* Michelle Coppoletta (Associate Ecologist, Sierra Cascade Province)
Colin Dillingham (District Wildlife Biologist, Mt Hough Ranger District, PNF)
Donna Duncan (Forest Minerals Administrator, PNF)