# Restoring Complexity to Industrially Managed Timberlands: The Mill Creek Interim Management Recommendations and Early Restoration Thinning Treatments[1]

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### Abstract

The Mill Creek Property was a commercial timberland acquired by the State of California to protect and restore local and regional ecological values and provide opportunities for compatible recreation. Interim Management Recommendations (IMR) were developed to guide protection, restoration, and public access of the Property until the California Department of Parks and Recreation (DPR) develops a General Plan. Using existing data as well as public and professional input, the IMR planning process identified management alternatives for forest restoration and other priority issues. Recommendations were based on spatial analysis of potential risks and benefits to resources.

The IMR identified 5,680 hectares (14,000 acres) of overly dense young coniferous stands needing restorative thinning to accelerate the development of late-successional forest characteristics and avoid the unnatural growth trajectories established by plantation–style forest management. Using public and private funds, a pilot project was designed and implemented to experimentally thin approximately 41 hectares (100 acres). A variable density thinning (VDT) prescription was used to lower tree densities and is expected to accelerate growth, increase stand level heterogeneity and adjust tree species composition. Tree growth, wildlife habitat and wildlife use are monitored against unthinned control areas using permanent plots. Results will inform the development of future prescriptions designed to restore late-successional forest characteristics.

*Key words: California, forests, restoration, salmonids, silviculture, state parks*

## Introduction

Following over 100 years of timber extraction (Madej and others 1986), the Mill Creek Property (hereafter referred to as Mill Creek) located in Del Norte County, California, was purchased and transferred to the California State Park System on June

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4, 2002. Support for the 60 million dollar, 25,000 acre acquisition was based on its strategic location between existing preserves and the outstanding quality of its salmon-bearing streams. Included in the sale's terms and conditions is an agreement that the property's primary objective shall be to restore late successional forest conditions and the associated natural functions for the benefit of the areas' fish and wildlife.

Restoration of Mill Creek's forests, streams and wildlife will require decades of carefully planned resource work to ameliorate the effects of timber harvesting and associated road building. For example, most of the park's 410 km (255 mi) of roads and skid trails will need to be decommissioned or re-engineered to minimize impacts to listed fish species. Thousands of acres of young, even-aged, nearly monospecific forest plantations will need to be thinned and treated to jumpstart ecological processes important to the development of complex habitats and biological diversity. Opportunities for public recreation and education will need to be built around ongoing restoration while considering the public's safety.

Anticipating that the development of a General Plan for the Property would take several years, Save-the-Redwoods League and the California Coastal Conservancy spearheaded the development of Interim Management Recommendations (IMR) using public and private funds. Based on existing geographic information system (GIS) data, public input, and advice from over 60 resource professionals, the IMR identifies four priority management areas to focus on in the short term: (1) road management, (2) forest management, (3) aquatic and terrestrial habitat protection, and (4) public access. The IMR identifies emergency management actions that if not taken in the next 10 years could jeopardize Mill Creek's natural resources and constrain future management opportunities intended to meet the Property's primary objective.

Today, unnaturally dense stands of young trees dominate Mill Creek's landscape because commercial extraction of timber occurred over a relatively short period (1954 to 2000). Cleared areas were either re-seeded by neighboring trees or were planted at a high density with native conifers. A high level of annual precipitation, productive soils and the use of seed-tree and clearcut silviculture led to the rapid and dense re-vegetation of cleared areas. Use of pre-emergent herbicides favored the growth of commercial conifers (principally Douglas-fir) to the detriment of native shrubs and herb species. Because Douglas-fir is better able to colonize newly cleared areas, it often dominated sites before other native conifers such as coast redwood could establish, resulting in unnaturally dense, monospecific stands.

Studies of pre-settlement disturbance regimes in the northern redwood region suggest that catastrophic stand-replacing events were rare, and that stand-modifying disturbances such as low intensity ground fire, flooding and localized windthrow were more common (Sawyer and others 2000). Stand development following human induced stand-replacing events such as those caused by the repeated use of seed tree or clearcut silviculture therefore establish artificial growth trajectories that are rarely found in the natural ecosystem. Undesirable effects such as stagnated growth, unbalanced species compositions, altered fire regimes and outbreaks of insect and pathogens can be expected from the artificially dense conditions. Plot data from the study region in thinned and unthinned even-aged regenerated stands indicate that in some locations, high tree densities may preclude the development of conditions found in older forests for decades or centuries (Thornburgh and others 2000, Veirs and Lennox 1982). In coastal Douglas-fir forests high tree densities, even, narrow spacing and late thinning have been shown to delay canopy differentiation, decrease biocomplexity, and lead to unstable stands (Wilson and Oliver 2000).

Experimentally conducted, restoration–based variable density thinning may be used to redirect unnatural growth trajectories to improve short and long term ecological values while contributing to an adaptive forest management framework. While thinning young second growth forest plantations is relatively new for the purposes of conservation, its foundation is based on a growing number of carefully conducted studies. In the redwood region for example, thinning has been shown to accelerate the growth of coast redwood (Oliver 1994, Veirs 1986) and lead to the development of understory shrub and bird densities typical of old-growth forests (Menges 1994, Thornburgh and others 2000). In Washington's coastal forests, thinning experiments designed to induce heterogeneity into forest canopies have demonstrated the importance of biocomplexity to various biotic communities, including soil microorganisms, vascular plants, fungi, birds, small mammals and vertebrate predators. Over ten years of experimentally conducted variable density thinning in these forest plantations has demonstrated a short term (<5 years) increase of these taxa in thinned stands relative to unthinned stands (Carey 2003).

The long-term ecological effects of restoration-based variable density thinning are as yet unknown, particularly for older stands. Initial studies from the redwood region suggest that cryptic elements of biodiversity (arthropods) may be significantly affected by repeated stand management (Willett 2001) and that older relatively unmanaged areas, even at the single tree scale, can support a rich and unique fauna (Camann and others 2001, Mazurek and Zielinski 2003). These studies suggest that over time, decisions regarding restoration thinning will need to consider benefits and impacts to a wide array of native species at different scales. Young (11 to 20 years), dense even-aged regenerated stands, like those needing immediate treatment at Mill Creek, are less likely to have redeveloped such cryptic elements of biodiversity. Such organisms tend to require a degree of habitat complexity and stability that develops over many years.

## Methods

### *The Study Area*

Over 410 km (255 mi) of road exist on the Mill Creek Property, and most were built over a relatively short period of time (1958 to 1977) (Madej and others 1986). Road densities across the property average four km/km$^2$ (6.4 mi/mi$^2$). Approximately 97 km (60 mi) of road were temporarily decommissioned in 2001 to 2002 by the former owner, and have not received maintenance since. State Park geologists have determined these roads pose an immediate and significant risk to Mill Creek's aquatic resources.

The IMR analysis determined that approximately 69 percent of its area supports trees than are pole size or smaller (<28 cm; 11 inches) while only six percent of its area supports trees that would qualify as mature (>61 cm; 24 inches). Historically, this area supported trees ranging from one to four meters (three to 12 ft) in diameter as the predominant forest type. Today, less than 81 hectares (200 acres) of old-growth forest remains, most of which is located in five isolated stands.

Despite the Property's rapid and nearly complete transformation from old-growth to early successional habitat, its underlying geology, productive capacity, and proximity to existing preserves will facilitate relatively rapid habitat recovery. Habitat for 26 special status wildlife species exists and continues to develop at Mill Creek, including habitat for species such as the northern spotted owl, marbled murrelet and Pacific fisher. Mill Creek's productive streams support a diverse assemblage of special status fish species including coho, Chinook, and chum salmon as well as steelhead and coastal cutthroat trout. At least 15 vegetation series and over 300 vascular plant species are present, including as many as 52 sensitive plant species (SHN 2000).

## *The Interim Management Recommendations*

The intent of the IMR was to synthesize and analyze existing resource information and based on this information, provide recommendations to DPR to guide interim management actions. The synthesis and analysis was also intended to provide a solid base from which DPR could prepare a General Plan for the park. Fortunately, the previous owner had collected and organized a large quantity of road, forest and stream data including sediment source locations and a detailed harvest history which was made available with the sale and transfer of the Property (Stimson Lumber Company 1998).

Scoping meetings and working groups were organized to solicit the input of resource professionals, experts from local universities and members of the public. Attendees identified management issues and defined the desired future conditions of Mill Creek. An analysis of opportunities and constraints and potential risks and benefits to resources was conducted using existing geographic data, and a systematic prioritization matrix linked to the geographic data. The analysis was then synthesized into a set of interim recommendations, suggestions for research and monitoring and recommendations for long-term restoration and management. This information was then checked against existing regulatory permitting requirements and thresholds to develop short-term interim management recommendations and a roadmap for more detailed planning and permitting.

Interim management objectives include promoting development of old-growth forest characteristics and minimizing the risk of catastrophic wildfire, both of which can be attained through silvicultural methods. Priorities for forest management during the interim period were established by identifying young second-growth forests where forest restoration would provide the greatest potential ecological benefits including buffering known old growth, protecting habitat of sensitive species, providing connectivity, and effectively reducing catastrophic wildfire risk. The IMR emphasized that for young even-aged regenerated stands, a narrow window of opportunity exists to realize the benefits of thinning before these stands enter the stem exclusion phase.

Data used for the analyses included an electronic vegetation database developed by Stimson Lumber Company to manage industrial forests and associated natural resources within their ownership; the database was substantially modified by Stimson to track stand age and silvicultural treatments. Database attributes used in this analysis include (1) date of stand birth (time since regeneration began) based on aerial photographs dating back to the 1950s, and (2) vegetation type based on aerial photograph interpretation and/or field mapping. In addition, another electronic database of silvicultural treatments and timing, including records of pre-commercial thinning (but not commercial thinning) was provided by Stimson Lumber Company.

Other data included buffers around marbled murrelet and northern spotted owl nesting sites, the regional surface fuel maps for California developed by the California Interagency Fuel Mapping Group, a 10-m Digital Terrain Model (DTM) to identify ridge crest positions where lightning strikes are most likely to occur, and buffers around public use areas, the mill site, picnic sites, adjacent to the primary road network and along the interior of the property boundary.

Opportunities were identified and priorities for management were established using a matrix. Indicators were assigned various scores based on their relative influence on the desired objective; higher scores reflected a greater risk or management priority *(table 1)*. The spatial distribution and coincidence of indicators across the property were analyzed over a 10-meter grid spacing using GIS. The cumulative score for each grid cell was then used to establish priority areas for interim management activities, such as thinning for ecological benefits and fuels reduction.

**Table 1—***Stand level characteristics used to prioritize forest restoration. Landscape scale variables (connectivity) were used in combination these scores to provide a composite priority ranking for each polygon.*

| Age class (years) | Precommercial thinning | Area | Score | Relative ranking |
|---|---|---|---|---|
| 0-5 | - | - | 0 | low |
| 6-10 | - | <3 ha | 2 | mod-high |
| 6-10 | - | >3 ha | 3 | high |
| 11-20 | unthinned | <3 ha | 3 | high |
| 11-20 | unthinned | >3 ha | 4 | very high |
| 11-20 | thinned | - | 0 | low |
| 21-40 | - | - | 1 | moderate |
| >40 | - | - | 0 | low |

## *Initial Projects*

The pilot forest restoration project's planning and implementation generated useful information with respect to old forest structure that will help guide the design of future projects. A project-related literature review revealed that old redwood forest canopy densities are highly variable, ranging from 50 to 380 trees/ha (20 to 150 trees/ac) (Dagley and O'Hara 2003). Locally, historic timber plot data from three large ownerships indicate average old-growth tree densities of 79 trees/ha (32 trees/ac) (Hammon and others 1969). The same data indicates that for the Mill Creek Property as a whole, coast redwood was the dominant species in the old-growth condition, representing 70 percent of the standing volume whereas Douglas-fir only represented 27 percent of the overall volume. Today young, even-aged regenerated stands at Mill Creek 12 to 15 years of age can support 1,728 to 2,222 trees/ha (700 to 900 trees/ac) and have tree species compositions with an over-abundance of Douglas-fir. One stand for example, had a nearly inverse composition (76 percent Douglas-fir, 24 percent coast redwood) compared to the old-growth reference condition despite it being located on an lowland alluvial terrace.

Approximately 49 ha (120 ac) of overly dense high priority forest was selected for the pilot experimental thinning trial. Stands were selected based on the IMR analysis, and aerial photo interpretation; field reconnaissance was then used to find simple, even-aged stands with little to no apparent crown differentiation. The three sites selected were divided into a total of 18 treatment blocks, in which one of three treatments was applied *(table 2).* Target densities refer to the density of dominant trees expected to develop with time assuming a maximum mortality of 33 percent[6] over the vulnerable period in the stand's development. Target densities were based on a desire to adjust the dominant tree density to a level resembling old forest tree densities in the region, using one relatively heavy thinning. Such an approach, if successful, may be used in situations where road decommissioning will preclude future management access.

**Table 2—***Variable density thinning treatment design.*[1] *Acreage column sums the treatment acreage for all three sites.*

| Treatment name | Post treatment density | Target density | Acreage |
|---|---|---|---|
| High Density VDT | 150 trees/acre | 100 trees/acre | 44.5 |
| Low Density VDT | 75 trees/acre | 50 trees/acre | 51.5 |
| Controls (No Treatment) | Unchanged | NA | 24 |
| | | Treatment acreage | 96 |
| | | Total acreage | 120 |

[1] Treatment design by O'Hara & Dagley, UC Berkeley Natural Resources Department.

Trees to be retained were selected using a randomization process and a species priority list. Within small (6.4 x 6.4 m [21 x 21 ft]) marking cells, a random number between zero and three was generated, corresponding to the number of trees to be retained (leave trees) within that cell. After the number of leave trees was determined, the tallest individual(s) of preferred species were marked for retention. Leave tree preference was based on the current under–representation of coast redwood and the over–representation of Douglas-fir. Species priorities were arranged as follows: (1) coast redwood; (2) western hemlock, grand fir, Sitka spruce, western red cedar, Port Orford cedar and red alder; (3) Douglas-fir, tanoak, madrone, and bay. The minimum retained tree height was set at approximately 1.4 m (4.5 ft), in order to retain enough redwood saplings to significantly alter the stand species composition. The pattern of retention was randomized to eliminate the uniform plantation pattern of live trees and to encourage a non-uniform pattern of future branch development. The latter structural goal may in time facilitate the development of a more diverse understory plant assemblage (Carey 2003).

Trees were thinned using chainsaws by the local California Conservation Corps (CCC) and a private sub-contractor. Felled trees were left lying on the forest floor, with the exception of roadside areas in which fuels were removed for a distance of 10 m (30 ft) from the road edge.

[6] This mortality estimate is an educated guess based on experience. Annual mortality figures for stands of this age class are not available. A 33 percent attrition rate is a conservative over-estimate of the expected mortality.

Prior to the commencement of thinning operations, wildlife habitat monitoring plots were installed by biologists from the California Department of Fish and Game, in a subset of treatment units (High, Low, and Control). Wildlife habitat elements as used in the California Wildlife Habitat Relations (CWHR) model were recorded, as was the presence or absence of small and large mammals using live traps and motion sensing cameras.

Following the completion of thinning, permanent tree growth and mortality monitoring plots were installed in each of the 18 treatment blocks. Trees per plot, species composition and diameters were measured to establish the baseline post–thinning conditions. These plots will be measured again on a five to 10 year monitoring schedule to track changes in growth and mortality over time.

## Results

In the three and a half years since the acquisition, State Parks and its partners have initiated implementation of the IMR *(table 3)*. In addition to focusing on the highest priority resource problems, initial projects have sought to establish the technical and professional knowledge base needed to develop a long-term integrated ecological restoration plan for the entire 25,000 park. For example, data from a property-wide road sediment inventory is being combined with geologic and hydrologic information related to erosion potential to identify and prioritize those areas that pose the greatest risk to aquatic resources. Concurrently, data from a detailed forest inventory of young stands (recently completed) has been analyzed to provide a refined assessment (relative to the IMR) of thinning priorities. Together, these informational building blocks have been used to develop a five-year coordinated approach to watershed restoration.

**Table 3**—*A sample of priority interim management recommendations and current status. See the Interim Management Recommendations (Stillwater Sciences 2002) for a more detailed list of recommended actions.*

| Interim Management Recommendation | Status: March 2006 |
|---|---|
| Inventory and establish treatment priorities for existing road and log landings | DPR lead field inventory complete. Data entry and site-specific repair prescriptions being developed |
| Develop an inspection and maintenance schedule | Roads have been continually inspected and maintained every winter since the acquisition. A more detailed maintenance schedule is being developed |
| Decommission non-essential roads and treat associated hillslope erosion | Funding to decommission 17 – miles of high risk roads has been secured. Ca. 12 miles of decommissioning work conducted in the summer of 2004 and 2005. |
| Conduct field surveys to prioritize forest restoration projects | A streamlined forest inventory for unthinned stands 11 – 24 years of age has been designed, implemented and analyzed for ca. 5,500 acres. A prioritization matrix reflecting within stand conditions and the road removal schedule has identified 3,500 acres of high and very high priority forest needing restoration. |
| Restore second growth forests | 100 – acres of overly dense plantation-like forest were thinned in the winter of 2003. An additional 400 – acres received treatment in 2004/2005. A five-year, 3,500 acre forest restoration project has been developed based on the recently completed forest inventory and in collaboration with local resource experts. The *Forest Ecosystem Restoration and Protection Project (FERPP)* is coordinated with the approved five-year road removal plan. An accompanying effectiveness monitoring plan has been developed to evaluate tree level and stand level responses to different restoration prescriptions. |
| Control the spread of plant pathogens | Localized eradication of infected trees has been conducted and seasonal equipment use limitations observed. |
| Establish special management areas | Isolated old-growth stands receive special consideration (setbacks / observance of critical periods) when conducting restoration projects. |
| Continue long-term salmonid monitoring | The 10 – year salmonid monitoring record has remained unbroken using public funds from the Department of Fish and Game. Funds secured to analyze population data and refine monitoring. White paper generated by Stillwater Sciences and the Mill Creek Fisheries program in collaboration with Humboldt State University. |
| Provide educational and service – learning opportunities | Summer lead docent tours have been conducted for the public every summer since the acquisition. More recently, winter salmon viewing and equestrian tours have been provided by DPR. |

Given the recent completion of the pilot forest restoration project, only the pre-thinning habitat data and post-thinning tree counts are currently available. Pre-treatment wildlife habitat and wildlife use measurements indicate the treated stands are structurally simple, inhibit primary productivity and do not support rich or abundant wildlife populations. Stands were found to be dominated by a uniform monoculture of closely spaced Douglas-fir trees with canopy cover estimates ranging from 97 to 100 percent. The principal ground cover consisted of decomposing conifer needles (duff). Shrub and herbaceous cover is nearly absent, consisting of sparse collections of evergreen huckleberry and sword fern. Legacy structures are limited to logging slash, which includes pieces typically <51 cm (<20 inches) in diameter and stumps. Out of 176 live traps set, biologists captured a total of eight deer mice; no other small mammal species were noted. After more than 60 days, baited motion sensing wildlife cameras detected a single mule deer.

Preliminary inspection of the permanent tree growth and mortality plot data suggest that the two post thinning target densities were generally met *(table 4)* and that species composition was successfully shifted to include more coast redwood *(table 5)* (O'Hara and Dagley 2006)[7]. Where the pre-thinning condition consisted almost entirely of Douglas-fir, inter-planting of coast redwood may be needed to achieve a representative species balance.

**Table 4**—*Post treatment tree densities for three experimental thinning sites on the Mill Creek Property, Del Norte County.*

| Site | Treatment | Trees per acre |
|---|---|---|
| Childs Hill | Control | 657 |
| Cougar Ridge | | 682 |
| Moratorium | | 1357 |
| Average | | 899 |
| Childs Hill | High (Target – 150 TPA)* | 166 |
| Cougar Ridge | | 113 |
| Moratorium | | 140 |
| Average | | 140 |
| Childs Hill | Low (Target – 75 TPA)* | 78 |
| Cougar Ridge | | 67 |
| Moratorium | | 84 |
| Average | | 76 |

*TPA – trees per acre

[7] Data adapted with permission from O'Hara and Dagley.

**Table 5**—*Percent composition by tree species from unthinned (controls) and post thinning sample plots.*

| **Childs Hill** | ***Controls*** | ***High density*** | ***Low density*** |
|---|---|---|---|
| Redwood | 3.3 percent | 36.7 percent | 18.1 percent |
| Douglas-fir | 89.6 percent | 59.6 percent | 74.8 percent |
| Other | 7.1 percent | 3.6 percent | 7.1 percent |
| **Cougar Ridge** | | | |
| Redwood | 41.1 percent | 93.8 percent | 52.2 percent |
| Douglas-fir | 55.0 percent | 6.2 percent | 38.1 percent |
| Other | 3.9 percent | 0.0 percent | 9.7 percent |
| **Moratorium** | | | |
| Redwood | 24.0 percent | 67.9 percent | 71.9 percent |
| Douglas-fir | 33.2 percent | 22.1 percent | 20.4 percent |
| Other | 42.9 percent | 10.0 percent | 7.8 percent |

## Discussion

In his conclusion to The Redwood Forest, Reed Noss presents recommendations for protection of the coast redwood forest: a globally significant ecosystem (Noss 2000). These include protection of landscapes with rare species and communities, better connectivity among late-successional redwood forests, increased protection of critical watersheds, and the restoration of areas of degraded redwood forests. The Mill Creek project embodies these recommendations and has the potential to serve as a model for restoring the integrity and resilience of California's low elevation coastal forest ecosystems, which have been simplified by years of intensive timber management.

The IMR process and resulting report has provided a valuable decision-making tool used to guide short-term, emergency management actions. It demonstrated how data collected for one purpose, in this instance commercial timber extraction, can be utilized to inform new management objectives, in this instance ecological restoration. In conjunction with DPR's strong commitment and a focused Advisory Committee, Mill Creek's restoration is not only underway, but has attracted the support of both public and private conservation interests. Implementation hurdles and cost estimates from the pilot projects have been used to build credible proposals for ongoing restoration, several of which are expected to receive funding in 2004.

Restoring complexity to industrially managed timberlands is an emerging field with a relatively short history. The Mill Creek Property presents a unique opportunity to develop and test forest restoration techniques at a large scale with a clear focus on forest ecology. In the coast redwood ecosystem, where the extent of primeval redwood forest is estimated to be four to five percent of historic levels, forest restoration promises to fulfill the acknowledged need to grow more old growth (Noss 2000) and assure the long-term viability of the redwood forest ecosystem.

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