Redwood
National Park

National Park Service
US Department of the Interior

Redwood National Park Middle Fork Lost Man Creek Second-Growth Forest Restoration Environmental Assessment

Redwood National Park
Humboldt County, California
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INTRODUCTION

Redwood National Park was established by Congress in 1968 to "preserve significant examples of the coastal redwood … forests and the streams and seashores with which they are associated for purposes of public inspiration, enjoyment, and scientific study." (Public Law 90-545).

In 1978, Congress expanded the national park to encompass 50,000 acres that had been privately owned timber lands in the lower one-third of the Redwood Creek watershed, in part "to provide a land base sufficient to insure preservation of significant examples of the coastal redwood in accordance with the original intent of Congress, and to establish a more meaningful Redwood National Park for the use and enjoyment of visitors." (Public Law 95-250).

The 1978 expansion area included approximately 38,000 acres that had been logged between 1950 and 1978. The common logging practice in the region at that time was clearcut tractor logging in which almost all old-growth trees and associated vegetation were cleared off a site and the logs dragged out using tractors. The timber harvest practices damaged the watersheds and fragmented the old-growth forests of the lower Redwood Creek basin. The 1978 park expansion legislation directed the National Park Service (NPS) to develop and implement "a program for the rehabilitation of areas within and upstream from the park contributing significant sedimentation because of past logging disturbances and road conditions..." to protect the existing irreplaceable park resources, including redwood forests and streams.

To ensure quicker forest regeneration after logging, clearcut areas were planted or reseeded as required by forest practice laws in effect at the time of logging. Seed mixtures used in reseeding were generally not reflective of the original species composition or ratios of one species to another. Seeds or seedlings were not always obtained on-site or within the local area. Trees planted as seedlings were often specially bred and started in nurseries.

The mild climatic regime, long growing season, and excellent site quality in the park help promote maximum relative stand density. In commercially managed redwood forests, stands that have been clearcut are typically thinned after 20 years of regeneration. Thinning is a silvicultural treatment intended to reduce stand density to maintain or improve growth rates of residual trees, promote stem quality and vigor, and redistribute growing space during the stem exclusion phase of forest development, which can create larger trees and more visually attractive stands over time (DeBell et al. 1997, Helms 1998). Improving the growth potential of remaining trees by reducing competition from undesirable, usually overtopping, competitive vegetation is also known as "release" (Helms 1998).

With the creation of Redwood National Park in 1968 and expansion in 1978, commercial operations including active forest management and silvicultural thinning ceased. Until 2009 the NPS had not actively managed its second-growth forests on a large-scale. The lack of management resulted in second-growth forest conditions considered ecologically unhealthy. Most of the second-growth forests in the park retain the legacy of the regeneration methods used to initiate a new commercial forest stand without the subsequent silvicultural thinning needed to reduce the densities and release the remaining trees. Many of the second-growth forest stands that remain are primarily high-density, even-age Douglas-fir stands, with little canopy structure and no understory development.

Several areas of second-growth forest in the park have been thinned to determine the response of second-growth forest stands to thinning as a forest restoration technique and to determine the logistical and financial feasibility of thinning in the park. Thinning experiments were conducted on 200 acres along Holter Ridge road in 1978 (Veirs 1986); on 40 acres along Bald Hills Road in 1995 (Stuart and Cussins 1994, Teraoka and Keyes 2011) and the same stand was retreated in 2005; on 45 acres along the A972 Road on the west side of Redwood Creek in 2007; and most recently along on 30 acres along Holter Ridge Road. These projects were conducted by park vegetation management staff. The Bald Hills project and the two Holter Ridge projects were conducted as part of forestry graduate degrees from Humboldt State University in Arcata. The results of these small-scale projects have shown that thinning enhances the growth and vigor of the remaining trees, promotes development of understory diversity, and allows a more rapid development of new tree cohorts.

In 2003, park staff began an inventory of second-growth forests throughout the national park to document the range of forest conditions and prioritize the areas surveyed for possible restoration. Each stand was given a summary score based on stand density index, number of trees, basal area, species composition, crown ratio, average stand height, average shrub cover, and redwood regeneration. Other factors considered included road access, proximity to intact old-growth forests, and the presence of old-growth trees left after original logging (residuals). Those stands with the highest summary score were assigned the highest priority for restoration treatments. Based on the summary score, the South Fork of Lost Man Creek was selected as the first area for large-scale thinning treatments. The implementation of the South Fork of Lost Man Creek Second Growth Forest Restoration Plan began in 2009 and was completed in 2011. Using the same scoring system, the Middle Fork of Lost Man Creek (Figure 1) had been identified as the second area for large-scale thinning treatments.

The entire Lost Man Creek watershed was intensively logged from the 1950s to the 1970s. The Middle Fork of Lost Man Creek was clear-cut logged in 1954 and 1962. The area is adjacent to a large stand of contiguous old-growth forest with residual old-growth trees remaining throughout the area. The forest stands are dominated by Douglas-fir rather than having a more diverse species composition. Tree densities are as high as 1900 trees per acre with more than half the trees co-dominant in the canopy. In comparison, old-growth redwood forests average 700 trees per acre with approximately 32 dominant trees per acre (Guisti 2004). In the project area, trees greater than 8 inches diameter at breast height (dbh) are typically dominant or co-dominant. Most of the trees are less than 24 inches dbh and exhibit 20% – 30% live crown ratios, Tree heights are relatively uniform throughout the project area. Crown foliage is reduced and stands have formed closed canopies that allow very little light penetration to the forest floor. There is little understory vegetation, conifer recruitment, and multi-layered canopy development in the project area.

Purpose of and Need for Action

The NPS proposes to thin second-growth forests on 1,125 acres in the Middle Fork of Lost Man Creek watershed to reduce stand density and alter species composition to promote growth of remaining trees and understory vegetation, development of multistoried canopy, and increase the ratio of redwood to Douglas-fir. This action is needed to accelerate development of forest characteristics more typical of late seral and old-growth redwood forests in the park.

The regeneration methods used to initiate stands within the Middle Fork Lost Man Creek area was clear-cutting followed by a mix of natural reseeding augmented by aerial seeding and tree planting. Whether initiated by aerial seeding or by natural seeding from leave trees (trees left after logging) or surrounding forests, species composition has been altered dramatically, with Douglas-fir becoming the dominant tree species within the project area. Current inventories show that only 16% of the trees in the Middle Fork Lost Man project area are coast redwood, while 50% are Douglas-fir; likewise redwood comprises 26% of the total basal area while Douglas-fir comprises

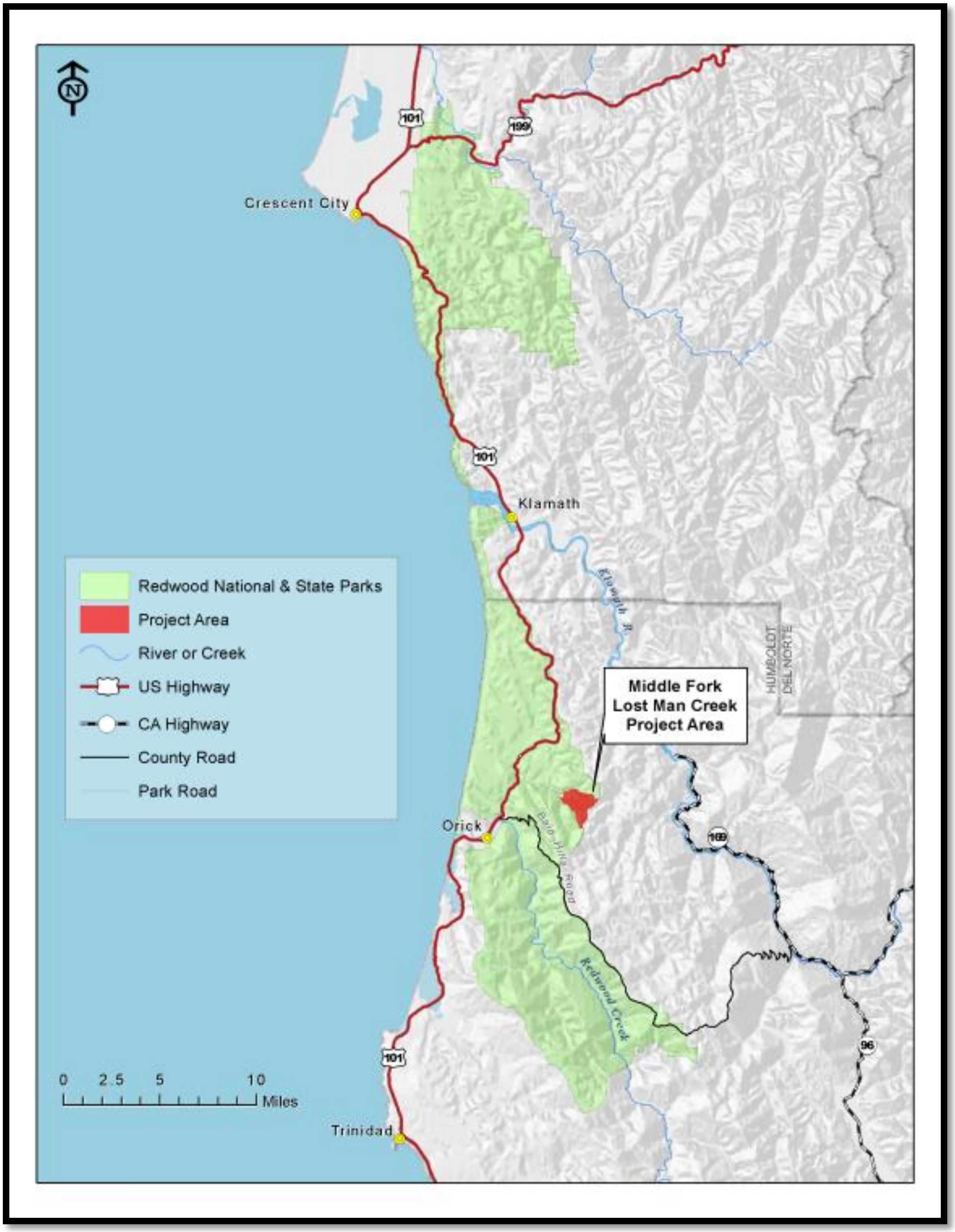


Figure 1. General location

53% of the total basal area. Prior to timber harvest, redwoods were the dominant species within the project area.

Growth and yield studies have shown that Douglas-fir tends to outgrow redwood in height in the early to middle stages of stand development, which suggests that Douglas-fir stratifies into dominant canopy positions sooner than redwood when both species are initiated at the same time and place (Lindquist and Palley 1963, Wensel and Krumland 1986). In the case where Douglas-fir is the dominant species in heights and in numbers, redwood would have a competitive disadvantage and would not likely dominate Douglas-fir in the future (Dagley and O'Hara 2004).

The excessive Douglas-fir densities found in Redwood National Park after logging old-growth redwood forests may last for centuries (Agee 1993). To mimic the composition and architecture of natural redwood stands, density management of Douglas-fir via thinning, planting, and adjusting structure is needed (Agee 1993, 2002; Chittick 2005; Chittick and Keyes 2007; Dagley and O'Hara 2004; Keyes, Perry, and Plummer. 2010; O'Hara, Leonard, and Keyes 2012; Plummer 2008; Teraoka 2004; Teraoka 2012; Teraoka and Keyes 2011).

Along the ridges of the project area, tanoak that was cut has resprouted vigorously from the stumps. Tanoak dominates these stands in high densities, resulting in smaller diameter trees, little development of understory vegetation, and reduced space for conifer regeneration.

Although stands in the project area are approaching 60 years of age, the quality of wildlife habitat is considered low because of the high stand density, the lack of understory vegetation, and the lack of heterogeneity in tree spacing. The project area is adjacent to one of the largest contiguous blocks of unlogged redwood forest in the park, which is suitable habitat for threatened marbled murrelets and northern spotted owls. The height differential between the second-growth and old-growth forests can alter environmental conditions for hundreds of feet within the old-growth, creating an edge effect in which temperature, light and other microclimate characteristics are significantly altered (Russell and Jones 2001). Thinning the second-growth forests along the edge of the old-growth would, more quickly, reduce edge related environmental conditions by encouraging release of remaining trees and creating a buffer of larger second-growth trees with a multistory canopy. Habitat provided by residual old-growth redwood trees throughout the project area would be improved by thinning surrounding dense second-growth to promote diversity in canopy characteristics and development of understory vegetation.

The goal of thinning in the project area is to accelerate the transition of these young forests to mature forest in less time than would occur under random stochastic disturbance regimes. In comparison to unlogged old-growth forests, the second-growth forests in the project area are highly impaired, as measured by excessive tree density, low tree vigor and stability, homogeneous spatial and vertical tree structure, lack of understory vegetation diversity, and the overabundance of Douglas-fir in relation to redwood. To rely solely on natural disturbances to reduce the impairment would delay the development of desired structural characteristics and habitat complexity found in unlogged mature forests and thinned second-growth forests. Without silvicultural treatments to manage existing conditions, these second-growth stands, dominated by Douglas-fir, are expected to persist in an impaired condition for many decades or even centuries (Agee 1993) before they fully recover ecological and structural characteristics resembling those found in the pre-harvest forest of the project area or in current adjacent redwood dominated old-growth forests.

The primary focus of forest restoration work within the park's second-growth forests is to reduce stand density to promote growth and maintain vigor of the remaining trees and to adjust species composition by reducing stand density of Douglas-fir. This plan describes one action alternative to initiate restoration of second-growth forests using silvicultural treatments over the life of the plan. A no action alternative is presented as required by National Environmental Policy Act (NEPA) and to compare the existing impaired conditions with the results of potential treatments.

Relevant Laws, Policies, Guidelines, and Plans

Legislation, policies and plans applicable to management of second-growth forests in the national park including disposal of woody biomass generated by the thinning are discussed below.

Legislation—The 1968 legislation that established the park directed the NPS to minimize human-induced impacts to terrestrial and aquatic resources within the park [Public Law 90-245 §3(e)]. The 1978 expansion legislation directed the NPS to develop a comprehensive general management plan (GMP) with objectives, goals, and proposed actions designed to assure the preservation and perpetuation of a natural redwood forest ecosystem [Public Law 95-250 §104(b)(1)]. The 1980 GMP described initial research being conducted to characterize succession on cutover forestlands, with a goal of reestablishing a more nearly natural vegetation pattern on the disturbed lands.

In 2005, the Department of the Interior published a final rule (48 CFR Parts 1437 and 1452) under the authority found in the NPS Organic Act (16 USC 1) outlining procedures to allow service contractors the option to remove woody biomass by-products generated as a result of Department land management activities whenever ecologically appropriate. Ecological benefits of removing woody biomass include reduced threat of wildfire, and improved forest health, wildlife habitat, and watershed protection.

NPS Management Policies—The NPS is obligated by law to manage the parks in such manner as to leave them in an unimpaired condition (Management Policies 1.4.3, NPS 2006). NPS Management Policies expand upon the legal and regulatory requirements and direct the NPS to manage the resources of parks and maintain them in an unimpaired condition (Management Policies 4–Introduction).

Management of second-growth forests in the park is consistent with National Park Service 2006 Management Policies including the following:

- re-establish natural functions and processes in human-disturbed components of natural systems in parks.
- return human-disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated.
- use best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological-community structure and function.
- manipulate landscape and vegetation conditions altered by human activity where the park management plan provides for restoring the land to a natural condition.

In 2004, the NPS issued a memorandum directing park superintendents to implement the Department's policy to utilize woody biomass by-products from restoration projects wherever ecologically and economically appropriate. The Departmental policy was finalized through the

final rule published in the *Federal Register* [May 20, 2005, Vol. 70, No. 97, pages 29208-29211] which amended 48 CFR Parts 1437 and 1452, described above under applicable legislation.
NPS Natural Resource Management Guidelines—The long-term goals of the second-growth forest restoration program have been developed in accordance with NPS policies and guidelines for restoration of disturbed lands. The Service-wide objective for disturbed area restoration is restoration of soil-geomorphic, chemical, and biological characteristics and processes that were or are affected by modern human activities, so that the site will eventually reintegrate with the surrounding natural ecosystem functions and processes.

NPS Reference Manual 77 for implementing Director's Order 77: Natural Resource Protection defines disturbed lands as areas where the integrity of the natural setting and natural system processes has been directly or indirectly affected by human activities such as resource extraction, visitor use, development or maintenance, or invasion of nonnative species.

Natural system restoration is defined as the long-term process of assisting the recovery of disturbed areas and reintegrating the site into the surrounding natural system so that the area reaches a planned condition and, ultimately, returns to its former unimpaired condition. Restoration involves active management (purposeful manipulations) of the disturbed habitat, such as biological (re-introduction of species), structural (removal of invasive woody or nonnative species), physical (restoration of natural topography), or chemical (mineral waste mitigation). Active management may also include removal of the anthropogenic (human-caused) disturbances that are causing resource degradation or that are preventing natural recovery of a site.

Lands are considered to be restored at the point in the project where disturbed land areas no longer require active management, i.e., the site has reached a planned condition, but not necessarily the former or unimpaired condition. Conditions and processes following restoration should replicate those of the ecological zone in which the disturbance occurs, including the biological and physical components of the ecosystem, such as the geomorphology, hydrology, soils, biodiversity, and natural process linkages.

General Management Plan—. Redwood National Park is one of four park units that comprise Redwood National and State Parks. Three state parks within the Congressionally-designated national park boundary (Jedediah Smith Redwoods, Del Norte Coast Redwoods, and Prairie Creek Redwoods) have been jointly administered with the national park for operational efficiencies in protecting resources and serving visitors. In cooperation with the California Department of Parks and Recreation, the NPS prepared a joint General Management Plan/General Plan (GMP/GP) accompanied by a Final Environmental Impact Statement/Report (FEIS/R) in 1999 to guide joint management of the parks for 15-20 years (USDI/CDPR 1999). The Record of Decision (ROD) signed in April 2000 summarizes the management decisions of the NPS described in the FEIS (USDI 2000). The Middle Fork Lost Man Creek Second-Growth Forest Restoration environmental assessment is tiered off the Redwood National and State Parks *1999 Final General Management Plan/General Plan, Environmental Impact Statement/Environmental Impact Report*. The 2000 GMP directed that forest restoration activities in the parks should emphasize use of silvicultural methods in second-growth forests to re-attain old-growth characteristics in the shortest time possible.

Management goals in the 2000 GMP that are relevant to forest restoration in the Middle Fork Lost Man Creek include

- Protect and preserve the natural resources of the parks; and
- Restore lands, ecosystems, and processes that have been altered by modern human activities.

Natural resource management and protection strategies from the GMP that guide forest restoration include

- Support the perpetuation of ecosystem processes and components, including the redwood forest ecosystem as the prime RNP resource; and
- Restore and maintain RNP ecosystems as they would have evolved without human influences since 1850.

Previous Management of Second-Growth Forests in the Park

Forest restoration planning began in 1978 with an inventory of harvested forests within the lands acquired for the park in 1968 and 1978. Second-growth forests were visible on aerial photographs and easily distinguished from old-growth forests and other vegetation types. The inventory based on air photos produced an initial estimate of about 39,000 acres of old-growth and about 51,000 acres of second-growth forests.

Immediately following the 1978 inventory, park scientists established an experimental thinning study along Holter Ridge Road to determine the effectiveness and feasibility of thinning as a tool to restore second-growth forests (Veirs 1986). Additional thinning experiments have been conducted in the Whiskey 40 area along Bald Hills Road (Stuart and Cussins 1994; Keyes and Teraoka 2011), in a stand on the A-972 road on the west side of Redwood Creek, and a biomass utilization experiment using skyline yarding technology off of Holter Ridge known as the *Yoader Study* (Han and Arguello 2012). The South Fork of Lost Man Creek Second Growth Forest Restoration Plan (2008) was the first plan implemented for large-scale forest restoration in Redwood National Park. Park vegetation management staff has implemented a long-term monitoring program of the experimental thinning study areas (Figure 2) and the South Fork of Lost Man Creek project (Figure 2).

1978 Holter Ridge Study (Chittick 2005; Chittick and Keyes 2007; Veirs 1986)—The Holter Ridge thinning study was conducted by NPS Research Scientist Steven Veirs in 1978 to demonstrate how thinning can alter stand development trajectories to restore the forest structure found in old-growth forests. The goal of the study was to determine the effects of thinning to varying stand densities and its effect on the development of understory vegetation and overstory tree response. The 200-acre study area was a mixed stand of second-growth coast redwood, Douglas-fir and tanoak harvested in 1954. Stand regeneration used the seed tree method, in which an average of one redwood seed tree per acre was left and the stand allowed to regenerate from natural seeding. Pre-treatment stand densities averaged more than 1000 trees/acre [also referred to as stems/acre], with densities on some plots as high as 3000 trees/acre. Old-growth stands nearby were found to be predominantly redwood with densities of dominant trees ranging from 10-35 trees/acre for redwood and 1-4 trees/acre for Douglas-fir. In the second-growth stands, redwood/Douglas-fir ratios were observed to be 1:1 on more xeric (dry) sites and ratios of 12:1 on mesic (moist) sites.

The Holter Ridge study consisted of three treatments and a control. Each treatment area was divided into two parts, with varying conifer spacing (10- to 12-ft and 16- to 18-ft), treatment of hardwoods (10- to 12 ft with hardwoods cut or included in spacing), or treatment of the slash (10- to 12-ft with slash lopped or not lopped). Size limits for trees cut were 18 inches dbh for redwood sprouts, 10 inches for free-standing redwoods, and 12 inches for Douglas-fir. In all units the numbers of redwood stump sprouts were to be thinned to 30-50% of the dominant sprouts. After thinning, densities ranged from 150-790 stems/acre with the controls ranging from 1170-3410 stems/acre.

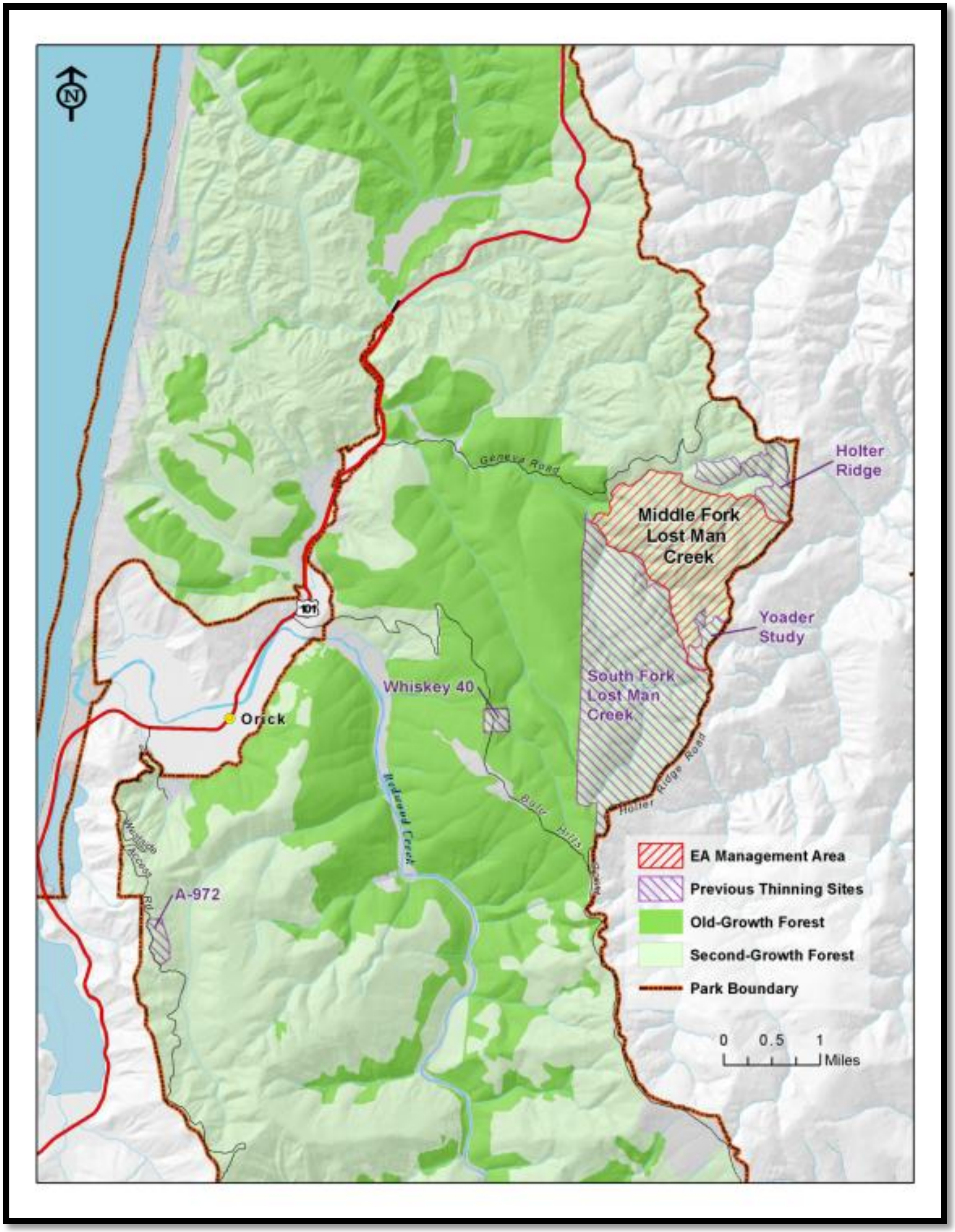


Figure 2. Thinning projects in Redwood National Park

The study site was sampled several times between 1979 and 2003. Mortality from 1979 to 2003 showed a positive relationship to the number of stems/acre after thinning, i.e.., the more trees that were cut, the less mortality was observed in remaining trees. The number of redwood sprouts was positively correlated to the number of redwoods thinned but very few sprouts grew larger than 2 inches dbh. The changes in percent cover of herbaceous and shrub species showed a negative correlation to stand density, i.e.., the percent cover of herbaceous and shrub species was higher in thinned plots. There was no stratification in the canopy in the control plots but the thinned plots showed stratification into an upper canopy of redwood and Douglas-fir and a lower canopy of redwood and tanoak. After 25 years, the thinned stands are beginning to show characteristics of a mature forest while the control sites continue to be dominated by small-diameter Douglas-fir.

1995 Whiskey-40 Study (Stuart and Cussins 1994, Teraoka 2004; Teraoka and Keyes 2011)—In 1995, RNP vegetation management staff established a demonstration project in a 40-acre clearcut called the Whiskey-40 along the Bald Hills Road to provide an opportunity for the public to view the results of thinning as a technique to restore second-growth forests. The Whiskey-40 unit was clearcut in 1963, burned, and aerially seeded using local and offsite seed sources. The site was chosen because of the poor condition of the forest stand and its location along a highly traveled route easily viewed by park visitors. The stand was even-aged and in the stem exclusion phase of stand development, densely stocked with small trees, had little understory or multi-layered canopy development, an overabundance of Douglas-fir and conifer species not native to the stand. The Whiskey-40 project offers visitors the opportunity to see the striking visual contrast between an overstocked second-growth forest and adjoining old-growth redwood forest.

The Whiskey 40 thinning demonstration was planned as a three-entry prescription at 20-year intervals. In first thinning entry, the prescription called for a “thin from below” in which all trees of any species less than or equal to 4.5 inches dbh would be removed, as well as any size Sitka spruce and Port-Orford-cedar, or any other conifers not native to the site. On the second entry 20 years after the first thinning, the original prescription called again for a “thin from below” with removal of all trees less than 9 inches dbh. On the third and last entry in 2035, 40 years after the initial thinning, the prescription called for a “thin from below and above for spatial pattern” with all remaining tanoak retained.

The project began in 1995 as planned. Four acres were left unthinned for a control. The other 36 acres were “thinned from below” with all stems smaller than 4.5 inches dbh and all Port Orford-cedar and Sitka spruce removed. This prescription removed approximately 75% of the trees per acre (approximately 550 trees per acre were retained) and 30% of the basal area per acre for trees of all species 1 inch dbh or greater.

In 2002, seven years after the first treatment, NPS forestry staff re-evaluated the plots shrub and herbaceous understory had developed, and trees were beginning to regenerate. Residual tree growth was enhanced as shown by a 33.6% gain in basal area, and mortality was minor. The results, however, also showed that Douglas-fir remained competitive in the upper canopy and that the treatment did not provide sufficient growing space for the remaining trees on a longer-term basis. The study concluded that the thinning improved stand conditions but did not fully satisfy restoration goals and that other thinning method and/or increasing thinning intensities are likely to be more effective at promoting redwood dominance.

Based on the 2002 observations, the NPS forestry staff began the second thinning in 2005 with a more aggressive prescription 10 years ahead of the originally scheduled second entry. The revised prescription called for a “thin-from-below” (i.e. “low thinning”) with a 30% basal area reduction of all species of trees greater than 4.5 inches dbh, resulting in 270 trees per acre retained after thinning. This revised prescription targeted mostly Douglas-fir, in addition to remaining exotic conifers. This prescription was implemented on 26 acres of the Whiskey- 40 that had been thinned in 1995 Areas retained from the original project include the 4-acre control, and 10 acres of the stand that had been thinned in 1995.

2007 A-972 experimental thinning unit—The A-972 experimental thinning unit was established in 2007. This study was developed to investigate the growth and development of mixed-species second-growth stands under different single-entry, density management treatments.

The study site covered 45 acres between the West Side Access Road and the A-972 Road. The stand was clearcut in 1968 and developed into an even-aged forest with a continuous canopy, and was in the stem exclusion phase of stand development. Species composition was heavily skewed towards Douglas-fir, mixed with redwood, Sitka spruce and red alder *(Alnus rubra)*. Understory vegetation was nearly absent.

The objectives of the A-972 study were to determine how initial stand densities in mixed-species second-growth redwood stands affect forest structure and composition under a single-entry thinning treatment.

The treatments were designed to include a wide range of initial stand densities to monitor subsequent stand development. Prescriptions called for two thinning methods—thinning from below and crown thinning—and two thinning intensities—a 45% retention and a 80% retention of the existing stand basal area.

The stand was thinned in October 2007. All species, including redwood, in any size-class were cut to meet the respective basal area and thinning method targets, although redwood was preferentially selected for retention.

2011 Yoader experimental thinning unit (Han and Arguello 2012)—The Yoader experimental thinning unit was designated in 2009. It covers 30 acres between the A-141 Road and A-120 Road off of Holter Ridge Road in Lost Man Creek. The study was initiated to test the cost effectiveness of using a small skyline yarding machine known as a "yoader" for forest restoration. An economic analysis was conducted to compare the costs of using a yoader to remove biomass from steep slopes versus the costs of lopping and scattering the biomass.

The stand was clearcut in 1962. The stand had primarily an even-aged, continuous canopy, and was in the stem exclusion phase of stand development. Species composition was heavily skewed towards Douglas-fir, mixed with redwood, western hemlock *(Tsuga heterophylla)* and grand fir *(Abies grandis)*. Understory vegetation was nearly absent.

The specific study objectives were:

- Evaluate overall economic feasibility of utilization of woody materials generated from thinning treatments in Redwood National Park,
- Quantify and compare economics between the lop-and-scatter method and the alternative method (using the yoader to pull boles to roadsides leaving only limbs and tops on-site),
- Identify and evaluate important stand and treatment variables that determine overall economics of thinning treatments,
- Develop prediction models that can be used to estimate thinning treatment costs in other places using the stand and treatment variables, and

- Evaluate the amount of damage to residual trees from thinning operations and develop strategies to minimize impacts on residual stands.

The stand was thinned from June through August 2011. The results of the economic analysis suggest that a yoader or similar skyline yarding equipment can be used to treat woody biomass on steep slopes to accomplish the objective of forest restoration, and that using skyline yarding equipment is a cost-effective operational tool that the park can utilize for restoration projects (Han and Arguello 2012).

2009-11 South Fork of Lost Man Creek Second Growth Forest Restoration Plan—The 2008 South Fork of Lost Man Creek Second Growth Forest Restoration Plan (NPS 2008) described forest restoration treatments throughout a 1,700 acres project area. The plan objective was to accelerate restoration of forest characteristics more typical of late-seral and old-growth redwood forests in the park, address species composition imbalances, and reduce tree density. The restoration plan called for implementing five different prescriptions throughout the project area including moderate-intensity thinning from below, low-intensity crown thinning, a diameter-based spacing rule (or a "Dx thinning rule") for tanoak-dominated stands, low-intensity thinning from below adjacent to old-growth forest, and low-intensity thinning in riparian management zones. Some acres were left unthinned because of sensitive resources, i.e., wetlands, overly steep slopes, and unstable soils. The park utilized contracts for the removal and sale of merchantable wood (trees large enough to sell to a mill for use as lumber or other products), generated by this project, on approximately 365 acres. The timber sale was conducted on slopes less than 30% using ground-based logging systems. On the remaining 1,335 acres of the project, thinned trees were left on-site to decompose naturally. The project was successfully implemented from 2009 through 2011. Post-thinning data showed that species composition shifted in favor of redwood (Teraoka 2012). Permanent plots will be revisited every five years to:

- Evaluate changes and trends in the ecosystem as a response to the treatments over time.
- Provide insight regarding the development of young, upland-mixed-redwood forest types.
- Develop the indicators and the basic understanding necessary to incorporate adaptive management techniques (or novel techniques) for similar stands within future forest restoration project areas.

Relationship of Second-Growth Forest Restoration to Other Management Projects

The NPS has undertaken several resource management projects in the vicinity of the proposed second-growth forest restoration project. Proposals for second-growth forest restoration have been coordinated with the watershed restoration program and the fire management program. Watershed restoration projects have been conducted within the proposed project area boundary.

1981 Watershed Rehabilitation Plan

The 1981 watershed rehabilitation plan described initial work needed to control and diminish human-induced erosion rates on areas that had been recently logged prior to park expansion. At that time, resource management staff proposed to replant Douglas-fir and redwood on logged areas that showed unusually slow progress in natural recovery, on the assumption that active revegetation was needed to reestablish vegetation on logged areas that had not been reseeded. As rehabilitation techniques were developed since the inception of the restoration program in 1978, monitoring has shown that the native plants in the seed bank in the soil colonize rehabilitated areas without the need for active revegetation.

2006 Lost Man Creek Watershed Restoration Plan
Watershed restoration in the Lost Man Creek area was conducted between 2006 and 2010 under a separate plan approved in 2006 to guide removal of logging roads and restoration of landforms to reduce potential erosion that could damage aquatic habitats in the Lost Man Creek watershed (NPS 2006b). All roads scheduled for removal have been completed with the exception of the A-131 road, which may be completely removed in the future.

Part of the Lost Man Creek watershed restoration overlapped the project area for management of second-growth forests described in this plan. Portions of the Holter Ridge, Geneva, A-131, and A-121, roads would be used for project access under the proposed action for second-growth forest restoration. Ridgeline portions of the A-121 will be retained for access for fire management.

2010 Fire Management Plan
The 2010 Redwood National and State Parks Fire Management Plan (FMP) (NPS 2010) describes how wildfire and fuels are managed to protect park resources. In the Middle Fork of Lost Man Creek, wildfires may be managed for resource benefit but will most likely be immediately suppressed because of the proximity of the project area to private timber lands. The FMP addresses the use of prescribed fire as a tool for management of second-growth forests but no prescribed fire units have been established in the project area under the current FMP.

Under the 2010 FMP, a shaded fuel break at a maximum width of 100 feet is being constructed on both sides of Holter Ridge Road. The shaded fuel break in the vicinity of Holter Ridge would not affect any of the prescriptions proposed for management of second-growth forest.

Public Involvement for Second-Growth Forest Restoration
The NPS sent letters to 127 agencies, organizations, and individuals in November 2011, soliciting comments on the proposal to restore second-growth forests in the Middle Fork of the Lost Man Creek watershed. Letters were sent to Yurok Valley Tribe, Trinidad Rancheria, Resighini Rancheria, Big Lagoon Rancheria, and Elk Valley Rancheria. One public meeting was held in Arcata on December 13, 2011; three Orick residents attended. The NPS met regularly with the USFWS and NOAA Fisheries to discuss threatened and endangered species protection measures as the project was developed.

The following issues were raised at the public meeting:

- Knowledge of the exact pre-logging species composition.
- Relationship of proposed plan to the park GMP and enabling legislation.
- Increased growth rates on redwood will weaken trees.
- Bear damaged and bear killed trees as a result of thinning.
- Too much money spent on lop-and-scatter operations; if the project can pay for itself, this would be a better option.

Consultation with Other Agencies
Endangered Species—Informal consultation on this project began with a meeting at an Interagency Consultation Team (ICT) on November 3, 2010. A second meeting with the ICT was held on February 2, 2011. The ICT includes representatives from the National Park Service, the U.S. Fish and Wildlife Service, the Arcata Fish and Wildlife Office (USFWS), and the Arcata office of NOAA Fisheries. The ICT meets quarterly to discuss proposed Redwood National Park projects and to determine whether the proposed projects require informal or formal consultation under requirements of Section 7 of the Endangered Species Act. Based on discussions of potential

impacts of the proposal to listed terrestrial and aquatic species, informal consultation was conducted with USFWS and with NOAA Fisheries.

At the ICT, NPS vegetation management staff presented information regarding details such as number of trees proposed for cutting, specific prescriptions to be utilized, and operational details related to removal of wood products. Discussions took place regarding potential impacts to aquatic and terrestrial systems with and without forest manipulation. Marbled murrelet survey data and residual habitat also were reviewed and discussed in the context of thinning activities. There was discussion regarding the risks associated with treatment activities, including noise production in association with heavy equipment operations near residual old-growth trees.

The NPS submitted a final biological assessment (BA) to the USFWS on November 14, 2011 that described the project, potential effects of the project on northern spotted owls and marbled murrelets, and measures to minimize adverse effects on these two species. The USFWS issued a Letter of Concurrence (LOC) file number AFWO-12B0009-11I0011, dated December 9, 2011, which concurred with the NPS determination that the project may affect, but is not likely to adversely affect the northern spotted owl and marbled murrelet.

The NPS prepared a biological assessment that described potential effects of the project on Southern Oregon/Northern California Coast (SONCC) coho salmon, California Coastal (CC) Chinook salmon, and Northern California (NC) steelhead trout, and measures to avoid or minimize adverse effects on these species and designated critical habitat for these species. The NPS submitted the BA to NOAA Fisheries requesting informal consultation on March 05, 2012. The NPS determined that, based on the design and timing of the proposed actions, the project may affect, but would not adversely affect SONCC coho salmon, CC chinook salmon, NC steelhead trout and their respective critical habitats and Essential Fisheries Habitats. NOAA Fisheries issued LOC file number 2012/00806, dated July 2, 2012 that concurred with the NPS determination.

Cultural Resource Consultations

Federal land management agencies are required to consider the effects of their proposed actions on properties listed in, or eligible for inclusion in, the National Register of Historic Places (i.e., historic properties), and allow the Advisory Council on Historic Preservation a reasonable opportunity to comment as per the National Historic Preservation Act, as amended and its implementing regulations at 36 CFR 800. Agencies are required to consult with federal, state, local, and tribal governments/organizations, identify historic properties, assess adverse effects to historic properties, and negate, minimize, or mitigate adverse effects to historic properties while engaged in any federal or federally assisted undertaking (36 CFR Part 800).

The NPS notified the California state historic preservation officer (SHPO) and Yurok tribal heritage preservation officer (THPO) on February 15, 2013 that an environmental assessment was being prepared, and sought concurrence with the NPS finding that proposed action would have no adverse effect to historic properties. The SHPO concurred with the NPS finding on September 27, 2013 (reference NPS_2013_0227_002). No comments were received from the Yurok THPO. The cultural resources inventory for the project was prepared by the Yurok Tribe under task agreement with Redwood National Park with contributions from the Yurok THPO.

NPS policies require consultation with affected American Indian groups. Notices about the environmental assessment being prepared were sent to Big Lagoon Rancheria, Elk Valley Rancheria, Resighini Rancheria, Trinidad Rancheria, and Yurok Tribe on November 18, 2011. In addition, NPS entered into a task agreement with the Yurok Tribe Cultural Resource Department to conduct cultural resources inventories needed to support the efforts of the NPS to comply with Section 106 of the National Historic Preservation Act and its implementing regulations 36 CFR 800.

Ethnographic interviews conducted in 2000 provided information about the project area being used for resource procurement and fishing along the lower reaches of the Lost Man Creek watershed (McConnell and Eidsness 2000). Yurok Tribe Cultural Resource Specialist Rosie Clayburn initiated consultation specific to this project with the Yurok Tribe Culture Committee on November 25, 2011 in Klamath, California. During this meeting, basic information was shared with committee members and the Yurok THPO regarding the project. The discussion revolved around the project, its purpose, and location. Rosie Clayburn went back to Culture Committee on January 27, 2012 in Klamath, California. Notes from these meetings are on file at the Yurok Culture Department and Redwood National Park, Cultural Resource Program Manager Files, and results of the consultations are summarized in *Cultural Resources Inventory and Assessment, Phase 2 Second Growth Management, Middle Fork Lost Man Creek, Redwood National Park, Humboldt County, California* (Clayburn 2012).

ALTERNATIVES

This environmental assessment analyzes the effects of Alternative 1 (No Action) and Alternative 2 (Proposed Action and Environmentally Preferred Alternative). The proposed action calls for using silvicultural thinning to restore second-growth forests on 1,125 acres in the Middle Fork of Lost Man Creek watershed. No other alternatives were identified that would meet the purpose and need of the project and have meaningful differences in environmental effects from the proposed action. A No Action alternative is analyzed for comparison of existing conditions with the Proposed Action, as required under NPS policies and guidelines for implementing NEPA.

The following assumptions were used to develop alternatives for management of second-growth forests in the Middle Fork of Lost Man Creek. These assumptions are derived from observations of second-growth forests and results of thinning experiments conducted in the park, and on timber operations and forestry research outside the park

- There is no natural precedent for the distribution and abundance of second-growth forests in the project area or the parks.
- The second-growth forests represent an unnatural condition that does not mimic a forest that would result from any natural disturbance event.
- Existing old-growth forest stands developed under different ecological conditions and from different forest conditions than those found in dense, closed canopy stand characteristics of the second-growth in the project area.
- Regeneration of old-growth stands occurred over a prolonged period at low densities with minimal self-thinning.
- Second-growth stands in the project area grow less vigorously under high density conditions in a highly competitive environment.
- Old-growth trees initially grow quickly (diameter tree size) for many decades before achieving a slower steadier growth rate.
- Growth rates (diameter) of second-growth trees in unthinned stands are less than growth rates of similar aged trees growing in thinned stands.
- Thinning second-growth forest stands increases diameter growth rates of remaining trees.
- The boundary between second-growth and old-growth forests creates micro-climate conditions that reduce quality and functionality of wildlife habitat along the boundary and extend into the old-growth for several hundred feet, i.e., an edge effect.
- The high tree density will delay the stands acquisition of redwood old-growth stand characteristics for centuries.
- Thinning with lop-and-scatter operations will affect canopy trees, leave more residual trees in the stand, cost more, will have no impact on the ground surface, and will have higher fuel accumulations than biomass removal operations.
- Thinning with biomass removal will maximize residual tree growth, significantly reduce Douglas-fir representation, cost less, impact ground surface via removal of woody debris, and minimize fuel accumulation.
- Crown thinning operations will alter stand developmental trajectories more than no active management but less than low or variable density thinning operations.
- Funding for forest restoration is limited.

The 1,125 acre project area is bordered by old-growth redwood forest to the west, private timberlands owned by Green Diamond Resource Company to the east, the South Fork of Lost Man Creek Forest restoration project area (completed in 2011) to the south, and Lost Man Creek to the north. The 50–60 year old forests within the project area have been divided into 18 management units based on road access, topography, and slope position.

Under the no action alternative and the proposed action, wildfires may be managed for resource benefit as described in the 2010 Fire Management Plan.

Definitions—A treatment (or prescription) includes a *thinning method*, a *thinning intensity*, and an *operational method*.

Thinning method refers to any silvicultural treatment made to reduce stand density primarily to redistribute growth among remaining trees and enhance forest health. The specific thinning methods proposed for this project includes *crown thinning, thinning from below, and variable-density thinning. Crown thinning* is a method of thinning that focuses on the removal of trees from the dominant or co-dominant crown classes to benefit adjacent trees of the same crown class. *Thinning from below* (*low thinning*) is a method of thinning that focuses on the removal of trees from the lower crown classes (i.e., suppressed, intermediate, and co-dominant crown classes) to benefit trees in the upper crown classes (i.e., co-dominant and dominant crown classes). *Variable-density thinning* refers to the enhancement of spatial variability by varying the thinning intensity throughout the stand and inducing fine-scale variation in the forest canopy.

Thinning intensity refers to the amount of stand density removed per unit area at any one time (generally expressed as percentage of stand density reduced or stand density retained). The specific thinning intensities used for this document includes a 25% basal area reduction and a 40% basal area reduction.

Operational method refers to the method by which trees are felled (mechanized or manual) and how woody material is treated and/or removed from the treatment area. Examples of operational methods include *lop-and-scatter operations, ground-based operations,* and *cable-yarding (*or *skyline) operations*. *Lop-and-scatter operation*s refers to an operational method that uses chainsaws to fell trees that are cut into small pieces (i.e., lopped) and broadcast (i.e., scattered) throughout the treatment area for natural decomposition; no woody material is removed from the treatment area. *Ground-based operations* refers to an operational method that uses ground-based mechanized equipment (e.g., feller-buncher, skidder, harvester/processor) to fell trees and/or skid logs or whole trees from the stump area to the landing or roadside area. *Cable (*or *skyline) yarding operations* refers to an operational method that uses a cable yarding machine, an overhead system of winch-driven cables, to pull logs or whole trees from the stump area to the landing or roadside area.

Number of trees is a simple count of individual trees per unit area regardless of size (generally expressed as trees per acre). *Basal area* refers to the cross-sectional area of all stems in a stand measured at breast height and expressed per unit of land area (e.g., ft^2 per acre). *Diameter at breast height* (*dbh*) is the diameter of a tree measured at breast height, which is the measurement of the outside bark diameter 4.5 ft above the forest floor. *Wood volume* refers to the 3-dimensional area of wood fiber (generally expressed in board feet). *Biomass* refers to the weight of wood fiber (generally expressed in tons). Please refer to the glossary for additional definitions.

Alternative 1 (No Action)
The No Action alternative is required under NPS guidelines for compliance with the National Environmental Policy Act (NEPA) and is used to compare existing conditions with the other alternatives. “No Action” means either a continuation of existing management practices or “no project.” In this case, “No Action” means that the second-growth forests would not be thinned or

otherwise manipulated to accelerate development of old-growth characteristics but current monitoring of second-growth forests would continue.

Under the No Action alternative, second-growth forests in the Middle Fork of Lost Man Creek watershed would not be treated or manipulated with silvicultural techniques to reduce stand density or alter species composition. Existing stand conditions and stand development processes would be allowed to progress under stochastic disturbance regimes.

Alternative 2: Thinning with Biomass Removal Operations in High-Access Areas and Thinning with Lop-&-Scatter Operations in Limited-Access Areas (Proposed Action and Environmentally Preferred Alternative)

Under Alternative 2 (the Proposed Action), eight prescriptions (Table 1) would be used depending on access, slope, existing tree species composition, proximity to streams, and proximity to contiguous old-growth forest.

Each prescription would use a different combination of one of three silvicultural methods (low thinning, crown thinning, or variable-density thinning), one of three thinning intensities (25%, 30%, or 40% reduction in basal area), and one of three operational methods (biomass removal using ground-based operations, biomass removal using skyline operations, or lop-and-scatter operations) (Table 1; Figure 3).

NPS vegetation management staff sampled stands throughout the project area using standard forest cruising methodologies. Cruise data were used to characterize the existing stand conditions, describe baseline untreated conditions, and estimate numbers, sizes, volumes and species of trees to be felled and retained to accomplish restoration objectives for the action alternative.

Table 2 lists all the stands that would be treated and the proposed treatments by stand for the entire project. Estimates of the merchantable volumes, number and size of trees that would be thinned, and pre- and post-treatment stand conditions are listed in Tables 3, 4 and 5. The project is planned for completion over five years, but the start date depends on available funding and the total duration depends on weather-related accessibility to portions of the project areas.

TABLE 1. SILVICULTURAL PRESCRIPTIONS FOR THE PROPOSED ACTION

Prescription Name	Silvicultural Method	Intensity[1] (%)	Operational Method[2]
Low Thinning with Ground-Based Operations	Low Thinning	40%	Biomass Removal: Ground-Based Operations
Variable-Density Thinning with Ground-Based Operations	Variable-Density Thinning	40%	Biomass Removal: Ground-Based Operations
Low Thinning with Skyline Operations	Low Thinning	40%	Biomass Removal: Skyline Operations
Low Thinning with Lop-&-Scatter Operations	Low Thinning	40%	Lop-&-Scatter Operations
Crown Thinning with Lop-&-Scatter Operations	Crown Thinning	25%	Lop-&-Scatter Operations
Variable-Density Thinning with Lop-&-Scatter Operations	Variable-Density Thinning	40%	Lop-&-Scatter Operations
Old-Growth Buffer	Low Thinning	30%	Lop-&-Scatter Operations
Riparian Management Zones (RPZ)	Low Thinning/Crown Thinning	Canopy Cover Restrictions	Lop-&-Scatter Operations

[1]= Intensity is expressed in maximum percent basal area removed. RMZ's would be treated as described in the Minimization Measures and Best Management Practices section.
[2]= All Ground-Based Operations would occur on slopes less that 36%. Skyline Operations and Lop-&-Scatter Operations have no slope limitations other than specified in the Minimization Measures and Best Management Practices section.

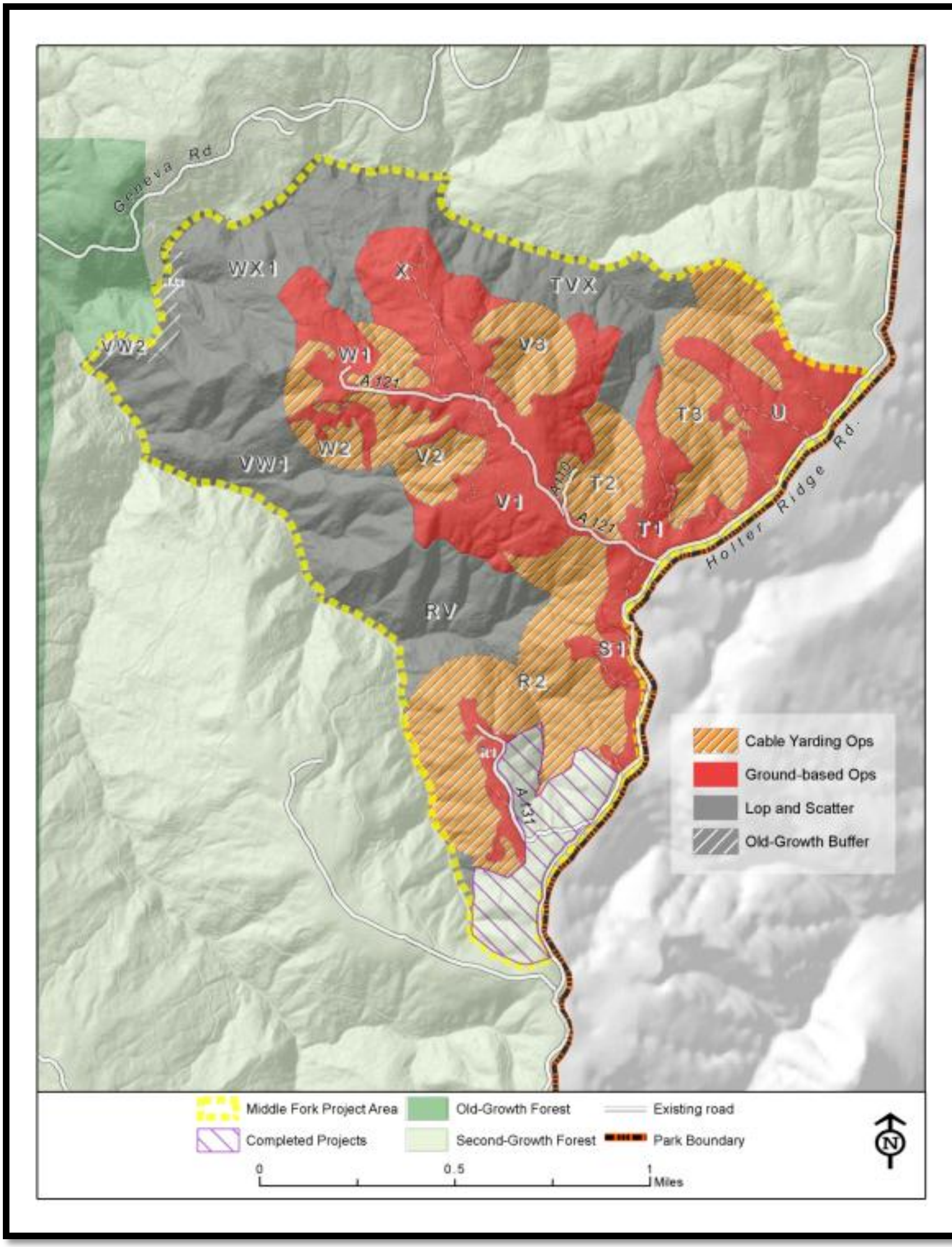


Figure 3. Project area

TABLE 2. PROJECT UNITS, ACREAGES, AND PROPOSED TREATMENT OPTIONS (X)

		Treatments						
Operational Method[1]		Ground-Based Operations		Skyline Operations	Lop-&-Scatter Operations			
Silvicultural Method[2,3]		Low Thin	VDT	Low Thin	Low Thin	Crown Thin	VDT	Old-Growth Buffer
Unit Name	Acres							
R1	14	X						
S1	19	X						
T1	47	X						
U	57		X					
V1	124	X						
W1	35	X						
X	40	X						
R0	4				X	X	X	
RV	76				X	X	X	
TVX	79				X	X	X	
VW1	135				X	X	X	
WX1	114				X	X	X	
X1	25				X	X	X	
VW2	8							X
WX2	10							X
R2	137			X				
T3	74			X				
V2	43			X				
V3	32			X				
W2	19			X				
T2	32			X				
Total Acres	1,125	-		-	-			
Acres by Operational Method		337		338	450			
Acres (Silvicultural Method and Operational Method)		280	57	338	432	-	-	18

[1]= Ground-based and Skyline Operations requires the use of heavy equipment to remove the biomass from the site. Under Lop-&-Scatter Operations, biomass would be left on-site.
[2]=Low thinning and Variable-density thinning (VDT) would target a 40% reduction in stand basal area; Crown Thinning would target a 25% reduction in stand basal area, the old-growth buffer would target a 30% reduction in stand basal area using the low thinning silvicultural method.
[3]=Riparian management zones are not defined in acreage.

TABLE 3. STAND CHARACTERISTICS BEFORE AND AFTER THINNING USING LOW THINNING OR VARIABLE DENSITY THINNING

Sample Unit Name[1]	Basal area per acre (ft^2)							Number of trees per acre							Number of trees cut per acre	
	Unthinned				Thinned			Unthinned				Thinned				
	PSME[2]	SESE[3]	LIDE[4]	Total[5]	PSME	LIDE	Total	PSME	SESE	LIDE	Total	PSME	LIDE	Total	PSME	LIDE
S	209	82	36	354	68	36	214	235	92	112	469	31	112	265	204	0
T	150	77	17	253	49	17	152	344	69	87	513	44	87	213	300	0
U	182	116	21	324	53	21	195	230	118	60	411	21	60	203	209	0
V - East	120	80	95	307	30	62	182	201	77	296	597	15	117	231	186	179
V - West	138	43	84	266	48	67	158	200	37	196	433	21	112	169	179	84

[1]Sample Unit Name = Sample Unit S represents Management Units S1, R1, and R2; Sample Unit T represents Management Units T1, T2, and T3; Sample Unit U represents Management Units U, and T3; Sample Unit V-East represents Management Units V1, V3, and X; Sample Unit V-West represents Management Units V1, V2, W1, and W2.
[2]PSME = Douglas-fir (*Pseudotsuga menziesii*)
[3]SESE = Coastal redwood (*Sequoia sempervirens*)
[4]LIDE = Tanoak (*Lithocarpus densiflorus*)
[5]Total = Species with relatively small proportional compositions that were observed in the sample are represented in the totals for basal area per acre (ft^2) and number of trees per acre. Such species included western hemlock, grand fir, and red alder.
Note: Sample units represent areas within the project area where data were collected. Prescription calls for low thinning or variable density thinning silvicultural method with a 40% basal area reduction.

TABLE 4. STAND CHARACTERISTICS BEFORE AND AFTER THINNING USING THE CROWN THINNING

Sample Unit Name[1]	Basal area per acre (ft^2)							Number of trees per acre							Number of trees cut per acre	
	Unthinned				Thinned			Unthinned				Thinned				
	PSME[2]	SESE[3]	LIDE[4]	Total[5]	PSME	LIDE	Total	PSME	SESE	LIDE	Total	PSME	LIDE	Total	PSME	LIDE
S	209	82	36	354	120	36	265	235	92	112	469	157	112	392	77	0
T	150	77	17	253	86	17	189	344	69	87	513	236	87	405	109	0
U	182	116	21	324	101	21	242	230	118	60	411	140	60	321	90	0
V - East	120	80	95	307	54	84	228	201	77	296	597	116	279	495	85	16
V - West	138	43	84	266	81	73	197	200	37	196	433	152	175	364	48	20

[1]Sample Unit Name = Sample Unit S represents Management Units S1, R1, and R2; Sample Unit T represents Management Units T1, T2, and T3; Sample Unit U represents Management Units U, and T3; Sample Unit V-East represents Management Units V1, V3, and X; Sample Unit V-West represents Management Units V1, V2, W1, and W2.
[2]PSME = Douglas-fir (*Pseudotsuga menziesii*)
[3]SESE = Coastal redwood (*Sequoia sempervirens*)
[4]LIDE = Tanoak (*Lithocarpus densiflorus*)
[5]Total = Species with relatively small proportional compositions that were observed in the sample are represented in the totals for basal area per acre (ft^2) and number of trees per acre. Such species included western hemlock, grand fir, and red alder.
Note: Sample units represent areas within the project area where data were collected. Prescription calls for crown thinning silvicultural method with a 40% basal area reduction.

TABLE 5. ESTIMATED STAND VOLUMES IN 1,000 BOARD-FEET (MBF) PER ACRE

Unit Name	Acres	Operations	Total Vol/ac (mbf)	Merchantable Vol Removed/ac (mbf)[1]	Biomass Vol Removed/ac (mbf)[2]
R1	14	Ground-Based	49.0	23.1	1.5
S1	19		49.0	23.1	1.5
T1	47		20.6	7.4	2.5
U	57		41.6	18.2	1.6
V1	124		28.3	15.6	1.8
W1	35		29.3	15.6	2.5
X	40		27.3	15.5	1.0
R2	137	Skyline	49.0	23.1	1.5
T3	74		31.1	12.8	2.1
V2	43		29.3	15.6	2.5
V3	32		27.3	15.5	1.0
W2	19		29.3	15.6	2.5
T2	32		20.6	7.4	2.5
Means			33.2	16.0	1.9

[1]Merchantable volume = estimated maximum volume of woody material that meets the minimum standards for sawtimber.
[2]Biomass volume = estimated volume of woody material that does not qualify for sawtimber but can be utilized as cogeneration biofuels.
Note: Volume estimates represent the stem volume of living conifers greater than 4.5" dbh.

<u>Minimization Measures and Best Management Practices</u>
The following measures and BMP's were developed through informal consultation with the USFWS and NOAA Fisheries.

Normal Operating Season and Weather Restrictions
Surveys for spotted owls and marbled murrelets, following established regulatory protocols, have or would be conducted in all areas containing suitable habitat in or within 0.25 mile of proposed work areas.

Chainsaw work would not occur within 500 feet of known occupied, or assumed occupied, suitable marbled murrelet habitat during the marbled murrelet breeding season (March 24–September 15).

Chainsaw work occurring within 500 feet of suitable, but not known or assumed to be occupied marbled murrelet habitat would occur two hours after sunrise until two hours after sunset during the marbled murrelet breeding season (March 24–September 15).
Work that generates noise above ambient sound levels would not occur within 0.25 miles of a northern spotted owl detection site during the spotted owl noise restriction period (February 1–July 9). If a spotted owl activity center is found to have chicks, then no tree removal would occur during the period February 1–September 15 within the activity center stand or 70-acre core area surrounding the activity center.

Work would occur throughout the year where possible. In areas where sensitive bird species might be disturbed during nesting seasons, in areas where soil erosion would adversely affect streams, or where unstable slopes could erode, work would be restricted to certain seasons, days, or hours of the day.

In areas where soil erosion might affect streams, all project work would be completed during the normal operating season (NOS) between June 15 and October 15. If more than 0.5 inch of rain is forecast during the NOS, project operations would temporarily cease and sites would be winterized. If periods of dry weather are predicted after October 15, additional work would be permitted if it can be completed within the window of predicted dry weather. Work sites, including roads and landings, would be winterized at the end of the NOS. Winterization includes: 1) grading exposed road and landing surfaces to allow water to freely drain across them without concentrating, ponding or rilling, 2) installing rolling dips/drains to drain steeper sections of road necessary to convey concentrated water across exposed road and landing surfaces, 3) clearing clogged drainage ditches or culverts, and 4) installing silt fences and other erosion control devices where needed to prevent sediment from reaching stream channels or water source.

Work is expected to occur year round with the exception of areas within 500 feet of the contiguous old-growth forest on the west side of the project area.

Crews would leave in reserve the 0.25-mile zone closest to the old-growth forest edge untreated until after 15 September but before 24 March. Portions of Holter Ridge roads that cross the old-growth forests and the 0.25 mile buffer would be utilized by trucks to haul logs or equipment during the summer months. Thinning and other noise-producing project work would be subject to seasonal murrelet restriction period (March 24 – September 15).

General Operating Restrictions

There are operating requirements that would apply to any area where trees would be removed off-site. The operating requirements would minimize adverse effects on soils, streams, wetlands, sensitive wildlife, and trees targeted for preservation.

The total project area is 1,125 acres of which biomass removal operations are proposed on 675 while lop-and-scatter are proposed on 450 acres. If any or all 675 acres proposed for biomass removal operations cannot be implemented, i.e., road access is no longer available or no bids are submitted, then those areas would be treated using lop-and-scatter operations with the respective silvicultural method and thinning intensity.

Trees to be cut in 40% basal area reduction sites would be marked by NPS vegetation management staff. NPS vegetation management staff would be on-site as necessary to ensure that operations are being conducted according to prescriptions.

Thinning in area delineated for lop-and-scatter operations would be conducted by contract crews using gas-powered chainsaws.

No heavy equipment (felling, yarding, or otherwise) would be allowed within the dripline of any residual old-growth trees or aggregate areas in order to prevent damage to trunks and root systems. No damage from yarding activities would be allowed within 50 feet of any residual old-growth tree.

Trees growing under the dripline of old-growth trees would not be removed. No trees within 50 feet of the dripline which extend equal to or greater than the height of the lowest live branch of an old-growth residual tree would be removed. Smaller trees that don't extend to the lowest live branch may be cut according to the prescription in the rest of the unit. Where residual trees are aggregated (tree canopies within 30 feet of each other), a no treatment zone would be established around the outer edges of the trees.

No old-growth trees of any species would be cut. The largest trees removed would not exceed 24 inches dbh. No trees would be felled towards residual trees, trees with value as wildlife habitat, or trees targeted for preservation (large conifers or hardwoods, deformed trees, redwood stump sprouts).

Felled trees and slash would not be piled or burned. Felled trees that are not removed offsite would be limbed, bucked, and lopped to get the wood in contact with the forest floor. Fuel residues created by disturbed vegetation or slash from felled trees would be lopped, scattered and left on-site to a maximum average fuel depth of 24 inches. However, brush piles of greater height may be created intentionally for wildlife habitat.

All existing downed woody material and snags would be retained. Snags felled for operational or safety reasons would be left on site as large wood.

After treatment, regardless of prescription, an average of 60% canopy cover of trees greater than 11 inches dbh must be retained throughout the stand, and an average of 100 square feet basal area for all trees greater than 11 inches dbh must be retained throughout the stand.

No pre-existing woody debris would be removed from any unit. If whole trees are initially brought out of a unit for processing, the slash (tree tops, branches etc.), if not used for cogeneration material, would be brought back into the unit and used as ground cover to reduce erosion.

Logs would not be skidded against residual trees or groups of trees to be retained. Logs would be skidded with the leading end clear of the ground. Logs would be end-lined as needed to protect resources or residual trees from unnecessary damage.

All felled trees up to eight inches dbh qualifying for cogeneration biomass material can be loaded and trucked to a cogeneration power plant. If this material is not removed, it would be limbed, bucked, and lopped to get the wood in contact with the forest floor. All unmerchantable woody material (including cull logs, limbs, bark, and other woody debris) would be lopped and scattered throughout the project area. This slash, along with limb wood from larger trees, would be used as ground cover after equipment operations are completed or before the onset of winter rains.

Site Access

Thinning crews would drive as close to project sites as possible using existing roads and skid trails (Figure 4).

All vehicles and equipment utilized in this project would be cleaned prior to entering park to prevent transmission of non-native invasive plants or forest pathogens.

Equipment, both hand tools and heavy equipment, would be inspected daily to check for leaks. Equipment that may leak lubricants or fuels would not be used until leaks are repaired. All equipment would be stored, serviced and fueled outside of riparian areas and away from stream crossings. Fuel trucks would transport fuel for the equipment to the project site. Fuel would be stored on-site. A spill plan and materials for spill containment would be required. In the event of a spill, work would be stopped immediately, clean up would begin and the appropriate authorities would be notified.

Road Use and Road Work Restrictions
All access would occur on existing roads (Figure 4). Access roads would typically be traveled almost exclusively by park staff during the work planning phase driving light duty vehicles to and from a site each day. Once operations begin, vehicle use (heavy equipment or light duty) on access roads would increase.

Hand and heavy equipment crews would drive into the project area using existing roads. Log trucks and equipment would access the project area via the Holter Ridge Road. Holter Ridge Road is a fully rocked park administrative road maintained for year-round access. Access within the project area would be on the existing, native-surfaced A-121 and A-131 roads and their spurs which run primarily along ridge tops. Roads may be watered to provide for dust abatement. Water tender operators would not be allowed to obtain water from creeks, springs, ponds, or other natural features in the park.
Rocking of all or portions of the A121 road would occur. Rock would be taken from an existing park quarry known as the Geneva Road borrow pit (Figure 4).

Winterization measure as described in the <u>Minimization Measures and Best Management Practices</u> apply to all road work as well.

Existing Roads to be Reopened
Approximately 4.5 miles of existing roads that occur in the project area would potentially be reoccupied (Figure 4). These roads have not been maintained and have naturally revegetated, primarily with Douglas-fir, red alder, and/or ericaceous species such as evergreen huckleberry and salal.

There are a combined 10 spur roads off of Holter Ridge Road, the A-121 Road, and the A-131 Road that would be re-opened. These roads vary in length from 300 feet to 0.42 miles long, totaling 2.24 miles. Approximately 475 feet of the A-121 Road will be re-routed through a site already disturbed by the watershed restoration program.

Use of Existing Landings and Skid Trails
Only existing landings (Figure 4) that were constructed for commercial logging operations prior to park establishment would be used. Thirty-four potential landing sites have been identified. Of those, 13 landing sites are already open and ready for use. New landings would not be constructed; however, additional old, existing landings would be reopened if needed. Landings would be kept to the minimum size needed to accomplish the job and existing road surfaces would be used as much as possible. Reopening old landings would be similar to reopening old roads: brush and small trees would be removed and minimal grading and possible stump removal may occur. Landings would not be larger than one-tenth of an acre each. Landing winterization would be applied consistently as already described for this project.

Only existing skid trails would be used for project operations. Skid trail widths would be limited to what is operationally necessary for the equipment. Skid trails would be blocked where they access main roads following completion of ground-based yarding.

Tire tracks, skidding ruts and other depressions and surface irregularities would be obliterated and restored to pre-disturbance surface condition where practicable. Erosion control measures such as water bars and slash placement on skid trails and disturbed soils where the potential for erosion and delivery of sediment to waterbodies, floodplains, and wetlands exists would be implemented. Culverts, water bars, and other damaged drainage structures would be repaired or replaced. Logging slash including cull logs, chunks, limbs, bark, and other woody debris that is not removed would be spread uniformly and would not exceed an average of 24 inches in depth.

Streamside Protection Measures
Best management practices would be applied to up to 20.4 miles of streams and potential flow paths water quality and wetland functions and values (Figure 5). Potential flow paths are areas that may constitute potential swale and intermittent stream features. All streamside protection zones would be clearly marked by park staff on the ground.

Streamside and wetland buffers and prescriptions would vary based on

- Stream type (swale, intermittent, perennial);
- Stream power (channel development, stream order); and
- Geomorphic setting (slope steepness of streamside areas, presence of unstable areas).

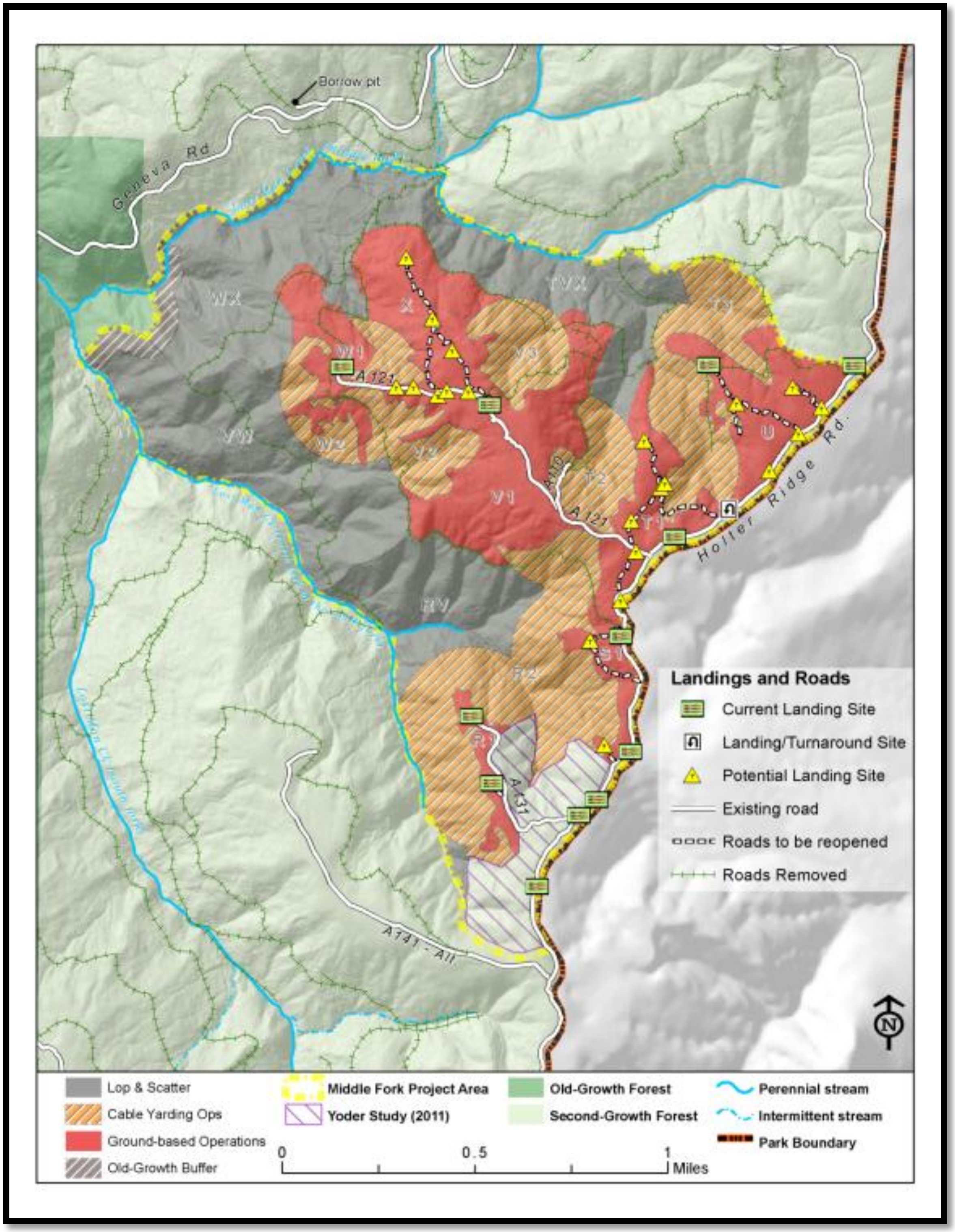
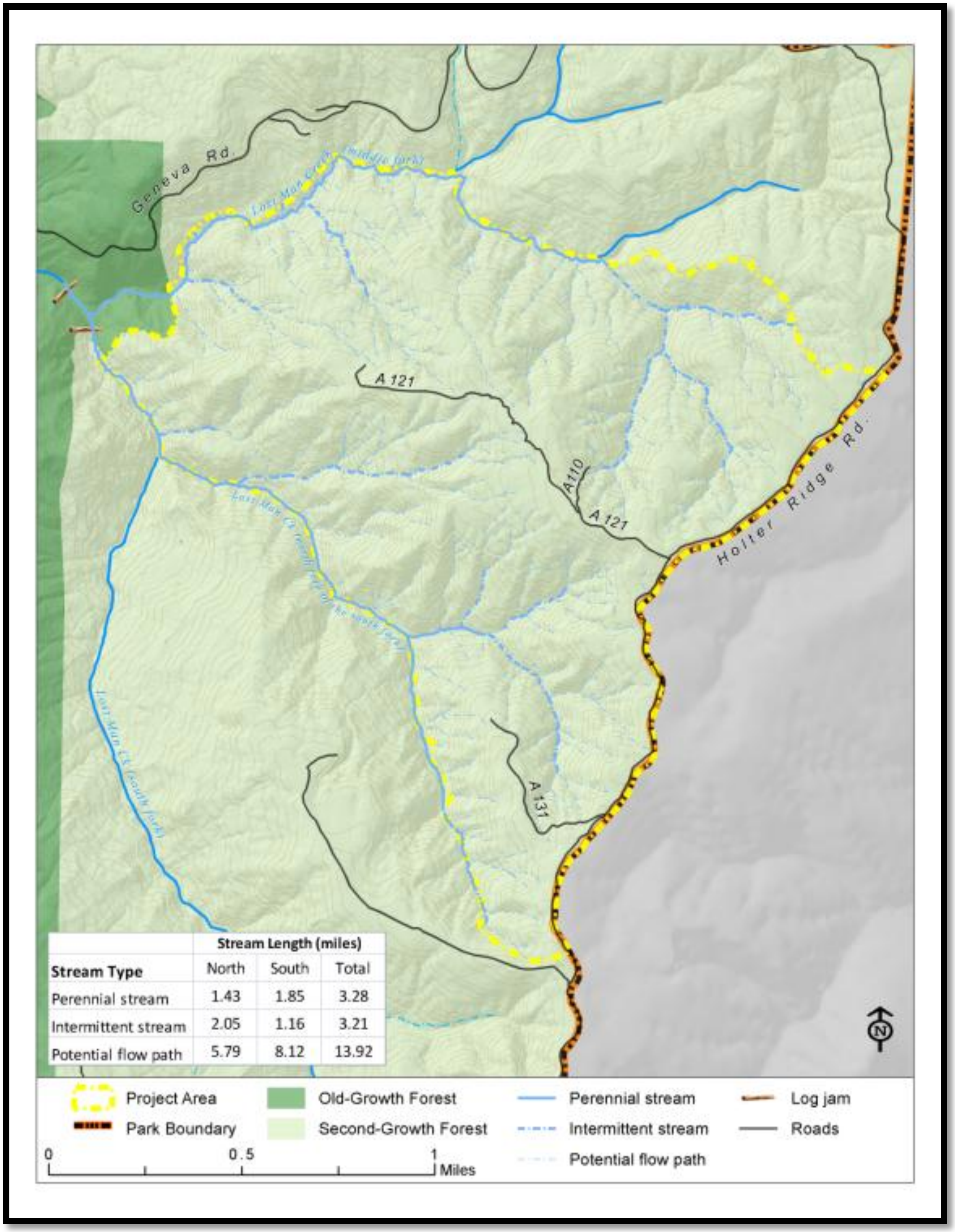


Figure 4. Roads, proposed locations of log landings, and location of borrow pit



Stream Type	Stream Length (miles)		
	North	South	Total
Perennial stream	1.43	1.85	3.28
Intermittent stream	2.05	1.16	3.21
Potential flow path	5.79	8.12	13.92

Figure 5. Streamside Buffer Zones

The majority of streams in the project area are riparian zones along intermittent and perennial streams. Swales are topographic depressions on a hill slope that show no evidence of surface flow or channel development. An intermittent stream is a stream that only flows at certain times of the year, when it receives water from springs or some surface source. Streams 3rd order and above are considered perennial streams. There are approximately 3.2 miles of intermittent streams, 3.3 miles of perennial streams, and 13.9 miles of potential flow paths.

Except for very limited areas along the perennial section of the Middle Fork of Lost Man Creek, thinning would not occur within 500 feet (each side) of perennial streams. Ground-based operations or skyline operations would not operate within 500 feet of a perennial stream.

For intermittent and ephemeral streams on slopes less than or equal to 30 percent, streamside protection zones would be a minimum 50 feet wide or to the break-in-slope, whichever distance is greater. For intermittent and ephemeral streams on steeper (31 to 45%) slopes, streamside protection zones would be at least 100 feet wide or to the break-in-slope, whichever distance is greater. Thinning treatments would retain at least 70 percent post-treatment tree canopy.

Trees that are felled within streamside protection zones would be lopped to get them in contact with the ground and left on-site. No trees would be felled into intermittent or ephemeral stream channels. No trees that contribute to stream bank stability (as determined and marked by park staff) would be felled.

All trees would be retained on unstable and potentially unstable areas, regardless of slope steepness and within the 50-foot-wide zone that surrounds the feature. Park staff would identify and delineate such unstable and potentially unstable areas on the ground.

Winterization methods, as described in the *Minimization Measures and Best Management Practices Section*, would be applied to protect streams from sediment.

All equipment, including hand tools, heavy equipment, and cable yarding equipment, would be inspected daily to check for leaks. Equipment that may leak lubricants or fuels into a stream would not be used until leaks are repaired. All equipment would be stored, serviced and fueled outside of riparian areas and away from stream crossings. A spill plan and materials for spill containment would be available to onsite personnel and all personnel would be trained in spill containment. In the event of a spill, work would be stopped immediately, clean-up would begin and the appropriate authorities would be notified.

Cable yarding corridors that cross intermittent or ephemeral streams would be approximately 10 feet wide and all trees would be fully suspended in the air through streamside protection zones of intermittent and ephemeral streams.

Equipment would not operate in, or cross swale features, where slope steepness is greater than 30%. Such features would be delineated by park staff on the ground.

<u>Biomass Removal Operations and Silvicultural Prescriptions</u>
The proposed action calls for a basal area reduction of 40% on 675 acres (of the total 1,125 acre project area) using biomass removal operation. Thinning would be used to reduce overall stand densities to stimulate stand growth and development, to release dominant trees, to improve conditions for development of understory vegetation, and improve stand level representation of redwood. Merchantable wood would be removed and sold to offset the cost of conducting the thinning work and hauling the woody biomass off-site. Excess biomass not meeting the minimum

merchantable wood standards but which would qualify for cogeneration material may be removed off-site. In addition, the cut trees would be removed to minimize woody debris accumulation on the forest floor. Contract crews would be allowed to remove merchantable wood from the project in exchange for implementing the planned prescription. It is expected that the value of merchantable wood would be sufficient to pay for the thinning activities on these 675 acres.

There are three silvicultural prescriptions that would be used under the biomass removal operations. Low thinning with Ground-Based Operations on slopes less than 36% would be conducted on 280 acres. Variable Density Thinning with Ground-Based Operations on slopes less than 36% would be conducted on 57 acres. Low thinning with Skyline Operations on slopes steeper than 35% would be conducted on 338 acres.

Low Thinning with Biomass Removal using Ground-Based Operations
On approximately 280 acres of the project area with up to 35% slope (Figure 3; Table 2), the low thinning silvicultural method using ground-based operations would be used, and stand basal area would be reduced by 40%.

The prescription calls for low thinning to reduce overall stem density of Douglas-fir. An average of 268 trees per acre would be removed (Table 3). Thinning would target Douglas-fir in the size class range from 5- to 24-inch dbh (partial removals from 16- to 24-inch dbh).

Trees in the 5-inch diameter size class would be removed first, with successively larger trees removed until the 40% target is met. Overstory trees would be selected for removal based on maximizing release of redwood trees and other identified larger conifers. Some redwood on skid trails might be removed to provide access for equipment into the stand. Tanoak 12 inches or less in diameter might also be cut along skid trails and within the unit to meet the stand basal area reduction target. Trees removed on skid trails would count toward the stand basal area target reduction.

A variety of equipment would be used, from chainsaws to heavy equipment such as harvesters, feller-bunchers, loaders, processors, and skidders to fall, skid, process, and load the wood for removal off-site. Chainsaws and/or harvesters would be used to fall targeted trees except where heavy equipment is prohibited to protect endangered species, streams, and wetlands. Skidders would remove logs from the stump area by skidding the tree or log to a landing. At the landing, a processor would limb and buck the material into lengths appropriate for hauling to the mill or the cogeneration power plant. Loaders would be used to load log trucks. Log trucks would transport logs from the project area to a mill or cogeneration power plant.

Variable-Density Thinning with Biomass Removal using Ground-Based Operations
Unit U (57 acres) (Figure 3; Table 2), would be treated using the variable-density thinning silvicultural method. Variable density thinning attempts to enhance spatial variability by varying the thinning intensity throughout the stand and inducing fine-scale variation in the forest canopy. Thus, a mosaic of tree densities would occur throughout the unit.

The variable density thinning method that would be used for this project is known as the "randomized grid variable-density thinning" (O'Hara et al. 2010 and O'Hara et al. 2012). The grid would consist of 104 ft ×104 ft squares (approximately 0.25 acre) throughout the entire stand. The squares would be delineated on-the-ground with flagging prior to any marking or cutting. Each square would be thinned at a different intensity. Five thinning intensities would be used (0-10%, 25%, 40%, 55%, or 70-80% reduction in basal area). The probability of selecting these thinning intensities for any given square is outlined in Table 6. Regardless of the thinning intensity selected for any given square, the square would be thinned from below (the smallest diameter trees would be removed first, with successively larger trees removed until the target reduction is met). The average stand basal area reduction (i.e., the average reduction in basal area from all the squares) would be 40% (leaving approximately 210 ft^2 of stand basal area). Where a 70-80% reduction in basal area occurs, all redwoods and any trees greater than 24 inches dbh would be retained. An average of 268 trees per acre would be removed (Table 3).

TABLE 6. SUMMARY OF RANDOMIZED GRID VARIABLE-DENSITY THINNING.

% Reduction in Basal Area	0-10	25	40	55	70-80
Probability of Selection (%)	5	20	50	20	5
Approx. Basal Area Retained (ft^2/ac)	350-315	260	210	160	10-70
Approx. acres to be treated	3	11	29	11	3

Note: Range of thinning intensities, the probability of selecting the thinning intensity for any given square, the approximate basal area retained (assuming 350 ft^2/ac) and the corresponding number of acres to be treated for 57 acres in the unit.

The same suite of equipment would be used as outlined in the *Low Thinning with Biomass Removal using Ground-Based Operations* silvicultural prescription.

Low Thinning with Biomass Removal using Skyline Operations
On approximately 338 acres of the project area with slopes greater than 35% (Figure 3; Table 2), the low thinning silvicultural method using skyline operations would be used, and stand basal area would be reduced by 40%. An average of 268 trees per acre would be removed (Table 3).

The low thinning silvicultural method outlined in *Low Thinning with Biomass Removal using Ground-Based Operations* prescription would also be used in skyline operations. The primary difference is the type of heavy equipment used and tree falling operations.

A variety of equipment would be used. All trees would be felled using chainsaws. Felled trees would be processed (cut to log length and limbed) using chainsaws prior to skyline yarding. All non-merchantable trees, trees that do not qualify as biomass fuel that are felled, and all limb wood, tree tops and other material created from processing would be lopped to get the wood in contact with the forest floor. Merchantable trees or trees that qualify for biomass fuels would be skyline yarded to a landing, skid trail, or road using a cable yarder or yoader. Regardless of the type of skyline system used, a slackpulling carriage would be used to skid felled trees to the main cable yarding corridor. Cable yarding corridors are generally not larger than 10 feet in width. Tail holds (anchors the end of a mainline) can be trees, stumps, or another piece of heavy equipment. If trees are used as a tail hold they would not be old-growth trees of any species; second-growth trees (preferable Douglas-fir) would be used. Heavy equipment may be used as a tail hold if appropriate. Guylines would be anchored to old-growth stumps, second-growth stumps, or second-growth trees; old-growth trees of any species would not be used to anchor guylines).

Yoaders allow more flexibility for access and do not require the use of guylines. A yoader can be stationed at landings or on road surfaces. If the break-in-slope is not accessible from the road or a landing, a yoader could use existing skid trails on flat areas (gentle slopes) to access steep areas (i.e., break-in-slope) for cable yarding. The general yarding distance would not exceed 600 feet. A track or tire skidder may be used to skid trees from the yoader station to a landing or road. A loader, at the landing site or road, would be used to sort logs and load log trucks.

The traditional yarder to be used is called a "shovel yarder," which allows more flexibility in access. Shovel yarders can be stationed at, and can yard from, small landings and road corridors (landing are not necessary if certain road conditions apply). The general yarding distance would not exceed 1,500 feet. A loader at the landing site or road would be used to load log trucks.

Regardless of skyline system, deflection (the vertical distance between the cord and the skyline measured at mid-span) would determine the amount of ground disturbance. In general, there is very little ground disturbance as only the tail end of the logs skip along the ground as they are hoisted up to the yarder. Most of the ground disturbance would occur closer to the yarder as the logs reach the break-in-slope adjacent to and below the yarder.

Riparian Management Zones for Skyline Operations—Thinning conducted in intermittent and ephemeral stream buffers would be restricted to lop-and-scatter operations except for what is stipulated in the cable yarding corridors. Lop-and-scatter operations would be conducted by hand fallers within the streamside buffers.

Other BMP's for Skyline Yarding Operations:

- Skyline yarding corridors through streamside buffers would be allowed where needed and the corridors would be a maximum of 20-feet wide, but would generally range between 10 to 15-feet wide.
- Skyline yarding corridors would be designed to be as perpendicular to streamside buffer features as practicable.
- For streamside buffers protecting intermittent and ephemeral streams, debris from merchantable trees and all non-merchantable trees cut inside of the streamside buffer would be left on-site to provide stream bank armoring.
- Lateral skidding would not be permitted within streamside buffers protecting intermittent and ephemeral streams.
- Rub trees would be designated outside of streamside buffers to protect leave trees within the streamside buffers during lateral skidding.
- In swales, one end suspension of logs would be required within the area to minimize soil compaction, soil disturbance and damage to reserve trees.
- Full suspension of logs would be required over intermittent and ephemeral streams.

<u>Lop-and-Scatter Operations</u>

Under the proposed action, 450 acres of the 1,125-acre project area, where vehicle access is unavailable, would be treated with an array of silvicultural prescriptions. Regardless of prescription, and all felled trees would be lopped and scattered. No felled trees would be yarded; no heavy equipment would be utilized in these areas. These areas were defined because they may not be accessible either by ground-based operations or cable yarding operations, and thus slope classes throughout these areas vary.

Crown thinning and/or low thinning would be the primary silvicultural methods used for lop-and-scatter operations (Table 2). Variable-density thinning may be used if operational constraints permit. If variable-density thinning is used, it would be prescribed as stated in *Variable-Density Thinning with Biomass Removal using Ground-Based Operations*.

Crown thinning is a thinning method that removes trees in the upper crown classes (i.e., co-dominant and dominant trees) to benefit adjacent tree of the same crown classes. Overstory Douglas-fir trees would be felled to maximize release of adjacent dominant redwood and/or other large conifers. The intent is to primarily stimulate growth and development (release) of dominant trees, improve stand level representation of redwood, and minimize fuel depth of woody debris. Crown thinning would target the removal of Douglas-fir in the size class range from 8- to 20-inches dbh, and would remove, on average, 89 trees per acre (Table 4) and 25% of the stand basal area. To meet the basal area reduction, larger diameter Douglas-fir (up to 24 inches dbh, but the vast majority would be restricted to 20 inches dbh and less) would be cut first, working down the dbh size classes until the target basal area reduction of 25% is met. One-quarter of the basal area would be retained in each selected diameter class. Selecting overstory trees to remove would be based on maximizing response and release of dominant redwood and/or other large conifers. A minimum of 60% overstory canopy cover would be retained.

Low thinning would primarily target Douglas-fir from 5- to 24-inches dbh (partial removals from 16 – to 24 inches dbh) and would remove an average of 268 trees per acre (Table 3). To meet the basal area reduction target (up to 40%), small diameter Douglas-fir would be culled from the stand by removing most of the trees less 16 inches dbh. Selected overstory trees would be removed based maximizing response and release of redwood trees and other desired conifers. A minimum of 60% overstory canopy cover would be retained.

All tree felling would be conducted by contract hand crews using chainsaws. Trees to be cut would not be marked by park staff, except in special streamside treatment areas (below). No redwoods are planned for removal for any lop-and-scatter operation. All felled trees would be limbed, bucked, and lopped to get the wood in contact with the forest floor. No heavy equipment would be used and no ground disturbance would occur. Unit prescription adherence by contract hand crews would be overseen by park staff.

<u>Old-Growth Buffers and Riparian Management Zones</u>
Two special area prescriptions would be applied in areas with specific conditions. In selected perennial stream buffers, a 40% reduction in basal area would be applied to create large trees for future stream recruitment of large wood. Within 300 feet of old-growth forest (18 acres), the prescription was designed to reduce short-term indirect adverse effects on sensitive wildlife that occupy old-growth forests.

Old-Growth Forest Buffers—Approximately 18 acres within 300 feet of contiguous old-growth forests in two units in the project area (Figure 3) would be treated using a uniform thin from below to reduce overall stem density. No redwoods would be removed in the old-growth buffer. Approximately 150 trees per acre in the size classes from 5- to15-inches dbh would be removed on average. Stand basal area would be reduced by 30% or less. Trees removed would be selected to maximize release of dominant redwoods and other conifers, in order to stimulate development of potential nest trees and nesting habitat components such as large branches and cover trees. Sufficient canopy cover would be maintained to prevent rapid shrub proliferation and minimize the creation of food resources for corvids until forests recover. A minimum of 60% overstory canopy cover would be retained in the old-growth buffer areas after treatment. No skid roads, skyline yarding corridors, or landings would be used in old-growth buffer units because no trees would be removed offsite.

Special Riparian Thinning Areas within 200 feet of Perennial Streams—A 40% reduction in basal area would be implemented in limited areas within 200 feet of the perennial portion of the Middle Fork of Lost Man Creek. All work would be accomplished by hand crew, no ground based equipment would be used and no tree yarding would occur. All cut trees would be left on site and lopped and scattered to get them in contact with the ground. The purpose of the thinning is to promote development of large trees more quickly along perennial streams that may in the future be recruited into the stream as large wood. Thinning in this zone would only occur on slopes with less than 25% gradient, which occur in very limited areas, totaling no more than 10 acres and occurring along less than 0.25 miles of stream length in total, along isolated stream reaches of no more than 300 feet long each. Thinning would retain at least a 60% post-treatment tree canopy. Each riparian thinning area would be clearly delineated on the ground and all trees to be cut would be marked by park staff.

Documentation and Post-Operations Monitoring

Completed projects would be visited within a year of project completion as safety permits. Photo points that were established during the original surveys would be re-photographed. Vegetation management staff would establish permanent plots to determine the stand characteristics before and after management is completed to monitor restoration effectiveness and recovery in treated areas. An annual project summary report would describe site conditions and logging history prior to restoration, restoration work accomplished, costs, preliminary monitoring results, and any recommendations for future work at other sites.

Environmentally Preferred Alternative

The environmentally preferred alternative is the one that best meets the criteria identified in Section 101 of the National Environmental Policy Act as outlined below.

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural and natural aspects of our national heritage.
- Enhance the quality of renewable resources.

The NPS has determined that Alternative 2 – Thinning with Biomass Removal Operations in High-Access Areas and Thinning with Lop-&-Scatter Operations in Limited-Access Areas (the Proposed Action) is the environmentally preferred alternative. This alternative would accelerate the development of late-seral forest characteristics more quickly than the no action alternative and would reduce remaining fuels following treatment.

The proposed action differs from no action in the following ways:

- Create canopy gaps to reduce crown fire potential and to allow for canopy differentiation
- Accelerate stand development, release of individual trees, habitat diversity, and reduce edge impacts more quickly than the no action alternative.
- Restore species composition and Douglas-fir/redwood ratio to more closely resemble old-growth forests, where the no action alternative would favor Douglas-fir as the dominant species.
- Maximize redwood survival and vigor.

The no action alternative is not the environmentally preferred alternative because:

- forest stands would continue to be overstocked with predominantly Douglas-fir trees while fewer redwood trees would be present compared to old-growth stands
- canopy cover would inhibit the growth of understory vegetation that is typically found in old-growth forest
- unthinned second-growth forest stands provide poor quality wildlife habitat due to density of trees and lack of understory vegetation

- fire hazard would remain high, with conditions suitable for wildfire that could spread outside the second-growth, with a potential to damage old-growth forests and increase risk to human life, safety, and property

Alternatives Eliminated from Further Consideration

The NPS analyzed a variety of different silvicultural approaches and techniques for the first large-scale project in 2008 to restore second-growth forests in the South Fork Lost Man Creek project area. These options are described below. For the Middle Fork project, the NPS reconsidered these options and determined that these options either do not meet the purpose and need for the project, are inconsistent with the 1999 GMP or other approved plans, or that the NPS does not currently have the authority to pursue these options.

Low-intensity Thinning From Below

A basal area reduction of 25-30% (low-intensity thin from below) was considered. Results from thinning conducted in the Whiskey 40 and the Holter Ridge areas show that thinning from below would not release the dominant and co-dominant trees because this method concentrates on cutting trees in the intermediate and suppressed crown classes. The low-intensity thin from below would not restore old-growth conditions in as short a time as the proposed action or the low-thin-from-above alternatives. Therefore, this alternative would not meet management objectives outlined in the 1999 GMP and was not carried through for full analysis.

High-Intensity Thinning From Below

A basal area reduction of greater than 50% from below was considered. This alternative was dismissed because the number of trees cut would increase the fire hazard from increased fuels on the ground and increase the vulnerability to windthrow of the relatively few remaining trees (on the order of 100 standing live trees per acre over 4.5 inches dbh). There would be an increased potential for wildfire and windthrow. Therefore, this alternative would not meet management objectives for fire management in the park and was not carried through for full analysis.

Multiple-Entry Option

A multiple-entry option was considered. This would require 2 or more thinning entries over time, 5 to 20 years apart, where each successive entry would further release desired leave trees, which allows for more control over stand characteristics and development of old-growth characteristics. This alternative was not carried through for full analysis because logistical planning for future entries would be difficult, there are too many acres of park second-growth needing initial action, and funding for future entries is unpredictable.

Prescribed Fire

Use of prescribed fire as a technique to thin second-growth forests was considered. There is little experimentation on using prescribed fire as a second-growth forest restoration tool on a relatively large scale. It is difficult to predict the level of mortality that a prescribed burn would cause and the overall forest characteristics created after a burn. It is unknown if prescribed fire could directly restore redwood as the dominant species at the stand level. It is unknown what intensity of prescribed fire would be needed to restore or accelerate development of ecological processes and characteristics found in mature forests. Further study is needed to test fire effects in high density second-growth stands dominated by Douglas-fir. Experimental use of prescribed burning in second-growth was addressed in the 2010 Redwood National Park Fire Management Plan. Given the high degree of uncertainty associated with prescribed fire and second-growth forests in RNP, this alternative was not carried through for full analysis.

AFFECTED ENVIRONMENT

This section describes the resources that would be affected by proposed management of second-growth forests in the Middle Fork of Lost Man Creek, or that affect the resources, within the project area, the park, and the region.

Setting

Redwood National Park lies along the Pacific coast on the western edge of the Coast Ranges of northwestern California. The park includes submerged coastal lands, beaches, estuaries, rivers, ancient redwood groves, spruce, and fir forests, grasslands, oak woodlands, and second-growth coniferous forests.

U.S. Highway 101, a major north-south transportation route along the Pacific Coast, runs through the park and serves as the primary highway access to the Lost Man Creek area. Lost Man Creek Road, a paved former major logging haul road now used for park access, leaves the highway about four miles north of the town of Orick and follows Little Lost Man and Lost Man creeks for about one mile, ending at the Lost Man Creek Picnic Area. From the picnic area, a network of former logging roads now provides administrative and recreational access into the Lost Man Creek watershed.

Lost Man Creek is a major tributary of Prairie Creek, which is itself the largest and the last major tributary to join Redwood Creek before it runs into the ocean. The Lost Man Creek watershed makes up about one-third of the Prairie Creek watershed. The 1,125 acre project area is located in the Middle Fork Lost Man Creek sub-basin.

Overview of Logging in the Park and Project Area

Most of the timber harvesting in what is now Redwood National Park occurred between 1950 and 1978. By 1978, at the time of park expansion, approximately 69% of the lower third of the Redwood Creek watershed had been logged representing 45,000 to 50,000 acres of forested areas.

Almost 90% of what was old-growth redwood forest in the Middle Fork of Lost Man Creek was tractor-logged in the 1950s and 1960s. Other sub-basins with Lost Man Creek were also logged during the same period with the exception of the lower reach of Lost Man Creek. The unlogged old-growth forest along lower Lost Man Creek represents approximately 15% of the forested area in the watershed (Table 7).

TABLE 7. CHARACTERISTICS OF LOST MAN CREEK WATERSHED AND SUB-BASINS

Sub-basin	***Drainage Area (acres)***	***Area in Old-Growth (acres)***	***Area in Second-Growth (acres)***
Middle Fork Lost Man Creek	1,444	35	1,409
South Fork Lost Man Creek	2,522	304	2,218
Larry Damm Creek	1,181	245	936
North Fork Lost Man Creek	1,422	135	1,287
Areas between streams	1,160	1,116	44
Basin Totals	7,729	1,835	5,894

Because of the size of old-growth redwoods and their tendency to shatter upon impact, unique felling techniques were needed to fall redwoods. Larger infrastructure was needed to move the large logs to a place where trucks could haul the logs to a mill. Bulldozers were used to construct layouts (beds layered with smaller trees used to soften the impact of a falling old-growth tree), skid roads, landings, and haul roads. Layouts as large as 15 feet wide and 300 feet long were built on a straight, even grade and carved into hillslopes in whatever contour direction was most favorable for felling a tree or cluster of trees. After falling all the old-growth trees in an area, layouts were sometimes connected to create skid roads that were used to drag these large trees to landings on nearby haul roads. Additional skid roads were created to drag large logs to landings where logs were loaded onto trucks and hauled to a mill. Landings were constructed wherever they were needed by pushing dirt and debris to create a flat place where logs could be moved onto trucks. Log landings 50-100 feet on a side were spaced close together on haul roads to minimize yarding distances on skid roads. Skid roads that were used repeatedly to drag logs from the forest to a landing often became wide enough to use as small haul roads. Haul roads were built 30-50 feet wide to accommodate two trucks and to allow trucks to move quickly. These large-scale operations disturbed the ground down to bare mineral soil on many thousands of acres (Figure 6).

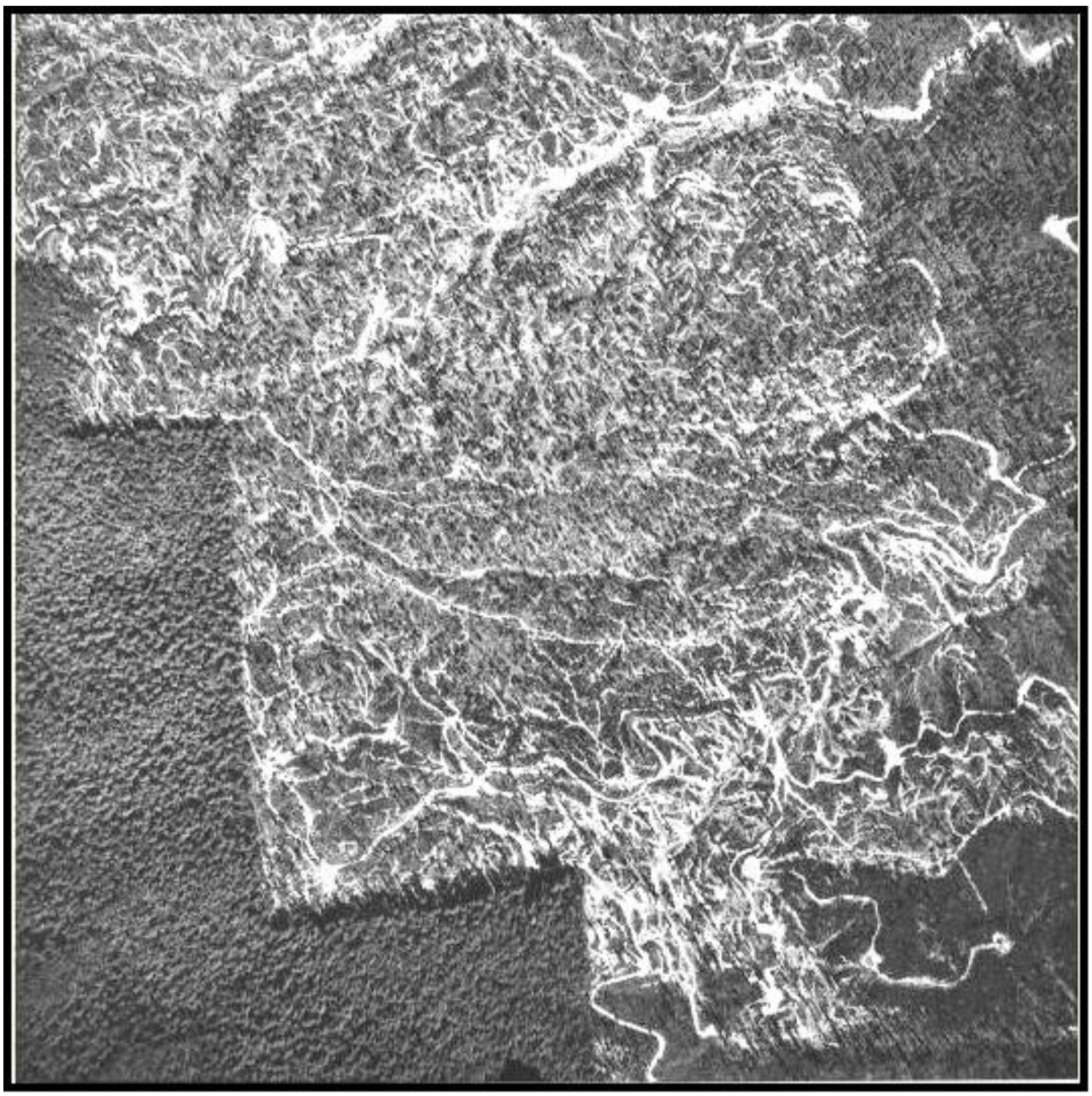


Figure 6. 1950s era clearcut north of project area.

Vegetation readily re-established on these heavily disturbed landscapes after logging. The type of vegetation that developed into second-growth stands within RNP depended on several factors, including the dominant vegetation at the time of cutting; whether the cutting was selective or clear-cutting; the type of equipment used; the slope, aspect, soil type, productivity, and elevation of the area logged; the size of the disturbance; and the type of regeneration (natural regeneration from adjacent stand or seed trees, planting seedlings, vegetative reproduction, or aerial seeding).

The project area was logged under the regulations of the California Forest Practice Act (FPA) of 1945. This FPA required that 4–8 seed trees/acre be retained after logging to ensure the regeneration of native trees. The redwood seed trees were supplemented by the aerial application of Douglas-fir seed at a rate of 4–5 lbs/acre. Aerial seeding operations resulted in stand densities of live trees ranging up to 3000 trees/acre in many parts of what would become Redwood National Park.

The general pattern of forest development after a major disturbance such as clear-cut tractor logging begins with short-lived annual and biennial herbs in the first 3 years after harvest. Shrub communities then develop, either from plants that have survived timber harvest, from the seed bank in the soil, or from invading species that capitalize on the disturbed soils, lack of competition and abundant light after the forest canopy is removed. Hardwood shrubs become abundant within 2–5 years following disturbance and can dominate for up to 20 years. In the project area, shrub dominance likely lasted for 5 years or less. Eventually, tree species dominate the site by occupying the available growing space until one or more environmental factors become limiting.

Sunlight is most commonly the limiting environmental factor in the Lost Man Creek project area. Overstory trees occupy most of the available growing space and reduce the amount of light reaching the forest floor. Reduced light levels exclude all but the most shade tolerant species from the understory and create intense competition among the overstory trees. Second-growth forests managed for commercial timber production are thinned at least once before harvesting to encourage growth and development of remaining trees.

In the project area and most other second-growth stands in the parks, lack of pre-commercial thinning has dramatically slowed the development of the forests. Second-growth forests in RNP have a pronounced imbalance in species composition with Douglas-fir dominating stands that were originally dominated by redwoods, extreme tree densities of up to 2,500 trees per acre, homogenous height and depth of canopy, small tree diameters in relation to tree height, and little or no understory.

Climate

The Pacific Ocean is a moderating influence on the climate of the parks, producing wet, mild winters and relatively dry summers with frequent coastal fog.

The northwestern Coast Range receives the heaviest rainfall of any area in California. Annual rainfall averages 70 inches but can vary erratically between locations. Inland areas along the Smith River may have more than 100 inches of annual precipitation. Although it can rain any time, most precipitation falls between November and March. Winter storms from the Pacific Ocean bring intense rainfall over several hours or days, particularly warmer storms from lower latitudes. These storms may cause both small streams and larger rivers to flood. Rainfall generally increases with altitude within the parks, but rainfall is also affected by distance from the ocean and variations in slope aspect. Snow falls infrequently at elevations above 1,600 feet and rarely at lower elevations but it usually does not persist, even at higher elevations inland.

Mean daytime temperatures at Prairie Creek Redwoods State Park near the Middle Fork Lost Man Creek project area are 47°F in January and 59°F in June. Along the coast, temperatures vary only slightly from summer to winter. Temperatures above 90°F or below freezing are rare. Inland areas such as Lost Man Creek have a greater annual temperature fluctuation, with summer high temperatures commonly reaching 90°F and winter temperatures around freezing.

Prevailing winds are northwesterly, bringing cool, moist air and frequently fog to the coastal areas, the lower Redwood Creek basin and the Lost Man Creek watershed. Intense winter storms may be accompanied by damaging winds. Occasionally in the fall, a warm dry wind from the east produces a rapid drying effect, intensifying fire hazards in the normally moist redwood forests.

Air Quality

Redwood National Park is designated as a class I airshed pursuant to Part C of the Clean Air Act, as amended (42 U.S.C. 7401 *et al*.). Class I designations are given to areas where air quality is cleaner than the national ambient air quality standards. Class I areas have the most stringent regulations for the protection of air quality, permitting the lowest increments of air quality degradation. The California Air Resources Board assigns the park to the North Coast Air Basin, under the jurisdiction of the North Coast Unified Air Quality Management District.

Air quality in RNP is considered good to excellent because of the low population, scarcity of pollutant sources, and prevailing westerly ocean winds. Local views and scenes are often obscured by fog, rain, low clouds, salt spray haze, and natural forest haze inversion. All federal standards for regulated air pollutants are consistently achieved, including those for ozone, carbon monoxide, particulate matter, nitrogen dioxide, sulfur dioxide, and lead. The most significant air pollutants in the parks are PM_{10} and $PM_{2.5}$ (particulate matter less than 10 and 2.5 micrometers, respectively, in diameter), which is primarily from widespread non-industrial burning including prescribed fire, wildland fire, and the industrial burning of timber harvest slash piles. In the past, total suspended particulates exceeded air quality standards, but improved technology, better use of materials, and fewer sawmills (and especially wood waste or 'tepee' burners) in the region have resulted in a reduction in suspended particulates.

Topography, Geology, and Soils

The project area is within Lost Man Creek sub-basin and includes portions of Holter Ridge, which is the watershed divide between Klamath and Redwood Creek basins. Elevations range from 80 to 2,250 feet. Topography consists of tectonically active, intricately dissected, steep and very steep (30 to 75 % slopes), mountain slopes and gently sloping summits and ridges (0 to 30 % slopes).

Bedrock is composed primarily of sandstone and mudstone of the Jurassic-Cretaceous Franciscan assemblage and weakly consolidated fluvial sediments of the Plio-Pleistocene Prairie Creek Formation. The Prairie Creek Formation represents near shore marine, beach and estuarine deposits of the ancestral Klamath River. The relatively resistant sandstone of the Franciscan assemblage generally results in steep slopes; narrow, confined canyons; and high-energy stream flow in comparison to the gentler topography and less confined stream reaches of the Prairie Creek Formation. The large amounts of winter precipitation, tectonically active landscape with two major faults (Lost Man and Surpur Creek faults), steep terrain, and medium textured soils are major contributing factors to high erosion rates.

The 2008 Soil Survey of Redwood National and State Parks report identifies soils in the project area as primarily the Coppercreek, Slidecreek, Sasquatch and Sisterrocks soil types, formed in colluvium derived from sandstone and mudstone. These soils are characterized by loam to gravelly loam surface textures with 3 to 8 % organic matter content and clay loam to extremely gravelly loam subsoils. The Ossagon, Squashan, Surpur and Mettah soil types formed in colluvium and residuum are derived from the weakly consolidated fluival sediments of the Prairie Creek Formation. These soils tend to have loam to gravelly loam surface textures with 3 to 5 % organic matter content and clay loam to extremely gravelly loamy sand subsoils.

Soil erosion is most strongly dependent on rainfall, topography, and vegetative cover. On steep, highly dissected slopes, water is the most common cause of soil erosion. Erosion on undisturbed forested mountain slopes is infrequent. Thick organic layers and soil layers with abundant pore space allow rainwater to infiltrate into the soil. Soil erosion can occur when the organic and mineral surface layers are removed or compacted as a result of logging, road building or other disturbances. Compaction and rutting reduce the movement of water into soil and tend to increase surface runoff. The unconsolidated sediments of the Prairie Creek Formation are readily mobilized by surface runoff, especially where the sediments have been cut and side-cast to construct roads, and natural drainage patterns have been altered by logging. These sediments are also susceptible to natural and disturbance-induced landslide processes.

Water Resources

The Middle Fork of Lost Man Creek is within the Redwood Creek watershed. Redwood Creek flows northwesterly for 55 miles through a 280-square-mile watershed from an elevation of 5,000 feet to the Pacific Ocean near Orick. The Redwood Creek watershed is characterized by high relief, steep unstable slopes, and narrow valley bottoms.

Hydrology—Annual rainfall variations produce highly variable annual streamflow in park streams, including Lost Man Creek and its tributaries. Streamflow also varies seasonally, owing to the highly seasonal distribution of rainfall. Winter flood flows can be as much as four orders of magnitude higher than summer low flows. Tributaries with drainage basins smaller than about 1 square mile are commonly dry during summer months (Janda, Nolan, Harden, and Colman 1975).

Stream discharge is not measured regularly for the Middle Fork of Lost Man Creek. Regular stream discharge measurements have been taken on Redwood Creek in Orick since 1953. Peak annual flows ranged from a low of 2,300 in February 2001 to the highest flow on record of 50,500 in December 1964. Between 1953 and the present, there have been five years with a peak annual flow at or near 50,000 cfs, and three years with flows at or around 40,000 cfs. The most recent flow above 40,000 cfs occurred on January 1, 1997 (40,300 cfs).

There are approximately 3.2 miles of intermittent streams, 3.3 miles of perennial streams, and 13.9 miles of potential flow paths that may constitute potential swale and intermittent stream features.

Water Quality—The Middle Fork of the Lost Man Creek is an upper watershed tributary to Lost Man Creek, which flows into Prairie Creek, which eventually flows into Redwood Creek at the north end of the town of Orick. Redwood Creek is currently listed as sediment and temperature impaired under the Clean Water Act Section 303(d). The Environmental Protection Agency adopted a Total Maximum Daily Load (TMDL) for sediment in Redwood Creek in 1998. Beginning in 1998 in conjunction with the EPA, the North Coast Regional Water Quality Control Board formulated a “Water Quality Attainment Strategy and Implementation Plan” to achieve the water quality objectives for the Redwood Creek watershed. Park staff and researchers are actively implementing the strategy and plan on both parklands and on private lands when landowners request assistance from park staff.

The TMDL identified 10 sources of sediment delivery for the Redwood Creek watershed. Two sources of naturally occurring sediment delivery are earthflows/block slides and tributary landslides. The other 8 are controllable to some extent: 1) erosion associated with roads, skid trails, and landings; 2) gully erosion; 3) bare ground erosion associated with human activities; 4) stream bank erosion associated with human activities; 5) tributary landslides (road-related); 6) tributary landslides (harvest-related); 7) main stem landslides, many of which are natural, and the delivery of sediment may be controllable to varying degrees; and 8) debris torrents. Accelerated erosion from land use practices and other causes is impacting the migration, spawning, reproduction, and early development of cold water anadromous fish including coho and Chinook salmon and steelhead trout.

Water quality monitoring in the Lost Man Creek watershed was begun in WY2003 to measure suspended sediment yields and turbidity responses to ongoing road removal. (A water year begins October 1 of the previous calendar year i.e., WY 2003 began October 1, 2002 and ended September 30, 2003). In WY2003, monitoring was done solely at the watershed outlet (Lost Man Creek at Hatchery, or LMC) and at the mouth of the South Fork (SFL) (Klein 2006). Monitoring was begun in Middle Fork Lost Man Creek (MFL) and two other Lost Man Creek tributaries in WY2004: North Fork Lost Man Creek (NFL) and Larry Damm Creek (LDC). The project ended in September, 2011.

The purpose of the monitoring was to document the effects of road removal on downstream turbidity and suspended sediment concentrations, and to provide feedback for adaptive management to refine erosion control methods and maximize cost-effectiveness of watershed restoration technique. To evaluate road removal effects, turbidity and suspended sediment concentrations from Lost Man Creek were compared with monitoring data collected in nearby, nearly pristine watersheds and by evaluating changes over time in watersheds where road removal work was implemented.

Middle Fork Lost Man Creek was comparatively low in turbidity and suspended sediment loads for the first two years of monitoring, until WY2005, when it jumped to nearly twice that of its nearest neighbor, the North Fork Lost Man Creek (Klein, 2012). Although that might have been a delayed effect of road work done in 2000-01, because it occurred several years after the most recent road work (in 2001) it was more likely caused by either natural or legacy erosion. MFL contributed similar suspended sediment to NFL in WY2006 and WY2009, but exceeded NFL in WY2007 and was less than NFL in WY2008. Explanations for this see-saw relationship are likely not due to differences in road removal: between 2007 and 2008: MFL had twice as much road length treated as NFL in 2006 (just prior to WY2007 monitoring) and less than half that in NFL in 2008 (just prior to WY2009 monitoring), the opposite of what would be expected were the turbidity differences due to road treatments. Consequently, differences must be due to legacy and natural erosion sources operating within the watersheds. As of WY2011, was second only to SFL in both road miles treated and sediment loads among the Lost Man Creek tributaries.

Evaluating effects of second-growth management on Lost Man Creek suspended sediment yields is confounded by lingering effects of sediment delivery from road removal and legacy erosion. Any effects of forest management appear to be quite small because the sediment loads in recent years have remained low. If second-growth management caused substantial erosion and sediment delivery within Lost Man Creek, the load ratios in control streams would be expected to rise but data do not show evidence of increased sediment delivery (Figure 7).

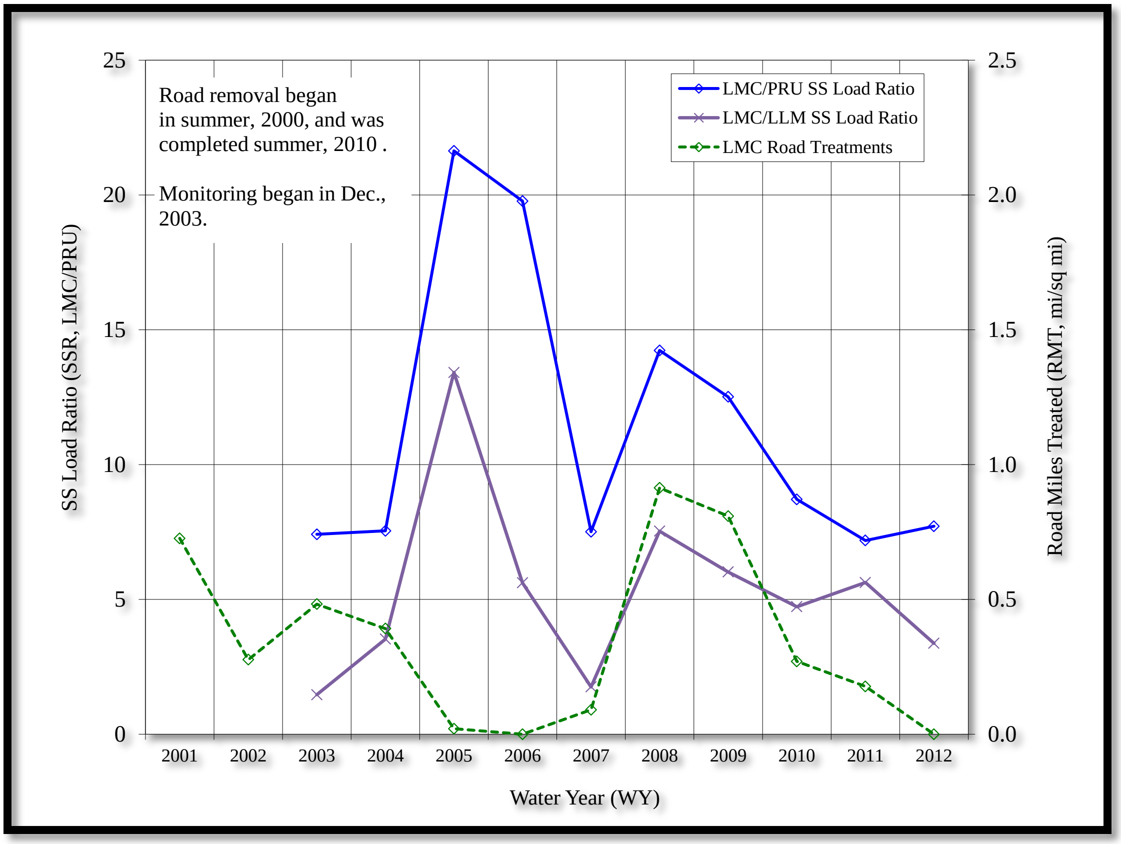


Figure 7. Comparison of load ratio of Lost Man Creek suspended sediment loads to control streams. Ratio of Lost Man Creek suspended sediment loads to two nearby, pristine control streams, Prairie Creek above Brown (PRU) and Little Lost Man Creek (LLM). *(updated from Klein (2011) with 2012 data).*

Stream temperature is important to the health of the aquatic ecosystem and can influence the distribution of fish and stream amphibians. Stream temperature in Redwood Creek has been monitored by park staff since the mid-1990s and indicates that high water temperatures during the summer may negatively impact juvenile salmon and steelhead. Based on the long-term temperature monitoring, Redwood Creek was listed as temperature-impaired under the Clean Water Act in 2002. Airborne thermal infrared imaging of main stem Redwood Creek was completed in late July 2003. The data showed temperatures in the upper reaches of the creek, near the headwaters were about 17.9^{o}C (64^{o}F) and generally increased downstream to about 28^{o}C (82^{o}F) in the central part of the watershed. In the mid to lower basin, stream temperatures remained warm and the average surface water temperature was 24.8^{o}C (77^{o}F). Stream temperatures are generally cooler as the creek approaches the ocean (Holden 2006).

Water temperature was continuously measured at 1-hour intervals in Middle Fork Lost Man Creek at two locations between June 12 and October 15, 2012. Water temperature at the lower location upstream of the confluence with the south fork ranged from 9.8°C (49.6°F) to 13.5°C (56.3°F), peaking in August. Mean water temperature was 11.7°C (53.1°C). At the upper Middle Fork site, approximately 1 km upstream, water temperature ranged from 9.4° (48.9°F) to 14.0°C (57.2°F), also peaking in August. Mean water temperature was 11.4°C (52.5°F).

Turbidity–Road work in Lost Man Creek, completed in 2010, should reduce suspended sediment loads and turbidities over the coming years, although legacy and natural erosion and sediment delivery will continue indefinitely on an episodic basis. The year-to-year variability in road treatment intensity was high, resulting in several years of very intense treatments and resultant turbidity increases. Peak storm turbidities, turbidities at the 10% exceedance level, and suspended sediment yields varied directly and approximately linearly with treatment intensity. In the Middle Fork Lost Man Creek Watershed, a total of 10.9 miles of road was treated in 2000-2001 and 2007-2010.

Floodplains and Wetlands
The lower main stem of Lost Man Creek has a gentle gradient and meanders within the steep-sided valley with narrow intermittent floodplains. The upper sub-basin streams have steeper gradients and narrow channels with no floodplains.

Tributaries of Prairie Creek with gradients low enough for floodplain development include Skunk Cabbage, Little Lost Man, Lost Man, May, Godwood, and Boyes Creeks. Lost Man Creek has only minor floodplain development along its lower reaches in the intact old-growth forest. These floodplains are discontinuous and narrow in comparison to floodplains along Prairie and Redwood Creeks. The relatively resistant Franciscan bedrock in the northeast and southern portions of the Lost Man Creek watershed generally results in steep slopes and narrow, confined canyon with little floodplain development in comparison to the gentler topography and less confined stream reaches that allow broad, meandering stream valleys of the Prairie Creek Formation in about one-third of the project area.

The NPS uses the Cowardin system to define wetlands (Cowardin et al., 1979). Two types of wetlands are depicted on the U.S. Fish and Wildlife 1987 National Wetlands Inventory (NWI) maps of the project area. These types are classified by the persistence of the stream, the substrate, and the duration of inundation (seasonal flooding regime), as well as the position in the drainage. The upper reaches of the streams are mapped as R4SBC (Riverine, Intermittent, Streambed, Seasonally Flooded) while the Middle Fork main stem is mapped as R3UBH (Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded). These riverine wetlands are present where the steep topography prevents the development of a floodplain.

In landscapes disturbed by timber harvest, small wetlands have developed where water is intercepted by undercutting the slopes with heavy equipment during construction of roads, skidroads, and landings. The water flows into road ditches and onto road surfaces. Road fills, immediately upstream of road-stream intersections, often possess wetland characteristics as the accumulated sediment becomes saturated by stream flows. The average size of these artificial wetlands is estimated at about 100 square feet. With proper drainage of roads or when the original topography is restored, these wetlands disappear. The primary function of these artificial wetlands is breeding habitat for amphibians. Restoration of stream crossings restores amphibian habitat by re-creating the original drainage channels.

Vegetation
The Middle Fork of Lost Man Creek second-growth forest restoration project area consists of 1,125 acres of second-growth forest dominated by Douglas-fir. The original vegetation community in the project site was coniferous forest dominated by coast redwood *(Sequoia sempervirens)* and Douglas-fir *(Pseudotsuga menziesii)*. Approximately 1,835 acres of old-growth coast redwood forest remain in western portion of the Lost Man Creek watershed. This old-growth is contiguous with the large tract of old-growth in lower Redwood Creek and Little Lost Man Creek.

Residual old-growth trees (trees present prior to and remaining after logging) found throughout the project area include redwood, Douglas-fir, giant chinquapin *(Chrysolepis chrysophylla)*, and Pacific madrone *(Arbutus menziesii)*.

There are old-growth redwood forests along the western boundary of the project area. The edge of the old-growth forest along the western boundary of the project area often differs from the interior of the stand in amount of sunlight, microclimate, and disturbance regime. Edge trees are often more susceptible to sunscald and wind damage including limb breakage, tree mortality, and wind-throw (trees uprooted or breaking due to force of wind). Russell and Jones (2001) found that the maximum depth of edge influence into old redwood forests was 200 meters (656 ft).

The entire project area is densely vegetated with regenerated stands of Douglas-fir, tanoak and redwood, with some giant chinquapin, Pacific madrone, and red alder. The overstory in second-growth stands is typically dominated by Douglas-fir with small numbers of redwood sprouting from old-growth stumps. Grand fir and western hemlock trees are occasionally present in the overstory.

The midstory is generally dominated by tanoak *(Lithocarpus densiflorus)* clumps and suppressed Douglas-fir. Where present, a sparse understory of herbaceous species and shrubs includes primarily salal, evergreen huckleberry, rhododendron and sword fern. There is little to no conifer regeneration. Tree regeneration tends to be tanoak sprouts and seedlings with occasional redwood sprouts.

Tanoak stands occur on most of the south-facing slopes of the project area. The overstory is dominated by tanoak in these stands, with a few Douglas-fir and lesser numbers of redwood stump sprouts. Although the conifers tend to be taller than the tanoak, tanoak dominates in number, canopy cover and basal area. Occasional giant chinquapin and Pacific madrone are present. Where understory occurs, evergreen huckleberry or rhododendron tend to be the dominant species.

The steep gradient of project area streams have inhibited the development of floodplains and associated riparian zones. Road building, timber harvesting, and associated bank erosion and landslides have altered the original riparian vegetation along creeks in the project area. The second-growth riparian forests are dominated by red alder, Douglas-fir and redwood. Sword fern dominates the riparian understory at moderate to high density.

Several disturbance mechanisms affect forests in the project area. Strong wind and saturated soils from winter storms creates small (less than 0.125 acre) areas of whole-tree windfalls (windthrow) scattered mostly along ridgelines in more exposed areas. Snow and wind can also break tree tops, killing trees outright or causing a strong lateral branching response in the affected tree, especially redwood. If the tree survives, this topping mechanism can create structural complexity desired for wildlife habitat in the forest canopy. Landslides are another physical process that can topple trees and create forest openings. There are examples of landslides where trees have been toppled where slopes are less stable due to sheared bedrock along faults, and on the steep, wet slopes of inner gorges, and headwater areas. Forest pathogens can weaken tree boles and increase susceptibility to windthrow. Douglas-fir is affected by red ring rot, a heart rot caused by the fungus *Phellinus pini* found throughout the project area. Another pathogen found throughout the project area, *Poria albipellucida,* causes white ring rot on redwood. Basal cavities caused by fires, damage from heavy equipment or logging, animals, and other disturbances that damage tree trunks are often the avenue for infection.

Sudden Oak Death syndrome (SOD) is caused by *Phytophthora ramorum*, an invasive plant pathogen with suspected origins in Asia. SOD has been found in the Redwood Creek drainage upstream of the park boundary but no live infections are known in the park.

Nonnative plants, also called exotic species, occur within the project area mostly along road edges. Common exotic species found along the roads include Scotch broom (*Cytisus scoparius)*, hairy cat's ear *(Hypochaeris radicata)*, bull thistle *(Cisium vulgare),* Canada thistle *(Cisium arvense)*, pampas grass *(Cortaderia jubata)*, Himalaya blackberry *(Rubus discolor)*, and foxglove *(Digitalis purpuria)*. Both the old-growth and second-growth forests within the project area are often too shady for most nonnative plant species and few exotic species have been observed in the forests within the project area.

Fish

Three species of anadromous salmon and trout that occupy the perennial streams downslope of the project area are discussed below under *Threatened and Endangered Fish*. Anadromous fish spend most of their life cycle in the ocean and return to freshwater to spawn.

Anadromous and resident salmonids identified in Redwood Creek and its major tributaries include steelhead and rainbow trout (*Oncorhynchus mykiss*), coastal cutthroat trout (*O. clarki clarki*), coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*). Most spawning and rearing occurs along the lower reaches of major tributaries and along the main stem of Redwood Creek.

Coastal cutthroat trout are native to northwestern California, inhabiting most coastal streams north of the Eel River. Adult anadromous cutthroat return to freshwater in late autumn and early winter and spawn in small streams between February and May. Cutthroat trout are often found in the summer in the Redwood Creek estuary. Some coastal cutthroat trout that occupy streams in the project area are anadromous but this species is not currently listed or proposed, or a candidate species for listing, as threatened or endangered. RNP fisheries staff suspects that a few resident, non-migratory populations of cutthroat trout inhabit the tributaries of Redwood Creek. The project area also is inhabited by resident rainbow trout (*Oncorhynchus mykiss*).

Other fish identified or reported in the freshwater reaches of the Redwood Creek watershed include the Klamath smallscale and Sacramento sucker, threespine stickleback, prickly and coast range sculpin, Pacific river lamprey, and western brook lamprey.

Wildlife

Animal species diversity is lower in the upland younger-aged redwood forest community in comparison to other plant communities (such as riparian forests) because of lower plant diversity and less structural complexity in the canopy of second-growth forests. Species diversity is especially low in the youngest second-growth stands that were reseeded without subsequent thinning, creating dense stands of small trees with minimal canopy development and understory vegetation.

Electrofishing on Middle Fork Lost Man Creek, above the confluence with South Fork, on October 15, 2012 caught the following fish and aquatic species: steelhead trout juveniles, coastal cutthroat trout, coastal giant salamander larvae, and a tailed frog adult. Other amphibians present in the project area in woody debris or other forest floor surface debris include ensatina and California slender salamanders. Roughskin newts are present in streams. Coastal giant salamander adults are common to moist coniferous forests under logs and bark. Pacific tree frogs and northern red-legged frogs are present. Alligator lizards, California red-sided garter snakes, and coast garter snakes are found in the project area.

Road ditches and other areas where roads or landings have failed or slumped create puddles that are sometimes used by frogs and some salamanders for breeding. Egg masses of northwestern salamanders have been observed in puddles in slumps in road fill in the Lost Man Creek watershed restoration project area.

Point count surveys for birds were conducted in the Lost Man Creek watershed restoration project area in both old-growth and shrubbier, open areas. The most common species detected in the canopy were brown creepers, chestnut-backed chickadees, and golden crowned kinglets. Mid-canopy species included Steller’s jays, Hutton’s vireos and Pacific-slope flycatchers. Pacific wrens and wrentits were common in the understory. Hermit, Swainson’s, and varied thrushes, and robins are present. Pileated woodpeckers were relatively numerous, with fewer hairy woodpeckers and northern flickers. The presence of Vaux’s swifts reflects the old-growth legacy of the project area. Northern pygmy owls were regularly detected, with saw-whet owls heard occasionally.

Black bear and black-tailed deer are the most common large mammals in the project area. Managed timberlands surrounding the park provide excellent habitat for bear and deer, and resulted in an increase in bear and deer numbers during the period of intensive logging. Use of second-growth forested areas by deer and black bear has declined relative to when these areas were first cut.

Other mammals likely to occupy the project area include fisher, gray fox, mountain lions, bobcats, coyotes, long-tailed weasels, raccoons, skunks, chipmunks, ground squirrels, brush rabbits, woodrats, flying squirrels, voles, shrews, deer mice, and bats but no surveys have specifically targeted mammals.

Sensitive Plants

There are no federally or state listed proposed, threatened or endangered plants in the project area. Sensitive plant species known to occur in the project area or potentially occurring based on similar habitat requirements and ranked by California Native Plant Society (CNPS) as having limited distribution or limited numbers are listed in Table 8. The common names and rankings given here are from the on-line edition of the CNPS *Inventory of Rare and Endangered Plants* (CNPS 2006). The rankings incorporate the CNPS Listing (1B, 2, 3, or 4) and a modifier from 1-3 indicating the degree of threat to a plant, with a lower number indicating a more serious threat. Threat code 1 indicates a plant that is seriously endangered in California (over 80% of occurrences threatened / high degree and immediacy of threat). Threat Code 2 indicates “fairly endangered in California (20-80% occurrences threatened)”, and Threat Code 3 is used for plants that are not very endangered in California (<20% of occurrences threatened or no current threats known.) These Threat Code guidelines represent a starting point in the assessment of threat level. Other factors, such as habitat vulnerability and specificity, distribution, and condition of occurrences, are also considered in setting the Threat Code. List 1B plants are rare throughout their range, generally endemic to California, and have a high vulnerability because of limited range or vulnerable habitat, low numbers of individuals per population, or limited numbers of populations. All 1B plants are eligible for listing under the California State Endangered Species Act or for full protection under the state Native Plant Protection Act. List 2 plants would all appear as List 1B plants except that they are common beyond the boundaries of California. List 3 plants are on a review list where more information is required to determine their status. List 4

TABLE 8. SENSITIVE PLANTS LISTED BY CNPS.

Common	Scientific Name	Habitat Type	CNPS Rank
California globe mallow	*Illiamna latibracteata*	coniferous forest/mesic	1B.2
Oneflower wintergreen	*Moneses uniflora*	mixed evergreen forest, redwood forest, Douglas-fir forest	1B
White-flowered rein orchid	*Piperia candida*	coniferous & broadleaf upland forests	1B.2
Small ground-cone	*Boschniakia hookeri*	coniferous forest	2.3
Seaside bittercress	*Cardamine angulata*	redwood forest, mixed evergreen forest, wetland-riparian	2.1
Meadow sedge	*Carex praticola*	meadows/seeps	2.2
Oregon gold thread	*Coptis lanciniata*	coniferous forest (streambank)/meadows	2.2
Coast fawn lily	*Erythronium revolutum*	coniferous forest mesic	2.2
Bog club-moss	*Lycopodiella inundata*	coniferous forest/mesic	2.2
Running pine	*Lycopodium clavatum*	coniferous forest/edges	2.3
Indian pipe[1]	*Monotropa uniflora*	coniferous & broadleaf forests	2.2
Howell's montia	*Montia howellii*	coniferous forest/seeps/ mesic roads	2.2
Seacoast ragwort	*Packera bolanderi* var. *bolanderi*	coniferous forest (banks)	2.2
Three-leaved foam flower	*Tiarella trifoliate var. trifoliata*	coniferous forest	3
Heart-leafed twayblade[2]	*Listera cordata*	coniferous forest/bogs	4.2
Purple onion grass	*Melica spectabilis*	coniferous forest/meadows/seeps	4.3
Leafy miterwort	*Mitella caulescens*	coniferous & broadleaf forests/meadows	4.2
California pinefoot[2]	*Pityopus californicus*	coniferous & broadleaf upland forests	4.2
Nodding semaphoregrass	*Pleuropogon refractus*	open coastal forest/ meadows	4.2
Trailing black currant[2]	*Ribes laxiflorum*	coniferous forest/mesic	4.3
Slender false lupine	*Thermopsis gracilis var. gracilis*	coniferous forest/meadows	4.3

[1]= occurs in Middle Fork Lost Man Creek second-growth forest restoration project area

plants are on the "watch list" and have limited distributions, but their vulnerability or susceptibility to threat is currently low.

In addition to CNPS-listed plants, park botanists have identified several species of plants throughout the parks as "park rare" which is defined as

- the taxon is native;
- it is not federally or state listed as sensitive, rare, threatened, endangered or a candidate for listing, or listed by CNPS;
- fewer than 5 populations exist, or total number of plants in the park is less than 100; and
- The population or number of individuals is larger than above but park populations are threatened because of limited distribution.

Park-rare plants are treated as CNPS List 4 plants for management and survey purposes. Project sites are surveyed for these species. Any individuals found are protected to the greatest extent practicable.

Four species designated as park-rare (Table 9) are known from other locations in the parks in habitats similar to those in the project area but have not been found on surveys of the Middle Fork Lost Man Creek second-growth forest restoration project area.

TABLE 9. PLANTS DESIGNATED AS "PARK-RARE."

Common Name	Scientific Name	# known populations	Habitat type	Known park locations
Goat's beard	*Aruncus dioicus* var. *pubescens*	3	streambanks	Smith River, Klamath Beach Road, Redwood Creek
Clasping twistedstalk	*Streptopus amplexifolius* ssp. *americanus*	1	moist coastal forest	Coastal Trail, Damnation Creek
Pacific yew	*Taxus brevifolia*	2	moist mixed conifer forest	Redwood Creek, Jedediah Smith state park campground
Sugarscoop, foamflower	*Tiarella trifoliata* var. *unifoliata*	1	moist shady banks	Boy Scout Tree Trail

Sensitive, Threatened, and Endangered Wildlife

The marbled murrelet (federally listed as threatened and state listed as endangered), northern spotted owl (federally listed as threatened) and Pacific fisher (federal candidate species) are known to occur in areas or habitats proposed for treatment in this plan. The project area does not contain any designated critical habitat for these animals or any other listed terrestrial species. Detailed species accounts and habitat requirements for murrelets, owls and fishers are found in the biological assessment of effects to threatened wildlife from this project (NPS 2011a).

Marbled murrelets are sea birds that nest in coastal old-growth forest along the west coast of North America. The largest population of murrelets in California is found in Redwood National and State Parks. Murrelet nests have been confirmed in forests in lower Redwood Creek, including the Lost Man Creek watershed.

The action area used to assess effects on marbled murrelets extends 0.25 miles beyond the project area and totals 2,106 acres; the project area is 1,125 acres. The action area includes 240 acres of low quality suitable marbled murrelet habitat made up of clusters of residual old-growth trees.

Surveys conducted in the Lost Man Creek watershed between 2003 and 2004 indicate marbled murrelets use a small proportion of the residual old-growth habitat within the far northwestern corner of the action area. Based on these survey results, plus use of residual habitat documented elsewhere throughout the species' range in California, Oregon, and Washington, the NPS assumes that all stands with trees providing nesting opportunities for marbled murrelets have the potential to be occupied unless surveys indicate probable absence at a site.

Northern spotted owls are forest-dwelling birds that nest in both old-growth and second-growth forests more than 40 years old. Suitable northern spotted owl nesting and foraging habitat consists of dense open-canopied forest stands, with associated large snags and large down logs. The action area contains 1,800 acres of suitable spotted owl habitat. Suitable habitat within the project area includes second-growth forest 40 years old or older, and moderate to high density second-growth forests with old-growth residuals regardless of the age of the second-growth. All of the 1,125-acre project area is considered to be suitable habitat. The presence of residual old-growth trees in the suitable habitat areas dominated by conifers improves the suitability of the habitat. Conversely, the very high stem densities and overall small average tree size of the conifers, lack of heterogeneous canopy structure, and lack of terrestrial shrub growth of the surrounding second-growth forest decreases habitat quality.

The NPS surveyed the entire action area in 2011 and 2012 for spotted owl presence (NPS 2011b). All of the area along the Lost Man Creek Trail/Holter Ridge Road has been surveyed every year since 1998. Spotted owls were not detected during annual surveys along the Lost Man Creek Trail/Holter Ridge Road from 1998-2013 or during specific surveys of the project action area in 2011-12.

Barred owls have been detected in three different places dispersed across the action area. It is unknown whether the lack of any historical spotted owl detections within the action area is due to barred owl presence excluding spotted owls or whether the overall habitat quality of the project area is precluding spotted owls from occupying the area.

Noise has been identified as a source of disturbance and thus a potential threat to northern spotted owls and marbled murrelets during their respective breeding seasons (February 1–September 15 and March 24–September 15). If an adult is disturbed by sudden loud noises and leaves a nest, an unprotected chick is at risk of being preyed upon. Avian nest predators, especially corvids (Steller’s jays and ravens), learn to associate human presence with any food or trash left behind, and are attracted by human noise and disturbance because of the potential for food.

Restriction periods have been established by the USFWS to protect marbled murrelets and spotted owls from noise disturbance during nesting season. During restriction periods, no activity that creates noise in excess of ambient noise is permitted. Background noise in the interior of the parks is generally much lower than in developed areas where people and vehicles create noise. Noise has only been measured in the second-growth areas of the park from a few sources such as chainsaws. Background noise measured by park staff in the forest ranged from 45 to 60 decibels (dBA). Human spoken conversation is generally considered to be about 45 dBA. Chainsaws used in the park were measured at 100 dBA at 10 feet away; 82 dBA at 100 feet; and 44 dBA at 500 feet. These were instantaneous measurements, rather than average sound levels measured over a period of time.

Pacific fishers are medium-size carnivores in the weasel family that live in forested areas. Fishers are a federal candidate species for listing as threatened. No forest carnivore surveys have taken place specifically within the project area. In 2002, no fishers were detected in 2 sample units along the northwestern and southern borders of the project area. There are no incidental observations of fishers within the action area in the park wildlife observation database. However, it is expected that fishers would use the action area for foraging, resting, or denning wherever suitable structures occur.

The number of acres of potentially suitable fisher habitat in the Lost Man Creek watershed equates to the amount of suitable spotted owl nesting and roosting habitat. Habitat structure for fisher denning, resting, and foraging is most likely present in residual old-growth.

Threatened and Endangered Fish

Three species of anadromous salmonids federally listed as threatened are known to occur immediately downstream of the project area: the Southern Oregon/Northern California Coasts (SONCC) coho salmon, the California Coastal (CC) Chinook salmon, and Northern California (NC) steelhead trout. The term “evolutionarily significant unit” (ESU) is used to identify the species and the streams in which they occur. The project area potentially contains designated critical habitat for all three ESUs. Detailed species accounts and habitat requirements for all three species are found in the biological assessment of effects to threatened fish from this project (NPS 2011a).

Anadromous fish spend most of their life cycle in the ocean and return to freshwater to spawn. Different stocks of fish of the same species may migrate into freshwater at different seasons and in different stages of maturity. These stocks are commonly referred to by the season when they migrate into freshwater, e.g., summer and winter steelhead or spring-run and fall-run Chinook.

The numbers of anadromous fish are governed by conditions in both freshwater and marine environments. Three factors have the greatest potential to affect the quality and quantity of freshwater habitat: water temperature, fine sediment, and habitat complexity or cover. Good freshwater habitat for anadromous fish contains complex habitat with both wood and rock, spawning gravels with low levels of fine sediment, water temperatures rarely more than 60°F, shade cover, and a well-developed riparian zone.

Salmonids require gravels free from excessive fine sediment to lay their eggs and for the eggs to develop into free-swimming fish. They also require deep pools for the young fish to feed and grow while protected from predators. The key fish habitat problems in Redwood Creek and its tributaries associated with sedimentation from past land use practices appear to be pool quality, gravel quality, and changes in channel structure which contribute to elevated temperatures.

Redwood Creek is used by Chinook and coho salmon, steelhead, and coastal cutthroat trout. The estuary is a holding area for juvenile fish before they migrate from freshwater to the ocean. Young Chinook salmon and some steelhead juveniles produced in the upstream reaches of the creek and the tributaries migrate downstream to the estuary in summer. Low summer river flows cause a sandberm to build that blocks the flow of the creek into the ocean. Chinook, steelhead, and sea-run cutthroat trout live in the estuary embayment where they feed on invertebrates and grow to a size that will enhance their chance for survival during the ocean stages of their life cycle. Juvenile fish migrate out to the ocean in the late fall or winter when the winter rains make the creek rise and break through the sandberm. Artificial breaching of the sandberm in the summer causes the juvenile fish to enter the ocean at a smaller size, which may decrease the chances of survival for these fish.

Anadromous fish populations in Redwood Creek have diminished substantially over the past 45 years. In 1965, CDFW estimated the spawning escapement as roughly 5000 Chinook, 2000 coho, and 10,000 winter steelhead. Although channel deepening and pool development have begun to increase in all but the lower few miles of Redwood Creek following the intensive logging prior to the enactment of the state Forest Practice Rules, the main stem lacks an adequate pool-riffle structure and cover. Coarse sediment deposited in the main stem allows a large proportion of summer base flows to infiltrate and flow subsurface, thereby limiting surface water available to fish and causing increased surface temperatures. Although sediment from Lost Man Creek affects only the lower portion of Redwood Creek below the mouth of Prairie Creek, sediment at that location contributes to subsurface flow conditions.

California Coastal Chinook Salmon—CC Chinook are the largest salmonids occurring in the parks' rivers and streams. Chinook spawn primarily in the larger streams, including Redwood Creek, and the main stems of Lost Man Creek and Prairie Creek.

Winter-run Chinook constitutes the main Chinook runs in RNP streams. These fish begin their upstream migration around November, if access through the Redwood Creek estuary is possible, and have spawned and died by January. Adult spring-run Chinook in Redwood Creek were observed in only one season since 1981, when the park began summer steelhead surveys, but are not typically considered to use the Redwood Creek watershed. Stream barriers may impede Chinook salmon spawning in the park tributaries, but they may be able to surmount some barriers that may impede the smaller coho salmon. Chinook typically return from the ocean to rivers, larger streams, and larger tributaries to spawn between November and early January. In spring, Chinook salmon fry (early life stage that develops from the egg) migrate downstream to rear in the Redwood Creek estuary before entering the ocean in the fall. Chinook salmon usually return to freshwater after three to four years in the ocean, although two-year-old male spawners are commonly observed.

Juvenile Chinook salmon in Redwood Creek do not spend time rearing in upstream areas but use the Redwood Creek estuary instead. Chinook salmon usually return to freshwater after three to four years in the ocean, although two year old male spawners are commonly observed.

The Prairie Creek Fish Hatchery operated continuously from the mid-1930s until October 31, 1992, producing at Chinook at various times along with coho salmon, and cutthroat, rainbow, and steelhead trout. Prior to 1978, most young Chinook salmon were released from Prairie Creek Fish Hatchery in the early spring. These were fish hatched from eggs taken only four or five months earlier. Capturing sufficient numbers of Chinook to obtain their eggs was difficult because of the low numbers of returning adult fish. The low numbers of returning adult Chinook are probably related in part to the conditions in the Redwood Creek estuary. Winter spawning/carcass counts in RNP continue to indicate low numbers of returning salmon (D. Anderson, personal communication).

Critical habitat for CC Chinook salmon was re-designated on January 2, 2006. Potentially suitable habitat for these fish in RNP occurs in the Redwood Creek basin and includes all stream and estuarine reaches accessible to the species. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of the species.

Critical habitat is defined in Section 3(5) (a) of the Endangered Species Act as "…the specific areas within the geographical area occupied by the species… on which are found those physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations or protection". In designating critical habitat NOAA Fisheries considers habitat elements and conditions required for all life stages of the species. In addition, NOAA Fisheries also focuses on the known physical and biological features (primary constituent elements) within the designated area that are essential to the conservation of the species. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

Lost Man Creek has about 3 miles of suitable habitat that is designated critical habitat under the above definition. Lost Man Creek's lower main stem has good riparian cover which keeps the water temperature low, large riffles with a wide variety of gravel sizes for spawning adults of all salmonid species, many deep pools for rearing, and instream cover for both adult and juvenile fish provided by large woody debris, boulders and bedrock. Fish surveys in Lost Man Creek have been done in two reaches, a lower reach and an upper reach. The lower Lost Man reach begins at the confluence of Prairie Creek and continues about 1.7 miles upstream to the second of the double bridges where Holter Ridge Road/bike-hike trail crosses Lost Man Creek. The lower Lost Man reach has been surveyed for spawning adults and carcasses since the 1980s. The upper Lost Man reach begins at the second double bridges and continues upstream for 1.2 miles to an extremely large log jam, which may be a fish barrier to Chinook. Surveys on the upper Lost Man reach began in December 2001.

Southern Oregon/Northern California Coast Coho Salmon—Coho or silver salmon are smaller than the Chinook, and spawn in Redwood Creek, Prairie Creek, and some of the smaller tributaries of these creeks including Lost Man Creek.

Coho salmon have a simple (relative to other anadromous Pacific salmon) three-year life cycle. Adult coho typically run up Redwood Creek to spawn from late October to early March depending on access through the Redwood Creek estuary. Adult migration through the Redwood Creek estuary is dependent on the mouth being open to the ocean. The conditions at the mouth depend on a combination of wave action on the sandberm, the volume of water in the estuary, and the flow of water in the stream. Recent data suggest that the peak of the spawning run is in late November. After hatching, juvenile coho salmon generally spend one full year rearing in freshwater before entering the ocean. Downstream migration of coho to the ocean from upstream Redwood Creek rearing areas occurs in early spring (March-April). Survey data from RNP indicate that these young salmon move directly into the ocean, spending a minimal amount of time in the estuary.

Coho use a variety of spawning sites but characteristically enter small coastal creeks or tributary headwaters of larger rivers to spawn. The tiny fry occupy shallow stream edges next to pools but move into deeper water as they grow. Coho salmon juveniles remain in the streams for one year before migrating to the ocean, typically between March and May. Most coho salmon return to freshwater after two years in the ocean. Optimal rearing habitat for juveniles is pools deeper than 3.5 feet that contain logs, large tree roots, or boulders in heavily shaded sections of the streams.

The total adult coho population in the Redwood Creek system may have once numbered more than 2,000. Most of the coho occurred in the Prairie Creek drainage and probably originated from the Prairie Creek Fish Hatchery (D. Anderson, RNP, field notes). Since the hatchery ceased operations in 1992, numbers of coho are probably much lower.

Coho salmon in the Redwood Creek basin occur in the mainstem and the larger low gradient tributaries. General stream surveys were conducted in the basin in 1980 and 1981 to describe and characterize the salmonid rearing habitat and distribution of juvenile salmonids. Migration barriers were identified during these surveys. No coho were found during these early electrofishing surveys above the barriers. However, subsequent surveys in the 1990s have detected coho in streams that did not have coho in 1980-81. Whether these barriers still exist, have changed to allow fish passage, or new barriers have been created is unknown. Based on these data, RNP fish biologists assume that coho occupy 26 miles of stream within the Lower Redwood Creek Basin. Structurally complex streams containing stones, logs, brush, and aquatic macrophytes support larger numbers of rearing coho juveniles (Scrivener and Andersen 1982) than do streams that lack these structural features.

NOAA Fisheries has designated critical habitat for the SONCC coho ESU between Cape Blanco, Oregon and Punta Gorda, California. The critical habitat unit is all stream and estuarine reaches accessible to the species and includes water, substrate, and the adjacent riparian zone. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of coho. The adjacent riparian zone is the area that provides shade, sediment transport, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter. Habitat quality in this zone is related to the quality of riparian areas, upland areas, and inaccessible or headwater or intermittent streams that provide key habitat elements, such as large woody debris and gravel, that are crucial for coho in downstream reaches (USDC 1999). Thus, the width of the riparian zone included as critical habitat is variable depending upon consideration of these factors.

Stream reaches accessible to coho salmon within the parks are designated critical habitat. Critical habitat includes all waterways, substrate, and adjacent riparian zones of estuarine and riverine sections accessible to coho salmon. Accessible sections are those within the historical range of the fish populations that can still be occupied by any life stage of coho salmon. There are no sections of streams within the parks that are inaccessible because of specific dams identified in the NOAA Fisheries proposal or because of longstanding, naturally impassible barriers such as natural waterfalls in existence for at least several hundred years.

Northern California Steelhead Trout— NC steelhead trout are found in Redwood and Prairie Creeks, and in most small order, high gradient tributaries to Redwood Creek. They are able to leap above barriers that might impede coho salmon. Whether logjams are barriers to movement depends upon stream dynamics such as the size of the logjam and the stream discharge as well as the timing and duration of the steelhead migration. These events change from year to year. For example, in previous years, no steelhead were found above a large log jam just downstream from the confluence of the Middle and South Forks of Lost Man Creek. However, steelhead were detected in 2012 just above the log jam.

Steelhead are the last of the salmonid species to return to freshwater in the annual cycle, generally between January and April. Steelhead juveniles rear in the streams for one to four years before their migration to the ocean. They then reside in marine waters for typically two or three years before returning to freshwater to spawn. Unlike other Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying. Most of the multiple spawners are females, provided there are no barriers to migration and adequate amounts of water are left in the stream during the dry summer months.

Steelhead can be divided into 2 reproductive types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration. These two types are termed "stream maturing" and “ocean maturing.” Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature, after which they spawn. Stream-maturing steelhead are also known as summer steelhead. Ocean maturing (or winter) steelhead enter freshwater in a mature state and spawn shortly after river entry. Summer steelhead return to a river or stream from spring to early fall and remain in deep pools until spawning occurs. The long freshwater holding time renders the adult summer steelhead especially vulnerable to predation and habitat changes such as decreasing flows and increasing temperatures.

Redwood Creek has both summer and winter steelhead. Survey data indicate a continuous decline of summer steelhead since surveys began in 1981. Forty-four adult fish is the highest total number observed during summer surveys of portions of the main stem of Redwood Creek. No adult fish were seen in 1989 and few fish were seen in the mid-1990s. No other streams within the parks in the Redwood Creek basin have been surveyed because these streams do not have large enough pools to support adult fish during the warm summer months.

Winter-run steelhead numbers are higher than summer steelhead numbers. Juvenile winter-run steelhead is the most common and widely distributed fish in the Redwood Creek basin. During sampling efforts in the summers of 1980 and 1981, steelhead trout occurred in 57 of the 111 tributaries surveyed (Anderson 1988, Brown 1988). In recent years, winter surveys have been conducted along the main stem of Redwood Creek (flows permitting), Lost Man Creek, Little Lost Man Creek, Prairie Creek, Mill Creek, and Bridge Creek. In the winter of 2000-2001, 10 live winter steelhead were observed in Redwood Creek (Holden 2002).

NOAA Fisheries designated critical habitat in January 2006 for the distinct population segment of Northern California steelhead between Redwood Creek, California and Russian River, California. The project area includes designated critical habitat for steelhead, which is essentially identical to the critical habitat for Chinook and coho salmon previously described.

Cultural Resources

Cultural resources in Redwood National and State Parks include archeological sites, historic structures, ethnographic resources, cultural landscapes, and museum objects, as defined in NPS Director's Order 28. Cultural resources can be sites, objects, structures, places, landscapes, or natural elements of places or landscapes.

General Prehistoric and Historic Context

Documented human occupation or use of land under Redwood National Park jurisdiction and vicinity date to as early as 5,000 to 7,000 years ago (Benson 1983, Tushingham et al. 2008). Evidence of prehistoric human activities include village sites, seasonal camps, and trail use sites reflected in the archeological record by artifact concentrations and associated features found in the Bald Hills prairies, along the coast, and in some instances within forested areas in the Redwood Creek basin and other perennial drainages. Historic-period activities on park lands included exploration, cattle and sheep ranching, dairies, farming, logging, mining, establishment of overland transportation routes, and World War II and cold war era military history.

American Indians have lived in the area continuously for thousands of years. They live in local communities, reservations, or rancherias around the parks, and continue to practice traditional lifeways. Lands that are now part of Redwood National and State Parks are within aboriginal Tolowa, Yurok, and Chilula territory. Tolowa territory extended north along the coast from Wilson Creek and included most of the Smith River watershed in the interior. Yurok territory bordered the Tolowa to the south and extended from Damnation Creek in the North to the Little River along the coast, and included the lower 45 miles of the Klamath River watershed. Chilula territory included most of the lower Redwood Creek drainage and included the Bald Hills area (Eidsness 1988).

The Klamath River Reservation was established along the lower portion of the river in 1855 through a presidential executive order. In the late 1860s and 1870s, a number of Americans took up residency on the reservation but were evicted in 1879. In 1891, President Harrison enlarged the nearby Hoopa Valley Indian Reservation to include lands along the Klamath River to one mile on either side of the river, from just upriver of Weitchpec to the Pacific Ocean, thus encompassing the original Klamath River Reservation. In 1892, Congress opened the reservation to homesteading by non-Indians and awarded allotments to Indians living along the river. Because of the homesteading, the majority of lands along the Klamath River within reservation boundaries are owned by non-Indians. The Hoopa-Yurok Settlement Act of 1989 divided the Hoopa Valley Indian Reservation into the Yurok and Hoopa Valley reservations. The Yurok and Hoopa Valley tribes are currently amending the Act to establish jurisdiction for lands and resources, and to provide the legal background for appropriation of funds, management of lands and resources, and development of infrastructure and economic opportunities for the Yurok Tribe.

Following severe flooding along the Klamath River in the winter of 1861-62, the reservation was essentially abandoned. A new reservation site was selected north of Crescent City. Numerous Tolowa were concentrated here, along with members of tribes from the Mad and Eel Rivers south of aboriginal Yurok territory.

The NPS has held regular consultations with the American Indian community since 1978, initially with five American Indian heritage advisory committees representing different geographic areas of the parks and different Indian groups. In the 1990s, consultations shifted from heritage advisory committees to tribal governments. Currently, there are five tribal governments whose members have ties to lands within the project area. These governments include the Yurok Tribe of the Yurok Reservation, California; Coast Indian Community of Yurok Indians of the Resighini Rancheria, California; Big Lagoon Rancheria of California; and Cher-Ae Heights Indian Community of the Trinidad Rancheria, California; and the Hoopa Valley Tribe of the Hoopa Valley Reservation, California.

In March 2009 a general agreement was renewed by the NPS, CDPR, and the Yurok Tribe, establishing and formalizing a government-to-government relationship. In addition, the Yurok Tribe, under the provisions of the Tribal Self-Determination Act of 1994, has assumed state historic preservation office functions for all lands within the reservation boundaries.

The first Euro-Americans in the area that is now Redwood National and State Parks were engaged in exploration, fur-trading, mining, and packing and freighting of supplies for mining camps along the interior rivers. Settlements were established along the coast, attracting farmers and ranchers who settled along the pack trails and coastal bottomlands. Other settlers farmed and raised cattle in the Bald Hills area and provided amenities for teamsters stopping en route to the interior mines. Often the pack trains would stop in Elk Camp Prairie and wait until there were sufficient numbers to make safe passage through Indian territory Most of these early farms and ranches were abandoned during the period of Indian conflict (Bearss 1969; Eidsness 1988). Later ranches, most notably the Lyon's family ranch, were established in the Bald Hills initially raising cattle, but later switching to sheep. Wool produced in the Bald Hills would become world renowned and ranching continued in the Bald Hills until the area was acquired for inclusion into the park (Bradley and Corbett 2001).

Archeological Resources

Archeological resources "are the remains of past human activity and records documenting the scientific analysis of these remains." As of September 2009, a total of 112 archeological sites are documented in the national park. These include prehistoric village sites, seasonal camps, procurement sites, and trail use sites. Historic period archeological sites include structures and associated features related to ranching and farming, and historic-period trash scatters related to settlement, logging, and mining, as well as various ranching landscape features such as fence lines and stock ponds.

Historic Structures

Structures "are material assemblies that extend the limits of human capacity," and comprise such diverse objects as buildings, bridges, vehicles, monuments, vessels, fences, and canals. There are no historic structures in the project area.

Ethnographic Resources and Traditional Activities on Park and Aboriginal Lands

Ethnographic resources "are basic expressions of human culture and the basis for continuity of cultural systems" and encompass both the tangible (native languages, subsistence activities) and intangible (oral traditions, religious beliefs). These can include archeological sites, old ethnographic village sites, travel routes, fishing and hunting camps, locations of ceremonial significance, and areas traditionally used to gather resources. Traditionally important plant resources include but are not limited to hazel shoots and nuts, salmonberry, tanoak, black oak, elderberry, ocean spray, gooseberry, huckleberry, honey suckle plant, "wild parsley," bear grass, horse tails, maple, madrone, licorice fern, and manzanita (Gates et al. 2000, 2002).

Among the local Yurok, and Hupa, many aspects of the traditional lifeways continue on both Redwood National and State Parks and adjacent lands. The parks contain sites that are integral to the practice of traditional American Indian spirituality, subsistence, and lifeways. Some fishing areas, gathering areas, and ceremonial sites now within Redwood National and State Parks have been used by the ancestral American Indian community for thousands of years. Certain dances are held, and others are being revived that entail the maintenance of dance sites with their traditional structures and the fabrication of dance regalia. Many of the arts, such as canoe making and basket weaving, also are practiced, which require certain natural resources — many of which are found within the parks. These arts are sources of economic as well as spiritual sustenance.

Cultural Landscapes
Cultural landscapes “are settings we have created in the natural world.” They are intertwined patterns of natural and constructed features that represent human manipulation and adaptation of the land. No cultural landscapes were identified in the project area.

National Register of Historic Places
The project area overlaps with a larger Bald Hills/Holter Ridge Traditional Cultural Property (TCP) as defined by the Yurok Tribe as being eligible for listing in the National Register of Historic Places (Clayburn 2012). Through archival research and consultation no specific gathering resources were identified in the project area. However there are resource gathering areas known by Yurok in the greater Lost Man Creek watershed (Clayburn 2012). No other prehistoric or historic sites, districts, structures, buildings, or objects eligible for or listed in the National Register of Historic Places were identified within the project area.

Socioeconomic History
Humboldt County Recorder’s Office research and oral history interviews conducted by Van Kirk (1999) indicate that after Euro-American settlement of the region, the project area consisted of public domain lands under the jurisdiction of the U.S. General Land Office. These public domain lands were patented in numerous 160-acre parcels following enactment of the Timber and Stone Act of 1878, and later consolidated into 2 large ownerships. There was no “settlement”, e.g. farms, ranches or homes, in the Lost Man Creek watershed.

The logging industry was established in Humboldt County in 1850, as a direct result of Euro-American settlement and the demand for housing and manufactured goods (Sloan 2007). Logging of old growth redwood forests began in 1855 (Bearss 1969). Early logging efforts targeted pine, fir, and spruce and later smaller diameter redwood trees, in large part because most loggers were unfamiliar with redwood, particularly massive old growth redwood. By 1854 there were 9 lumber mills operating in Humboldt Bay but several joined together to form the Humboldt Lumber and Manufacturing Company.

By 1860, Humboldt County was the second largest lumber-producing county in California. As larger logs were taken, they were floated on streams and rivers to the coast for milling and shipping. Eventually skid roads were created to haul logs to nearby mills for processing. Early hauling methods relied on pack animals, or donkey or oxen trains to haul logs out of timber units to other mills. The invention of the “bull donkey” in 1892 represented the first mechanical means for hauling logs. As machinery and road-building evolved over the next decades, the logging industry was able to venture further inland to obtain logs rather than relying on timber stands close to rivers and the coastal ports. Logging in the region peaked following World War II, with the availability of better roads, heavy machinery, and chainsaws to reach old growth stands and cut, haul, and mill old growth lumber at a scale previously impossible.

Intensive logging in the Redwood Creek and Lost Man Creek areas occurred after World War II, from the late 1940s -1960s (Van Kirk 1999). The population of Orick grew from 50 before World War II to 1250 in 1948. Where a single lumber mill had been in operation since the 1930s, 4 new mills were operating by 1947—Lumberman’s Supply on McComb’s Rand on Bald Hills, the Sunset Shingle Mill at the mouth of Prairie Creek, Harding’s Mill, and the Geneva Lumber Company.

Geneva Lumber Company established its mill at the mouth of Little Lost Man Creek. Geneva Lumber Company sold its operation to the Hammond Lumber Company in 1954, which in turn sold their operation to Georgia Pacific in 1956.

The Hill-Davis Lumber Company, Arcata Redwood Company, Sage Land and Lumber Company, and the Geneva Lumber Company built a series of haul roads throughout the Bald Hills, Redwood Creek, Prairie Creek, and Lost Man Creek watersheds. The major haul roads (Geneva, Lower B 500 and Holter Ridge) plus numerous spur roads were built in incremental segments as the loggers extended their reach into the timberlands. Geneva Road was built in 1947 as a primary haul route to the Geneva Lumber Company mill at the mouth of Little Lost Man Creek.

By the time logging in Lost Man Creek began after World War II, the majority of the watershed was owned by two timber companies. The property line between these owners split the basin roughly along a north-south line, with Hill-Davis owning the western portion, and Sage Land and Lumber owning the eastern portion.

Logging south of Geneva Road on both ownerships ended with park establishment in 1968. North of Geneva Road, logging in the middle and lower portions of Larry Damm and the North Fork watersheds culminated in the early 1970s just prior to park expansion. Only the lower portion of the watershed was not logged.

Logging in the Lost Man Creek watershed ceased altogether with the expansion of Redwood National Park in 1978. The creation and expansion of the national park in 1968 and 1978, the removal of most of the old growth trees, and the enactment of legislation protecting water quality and endangered species contributed to the decline of the logging industry as the principal source of income for Orick.

Most of the existing road systems in the park are remnants of haul and skid roads between old growth stands and nearby mills. Major haul roads such as Geneva Road and Holter Ridge Road are maintained by NPS for access into park lands for management and restoration purposes and as recreational trails.

Visitor Use and Experience

Total visitation to the national park in 2012 was reported as 352,517 visits. There are no separate statistics for visitation in the project area. The visitor facilities nearest to the project area are the Holter Ridge Bike Trail and the Lost Man Creek picnic area. The Geneva and Holter Ridge roads were opened to hiking and bicycling in the late 1980s as the Lost Man Creek Trail and Holter Ridge Bike Trail; these trails are roads maintained for administrative access by park vehicles. The picnic area is located about 0.1 miles upstream of the confluence of Larry Damm and Lost Man Creeks and serves as the trailhead for the bike trail. Visitor use has primarily been in the old-growth forests of the lower Lost Man Creek watershed and along the hiking/biking trail. The Lost Man Creek portion of the hiking-biking trail passes though old-growth forest for about 1.5 miles before entering second-growth forest and joining Holter Ridge Road and the B Line North at the ridgetop. At the junction, Holter Ridge Road runs south for about 8 miles to join Bald Hills Road.

From the intersection with Geneva (Lost Man Creek Trail) and Holter Ridge Roads, the B Line North runs 4.5 miles north and joins the Highway 101 Bypass north of the Newton B. Drury Scenic Parkway exit off the freeway.

The primary scenic resources in RNP are the coastal redwood forest, the vistas of the Pacific Ocean and the rocky shoreline, and the oak woodlands and open prairies of the Bald Hills. The coast redwood grows as a natural forest only in a narrow strip along the northern California and southernmost Oregon coast. Of the two million acres of old-growth redwood that existed in 1850, less than 5% are protected in national, state and local parks. Redwoods are the tallest living things; several of the tallest known trees in the world are in the parks.

Timber harvest and road building have altered the scenic qualities and vistas throughout the parks. Clearcut blocks are visible as distinct and sometimes abrupt vegetation changes on the forested hillslopes. The linear imprints of logging roads, including roads that have been removed under the watershed restoration program, are frequently encountered in both logged and unlogged forests but the roads are becoming less visible as the forest canopy regrows. The project area itself does not feature the open vistas seen along Highway 101 and the Bald Hills Road. Visitors driving, bicycling, or hiking along Lost Man Creek Road or the Holter Ridge Bike Trail are within a closed-canopy forest. Because of safety considerations created by intensive heavy equipment work associated with watershed restoration and proposed second-growth forest restoration activities, visitor use of the project area is discouraged during project operations.

Other visitor activities in the vicinity of the project area include wildlife viewing, primarily for Roosevelt elk, and guided walks originating at the Elk Meadow Trailhead, environmental education for local schoolchildren at the Wolf Creek Outdoor School, and evening campfire programs at the Gold Bluffs Beach and Elk Prairie campgrounds in Prairie Creek Redwoods State Park.

Park Operations
The current vegetation management program in Redwood National Park is staffed by of a core group of specialists including a supervisory botanist, a plant ecologist, and forester, as well as biological technicians. Support is provided from various disciplines of the Resource Management and Science division, including specialists in fish and wildlife, geology, hydrology, cultural resources, fire management, and GIS. Supporting research includes studies of erosion and sedimentation, vegetation, fisheries, wildlife, soils, hydrology, fire effects, and cultural resources.

The Vegetation Management branch implemented forest restoration projects from 2009 through 2011 in the Lost Man Creek area under the 2008 South Fork of Lost Man Creek Second-growth Forest Restoration Plan (NPS 2008). The plan described forest restoration treatments in 1,700 acres. The plan objective was to accelerate restoration of forest characteristics more typical of late-seral and old-growth redwood forests in the park, address species composition imbalances, and reduce tree density. Monitoring the South Fork project area is on-going. Plots are re-measured every five years.

The Geologic Services branch has conducted watershed restoration in the Lost Man Creek area between 2006 and 2010. The removal of logging roads and restoration of landforms was conducted to reduce potential erosion that could damage aquatic habitats in the Lost Man Creek watershed (NPS 2006b).

The Middle Fork of the Lost Man Creek second-growth forest restoration project area is included in the coniferous forest fire management unit described in the 2010 Redwood National and State

Parks Fire Management Plan (NPS 2010). Wildfires may be managed for resource benefit but will most likely be immediately suppressed because of the proximity of the project area to private timberlands. No prescribed fire projects are planned for the project area. Under the 2010 FMP, a shaded fuel break at a maximum width of 100 feet is being constructed on both sides of Holter Ridge Road. The shaded fuel break in the vicinity of Holter Ridge would not affect any of the prescriptions proposed for management of second-growth forest.

Park road crews maintain roads in the parks at various levels. Roads used by visitors are maintained at a high level, with periodic grading, ditch and culvert cleaning, and repair and maintenance of road surfaces and drainage structures. On abandoned logging roads scheduled for removal, maintenance is less regular, and focused mainly on erosion control and safety rather than on driver comfort and convenience. Road maintenance costs are approximately $1,700 per mile for brushing, ditch cleaning, and culvert maintenance. These costs are expected to increase as fuel costs increase.

Park operations related to visitor education and interpretation of park resources were described above in the visitor use and experience section.

ENVIRONMENTAL CONSEQUENCES

This section examines the effects of the alternatives for restoration of second-growth forests in the Middle Fork of Lost Man Creek on the natural and cultural resources in the project area, the park ecosystem, park visitors, park operations, and adjacent communities. These effects are discussed in relation to other past, present, and reasonably foreseeable actions related to the alternatives and to the resources in the parks and the region.

Methodology

Impacts on a particular resource are predicted based on impacts observed and measured from similar projects, relevant scientific research and publications, and best professional judgment of park specialists, registered professional foresters and other forestry professionals, and academic foresters familiar with the resources and forestry practices in the redwood region. Impact analyses based on best professional judgment of park resource managers are derived from their analyses of effects of restoration actions within and outside of RNP, including past monitoring; discussions with knowledgeable local and regional foresters, botanists, forest ecologists, geologists, biologists, and cultural resource and watershed restoration specialists; and reports and studies prepared by academic, industry, and government agency personnel on the effects of forest management in the region and in areas that have been logged.

Impact Definitions for Natural Resources

Impacts are analyzed according to the type of impact (beneficial or adverse), the timing and duration of impact (short-term, long-term, one-time, occasional, and repeated) and the severity or intensity of impact (no effect, negligible, minor, moderate, or major). These factors are also considered in the context of the geographic location of the park and the region.

Context—The context of an action includes consideration of the effects on resources in the project area, and on similar resources within Redwood National and State Parks, the local area surrounding the parks, and the region.

The geographic context of an impact includes consideration of the project area, the parks as a whole, and local and regional conditions.

Timing and Duration—The timing of an impact is also part of its context. For example, removing brush and trees along a road in October does not affect nesting birds but brushing the same road in June would affect any birds that might be nesting in the vegetation.

The duration of an impact considers whether an effect would happen immediately, the length of time over which an impact occurs, and how long it would be noticeable. Duration is defined as short-term or long-term, although the duration of an effect is related to the resource affected. In general, long-term effects would be those that are repeated over at least several years or that would not be immediately noticeable.

Short-term effects on annual vegetation would generally be on the order of a year or less, because a year includes one complete growing season. In the context of resources such as soils or plant communities, or for long-lived plants such as redwood trees, or for geological processes such as flooding, long-term refers to effects on the order of decades to centuries.

Research has shown that thinning will affect canopy stratification. Trees of different ages and growth habits will produce multiple layers in a canopy, including a well-developed mid-story but that this effect may take decades or centuries to develop fully. Therefore the effect of thinning on canopy stratification is a long-term effect. An understory can begin to develop within 2 years of thinning. Therefore the effect of thinning on the understory is defined as a period less than 2 years and long-term effects would occur in a period of 2 years or longer.

Type—The type of impact describes whether an action would benefit or harm a resource. A beneficial effect improves the condition of a resource, protects it from damage or loss, or favors the persistence of a resource. A harmful or adverse effect is one that worsens the condition of a resource, damages or degrades a resource, leads to the loss of the resource, alters it irretrievably in an undesirable way or changes its essential character so that the resource no longer possesses integrity or its defining characteristic. Adverse effects are unfavorable to the conservation and preservation of the resource.

Intensity—Intensity, degree, or severity of an impact refers to how much of an effect an action has on a resource and is described as negligible, minor, moderate, or major. Major effects are considered significant. Determining intensity relies on understanding the range of natural variation of a resource. If an action has no effect on a resource, or if the effect is barely noticeable or measurable, the effect is considered negligible. Negligible effects are those that are unnoticeable, undetectable, or result in no change to a resource, or that affect so few individuals that the effect cannot be distinguished from the natural variability for a resource. Significant effects are always noticeable and result in a permanent change to a resource over a large area.

Levels of change between negligible and significant are described as minor or moderate. Minor changes to a resource are detectable but there is no long-term or permanent alteration of the resource and the changes are within the range of natural variability. Minor effects are generally noticeable but result in only a slight change to a resource or occur in a small area, and do not change resource function.

Moderate effects are always noticeable, and result in some change to the resource or its function, and occur in several areas. If an action changes the resource completely or a change is irreversible, the effect is considered significant or major. Actions are more likely to result in a gradient of change rather than a distinct level of change, so that some effects may be judged “minor to moderate” to indicate that portions of a resource in different locations might be affected slightly differently by the same action. For natural resources that are distributed discontinuously across a landscape or where individual elements of a resource are not exactly equivalent to other individuals or pieces of the same resource, a range of effects from a single action is likely.

The intensity of an impact also includes consideration of how widespread or local the area of impact would be, the amount of a resource that might be affected, or the number of times an effect would occur. If an action affects all of a resource within the parks, that impact would be considered major or significant. For example, thinning one 30-acre forest stand within the project area (1,125 acres) would have negligible to minor effects on the forest habitats or their condition. Thinning of all stands within the project area would create a greater pattern of disturbance in the project area. Similarly, multiple entries to thin any one particular stand would have a greater effect than a single entry thin.

Intensity of effects on wildlife is determined based on the number of individuals affected in relation to the total population in the project area, the park, the region, and the range of the species. If only a few individuals of a plant or animal are affected, the impact would be considered negligible. If an action affects more than a few individuals but the effects are within the natural level of variability for a population or a resource, the effect is considered minor. If an action affects many or all individuals and causes changes to populations that are greater than the natural level of variability, the effect is considered moderate.

For sensitive wildlife and plants, there are two sets of definitions for intensity. The definitions used in this EA are based on the NEPA regulations (40 CFR 1500, *et seq.*) and the NPS guidelines for implementing NEPA. The USFWS uses a second set of definitions to accompany its determinations of effect based on its regulations for implementing the Endangered Species Act. Negligible effects on listed species for the purpose of this EA are defined as those that are unnoticeable or that the USFWS has determined to have "no effect." The USFWS has defined a "no effect" determination as the "appropriate conclusion when the action agency determines its proposed action will not affect listed species or critical habitat." USFWS defines impacts that result in a determination of "may affect but not likely to adversely affect" as "discountable or insignificant"; these effects are defined in this EA as minor. Adverse effects occur if impacts are not discountable, insignificant or beneficial. Impacts that are determined to be adverse but can be lessened or minimized, even though incidental take may still result, are considered moderate. An effect that is determined by the USFWS to result in jeopardy to a listed species is defined as major or significant.

Impact Definitions for Cultural Resources
Cultural resources are defined as archeological resources, prehistoric or historic structures, cultural landscapes, and traditional cultural properties. These resources are called "Historic Properties" when they are either listed in or are determined eligible for listing on the National Register of Historic Places under §106 of the National Historic Preservation Act (36 CFR 800, Protection of Historic Properties). Criteria for determining eligibility of listing such resources on the National Register include the following:

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded or may be likely to yield, information important in prehistory or history.

Potential impacts to historic properties either listed in or eligible to be listed in the National Register of Historic Places for this project were identified and evaluated in accordance with the Advisory Council on Historic Preservation's regulations implementing §106 of the National Historic Preservation Act (36 CFR 800, *Protection of Historic Properties*) by (1) determining the area of potential effects; (2) identifying resources present in the area of potential effects that are National Register listed or eligible; (3) applying the criteria of adverse effect to affected resources; and (4) considering ways to avoid, minimize or mitigate adverse effects.

Under the Advisory Council's regulations, a determination of no historic properties affected, adverse effect, or no adverse effect must be made for historic properties. A determination of no historic properties affected means that either there are no historic properties present or there are historic properties present but the undertaking will have no effect upon them (36 CFR 800.4(d)(1)). An adverse effect occurs whenever an impact alters, directly or indirectly, any characteristic of a cultural resource that qualifies it for inclusion in the National Register, e.g., diminishing the integrity (or the extent to which a resource retains its historic appearance) of its location, design, setting, materials, workmanship, feeling, or association. Adverse effects also include reasonably foreseeable effects caused by the alternatives that would occur later in time, be farther removed in distance or be cumulative (36 CFR 800.5(a)(1)). A determination of no adverse effect means there is an effect, but the effect would not meet the criteria of an adverse effect, i.e., diminish the characteristics of the cultural resource that qualify it for inclusion in the National Register (36 CFR 800.5(b)).

Thus, the criteria for characterizing the severity or intensity of impacts to National Register listed or eligible archeological resources, prehistoric or historic structures, cultural landscapes, and traditional cultural properties are the §106 determinations of effect: no historic properties affected, adverse effect, or no adverse effect. A §106 determination of effect is included in the conclusion section for analysis of impacts to each National Register-listed or eligible- cultural resource.

Applicable Laws, Regulations, and Policies

Endangered Species Act Section 7 Consultations—Section 7 of the Endangered Species Act of 1973, as amended (19 U.S.C. 1536 (c)), requires that federal agencies consult with the USFWS and NOAA Fisheries if agency actions have the potential to affect species listed or proposed for listing under the Endangered Species Act or designated critical habitat. The NPS and NOAA Fisheries agreed that none of the alternatives, including the no action alternative and the proposed action, would directly affect any listed or proposed threatened or endangered fish species.

Migratory Bird Treaty Act—The Migratory Bird Treaty Act (MBTA) protects migratory birds including hawks and songbirds. Several species protected under the MBTA nest in and around the project area. Seasonal restrictions on noise and habitat disturbance to protect nesting birds would be required under the action alternatives. The NPS avoids impacts to birds protected under the MBTA by managing vegetation suitable for nesting outside the primary nesting season for most migratory birds (May 1– July 31).

Cultural Resource Consultations— Federal land management agencies are required to consider the effects of their proposed actions on properties listed in, or eligible for inclusion in, the National Register of Historic Places (i.e., historic properties), and allow the Advisory Council on Historic Preservation a reasonable opportunity to comment as per the National Historic Preservation Act, as amended and its implementing regulations at 36 CFR 800. Agencies are required to consult with Federal, state, local, and tribal governments/organizations, identify historic properties, assess adverse effects to historic properties, and negate, minimize, or mitigate adverse effects to historic properties while engaged in any federal or federally assisted undertaking (36 CFR Part 800).

Effects of the Alternatives on Air Quality

In general, air quality in RNP and the surrounding area meets or exceeds standards set by the EPA because the prevailing winds come from the northwest across the ocean where there are no emission sources. Air quality returns quickly to very good to excellent after vehicles and equipment cease operating or stirring up dust. The amount of time for regional air quality to return to pre-disturbance condition depends on the prevailing winds and the movement of air masses but air stagnation or long-term inversions that cause poor air quality mostly occur during the late fall and early winter.

Effects on Air Quality under No Action—Under this alternative, there would be no dust generated or emissions from heavy equipment used for restoration, vehicles used to access project areas, or chainsaws used to fall trees within units. There would continue to be negligible adverse effects on air quality from emissions and dust from vehicles used for access to the project area for monitoring of second-growth forests.

Effects on Air Quality under the Proposed Action—Under the proposed action, there would be emissions from vehicles, heavy equipment, and gas-powered tools. Vehicle emissions would meet air quality standards required for operation in California. Emissions from vehicles and from gas-powered tools would be negligible, provided the vehicles and tools are in good working order.

Vehicles used to transport work crews would create dust on the unsurfaced roads during dry periods. Dust would be primarily generated by heavy equipment activities associated with removing downed trees from project sites, loading logs onto haul trucks at landings, and repeated use of haul trucks on dirt roads between project sites and the Bald Hills Road.

Canopy cover would be retained at over 50% coverage in all units, reducing the soil moisture loss and dry conditions that produce dust. There would be more dust generated on the 34 log landings (estimated to cover about 7 acres altogether) and along roads used to haul logs due to repeated use and less canopy cover. Dust produced at log landings and along road corridors would be mitigated by sprinkling the access roads with water carried on water trucks. Dust would coat vegetation in the immediate vicinity of the work site and roads corridors and would persist until winter rains wash it off. The adverse effects on air quality would be localized and short-term, with the longest period of reduced air quality occurring during work hours from July through October.

Emissions and dust would be localized, temporary and repeated while work is performed, and repeated over the duration of the project. The overall effect on air quality would be adverse, minor, and temporary because no significant air quality related values would be affected outside the immediate area where work is being conducted and the dust would be a temporary condition.

When lop-and-scatter operational methods are used, there would be emissions and dust generated by vehicles using roads for access and from chain saws. There would be no dust generated by heavy equipment hauling trees to landings or using roads to remove trees from the project sites.

Emissions and dust from vehicles and equipment would be localized, temporary and repeated while work is performed; these effects would continue for the duration of the project. Emissions would meet air quality standards required for vehicle, equipment and chain saw operation in California. Emissions would be negligible, provided the vehicles and tools are in good working order. The overall effect on air quality would be adverse, temporary, localized, and minor because no significant air quality related values would be affected outside the immediate area where work is being conducted and the dust and emissions would be temporary.

Cumulative Effects on Air Quality—Other sources of air pollution in or near the park include emissions generated by vehicles using public roads and highways that pass through the park, emissions from wood stoves, dust from vehicles on unsurfaced roads in and adjacent to the park, smoke from prescribed fires in and adjacent to the park, and smoke from wildfire. Smoke from prescribed and wildland fires are temporary and generally localized. However, large wildland fires can create unhealthy air quality that persists for several weeks, particularly in the Klamath and Trinity River valleys east of the parks. Wildland fires typically occur during late summer and early fall, prior to the onset of the rainy season. Prescribed burns are conducted under permit from the North Coast Regional Air Quality Control Board, which monitors air quality to ensure that air quality is protected.

Conclusions: Effects on Air Quality—None of the alternatives, including the proposed action, would have long-term or widespread adverse effects on air quality or air quality related values in the parks. Adverse effects on air quality from the action alternatives would be localized, temporary, minor along roads during the work periods, and negligible over the long-term.

The proposed action would have greater adverse effects on air quality because logs would be skidded to landings and hauled out on trucks but the overall effects on air quality would be temporary, minor in the short-term and negligible over the long-term term.

No significant air quality related values would be affected outside the immediate work area and the dust would be a temporary condition. Neither alternative would adversely affect any other value or resource such as scenic vistas. Therefore, the adverse effect on air quality and air quality-related values would be negligible to minor under the proposed action. The cumulative effects on air quality under any of the alternatives would be negligible, because the primary sources of air pollution in the project area are vehicle emissions on highways and smoke from wildfires and prescribed burns, and state air quality standards in the project area are rarely violated by either source.

Effects of the Alternatives on Soils, Topography and Geological Resources
Topography in the project area was altered by road construction and slope failures caused by roads. Soils in the project area have been previously disturbed by road construction and tractor logging. Tractor logging disturbs soils when bulldozers skid (drag) logs across the surface of the land. Tractor logging and road construction prior to park establishment resulted in erosion of bare soils, alteration of soil horizons, and interruption of soil formation processes.

Effects of the No Action Alternative—Under the no action alternative, there would be no new effects on soils, topography or geological resources because there would be no active management of second-growth. Adverse effects on altered topography and soils from past logging and road construction would continue. In some locations, these effects are significant and will persist for centuries if left untreated. Soils would recover over decades to centuries. In portions of the project area that are scheduled for watershed restoration, the adverse effects on soils, topography and geological resources would be reduced as roads are removed and topography is restored to resemble original conditions.

Effects on Soils, Topography and Geological Resources under the Proposed Action—Under the proposed action, there would be negligible effects on topography and geological resources because there would be no new construction of roads or landings.

There would be negligible adverse effects on soils from compaction of small areas of previously disturbed soil from personnel hiking to project sites. Best management practices described below for the effects on soils from the proposed action would minimize new adverse effects to soil. To minimize future erosion, culverts, water bars, and other drainage structures would be repaired or replaced.

Under the proposed action, unstable soils would be avoided. Adverse effects on soils on steep slopes (over 35%) would be minimized by using cable yarding operations rather than ground-based removal of merchantable felled trees.

Effects of the Proposed Action on Soils
Under the proposed action, 450 acres would be thinned with no woody biomass removal. On 675 acres, soils would be disturbed to conduct ground-based or cable yarding operations.

Approximately 26 miles of skid road and up to 34 landings would be reoccupied during the project. Approximately 7 acres of previously disturbed soils would be affected to reoccupy 34 landings ranging from 0.1 to 1.0 acres to remove woody biomass.

Under the proposed action, there would be no new adverse effects on soils from compaction from use of existing roads and landings. Soils on existing roads would be affected by vehicles driving to project sites and from maintenance of the roads, but these effects would be negligible compared to the effects on soils in the project area from original road construction and logging, and from subsequent erosion on unmaintained roads and drainage structures.

Under the proposed action, on slopes 35% or less, felled trees less than 8 inches dbh would be limbed, cut into shorter lengths and left on the ground in contact with the forest floor to speed decomposition and encourage soil formation processes. After heavy equipment work is completed, these smaller trees and other cut vegetation would be spread as mulch to protect soils until vegetation regrows. New damage to previously disturbed soils would be minimized by using existing skid trails and landings to remove and process logs 8- to 24-inches dbh on 675 acres under the proposed action.

Heavy equipment would create localized ground disturbance on reoccupied skid trails. Re-establishment of up to 34 landings would result in localized areas of bare ground with no canopy cover. Best management practices and post-treatment rehabilitation would minimize the exposure of bare soil to reduce surface erosion. Mulch would be spread on all skid roads and landings disturbed by this project.

Where woody biomass would be removed, soils would be protected from long-term adverse impacts through best management practices incorporated into restoration layout and contract provisions.

- Tire tracks/skidding ruts and other depressions and surface irregularities would be obliterated and restored to pre-disturbance surface condition.
- Ground-based operations would be limited to swales or slopes of 35% or less.
- Ground-based operations would be seasonally restricted to the part of the year when soil moisture content is at its lowest, and soils are most resistant to compaction (June–October).
- All vegetation not removed from the project area would be uniformly spread across skid trails to protect exposed soils and enhance soil productivity.
- Cable and ground-based yarding would be restricted to the use of equipment capable of maintaining a minimum of one-end log suspension to reduce surface disturbance.
- Some landings would be removed as part of the watershed restoration program. Landings on roads that would be retained for administrative access would be ripped, mulched, and/or planted with trees and shrubs to provide immediate ground cover.
- Equipment or long line operations would not be allowed to cross landslide features or riparian features including wetlands or channelized streams.
- Culverts, water bars, and other drainage structures damaged during operations would be repaired or replaced to prevent road failures that might damage soils and slopes.
- Cable yarding corridors would create relatively small nicks in the soil where deflection is poor, generally near the breaks in slope or near the landing area. These small areas of ground disturbance would be mulched using slash created from trees and shrubs to provide immediate ground cover.

Where lop-and-scatter operations are conducted, trees would be thinned by hand crew using chainsaws. Crews would limb the downed wood to ensure all lateral limbs and all parts of the bole are in contact with the ground to speed decomposition. There would be no new short- or long-term adverse effects to soils. Protecting soils adjacent to access roads through best management practices and post-treatment rehabilitation of any damaged drainage structures would be a long-term minor benefit.

Cumulative Effects on Soils, Topography and Geology
The original timber management practices (clear-cut tractor logging, road building, and minimal road maintenance) had significant direct adverse effects on soils from initial disturbance and subsequent erosion. Road and landing construction directly altered topography. After logging ceased, indirect adverse effects on soils and topography continued from erosion of disturbed soils and road-related slope failures in portions of the project area.

Cumulative effects on soils and topography in other areas of the park from tractor logging, road construction, and road-related erosion have been widespread, long-term, and adverse. These adverse effects are significant and were major factors leading to expansion of the national park in 1978. The watershed restoration program in the national park is reducing the adverse effects on soils and topography by removing unstable roads and restoring topography to resemble original conditions. Soils damaged by clearcut logging and tractor yarding are recovering as vegetation regrows, stabilizing disturbed areas and enhancing soil formation processes.

Under the proposed action, soils would be disturbed again on 675 acres where logs are skidded, and from reoccupying 34 landings and skid trails. After treatment, these areas would be rehabilitated and mulched to minimize new erosion. There would be less soil disturbance on 450 acres where heavy equipment would not be used to remove logs or on 338 acres within the 675 acres of biomass removal where cable yarding operations would be conducted. Soils in biomass removal treatment areas would be protected by mulching with the cut trees and branchwood following treatment. Some skid roads and landings would be rehabilitated under the watershed restoration program.

Conclusions: Effects on Soils, Topography and Geological Resources
Soils and topography in the project area were adversely affected by tractor logging and road construction prior to park establishment and expansion. These effects were significant. Adverse impacts to soils in parts of the project area from past logging practices were significant, especially in areas where roads caused major erosion and slope failures, and where soils were disturbed by dragging large trees to landings using tractors and other heavy equipment that disturbed the ground. Some slopes and soils in the project area have partially stabilized by regrowth of trees and shrubs.

Topography affected by past logging and road construction would not be restored to resemble original conditions under the alternatives for second-growth forest restoration. Topography would continue to be altered in the project area unless roads are removed under the watershed restoration program. In areas where roads caused major slope failures, the topography would remain altered even after restoration. Alteration of the original topography is considered to be an adverse effect in the park, especially when the altered topography leads to slope failure, soil erosion, and sedimentation of streams. This alteration is significant in some locations with unstable slopes and moderate to minor in areas with more stable soils and less steep slopes.

Soils would be protected under the proposed action by prohibiting cutting in areas with unstable or potentially unstable soils, and by using existing roads, skid trails, and landings. Disturbed soils would be rehabilitated after heavy equipment work. Soils would be protected under the action alternative by either prohibiting equipment operation in areas with slopes greater than 35% or leaving cut trees on the ground to act as mulch and to decompose. The short-term adverse effects on soils under the proposed action would be negligible, especially in comparison to the original significant adverse effects from tractor logging, road construction, and lack of road maintenance.

The proposed action would have short-term, adverse impacts to soils in the project area. Because these soils were previously disturbed by logging and road construction and because best management practices and rehabilitation measures would be implemented, the effect of the proposed action on soils would be minor in the short-term and negligible over the long-term. There would be negligible benefits to soils in the project over the very long-term as the forest recovers and additional roads are removed under the watershed restoration project.

Effects on Water Resources, including Water Quality, Floodplains and Wetlands
There would be no new adverse effects on water quality, floodplains or wetlands under the no action alternative. Adverse effects on these resources from previous logging and road building are significant and are described under cumulative effects.

Effects on Floodplains
There would be no direct effects on floodplains under the proposed action because the project area is located in the upper reaches of the watershed where high-gradient narrow stream channels inhibit the development of floodplains. Indirect effects on floodplains in the main stem of Lost Man and Prairie Creeks downstream of the project area are described under cumulative effects.

Effects on Water Quality and Riparian Wetlands
Under the proposed action, adverse effects to streams, water quality in streams, and riparian wetlands would be avoided or minimized by varying the thinning prescriptions based on stream type (wetlands, swale, intermittent, perennial), stream power (channel development, stream order) and geomorphic setting (slope steepness in streamside areas, presence of unstable soils). Park geologists would assess streamside areas to determine slope stability prior to equipment operations.

Riparian Thinning Areas
A similar crown thinning prescription will be implemented in limited areas within 200 feet of the perennial portion of the Middle Fork of Lost Man Creek. All work will be accomplished by hand crew, no ground based equipment will be used and no tree yarding will occur. All cut trees will be left on site and lopped and scattered to get them in contact with the ground. The purpose of the thinning is to promote development of large trees more quickly along a perennial stream that may in the future be recruited into the stream as large wood. Thinning in this zone will only occur on slopes with less than 25 percent gradient, which occur in very limited areas (see map in appendix I of BA), totaling no more than 10 acres and occurring along less than 0.25 miles of stream length in total, along isolated stream reaches of no more than 300 feet long each. Thinning will retain at least a 60 percent post-treatment tree canopy. Each riparian thinning area will be clearly designated on the ground and all trees to be cut will be marked by park staff.

Streamside Protection Measures Applied to All Thinned Areas

- Except for very limited areas along the perennial section of the Middle Fork of Lost Man Creek, thinning will not occur within 500 feet (each side) of perennial streams. In addition, ground based heavy equipment not will operate within 500 feet of a perennial stream, and cable yarding and associated cable yarding corridors will not occur within 500 feet of a perennial stream.

- For intermittent and ephemeral streams on slopes less than or equal to 30 percent, streamside protection zones will be a minimum 50 feet wide or to the break-in-slope, whichever distance is greater. Heavy equipment will not enter streamside protection zones. Thinning treatments will retain at least 60 percent post-treatment tree canopy. For intermittent and ephemeral streams on steeper (31 to 45 percent) slopes, streamside protection zones will be at least 100 feet wide or to the break-in-slope, whichever distance is greater. Thinning treatments will retain at least 70 percent post-treatment tree canopy.
- All trees cable yarded from intermittent and ephemeral streamside protection zones will be lifted clear of the ground to prevent nicking the ground before being yarded uphill.
- Cable yarding corridors that cross intermittent or ephemeral streams will be approximately 10 feet wide and all trees will be "flown" (i.e., fully suspended in the air) through streamside protection zones of intermittent and ephemeral streams.
- Trees that are felled within streamside protection zones will be lopped to get them in contact with the ground and left on site.
- All streamside protection zones will be clearly marked by park staff on the ground.
- No trees will be felled into intermittent or ephemeral stream channels.
- No trees that contribute to stream bank: stability (as determined and marked by park staff) will be felled.
- Equipment will not operate in, or cross swale features, where slope steepness is greater than 30 percent. Such features will be marked by park staff on the ground.
- All trees will be retained on unstable and potentially unstable areas, regardless of slope steepness and within the 50-foot-wide zone that surrounds the feature. A "Shalstab" slope stability analysis has been conducted to aid park staff in identifying unstable and potentially unstable areas. Park staff overseeing contracted logging crews will identify and mark such unstable and potentially unstable areas on the ground.
- All equipment, including hand tools, heavy equipment, and cable yarding equipment, will be inspected daily to check for leaks. Equipment that may leak lubricants or fuels into a stream will not be used until leaks are repaired. All equipment will be stored, serviced and fueled outside of riparian areas and away from stream crossings. A spill plan and materials for spill containment will be available to onsite personnel and all personnel will be trained in spill containment. In the event of a spill, work will be stopped immediately, clean-up will begin and the appropriate authorities will be notified.

Cumulative Effects on Water Resources, including Water Quality, Floodplains, and Wetlands
The cumulative adverse effects on hydrology, water quality, floodplains and wetlands in and around the project area, including Lost Man Creek and Redwood Creek, are related to past logging and road building practices, both within what is now the national park and upstream of current park boundaries. These practices are no longer allowed under current state law and regulations because of the damage caused to watersheds.

Because the project area watershed is now protected in the national park, future actions that would affect water quality are related to park resource management projects, especially watershed restoration projects that mitigate effects of past land use practices.

The project area is located within the Lost Man Creek watershed. Implementation of the Lost Man Creek watershed restoration project began in 1999 and was completed in 2010. Restoration would have a moderate long-term benefit to the water quality of Lost Man Creek. The effect of watershed restoration in the Lost Man Creek watershed would be a benefit to the water quality in Redwood Creek but the benefit would be negligible to minor because Lost Man Creek enters Redwood Creek very low in the watershed, and restoration in Lost Man Creek would not improve hydrological conditions or water quality in Redwood Creek upstream of its confluence with Prairie Creek.

Watershed restoration in the Lost Man Creek watershed would have negligible to minor short-term and minor to moderate long-term benefits to the floodplain in lower reaches of Lost Man Creek and to Prairie Creek. As restoration is completed within and outside the parks, and new logging roads upstream of the parks are constructed, repaired, and maintained to standards in the current California Forest Practice Act, there would be a long-term moderate benefits to the floodplain of Redwood Creek. Watershed restoration in Lost Man Creek would have a negligible benefit to the Redwood Creek floodplain, because Lost Man Creek and Prairie Creek enter the Redwood Creek floodplain at a point where the floodplain is confined by flood control levees.

Riparian wetlands in the Middle Fork Lost Man Creek project area, along Redwood Creek, and in some of the more heavily logged tributaries of Redwood Creek have been destroyed or degraded by the original logging and road construction, and the effects of road failures and road-related slope failures. Riparian zones along the main stem of Lost Man Creek were not destroyed because the lower portion of the watershed was not logged, so the riparian zone in the lower reaches of the creek retained most of its original functions and values. The long-term effect on riparian wetlands in the project area from proposed management of second-growth forests would be a minor indirect benefit, but the greatest benefit to riparian wetlands relies on the effectiveness of watershed restoration at preventing erosion that would lead to landslides that could bury riparian areas and vegetation with sediment.

The isolated wetlands that form behind blocked culverts, filled stream channels, ditches with no outflow, and slumps in road fills are drained during watershed restoration. These ponds and puddles serve as breeding habitat for some amphibians, which are adversely affected by loss of this habitat. The overall effect on the forest ecosystem from loss of these isolated created wetlands is negligible because the wetlands are not an original component of the ecosystem and have very limited functions and values. The adverse effect from loss of these wetlands is negligible compared to the potential adverse effects of loss of stream functions, including riparian wetlands, in the event of road and stream crossing failures.

Conclusions: Effects on Water Resources, including Water Quality, Floodplains, and Wetlands
The no action alternative would have no additional direct effects on water resources in the Middle Fork Lost Man Creek, including water quality, floodplains, and riparian wetlands. Cumulative indirect effects from past logging and road construction would continue to adversely affect water quality and riparian wetlands if roads and unstable slopes fail and the eroded sediment enters streams. These adverse effects are both short-term and long-term and range from minor to moderate, depending on much erosion occurs and how close the erosion occurs to a perennial stream.

Under the proposed action, there would be no effects on floodplains. Direct adverse effects on water quality and riparian wetlands would be avoided by establishing streamside protection zones in which no cutting would be permitted and under the proposed action by prohibiting heavy equipment from operating in swales greater than 30% or channel features. Indirect adverse effects on water quality would be avoided by using thinning prescriptions that protect slopes from erosion and by prohibiting work during wet periods if work would increase the potential for soil erosion and slope failure. The short-term adverse effects on water quality and riparian wetlands under the proposed action would be negligible. There would be minor benefits to water quality and riparian wetlands in the project area over the very long term as forest structure recovers and additional roads are removed under the watershed restoration program.

Effects of the Alternatives on Vegetation

Estimates for pre-treatment and post-treatment stand characteristics are presented in Table 10. Estimates for the proposed action are based on the specific management where woody biomass would be removed.

TABLE 10. AVERAGE PRE-TREATMENT AND POST-TREATMENT STAND CHARACTERISTICS.

Stand Characteristic (average)	Pre-treatment (No action)	Crown Thin - 25% Reduction	Low Thin and Variable-Density Thin – 40% Reduction
All Species			
Stand basal area (ft^2/ac)	301	224	180
Live trees per acre	484	395	216
Size of standing live trees (dbh)	10.7	10.2	12.4
Trees cut per acre	-	89	268
Size of cut trees (dbh)	-	12.5	9.1
Douglas-fir			
Basal area (ft^2/ac)	160	88	50
Live trees per acre	242	160	26
Size of standing live trees (dbh)	11.0	10.1	18.6
Trees cut per acre	-	82	215
Size of cut trees (dbh)	-	12.7	9.7
Redwood			
Basal area (ft^2/ac)	80	80	80
Live trees per acre	79	79	79
Size of standing live trees (dbh)	13.6	13.6	13.6
Douglas-fir to Redwood Ratios (Means of Unit ratios) for live trees			
Basal area (ft^2/ac)	2.0	1.1	0.6
Trees per acre	3.1	2.0	0.3

Effects of No Action on Vegetation—Under the no action alternative, there would be no direct effects on second-growth forests or other vegetation in the project area from thinning. The growth rate for the second-growth trees would continue to be less than for trees in thinned stands of second-growth trees growing in areas with similar site potential. The second-growth forests would continue have significantly smaller trees at a significantly higher density than the original forest. Understory vegetation would remain suppressed, as sunlight is prevented from reaching the forest floor.

Under this alternative, recruitment of seedlings would remain suppressed, which would maintain uniform stand characteristics and even-aged conifer tree demographics. Without a large-scale disturbance, unmanaged growth would continue to promote uniform tree heights and simple crown architecture. Tree crowns would recede as the stand ages, reducing the live crown ratio and slowing the diameter growth rates of trees as competition for light, water, and soil nutrients increases. The high densities would increase the potential for disease and insect infestation. High densities would also result in large height-to-diameter ratios, which would increase the potential for large-scale windthrows in severe storms. The project area would remain dominated by Douglas-fir, or by tanoak, regardless of the original species composition.

The forest would persist in this condition for centuries, with forest openings occasionally created by trees falling, wildfire, or disease outbreaks. Trees in the vicinity of forest openings would grow faster and larger. This would be a negligible benefit to second-growth forests in the project area because only a few trees would grow larger and the species composition would continue to be predominately Douglas-fir.

In the long-term, Douglas-fir would retain its dominant position in the canopy for hundreds of years, delaying the return of a redwood forest type. Species such as Sitka spruce, not normally found in the project area, would persist in the stand. While not as long-lived as Douglas-fir, the exotic species may persist for several hundred years. Understory vegetation would eventually return as disturbances (windthrow, snowfall damage, insect infestations, fire, disease) create canopy gaps and allow for sunlight penetration to the forest floor. Over centuries, stands within the project area would eventually develop late-successional forest attributes but the future forest community would resemble a Douglas-fir-dominated old-growth ecosystem rather than the redwood-dominated ecosystem that existed prior to the original harvest. Under this alternative, the significant adverse effect to the redwood forest ecosystem would persist for centuries.

Effects of the Proposed Action on Forest Structure
Thinning would reduce overall stand densities, stimulate stand growth and development, release dominant trees, improve conditions for development of understory vegetation and canopy, improve stand resilience to stressors such as pathogens and climatic events, and increase the numbers of redwood relative to Douglas-fir.

Thinning would contribute to the overall benefit to the forest community over the long-term as the retained trees grow at a faster rate. The growth rate for individual trees would be greater under the proposed action because larger trees would be retained (thin from below) and the removal of more trees would promote faster growth of retained trees.

Thinning would enhance the development of understory vegetation because there would be more light reaching the forest floor via creation of canopy openings. This benefit would occur over several decades.

There would be no direct short-term effects on adjacent old-growth trees from proposed thinning in the old-growth buffer area. Over the long-term, 328 acres of old-growth forests would benefit from a reduced edge effects as the thinned forest grows in the 300-foot-wide buffer adjacent to the old-growth forest. The benefit would be negligible for several decades and would gradually increase to a minor benefit that would persist for several hundred years until the trees in the buffer zone reach a size and height similar to the old-growth. The benefit to the old-growth trees adjacent to the buffer would be moderate after the trees grow to a size similar to the adjacent old-growth. There would be a negligible benefit to old-growth trees or old-growth forest outside the buffer zone.

In project areas outside the old-growth buffer, residual old-growth trees would be protected by retaining second-growth trees within the dripline of an old-growth tree and by retaining second-growth trees within 50 feet of the dripline of an old-growth tree if the second-growth trees are of a height greater than the height of the lowest living limb on the residual tree. Where thinning is allowed near residual trees, they would be further protected by directionally felling trees away from their base to eliminate damage to limbs or trunks. Trees of outstanding character (deformed trees, large hardwoods, redwood stump sprouts) would be protected by also directionally felling trees away from their base. These techniques would have a minor to moderate benefit to the residual old-growth trees and trees of outstanding character.

Cut vegetation that is spread evenly over a site would act as mulch to retain soil moisture to encourage growth of understory vegetation.

Riparian vegetation would be protected by establishing streamside protection zones. This would be a long-term minor to moderate benefit to the riparian vegetation that has regrown following clearcutting and loss of riparian zones from past logging practices.

Effects of the Proposed Action on Forest Structure
The proposed action would reduce overall stand densities, stimulate stand growth and development, release dominant trees, improve conditions for development of understory vegetation and canopy, and increase the numbers of redwood relative to Douglas-fir. Under a crown thinning prescription, there would be fewer trees cut and forest recovery would occur more slowly. The long-term benefit in areas that are thinned under a low-intensity prescription would require more time to occur than in areas thinned under low thinning or variable-density thinning prescriptions. Under the proposed action, there would be a greater overall long-term benefit in less time on the areas that are thinned using low thinning or variable-density thinning thinning prescriptions because more trees would be cut, a greater number of canopy gaps would be created, and the remaining trees would grow at a faster rate.

Development of understory vegetation and canopy would be enhanced and would occur faster on areas treated with the low thinning or variable-density thinning prescriptions compared to the crown thinning prescription. This would be a moderate benefit on the moderately thinned areas within several decades of the thinning. Understory and canopy development would occur more slowly on the with the crown thinning prescription because there would be less light reaching the forest floor and the canopy openings would be smaller after thinning. This would be a minor benefit as it would take longer than compared to the effect on the moderately thinned areas. Overall there will be a minor to moderate benefit to understory vegetation and canopy development under this alternative.

Under the crown thinning prescription, an average of 89 trees per acre would be removed, and the canopy cover would be reduced by 25%. The resulting woody debris would be lopped and scattered on the forest floor at a depth not to exceed 24 inches to act as mulch to protect soil and to encourage growth of understory vegetation. Under the crown thinning prescription, second-growth trees larger than 18 inches and less than 20 inches dbh would be retained unless removal is required to meet the restoration target in a specific unit.

Development of understory vegetation and canopy would be enhanced under crown thinning compared to the no action alternative, but less than the areas under moderately-intensity thinning under the proposed action. The overall effect to understory vegetation and canopy development would be minor.

Effects on Fuels under the Proposed Action
Under the proposed action, smaller diameter trees would be thinned preferentially before larger diameter trees. All of the smallest diameter trees, up to 8 inches dbh, would be left on site to provide mulch for covering skid roads and landings disturbed during the removal of larger diameter trees. Fuel loadings from this alternative are expected to increase from under 10 tons per acre to approximately 16 tons per acre after thinning. These fuels would be spread continuously across the ground surface to prevent excessive buildup of fuels in any one location and promote faster decomposition.

Fire hazard would be reduced by leaving wood in contact with the ground to speed decomposition on 503 acres, and by spreading cut vegetation to a depth less than 24 inches. There would be a minor reduction in fire hazard under the moderately thinned areas because the boles of trees over 8 inches dbh would be removed.

Where crown thinning is conducted, fuel loadings are estimated to increase from under 10 tons per acre to 20–30 tons per acre after thinning. These fuels would be spread discontinuously across the project area. Additionally, this alternative would thin the larger diameter size class of trees preferentially ahead of smaller diameter trees. Trees with larger diameters and suppressed crowns would not produce a heavy loading of branch wood.

Fire hazard would temporarily increase under crown thinning but would be mitigated by leaving wood in contact with the ground to speed decomposition and by spreading all woody debris to a depth less than 24 inches. The increased fire hazard, created under this alternative, is expected to decrease substantially within 10 to 15 years after treatment.

Cumulative Effects on Vegetation and Forest Structure

Vegetation along roads and trails throughout the parks, including access roads in the project area, would be brushed under the regular maintenance program. This would be a localized but widespread adverse effect on vegetation that is repeated over the long-term. The adverse effect is negligible because the vegetation is common in the park and throughout the region, regrows quickly, and has already been significantly affected by logging and road construction.

Watershed restoration in the park requires removal of vegetation growing on and adjacent to old road fill and landings. Vegetation removed for watershed restoration has regrown after clearcut logging. Old-growth forest is not affected by watershed restoration projects. Residual old-growth and mature trees are not removed for watershed restoration. The vegetation removed in watershed restoration projects is used for mulch to promote the regrowth of native species and reduce the potential for importing non-native plants that would be present in mulch obtained offsite. There would be an indirect long-term benefit to vegetation from enhancing soil formation processes by recovering and repositioning buried topsoil, and a direct minor long-term benefit to vegetation from recovering the original seedbank in the topsoil. The overall effect on vegetation from the Lost Man Creek project and other watershed restoration projects would be adverse from removal of vegetation (short-term for annual plants and shrubs but longer-term for long-lived trees) but that effect would be negligible to minor because the original vegetation was already cleared for road construction and logged in the adjacent areas.

The 48,300 acres of previously clearcut second-growth forests in RNP that are not treated would remain in a degraded condition. Logged areas of the parks would continue to recover although the recovery in some dense second-growth stands that were not thinned after replanting would require centuries to reattain characteristics and functions associated with old-growth forest. This is a significant adverse effect on old-growth redwood forest communities that would continue for centuries.

Conclusions: Effects on Vegetation

Under the no action alternative, second-growth forests in the project area would remain in the present condition with high stand density, small diameter trees, single layer canopy, little understory, and species composition that does not reflect the original redwood dominance. In comparison to community structure and function in unlogged redwood forests, this would be a significant, long-term, adverse effect. Over centuries, stands within the project area would eventually develop late-successional forest attributes, but the future forest community would resemble a Douglas-fir-dominated old-growth ecosystem rather than the redwood-dominated ecosystem that existed prior to the original harvest.

Removing the boles of trees under biomass removal would mitigate the short-term increase in fire hazard caused by the increase in woody debris by thinning. The woody debris left from this alternative would be trees less than 8 inches dbh and the branchwood of trees larger than 8 inches dbh. The fire hazard in these treated areas would decrease within about 10 years, as the fuels would be left in contact with the ground to hasten decomposition. This would be a minor long-term benefit to the forest in the project area and would be a negligible benefit to forest stands outside the project area.

There would be no short-term adverse effects on old-growth forest or residual old-growth trees under the proposed action. Over the long-term, there would be a moderate benefit to old-growth forest community function in the contiguous old-growth stands from thinning adjacent forests. The benefit would not be realized for centuries until the thinned forest re-attains the structure of old-growth forest.

Under the proposed action, thinning would reduce overall stand densities to stimulate stand growth and development, to release dominant trees, to improve conditions for development of understory vegetation, and improve stand level representation of redwood. Short-term adverse effects on park forests from cutting trees would be negligible because the trees occur in unnaturally high stand densities, and are not representative of original forest species composition. The effect of thinning would be a negligible short-term adverse effect and a moderate long-term benefit in the project area. The cumulative benefit to park forests under the proposed action would be minor because of the treated area would be less than 1% of the second-growth forests in the park.

Under the crown thinning prescription there would be fewer trees cut but forest conditions would not be restored as quickly and thinning would not promote growth of remaining trees or canopy development as effectively as the low thinning or variable-density thinning prescriptions. The effect of thinning under the proposed action would be a negligible short-term adverse effect with a minor long-term benefit. The benefit to park forests where crown thinning is conducted would be less than under a low thinning or variable-density thinning prescriptions.

Effects of the Alternatives on Wildlife and Fish

Under the no action alternative, there would be negligible short-term adverse effects on terrestrial wildlife because there would be no disturbance from equipment and no removal of vegetation. Over the long-term (on the order of decades but less than centuries), the no action alternative would continue to adversely affect wildlife because the dense second-growth does not provide good quality wildlife habitat. The forest is too dense for most wildlife to move through, the trees are too small to provide nesting and sheltering habitat for most wildlife species, and the lack of understory and layered canopy does not offer sheltering habitat or adequate food resources, including food for small predators that feed on smaller animals.

No fish-bearing stream reaches would be directly affected under the proposed action. The potential for adverse effects to aquatic resources and indirect effects on downstream fish-bearing reaches from increased temperature due to thinning would be negligible due to the small size and extent of areas proposed for riparian thinning along perennial streams; the retention of 60% canopy cover to provide shade; the presence of topographic shading and steep stream gradient; and the project location within the zone of coastal influence.

Under the proposed action, the thinning operations would increase noise and disturbance during daylight hours. More mobile wildlife species that are not tolerant of noise and human presence and that have home ranges larger than an operation area would move out of the area temporarily. Individuals of some small wildlife species, such as salamanders and shrews, would be killed either directly, by loss of shelter, or because their territories become uninhabitable and they cannot relocate to a new territory fast enough for survival.

In the old-growth buffer areas, the thinning prescription would maintain sufficient canopy cover to prevent rapid shrub proliferation and minimize the creation of food resources for corvids. Minimizing the corvid population would decrease the predation risk to nesting birds and small mammals.

The woody debris left on the ground after thinning provides habitat for seedlings, fungi, microorganisms, insects, amphibians, and small mammals. Larger pieces of wood provide shelter for small animals. These benefits would continue to improve habitat as the remaining trees grow larger, understory vegetation increases, and the canopy layers develop.

Thinning under the proposed action would improve wildlife habitat immediately by creating openings in the canopy and reducing stand density that would allow wildlife to move within the forest. Within two to three years, understory vegetation that provides shelter and food for small wildlife would increase.

Trees of outstanding character (deformed trees, large hardwoods, redwood stump sprouts) would be protected by directionally felling trees away from their base. These techniques would have a minor to moderate indirect benefit to wildlife that use such trees for nesting.

Over the long-term, the height differential between the second-growth and old-growth forests would be reduced, reducing edge effects on wildlife such as increased predation threat and microclimate changes.

Cumulative Effects on Wildlife and Fish

The effects on terrestrial wildlife from clearcut logging in what is now the park were localized on individual animals but widespread throughout timber harvest areas, and were generally adverse from loss of vegetation used for shelter and food over the short-term. Small, more sedentary animals were more affected than larger, more mobile animals such as birds and medium to large mammals because these animals could move out of an area when logging occurred. As forests regrew, some species such as deer, elk, and bear benefited from new browse. Populations of bear and elk probably increased as logged forests regrew because of the increased availability of some types of food resources such as shrubs favored by bears and elk for browse. Overall adverse effects on populations of terrestrial wildlife in the project area were negligible to major depending on the degree of mobility and whether a species favored old-growth habitats or could survive in logged areas. Effects on animals that are considered to be old-growth specialists are discussed under the threatened and endangered species section. Widespread loss of old-growth habitat to logging and development, reduced populations of some species leading some to be listed as threatened. Adverse effects on aquatic species, especially fish, following logging were more substantial than on terrestrial species because of major sediment deposition into streams and widespread loss of forest cover that caused higher stream temperatures. The overall initial effect on aquatic species was adverse, widespread over timber harvest areas and moderate to major, with aquatic species populations in smaller streams subject to greater adverse effects because the entire stream was damaged.

Outside the project area, adverse effects on wildlife populations from decreased habitat quality in unmanaged second-growth forests would continue over the very long-term until forests recover.

Conclusions: Effects on Wildlife and Fish

The adverse effects on wildlife populations under the no action alternative are gradually lessening but will persist for centuries as the forest recovers. Large tracts of unmanaged second-growth in the project area and throughout the park would continue to be poor quality wildlife habitat for many decades. The logging that occurred in the project area prior to park establishment and expansion had significant adverse effects on some terrestrial and most aquatic animal species. Small terrestrial animals that are less mobile were directly affected by logging by direct mortality and loss of shelter or territories. More mobile wildlife species were indirectly affected by widespread loss of forest habitat and damage to streams. Aquatic species were directly affected where stream channels were blocked with poorly constructed or inadequate drainage structures and indirectly affected by loss of shade when the forest canopy was removed and by sedimentation of streams from landslides and erosion from bare slopes. The adverse effects of sedimentation continued after forest vegetation regrew. Several species that suffered major population declines from loss of forest habitat due to logging throughout their range were listed as threatened under the federal or California endangered species acts.

Short-term effects on wildlife during project operations would be negligible to minor, depending on the species tolerance to disturbance and ability to move out of the project area. Adverse effects on individual animals would be significant for those individuals that are killed during project operations but direct effects on any population in the project area would be negligible because there is similar second-growth habitat throughout the parks and the second-growth habitat that would be affected by project work is of poor quality.

Long-term benefits on wildlife would be greatest in the moderately-thinned areas under the proposed action and in the old-growth buffer. These benefits would be minor initially and would increase to moderate as the forest structure is restored by development of the forest understory and canopy.

Effects of the Alternatives on Sensitive, Threatened and Endangered Species

One CNPS list 2 plant species is present in the project area. The plants will be protected to the greatest extent practicable. Trees will be directionally felled away from known locations. A population of bear grass occurs along Holter Ridge Road, which is used for access to the project area. This population is considered an ethnographic resource and is protected. There are no other sensitive plant species known to occur within the project area that would be affected by management of second-growth forests.

No fish-bearing stream reaches would be directly affected by the proposed action. The NPS determined that this project may affect but is not likely to adversely affect listed fish species or their respective critical habitats, based on the design and timing of the proposed action (NPS 2012). The project has the potential for adverse effects to Essential Fish Habitat from ground disturbing activities causing a small and temporary increase in turbidity, from the risk of petroleum products entering the stream network, and from minor and localized increases in stream temperature. The project would have limited effects to designated critical habitat from 1) ground disturbing activities causing a negligible increase in turbidity; 2) riparian thinning causing a negligible potential for increase in stream temperatures; and 3) the small possibility of petroleum products entering the stream network and decreasing water quality. The likelihood of sediment entering the stream network is low and the amount of sediment would be small. The likelihood of small amounts of petroleum products entering the stream network is also low. Areas

proposed for riparian thinning along streams with water present during the summer are very limited in size and extent, and sufficient riparian canopy would be retained so that any increase in stream temperatures would be minor and localized.
The project has the potential to affect northern spotted owls and marbled murrelets. No other listed or proposed species would be affected. Potential effects on the Pacific fisher, a federal candidate for listing, would be similar to the effects on northern spotted owls because the fisher occupies forest habitat that is also occupied by northern spotted owls.

The NPS determined, and the USFWS concurred, that the proposed action may affect but is not likely to adversely affect northern spotted owls or marbled murrelets. There would be no adverse effects to northern spotted owls because no nesting habitat would be removed; forest stands that remain after treatment would have 60% canopy cover of trees greater than 11 inches dbh and a basal area greater than 100 ft^2 per acre of trees greater than 11 inches dbh; there would be no noise disturbance during nesting season; and barred owls are likely to be present in the only activity center formerly occupied by spotted owls.

Long-term benefits to northern spotted owls would occur more quickly than long-term benefits to marbled murrelets because owls are able to occupy advanced second-growth forest for nesting and foraging but marbled murrelets require old-growth habitat for nesting that will take centuries to develop. The long-term survival of spotted owls in the project area is uncertain due to the expansion of barred owls into the activity center formerly occupied by spotted owls.

Cumulative Effects on Sensitive, Threatened and Endangered Species
The action area borders private industrial timber land on its eastern edge along Holter Ridge. Timber harvest has occurred in the recent years on this private land and is likely to continue in the future. Spotted owls and/or marbled murrelets that nest in habitat in the Lost Man Creek watershed near Holter Ridge Road would continue to be subject to increased noise disturbance from heavy equipment being operated on private lands, from helicopter logging that has occurred on private lands near the ridge top in the past few years, or from increased predation threat.

Cumulative effects on northern spotted owls would result from continued loss of suitable habitat over their range due to development, commercial logging, and from increasing competition with barred owls, which are expanding their range and are considered to constitute the most imminent threat to the recovery and continued survival of northern spotted owl populations.

Other actions throughout the parks that have the potential to affect listed species include watershed restoration, fire management, invasive plant control, facility construction and maintenance, and visitor use. Facility maintenance would have negligible short-term adverse effects on listed fish and their designated critical habitat from increased potential for erosion from disturbed soils.

Marbled murrelets are likely to be indirectly adversely affected by an increased nest predation threat from visitor and staff use of trails, trailheads, other park developments, and dispersed use areas because visitors inadvertently leave food scraps or feed wildlife in or near suitable habitat areas, thereby attracting potential predators. This threat of increased nest predation is greatest in campgrounds in Prairie Creek and Jedediah Smith Redwoods State Parks. Marbled murrelets are also likely to be directly adversely affected by disturbance of suitable habitat caused by visitor and staff vehicles traveling on existing RNP roads.

The total allowable incidental take authorized by the USFWS for marbled murrelets for all park operations conducted in 2012 is 2,632 acres of suitable habitat potentially affected by noise disturbance. Approximately 10,544 acres of suitable marbled murrelet habitat were subjected to an increased predation threat due to park operations and/or park visitor use. Projects for which take of murrelets due to noise disturbance was reported in 2012 were brushing trails, installing temporary bridges, campground maintenance, and visitor use of trails, trailheads, and campgrounds.

Northern spotted owls are likely to be adversely affected through the potential disturbance of suitable nesting habitat due to noise disturbance. The total allowable incidental take for northern spotted owls authorized by the USFWS for all park projects and operations conducted in 2012 is 2,160 acres of potentially suitable habitat potentially affected by noise disturbance for brushing trails, installing temporary bridges, and use of trails, trailheads, and other park facilities.

Fish stocks throughout the Pacific Northwest region are threatened by the cumulative impacts of livestock use, road construction, timber harvest, stream channelization, water diversions, hydroelectric development, overfishing, and the influence of hatchery fish on both disease resistance and genetic fitness of native stocks (USDC 1997).

Other on-going and reasonably foreseeable projects for which the NPS has prepared biological assessments and completed consultations with NOAA Fisheries for potential effects to listed fish species throughout the parks include annual and periodic road maintenance (NOAA Fisheries biological opinion and letter of concurrence 151422SWR02AR6347, March 2003) and fire management (NOAA Fisheries biological opinion and LOC 151422SWR04AR99149:BW, January 2005). The NPS requested incidental take for CC Chinook salmon, SONCC coho salmon, and NC steelhead under the NPS biological assessment prepared in 2003 for the Annual and Periodic Road Maintenance program, and the 2006 addendum. NOAA Fisheries authorized an unquantified amount of take based on miles of stream affected under a biological opinion and letter of concurrence 151422SWR02AR66347 issued in March 2003. The NPS also reported incidental and direct take of juvenile salmonids under an ESA 4(d) permit related to long-term studies of fish distribution and abundance in Redwood National and State Parks.

Conclusions: Effects on Sensitive, Threatened and Endangered Species
Based on the design and timing of the proposed actions, the proposed action is not likely to adversely affect SONCC coho salmon, CC Chinook salmon, NC steelhead trout and their respective critical habitats. The project contains adequate measures to avoid, minimize, mitigate, or otherwise offset adverse effects to EFH. Therefore, the effects to listed fish, critical habitat, and EFH from the project are expected to be negligible.

The proposed action may affect but is not likely to adversely affect northern spotted owls. Owls have not been observed to occupy a known activity center since 2002 and barred owls occupy the entire action area. No spotted owl nesting habitat would be removed and forest stands remaining after treatment would contain suitable nesting/roosting habitat. Short-term adverse effects on owls from noise and disturbance would be avoided by implementing seasonal noise restriction periods. The short-term adverse effects on northern spotted owls would be negligible.

The difference between the low thinning or variable-density thinning and the crown thinning prescriptions is a greater long-term benefit to owls from the low thinning or variable-density thinning due to greater habitat improvement in a shorter time. There would be a long-term minor benefit to owls from habitat improvement with a potential for a long-term benefit from habitat improvement in stands treated with low thinning or variable-density thinning.

The proposed action may affect but is not likely to adversely affect marbled murrelets. The proposed action would not directly affect marbled murrelets. No murrelet nesting habitat would be removed. Noise disturbance would be minimized by implementing seasonal noise restrictions. Thus, short-term indirect adverse effects on marbled murrelets would be negligible. Over the long-term (decades to centuries), the proposed action would accelerate development of late-successional forest structure and murrelet habitat which would increase the amount, quality, and distribution of murrelet habitat. Improving stand characteristics in second-growth forest would increase murrelet reproductive success by reducing edge effects along the old-growth forest, increasing quality of habitat in residual stands, and reducing potential for nest predation. These long-term indirect benefits to murrelets would be moderate adjacent to and within the project area, and negligible for murrelets elsewhere in the park.

Effects of the Alternatives on Cultural Resources

Effects on Cultural Resources under the No Action Alternative— Under the no action alternative, second-growth forests in the Middle Fork of Lost Man Creek watershed would not be treated or manipulated with silvicultural techniques to reduce stand density or alter species composition. Existing stand conditions and stand development processes would be allowed to progress under natural disturbance regimes. Forest and fuels monitoring in the Middle Fork of Lost Man Creek would continue. Therefore, no impacts to cultural resources would occur under the no action alternative for second-growth forest restoration. However, indirect effects of leaving stands untreated could result in increased long term adverse impacts if fire were to occur in these untreated stands. Under the definitions and regulations for implementing Section 106 NHPA, no historic properties would be affected by the no action alternative.

Effects on Cultural Resources under the Proposed Action—Under the proposed action, heavy equipment would be used for biomass removal. Since heavy equipment use is proposed, ground disturbance is likely that could affect historic properties. Heavy equipment would be used to remove logs from the treatment areas. Access to these units would be on existing maintained roads or on existing skid roads.

This project area overlaps with a larger Bald Hills/Holter Ridge Traditional Cultural Property (TCP) as defined by the Yurok Tribe as being eligible for listing in the National Register of Historic Places (Clayburn 2012). Documentation for this TCP is in-process under separate agreement with the Yurok Tribe, so its boundaries, contributing and non-contributing features, and integrity are not fully defined against the criteria of the National Register of Historic Places. In consultation with the Yurok Tribe, who ascribes significance to this TCP, there would be no adverse effect to the TCP. This is because forest restoration is consistent with Yurok values, such that the condition of the TCP would be improved from the proposed action (Clayburn 2012).

Through archival research and consultation no specific gathering resources were identified in the Project area, however there are resource gathering areas known by Yurok in the greater Lost Man Creek watershed (Clayburn 2012).

In consultation with the Yurok Tribe, the NPS found that the proposed action would have no adverse effect to historic properties in accordance with 36 CFR 800. The SHPO concurred on September 27, 2013 (reference NPS_2013_0227_002) with the NPS finding that the proposed action would have no effect on historic properties.

Continued use and maintenance of existing access roads would result in negligible to minor adverse impacts to cultural resources.

Cumulative Effects on Cultural Resources—Cultural resources throughout the remainder of the park would be unaffected by the proposed action. Fire suppression activities might affect the cultural resources in the project area.

Conclusions: Effects on Cultural Resources—Although important cultural resources may occur in the vicinity of the Lost Man Creek watershed, the proposed action would have negligible to minor adverse effects on as yet unknown cultural resources, these effects would be highly localized, and the effect would not be considered severe. In addition, activities undertaken under the proposed action would not change the treatment and management of archeological resources or other historic properties.

Effects of the Alternatives on Visitor Experience and Scenic Quality

Visitor use in the project area is limited to bicycle use of the Holter Ridge Bike Trail bordering the eastern edge of the project area. Under the no action alternative, the scenic quality of the project area would remain low due to past clear-cut logging and existing dense second-growth forest. There would be no effect on scenic quality of the existing old-growth forest adjacent to the project area. Under the proposed action, scenic quality would be affected initially during thinning operations but the adverse effect would be negligible because the existing dense second-growth is already unattractive to most park visitors. Under the proposed action, scenic quality would improve over decades, as thinned forests develop diverse understory vegetation and the forest canopy stratifies. The project area would not be considered highly scenic for centuries, compared to unlogged old-growth forest. In addition, private timberlands bordering the project area will continue to be subject to forest management activities. The Holter Ridge Bike Trail bordering the eastern edge of the project area would be used to remove logs under the proposed action and might be temporarily closed for visitor safety.

Cumulative Effects on Visitor Experience and Scenic Quality

Visitor experience and scenic resources in the park outside the project area would continue to be high quality in unlogged forests, in the prairies and oak woodlands, and along the coast. Other reasonably foreseeable actions that would improve the visitor experience in RNP include construction of new trails throughout the parks and development of visitor facilities in the Mill Creek watershed in Del Norte Coast Redwoods State Park.

Scenic qualities in the dense unmanaged second-growth forests outside the project area would continue to be degraded from poor stand conditions. Scenic quality of long-distance views in the clearcut areas of the park is improving as the forest develops but the poor scenic quality from close-up views will continue for centuries.

Conclusions: Effects on Visitor Experience and Scenic Quality

There would be negligible effects on visitor experience in the project area under including the proposed action and the no action alternative.

Under the no action alternative, scenic quality would continue to be low in the unthinned forest both within and outside the project area. The effect on long-distance views is minor to significant, depending on a visitor's perception and attitude toward logged forest in comparison to old-growth forest.

Under the proposed action, there would be a short-term decrease in visual quality during thinning operations but the overall effect on scenic quality would be negligible because the existing scenic quality is already low. Under the proposed action, scenic quality would improve as the thinned forest develops over the long-term. Under the proposed action, there would be a moderate benefit to scenic quality. The minor benefit to scenic quality from thinning would occur over a longer time than in the areas that are moderately thinned.

Effects of the Alternatives on Park Operations and Socioeconomics

Under the no action alternative, monitoring of second-growth forests would continue under current funding and personnel levels. This would include occasional experimental thinning projects on a small scale if funding becomes available. There would be no cost associated with planning or implementing a program to manage second-growth forests in the park.

Under the proposed action, there would be minor short-term impacts on park operations. Administrative functions would be needed, mostly related to the contracting. Vegetation management staff would spend time monitoring project implementation as the contracting officer's technical representative (COTR). Vegetation management staff would conduct post-treatment vegetation assessments to monitor short and long term results of thinning. The maintenance division may need to monitor road conditions on Holter Ridge and Geneva roads during the life of the project. Under the proposed action, there would be an increase in government spending, as contractors would be hired to implement the project. The estimated acre cost for implementing lop-and-scatter operations is $500 per acre. Under the proposed action, the estimated cost for implementing lop-and-scatter operations (450 acres) is $225,000. The excess merchantable biomass generated from the management units where ground-based operations (337 acres) and skyline operations (338 acres) would be used are expected to fully offset the cost of implementing the thinning operations in those units. However, if the current market value of the excess merchantable biomass does not cover the costs of implementing the ground-based operations and/or skyline operations, all or part of the combined 675 acres would be thinned using lop-and-scatter operations. These additional lop-and-scatter acres would add approximately $337,500 to the project cost. The total cost of implementing the proposed action is estimated to range from $225,000 for thinning on 450 acres to $562,500 for thinning on 1,125 acres.

Conclusions: Effects on Park Operations and Socioeconomics

Under the proposed action, there would be an economic benefit to the local economy from the sale of merchantable timber produced from 675 acres of biomass removal operations. The degree of benefit depends on the market value of timber at the time of production. There would be no benefit to the local economy under the no action alternative because this alternative does not provide local purchases of food, lodging, fuel or supplies or for sale of merchantable timber.

Under the action alternatives, normal park functions in existing divisions would be affected, but not beyond the scope and capabilities of the park to implement. Under the action alternatives, the socioeconomic environment of the park may benefit as dollars are expended via contracted services into the local economy.

LIST OF PREPARES

The following NPS personnel contributed to or were consulted in the preparation of this EA:

- David G. Anderson, Fishery Biologist
- Leonel Arguello, Supervisory Botanist
- Keith Bensen, Fish and Wildlife Biologist (ESA Section 7 consultations)
- Karin Anderson Grantham, Cultural Resource Program Manager (NHPA/Section 106, tribal consultations)
- Laura Julian, Biological Science Technician (Plants)
- Randy Klein, Hydrologist (retired)
- Aida Parkinson, Supervisory Environmental Specialist (NEPA)
- Scott Powell, Forestry Technician
- David Roemer, Chief, Resource Management and Science
- Stassia Samuels, Plant Ecologist
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- Kristin Schmidt, Wildlife Biologist
- Jason Teraoka, Forester (project leader)
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- Neal Youngblood, Geologist

The following were consulted in the preparation of this EA:

- Bill McIver, Wildlife Biologist, FWS, Arcata CA
- Leslie Wolff, Fisheries Biologist, NOAA Fisheries, Arcata CA

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Appendix A – Scoping Letter

United States Department of the Interior
California Department of Parks and Recreation
Redwood National and State Parks
1111 Second Street
Crescent City, California 95531

CALIFORNIA STATE PARKS

L7617 (MFLMC Second Growth Management)

November 18, 2011

Dear Friend of the Parks:

The National Park Service (NPS) is seeking your input on a proposal to use silvicultural techniques to accelerate recovery of 1048 acres of dense underdeveloped second growth forest in the Middle Fork Lost Man Creek (MFLMC). The MFLMC watershed, located north of Orick, regenerated after commercial timber harvest nearly 50 years ago to a dense, Douglas-fir dominated forest. The stands have been left untreated since that time. The purpose of this project is to reduce the time required for the restoration of conditions more typical of old growth redwood forests. The NPS is proposing to accelerate restoration of old growth forest conditions by thinning these second growth forests to reduce overall stem density and increase redwood dominance.

The NPS conducted similar silvicultural operations to restore forest stands and reduce impairment on about 1700 acres in the South Fork Lost Man Creek (SFLMC) area between 2009 and 2011. This project in the Middle Fork Lost Man Creek (MFLMC) would use similar treatments to accomplish the same objectives.

Specific short-term objectives of forest restoration in Lost Man Creek include:
- Stimulate growth and development of redwood or other desired conifers by reducing the number of stems per acre.
- Preferentially remove Douglas-fir to enhance redwood dominance
- Minimize excessive accumulation of ground fuel to reduce fire hazard.

General objectives and considerations include:
- Enhance forest structure and improve forest canopy development
- Enhance wildlife habitat
- Enhance aquatic systems and fish habitat
- Minimize soil erosion and impacts to aquatic systems
- Minimize attraction of avian nest predators such as jays and ravens near old growth forests

The SFLMC project treated 1493 acres to stimulate stand development with different prescriptions based on forest type and slope:
- Thinned 126 acres adjacent to old growth forests using lop-and-scatter
- Thinned 169 acres within tanoak dominated areas using lop-and-scatter
- Thinned 972 acres on steep slopes using lop-and-scatter
- Thinned 226 acres on gentle slopes and removed 2.5 million board-feet of woody biomass

The woody biomass generated by forest restoration on 226 acres was sold to the contractor to offset the cost of the restoration project to the government. The majority of trees removed for the SFLMC project were less than 16" dbh.

Page 1 of 4

Under the new proposal, the NPS would use the same suite of silvicultural treatments and forest operations used in the SFLMC project. We are also proposing to use variable density thinning (a silvicultural method) and cable yarding (a wood removal operation), which were not used in the SFLMC project.

Under the new proposal, the NPS would treat 1048 acres in MFLMC using standard silvicultural and forest operation methods:

- Thin 392 acres using a low thinning silvicultural method on 335 of the 392 acres; variable density thinning is proposed on 57 acres. Woody debris would be removed using ground-based yarding operations.
- Thin 242 acres using a low thinning silvicultural method. Woody debris would be removed using cable-yarding operations.
- Thin 414 acres using a crown thinning silvicultural method with lop-and-scatter operations and no woody debris removal.

We are soliciting input on this proposal from interested individuals, adjacent private landowners, organizations, and agencies to understand, address, and incorporate public views, issues, and concerns.

If you have any issues, new information, or input you believe should be considered in the environmental assessment that will be prepared for this forest restoration proposal, please send them in writing by January 2, 2012 to Steve Chaney, Superintendent, Redwood National and State Parks, 1111 Second Street, Crescent City, California 95531.

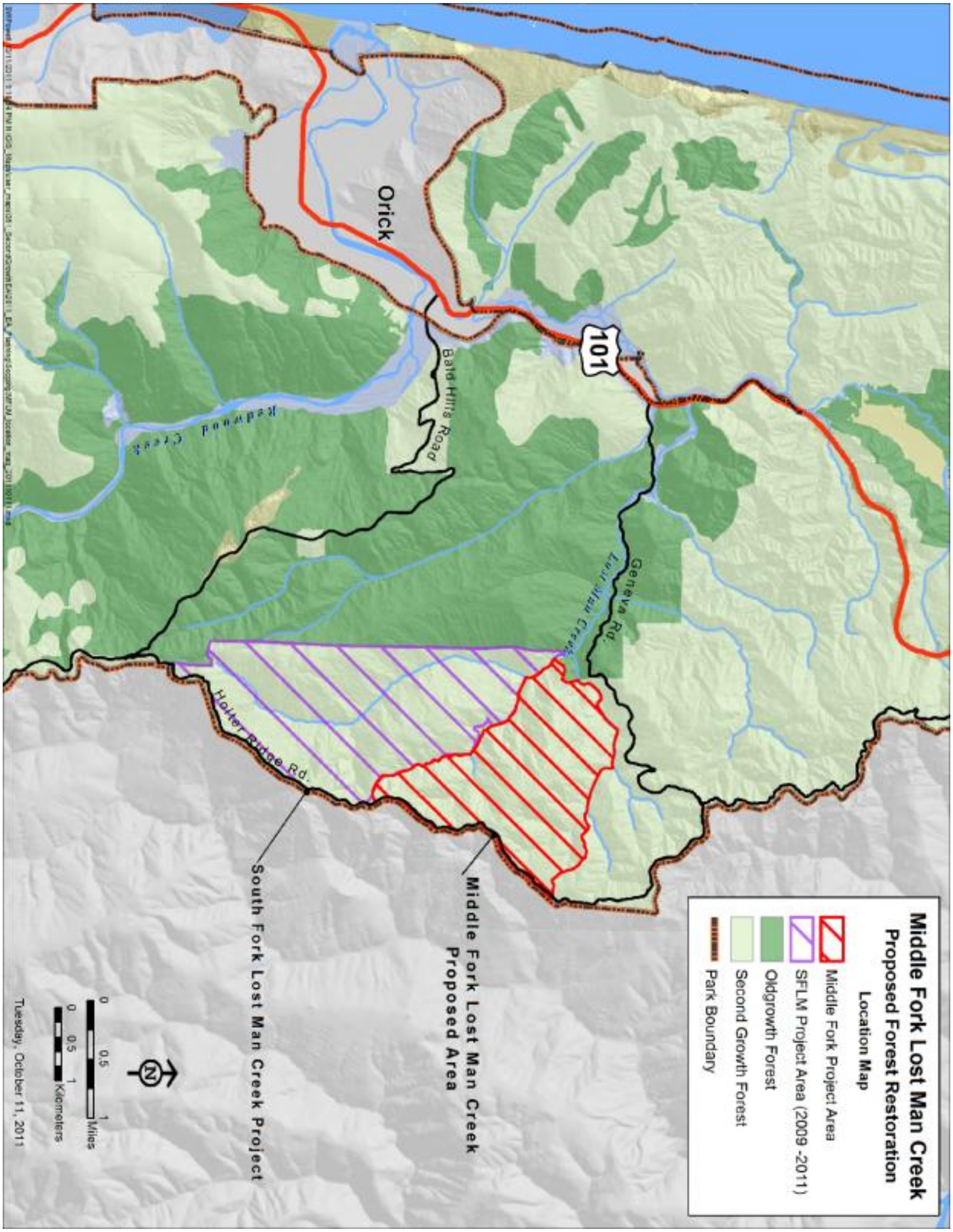
A public meeting will be held from 6:30pm – 8:30pm on December 13, 2011 at the Humboldt Area Foundation, located at 373 Indianola Road, Bayside, California 95524.

If you have further questions regarding this project, please contact Jason Teraoka at 707-465-7783 or via e-mail at Jason_Teraoka@nps.gov or visit the project home page at http://parkplanning.nps.gov and search under Redwood National Park for Middle Fork Lost Man Creek forest restoration.

Sincerely,

for Steve W. Chaney
National Park Superintendent

Enclosures
1) Map
2) Photographs: Before and After Second Growth Forest Restoration in Redwood NP


Middle Fork Lost Man Creek
Proposed Forest Restoration
Location Map
Middle Fork Project Area
SFLM Project Area (2009 -2011)
Oldgrowth Forest
Second Growth Forest
Park Boundary
Orick
101
Bald Hills Road
Redwood Creek
Geneva Rd.
Lost Man Creek
Holter Ridge Rd.
Middle Fork Lost Man Creek
Proposed Area
South Fork Lost Man Creek Project
0 0.5 1 Miles
0 0.5 1 Kilometers
Tuesday, October 11, 2011

Typical forest conditions at the South Fork of Lost Man Creek prior to treatment in 2009-2011 are similar to those in the proposed project area in the Middle Fork of Lost Man Creek. Forests are dominated by Douglas-fir with about 575 trees/acre and 300 ft^2 basal area/acre with very few redwoods and no understory vegetation (upper photos). High percent canopy cover creates intense competition for light (bottom left). Understory vegetation is limited to small patches (bottom right).

A stand after a lop-and-scatter crown thinning and a 25 percent reduction of the stand basal area to produce a stand basal area of about 225 ft^2/acre and about 490 trees/acre. This relatively light-intensity thin prescription preferentially removes a few dominant and co-dominant Douglas-fir trees to benefit an adjacent redwood tree of the same crown class. Cutting a few dominant or co-dominant trees results in the formation of small gaps (bottom photos) that allow the remaining trees to benefit from increased growing space while minimizing the fuel left on the ground.

After low thinning that reduced the stand basal area by 40 percent, stand basal area is about 180 ft^2/acre and about 300 trees/acre. This moderate-intensity thinning prescription preferentially cuts many Douglas-fir trees out of the lower crown classes to benefit redwood trees in the upper crown classes. Moderate-intensity thinning (left photos) creates much more available growing space. The biomass was removed from the site using old skid trails which are visible as linear openings in the forest (right). Skid trails were mulched using residual slash to reduce bare mineral soil.

Appendix B – Public Involvement

The EA, or a letter announcing its availability, has been made available or sent to local and regional offices of federal and state agencies, affected American Indian tribes, and local organizations listed below, in addition to individuals who have expressed an interest in similar park projects. Copies are available in local libraries, at park offices, and on the Internet on the NPS planning website (http://parkplanning.nps.gov/secondgrowth). The park has also issued a news release to its standard mailing list.

Federal Agencies
Bureau of Land Management, Arcata Resource Area, Arcata CA
U.S. Department of Agriculture, Forest Service, Six Rivers National Forest
U.S. Department of Agriculture, Forest Service, Southern Research Station
U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station
U.S. Department of Commerce, NOAA Fisheries, NMFS California Coastal Area Office, Arcata CA
U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata CA
U.S. Geological Service, Sacramento CA
U.S. Geological Service, Corvallis OR

United States Representatives
Congressman Jared Huffman (CA 2nd District)

State Agencies
CalFire, Fortuna CA
CalFire, Crescent City CA
California Department of Fish and Wildlife, Eureka CA
North Coast Regional Water Quality Control Board, Santa Rosa CA
North Coast Unified Air Quality District, Eureka CA

State Representatives
Assemblyman Wesley Chesbro

American Indian Tribes
Big Lagoon Rancheria
Elk Valley Rancheria
Hoopa Valley Tribe
Resighini Rancheria
Trinidad Rancheria
Yurok Tribe

County and Local Governments
City of Arcata
Del Norte County Board of Supervisors
Humboldt County Board of Supervisors
Humboldt County Public Works

Organizations and Businesses
Able Forestry
Audubon Society

Barnum Timber
Blue Ribbon Coalition
California Coastal Conservancy
California Native Plant Society
Del Norte Fire Safe Council
Environmental Protection Information Center
Ford Logging, Inc.
ForEverGreen Forestry
Friends of Del Norte
Great Tree Tenders
Green Diamond Resource Company
Humboldt Redwood Company
JRS Wood Salvage and Road Brushing
Klamath Chamber of Commerce
MacMullin Forestry and Logging
Mattole Restoration Council
National Park Conservation Association
Natural Resource Management Corporation
Northcoast Environmental Center
Northcoast Regional Land Trust
Orick Chamber of Commerce
Pacific Coast Fish, Wildlife and Wetland Restoration Association
Redwood Community Action Agency
Redwood Trails Resort
Save-The-Redwoods League
Sierra Club North Group
Sierra Pacific Industries
Siskiyou Project
Smith River Alliance
Stillwater Sciences, Inc.
Stoneman Forestry Service
The Nature Conservancy
Trees of Mystery
Western Lands Project
Western Timber
Z-Logging, LLC

<u>Universities</u>
California State University, Humboldt
University of Montana

<u>Libraries</u>
Del Norte County Public Library
Humboldt County Public Library, McKinleyville Branch
Humboldt County Library, Eureka Branch
Humboldt County Library, Arcata Branch
Humboldt State University Library

Appendix C – Glossary

Basal area (BA)—The cross-sectional area of a stem at *breast height* (see below) often expressed in square feet or meters. Stand basal area refers to the cross-sectional area of all stems in a stand measured at breast height and expressed in a unit of land area (i.e., square feet of basal area per acre or square meters of basal area per hectare).

Cable (or skyline) yarding operations—An operational logging method that uses a cable yarding machine, an overhead system of winch-driven cables, to pull logs or whole trees from the stump area to the landing or roadside area.

Crown Class—A category of tree based on its crown position relative to those of adjacent trees. Types of crown classes are as follows:

- Codominant- A tree whose crown helps to for the general level of the main canopy.
- Dominant- A tree whose crown extends above the general level of the main canopy.
- Intermediate- A tree whose crown extends into the lower portion of the main canopy.
- Suppressed- A tree whose crown is completely overtopped by one or more neighboring trees.

Cruise—A survey of a forest to sample the quantity, size, species, and quality of trees present, as well as to note terrain, soil conditions, drainage, and other data relevant to forest management.

Diameter at breast height (dbh)—The diameter of a tree at breast height (4½ feet above the ground) most often expressed in inches or centimeters. Average dbh of a stand is expressed as the diameter of the tree with the average basal area (quadratic mean diameter) rather than the average of all diameters in a stand (arithmetic mean diameter).

Differentiation—The divergence of growth patterns in individual trees due to the redistribution of growing space during stand development. Differentiation is manifest first as a divergence in diameter growth patterns, then in height, and leads to the formation of crown classes.

Even-aged—Descriptor of a stand having trees of approximately the same age, usually within a range of ten or twenty years, and normally a simple vertical structure.

Feller-buncher—A harvesting machine that cuts a tree with a shear or saw and carries one or more cut trees in its hydraulically operated arms as it moves to cut the next tree. It deposits small piles of cut trees on the ground to be transported by a skidder.

Ground-based operations—An operational logging method ground-based mechanized equipment (e.g., feller-buncher, skidder, harvester/processor) to fell trees and/or skid logs or whole trees from the stump area to the landing or roadside area

Harvester—A machine that falls trees and performs processing functions at the stump (see *Processor*).

Inventory—A set of objective sampling methods designed to quantify the spatial distribution, composition, and rates of change of resource parameters within specified levels of precision for the purposes of management.

Loader—A self-propelled machine with a grapple or tongs and a supporting structure designed to pick up and discharge trees or logs for the purpose of piling or loading.

Lop-and-scatter—A hand method of removing the upward-extending branches from tops of felled trees and bucking to keep slash low to the ground, to increase rate of decomposition, lower fire hazard, or as a pretreatment prior to burning.

MBF—Abbreviation for *thousand board feet*, used to measure volumes of timber or lumber which tend to be very large on forestry projects.

Processor— A machine that that performs two or more functions on a felled tree, including delimbing, debarking, bucking, measuring, or chipping (see *Harvester*).

Regeneration—Growth of seedlings and young trees below pole size, or to the establishment of such growth. Harvests or *regeneration cuttings* have, as a principal objective, the establishment of adequate regeneration of desirable species. Also called *reproduction*.

Silviculture—The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.

Skid—Method of transporting cut timber from the point of felling, limbing, and topping, to a landing for bucking into logs and loading onto a truck for removal from the forest. This is done along narrow, temporary trails by heavy equipment, i.e., skidders, bulldozers, etc.

Skidder— A self-propelled machine with, often articulated (hinged) in the center, for dragging trees or logs.

Slash—Waste from logging, including the tops and other unusable parts of trees.

Snag—A standing dead tree, generally of value for wildlife.

Stand—A section of forest having relatively uniform composition in regard to species, size structure, and density; distinguishable from other stands by attributes such as these. The stand is the basic unit of silviculture, since it is by stands that nearly all cultural treatments are prescribed. A stand type is the designation given one kind of stand within a particular classification system, and it normally consists of symbols referring to principal species, heights, and densities.

Stand Density—A quantitative measure that describes the degree of stem crowding within a stocked area. Absolute measures of stand density are often reported in terms of number of trees, basal area, or volume per unit area or relative to a standardized condition.

Thinning—A silvicultural treatment made to reduce stand density primarily to redistribute growing space and available resources, enhance forest health, or recover potential mortality.

Thinning from above (crown thinning)—A method of thinning that focuses on the removal of trees from the dominant or codominant crown classes to favor adjacent trees of the same crown class.

Thinning from below (low thinning)—Method of thinning that focuses on the removal of trees from the lower crown classes to favor trees in the upper crown classes.

Variable-density thinning—A method of thinning that focuses on the enhancement of spatial variability by varying the thinning intensity throughout the stand and inducing fine-scale variation in the forest canopy.

Yarder (and different types yoader)—A system of power-operated winches and a tower used to haul logs or trees from the stump area to a landing or roadside area.

Yoader—A loader that is converted into a small yarder (see *Yarder*).