Redwood
National Park

National Park Service
US Department of the Interior

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

Redwood National Park
Humboldt County, California
December 2008

Table of Contents

List of Figures

Page

List of Tables

Page

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 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. The NPS has not actively managed logged forests in what is now the park, which has resulted in second growth forest conditions considered unhealthy from both a silvicultural and ecological standpoint. 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 the technical 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 and repeated in the same stand ten years later (Stuart and Cussins 1994); and on 45 acres along the A972 Road on the west side of Redwood Creek in 2007. These projects were conducted by park vegetation management staff. The Bald Hills work was done as part of a graduate degree in forestry from Humboldt State University in Arcata. The results of these small-scale projects have shown that thinning promotes the growth of the remaining trees and development of both understory and a new cohort of trees.

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.

All of the South Fork of the Lost Man Creek watershed was intensively logged from the 1950s to the 1970s. Portions of the area were 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 1700 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 from 8 to 12” diameter at breast height (dbh) are typically dominant or co-dominant. Most of the trees are less than 24” dbh. Trees on which the branches have died on 70–80% of the trunk are common. 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 1700 acres in the South 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 restoration of forest characteristics more typical of late seral and old growth redwood forests in the park.

The regeneration methods used to re-initiate stands within the South Fork Lost Man Creek area were a mixes of natural reseeding augmented by aerial seeding and tree planting. Whether initiated by aerial seeding or by natural seeding from leave tree 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 19% of the trees in the South Fork Lost Man project area are coast redwood, while 45% are Douglas-fir. 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 were 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; Dagley and O'Hara 2004; Teraoka 2004; Chittick 2005).

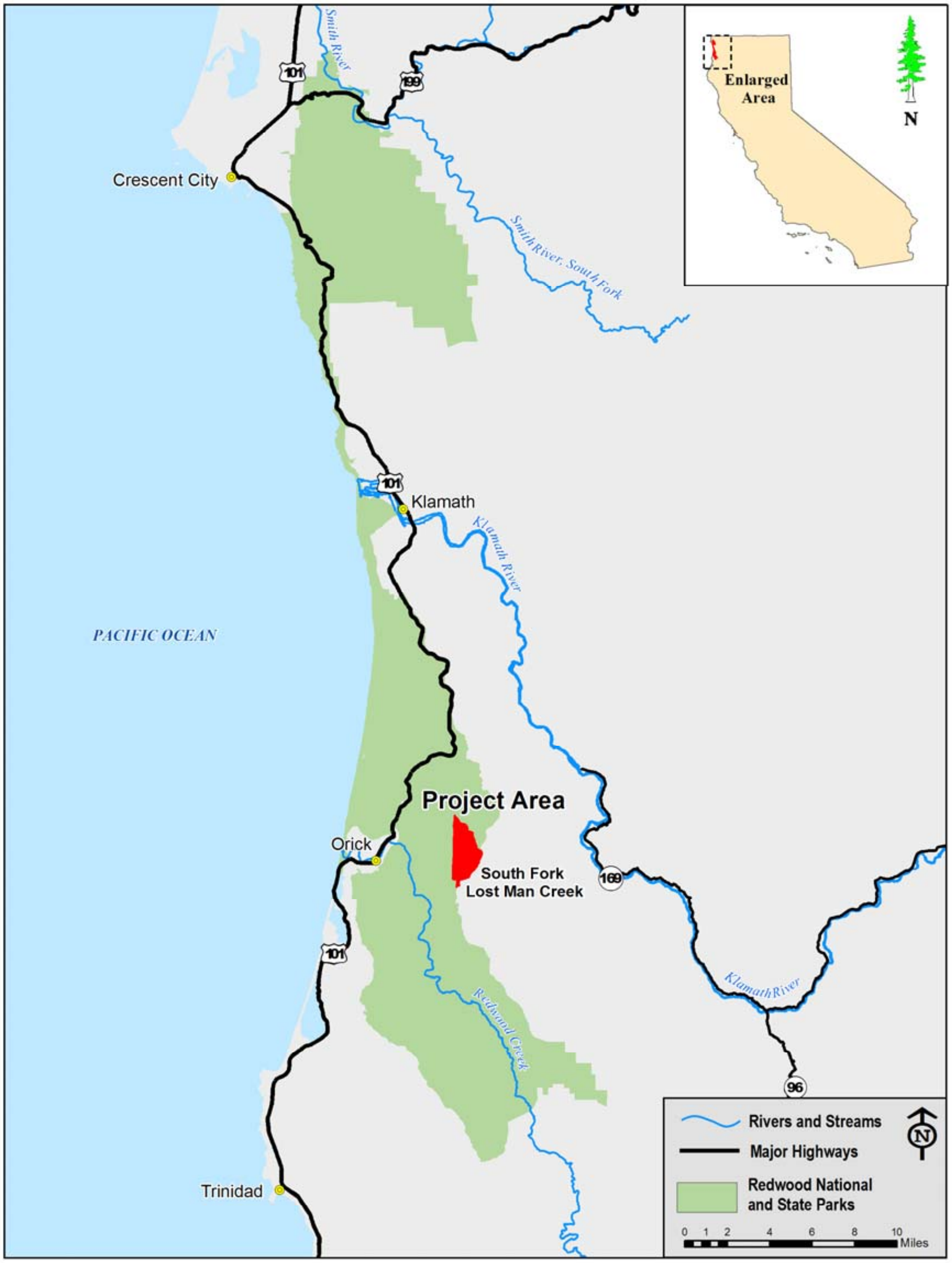
Along the ridges of the project area, tanoak that was cut has resprouted vigorously from the stumps. Tanoak dominates these stands in high densities, resulting in smaller diameter trees, little development of understory vegetation, and reduced space for conifer regeneration.

Although stands in the project area are approaching 50 years of age, the quality of wildlife habitat is considered low because of the high tree density and the general lack of understory vegetation. 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 different between the old growth and the unthinned second growth forests. Thinning the second growth forests along the edge of the old growth would reduce edge related environmental conditions in a relatively short time 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 natural disturbance regimes. The second growth forests in the project area are highly impaired, as measured by excessive tree density, lack of understory vegetation, and the overabundance of Douglas-fir in relation to redwood. To rely solely on natural disturbances to reduce the impairment would further 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 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 two alternatives 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.

Figure 1. General Location Map



Map 1. South Fork Lost Man Creek Second Growth Management Plan General Location Map

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 regulate use of 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 Management Policies (NPS 2006) 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.

NPS management policies relating to determination of impairment and unacceptable impacts are discussed in the Environmental Consequences section of this environmental assessment under applicable policies.

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 Servicewide 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.

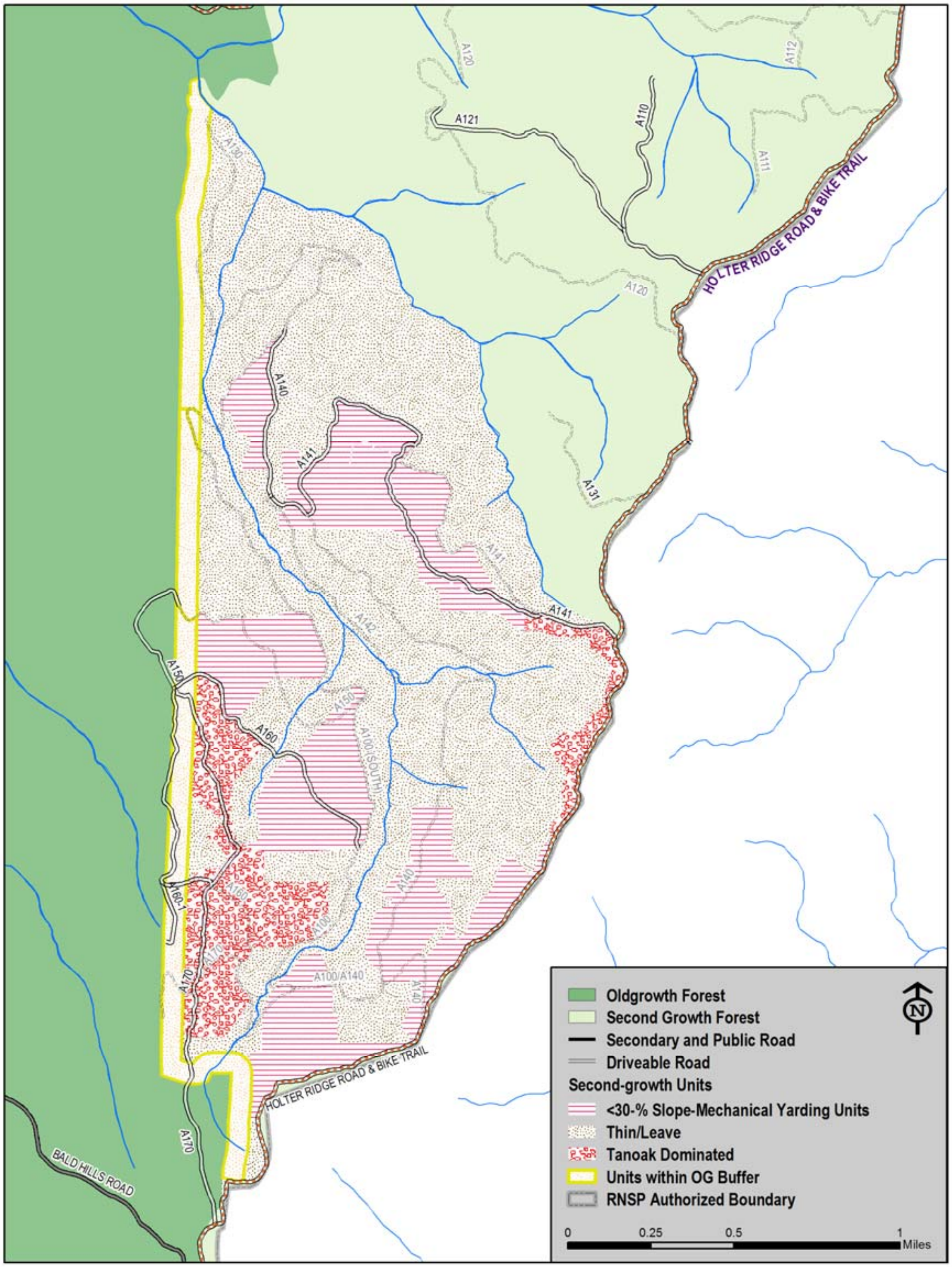
Natural system restoration is defined as the long-term process of assisting the recovery of disturbed areas and reintegrating the site into the surrounding natural system so that the area reaches a planned condition and, ultimately, returns to its former unimpaired condition. Restoration involves active 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.

Park General Management Plans — The natural resource management objective for second growth forest management described in the 1979 draft environmental statement for the GMP stated the NPS intent to thin second growth stands near areas used by visitors and on other lands as appropriate.

These natural resource management objectives were expanded in the resource management plans in 1982, 1984, 1986, and 1988 and subsequent updates from 1991 to 1999. 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 new 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 South 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 1999 GMP directed that forest restoration activities in the parks should emphasize use of silvicultural methods in second growth forests to reattain old growth characteristics in the shortest time possible.

Figure 2. Project Map



Map 2. South Fork Lost Man Creek Second Growth Management Plan
Second Growth Units

Management goals in the 1999 GMP that are relevant to forest restoration in the South 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 plot 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) and in a stand on the A-972 road on the west side of Redwood Creek. Park vegetation management staff are conducting long-term monitoring of thinning study areas.

Holter Ridge Study — 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 (Veirs 1986). 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’-12’ and 16’-18’), treatment of hardwoods (10’-12’ with hardwoods cut or included in spacing), or treatment of the slash (10’-12’ with slash lopped or not lopped). Size limits for trees cut were 18” dbh for redwood sprouts, 10” for free-standing redwoods, and 12” 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.

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" 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.

Whiskey-40 Study— 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 site was chosen because of the poor condition of the forest stand and its location along a highly traveled route for park visitors. The 30-year-old stand was densely stocked with small trees, had little understory or multi-layered canopy development, an overabundance of Douglas-fir, and exotic conifer species within 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 unit was clearcut in 1963, burned, and aerially seeded using local and offsite seed sources. This stand is primarily an even-aged forest, continuous canopy, and is in the stem exclusion phase of stand development. Species composition is heavily skewed towards Douglas-fir.

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" dbh would be removed, as well as any size Sitka spruce and Port-Orford-cedar, or any other exotic 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" 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" 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" dbh or greater.

In 2002, seven years after the first treatment, NPS forestry staff re-evaluated the plots. Although shrub and herbaceous understory had developed, and trees were beginning to regenerate, there was no appreciable increase in diameter or height of the remaining trees, and no canopy stratification. NPS staff concluded that the treatment failed to provide sufficient growing space for the remaining trees. Furthermore, a disproportionately high number of Douglas-fir remained on the treated area.

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 with a 30% basal area reduction of all species of

Figure 3. Location of Experimental Thinning Projects

Map 3. South Fork Lost Man Creek Second Growth Management Plan
Experimental Thin Sites, Redwood Creek Watershed

trees greater than 4.5" 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.

A-972 experimental thinning unit— The A-972 experimental thinning unit covers 45 acres between the West Side Access Road and the A-972 Road. This study was developed to investigate the growth and development of mixed-species second growth stands under different single-entry, density management treatments.

The stand was clearcut in 1968. The stand currently has primarily an even-aged, continuous canopy, and is in the stem exclusion phase of stand development. The regeneration method is unknown, but the stand appears to have either been aerially seeded or naturally regenerated. Species composition is heavily skewed towards Douglas-fir, mixed with redwood, Sitka spruce and red alder. Understory vegetation is nearly absent except for occasional small pockets of sword fern and salal.

The objectives of the A-972 study are to determine how initial stand densities in mixed-species second growth redwood stands affect forest structure and composition under a single-entry thinning treatment. Characteristics of forest structure and composition being measured include changes over time in

- tree sizes, tree vigor, stand differentiation and tree growth-to-stand density ratios;
- development of understory vegetation;
- rates of canopy closure, canopy stratification, and canopy competition; and
- fuel loading.

The treatments are designed to include a wide range of initial stand densities to monitor subsequent stand development. Prescriptions call for two thinning methods—low intensity thinning (thinning from below) and crown thinning (thinning from above)—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. Red alder was preferentially cut.

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.

Relationship of Second Growth Management to Current Park Projects

The NPS is undertaking several resource management projects in the vicinity of the proposed second growth management project. Proposals for second growth management have been coordinated with watershed restoration and fire management to provide road access needed for long-term protection of resources.

Lost Man Creek Watershed Restoration
Watershed restoration in the Lost Man Creek area is being 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).

Part of the Lost Man Creek restoration overlaps the project area for management of second Part of the Lost Man Creek restoration overlaps the project area for management of second growth forests described in this plan. Portions of the Holter Ridge, A170, A160, A140, and A141 roads would be used for project access under the proposed action for second growth management. Under the watershed restoration project, portions of the A170, A160, A140, and A141 roads used for second growth management will be completely removed by 2010; however, ridgeline portions of the A170, A160, and A141 will be retained for access for fire management.

Fire Management Plan
The 2004 Redwood National and State Parks Fire Management Plan (NPS 2004) describes how wildfire and fuels are managed to protect park resources. In the South Fork of Lost Man Creek, all wildfires are suppressed immediately. The FMP also covers use of prescribed fire to achieve specific resource management objectives. The current FMP does not call for prescribed fire as a primary tool for management of second growth forests. The FMP will be revised in 2009. The full suppression strategy for second growth forests in the South Fork of Lost Man Creek is expected to be carried over in the revised plan.

Under the 2005 FMP, a shaded fuel break at a maximum width of 100 feet is being constructed on both sides of Holter Ridge Road. The prescriptions for management of second growth forest in the vicinity of Holter Ridge would not encroach into the shaded fuel break.

Public Involvement for Second Growth Management
The NPS sent letters to 146 agencies, organizations, and individuals in June 2005, soliciting comments on the proposal to restore second growth forests in the South Fork of the Lost Man Creek watershed. Letters were sent to Hoopa Valley Tribe, Yurok Valley Tribe, Trinidad Rancheria, Resighini Rancheria, Big Lagoon Rancheria, Elk Valley Rancheria, Tolowa Nation, and the Smith River Rancheria. Two tribal meetings were held on April 13 and June 14, 2005 in Orick. One agency scoping meeting was held on June 8, 2005 in Arcata. Three public meetings were held in Arcata, Orick, and Crescent City on June 28, 29, and 30, 2005 respectively. The NPS met regularly with the USFWS and NOAA Fisheries to incorporate threatened and endangered species protection measures as the project was developed.

Issues Raised During Scoping
The following issues were identified by NPS staff during project development:

- Wildland fire hazard in dense second growth.
- Fuel levels after thinning.
- Project access in relation to roads to be removed under watershed restoration program.
- Disposition of woody biomass, including legal authority to sell it to offset costs.
- Protection of sensitive wildlife, including threatened bird species and nesting migratory birds.

The following issues were raised during public scoping:

- Size of trees to be cut.
- Fuel loading as it relates to fire potential.
- Fuel loading as it relates to adjoining old growth.
- Retention of larger hardwood species
- Public perception that selling logs from a National Park is precedence setting (it is not).
- Keeping the wood on the ground after cutting versus removal.
- Pre and post-thin monitoring for vegetation and aquatic habitats.
- Wildlife (including aquatic systems) effects from thinning.
- Relationship of proposed plan to the park GMP.
- Diversity of overstory tree species post-thinning.
- Thinning prescription and intended effects versus likely effects.
- Road decommissioning program and effects on forest thinning proposals.
- Contracting with private entities from local sources.
- Contracting with Yurok tribe.
- Financial obligation of project too high compared to project benefits.

Consultation with Other Agencies

Endangered Species—Informal consultation on this project began during an agency scoping session in Arcata, California in June 8, 2005. The project was presented in more detail at an Interagency Consultation Team (ICT) on February 15, 2006. The ICT includes representatives from the National Park Service, the U.S. Fish and Wildlife Service Arcata Fish and Wildlife Office (USFWS) and the Arcata office of NOAA Fisheries who meet quarterly to discuss proposed projects and determine whether the 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, formal consultation was conducted with USFWS but not with NOAA Fisheries.

At quarterly ICT meetings between 2006 and 2007, NPS vegetation management staff presented information regarding variables such as number of trees proposed for cutting, specific prescriptions to be utilized, operational details related to removal of wood products off-site. 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 also 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 August 2, 2007 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 Biological Opinion (BO) file number 8-14-2004-2133 81331-2008-F-0027, dated December 18, 2007, which concurred with the NPS determination that the project may affect but is not likely to adversely affect the northern spotted owl. The USFWS concluded in its biological opinion that the proposed action is not likely to jeopardize the continued existence of the marbled murrelet.

The NPS requested, and the USFWS authorized, incidental take of marbled murrelets on 237 acres from harassment associated with operation of heavy equipment during one breeding season, and on an additional 30 acres during 3 breeding seasons (March 24 through September 15). During the breeding season, equipment operation will be restricted to a daily limited operating period (LOP) between 2 hours after sunrise and 2 hours before sunset.

The NPS determined that this project would not affect listed fish, and therefore consultation with NOAA Fisheries under section 7 of the Endangered Species Act would not be required. However, 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 "no effect" BA to NOAA Fisheries on October 3, 2007. Because a "no effect" determination does not require a BO, NOAA Fisheries did not prepare a concurrence response.

Cultural Resource Consultations—The National Historic Preservation Act of 1966 requires federal agencies to consult with the state historic preservation officer (SHPO) if an undertaking would have the potential to affect properties listed or eligible for listing on the National Register of Historic Places. The NPS notified the SHPO in November 2004 that an environmental assessment was being prepared and outlined the project. The NPS sent a subsequent letter to the SHPO in March 2006 seeking concurrence with the preliminary findings and recommendations for protecting historic properties in the project area, including two sites on Holter Ridge. The SHPO responded in April 2006 with concurrence that a finding of No Adverse Effect with conditions outlined in the NPS recommendations was appropriate for this project.

NPS policies require consultation with affected American Indian groups. Ethnographic interviews that were 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. Consultation with the Yurok Tribe Culture Committee occurred on August 26, 2005 and November 18, 2005 in the Klamath tribal office. Notes from these meetings are on file at the Yurok Culture Department. The initial consultation with the Yurok Tribe Culture Committee resulted in the recommendation to speak in detail with a Yurok elder who has knowledge of the history of trails and logging history of the area and a traditional Yurok basket maker with resource knowledge of the area, particularly a bear grass area close to the coast used by Yurok basket makers.

A post-survey consultation on the survey findings was conducted with the Yurok Tribe Culture Committee on November 18, 2005. The location of the bear grass site on Holter Ridge Road was shared with the committee and recommendations were sought for future management. The Yurok Tribe Culture Committee recommended that the bear grass site be protected and managed to enhance and improve the health of this site.

ALTERNATIVES

Two action alternatives using silvicultural thinning to restore logged and reseeded forests on 1700 acres in the South Fork of Lost Man Creek watershed are analyzed in this environmental assessment: Moderate Intensity Thinning with Biomass Removal (the proposed action and the environmentally preferred alternative) and Low Intensity Thinning. A no action alternative is also analyzed for comparison of existing conditions with action alternatives, 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 South 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, i.e. all second growth stands in the project area were established within 5–10 years of each other.
- Existing old growth forest stands developed under different ecological conditions and from different forest conditions than those found in dense, closed canopy stands characteristic 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 slowly under high density conditions in a highly competitive environment.
- Old growth trees initially grow fast (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.
- Low intensity thinning will affect canopy trees, leave more trees in the stand, cost less, will have no impact on the ground surface, and minimize fuel accumulation
- Moderate intensity thinning will maximize stand density reduction, significantly reduce Douglas-fir representation, cost more, impact ground surface via removal of woody debris, and minimize fuel accumulation
- Low intensity thinning will alter stand developmental trajectories more than no action but less than moderate intensity thinning
- Funding for forest restoration is limited.

The 1700-acre project area is bordered by old growth redwood forest to the west, private timberlands owned by Green Diamond Resource Company to the east, Bald Hills Road to the south, and Lost Man Creek to the north. The 40–50 year old project area has been divided into 26 management units based on road access, topography, and slope position (See Table 1).

Under all alternatives, including no action and the proposed action, wildfires would be managed under a full suppression strategy as described in the 2005 Fire Management Plan. No change is anticipated to the existing fire management program in the South Fork of Lost Man Creek under the next revision of the fire management plan, scheduled for release in 2009.

Silvicultural definitions—A treatment prescription refers to the numbers, size or location of trees to be cut and any special conditions. Thinning intensity refers to the stand density removed per unit area at any one time. Number of trees removed per acre is a simple count of individual trees regardless of size. The diameter of a tree is measured at breast height (dbh), which is the measurement of the outside bark diameter 4.5 ft above the forest floor. Volume of biomass refers to the boardfeet of merchantable wood. Thinning from above (crown thinning) is 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 intensity thinning) is a method of thinning that focuses on the removal of trees from the lower crown classes to favor trees in the upper crown classes. Refer to the glossary for additional definitions.

Silvicultural prescriptions—Five harvest prescriptions would be used under both action alternatives depending on slope, existing tree species composition, proximity to streams and proximity to contiguous old growth forest.

Under the proposed action (Alternative 2 - Moderate Intensity Thinning With Biomass Removal), the prescription calls for a basal area reduction of 40% from below on 361 acres on slopes up to 30%. Merchantable wood (trees large enough to sell to a mill for use as lumber or other product) would be removed to reduce the fuel loading and sold to offset the cost on these 361 acres. Under the proposed action, 503 acres of the project area, where the slope is greater than 30%, would be treated with a 25% basal area reduction from above and felled trees would be lopped and scattered.

Under Alternative 3 - Low Intensity Thinning, 864 acres would be treated with a 25% basal area reduction prescription. Trees removed under this alternative would be left on the ground to decompose. The alternative prescribes thinning from above, where dominant or codominant trees are selected for cutting to benefit adjacent trees of the same crown class.

Under both action alternatives, three prescriptions would be applied in areas with specific conditions. In wetlands and stream buffers (622 acres), the prescription would depend on the type of stream and the geomorphic setting. Within 300 feet of old growth forest (104 acres), the prescription would be varied to reduce short-term indirect adverse effects on sensitive wildlife that occupy old growth forests. In areas dominated by tanoak (142 acres), a prescription would be used that would release selected conifers while minimizing tanoak stump sprouting.

There are also operating requirements common to both action alternatives that would apply to any area where trees would be removed. The operating requirements would minimize adverse effects on sensitive resources.

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 South 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.

Table 1. Project units and potential treatment options.

Unit Name	Treatment Options			
	Tanoak[1]	Old growth Buffer[1]	25% Basal Area Reduction[2]	40% Basal Area Reduction[3]
Unit A			X	X
Unit B			X	X
Unit AB			X	
Unit C	X			
Unit D	X			
Unit E	X			
Unit F	X			
Unit G			X	X
Unit H	X			
Unit I	X			
Unit J			X	
Unit JO			X	
Unit K			X	X
Unit KS			X	
Unit L			X	X
Unit LS			X	
Unit M			X	X
Unit ML			X	X
Unit MS			X	
Unit N			X	X
Unit NS			X	
Unit O			X	
Unit P			X	X
A100_A160 North Buffer		X		
South Buffer		X		
South Fork Region		X		

[1]= tanoak and old growth treatments would be the same under both the proposed action and the low intensity thin alternative
[2]= 25% basal area reduction would be implemented on 503 ac under proposed action and 864 ac under low intensity thin alternative
[3]= 40% basal area reduction would be implemented on 361 ac under proposed action

Actions Common to Thinning Alternatives

The following actions are common to site operations and thinning prescriptions for both the proposed action (Moderate Intensity Thinning with Biomass Removal) and low intensity thinning from above. Both action alternatives also include three special prescriptions that would be applied throughout the project area in sites within 300 feet of old growth forest (104 acres total), in stands dominated by tanoak (142 acres total), and in streamside and wetland buffers (622 acres total).

Table 1 lists all the stands that would be treated 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 2, 3, 4, and 5. The project is planned for completion over five years, but the start date depends on funding authorization and the total duration depends on weather-related accessibility to portions of the project areas.

NPS vegetation management staff sampled stands throughout the project area. Cruise data were used to characterize the existing stand conditions, describe baseline untreated conditions, and estimate numbers, sizes and species of trees to be felled and retained to accomplish restoration objectives under different management alternatives.

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 during all thinning operations. Silvicultural work would be done under contract.

Bald Hills Road, Holter Ridge Road, and portions of the A170, A160, A140, and A141roads would provide access into the project area. 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.

Thinning operations would be conducted by contract crews using gas-powered chainsaws. Thinning crews would drive as close to project sites as possible using existing roads and skid trails. Crews would not camp or remain on site beyond normal work hours.

No old growth trees of any species would be cut. The largest trees removed would not exceed 20 inches in diameter at breast height. No trees would be felled towards residual trees or trees of outstanding character (deformed trees, large hardwoods, redwood stump sprouts). Up to 5 trees per acre would be girdled to provide snags for wildlife habitat.

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 will 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.

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 fuel depth of 24 inches. If roads are available and accessible by heavy equipment, felled woody debris within 50 feet of roads would be chipped and scattered.

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.

Within 500 feet of old growth forest, work would be allowed between September 16 and January 31 to protect marbled murrelets and spotted owls from noise and disturbance during their nesting seasons. Spotted owl and marbled murrelet surveys have been conducted in all suitable habitat in or within 0.25 mile of proposed work areas. Additional spotted owl surveys would be conducted if two years have elapsed since the last survey of an area. If spotted owls are detected, no work that produces noise greater than ambient noise within 500 feet of the detection would occur from February 1 through July 31 and no tree removal would occur from February 1 through September 15 within the activity center stand or 70-acre core area surrounding the activity center. No work would occur from March 24 through September 15 within 500 feet of the contiguous old growth forest on the west side of the project area and two residual areas where marbled murrelet occupancy was documented in the northwestern portion of the project area. In residual old growth areas where surveys detected marbled murrelets, work from March 24 through September 15 that produces noise greater than ambient levels would be restricted to the time period from two hours after sunrise to two hours before sunset.

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" of rain is forecast during the NOS, project operations would temporarily cease and sites would be winterized. If periods of dry weather are predicted outside of the NOS, additional work would be permitted if it can be completed within the window of predicted dry weather. Work sites would be winterized at the end of each day when forecasts call for significant rains that may cause exposed roads or landings to erode. Winterization procedures would be supervised by an RNP geologist. Winterization procedures are measures to minimize erosion of exposed soils, including grading exposed road and landing surfaces to allow water to freely drain across them without concentrating or ponding or rilling; installing rolling dips/drains to drain steeper sections of road; clearing clogged drains; and installing silt fences and other erosion control devices where necessary to convey concentrated water across exposed road and landing surfaces.

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. A spill plan and materials for spill containment would be available to onsite personnel and all personnel shall know how to use them. In the event of a spill, work would be stopped immediately, clean up would begin and the appropriate authorities would be notified. Petroleum products, chemicals, hazardous materials, or water contaminated by these materials would not be allowed to enter flowing waters.

All vehicles and equipment utilized in this project will be cleaned prior to entering park to prevent transmission of exotic species, i.e. plants, animals, or pathogens (Port Orford cedar root rot, sudden oak death). Removal of all vegetative matter or mud from the undercarriage or tracks of vehicles and equipment is sufficient for this purpose. If vehicles or equipment travel to infected areas within California or Oregon during project implementation, they must be cleaned before re-entering the park.

Special Area Prescriptions

Specific prescriptions have been developed to treat 104 acres adjacent to old growth forest, 142 acres dominated by tanoak, and 622 acres of streamside and wetland buffers. These special area prescriptions are common to both the proposed action (moderate intensity) and the low intensity alternative.

Old Growth Forest Buffers— Approximately 104 acres within 300 feet of contiguous old growth forests in two units in the project area (Map 2) 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 5-15" dbh would removed on average (Table 2). Stand basal area would be reduced by 30% or less. Canopy 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. The average overstory cover of 80% would decrease to 65% in the old growth buffer areas after treatment. No skid roads or landings would be used in old growth buffer units because no trees would be removed offsite.

Table 2. Existing and proposed conditions in old growth forest buffers

	Basal Area per acre (ft^2/ac)					Trees per acre				
	Existing			Thinned		Existing			Thinned	
Unit	PSME[1]	SESE[2]	Total	PSME	Total	PSME	SESE	Total	PSME	Total
North Buffer	121	60	262	55	196	232	113	545	67	380
South Buffer	95	39	270	55	198	250	98	568	168	433

[1]PSME = Douglas fir (*Psuedotsuga menziesii*)
[2]SESE = Coast redwood (*Sequoia sempervirens*)

Tanoak-Dominated Stands— Cut stumps of tanoak sprout vigorously after logging, which has produced dense tanoak stands on approximately 142 acres of the project area, primarily along the southwestern ridge (Map 2). To minimize the sprouting response in tanoak while promoting conifer release and canopy development in these areas, thinning would occur around conifer trees selected for release (focal trees). Priority would be given to releasing redwoods, then dominant Douglas-fir, and lastly other dominant conifers. Other hardwood trees that are less common in these stands, such as Pacific madrone and giant chinquapin, may also be selected for release to maintain species diversity. To determine the treatment area radius around a focal tree, its dbh in *inches* would be multiplied by 2, and all trees would be cut in a radius within that many *feet* up to but not greater than 20 feet around the focal tree. No conifers larger than 10" dbh and no redwoods of any size would be cut around the focal tree. Second growth hardwoods of any size could be cut within the treatment radius of a focal tree. No basal area reduction target is proposed, but the basal area reduction would not exceed 20%. The thinning throughout the stands would be too sparse to decrease canopy cover measurably. All slash residue would be left on site regardless of slope. Trees removed along roads may be chipped to aid in decomposition of woody debris.

Streamside and Wetland Buffers—Special prescriptions and best management practices would be applied to 622 acres of streamside and wetland buffer areas to protect water quality and wetland functions and values (Map 4).

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)

The majority of wetlands in the project area are riparian zones along 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 15 miles of intermittent streams and 5 miles of perennial streams, and about 1 mile of swales throughout the project area.

Slopes 30% or less in steepness are defined as gentle slopes. Slopes between 31% and 45% are considered steep slopes. Slopes steeper than 45% are defined as extreme slopes. The majority of streams in the project area occur in areas with steep slopes. There are 139 acres adjacent to intermittent streams and 236 acres adjacent to perennial streams in areas of extreme slopes; no cutting would be allowed on these 375 acres.

All trees would be retained in streamside areas on extreme slopes. An NPS geologist would assess slope stability. All trees contributing to channel and bank stability would be retained. All trees would be retained on unstable and potentially unstable areas, regardless of slope steepness, and within a 50-foot-wide zone that surrounds the feature. All trees in the bankfull width of a channel would be retained. All trees that lean towards a channel would be retained for large woody debris recruitment. Heavy equipment would not operate in long-line from or cross channel features or swale features on steep slopes.

Wetlands protection zones would extend at least 100 feet wide from the outer edge of the riparian vegetation. Thinning treatments in wetland protection zones would retain at least a 70% post-treatment canopy.

In swales on gentle slopes, there would be no streamside buffer restrictions on vegetation treatments other than consideration of geomorphic stability. For swales on steep slopes, thinning treatments would retain at least a 50% canopy throughout the feature or within a 50-foot-wide zone on each side of the swale, whichever distance is greater.

For intermittent and ephemeral streams on gentle slopes, streamside protection zones would be a minimum of 50 feet wide or to the break-in-slope, whichever distance is greater. Thinning treatments would retain at least a 50% canopy.

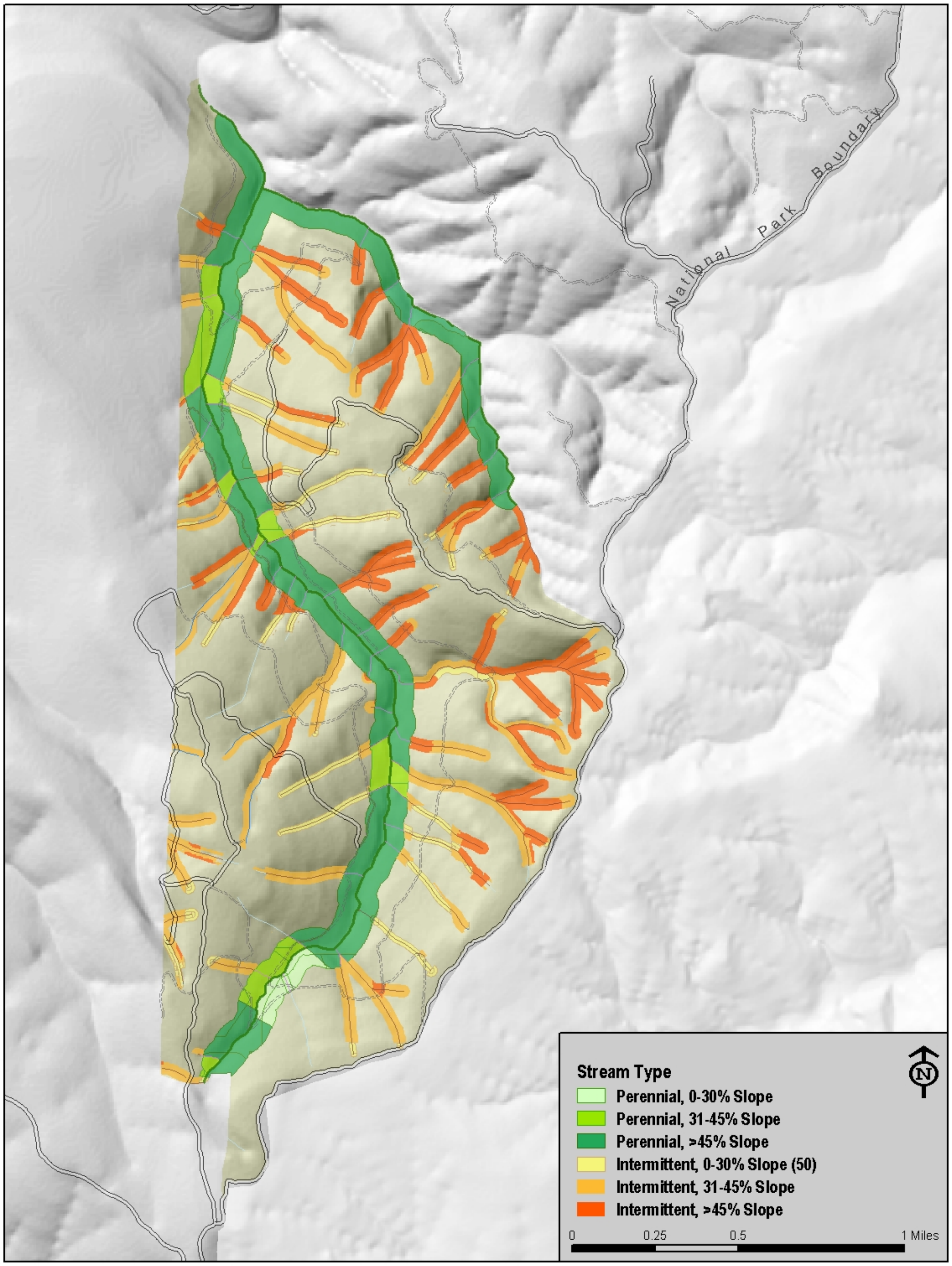
For intermittent and ephemeral streams on steep slopes, streamside protection zones would be at least 100 feet wide or to the break-in-slope, whichever distance is greater. Thinning treatments would retain at least a 70% canopy.

For perennial streams, streamside protection zones would be 300 feet in width from the outer edge of the channel, or to the break-in-slope, whichever distance is greater. On gentle slopes along perennial streams, at least a 70% canopy would be retained. On steep slopes, at least an 80% canopy would be retained.

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 for each unit 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.

Figure 4. Streamside Buffer Zones



Map 4. South Fork Lost Man Creek Second Growth Management Plan
Streamside Buffers

Alternative 2: Moderate Intensity Thinning with Biomass Removal for Fuels Reduction (Proposed Action)

Under the proposed action, two different prescriptions would be used depending on slope steepness and road access. A moderate intensity thin would reduce the basal area by 40% and the cut trees of merchantable size would be removed and sold to the contractor to offset the cost of thinning the trees and hauling them offsite. This prescription would be used on 361 acres. A low intensity thin prescription would reduce the basal area of a stand by 25% and cut trees would be left on the ground. This prescription would be used on 503 acres.

The moderate intensity thin would be used on slopes up to 30% and there are existing roads and skid trails that can be used to remove cut trees. Cut trees of merchantable size would be removed to reduce fuel accumulations and reduce fire hazard, and to offset costs of thinning. No mature trees larger than 20" dbh would be cut or removed. Trees larger than 15" but less than 20" dbh would be removed only to accomplish the restoration objectives at a specific site.

On slopes greater than 30%, the low intensity thin prescription would be used to stimulate forest regrowth while minimizing fuel accumulation on the forest floor. Under this prescription, felled trees would not be removed to minimize disturbance to soils that would be caused by skidding logs on slopes greater than 30%.

To maximize canopy openings under the low intensity thin prescription, selected dominant and/or co-dominant Douglas-fir trees would be thinned from above preferentially. The prescription would target Douglas-fir in the 8-to-20" dbh size range. Douglas-fir would be selected for thinning based on the size classes of all the Douglas-fir in the unit. The largest 10% (upper 10^{th} percentile of the diameter range measured in dbh in inches) would not be cut. Dominant and co-dominant Douglas-fir trees in the next smaller diameter range would be cut first, with subsequent removal of the smaller diameter classes until the basal area has been reduced by 25%. One-quarter of the basal area would be retained in each selected diameter class.

In areas under the low intensity thinning from above prescription, overstory Douglas-fir trees to be removed would be selected to maximize release of adjacent dominant redwood and/or other large conifers. Basal area would be reduced by 25% to stimulate release of dominant trees and increase the number of redwoods in the stand while minimizing fuel depth of woody debris.

This prescription would result in an average cull of 90 trees per acre (Table 3). The average overstory canopy cover would be decreased by about 20%. No redwoods are planned for removal under this prescription. Tanoak removed would not exceed 15% of total trees removed in any unit.

Table 3: Stand characteristics before and after thinning under the Proposed Action in areas with slopes greater than 30%

	Basal area per acre (ft²)					Number of trees per acre				
	Unthinned			Thinned		Unthinned			Thinned	
Unit Name	PSME[1]	SESE[2]	Total	PSME	Total	PSME	SESE	Total	PSME	Total
Unit AB	143	85	301	68	226	219	84	524	123	427
Unit J	171	37	312	92	226	369	29	507	260	399
Unit JO	123	53	275	55	206	244	33	603	113	471
Unit KS	113	68	276	44	207	147	87	396	72	321
Unit LS	125	100	280	56	211	172	128	422	89	339
Unit MS	171	162	365	80	274	179	196	439	87	347
Unit NS	86	159	307	46	291	67	231	329	28	291
Unit O	128	61	297	55	225	228	88	569	116	456

[1]PSME = Douglas fir (*Psuedotsuga menziesii*)
[2]SESE = Coastal redwood (*Sequoia sempervirens*)

On approximately 361 acres of the project area with up to 30% slope (map 2), a 40% basal area reduction prescription 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. 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 desired prescription. It is expected that the value of merchantable wood would be sufficient to pay for the thinning activities on these 361 acres.

A variety of equipment would be used, from chainsaws to heavy equipment such as harvesters, loaders, and skidders to fall and remove the wood. Chainsaws and/or harvesters would be used to fall targeted trees except where heavy equipment is prohibited to protect endangered species, streams, and wetlands. Loaders and/or skidders would remove logs from the project area, either by lifting or dragging the log to a landing. Log trucks would transport logs from the project area to a mill. Fuel trucks would transport fuel for the equipment to the project site. Fuel would be stored on-site; a spill plan would be required.

During removal of trees, equipment or long line operations would not be allowed to cross riparian features (wetland or channelized stream) or landslide feature. Equipment may operate in and cross through swale features providing slope steepness is less than 30%, but no skid trail construction would occur. No pre-existing woody debris would be removed from any unit. No trees would be felled towards residual trees or trees of outstanding character (deformed trees, large hardwoods, redwood stump sprouts). If residues are initially brought out of a unit for processing, the slash would be brought back into the unit and would be used as ground cover.

No felling or yarding heavy equipment 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.

For 40% basal area reduction, thinning would target Douglas-fir in the size class range from 5” to 20” dbh. The prescription calls for thinning from below to reduce overall stem density of Douglas-fir. An average of 287 trees per acre would be removed (Table 4).

Trees in the 5” 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 desired larger conifers. Some redwood on skid trails might be removed to provide access for equipment into the stand. Tanoak 12” 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.

All felled trees up to 8” dbh 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.

Log trucks and equipment would access the project area via Bald Hills road, Holter Ridge road, A170, A160, A141 and A140 roads (Map 5). If roads are watered to reduce dust, water tender operators would not be allowed to obtain water from creeks, springs, ponds, or other natural features in the park. No new roads would be constructed. Every attempt would be made to reoccupy existing skid roads to access trees in treatment units. Approximately 26 miles of existing skid roads, 15 miles of administrative roads, and up to 40 existing landings could potentially be reoccupied. All haul roads and landings would be removed under the park watershed restoration program.

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 and the two areas in the northwestern portion of the project area where marbled murrelets were detected. Work in areas where murrelets might be affected by noise would be subject to seasonal restrictions and daily limited operating periods.

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 the A150, A160, A170, and 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).

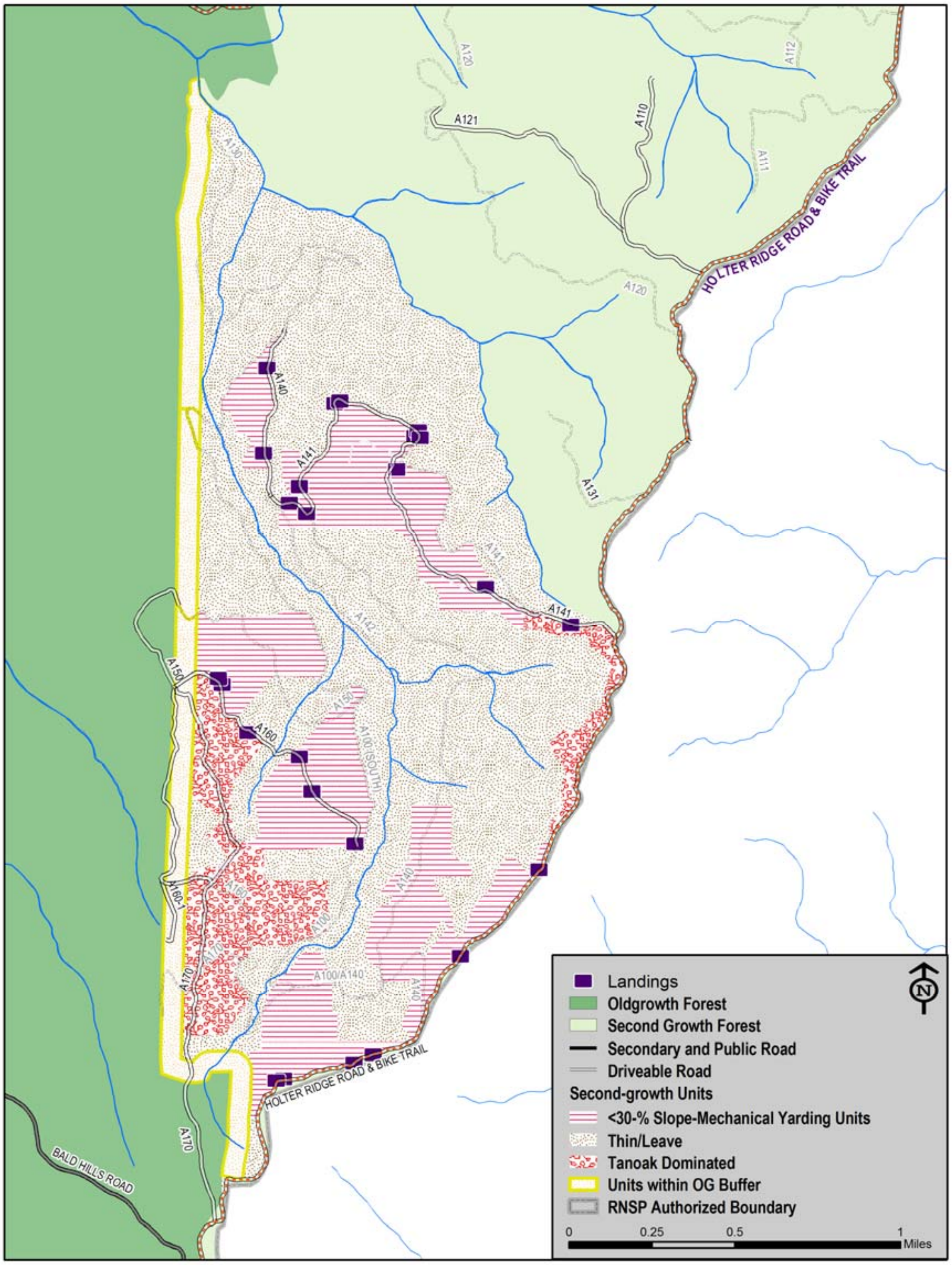
Surveys for spotted owls and marbled murrelets, following established regulatory protocols, have or would be conducted in all areas containing suitable habitat in or within 0.25 mile of proposed work areas. If spotted owls are detected near the low intensity thin areas, then no above ambient noise producing work would occur within 500 feet of the detection during the spotted owl noise restriction period (February 1 through July 31). If spotted owls are detected near the moderate intensity thin areas, then no above ambient noise producing work would occur within 0.25 mile of the detection during the spotted owl noise restriction period (February 1through July 31). If spotted owls are detected, then no tree removal or yarding would occur during the period from February 1 through September 15 within the activity center stand or 70-acre core area surrounding the activity center.

Table 4. Stand characteristics before and after thinning under the Proposed Action in areas up to 30% slope.

Unit Name	Basal area per acre (ft^2)							Number of trees per acre							Number of trees cut per acre	
	Unthinned				Thinned			Unthinned				Thinned				
	PSME[1]	SESE[2]	LIDE	Total	PSME	LIDE[3]	Total	PSME	SESE	LIDE	Total	PSME	LIDE	Total	PSME	LIDE
Unit A	161	59	28	287	45	28	171	340	85	75	602	31	75	293	309	0
Unit B	214	45	62	321	102	62	209	256	54	237	546	52	237	343	204	0
Unit G	126	54	66	281	37	40	166	233	96	139	575	27	97	326	206	42
Unit K	136	68	37	284	44	19	173	260	90	102	529	30	10	208	230	91
Unit L	162	74	88	326	51	71	197	272	92	199	578	33	123	262	240	76
Unit M	208	120	15	346	86	15	224	341	223	71	635	64	71	358	278	0
Unit ML	139	112	32	283	26	32	170	250	119	-	370	20	0	139	230	0
Unit N	182	229	4	442	50	4	309	210	340	26	624	24	26	438	186	0
Unit P	157	54	29	271	53	29	168	303	47	83	487	36	83	220	267	0

[1]PSME = Douglas fir (*Psuedotsuga menziesii*)
[2]SESE = Coastal redwood (*Sequoia sempervirens*)
[3]LIDE = Tanoak (*Lithocarpus densiflorus*)

Figure 5. Proposed Locations of Log Landings



Map 5. South Fork Lost Man Creek Second Growth Management Plan
Proposed Landings

Existing skid trails and landings that were constructed for commercial logging operations prior to park establishment would be identified and approved by park personnel. All felled trees 8” dbh or greater would be limbed, bucked to log lengths and yarded to existing landings using ground based equipment. Trees would be processed on landings and loaded onto log trucks for transport.

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. The number of chokers would be limited to as few as necessary to avoid damage to resources or residual trees.

Sites would be rehabilitated after operations. Tire tracks, skidding ruts and other depressions and surface irregularities would be obliterated and restored to pre-disturbance surface condition. Culverts, waterbars, 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 24” in depth.

If any or all 361 acres of the project area proposed for 40% basal area reduction cannot be implemented, i.e. road access has been lost, no bids are submitted, or some other unforeseen reason, then those areas will be treated with the lower intensity thinning prescription (25% basal area reduction), as proposed for those areas over 30% slope.

Alternative 3: Low Intensity Thinning From Above

A low intensity prescription would be used on 864 acres to release dominant trees by maximizing canopy openings while not exceeding a 25% basal area reduction. The low intensity thin prescription is designed to minimize fuel accumulation on the forest floor by falling fewer trees than proposed under the 40% basal area thin. This is the same prescription that would be used under the proposed action where slopes are greater than 30%.

Under this alternative, selected dominant or co-dominant Douglas-fir trees would be removed to maximize openings in the canopy. Overstory trees would be selected to release of dominant and co-dominant redwood and/or other large conifers.

Douglas-fir would be selected for thinning based on the size classes of all the Douglas-fir in the unit. The largest 10% (upper 10^{th} percentile of the diameter range measured in dbh in inches) would not be cut. Dominant and co-dominant Douglas-fir trees in the next smaller diameter range would be cut first, with subsequent removal of the smaller diameter classes until the basal area has been reduced by 25%. One-quarter of the basal area would be retained in each selected diameter class.

The low intensity thinning from above prescription would result in an average cull of 99 trees per acre (Table 5). The average overstory canopy cover would be decreased by about 20%, from 80% down to 60%. No redwood removal is planned under this prescription. Tanoak removed would not exceed 15% of total trees removed in any unit.

Table 5. Stand characteristics before and after thinning under the Low Intensity Thin alternative.

Unit Name	Basal area per acre (ft^2)					Number of trees per acre					Number of trees cut per acre
	Unthinned			Thinned		Unthinned			Thinned		
	PSME[1]	SESE[2]	Total	PSME	Total	PSME	SESE	Total	PSME	Total	PSME
Unit A	161	59	287	89	215	340	85	602	234	496	106
Unit AB	143	85	301	68	226	219	84	524	123	427	96
Unit B	214	45	321	135	243	256	54	546	178	468	78
Unit G	126	54	281	53	208	233	96	575	130	471	103
Unit J	171	37	312	92	226	369	29	507	260	399	108
Unit JO	123	53	275	55	206	244	33	603	113	471	131
Unit K	136	68	284	66	214	260	90	529	151	420	109
Unit KS	113	68	276	44	207	147	87	396	72	321	75
Unit L	162	74	326	81	246	272	92	578	158	463	114
Unit LS	125	100	280	56	211	172	128	422	89	339	82
Unit M	208	120	346	122	260	341	223	635	232	526	109
Unit ML	139	112	283	70	214	249	119	370	143	263	106
Unit MS	171	162	365	80	274	179	196	439	87	347	92
Unit N	182	229	442	73	332	210	340	624	77	491	133
Unit NS	86	159	307	46	291	67	231	329	28	291	39
Unit O	128	61	297	55	225	228	88	569	116	456	112
Unit P	157	54	271	89	203	303	47	487	209	393	99

[1]PSME = Douglas fir (*Psuedotsuga menziesii*)
[2]SESE = Coastal redwood (*Sequoia sempervirens*)

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.
- 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 Moderate Intensity Thinning with Biomass Removal for Fuels Reduction (the Proposed Action) is the environmentally preferred alternative. This alternative would accelerate the development of late-seral forest characteristics more quickly than the low intensity thin alternative and would reduce fuels remaining following treatment.

The moderate intensity thinning on 361 acres under the proposed action differs from low intensity thinning because the proposed action would

- Create larger canopy gaps to reduce crown fire potential and to allow for canopy differentiation, where the low intensity would create smaller canopy gaps.
- Accelerate stand development, release of individual trees, and habitat diversity, and reduce edge impacts more quickly than the low intensity thin alternative.
- Minimize the fuel hazard on one-third of the project area compared to the low intensity thin alternative.
- Restore species composition and Douglas-fir/redwood ratio to more closely resemble old growth forests, where the low thin alternative would still 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;
- forest understory would continue to be absent in the presence of high canopy cover;
- forest stands would continue to provide poor quality wildlife habitat;
- fire hazard would remain high, with conditions suitable for wildfire that could spread outside the second growth.

The low intensity thin alternative is not the environmentally preferred alternative because a 25% basal area reduction would not fully produce late-seral conditions nor restore species composition to pre-disturbance levels as quickly as the proposed action. Douglas-fir would continue to be the dominant species using the low intensity thin prescription, resulting in species composition that differs from the original community type.

Alternatives Eliminated from Further Consideration — The NPS analyzed a variety of different approaches and techniques for restoring second growth forests in the South Fork of Lost Man Creek project area. The NPS 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" 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. Prescribed fire carries an unacceptably high risk to adjacent private lands in the event of an escaped prescribed burn. There is also 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. Clearly further experimental study is needed to test fire effects in high density, Douglas-fir dominated second growth stands. Experimental use of prescribed burning in second growth will be addressed in the next revision of the park's Fire Management Plan, scheduled for release in December 2009. 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, or that affect the resources, within the project area, the park, and the region.

Setting

Redwood National and State Parks lie along the Pacific coast on the western edge of the Coast Ranges of northwestern California. The parks include 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 parks 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 1700-acre project area is located in the South Fork Lost Man Creek sub-basin.

Overview of Logging in the Park and Project Area

Most of the timber harvesting in what is now RNP 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.

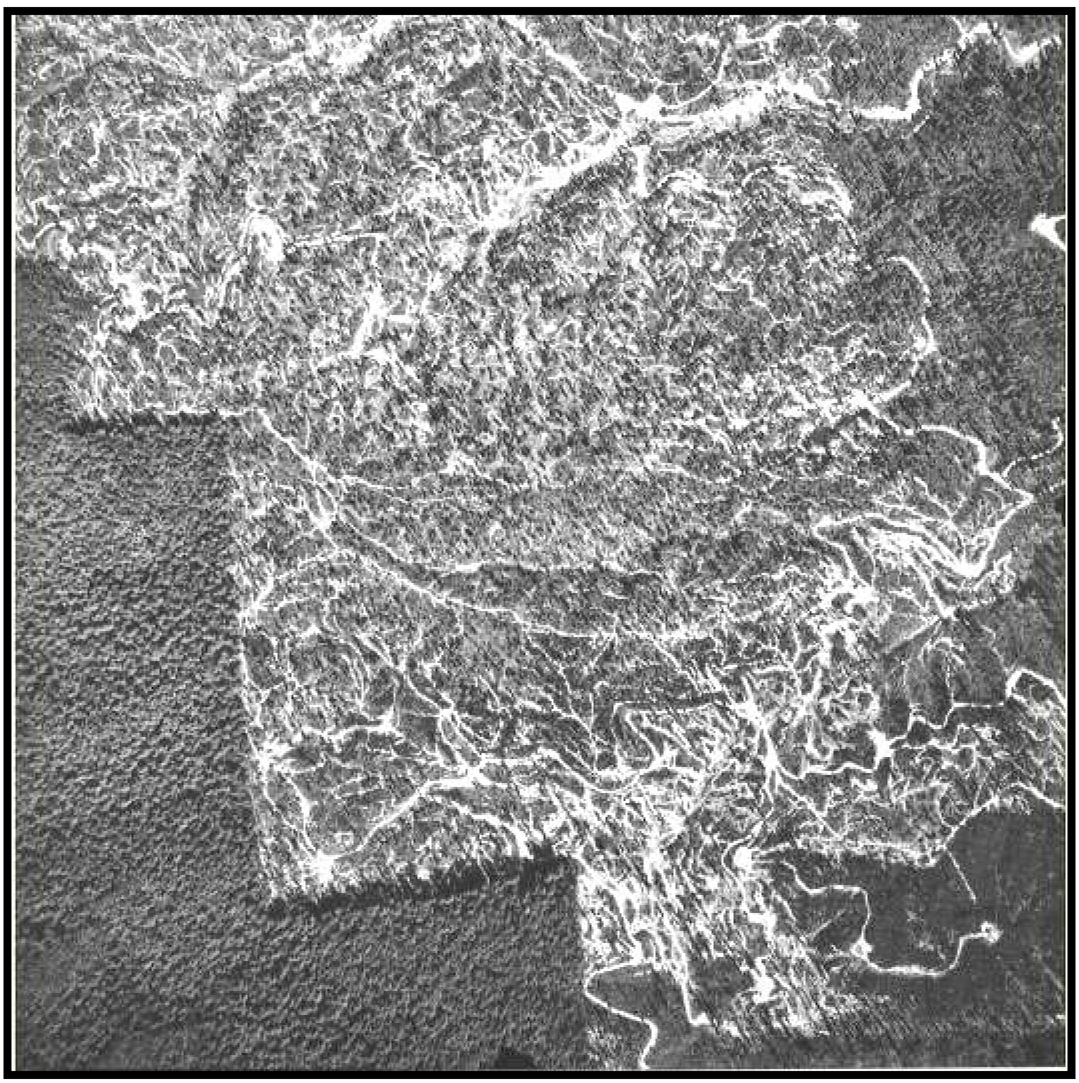
Almost 90% of what was old growth redwood forest in the South Fork of Lost Man Creek was tractor-logged in the 1950s and 1960s. Other sub-basins with Lost Man Creek were also logged during the same period with the exception of the lower reach of Lost Man Creek. The unlogged old growth forest along lower Lost Man Creek represents approximately 15% of the forested area in the watershed (Table 6).

Table 6—Characteristics of Lost Man Creek Watershed and Sub-basins

Sub-basin	***Drainage Area (acres)***	***Area in Old Growth (acres)***	***Area in Second growth (acres)***
South Fork Lost Man Creek	2522	304	2218
Larry Damm Creek	1181	245	936
North Fork Lost Man Creek	1422	135	1287
Middle Fork Lost Man Creek	1444	35	1409
Areas between streams	1160	1116	44
Basin Totals	7,729	1835	5894

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 Clear-Cut Immediately 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 South Fork 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 2500 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 South 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

Topography – Topography refers to the shape and relief of the surface of land, ranging from flat to rolling to mountainous. Rapid tectonic uplift; abundant, intense rainfall; and sheared bedrock make much of the parks highly erodible, deeply incised, and generally rugged.

Elevations in the Lost Man Creek watershed range from about 200 feet above sea level at the confluence with Prairie Creek to about 2,250 feet along Holter Ridge. Slopes in the project area are near level at the ridge tops to near vertical within the inner gorges of perennial streams. Overall, slope steepness averages about 35-40% in the project area.

Geology – The parks are underlain primarily by Jurassic-Cretaceous aged rocks of the Franciscan assemblage, a collection of sandstone, siltstone, schist and minor amounts of conglomerate with isolated exposures of chert and volcanic greenstones. The Franciscan complex is bounded on the west by the Cascadia subduction zone and on the east by the South Fork Mountain fault (or Coast Range thrust). The Prairie Creek area is underlain by Plio-Pleistocene coastal plain sediments of the Prairie Creek Formation. Quaternary alluvial and marine deposits blanket the stream valleys and coastal areas of the parks.

Tectonics and Geological Processes – The California coast is tectonically very active, and its complex geology and topography are controlled by movement along faults and crustal plates. The tectonics of the nearby triple junction and by the Cascadia Subduction Zone influences geologic processes. Most of the land encompassed by the parks has experienced recent tectonic uplift. This uplift has been manifested in steep streamside slopes ("inner gorge") along major streams.

Many areas of the parks are susceptible to landslide processes such as debris slides and avalanches, block falls, shallow and deepseated landslides, and earthflows. During periods of high precipitation, slope failures commonly occur in watersheds impacted by logging activities and along steep terrain throughout the parks.

As with most of northwestern California, geologic structure in the Lost Man Creek watershed is governed by several parallel north-northwest trending faults. These faults range from low-angle thrust faults to vertical faults and form some of the boundaries between the different lithologic units in the northern portion of the Lost Man Creek watershed.

Within the project area, the geomorphic features and processes are a direct result of the physical characteristics of the two geologic units, tectonic activity and faulting, rainfall and disturbance by logging and road building.

The project area is underlain by two distinct rock types - the Coherent Unit of Lacks Creek which consists of graywacke sandstone, mudstone, and conglomerate and underlies most of the area, and the Prairie Creek Formation, exposed primarily along the ridges forming the eastern edge of the project area. The Prairie Creek Formation represents the onshore and nearshore portion of an extensive sedimentary sequence deposited near the mouth of the ancestral Klamath River. It is dominantly composed of fluvial sediments but also includes nearshore marine, beach, and estuarine deposits. The Prairie Creek Formation is divided into four units distinguished by sediment composition. The ridge tops in the eastern part of South Fork Lost Man Creek watershed are capped by the Surpur Creek Unit, a gravelly fluvial deposit within the Prairie Creek Formation

The area underlain by the Prairie Creek Formation is relatively gentle, and the sediment tends to accumulate in broad, meandering stream valleys. The unconsolidated sediments of the Prairie Creek Formation are readily mobilized by surface runoff, especially where the sediments have been cut and sidecast to construct roads, and natural drainage patterns have been altered by logging. These sediments are also susceptible to natural and disturbance-induced landslide processes.

The relatively resistant bedrock of the Coherent Unit of Lacks Creek 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.

Gully erosion is apparent in both natural and disturbed settings throughout the park (Janda et al., 1975). On unlogged forested hillslopes, gully erosion is related to subsurface piping through root channels. On logged hillslopes, extensive networks of rills and gullies have developed from streamflow diversions at road and skid road stream crossings, from ditches, and from interception of subsurface flow along roads and trails. Surface erosion of logged areas may also have increased as a result of decreased interception of rainfall by the forest canopy following harvest.

Previous studies have documented large increases in gully erosion on lands where timber has been harvested or where roads have been constructed (Janda et al., 1975; Nolan et al., 1976; Walter, 1985; Hagans and Weaver, 1987).

Soils – Most of the soils in the parks have strongly developed surface horizons, rich in organic matter and nutrients. There are particularly high levels of organic matter and nutrients in the surface horizons of soils developed under the parks' coniferous forests, oak woodlands and prairies. This high organic matter content contributes to the high natural growth rate of the vegetation in these plant communities.

Soil development occurs in response to the weathering of the parent materials (rocks and alluvial deposits) and input from surface materials (vegetation), and varies depending on the topography (slope, aspect, and hydrologic features), underlying rock composition, and time. For the most part, the soils in the parks are well developed because the mild wet climate has caused a high degree of weathering of the underlying materials.

Soils found in the project area can be grouped into eight generalized map units (Table 7). Upland soils in the project area are well drained (seasonal high water table is at a depth greater than 100 centimeters), and very deep (greater than 152 cm to bedrock). In general the surface layer is a brown to very dark brown gravelly to very gravelly loam. Surface layer organic matter is greater (very dark brown) in vegetation communities dominated by a deciduous shrub or fern dominated understory, as compared to an evergreen shrub dominated understory. As a result, available water holding capacity and nutrient storage and availability are greater. The subsurface layer is a yellowish brown to pale yellow clay loam to very gravelly loam dominated by low amounts of organic matter and non-expanding, low activity clays, hence nutrient storage and availability is low.

Table 7. Generalized Soil Map Units for the Project Area

Soil Unit Number	Map Unit Name	%Slope Location
290	Surpur-Mettah complex	9 to 30% slopes
531	Atwell-Coppercreek complex	30 to 50% slopes
534	Coppercreek-Ahpah-Lackscreek complex	15 to 30% slopes
542	Coppercreek-Slidecreek-Lackscreek complex	30 to 50% slopes
558	Tectah-Coppercreek-Trailhead complex	0 to 30% slopes
582	Slidecreek-Lackscreek-Coppercreek complex	50 to 75% slopes
591	Sasquatch-Sisterrocks-Ladybird complex	30 to 50% slopes
592	Sisterrocks-Ladybird-Footstep complex	50 to 75% slopes

Most of the soils are classified as Paleohumults and Haplohumults. Humults are well-drained ultisols that have high organic matter content. Ultisols are strongly leached, acid forest soils with relatively low native fertility. They are found primarily in humid temperate and tropical areas of the world, typically on older, stable landscapes. Intense weathering of primary minerals has occurred, and much of the calcium, magnesium, and potassium have been leached from these soils. Ultisols have a subsurface horizon in which clays have accumulated, often with strong yellowish or reddish colors resulting from the presence of iron oxides. Because of the favorable climate regimes in which they are typically found, ultisols often support productive forests.

The surface layer in soils within the project area contains 3-8% organic matter. Organic matter in its various forms improves soil productivity. Organic matter within the soil increases nutrient availability and storage, and increases pore space, which in turns allows the soil to store more water available for plant growth. Organisms within the surface layer, including fungi and bacteria, drive nutrient cycling by decomposing organic matter, which releases nutrients for plant growth.

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 in undisturbed forest communities 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. Compaction and rutting reduce the movement of water into soil and tend to channel surface water.

Water Resources
The South 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 et al., 1975).

Stream discharge is not measured regularly for the South 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).

Water Quality—The South 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 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) mainstem 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 Lost Man Creek and South Fork Lost Man Creek to measure erosion and turbidity associated with road removal began in water year (WY) 2003 (Klein 2006). (A water year begins October 1 of the previous calendar year i.e., WY 2003 began October 1, 2002 and ended September 30, 2003). The purpose of the monitoring is 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. The monitoring compares turbidity and suspended sediment concentrations in nearly pristine watersheds and changes over time of these parameters in watersheds where road removal work has been completed.

South Fork Lost Man Creek was used as a 'control' tributary watershed in WY2003 even though it had road removal work completed in 2000 and 2001. In WY2003 peak turbidity in South Fork Lost Man Creek was comparable to that in the nearly pristine Little Lost Man Creek watershed. In WY 2004, turbidity levels in South Fork Lost Man Creek increased by a factor of about 2 – 3 relative to that measured at the monitoring site on Little Lost Man Creek. This increase was attributed to recent debris slides within 1.25-mile upstream of the South Fork Lost Man Creek monitoring site. Turbidity levels on South Fork Lost Man Creek continued to stay in this comparable level to Little Lost Man Creek until the WY2007 when the South Fork turbidity levels rose to about 4 – 6 times that measured at the Little Lost Man Creek gage. This increase likely reflected the effects of renewed road removal work in South Fork. Turbidity monitoring data for the water years 2003–2005 show that peak turbidities increase in watersheds where road removal projects have occurred the previous season. The turbidity decreases rapidly after completion of work in a tributary and increases with storm severity.

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 mainstem 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 measured in Lost Man Creek between July 1 and August 31, 2005. Temperature ranged from 12.5^{o}C (54.5^{o}F) to 16.7^{o}C (62.1^{o}F).

Floodplains and Wetlands

The lower mainstem 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 low enough gradients that floodplains have developed 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 South Fork mainstem 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 South Fork Lost Man Creek second growth management project area consists of 1,700 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 (Table 6). 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, Pacific madrone, and western redcedar. An old growth stand of western redcedar estimated at 10 acres occurs in the northwestern portion of the project area.

There are old growth redwood forests along the southern and western boundaries 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 *(Lithocarpus densiflorus)* and redwood, with some giant chinquapin *(Chrysolepis chrysophylla)*, Pacific madrone *(Arbutus menziesii)*, western redcedar *(Thuja plicata)*, and red alder *(Alnus* *rubra)*. The overstory in second growth stands is typically dominated by Douglas-fir with small numbers of redwood sprouting from old growth stumps. Grand fir *(Abies grandis)* and western hemlock *(Tsuga heterophylla)* trees are occasionally present in the overstory.

The midstory is generally dominated by tanoak 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.

The western topographic divide that separates the Little Lost Man Creek and Lost Man Creek watersheds is dominated by second growth tanoak stands. Tanoak stands also occur along Holter Ridge along the easternmost edge 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 tends to be the dominant species.

The northwestern portion of the project area is dominated by redwood. In this relatively flat, wet area, the overstory consists almost completely of redwood, with Douglas-fir as a strong competitor. Grand fir and western hemlock are scattered throughout the stand. Very little tanoak is present. Sword fern is the dominant understory 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. There is an alder-dominated stand located near the A130 road, west of Lost Man Creek. Alder dominance may continue for 50 to 100 years. Major disturbances such as landslides might extend alder dominance much longer.

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 are 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.

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, if any, exotic species have been observed in the forests within the project area.

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.

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. Pacific giant salamander larvae are found in some of the perennial streams with adults common to moist coniferous forests under logs and bark. Pacific giant salamander larvae have been observed in the South Fork of Lost Man Creek, and probably occur throughout perennial streams in the Lost Man Creek watershed. Pacific treefrogs and northern red-legged frogs (*Rana aurora)* are present. Tailed frogs have been found in Lost Man Creek. 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. Winter 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 mountain lions, bobcats, coyotes, grey foxes, long-tailed weasels, raccoons, skunks, chipmunks, ground squirrels, brush rabbits, woodrats, flying squirrels, voles, shrews, and bats but no surveys have specifically targeted mammals.

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*), coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*). Most spawning and rearing occurs along the lower reaches of major tributaries and along the mainstem 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 Redwood Creek include the Humboldt sucker, threespine stickleback, coastrange sculpin, Pacific lamprey (*Lampetra tridentata*), tidewater goby and eulachon.

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

Table 8—Sensitive Plants Listed by CNPS

Common	Scientific Name	Habitat Type	CNPS Rank
California globe mallow	*Illiamna latibracteata*	coniferous forest/mesic	1B.2
White-flowered rein orchid	*Piperia candida*	coniferous & broadleaf upland forests	1B.2
Small ground-cone	*Boschniakia hookeri*	coniferous forest	2.3
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[1]	*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
Woodnymph	*Moneses uniflora*	coniferous & broadleaf upland forests	4.3
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 South Fork Lost Man Creek second growth management project area
[2]= occurs in Lost Man Creek watershed but not found in South Fork Lost Man Creek second growth management project area

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 South Fork Lost Man Creek second growth management project area.

Table 9—Plants Designated as "Park-rare"

Common/	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) and northern spotted owl (federally listed as threatened) 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 birds or any other listed terrestrial species. Detailed species accounts and habitat requirements for murrelets and owls are found in *A Conservation Strategy for Managing Threatened and Endangered Species in Redwood National and State Parks* (Sakai 2003, as amended) and in the biological assessment of effects to threatened wildlife from this project (Bensen 2007).

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 Oregon and California is found in Redwood National and State Parks. Murrelet nests have been confirmed in forests in lower Redwood Creek.

The action area used to assess effects on marbled murrelets extends 0.25 miles beyond the project area and totals 2,714 acres; the project area is 1,732 acres, which has been rounded to 1,700 acres elsewhere in this document. The action area includes 748 acres of suitable marbled murrelet habitat, most of which is the contiguous old growth in a 0.25-mile wide buffer strip on the west side of the action area that will not be thinned. The contiguous old growth habitat is considered to be high quality. The NPS has determined that there are 94 acres of suitable murrelet habitat within the project area of residual old growth single trees or clusters of trees. Depending on the location of the residuals and the size of the clusters, these 94 acres containing individual residual trees and residual clusters include 17 acres of high quality habitat, 68 acres of moderate quality habitat, and 9 acres of low quality habitat.

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 action area. Murrelet activity appeared to decrease with increasing distance away from the contiguous old growth. 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 2,464 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 1700-acre project area is considered to be suitable habitat except for the 142 acres dominated by dense stands of regenerating tanoak in the southwestern portion of the project area. Almost all of the tanoak stands are unsuitable spotted owl habitat because the extremely high tanoak stem density makes flight difficult for owls. 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 about two-thirds of the action area (1,815 acres of the 2,714-acre action) from 2003-2006 for spotted owl presence. All of the area along the Lost Man Creek Trail/Holter Ridge Road has been surveyed every year since 1998. No spotted owls have ever been found within the action area. Barred owls been detected in 3 different places dispersed across the action area. A barred owl pair was detected in the area farthest north, which most likely represents a barred owl territory. The other two detections were of single barred owls and may or may not be territories. 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 through September 15 and March 24 through 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 west-central 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 is not known, but probably equates roughly with 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 in 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 contains designated critical habitat for all three ESUs.

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, CDFG roughly estimated the spawning escapement of 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 mainstem lacks an adequate pool-riffle structure and cover. Coarse sediment deposited in the mainstem 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—California Coastal 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 RNP 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 California Coastal 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 mainstem 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. Park 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. 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 Southern Oregon/Northern California Coast coho USU 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— Northern California 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.

Steelhead is 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 mainstem 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 mainstem 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

Redwood National and State Parks contain a significant set of cultural resources including archeological sites, historic structures, cultural landscapes, ethnographic properties, and objects.

Archeological Resources—The majority of archeological sites in the parks are prehistoric. Sites are recorded throughout the parks along the coast, inland and especially in the Bald Hills of the Redwood Creek basin. These sites include temporary and seasonal camps, trail use sites, and villages and sacred places. Altogether the sites represent a continuous record of habitation by at least three different Native American groups and their ancestors, extending over 4,500 years to after Euro-American contact at about 1850. Fish, game, and acorns were particularly significant foods for the local Native Americans. In addition to villages of wooden plank houses and sweathouses, there were also numerous temporary summer camps and specialized use areas throughout the region. An extensive trade and travel network also existed. Today, the Tolowa, the Yurok, and the Hupa have ancestral ties to the parks. At the time of contact, the Yurok lived along the coast and the Chilula along Redwood Creek. The Chilula, whose territory included parklands in the Redwood Creek basin, were almost decimated after contact; most of those who remained were assimilated by the Hupa to the east of the parks.

The project area is within the ancestral lands of the Yurok people. Review of ethnographic literature, consultations with Native Americans, and archeological surveys indicate that the pre-historic uses of the heavily forested Lost Man Creek watershed were primarily fishing, gathering, and hunting (Sloan 2006, 2007). Trails passed through the area, but no settlements were reported (Sloan 2006, 2007; McConnell and Eidsness 2000).

Historic archeology in RNP consists of remains of Euro-American settlement and activities from the late 1800s. Evidence of historic settlements, ranching, logging, mining, and recreation are all types of resources that can be found. Logging was the primary historic activity that occurred in the project area. One former logging camp dating to the 1960s is located near the project area.

Ethnographic Properties—Important traditional Yurok plant resources located in the project area include alder, cascara, hazel, huckleberry, iris, maidenhair fern, redwood, salmonberry, sword fern, thimbleberry, wild ginger, and *Woodwardia* fern (Sloan 2006; McConnell and Eidsness 2000). Two known ethnographic resources are documented in the Lost Man Creek watershed restoration project areas, a bear grass *(Xerophyllum tenax)* patch and a “goose pen” tree. The bear grass site may be eligible for listing on the National Register of Historic Places.

Historic Resources—After the Redwood Highway was completed in 1935 through the Orick-Prairie Creek area, a temporary fish hatchery and egg collecting station were established on Prairie Creek near Lost Man Creek. These facilities were rebuilt on Lost Man Creek in 1936 as a permanent facility, the Prairie Creek Fish Hatchery. Salmon and trout were hatched at this facility. The hatchery ceased operations in 1992, closed in 1993, and was acquired by the NPS in 1996. It was listed on the National Register of Historic Places in 2000. The hatchery buildings have been "mothballed" until additional funding is available for renovation and reuse in a manner that retains the integrity of the structures and contributing elements that make it eligible for listing on the National Register. The hatchery and its contributing elements are located outside the area of potential effect for the proposed second growth management project.

A former logging camp dating from approximately the 1920s to the 1940s was found in the project area near Holter Ridge during field surveys conducted during this investigation. The dump site associated with the camp appears to be more than 50 years old and would meet criteria for eligibility to the National Register of Historic Places based on its ability to convey information about logging operations and human activities in lands now within the Lost Man Creek watershed of Redwood National Park. The site appears to be completely intact. Surface evidence found approximately 28 artifacts including car parts, and broken glass and ceramics (Sloan 2007). The camp is likely eligible for listing on the National Register at the local level based on its integrity, the artifacts it contains, and its information potential to convey the settlement and use history of lands in Humboldt County.

A former ranch site was found on Holter Ridge during field surveys conducted for the Lost Man Creek watershed restoration project. The site contains historic fenceline features and a historic trail segment. Non-contributing elements at the ranch site include a pile of concrete debris and an old structure called the "powderhouse" that was constructed by NPS staff in the 1980s during initial phases of watershed rehabilitation.

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 2007 was reported as 385,171 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 management 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 at RNP 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 Geologic Services branch is conducting watershed restoration work in Lost Man Creek to address potential erosion sources and to restore topography and hydrologic processes damaged by road construction. The road removal program will run concurrently with the proposed second growth management.

The South Fork of the Lost Man Creek second growth forest restoration project area is included in the coniferous forest fire management unit described in the 2004 RNP Fire Management Plan. All wildfires in this area will be suppressed and there are no planned prescribed fire projects. Some of the roads in the project area will be retained for fire access and will be maintained to allow access by fire equipment. The fire management plan is scheduled for revision in 2009 but no changes are anticipated to the existing management of second growth forests in the project area. Existing fire management includes construction of a shaded fuel break along Holter Ridge Road in the project area.

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 $1700 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 South 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, as well as any potential for impairment of park resources and values.

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 (1700 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 has 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 through July 31).

Cultural Resource Consultations—The National Historic Preservation Act of 1966 requires federal agencies to consult with state historic preservation officer (SHPO) if an undertaking would have the potential to affect properties listed or eligible for listing on the National Register of Historic Places. The NPS is also required to consult with affected American Indian tribes.

Non-Impairment of Park Resources and Values—The NPS is required by law to manage park resources and values in such a way as to leave them unimpaired, unless a particular law directly and specifically provides otherwise. NPS management policies require that environmental documents disclose whether an action has the potential to impair park resources or values. Impairment is defined (Management Policies 1.4.5, NPS 2006) as an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values. Whether an impact meets this definition depends on the particular resources and values that would be affected; the severity, duration and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question and other impacts. An impact is less likely to constitute impairment if it is an unavoidable result, which cannot reasonably be mitigated, of an action necessary to preserve or restore the integrity of park resources and values. An impact would be more likely to constitute impairment if it affects a resource or value whose conservation is necessary to fulfill specific purposes identified in the park's establishing legislation, or which are key to the natural or cultural integrity of the park or the opportunities to enjoy the park, or which are identified in the park's general management plan as being of significance.

NPS Management Policies also require that NPS managers determine whether impacts that might result from an action are unacceptable. Unacceptable impacts are those that fall short of impairment but are not acceptable in a park's particular environment (Management Policies 1.4.7.1, NPS 2006). Unacceptable impacts are those, individually or cumulatively, that would among other things

- be inconsistent with a park's purposes or values;
- impede the attainment of a park's desired future conditions for natural or cultural resources; or
- unreasonably interfere with a park's program's or activities or an appropriate use.

Analyses and findings for unacceptable impacts and non-impairment of resources or values follow the analyses of effects for each park natural and cultural resource topic.

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 (Moderate Intensity Thin and Biomass Removal for Fuels Reduction)— 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 40 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.

Effects on Air Quality under the Low Intensity Thin Alternative—Under the low intensity thin alternative, 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, dust from the watershed restoration project in Lost Man Creek that will continue through 2010, 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 on 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 either the low intensity thinning alternative or 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.

Non-Impairment of Air Quality— None of the alternatives, including no action and the proposed action, would have long-term adverse effects on air quality or air quality related values in the parks. Short-term adverse effects on air quality from the action alternatives would be negligible to minor. Therefore, none of the alternatives, including the proposed action, would impair air quality or air quality related values in the park. The adverse effects on air quality from vehicle and equipment emissions, and from dust from driving on unpaved roads to and from the project area, would be localized, short-term, and negligible to minor, and are therefore acceptable.

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 Common to Thinning Alternatives—Under both the proposed action and the low intensity thin alternative, 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, waterbars, and other drainage structures would be repaired or replaced.

Under both the proposed action and the low intensity thin alternative, adverse effects on unstable soils and in steep slopes (over 30%) would be minimized by cutting fewer trees (low intensity thinning) and leaving cut trees on the ground to protect soils from erosion after vegetation cover is removed.

Effects to Soils from Wildfire—The potential for adverse effects to soils from wildfire would increase as fuels on the forest floor increase after thinning operations. A wildfire may spread more readily or burn more intensely as it encounters the needlecast and branchwood (woody debris less than 3” in diameter) and boles from felled trees. A higher intensity fire would increase overall mortality of trees in the stand and potentially cause damage to the organic component of soils. Needlecast and branchwood are the primary carrier of fire across the forest floor, because smaller fuels catch fire more easily. The boles of trees, which typically do not contribute to fire spread, would be mostly unavailable as a source of fuels within 10 to 15 years post treatment due to decomposition, based on observations from thinning experiments in similar second growth forests in the park.

Under the proposed action, smaller diameter trees would be thinned preferentially before larger diameter trees. All of the smallest diameter trees, up to 8” 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 build up of fuels in any one location and promote faster decomposition.

Under the low intensity thin alternative, 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 branchwood.

Therefore, the effect to soils from wildfire under both thinning alternatives would be adverse and short-term, as the primary fuel component most responsible for fire spread (needlecast and branchwood) would decompose within 3 to 5 years of thinning operations and the boles of trees would show significant decomposition within 15 years.

Effects of the Proposed Action on Soils
Under the proposed action, 503 acres would be thinned at a low intensity with no woody biomass removal. On 361 acres, soils would be disturbed to conduct a moderate intensity thin and remove the woody biomass, using heavy equipment to remove the boles of trees 8” dbh or larger. Approximately 26 miles of skid road and up to 40 landings would be reoccupied during the project. Approximately 7 acres of previously disturbed soils would be affected to reoccupy 40 landings ranging from 900–20,000 sf 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 361 acres with slopes 30% or less, felled trees less than 8” 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 8-20” dbh on 361 acres under the proposed action.

Heavy equipment would create localized ground disturbance on reoccupied skid trails. Re-establishment of up to 40 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. Trees would be planted on landings not removed as part of the watershed restoration program.

On the 361 acres from which 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 30% 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/July through October).
- All vegetation not removed from the project area would be uniformly spread across skid trails to protect exposed soils and enhance soil productivity.
- 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 tree 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, waterbars, and other drainage structures damaged during operations would be repaired or replaced to prevent road failures that might damage soils and slopes.

Effects of the Low Intensity Thin Alternative on Soils
Under the low thin alternative, 864 acres would be thinned by handcrews 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 361 acres where logs are skidded, and from reoccupying 40 landings and about 26 miles of skid trails. After treatment, these areas would be rehabilitated and mulched to minimize new erosion. There would be less soil disturbance on 864 acres under the low intensity thin alternative and 503 acres treated with the low intensity thin prescription under the proposed action where heavy equipment would not be used to remove logs. Soils in the moderate intensity thin prescription 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 on 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 management. 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 both action alternatives by prohibiting equipment operation in areas with slopes greater than 30% and leaving cut trees on the ground to act as mulch and to decompose. The short-term adverse effects on soils under the proposed action and the low intensity thin alternative 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.

Non-Impairment of Soils, Topography and Geology

Under the no action alternative, there would be no new effects on soils, topography or geological resources. Soils and topography in portions of the project area were impaired by the original logging and road construction. Impairment to soils is gradually being reduced as vegetation regrows and soil formation processes act over the long-term. Topography in portions of the project area would remain altered, and in some areas, impaired by the original tractor logging and road construction until watershed restoration treatments are implemented.

Under the proposed action and low intensity thin alternative, there would be no alteration to topography because existing skid trails and landings would be reoccupied under the proposed action and existing roads would be used for access under both action alternatives. Adverse effects to previously disturbed soils from compaction by work crews, and from heavy equipment on stable soils on slopes 30% or less, would be short-term. Any areas of soil exposed or damaged by heavy equipment would be rehabilitated after thinning operations are completed. Adverse effects to soils on slopes steeper than 30% would be avoided by using cut trees and branches as mulch to reduce erosion and by prohibiting heavy equipment operations under the proposed action. These short-term adverse effects on soils are acceptable because the soils are previously disturbed and because restoration of forests would result in long-term benefits to forest soils by minimizing or avoiding any new erosion and by restoring conditions that promote soil formation processes.

Therefore, neither the proposed action nor the low intensity thin alternative would cause further impairment to soils or topography. Both action alternatives would reduce the logging- and road-related impairment to soils over the long-term by promoting soil formation processes.

Effects of the Alternatives 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 or the low-thin alternative 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 mainstem of Lost Man and Prairie Creeks downstream of the project area are described under cumulative effects.

Effects on Water Quality and Riparian Wetlands Common to Thinning Alternatives—Under the proposed action and the low intensity thin alternative, 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.

Under the proposed action, no ground-based heavy equipment would be allowed within any stream protection zone, except for swale features on slopes 30% or less. To protect water quality from indirect adverse effects from soil erosion that might result from use of heavy equipment, woody biomass would not be removed on slopes greater than 30%. Heavy equipment would be prohibited from operating in or crossing channels on any slope and swales on slopes over 50%. The low intensity thin alternative would not require heavy equipment; all thinning would be done with chainsaws by handcrews and no woody biomass would be removed.

Best management practices (BMPs) would be used where streams, water quality or riparian wetlands could be adversely affected.
BMPs to be incorporated into thinning prescriptions include

- retaining all trees in the bankfull width of a stream channel;
- retaining trees that contribute to channel and bank stability;
- retaining all trees in streamside areas where slope steepness exceeds 45%;
- prohibiting cutting on unstable or potentially unstable areas regardless of slope steepness and within 50 feet of such areas; and
- retaining trees that lean toward a stream channel to enhance recruitment of woody debris.

The above BMPs also apply to swales (topographic depressions on hillslopes that show no evidence of surface flow or channel development) on slopes 30% or less. In swales on slopes greater than 30%, an additional BMP requires thinning prescriptions that retain at least a 50% post-treatment tree canopy throughout the swale or within 50 feet on either side of the swale, whichever distance is greater.

Streamside protection zones vary in width depending on the stream type and slope steepness.

To protect riparian wetlands, the BMPs would apply within 100 feet on either side from the outer edge of the riparian zone.

In ephemeral and intermittent streams on slopes 30% or less, streamside protection zones would be a minimum of 50 feet wide or to a break in slope, whichever is greater, and a thinning prescription that retains at least a 50% post-treatment tree canopy. For ephemeral and intermittent streams on slopes of 31- 45%, the streamside protection zone would increase to 100 feet wide or the break in slope, and a 70% post-treatment canopy would be retained.

For perennial and higher order streams, streamside protection zones would be increased to 300 feet from the outer edge of the channel with 70% post-treatment canopy retention on slopes 30% or less and an 80% canopy retention on slopes between 31% and 45%.

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. The Lost Man Creek watershed restoration project was begun in 1999 and is scheduled for completion 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 South 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 on 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 South 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 and the low intensity thin alternative, there would be no effects on floodplains. Direct adverse effects on water quality and riparian wetlands would be avoided under both thinning alternatives 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 or channel features. Indirect adverse effects on water quality would be avoided under both thinning alternatives 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 or the low intensity thin alternative would be negligible.

Non-Impairment of Water Resources, including Water Quality, Floodplains and Wetlands
Water quality and riparian wetlands in portions of the project area were impaired by logging and road construction prior to becoming part of the park. This impairment to watersheds was a primary reason for park expansion. The effects on watersheds in the park from past logging and the resulting park expansion legislation are directly responsible for the definition of impairment and the “no derogation” standard that applies to management of all units in the national park system (Management Policies 2006). Under the no action alternative, adverse effects on water quality and riparian wetlands in the project area would continue to decrease as the watershed recovers from past logging and road construction. If major storms cause roads to fail, and eroded sediment enters a perennial stream, water quality and riparian wetlands might be impaired in some areas depending on the intensity of the storm and the extent of erosion. Therefore, the existing impairment to water quality and riparian wetlands in the project area would continue under the no action alternative but would gradually decrease over the very long-term.

Under both the proposed action and the low intensity thin alternative, streamside protection zones would be established and best management practices would be used to avoid or minimize adverse effects on water quality and riparian wetlands from thinning of second growth forests. Therefore, water quality and riparian wetlands would not be impaired under either thinning alternative. The negligible indirect adverse effects on water quality and riparian wetlands from minor soil disturbance under either action alternative would be acceptable because these resources would benefit over the long-term from restoration of forests.

Effects of the Alternatives on Vegetation
Estimates for pre-treatment and post-treatment stand characteristics under all alternatives are presented in Table 10. Estimates for the low intensity thin alternative are based on data from all units and for trees greater than 4.5" dbh. Estimates for the proposed action (moderate intensity thin) are based on the specific units with slopes 30% or less where woody biomass would be removed. Stand characteristics in units where no woody biomass would be removed under the proposed action would be the same as the low intensity thin alternative.

Table 10. Pre- and Post-Treatment Stand Characteristics

Stand Characteristic (average)	Pre-treatment (No action)	Low Intensity Thin 25% Above	Moderate Intensity Thin (Preferred Action) 40% Below
All Species			
Stand basal area (ft^2/ac)	316	237	199
Live trees per acre	550	443	288
Size of standing live trees (dbh)	10	10	12
Trees cut per acre	-	99	262
Size of cut trees (dbh)	-	12	9
Douglas-fir			
Basal area (ft^2/ac)	165	86	55
Live trees per acre	274	168	35
Size of standing live trees (dbh)	11	10	17
Trees cut per acre	-	99	239
Size of cut trees (dbh)	-	12	9
Douglas-fir to Redwood Ratios (Means of Unit ratios) for live trees			
Basal area (ft^2/ac)	2.3	1.2	0.8
Trees per acre	3.1	2.5	0.4

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 on 142 acres, 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 Thinning 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.

Both thinning alternatives 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.

Under both action alternatives, 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.

Minimizing the stump-sprouting response in the 142 acres dominated by tanoak would reduce the fire hazard in these areas. To minimize the sprouting response in cut tanoak, removal would be limited to those tanoaks around suitable conifers to provide for release and canopy development of retained trees. Priority would be given to releasing redwoods, then dominant Douglas-fir, other dominant conifers, and finally hardwood trees that are less common in these stands, such as madrone and giant chinquapin. This would contribute to the overall long-term benefit to the forest. The benefit would be minor in the short-term and moderate as the forest stands grow.

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 on Forest Structure Specific to the Proposed Action

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 the low intensity thin prescription on 503 acres, 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 a moderate intensity prescription. Under the proposed action, there would be a greater overall long-term benefit in less time on the 361 acres that are moderately thinned 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 the 361 acres treated with the moderate intensity thin prescription compared to the low intensity thin prescription on 503 acres. This would be a moderate benefit on the 361 acres within several decades of the thinning. Understory and canopy development would occur more slowly on the 503 acres with the low intensity thin 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.

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". There would be a minor reduction in fire hazard under the moderately thinned areas because the boles of trees over 8" dbh would be removed.

Effects on Forest Structure Specific to the Low Intensity Thin Alternative

Under the low intensity thin alternative, an average of 99 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" to act as mulch to protect soil and to encourage growth of understory vegetation. Under the low intensity thin alternative, second growth trees larger than 18” and less than 20” 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 this alternative, compared to the no action alternative, but less than the 361 acres moderately thinned under the proposed action. The overall effect to understory vegetation and canopy development would be minor.

Fire hazard would temporarily increase under this alternative, 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”. The increased fire hazard, created under this alternative, is expected to decrease substantially within 10 to 15 years of the thin.

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 effect on vegetation from the Lost Man Creek watershed restoration project scheduled for completion in 2010 would be localized on 216 acres of second growth forest on and along roads that are being removed. This would be a negligible to minor adverse effect because the vegetation to be removed has grown back following logging and road construction that destroyed the original vegetation community. 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 on 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 on 361 acres would mitigate the short-term increase in fire hazard caused by the increase in woody debris created under the moderate intensity thinning. The woody debris left from this alternative would be trees less than 8" dbh and the branchwood of trees larger than 8" dbh. The fire hazard in these treated areas would decrease within about 10 years, as the fuels left in contact with the ground decompose. 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 either action alternative from the proposed thin prescription (less than 30% basal area reduction) in the 104 acres of old growth buffer. 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.

Thinning in the 142 acres dominated by tanoak would promote growth of selected individual conifers. This would be a moderate, long-term benefit to individual conifers selected for release and a negligible long-term benefit to forest stands throughout the project area. Minimizing the stump-sprouting response of tanoak would be a minor long-term benefit within the 142 acres and a negligible long-term benefit to forest stands in the project area. There would be a negligible benefit to forest canopy on the 142 acres because the sparse thinning would not alter the canopy.

Under the proposed action, a moderate thin on 361 acres 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. 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 moderate intensity thinning on 361 acres 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 low intensity thin prescription (864 acres under the low intensity thin alternative and 503 acres under the proposed action), there would be fewer trees cut but forest conditions would not be restored as quickly and low intensity thinning would not promote growth of remaining trees or canopy development as effectively as the moderate thin. The effect of thinning on 864 acres under the low intensity thin alternative and on 503 acres under the proposed action would be a negligible short-term adverse effect with a minor long-term benefit. The benefit to park forests would be less than under a moderate intensity thin prescription.

Non-Impairment of Vegetation Resources
Clearcut logging impaired the old growth forest communities. Because Douglas-fir trees are fast–growing and long-lived, failing to act (no action) would allow the imbalance in species composition (Douglas-fir to redwood ratio) to persist for centuries.

The action alternatives would reduce the impairment within the project area by shortening the time for portions of the park forests to reattain old growth forest characteristics, structure, and function. The impairment to park forests would continue for centuries on the 48,300 acres of untreated second growth forest outside the project area.

The impairment on 361 acres that are moderately thinned would decrease more quickly than the low intensity thin prescription on 503 acres under the proposed action and on the 864 acres under the low intensity thin alternative.

Removal of trees on 361 acres under the proposed action is acceptable because this would decrease the fuel loading and fire hazard and is needed to meet the restoration goals of the 1980 and 1999 GMP. Allowing the second growth forest to remain untreated under the no action alternative creates an unacceptable impact because the restoration goals in the 1980 and 1999 GMPs would not be met.

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.

There are no effects on fish or aquatic biota under either of the action alternatives because cutting would be restricted to 70% to 80% canopy retention within 300 feet of perennial streams and 50% to 70% canopy retention within 100 feet of intermittent streams and there are no fish-bearing stream reaches that would be affected by project work.

Under both the proposed action and the low intensity thin alternative, 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.

Under the old growth buffer areas, the 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 and the low intensity thin alternative 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 on 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 361 acres that are moderately thinned under the proposed action, and in the 104 acres of 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.

Non-Impairment of Wildlife and Fish Resources
None of the alternatives would have direct adverse effects on fish because there are no fish-bearing streams that would be affected by management of second growth forest in the project area. There would be negligible indirect benefits to fish from management of second growth forests and negligible indirect adverse effects from allowing second growth forests in the project area to develop without active management (no action). Therefore, fish populations would not be impaired under either action alternative or under the no action alternative. The impairment to fish populations in park streams outside the project area, including Redwood Creek, would continue but is lessening as the habitat recovers, watershed management practices outside the parks improve, and the watershed restoration occurs both in and outside the park.

Under the no action alternative, indirect adverse effects on wildlife from poor quality habitat in unmanaged forests would continue for decades to centuries. Despite the poor quality habitat in second growth forests in the project area, there is sufficient good quality habitat remaining elsewhere in the park to support wildlife populations. The original logging caused an impairment to park wildlife populations from destruction and degradation of habitat but that impairment is gradually decreasing as forests develop. Therefore, the no action alternative would not further impair wildlife resources but unmanaged forests create an unacceptable long-term effect on wildlife from persistence of poor quality habitat.

There would be negligible short-term adverse effects on individuals of small, less mobile wildlife species during thinning operations under either action alternative, and minor to moderate long-term benefits to all wildlife from improvement of habitat as the forest, understory, and canopy develops following thinning. These adverse effects are short-term. Second growth forest restoration under either the proposed action or the low intensity thin alternative would have long-term benefits as habitat improves. Therefore, there would be no impairment to wildlife resources under either action alternative. The short-term adverse effects from thinning would be acceptable because the existing habitat that would be affected by the proposed action is poor quality and would be improved by thinning.

Effects of the Alternatives on Sensitive, Threatened and Endangered Species
Two CNPS list 2 plant species are present in the project area. The locations of these plants have been mapped and they will be protected to the greatest extent practicable. None of these plants occur in moderate intensity thin areas of the proposed action. 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.

The NPS determined that this project would not affect listed fish species or their critical habitat. NOAA Fisheries concurred with this determination.

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 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. There would be long-term benefits to northern spotted owls under the proposed action from habitat improvement through acceleration of development of late-successional forest structure. The short-term effects on the northern spotted owl would be the same from the 25% basal area reduction (low intensity thin prescription) on the 503 acres under the proposed action and the 864 acres under the low intensity thin alternative and in the tanoak areas, the old growth buffer, and the streamside protection zone. The difference between the proposed action and the low intensity thin alternative is a greater long-term benefit from the moderate intensity thin on the 361 acres under the proposed action due to greater habitat improvement in a shorter time.

The proposed action and the low intensity thin alternative would alter approximately 1539 acres of suitable northern spotted owl habitat. The existing habitat is poor quality and the short-term adverse effects on owls from habitat alteration would be negligible. Short-term adverse effects from noise and disturbance would be avoided by prohibiting work that creates noise within 0.25 mile of nesting and roosting habitat from February 1 through July 31, unless surveys determine that a site is unoccupied or the owls are not nesting.

Deformed trees and snags would be retained and protected from loss by felling trees in a direction that would avoid hitting the retained trees. This would have a minor to moderate indirect benefit to northern spotted owls that use deformed trees for nesting.

In the old growth forest buffer, low intensity thinning would maintain sufficient canopy cover to prevent rapid shrub proliferation and minimize the creation of food resources for corvids. Canopy trees would be selected for removal based on maximizing release of dominant redwoods and other conifers to stimulate development of potential nest trees and nesting habitat components such as large branches and cover trees in this old growth buffer area. This would be a minor indirect long-term benefit to marbled murrelets and northern spotted owls from minimizing nest predation.

The proposed action would affect suitable marbled murrelet nesting habitat in residual stands and adjacent to suitable nesting habitat in contiguous old growth stands. Marbled murrelets would be affected by modification of second growth forest surrounding 94 acres of scattered residual trees and clustered residual trees, and by treatments in second growth adjacent to 70 acres of contiguous old growth forest in the old growth buffer. Short-term habitat modification would occur on 5 acres of occupied residual stands and 89 acres of unoccupied residual stands. The second growth stands currently contribute to murrelet nesting success by protecting nests from weather, supporting adequate microclimate conditions, and minimizing predation. Residual and old growth trees would be protected by restricting cutting to trees shorter than the height of the lowest live limb and prohibiting yarding operations within a 50-foot-diameter circle around the dripline of residual or old growth trees. The proposed action would initially reduce canopy density and stand volume in second growth forest surrounding the residual trees, and would increase edge-related effects (weather, microclimate, and predation). Over the very long-term, 1710 acres that are treated would become higher quality nesting habitat. The proposed action would have long-term benefits to marbled murrelets from increasing the amount, quality and distribution of nesting habitat.

There would be no direct adverse effects on marbled murrelets from injury or mortality due to tree-felling under any of the alternatives, including the proposed action and no action. Indirect effects to marbled murrelets from increased risk of predation would be minimized by using a thin from below prescription within 300 feet of the contiguous old growth forest to minimize proliferation of berry-producing shrubs and other food resources for Steller's jays and other corvid nest predators.

The proposed action would cause direct adverse effects on marbled murrelets from harassment from noise from chainsaws, felling, hauling, yarding, and truck traffic on 237 acres of occupied nesting habitat for one breeding season and 30 acres of occupied nesting habitat for three breeding seasons. An additional 164 acres of murrelet nesting habitat would be modified due to proposed thinning (5 acres of occupied residual stands, 89 acres of unoccupied residual stands, and 70 acres of occupied old growth forest.). Effects on marbled murrelets under the low intensity thin alternative would be similar to the proposed action although there would be no noise disturbance from yarding, hauling, or truck traffic. Under the low intensity thin alternative, chainsaws would create noise on 237 acres of occupied nesting habitat for one breeding season and 30 acres of occupied nesting habitat for three breeding seasons. An additional 164 acres of murrelet nesting habitat would be modified due to proposed thinning (5 acres of occupied residual stands, 89 acres of unoccupied residual stands, and 70 acres of occupied old growth forest.).

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.

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 in 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. Watershed restoration and facility construction and maintenance would have minor short-term adverse effects on listed fish and their designated critical habitat from increased potential for erosion from disturbed soils (watershed restoration, road maintenance, construction of the Aubell maintenance facility). Construction, maintenance, and visitor use of campgrounds, picnic areas, and trails would increase the predation threat to northern spotted owls and murrelets by attracting jays, ravens, and other corvid nest predators, especially in campgrounds.

The total allowable incidental take authorized by the USFWS for marbled murrelets for all park projects for consultations completed by December 2005 is 5,671 acres of habitat potentially affected by noise disturbance. The NPS reported potential incidental take on 3,687 acres (64% of total allowed) in 2005. Projects for which take of murrelets due to noise disturbance was reported in 2005 were annual maintenance of facilities, roads and trails (2,110 acres in six locations under authorization originally obtained in 1998); Skunk Cabbage Trail use (59 acres under 1998 authorization); and Howland Hill Road repair (1,577 acres under 1999 authorization). Projects for which take was authorized but not reported in 2005 because no actions were taken under these authorizations are two watershed restoration projects (take originally authorized in 1998 and 2001); helicopter use for emergency access (2001 authorization); and culvert replacement on the Mill Creek and Lost Man Creek trails (2005 authorization).

Marbled murrelets are likely to be indirectly adversely affected by an increased nest predation threat from visitor and staff use of proposed trails and trailheads under the draft trail and backcountry use plan as well as visitor and staff use of existing RNP developments and dispersed use areas caused by visitors inadvertently leaving food scraps or feeding wildlife in or near suitable habitat areas and thereby attracting potential predators. 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 NPS requested, and the USFWS authorized, incidental take for increased predation threat and noise disturbance effects amounting to 12,830 acres caused by existing visitor and staff use of park developments and an additional 1,188 acres from the proposed action for a total of 14,018 acres. Marbled murrelets are also likely to be adversely affected through the potential disturbance of suitable nesting habitat by emergency trail maintenance occurring on the proposed East Side Trail in the Redwood Creek basin (for the clearing of two large fallen trees with chainsaws during the seasonal noise restriction period). The NPS reported incidental take of marbled murrelets from an increase threat of predation for Lost Man Creek watershed restoration (17 acres) and visitor use of trails, picnic areas, and campgrounds (10,306 acres.)

In 2007, the NPS reported incidental take of marbled murrelets on 3,344 acres due to noise disturbance from various sources, and on 3 acres from habitat degradation due to watershed restoration in Lost Man Creek. In 2007, incidental take for noise disturbance was reported from annual facility maintenance (508 acres); watershed restoration in Lost Man Creek (114 acres); and visitor use of trails, picnic areas, and campgrounds (2,171 acres).

The total amount of spotted owl nesting, roosting and foraging habitat that would be degraded by construction of proposed trails is approximately 14.5 acres spread throughout more than 69,000 acres of suitable habitat (0.02%) throughout RNP.

Spotted owls are likely to be adversely affected through the potential disturbance of suitable nesting habitat by emergency trail maintenance occurring on the proposed East Side Trail (for the clearing of two large fallen old growth trees with chainsaws during the seasonal noise restriction period). The NPS requested, and the USFWS authorized, 250 acres of incidental take for conducting emergency trail maintenance. Based on past trail maintenance records, it is not expected that these 250 acres would be disturbed every year. Spotted owls are also likely to be adversely affected by noise disturbance of suitable nesting habitat caused by visitor and staff vehicles on existing and proposed-to-be opened RNP roads. The NPS requested, and the USFWS authorized, an additional 2,225 acres of incidental take for this noise disturbance.

The total allowable incidental take for northern spotted owls authorized by the USFWS for all park projects under consultations completed by December 2005 is 5,167 acres of habitat potentially affected by noise disturbance. The NPS reported potential incidental take of northern spotted owls on 775 acres (15% of total allowed) in 2005 due to noise disturbance for annual maintenance of facilities, roads and trails due to downed tree removal and brushing trails. Other

sites and projects for which incidental take of marbled murrelets was reported either do not affect northern spotted owls (helicopter use, Lost Man Creek watershed restoration under the 2001 authorization) or surveys were completed to determine that no owls would be affected in these areas. In 2007, the NPS reported incidental take of northern spotted owls due to noise disturbance on 125 acres due to facility maintenance and 2,604 acres due to visitor use.
For the Lost Man Creek watershed restoration project adjacent to the proposed second growth management project area, the NPS requested, and the USFWS authorized, incidental take of marbled murrelets expected from harassment of nesting birds due to operation of heavy equipment in 2 acres of occupied nesting habitat during the breeding season; harm of murrelets due with an increased risk of corvid predation on 66 acres of nesting habitat; and harm of murrelets associated with 7 acres of nesting habitat due to habitat degradation. The USFWS biological opinion concluded that the level of anticipated take from this project is not likely to result in jeopardy to the marbled murrelet, or destruction or adverse modification of critical habitat for the marbled murrelet. No incidental take of northern spotted owls was requested for the Lost Man Creek watershed restoration.

On-going projects for which consultations with the USFWS have been completed and which have been determined that the projects may affect but are not likely to adversely affect northern spotted owls or marbled murrelets are management of exotic plants throughout RNP, fire management throughout the parks, management of Port-Orford-cedar in the northern part of the parks, and vehicle beach access (although beach access does have adverse effects on western snowy plovers and the NPS has been authorized direct take of one plover annually.)

Projects for which consultations with the USFWS have been completed but the project has not been implemented include rehabilitation of Alder Camp Road in Del Norte County, and development of visitor facilities at Freshwater Lagoon Spit. The USFWS has concurred with the NPS determination that these projects may affect but are not likely to adversely affect northern spotted owls or marbled murrelets.

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); previous Lost Man Creek Watershed Restoration projects (151422SRW01AR54:BW, July 2003); fire management (NOAA Fisheries biological opinion and letter of concurrence151422SWR04AR99149:BW, January 2005); and relocation of the RNP maintenance facility (NOAA Fisheries biological opinion 151422SWR2003AR8948:BAD, October 2005). The maintenance facility project is located outside the Redwood Creek watershed and will not have any effects on fish in the project area or in Redwood Creek.

The NPS requested incidental take for California Coastal Chinook salmon, Southern Oregon/Northern California Coasts coho salmon, and Northern California 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.

Based on the size, nature and duration of the Lost Man Creek watershed restoration project, the NPS determined that the watershed restoration project may affect and is likely to adversely affect California Coastal Chinook salmon, Southern Oregon/Northern California Coasts coho salmon, and Northern California steelhead, their habitat, and Essential Fish Habitat. However, the short term adverse affects are outweighed by the long-term benefits to the species and their habitats from the long-term reduction in sedimentation of streams in the project area.

Conclusions on Effects on Sensitive, Threatened and Endangered Species
There would be no effect on listed fish species or their critical habitat under any of the alternatives for second growth forest management, including the proposed action and the no action alternative.

The NPS determined, and the USFWS concurred, that the proposed action may affect but is not likely to adversely affect northern spotted owls, and that the proposed action is likely to adversely affect marbled murrelets. These determinations also apply to the effects on owls and murrelets under the low intensity thin alternative.

The short-term adverse effects on the northern spotted owl and the marbled murrelet would be the same from the 25% basal area reduction (low intensity thin prescription) on the 503 acres under the proposed action and the 864 acres under the low intensity thin alternative and in the tanoak areas, the old growth buffer, and the streamside protection zones.

The proposed action and the low intensity thin alternative would alter approximately 1539 acres of suitable northern spotted owl habitat. The existing habitat is poor quality and the short-term adverse effects on owls from habitat alteration would be negligible. Short-term adverse effects on owls from noise and disturbance would be avoided by observing noise restriction periods. The short-term adverse effects on northern spotted owls would be negligible.

The difference between the proposed action and the low intensity thin alternative is a greater long-term benefit to owls from the moderate intensity thin on the 361 acres under the proposed action due to greater habitat improvement in a shorter time. There would be a long-term minor benefit to owls from habitat improvement due to low intensity thinning on the 503 acres under the proposed action and 864 acres under the low intensity thinning alternative, with a potential for a moderate long-term benefit from habitat improvement in the 361 acres that are moderately thinned under the proposed action.

The proposed action would cause direct adverse effects on marbled murrelets from harassment from noise from chainsaws, felling, hauling, yarding, and truck traffic on 237 acres of occupied nesting habitat for one breeding season and 30 acres of occupied nesting habitat for three breeding seasons. An additional 164 acres of murrelet nesting habitat would be modified due to proposed thinning (5 acres of occupied residual stands, 89 acres of unoccupied residual stands, and 70 acres of occupied old growth forest.) These effects are considered moderately adverse. The NPS has requested, and the USFWS authorized, incidental take of marbled murrelets for these adverse effects. The number of acres of nesting habitat subject to disturbance would be minimized by implementing daily limited operating periods for noise-generating work. Over the long-term (decades to centuries), the proposed action would accelerate development of late-successional forest structure and murrelet habitat on 1710 acres of second growth forest, 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.

Non-Impairment of Sensitive, Threatened and Endangered Species
Thinning second growth forests under either action alternative would not affect listed fish species or their critical habitat, and therefore would not cause impairment to fish resources. Under the no action alternative, the impairment to fish populations caused by direct loss of habitat outside the project area and widespread erosion resulting from the original logging and road construction would continue. However, leaving the second growth forest in the project area unmanaged would not cause further impairment to listed fish or their critical habitat as the forests gradually recover without additional manipulation.

The NPS determined, and the USFWS concurred, that the proposed action may affect but is not likely to adversely affect northern spotted owls. The low intensity thin alternative would have fewer short-term adverse effects on owls because fewer trees would be removed but the long-term benefits would require a longer time to occur because the remaining trees would not grow as fast as under the proposed action (moderate thin alternative). The no action alternative would continue to have both short- and long-term adverse effects on owls because habitat quality would remain low. None of these alternatives would increase the existing impairment to spotted owl populations but the level of impairment under the no action alternative would persist significantly longer than under either action alternative. Range expansion of the barred owl is increasing the potential for impairment to spotted owl populations but none of the alternatives would affect the process of barred owl range expansion. The short-term adverse effects on owls from short-term alteration of poor quality habitat under the proposed action and the low intensity thin alternatives are acceptable impacts that would result from implementation of the management direction outlined in the 1999 GMP/EIS, the USFWS recovery plan for the northern spotted owl, and the 1978 legislation expanding Redwood National Park.

The USFWS concluded that implementation of the proposed action would not affect designated critical habitat for the marbled murrelets and is not likely to jeopardize the continued existence of marbled murrelet because the modification of habitat and harassment are relatively short-term and are not expected to have a long-term adverse influence on murrelet numbers and reproduction. The USFWS authorized incidental take from harassment (noise and disturbance) on 237 acres of occupied nesting habitat for one breeding season and 30 acres of occupied habitat for three breeding seasons, and from modification of 164 acres of nesting habitat. The USFWS believes that the adverse impacts of the proposed action would be minimized by measures incorporated into project design. The biological opinion issued by the USFWS for the proposed action reiterated that the USFWS recovery plan for the marbled murrelet identifies silvicultural techniques such as thinning to increase the rate of developing new murrelet habitat as an action that must be taken to prevent a significant decline in murrelet populations or habitat quality. Therefore, the proposed action would not cause impairment to marbled murrelets. The short-term adverse effects on murrelets from noise disturbance under the proposed action are acceptable impacts that would result from implementation of the management direction outlined in the 1999 GMP/EIS, the USFWS recovery plan for the marbled murrelet, and the 1978 legislation expanding Redwood National 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 South 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 South Fork of Lost Man Creek would continue. Therefore, no impacts to cultural resources would occur under the no action alternative for second growth management. However, indirect affects 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 on 9 units covering 361 acres of the project area where slope is less than 30%. 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.

No ground disturbance is proposed in the remaining 1371 acres of the project area.

Access routes for heavy equipment and travel in the proposed action would include use of Holter Ridge Road and portions of the A170, A160, A141, and A140 roads. Four historic properties are located within the vicinity of these access routes. These are a patch of beargrass that has ethnographic significance to Yurok people, an isolated goosepen tree that also has ethnographic significance to Yurok, a historic period logging camp from the 1960s, and the former Holter Ridge ranch site. Consultation with the California SHPO was conducted on access and road maintenance for the on-going watershed restoration project in Lost Man Creek. It was determined that no adverse affect or impact is expected to the beargrass site, the goosepen, the 1960s logging camp or the former Holter Ridge Ranch site from access and maintenance of access roads (SHPO Reference No. NPS060328A(NPS 2008).

In addition, a 1920s-1940-era logging camp site was identified in Unit A of the project. A dump site associated with the camp appears to be more than 50 years old and would meet criteria for eligibility to the National Register of Historic Places based on its ability to convey information about logging operations and human activities in lands now within the Lost Man Creek watershed of Redwood National Park. The site appears to be completely intact. Surface evidence found approximately 28 artifacts including car parts and broken glass and ceramics (Sloan 2007).

The camp site located in Unit A is likely eligible for listing on the National Register at the local level based on its integrity, the artifacts it contains, and its information potential to convey the settlement and use history of lands in Humboldt County. Few if any such historic archeological resources have been evaluated in Redwood National Park or in Humboldt County. Therefore such dumpsites are assumed to retain significance until a historic archeological context is defined for such resources. The NPS has requested funding for such an evaluation, but this is likely to not be funded for many years.

Protection measures for the logging camp would include avoiding all logging activities within 20 meters of the observed deposit. Flagging would be used to mark the exclusion zone. The site would be protected by hand thinning with chainsaws directionally falling trees away from the deposit of artifact materials. The NPS project manager would be on site when work is to occur within Unit A and would coordinate with equipment operators to ensure that all equipment remains within the existing road corridor and is not driven onto the site. This treatment would result in negligible adverse impacts to this cultural resource. Under Section 106 of the NHPA, the proposed protection measures would result in no adverse affect to this historic property under the proposed action.

Continued use and maintenance of existing access roads would result in negligible to minor adverse impacts to cultural resources. The bear-grass site along Holter Ridge Road would be marked to protect it from being cut during brushing or damaged by equipment used for road maintenance.

Effects on Cultural Resources of the Low Intensity Thin Alternative —Effects under the low intensity thin alternative would be less than under the proposed action because no heavy equipment use is proposed. Protection measures for the historic 1940s logging camp would include flagging the site to identify its location to crews felling trees and directionally falling trees away from the deposit to avoid direct damage. Continued use and maintenance of existing access roads would result in negligible to minor adverse impacts to cultural resources. No adverse affected to historic properties as defined under Section 106 of the NHPA would be expected from implementation of this alternative.

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

Conclusions on Effects on Cultural Resources—Both the proposed action and low intensity thin alternative would have negligible to minor adverse affects 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 or under the low intensity thinning alternative would not change the treatment and management of archeological resources or other historic properties.

Under the terminology of Section 106 of the National Historic Preservation Act, no adverse affect to historic properties determined eligible for or listed on the National Register of Historic Places is expected from the proposed action. As with the Endangered Species Act, the NPS consults with the SHPO only on the proposed action. The low thin alternative would not affect any additional cultural resources and therefore, would not be expected to adversely affect any historic properties determined eligible for or listed on the National Register of Historic Places.

Non-Impairment of Cultural Resources— No adverse effects to historic properties are anticipated in the project area under the no action alternative (no active management of second growth forests). Therefore, there would be no impairment to cultural resources under the no action alternative.

No adverse effects to historic properties are anticipated from the proposed action (moderate intensity thinning with biomass removal). Therefore, there would be no impairment to cultural resources under the proposed action.

No adverse effects to historic properties are anticipated from the low intensity thin alternative. Therefore, there would be no impairment to cultural resources under the low intensity thin alternative.

Thinning trees as described under the proposed action is acceptable because there would be no adverse effects to cultural resources. Similarly, thinning trees as described under the low intensity thin alternative would be acceptable because there would be not adverse effects to cultural resources.

Effects of the Alternatives on Visitor Experience and Scenic Quality
There is no current or planned visitor use in the project area. Under the no action alternative, the scenic quality of the project area would remain low. There would be no effect on scenic quality of the existing old growth forest adjacent to the project area. Under both action alternatives, 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 both action alternatives, 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. 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. The impairment to scenic quality of long-distance views in the clearcut areas of the park is decreasing as the forest develops but the poor scenic quality from close-up views will continue for centuries.

Conclusions on Effects on Visitor Experience and Scenic Quality
There would be negligible effects on visitor experience in the project area under any of the alternatives, 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 and the low intensity thin alternative, 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 and the low intensity thin alternative, 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 in the 361 acres that are moderately thinned because there would be more vigorous response. There would be a minor benefit to scenic quality from a low intensity thin on 864 acres under the low intensity thin alternative and on 503 acres under the proposed action. The minor benefit to scenic quality from low intensity thinning would occur over a longer time than in the areas that are moderately thinned.

Non-Impairment of Scenic Resources and Opportunities for Enjoyment
There is no existing or planned visitor use in the project area. There might be temporary closures of the Holter Ridge Bike Trail during log hauling operations under the proposed action but other park trails would remain open. Scenic quality of the project area would be initially decreased during thinning operations under both action alternatives and would gradually improve as the thinned forest develops an understory and a stratified canopy. Scenic quality would overall improve more quickly under the proposed action and would eventually be more improved than scenic quality under the low intensity thin alternative. Therefore, scenic resources would not be impaired under the proposed action or the low intensity thin alternative. Under the no action alternative, scenic quality of the project area would remain impaired in the dense forest with no understory or multilayered canopy.

Temporary closure of the Holter Ridge Bike Trail is acceptable, as other opportunities for enjoyment of the park and its resources, including other hiking and mountain biking opportunities, are available in the parks and the region. The initial decrease in scenic quality during, and for several years after, thinning operations is an acceptable impact because it is temporary and is a result of an action needed to attain the desired future condition.

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 that are generally implemented by crews contracted through the California Department of Corrections. 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 negligible, short-term impacts on park operations. Administrative functions would be needed, mostly related to the park's contracting office. Vegetation management staff would spend some of their 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 per acre cost for implementing the low intensity thin is $700. Therefore, under the proposed action, the estimated cost for implementing the low intensity thin (thinning and leaving cut trees on site) on 503 acres is $352,100. The estimated cost for implementing thinning prescriptions in old growth buffers (104 acres), tanoak dominated zones (142 acres), and streamside buffer areas (only 247 acres will be thinned as the remaining 375 acres of streamside buffer areas are located on slopes greater than 45% and will not be thinned) is $345,800. For the moderately thinned areas under the proposed action, the value of the trees removed from the 361 acres is assumed to pay for the work. If market forces, however, do not allow the value of the wood removed to cover the costs for implementing the thin, the 361 acres would be thinned under the low intensity prescription and the wood left on site. These additional acres would add approximately $252,700 to the project cost. The total cost of implementing the proposed action is estimated to range from $697,900 for thinning on 996 acres (excluding moderately thinned areas and steep streamside buffer areas) to $949,900 for thinning on 1357 acres (excluding only steep streamside buffer areas).

Under the low intensity thin alternative, there would be negligible, short-term impacts on park operations, mostly related to contracting within park administrative functions, and resource management staff oversight of project implementation as COTR's and implementing short and long-term post-thin monitoring . Under the low intensity thin alternative, the estimated cost for implementing this action would be $949,900 on 1357 acres (excluding steep streamside buffer areas).

Conclusions on Effects on Park Operations and Socioeconomics
Under the proposed action, there would be an economic benefit to the local economy from sale of merchantable timber produced from the 361 acres. 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, nor under the low intensity thin alternative because these alternatives do not provide for sale of merchantable timber. There would be no impact to park operations or socioeconomics other than business as usual under the no action alternative. 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, and are therefore acceptable. Under the action alternatives, the socioeconomic environment of the park may benefit as dollars are expended via contracted services into the local economy, and are therefore acceptable.

List of Preparers

- Karin Anderson, Cultural Resource Program Manager, NPS, Orick CA
- Leonel Arguello, Vegetation Program Manager, NPS, Orick CA
- Aida Parkinson, Supervisory Environmental Specialist, NPS, Orick CA
- Jason Teraoka, Forester, NPS, Orick CA

Consultation and Coordination

- Keith Bensen, Fish and Wildlife Biologist, NPS, Orick CA
- Judy Wartella, GIS Specialist, NPS, Arcata CA
- Robin Hamlin, Wildlife Biologist, FWS, Arcata CA
- Wendy Cole, Fisheries Biologist, NOAA Fisheries, Arcata CA

References

Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC.

Agee, J. K. 2002. The fallacy of passive management. Conservation in Practice 3(1): 18-25.

Anderson, D.G. 1988. Juvenile salmon habitat of the Redwood Creek basin in Humboldt County, California. Master's Thesis. Humboldt State University, Arcata, CA. 99 pp.

Bearss, E. C. 1969. History, Basic Data, Redwood National Park, Del Norte and Humboldt County. Division of History, Office of Archeology and Historic Preservation. National Park Service, United States Department of the Interior. Reprinted March 1982. Copy available at park office in Orick, CA.

Bensen, K. 2007. A Biological Assessment of Impacts to Terrestrial Threatened and Endangered Species from the South Fork Lost Man Creek Second growth Management Plan in Redwood National and State Parks. On file at park offices in Orick, CA. 31 pp.

Brown, R.A. 1988. Physical rearing habitat for anadromous salmonids in the Redwood Creek basin, Humboldt County, California. Master's Thesis. Humboldt State University, Arcata, CA. 132 pp.

California Native Plant Society. 2006. CNPS Inventory of Rare and Endangered Plants. CNPS Inventory On-line. http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi. v7-06a, 1-24-06.

Chittick, A. J. 2005. Stand structure and development following thinning in a second growth forest, Redwood National and State Parks. Master's thesis. Department of Forestry, Humboldt State University. Arcata, CA.

Cowardin, L.M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC. Publ. No. FWS/OBS-79/31. 107 pp.

Dagley, C. M., and K. L. O'Hara. 2004. Potential for old forest restoration and development of restoration tools in coast redwood: A literature review and synthesis. A report to Save-The-Redwoods League. San Francisco, CA.

DeBell, D. S., R. O. Curtis, C. A. Harrington, and J. C. Tappeiner. 1997. Shaping stand development through silvicultural practices. Pp. 141-149 in *Creating a forestry for the 21st century.* K.A. Kohm and J.F. Franklin, eds. Island Press. Washington, D.C.

Hagans, D. K., and W. E. Weaver. 1987. "Magnitude, Cause and Basin Response to Fluvial Erosion, Redwood Creek Basin, Northern California." Pp. 419-428 in *Erosion and Sedimentation in the Pacific Rim Steeplands—Proceedings of a Symposium, Corvallis, Oregon, 1987*, R. Beschta, T. Blinn, G. E. Grant, G. G. Ice, and F. J. Swanson, eds. International Association of Hydrological Sciences, IASH-AISH Publication No. 165.

Helms, J.A. (editor). 1998. The Dictionary of Forestry. Society of American Foresters, Bethesda, MD. 210 pp.

Holden, B., III. 2002. Redwood Creek basin 2000-2001 spawning and carcass survey. Annual Progress Report. Redwood National and State Parks, Orick, CA. Available at park office in Orick, CA.

Holden, Baker, III. 2006. A biological assessment of impacts to aquatic threatened species from Lost Man Creek erosion control and disturbed land restoration plan in Redwood National and State Parks (RNP). Redwood National and State Parks. On file at park offices in Orick, CA.

Janda, R. J., K. M. Nolan, D. R. Harden, and S. M. Colman. 1975. Watershed conditions in the drainage basin of Redwood Creek, Humboldt County, California. U.S. Geological Survey Open-File Report 75-568. 266 pp.

Klein, Randy. 2006. Erosion and Turbidity Monitoring in Lost Man Creek, Redwood National and State Parks Annual Report for Water Year 2005 and Retrospective on Water Years 2003-2005. On file at park offices in Arcata, and Orick, CA.

Lindquist, J. L., and M. N. Palley. 1963. Empirical yield tables for young-growth redwood. California Experiment Station. Division of Agriculture, University of California. Bulletin 796. Berkeley, CA.

McConnell, R. B., and J. P. Eidsness. 2000. Report on Ethnographic Inventory/Contemporary concerns for Lost Man and Little Lost Man Creek Watershed Restoration Project. Copy available from park archives in Orick, CA.

National Park Service, U.S. Department of the Interior. 2004. Redwood National and State Parks Fire Management Plan. Copy available at park office in Orick, CA.

National Park Service, U.S. Department of the Interior. 2006. Management Policies 2006. Washington, D.C.

National Park Service, U.S. Department of the Interior. 2006b. Lost Man Creek Watershed Restoration Plan Environmental Assessment. Redwood National and State Parks. Copy available at park office in Orick, CA.

Nolan, K.M., and D. R. Harden. 1976. Graphic and tabular summaries of water and suspended-sediment discharge for two periods of synoptic storm sampling during 1975 in the Mill Creek drainage basin, Del Norte County, California: U.S. Geological Survey, Open-File Report 76-473, 13 p.

Russell, W.H., and C. Jones. 2001. The effects of timber harvesting on the structure and composition of adjacent old growth coast redwood forest, California, USA. *Landscape Ecology* 16:731-741.

Sakai, H. 2003. A conservation strategy for managing threatened and endangered species in Redwood National and State Parks. Unpub. Rep. on file at South Operations Center, Orick, CA

Scrivener, J. C., and B. C. Andersen. 1982. Logging impacts and some mechanisms which determine the size of spring and summer populations of coho salmon fry in Carnation Creek. *In*: Proceedings of the Carnation Creek Workshop: a ten year review. G. F. Hartman, ed. Pacific Biological Station, Nanaimo, BC, Canada.

Sloan, K. 2006. Addendum South Fork and Middle Fork Lost Man Creek Cultural Resources Inventory and Assessment, Redwood National and State Parks. Yurok Tribe Environmental Program, Klamath, CA. Prepared for NPS under Task Agreement Number J84859599A7. Copy available at park office in Orick, CA.

Sloan, Kathleen. 2007. Second Growth Management Cultural Resources Inventory and Assessment, Redwood National and State Parks, Humboldt County, California. Conducted under Task Agreement J8482060069.

Stuart, J. D., and D. Cussins. 1994. Restoration of a 32-year-old stand to an old growth-like condition in Redwood National Park. Pp. 509-510 in Proceedings of the 1994 Society of American Foresters/Canadian Institute of Forestry Convention. September 18-22. Anchorage, AK.

Teraoka, J. R. 2004. Stand response to restoration silviculture in a second growth redwood stand, Redwood National and State Parks. Master's thesis. Department of Forestry, Humboldt State University. Arcata, CA

U.S. Department of Commerce, National Marine Fisheries Service, National Oceanographic and Atmospheric Administration. 1999. Designated critical habitat; central California coast and southern Oregon/northern California coasts coho salmon; final rule and correction. Fed. Reg. 64(86):24049-24062.

U.S. Department of Commerce, National Marine Fisheries Service, National Oceanographic and Atmospheric Administration. 1997. Endangered and threatened species; threatened status for the southern Oregon/northern California coast evolutionarily significant unit (ESU) coho salmon; final rule. Fed. Reg. 62(117):33038-33039.

U.S. Department of the Interior and California Department of Parks and Recreation. 1999. Redwood National and State Parks, Humboldt and Del Norte Counties; final general management plan/ general plan; environmental impact statement/ environmental impact report. Vol. 1: USDI National Park Service and California Department of Parks and Recreation. Denver, CO.

U.S. Department of the Interior, National Park Service. 2000. Record of Decision for Final environmental impact statement and general management plan for Redwood National and State Parks. Humboldt and Del Norte Counties, California. Copy available at park offices in Crescent City and Orick, CA.

Veirs, S. D. 1986. Redwood second growth forest stand rehabilitation study, Redwood National Park: five year evaluation of 1978-79 thinning experiments. Draft report. On file, Resource Management and Science Division, Redwood National Park. Orick, CA.

Walter, T. 1985. Prairie gully erosion in the Redwood Creek basin, California: Redwood National Park Technical Report 16, National Park Service, Redwood National Park, Arcata, CA. 24 pp.

Wensel, L. C., and B. Krumland. 1986. A site index system for redwood and Douglas-fir in California's north coast forest. Hilgardia 54(8) 1-14.

Van Kirk, S. 1999. Historic Resources Study, Lost Man and Little Lost Man Watersheds. Copy available in park archives, Orick, CA.

Internet references

http://forestry.about.com/library/glossary/blforgld.htm, accessed May 7, 2008.

http://www.nature.nps.gov/rm77/restore/, accessed July 1, 2008.

Appendix A – Scoping Letter

United States Department of the Interior
California Department of Parks and Recreation

CALIFORNIA STATE PARKS

Redwood National and State Parks
1111 Second Street
Crescent City, California 95531

L7617 (Second-growth Management)

May 23, 2005

Dear Interested Party:

Subject: Second-growth Forest Management Plan

Reference: Request for Comments on the Preparation of a Second-growth Forest Management Plan (General Scoping)

The National Park Service (NPS) is proposing to manage 1,700 acres of dense, structurally underdeveloped, Douglas-fir dominated second growth forests in the upper watershed of Lost Man Creek, north of Orick to accelerate the development of old growth redwood forest characteristics.

The second growth proposed for management was originally harvested in the mid-1950s and early 1960s prior to the creation of Redwood National Park in 1968. Having developed without active management, these stands exhibit unhealthy conditions such as high tree density, growth stagnation, unbalanced species composition, uniform canopy structure and height, and little wildlife habitat. These stands can be treated to accelerate the development of old growth characteristics by reducing overall stem density, reducing Douglas-fir canopy dominance, and encouraging the development of stand-structure.

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 in an environmental assessment on the proposed action. The type of input that will be most helpful is information that could be used to develop alternative ways to achieve the goal of accelerating development of a late seral redwood forest. Among the considerations for this project, we would especially like suggestions on the appropriate size, number, and species of trees to be removed, and how to dispose of woody debris generated by the project. The NPS has been authorized to sell wood generated by forest restoration projects to offset restoration costs and reduce fire hazards. We will consider this possibility as part of the overall plan to manage second growth forests. An outline of possible alternatives for management of second growth forest stands is attached.

We are also seeking information on extraordinary circumstances that you may know of that may be associated with this proposal. Extraordinary circumstances are conditions that might cause this proposal to have significant environmental effects, including adverse effects on:

- Rare, sensitive, threatened and/or endangered plants and animals and their habitats
- Soils and watershed processes
- Floodplains and riparian wetlands
- Historic and prehistoric sites or features
- Socioeconomics and adjacent communities

If you have comments, new information, or input on extraordinary circumstances regarding this proposal, please send them in writing by June 24, 2005, to Bill Pierce, Superintendent, Redwood National and State Parks, 1111 Second Street, Crescent City, California 95531. If you have further questions regarding this project, please contact Supervisory Botanist Leonel Arguello at 707-464-6101 extension 5280 or via e-mail at Leonel_Arguello@nps.gov.

Bill Pierce
Superintendent

Enclosures

Scoping Document
Second-growth Forest Restoration Project
Redwood National and State Parks
National Park Service
May 19, 2005

WHY MANAGE SECOND-GROWTH?

Redwood National Park was established in 1968 to preserve significant examples of the primeval coastal redwood forest. The park was expanded under Public Law 95-250 in 1978 to include about 50,000 acres of former commercial timber lands that had been logged as many as 50 years earlier. After harvest and stand regeneration, and usually within 20 years of establishment, a commercial stand is normally thinned to increase the growth and development of the remaining trees, allowing them to achieve merchantable size more quickly. None of the second growth stands in the park have been thinned since harvest. In some areas this has resulted in dense, poorly developed stands, dominated by Douglas-fir and tanoak.

Following park expansion, the NPS was directed to develop a watershed restoration program to minimize human-induced erosion due to logging and road conditions and to encourage the return of a natural vegetation pattern. The watershed restoration program has focused on reducing sedimentation of streams due to road conditions. Forest management research and observations of logged forests in the park and elsewhere indicate that poorly developed or stagnant second growth stands are likely to persist for many decades, in the absence of disturbance. This would result in unnatural patterns of forest vegetation at risk to fire, disease, and possibly stand failure. Further complicating development of a natural pattern of vegetation is the species composition imbalance favoring Douglas-fir and tanoak over redwood. In 2000, the NPS approved a General Management Plan that formally recognized the need to actively manage the second growth forests to restore old growth redwood forest conditions in the shortest time.

The purpose of the proposed action is to accelerate development of late seral redwood forest structure and complexity in logged forest stands in the Lost Man Creek watershed. This project area was chosen for several reasons. Forest assessments conducted by park staff have identified the project area forests as poorly developed when compared to other logged areas in the park. Secondly, although stand ages approach 50 years, much of the project area remains unsuitable as wildlife habitat, particularly for threatened bird species. The project area, however, is adjacent to one of the largest contiguous blocks of unlogged redwood forest in the park, which is suitable habitat for many species. The dramatic edge (height differential) between the second growth and old growth forests can change environmental conditions within the old growth for many hundreds of feet. Managing stagnant forests abutting the old growth would reduce edge related environmental conditions in a relatively short time by allowing trees to grow and provide a canopy buffer. There are also residual old growth redwood trees throughout the project area that would benefit from management of the surrounding dense second growth. Lastly, the Lost Man Creek area is scheduled for watershed restoration activities in which some of the existing logging roads would be removed. After roads are removed, forest management would be more costly because crew and equipment access would be limited.

WHAT WE WOULD LIKE TO ACHIEVE

Specific short-term objectives of managing second growth in the Lost Man Creek include:

- Stimulate growth and development of redwood or other desired conifers by reducing the number of stems per acre.
- Remove Douglas-fir to increase the ratio of redwoods to Douglas-fir; redwoods are not targeted for removal.

- Remove exotic tree species such Port-Orford-cedar and Sitka-spruce which do not occur naturally in the Lost Man Creek watershed and Monterey pine which is non-native in the region.
- Minimize excessive ground fuel accumulation to reduce fire hazard.

General objectives and considerations include:
- Enhance forest structure and improve forest canopy development
- Enhance wildlife habitat
- Minimize soil erosion and impacts to aquatic systems

WHAT COULD BE DONE TO ACHIEVE OBJECTIVES
To achieve the short-term objectives listed above, possible alternative treatments have been identified based on silvicultural techniques used in forest restoration projects conducted in the parks and reported elsewhere in the literature. These treatment strategies account for different conditions throughout the 1700-acre project area.

- **Stimulate Growth Of Trees In Overstocked Areas (1314 acres)**
  Potential alternatives are to reduce the stand basal area by either 25% or 40% from existing levels. The intent is to reduce overall stand densities to levels that would primarily stimulate growth and development (release) of remaining trees and secondarily to provide for understory development and improve development of habitat. Douglas-fir is primarily targeted for removal to improve stand level representation of redwood. Proposed treatments include thinning from above (remove larger diameter trees) or below (remove smaller diameter trees) to reduce overall stem density, managing fuels to minimize fire risk, and providing growing space for remaining trees to grow.

  For the 25% basal area reduction alternative, thinning would target removal of Douglas-fir or tanoak in the size class range from 8" to 20" dbh, and would remove, on average, 135 trees per acre. Thinning trees from below is not proposed in these areas since it does not maximize response of overstory trees. Selecting overstory trees to remove would be based on maximizing response and release of dominant redwood and/or other large conifers.

  For the 40% basal area reduction alternative (only 355 acres proposed, 25% BA reduction elsewhere as described above**)**, thinning would target removal of primarily Douglas-fir in the size class range from 5" to 15" dbh, and would remove on average 278 trees per acre. Thinning from below would be utilized to reduce overall stem density of Douglas-fir. Selected overstory trees would be removed based on maximizing response and release of redwood trees and other desired conifers.

  The following table summarizes prescription alternatives within a 27 acre stand. The values represent trees that are ≥ 5 inches dbh.

	Unthinned			**Reduced by 40% (Low Thin)**		**Reduced By 25% (Crown Thin)**	
	Doug-fir	**Redwood**	**Total**	**Doug-fir**	**Total**	**Doug-fir**	**Total**
Basal Area ft^2/ac	**214**	**45**	**321**	**102**	**209**	**135**	**242**
Ave #Trees/ac	**256**	**54**	**546**	**52**	**343**	**178**	**469**
Ave #Trees Taken/ac				**204**		**77**	

- **Thinning Adjacent to Old Growth Forests (105 acres)**
  Within 300 feet of old growth forests, stand basal area would be reduced by ≤ 30%, primarily utilizing a uniform thin from below to reduce overall stem density. The intent is to maintain sufficient canopy cover to prevent rapid shrub proliferation and minimize the creation of food resources for corvids. Removal of trees would occur in the size class range from 5" to 15" dbh, and would remove on average 150 trees per acre. Selection of canopy trees for removal would be based on maximizing release of dominant redwoods and other conifers to stimulate development of potential nest trees and nesting habitat components such as large branches in these old growth buffer areas.

- **Thinning within Tanoak Thickets (172 acres)**
  Tanoak sprouts profusely from cut stumps, which has resulted in dense tanoak thickets on the western ridges of the project area. To release conifers while minimizing the sprouting response in tanoak, removal of some trees is proposed around suitable conifers to provide for release and canopy development of retained trees. Trees removed may include both hardwoods and other conifers and will be selected to maximize growth and development of the retained conifers. Priority would be given to releasing redwood trees, then dominant Douglas fir, and lastly other dominant conifers.

  Residual old growth trees are uncommon in these tanoak-dominated areas. If residuals are present, trees removed would be selected to maximize release of young conifers growing within 50 feet of the residual. The intent is to accelerate development of a suitable buffer of coniferous trees around the residual tree. Trees removed may include both hardwoods and other conifers and will be selected to maximize growth and development of the retained conifers.

- **Minimize Fuel Accumulation (all areas)**
  Slope steepness would guide basal area reduction targets and how tress would be managed once cut. On slopes steeper than 35%, the stand basal area would be reduced by ≤ 25%, primarily by thinning crown trees. Under this scenario, cut trees would be left on site to decompose naturally or girdled to provide wildlife habitat relatively quickly. Recently collected data indicate that on average 115 trees per acre would be felled or girdled in these areas, ranging in diameter from 8 to 15 inches. Trees felled will be bucked and limbed to provide as much ground contact as possible to speed decomposition. Depth of fuels will not exceed 24 inches. Girdling will be strategically employed to prevent overloading of ground fuels.

  On slopes ≤ 35%, the stand basal area would be reduced by up to 40% (moderate thinning from below with selected canopy trees removed). Cut trees would be removed from gentle slopes using heavy equipment. Cut trees would be moved to nearby landings, where trees would be processed for loading onto trucks and transported. The park will consider incorporating the value of the wood as a means of offsetting overall project costs. Limbwood from felled trees would be left on site to provide ground cover for skid trails, after heavy equipment operations have been completed. Trees will be girdled to provide immediate wildlife habitat.

  No new roads or landings would be constructed. Equipment would use the existing skid trail network for interior access to project sites and existing roads and landings for processing and staging the wood prior to removal off site. Approximately 26 miles of existing skid roads, 15 miles of administrative roads, and 20 existing landings would be reoccupied during the project. All haul roads and landings will be removed under the scheduled road removal program to be completed in FY08.

In both tanoak-dominated areas and within the old growth buffer areas, all trees cut would be left on site regardless of slope. Trees removed along roads may be chipped to reduce the fire hazard.

- **Streamside and wetland management considerations (109 acres)**
  General treatment activities in streamside areas would be based on:
  - Stream type (ephemeral, intermittent, perennial)
  - Stream power (channel development, stream order)
  - Geomorphic setting (slope steepness of streamside areas, presence of unstable areas)

  Best management practices to protect streams, riparian, ponds and wetlands include:
  - All trees in the bankfull width of a channel would be retained.
  - All trees contributing to channel and bank stability would be retained.
  - All trees would be retained and equipment would not operate in streamside areas where slope steepness exceeds 45%.
  - All trees that lean towards a channel would be retained for large woody debris recruitment.
  - 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.
  - Equipment would not operate in or cross channel and swale features.
  - A park geologist would assess streamside buffers in thinning units for slope stability.

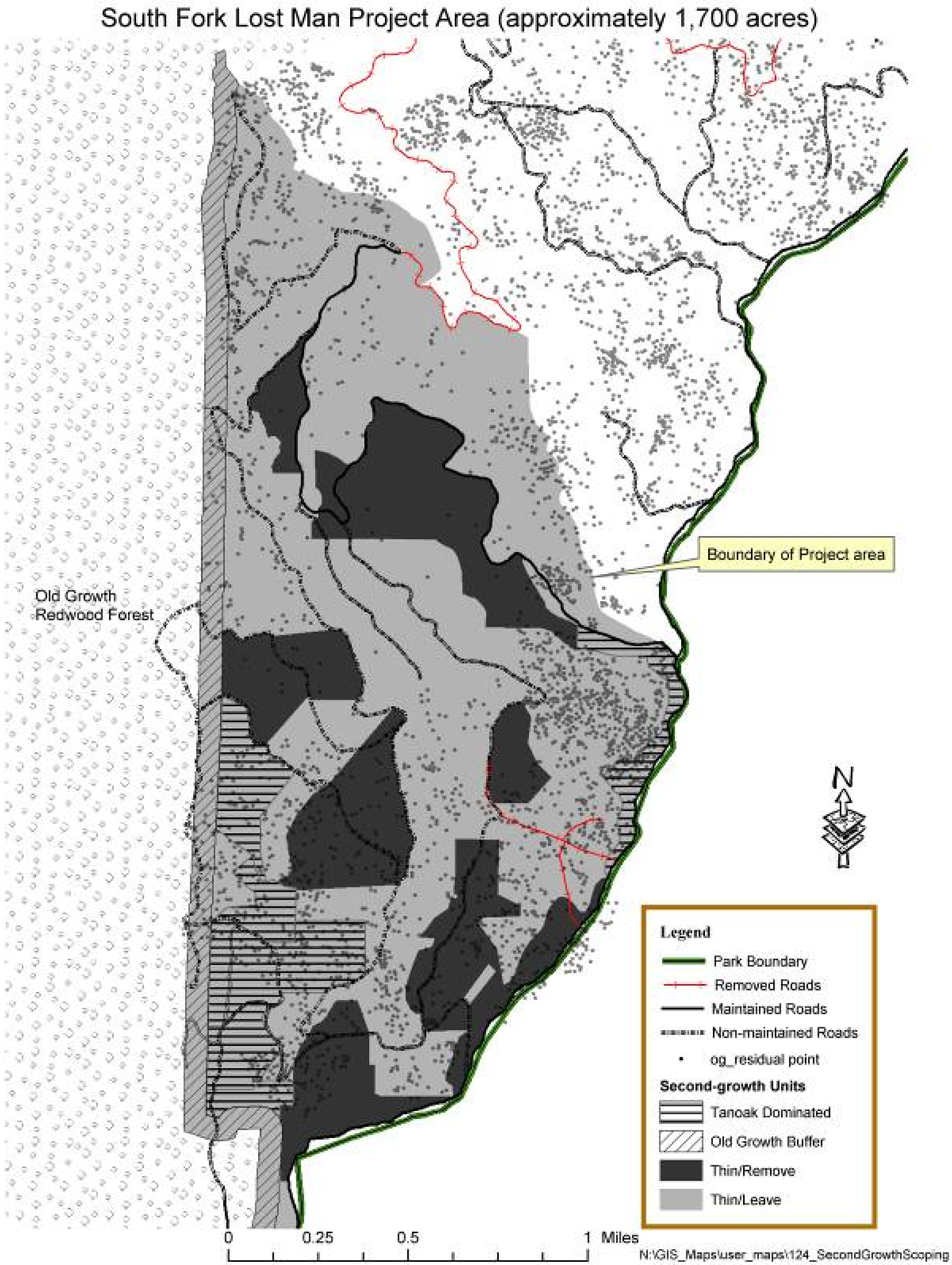
  Prescriptions Categories:
  1. For wetlands, protection zones would be at least 100 feet wide from the outer edge of the riparian vegetation. Thinning treatments would retain at least a 70% post-treatment tree canopy.

  2. Swales are topographic depressions on the hillslope that show no evidence of surface flow or channel development. On gentle (≤ 30%) slopes, there would be no restrictions on vegetation treatments except as outlined above. On steeper (> 30%) slopes, thinning treatments would retain at least a 50% post-treatment tree canopy throughout the feature or within a 50-foot-wide zone (each side of swale), whichever distance is greater.

  3. For intermittent and ephemeral streams on gentle (≤ 30%) slopes, streamside protection zones would be a minimum 50 feet wide or to the break-in-slope, whichever distance is greater. Thinning treatments would retain at least a 50% post-treatment tree canopy.

  4. 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 a 70% post-treatment tree canopy.

  5. For perennial and 3rd-order and above streams, streamside protection zones would be 300 feet wide from the outer edge of the channel or floodplain, or to the break-in-slope, whichever distance is greater. On slopes ≤ 30% steepness, thinning would retain at least a 70% post-treatment tree canopy. On slopes > 30%, thinning would retain at least an 80% post-treatment tree canopy.


South Fork Lost Man Project Area (approximately 1,700 acres)
Old Growth
Redwood Forest
Boundary of Project area
N
Legend
Park Boundary
Removed Roads
Maintained Roads
Non-maintained Roads
og_residual point
Second-growth Units
Tanoak Dominated
Old Growth Buffer
Thin/Remove
Thin/Leave
0
0.25
0.5
1 Miles
N:\GIS_Maps\user_maps\124_SecondGrowthScoping

Appendix B – Public Involvement

The following officials, agencies, American Indian tribes and groups, organizations, and individuals received a copy of the environmental assessment or a letter announcing its availability and its location on the Internet.

Congressman Mike Thompson
State Senator Wes Chesbro
Assemblywoman Patty Berg
Chairperson, Humboldt County Board of Supervisors

Bureau of Land Management, Arcata
NOAA Fisheries
Six Rivers National Forest
United States Fish and Wildlife Service
United States Geological Service, Arcata
California Department of Fish and Game, Eureka
CalFire, Fortuna
California State Office of Historic Preservation
North Coast Regional Water Quality Control Board

Big Lagoon Rancheria
Hoopa Valley Tribe
Resighini Rancheria
Tolowa Nation
Trinidad Rancheria
Yurok Tribe

Able Forestry
Barnum Timber
Green Diamond Resource Company
Sierra Pacific Industries

Audubon Society
Blue Ribbon Coalition
California Native Plant Society
Environmental Protection Information Center
National Park Conservation Association
Northcoast Environmental Center
Northcoast Regional Land Trust
Redwood Community Action Agency
Redwood Region Economic Development Commission
Save-The-Redwoods League
Sierra Club North Group
Siskiyou Project
Smith River Alliance
Stillwater Sciences, Inc.

Humboldt State University, Department of Forestry

Erik Jules
John Stuart
George Robinson
Morgan Varner

Humboldt County Library, Main Branch
Humboldt County Library, McKinleyville Branch
Humboldt State University Library

Appendix C - Glossary

Basal area (BA)—The cross-sectional area of a stems 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).

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.

Inventory—An accounting of the quantity, quality, and value of timber on a given area of forest, determined by conducting a cruise and then expanding the sampling data by statistical methods to reach an estimate of the total content of the forest.

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

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.

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—Method of thinning that focuses on the removal of trees from the lower crown classes to favor trees in the upper crown classes.