A Multi-party Monitoring Protocol

for the

Cat Creek Stewardship Project



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Introduction

The Cat Creek Stewardship Project (Cat Creek project) is a collaboratively designed forest restoration project in the Gifford Pinchot National Forest (GPNF) in southwest Washington State. This Monitoring Protocol is designed to be an evaluative tool for local stakeholders to monitor and assess the socio-economic and ecological impacts of the Cat Creek Stewardship Project. The monitoring protocol could be used as a template for other restoration-based forestry projects in the GPNF. In addition, the protocol may have value to stakeholders involved in restoration-based forestry projects in other areas.

The Cat Creek Stewardship Project is a product of the Pinchot Partnership (Partnership), a collaborative stakeholder group that is actively engaged in GPNF management issues. The Cat Creek project, which calls for thinning forty-three acres of dense second growth forest, has ecological, economic and social goals:

- Develop late-successional forest structure and habitat through active forest management.
- Generate social and economic benefits for local communities, individuals involved in natural resource professions and other stakeholders.
- Provide the Pinchot Partnership with an opportunity to combine unique perspectives and develop a shared understanding of a forest management project.

The design, implementation and evaluation of the Cat Creek Stewardship Project follows an adaptive management process. The Cat Creek project is designed to test innovations and suppositions associated with restoration-based silviculture. The project employs new approaches in project planning, implementation and analysis, including: collaborative decision-making and design processes, adaptive management, innovative contracting mechanisms, and multi-party monitoring.

How this document is organized

This chapter and sections of this document follow the steps in the adaptive management process (see Figure 1 below). Adaptive management, which is discussed in more detail in Chapter 1, is a problem-solving process that approaches forest management activities as experiments.

The cycle begins with a problem – without a problem (or opportunity) there would be no instigation for management activities. Project goals and objectives are set during a design phase, as are indicators that will be used to measure the effectiveness of a project in meeting those objectives. Following implementation, indicator data are collected, recorded and evaluated through a monitoring and assessment process. At this point stakeholders can assess to what degree objectives were reached as well as evaluate their assumptions and hypotheses. Before more project planning occurs, stakeholders can transfer newly gained knowledge and make adjustments moving into the next planning process. In this sense, adaptive management becomes a cyclical learning and adaptation process. Thus, for this document, the chapters mirror the Cat Creek adaptive management process.

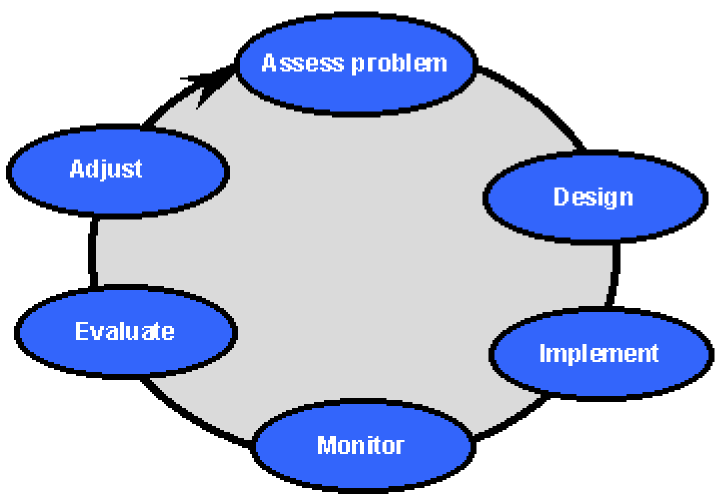

Figure 1: The cyclical adaptive management process

Courtesy of British Columbia Ministry of Forestry
Available at: http://www.for.gov.bc.ca/hfp/amhome/Amdefs.htm

Chapter 1: Collaborating to address socio-ecological problems

Chapter 1 introduces the collaborative efforts on the GPNF and describes the local social and ecological problems that drove the formation of the Partnership. The chapter also introduces the "working hypothesis" of the Partnership – that restoration-based forestry can simultaneously achieve socio-ecological objectives. The chapter also introduces the reader to the Cispus Adaptive Management Area along with a primer on the principles of adaptive management and multi-party monitoring.

Chapter 2: Designing the Cat Creek Stewardship Project

Chapter 2 introduces the design elements of the Cat Creek project. This includes an introduction to the scientific literature on variable density thinning as well as a description of innovative contracting authorities that will be pilot tested in the project. The chapter also examines how broad Partnership goals are fine-tuned into salient project objectives. The chapter concludes with an abbreviated description of the Cat Creek stand as well a summary of the project prescription (full text for both is available in Appendix B).

Chapter 3: Ecological silviculture and Socio-economic Monitoring Protocols

Chapter 3 introduces the two monitoring protocols: 1) Ecological silviculture and 2) Socio-economics. Objectives, rationale and indicators are discussed for each. Sampling design, data analysis as well as personnel, training and equipment requirements are outlined. The chapter concludes with a section on the necessity of long-term planning, funding and resources to sustain monitoring and adaptive management.

Chapter 4: From Project to Program

Chapter 4 concludes the document and raises discussion points, such as moving from a project to a programmatic monitoring program.

References and appendices provide the reader with more detail.

Chapter 1 – Collaborating to address socio-ecological problems

The Pinchot Partnership

In February 2003, a diverse group of individuals convened in Packwood, located in the northern portion of the Gifford Pinchot National Forest (GPNF) in the Cowlitz River valley in Washington State. The members identified themselves as the Gifford Pinchot Collaborative Working Group, and then later, the Pinchot Partnership (Partnership). Partnership meetings and planning sessions have drawn a variety of interests including: local and county economic development interests, county and federal elected officials, state and local labor union representatives, timber industry representatives, conservation and environmental interests, Native American tribal members and Forest Service employees.

Identifying socio-ecological problems

As we mentioned in the introduction, adaptive management processes typically begin with the identification of a problem or set of problems. Working under the premise that cooperation could be more productive than conflict, the Partnership was created to collaboratively respond to pressing social, economic and ecological problems on the Gifford Pinchot National Forest and surrounding communities. Every participant (and affiliated institution) brought a mix of social, economic and ecological concerns to the process. Generally, social and economic concerns stemmed from the loss of jobs related to declining timber production in the Cowlitz Valley following drops in federal timber harvest in the 1980s and 1990s. Social problems also included a fraying of the social fabric of the local communities along the valley. For example, some participants discussed diminishing school class sizes in Packwood or the out-migration of young families from the Cowlitz Valley. Social problems were also characterized as conflicting paradigms over natural resource use, which led to polarization and paralysis in federal forest projects. First and foremost, the Partnership was intent on working together to solve collective problems.

Ecological problems were generally characterized as fragmented forest landscapes and associated declines in ecosystem integrity and native biodiversity, including losses of threatened and endangered species such as northern spotted owls or native salmonids. Of particular ecological concern were diminished levels of old-growth forests on the GPNF landscape. Diminished connectivity between unroaded areas was also an ecological issue of concern.

A learning question: Can restoration-based forestry achieve multiple-objectives?

Members of the Partnership attempted to bridge the social, economic and ecological problem areas by proposing that certain types of timber management could alleviate pressure in all of the problem areas. The supposition was based upon evidence from other management scenarios, as well as scientific literature. The Partnership speculated that restoration-based forestry may be able to encourage the recovery of ecological health while providing social and economic benefits like jobs, wood products and the resolution of longstanding conflicts. Thus, the Partnership agreed to collaboratively promote, design and implement forest management activities on GPNF administered lands that would simultaneously benefit forest ecosystem health and local communities' social and economic wellbeing. Members of the Partnership could not say with certainty that this type of "win-win" forestry was achievable on the GPNF, but the members were willing to experiment with the idea. It is this multi-objective supposition, or hypothesis, that drives the purpose and need for this document. Systematic multiparty monitoring will allow the Partnership to assess whether or not their supposition was correct.

The Cispus Adaptive Management Area

The location of an Adaptive Management Area (AMA) in the northern GPNF offered a land base for the Partnership to conduct real-time "experiments" with their multi-objective, restoration-based forestry supposition.

The Northwest Forest Plan (NWFP), which regulates federal forest management in the Pacific Northwest, designated certain lands as Adaptive Management Areas (AMAs). The NWFP established the Cispus Adaptive Management area in the northern portion of the GPNF (Figure 2). The Cispus AMA lies in the Cowlitz Valley Ranger District of the GPNF and spans roughly 145,000 forested acres in Lewis and Skamania counties.

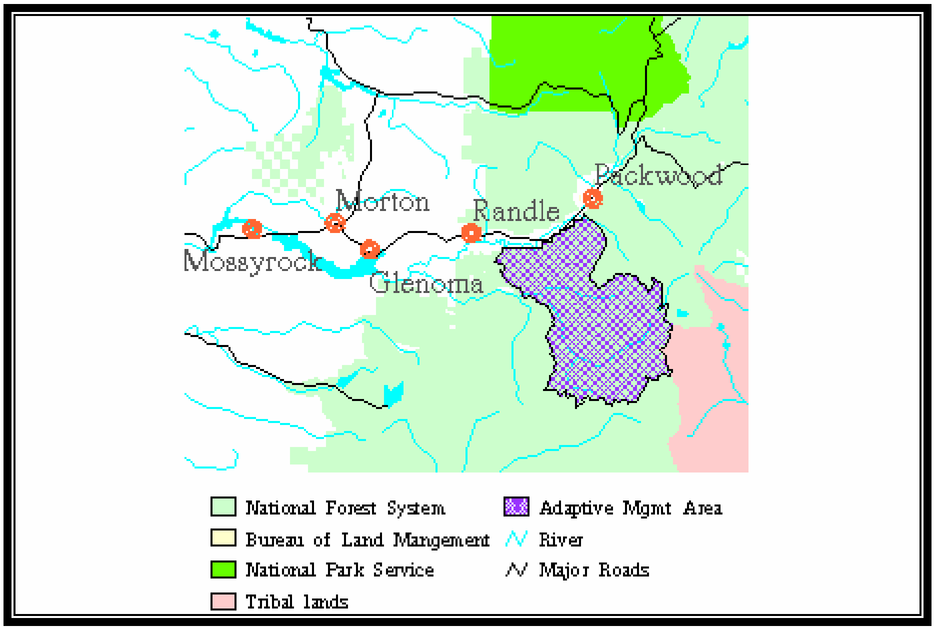

Figure 2: Map of Cispus Adaptive Management Area and surrounding communities (Source: USFS)

A stated objective of the Cispus AMA accomodates the driving thesis of the Partnership: "The development and testing of innovative approaches … (for the) integration of timber production with maintenance of late-successional (older) forests…." (USDA Forest Service, 1995) The Partnership thus identified the Cispus AMA as the ideal testing ground for the group's multi-objective supposition – that it is possible, and feasible, to integrate socio-economic and ecological objectives through restoration-based forestry. The AMA objectives also include efforts to further experimentation, learning and adaptation with policies and management techniques; processes that had been highlighted and vocalized by the Partnership as well. Indeed, the Partnership was an experiment in collaborative learning in its own right; its members embraced the idea that shared learning could lead to reductions in conflict and gridlock. This learning and "growing" process is the basis of what is called adaptive management.

Principles of adaptive management

This document is meant to be a tool for the stakeholders involved in the Pinchot Partnership. The Partnership asked our team to produce a "monitoring protocol" that could be used to assess the *socio-ecological* impacts of the Cat Creek project. Thus the document contains the description of ecological and social indicators and methods to collect data associated with those indicators. According to the Forest Service, "An *indicator* is a unit of information measured over time that documents changes in a specific condition. The most useful indicators are expressed in specific terms and measure aspects of the goal that people care about." (USDA Forest Service, 2005) Thus indicators allow us to measure "how effectively" we are achieving our management goals and objectives. Thus, the document goes beyond a simple explanation of monitoring. Monitoring, in the Cat Creek context, is simply one component in an adaptive management learning process that allows us to track the impacts of management activities on social, economic and ecological variables of interest over time.

The concept of adaptive management has been evolving since its theoretical conception several decades ago (Holling, 1978) and has achieved widespread usage within the natural resource policy arena. Although adaptive management has a variety of definitions and subtleties, the fundamental concept is quite straightforward: Policies and management actions should be treated as learning experiments. According to one source, adaptive management "...embodies a simple imperative: policies are experiments; learn from them" (Lee, 1993). The Forest Service defines adaptive management as, "A continuous process of action-based planning, monitoring, researching, evaluating, and adjusting with the objective of improving implementation and achieving the goals that have been identified" (USDA Forest Service, 1995).

For the Partnership, the concept of adaptive management allows for "hypothesis testing" via active forest management in places like Cat Creek. As mentioned earlier, the Partnership is working under the supposition (based on other case studies and scientific experiments) that restoration-based forestry operations can lead to socio-ecological benefits. Cat Creek is where the group will begin testing that concept.

Figure 3 illustrates the adaptive management process again. If we walk through the steps, we see that problems act as instigators for the project or policy. In the case of Cat Creek, the problem was generally defined as the lack of late-successional forest (i.e. acres of "old-growth") conditions on the landscape along with the absence of economic opportunities in natural resource management for local communities (i.e. jobs and wood products) and other diminishing social values. The problem areas stimulate the design (Step 2) of solutions that may or may not impact the problem areas – in this case that would be the strategies, policies or management activities that can provide socio-ecological benefits. Members of the Partnership *predicted* that restoration-based forestry projects could achieve multiple objectives.

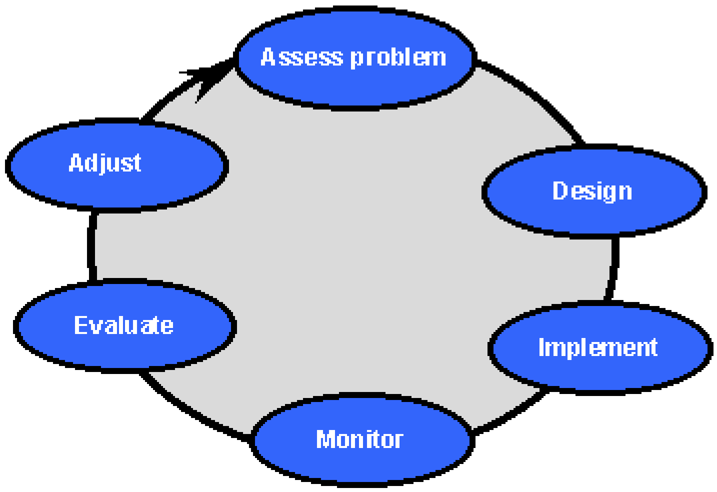

Figure 3: The cyclical adaptive management process

Following the design of a potential "solution" (in the case of Cat Creek, the design of a forestry prescription), the adaptive management process cycles through implementation, monitoring, evaluation and adjustment. Those steps are described next.

Multiparty Monitoring

Monitoring and evaluation follows the design and implementation stages of the adaptive management process (see Figure 2). Essentially, monitoring allows for the collection of data that will indicate the effect of the management activity on a variety of variables, or indicators. For example, to test the ecological impacts of restoration-based forestry we may measure tree growth, or the diversity of species in a forest stand, over time. Or, to evaluate the social impacts of a management project we may collect data on jobs or pay rates for individuals involved in the project. Thus, monitoring provides feedback to management actions and leads to adjustments and refinements of subsequent projects. Monitoring allows us to assess whether our predictions were true or false. We can assume that restoration-based forestry will lead to positive social and ecological outcomes, but the only way to "test" that supposition is to actively collect data that will indicate whether we achieved our objectives.

A monitoring design, or sampling design, is created prior to project implementation. The design process defines the indicators, the methods to measure the indicators, the location and frequency of measurement, as well as designating who will collect the data and how it will be analyzed and stored. (USDA Forest Service, 2005)

Multiparty monitoring is a data collection method that incorporates stakeholders into the monitoring and evaluation processes. Under this protocol, groups of stakeholders will have the opportunity to embark together into the woods to collect ecological data or may participate in collecting qualitative social data (i.e. conducting surveys or interviews). Multiparty monitoring encourages learning, as well as teaching, amongst all participants. It seems likely that stakeholders will learn more about the social and ecological impacts of forestry projects by actively collecting data themselves rather than reading reports provided by "experts." A diverse group of individuals is also more likely to bring greater breadth to the monitoring process in terms of questions, indicators, perspectives and objectives. This monitoring protocol is intended to be used by a variety of stakeholders and should also be considered a "living" document. Ultimately, it is the stakeholders who determine what types of values and variables to measure.

Chapter 2 – Designing the Cat Creek Stewardship Project

After formation, and eager to test their "win-win" multi-objective forestry supposition in the Cispus AMA, the Partnership set out to design an experimental thinning project. The first step was a common first step: the acquisition of funding for a project. The Partnership submitted two project proposals to the Gifford Pinchot North Resource Advisory Committee (RAC) in the spring of 2003.[1] One project, the Cat Creek Stewardship Project, proposed to thin a "non-commercial" plantation in order to test the multiple benefit supposition: simultaneously improving wildlife habitat and future timber value.[2] In October of 2003, this project received approval and full funding from the RAC. At that point, the Partnership could commence with project design, including researching and documenting the science and policy elements that would be tested through the project, translating program goals into stand-level objectives, and drafting the silvicultural prescription. Those elements are discussed in the following sections.

Designing a restoration-based forestry project

As mentioned above, the Partnership was intent on experimenting with restoration-based forestry projects. The Partnership was stimulated to move forward with adaptive experimentation based upon emerging case studies and experiments with restoration-based forestry within the scientific community. These studies provided "evidence" that supported the dual-objective strategy of the Partnership. The Partnership set out to design a restoration-based forestry project that would incorporate this evidence and latest science. This section illustrates the science which forms the reasoning behind the restoration-based forestry suppositions.

There exists a large and growing body of scientific evidence that has shown that thinning can accelerate the development of late-successional structures and habitats and increase biodiversity in young stands (Tappeiner et. al. 1997, Hayes et al. 1997, Bailey & Tappeiner 1998, Carey et al. 1999b, Hunter 2001, Muir et. al. 2002). Research by Garman (2003), Poage and Tappeiner (2002), and

[1] Resource Advisory Committees were established under the Secure Rural Schools and Community Self-Determination Act of 2000. The bill was designed to stabilize payments to counties that in the past had been associated with levels of timber harvest. The Act allows counties to spend 15-20% of the appropriated funds on projects that protect, restore or enhance federal lands (Title II Projects).

[2] The term "non-commercial" is used here to distinguish its value from either a pre-commercial or a commercial thin. It is meant to describe a stand that is not yet of commercial value, yet does contain some merchantable material that will be sold.

Oliver and Larson (1996) suggests that many of today's young, previously harvested stands may need active management to ensure they are on developmental pathways similar to those that resulted in natural, late-successional forests. Additionally, Heiken (2003), Spies and others (2002) argue that thinning is necessary to address the reduction of late-successional habitats across the landscape from past forest management activities.[3]

Most of this evidence has come from retrospective studies in stands thinned using traditional commercial thinning strategies designed to maximize growth and economic value of crop trees and not to achieve specific habitat goals. Because commercial thinning tends to simplify stands by creating more uniform spacing and removing non-commercial species, forest ecologists, wildlife biologists and silviculturalists have developed thinning strategies designed to increase biodiversity and structural complexity, as well as increase crop tree value (Carey 2003, Curtis et al. 1998, Franklin et. al. 2002, Spies et al. 2002).These new strategies have been called "thinning for diversity" (Hunter 2001), "variable density thinning" (Carey 2003), "ecological thinning" (Erckmann and others 2000), and even "new forestry" (Holmberg et. al. 2003). This protocol will use the term variable density thinning (VDT).

VDT seeks to both speed the development of late-successional forests and allow younger stands to provide some of their structure and function, mainly as wildlife habitat. It attempts to address the lack of legacies (large trees, snags, wildlife trees, downed logs, undisturbed patches of old growth), high densities, low level of plant diversity, and spatial uniformity associated with stands that were clear-cut and planted. Instead of viewing fires, wind, root rots, insects and others small and medium scale natural disturbance agents as threats to timber value, VDT works with and mimics these natural processes to create the horizontal patchiness and multiple canopy layers typically found in natural young stands, as well as late-successional forests. This complexity creates diverse understory light environments that promote a wide array of ecological niches, leading to higher plant and animal diversity.

VDT treatments are very new and have mainly been designed and installed in numerous long term scientific experiments established to test the ecological and silvicultural effects of VDT (Carey et al.

[3] See Appendix D (Rural Technology Initiative 2003) for a concise summary of this research or Hunter (2001) for a longer review.)

1999, Hunter 2001, Harrington and Carey 1996). Although these experiments have produced useful results, there is still a relative scarcity of information regarding the economic, silvicultural and ecological tradeoffs, especially compared to traditional commercial thinning, which is easier and more efficient to implement. On an operational level, VDT is currently in transition from scientific experimentation to management level application. While most of the objectives of VDT are relatively straightforward, defining and achieving the desired level of horizontal patchiness is complex and challenging. Several approaches have emerged.

Land managers at Fort Lewis, Wash., have been implementing a version of VDT for over a decade and have developed descriptive marking guidelines to achieve the goals of VDT (Public Forestry Foundation 2001). Summer field technicians who are trained by permanent employees do most of the marking of trees to be removed. Although this approach produces variable and diverse stands, it is not quantitative and relies almost completely on the judgment of the markers, many of whom have little forestry knowledge or experience.

A much more quantitative approach has been developed based on results from the Forest Ecosystem Study (Carey et. al. 1999a) and extensive research into horizontal spatial patterning found in 11 late-successional and mature stands in southwestern Oregon (Carey et. al. 1999). Topographic features (ridges, riparian areas, wetlands, cliffs, etc.), forest disease incidence (i.e. root rot pockets), and logging system features (cable corridors, skid roads, landings) are used to establish the initial spatial variability. Then, based on stand conditions, a range of three to four target densities are determined from high to low density. The stand is thinned to achieve a 2-to-1 ratio of higher to lower density patches. Patches are designated on a scale of one-half to one acre. One of the target densities is typically no-thinning (skips), and small gaps can be added to increase variability even further (Carey, pers. comm. 2004). Although quantitative, this approach has proven difficult for managers to lay-out and monitor in the field, especially within the constraints of traditional public agency contracting procedures.

The third approach to spatial variability has been developed by U.S. Forest Service silviculturalists in various ranger districts (Harrington pers. comm. 2004, Obedzinski pers. comm. 2004) in western Oregon and Washington. The Washington State DNR is also preparing to implement this approach (Holmberg 2003). Gaps and skips are added to a conventional thinning prescription based on a

Table 1: Comparison of Variable Density Thinning with Commercial Thinning

	Variable Density Thinning	Commercial Thinning
Main Objectives	Accelerate development of late-successional structure & habitats Increase biodiversity	Release growing space to increase growth and value of crop trees Interim income
Horizontal Patchiness	Increases or maintains - Creates patches of different densities throughout stand, including skips (reserves) and gaps.	Decreases - Creates more uniform spacing to maximized crown space for crop trees
Vertical Structure (Multiple Canopy Layers)	Maintains & accelerates - Retain & release shade tolerant species and advanced regeneration - Planting of shade-tolerant species	Maintains or decreases - Focus on overstory crop trees: no attention to advanced regeneration. - Removes intermediate and suppressed
Species Diversity	Increases or maintains - Retains and releases minor species. - Greater vertical and horizontal complexity creates diverse niches. - Planting of understory trees & shrubs	Decreases - Removes non-commercial species. - Uniform spacing and tree size creates a uniform light environment that favors dominant shrubs and lowers diversity.
Snags, wildlife trees & CWD	Increases or maintains - Retains these structures as much as practical. - Follow-up treatments to increase where needed	Decreases - Some structures retained to meet regulatory requirements. - Remainder are removed for safety, operational efficiency, or pulp.
Natural Disturbance Agents	Works with - Leaves alone, promotes, or contains. - Seeks to mimic structural complexity created by natural disturbances.	Suppresses - Eliminates or contains. - Threat to timber value
Reserves (Skips)	Left as high density patches or to protect important structures or species.	None unless required - Can be required in riparian, sensitive, or in-accessible areas.
Soil protection	Minimizes - Generally leave slash on site depending on soil and fire risk.	Minimizes as economical - Leave slash or pile and burn, depending on soil, costs, and fire risk.
Operational Issues	More complex - All harvesting systems can be used - Requires greater operator skill	Straightforward
Economics	Produces Revenue & Increases Growth	Maximizes Revenue & Increases Growth

single desired density. Outside of the clearly marked gaps and skips, spacing, basal area or trees per acre targets are used to monitor contract compliance. Releasing and/or not thinning specific desired species typically adds additional complexity. Other creative mechanisms have been devised, such as not counting certain species in density measurements, varying spacing targets for specifically marked trees, or using landscape or logging system features such as streams, ridges, roads, or yarding corridors to divide stands into smaller units and thinning them to different densities. This approach is by far the easiest to implement on a consistent basis. However, the pattern and scale of horizontal patchiness can be somewhat arbitrary and is not based on a framework derived from specific habitat requirements or unmanaged forests that are known to provide desired habitats.

Incorporating innovative contracting mechanisms

In addition to testing innovation in silvicultural design, the Cat Creek project also incorporated innovative contracting mechanisms that would be "pilot tested" through the monitoring process. These so called "Stewardship Contracting Authorities" were authorized in 2003[4], and the Partnership determined that the goals of the legislation overlapped with the goals of the group. Namely, the contracting innovations were intended to assist in the restoration of forests while meeting local and rural community needs. According to the legislation, the goals of Stewardship Contracting are to:

> "Achieve key land-management goals that improve, maintain, or restore forest or rangeland health; restore or maintain water quality; improve fish and wildlife habitat; reestablish native plant species and increase their resilience to insect and disease; and reduce hazardous fuels that pose risks to communities and ecosystem values through an open, collaborative process. The legislation also requires that projects meet local and rural community needs in addition to the land management goals."[5]

[4] Section 323 of Public Law 108-7, The Consolidated Appropriations Resolution, 2003
[5] Ibid

Stewardship Contracting authorizes a number of unique contracting mechanisms and processes to achieve the above-mentioned goals.[6] The Partnership decided to incorporate several innovative contracting mechanisms into the Cat Creek project design. By doing so, the mechanisms could be tested as tools for improving the efficiency and effectiveness of restoration-based thinning projects. Below is a short explanation of the mechanisms along with some of the testable assumptions. The contracting effectiveness indicators will be further explained in Chapter 3 under the Socio-economic Monitoring Protocol.

Best Value Contracting (BVC) is a required procedure for all Stewardship Contracting projects. BVC allows the Forest Service to select contractors based on select factors beyond low or high-bid, including but not limited to: the contractor's vision to achieve the technical nature of the project and to meet the ecological goals; the experience and references of the contractor; and, the commitment of the contractor to hire local residents. The objective behind BVC contracting is to select contractors that provide "best value" to the federal government in satisfying the performance goals of the project.

Designation by Prescription (DxP) is defined as: "A method of designating trees for removal without marking individual trees by describing the desired end result of the treatment." Sales that utilize DxP must be scaled at the mill, and paid for based on weight (tons). DxP allows the logging contractor to use his or her best judgment, within clear guidelines set forth in the prescription, in selecting which trees to cut. Traditionally agency staff made the tree selection decisions in thinning sales by marking trees with paint. The high cost of marking compared to the low value of individual trees in young stands has made marking less attractive in recent years. Theoretically, DxP reduces these costs and puts faith in the expertise and experience of the contractors who have direct knowledge of the capabilities and limitations of their harvesting machinery. By including the contractor in the decision making and providing flexibility, DxP generally results in less damage to the remaining trees, soils, and other important ecological features. DxP does require more intensive contract compliance and greater contractor knowledge, however.

[6] See: http://www.redlodgeclearinghouse.org/legislation/stewardship3.html for more information on contracting authorities. Also see Community-Based Forest Stewardship at: http://www.pinchot.org/

Exchange of "goods for services": In typical timber situations, the Forest Service uses service contracts to perform services (using a traditional low-bid process) and timber sale contracts to conduct the removal of commercial products. The "goods for services authority" allows the Forest Service to combine these two contracts – using the value of commercial products to offset the costs of services. The rationale is that such blending will reduce costs to the government and achieve other planning and implementation efficiencies.

Designing project objectives

A third aspect of project design involves transforming broad program-level goals into project or stand-level objectives that can be directly associated with measurable indicators. Project level objectives with measurable indicators allow stakeholders and program managers to determine to what degree project objectives and program goals are being achieved.

Additional stand level objectives were provided by existing management direction. The Cat Creek stand is classified as Managed Habitat/Habitat Development under the Cispus Adaptive Management Area Landscape Analysis Design (LAD). This designation accommodates moderate timber harvest but emphasizes the restoration, maintenance and connectivity of late-successional forest. Using the framework of the LAD objectives, recommendations from the Middle Cispus Watershed Analysis, and feedback from local community members, the Pinchot Partnership and its monitoring advisory team selected a treatment area (stand) and then defined a set of management objectives for the Cat Creek Stewardship Project.

Project-level Ecological and Silvicultural Objectives

1) Accelerate the development of late-successional forest structure and habitat. This includes:
    a. Large trees: >40" diameter at breast height (dbh) with complex crowns
    b. Wildlife trees: live trees with rot (decadence), complex branch systems, and/or other habitat structures.
    c. Large snags: >10" dbh
    d. Large course woody debris (CWD): >12" larger end diameter and >15' in length

    e. Multiple canopy layers, including shrub and herbaceous layers
    f. Horizontal patchiness: a stand with openings and patches of difference densities (spatial heterogeneity).
    g. A diverse plant community including hardwood and conifer trees, tall shrubs, low shrubs, herbs, epiphytes, lichens, fungi, herbs and others
2) Preserve options for future harvesting and increase the future timber value of the stand.
3) Minimize damage and disturbance to riparian areas and soils.

Project-level Social and Economic Objectives

1) Produce and develop:
    a. Local employment opportunities
    b. New and useful skills and experience for contractors/workers
    c. Income/wages for local contractors/workers
    d. A diversity of wood products
    e. Net revenue
2) Compare the effectiveness of Cat Creek silviculture operations and innovative contracting mechanisms to standard operations and contracting methods
3) Assess effectiveness of collaborative processes, including decision-making, project design and multiparty monitoring. Also improve intra Partnership communication, participation and group learning.

An additional step in the project design phase was the formulation of the silvicultural prescription, which is crafted to meet stand level objectives. A summary of the prescription follows. The entire prescription can be accessed in Appendix B.

Silvicultural Prescription

Drafting a silvicultural prescription for Cat Creek was a critical part of the design process. The prescription, which dictates how logging will take place in the stand, translates ecological and silvicultural objectives to the ground. The prescription is also where the bulk of the adaptive testing takes place. Upon monitoring the impacts of the project, the planners can go back to the prescription and assess where future changes may be made to increase desired effects or decrease undesired impacts. The prescription is also where scientific hypotheses are translated into "on-the-ground" experimental actions.

This Cat Creek thinning prescription was designed with the understanding that the stand may be entered again in the next 15-30 years for a second thinning if deemed necessary to achieve ecological objectives. The stand will be managed to create late-successional structure and habitat in a 100 year or greater time frame.

The primary objectives of this entry are to reduce stocking levels and open up sufficient growing space to:

- Significantly increase growth rates of dominant and co-dominant trees
- Accelerate the growth and continued establishment of advanced regeneration
- Prevent stagnation and mortality of intermediate and co-dominant western red cedar, western hemlock, minor conifer species and hardwoods

Due to the high degree of variability and diversity within the stand, the long-range management timeframe, and the opportunity for future entries, this thinning entry attempts to work with the existing horizontal heterogeneity and natural development processes to encourage structural and species diversity, rather than impose a set level of density, spacing, or variability. Instead of density or spacing targets, thinning guidelines are based on proportionally removing 50% of 8-14.9" dbh Douglas-fir within 1/20th acre areas throughout the stand, as well as all Douglas-fir under 8"dbh and some western hemlock infected with dwarf mistletoe. We predict that this will result in a similar horizontal spacing pattern post thinning as currently exists within the stand. The goal is to avoid simplifying the existing horizontal spacing patterns that have developed through a combination of human intervention (logging and replanting) and natural processes (regeneration, disturbances, and response to site-specific conditions).

The thinning treatment will reduce stand density to an average Curtis RD of 33. Approximately 40% of the stand basal area will be removed. Although canopy cover is estimated to drop to 68%, which is just below the 70% level recommended in the Watershed Analysis, crown expansion after thinning will move the stand back above this level within a few years.

Approximately 10% of the stand will be reserved in skips and 3 1/5th acre gaps will be created. Structures, such as snags, CWD, hardwoods, etc., critical to biodiversity will be protected in skips or through special designation. Additional snags and wildlife trees (2/acre) will be created after the thinning operation is complete. Harvesting will require a combination of ground and cable based yarding.

Service activities include: placing slash on skid trails, cable yarding corridors and landings to reduce compaction and erosion potential, reconstructing and then decommissioning post-harvest approximately 4000 lineal feet of road 78-638, precommercial thinning of approximately 150 acres.

Chapter 3 –Multiparty Monitoring Protocols

As mentioned earlier, a monitoring program provides a mechanism for evaluating the effectiveness of specific management activities and allows planners to assess to what degree they are achieving their stand-level project objectives (see Chapter 2). A monitoring program that is implemented across a program area (i.e. multiple stand-level projects) can inform planners on the effectiveness of a program in meeting broad goals (i.e. alleviating socio-ecological problems). It is important to note that a single project cannot alleviate broad systemic level problems – no member of the Partnership expects a "magic bullet" – however, without a reliable monitoring plan one would only be able to anecdotally gauge the impact of multiple projects on those problems. A long-term monitoring plan, and the consistent use of indicators, increases our ability to measure change in social and ecological conditions.

To assess whether project objectives are being met, and to what degree, corresponding indicators are formulated and defined. Useful indicators can be readily measured, analyzed, recorded and reported for use in future management, comparative analysis and learning. Indicators should be used repeatedly, so as to provide a common set of data that can be tracked over time. It is important to note that, using adaptive management principles, indicators can be modified, added or removed according to their utility.

Ecological and Silvicultural Monitoring Plan

This section describes specific ecological and silvicultural objectives for Cat Creek, the associated monitoring indicators, as well as the rationale behind the indicators. The rationale is included so the protocol can be upgraded as new science emerges, or to allow specific objectives to be used for different projects or at the programmatic level.

This ecological monitoring plan is modeled after guidelines for ecological monitoring used by The National Park Service and United States Geological Survey (Oakley et al. 2003), and multiparty monitoring guidelines for forest restoration developed by the US Forest Service (USFS 2005).

The broad ecological objective of the Cat Creek Collaborative Thinning Project is to accelerate the development of late-successional forest conditions. This objective must be broken down into several components in order to identify indicators and implement an informative, efficient monitoring plan.

In the remainder of this section, we present rationale for several specific ecological objectives, and identify suitable monitoring indicators for each. We also present a sampling design; develop field protocols; outline appropriate data analysis techniques; discuss personnel, training and equipment requirements; and suggest strategies for maintaining a long-term ecological monitoring program.

Ecological Silviculture Objectives: Rationale and Indicators

Ecological Silviculture Objective 1: Maintain or increase growth rates of dominant and co-dominant trees.

Monitoring Indicators: Current 10 year radial growth; Mean tree dbh, Basal area growth; Volume growth, height growth.

Rationale: Large diameter live trees are a defining characteristic of late-successional forest structure in Pacific Northwest forests (Franklin et al. 1981, Franklin and Spies 1991). In part, accelerating the development of late-successional forest conditions requires increasing individual tree growth rates. A principal objective of thinning in any management context is to increase individual tree growth rates. The beneficial effects of wide initial spacing and thinning on residual tree volume growth are well-known (Assman 1970, Reukema and Bruce 1977, Drew and Flewelling 1979, Reukema 1979, Curtis and Marshall 1986, Marshall 1991, Marshall et al 1992, Smith, et al. 1997, Tappeiner et al. 1997). Thinning dense stands reduces competition between neighboring trees by reducing the number of individual trees competing for scarce resources available within a discrete area, thereby increasing the growing space (i.e. resources) available to residual stems. Inter-tree competition due to high stem densities can reduce tree growth and vigor to the point of inducing mortality. While competitive mortality is a natural phase of stand development in many forests (Oliver and Larson 1996) and in many Douglas-fir stands (Franklin et al. 2002), judicious thinning can accelerate forest stands through this process towards a desired structural condition, such as late-successional structure.

Ecological Silviculture Objective 2: Promote the development of structurally complex, decadent individual trees.

Monitoring Indicators: Crown ratio, epicormic branches development, decadence (rot) and damage.

Rationale: Large, complex tree crowns provide much of the fine-scale structural complexity characteristic of old-growth Douglas-fir forests. This structural complexity provides critical habitat for many elements of biological diversity (Franklin et al 1981, Franklin et al. 2002). Recent research has described the age-related development of Douglas-fir crown structure (Ishii and McDowell 2002). This process-based research and suggests that active management could accelerate the development of structurally complex tree crowns.

Ecological Silviculture Objective 3: Maintain and increase horizontal patchiness

Monitoring Indicators: Histogram of plot densities, SE, CV of plot densities or RD

Rationale: Old-growth Douglas-fir forests are characterized by spatial heterogeneity, with tree distribution broken by canopy gaps (Franklin et al. 2002) Results of several studies suggest that old-growth forests and forests suitable for spotted owl habitat are characterized by spatial variation in overstory tree density (reviewed in Carey et al 1999). Lindenmayer and Franklin (2002) provide an excellent review of strategies for managing young stands for biodiversity, and highlight the utility of variable density thinning prescriptions at achieving multiple management objectives, particularly the creation of a spatially heterogeneous stand structure.

Ecological Silviculture Objective 4: Provide for future recruitment of large diameter snag and coarse woody debris (CWD)

Monitoring Indicators: Diameter growth, volume growth, tree mortality

Rationale: Large diameter snags and CWD are vital components of a late-successional forest (Franklin et al. 1981) and are critical habitat structures for many plants, animals and fungi (Harmon et al 1986). Thinning cannot provide an immediate increase in the amount of large-diameter snags and CWD within the stand. However, by accelerating the growth rate of live trees the stand will develop the capacity to produce large-diameter snags and CWD sooner.

Ecological Silviculture Objective 5: Accelerate the development of multiple tree canopy layers.

Monitoring Indicators: Seedling and sapling density, shade-tolerant tree recruitment into larger size classes, height growth.

Rationale: A multi-layered or continuous canopy structure dominated by shade-tolerant conifer species in the understory is characteristic of late-succession and old-growth Douglas-fir forests (Spies and Franklin 1991, Van Pelt and Franklin 2000, Franklin et al 2002). Canopy structure regulates the understory light environment (Parker 1997), which controls, at least partially, understory plant community growth and development (Del Rio and Berg 1979, Van Pelt and Franklin 2000). Continuous canopy structure is also important habitat for some wildlife species, such as the Northern spotted owl.

Thinning is known to increase conifer seedling establishment, growth and survival. Bailey and Tappeiner (1998) found thinned Douglas-fir stands had significantly higher conifer seedling densities and frequencies than unthinned stands, but were very similar to old-growth stands. Following a reconstruction of the development of an old-growth Douglas-fir stand within the Cispus River watershed and only a few miles from Cat Creek, Winter and others (2002) concluded that canopy disturbances had played an important role in the structural development of the stand by releasing shade tolerant trees. Variable density thinning can mimic this process by removing some overstory trees, allowing shade tolerant conifers already established in the stand to grow and eventually occupy the mid-canopy.

Ecological Silviculture Objective 6: Promote understory shrub and herb growth and diversity.

Monitoring Indicators: Herb cover and diversity, shrub cover, height and diversity.

Rationale: A well developed shrub and herb understory community is characteristic of old-growth Douglas-fir forests (Spies and Franklin 1991). Shrub and herb layers constitute important habitat and food resources for many animal species (Mannan and Meslow 1984, Carey and Johnson 1995, Hayes et al. 1995, Hagar et al 1996). A well developed shrub layer with large individual plants provides important habitat for wildlife species (Hayes and Hagar 2002).

Young, dense stands, such as Cat Creek, often support depauperate understory communities (Franklin and Dyrness 1988). Bailey and Tappeiner (1998) found that thinning in 40 to 100-year-old Douglas-fir stands stimulated shrub development and concluded that thinning accelerates the development of late-successional understory structure. Bailey and Tappeiner's findings corroborates earlier work by Tappeiner and Zasada (1993), who found that thinned stands had greater understory shrub and hardwood tree seedling emergence and survival than unthinned stands.

Ecological Silviculture Objective 7: Maintain approximately 70%+ canopy closure

Monitoring Indicators: Canopy closure estimates derived from stocking, dbh, height, and crown volume measurements.

Rationale: The Cat Creek Watershed Analysis plan recommends that canopy closure be maintained at 70% or higher to reduce risk of flooding damaging from rain on snow events.

Ecological Silviculture Objective 8: Preserve options for future harvesting and increase the future timber value of the stand.

Monitoring Indicators: Diameter class distribution, species distribution, stocking densities, Current 10 year radial growth, height growth, stand level basal area and volume growth, levels of defect.

Rationale: The management objectives for this stand include both ecological and wood production goals. Because public values change through time it is desirable to maintain as many options for future management decisions as possible. As described in Objective 1, the increases in stand growth as a result of thinning have been well established. One of the chief uncertainties regarding variable density thinning vs. commercial thinning is the degree to which total stand growth, wood quality, and market value are reduced to meet structural and species diversity goals. It is also possible that the greater species diversity encouraged by VDT will provide for greater protection against catastrophic disturbance and changes in timber markets.

Ecological Silviculture Objective 9: Protect and minimize damage to existing snags, CWD, wildlife trees, and rare species during harvest operations.

Monitoring Indicators: Post harvest assessment of damage to specifically flagged structures, as well as unmarked structures. Comments on effectiveness of different strategies and associated costs from operator and sale administrator in post harvest surveys.

Rationale: One of the chief goals of variable density thinning is to maintain and increase the numbers of these critical structures. However, damage and loss of some existing structures is inevitable during any thinning operation. The extent to which these can be protected while maintaining reasonable operational efficiency is a critical question in ecological thinning. Various strategies will be used to achieve the maximum degree of protection including placing critical structures in skips, flagging of structures, specific contract language requiring protection, and allowing the operator to choose which trees will be thinned. In general, sale administrators will involve the operator as much as possible in developing methods to protect these structures.

Ecological Silviculture Objective 10: Minimize long-term soil and understory vegetation impacts due to logging operations.

Monitoring Indicators: soil displacement, rill erosion, culvert failure, sediment transport along decommissioned road, herb cover and diversity, shrub cover, height and diversity.

Rationale: Any thinning operation requires the design and use of a transportation system for heavy equipment. In areas where equipment use is concentrated, such as roads, yarding corridors and skid trails, long-term damage to soil and understory communities is a real possibility. Some soil disturbance is very likely beneficial because it provides sites for germination and establishment of understory plants and shade tolerant trees, ultimately helping achieve Ecological Silviculture Objectives 6 and 7. However, too much disturbance can lead to excessive soil compaction and erosion, which can in turn compromise plant community development and potentially impact riparian areas.

Table 3. Ecological silviculture and monitoring indicators for the Cat Creek Thinning Project.

Objective	Indicator
1. Maintain or increase growth rates of dominant and co-dominant trees	Current 10 year radial growth; Mean tree dbh; Basal area growth; Volume growth; height growth
2. Promote the development of structurally complex, decadent individual trees	Crown ratio; epicormic branch development; decadence (rot) and damage
3. Maintain and increase horizontal spatial variability	Histograms of tree density and Curtis Relative Density
4. Provide for future large diameter snag and CWD recruitment	Diameter growth; volume growth; tree mortality
5. Accelerate the development of multiple tree canopy layers	Seedling and sapling density; shade-tolerant tree recruitment into larger size classes; height growth
6. Promote understory shrub and herb growth and diversity	Herb cover and diversity; shrub cover; height and diversity
7. Maintain approximately 70%+ canopy closure	Canopy closure estimates derived from stocking, dbh and height
8. Preserve options for future harvesting and increase the future timber value of the stand	Diameter class distribution; species distribution; stocking densities; current 10 year radial growth; height growth; stand level basal area and volume growth; amount of defect
9. Protect and minimize damage to existing snags, CWD, wildlife trees, and rare species during harvest operations.	Damage to existing structures; Post-treatment snag density; Comments on effectiveness of different strategies and associated costs from operator and sale administrator in post harvest surveys
10. Minimize long-term soil and understory vegetation impacts due to logging operation	% exposed mineral soil; soil displacement; rill erosion; herb cover and diversity; shrub cover; height and diversity

Ecological Silviculture Sampling Design

The principal function of an ecological monitoring program is to asses the success of a particular management activity at achieving a desired future condition or outcome. Natural resource monitoring rests on the assumption of a causal link between management (in other words, the treatment) and the response (in this case, accelerated development of late-successional forest structure.) In forestry, this assumption is built on a long history of research and the aggregated professional experience of forest managers. The site-specific validity of this assumption can be greatly improved by establishing a control or reserve area adjacent to the treated area for comparison purposes. However, due to the limited size of the Cat Creek Thinning Project, it is not feasible to set aside a control unit. Instead, we develop a set of expected outcomes to which actual outcomes can be compared. Future, larger-scale variable density thinning projects implemented the Cispus AMA should utilize a paired treatment-control design in order to substantiate the assumption of causality and to test for a change in the rate of structural development in treated versus untreated stands.

It is important to recognize that natural resource monitoring for adaptive management purposes is not the same as a replicated scientific experiment. Formal statistical hypothesis testing is generally not an appropriate application of monitoring data, particularly at the individual project level. Inferences and generalizations from monitoring data must be made cautiously; monitoring virtually always employs pseudo-replication and actual type two error rates may be much higher than those calculated from monitoring data. Additionally, due to management objectives, operational constraints and land-use designations, treatments are almost never randomly assigned. While statistical tests may not be appropriate with monitoring data, there are many exploratory data analysis techniques that can be used to extract valuable information in the interest of informing adaptive management planning and decision making processes. We review data analysis techniques in a later section.

A long-term ecological monitoring program has three major components: measurements, space and time. The measurements are characterizations of forest structure and composition (e.g. tree density, DBH, % shrub cover) and are directly related to the indicators identified above. The spatial component of a monitoring plan defines how aggregations of measurements, sample units, are arranged in space. The long-term nature of ecological monitoring necessitates a temporal component defining the frequency with which measurements are repeated at a particular location. In this document, methods for specific measurements are described in detail in Appendix B. In the remainder of this section we describe the spatial and temporal components of the Cat Creek Ecological Monitoring sample design.

Sampling for monitoring of Ecological Silviculture Objectives 1-9 will follow a systematic design with a random start (Avery and Burkhart 1994). That is, sample plots will be distributed systematically throughout the entire treatment area. While a systematic design has some statistical limitations, it has several features that make it particularly attractive for use in a multiparty monitoring program. A systematic sample ensures full coverage of the project area, a desirable feature in many natural resource applications. Additionally, a systematic design is logistically much simpler; once the first sample plot has been located all other plots can be easily on the sample grid.

Each sample plot location will be recorded with a natural resource management-grade Global Positioning System (GPS) receiver. Actual plot center locations will be recorded in the field with the GPS. Plots have been installed (August, 2004) prior to the thinning treatment in order to establish baseline conditions. Plots are inconspicuously marked, with no trees tagged or painted, so that the loggers do not unconsciously bias their implementation of the thinning prescriptions. Immediately post-treatment, plots will be revisited and measured in order to quantify treatment implementation. Plots will be remeasured 5 years after initial installation. Following the initial 5 year remeasurement, plots will be remeasured every 5 or 10 years, for as long as the Partnership deems useful. Plots should be remeasured at least every 10 years throughout the lifetime of the monitoring effort; temporal resolution finer than 5 year intervals is not necessary given the Ecological Silviculture Objectives and anticipated applications of the monitoring data. The initial sample size estimate for the Cat Creek Monitoring Project is n = 24 sample plots.

Sampling for assessment of Ecological Silviculture Objective 10 will not follow a simple random design. Due to the very specific nature of Objective 10, monitoring will be based on qualitative measures, primarily photo-documentation of soil disturbance and subsequent vegetation recovery in yarding corridors and skid trails.

Personnel, Training and Equipment Requirements for Ecological Silviculture Monitoring

This monitoring field protocol (Appendix B) has been designed so that a diverse group of citizen stakeholders could, with the assistance of one forestry professional or ecologist, implement the program and conduct ongoing monitoring. At least one member of the field crew must possess solid Pacific Northwest plant identification skills. Some measurements require specialized equipment, including an increment borer, GPS unit and laser rangefinder. Most of the required equipment can be used accurately and efficiently by inexperienced field crew members after a brief initial training. This equipment, and training in its use, should be obtained through collaboration with the local US Forest Service district office and/or the University of Washington, College of Forest Resources.

We estimate that the projected 24 Ecological Monitoring Plots can be established or remeasured in two days by four people working in teams of two individuals each. This estimate assumes that each team of two will include one individual with plant identification and forestry field skills, and that each team will have a complete set of the equipment listed in Appendix B.

Data Analysis for Ecological Silviculture Monitoring

Initial analysis of the data generated by the Cat Creek ecological and silvicultural monitoring program will be limited to graphical analysis and summary statistics. Many of the monitoring indicators rely on comparisons of mean values (in other words, mean tree DBH, mean shrub or herb cover, mean seedling density). However, for some objectives, such as Ecological Silviculture Objective 3, the relevant monitoring indicators assess variability in the population. In both cases, however, it is important to include mean values and measures of variability for the indicator measured. Reporting confidence intervals or other measures of variability with mean values makes critical assessment of the data for a treatment response possible.

In the context of adaptive natural resource management, it is appropriate to develop some informal hypotheses about the anticipated response of the various indicators. This allows managers to focus their analysis of monitoring data and identify specific areas where the management prescription did not yield the expected result. Specifying *a priori* responses to treatments, in terms of the absolute or relative *magnitude* of the response, for adaptive management hypotheses is very difficult and is probably not even appropriate. However, hypotheses about the anticipated *direction* of change—

increase or decrease—are quite reasonable. We present anticipated changes for several indicator variables (Table 4). These informal hypotheses should be used to focus initial ecological monitoring data analyses in order to assess the success of the prescription at achieving the stated objectives, and inform future iterations of adaptive-management-based variable density thinning prescriptions in the Cispus AMA.

This document will serve as the primary record of monitoring objectives and protocols for the Cat Creek Stewardship Project. The detailed protocols described in Appendix B (field methods) are designed to allow periodic remeasurement by different field personnel. Methods are described in adequate detail such that there should be no variation in implementation from one field crew to another, or between measurement periods. At some point in the future, changes to the protocol presented in this document may need to be made. If protocol changes become necessary, the motivation for the change (e.g. new objective or technological/methodological advances) and the addition or deletion of specific protocol must be documented in detail. Any updates to this document should be stored with the original document. This will allow future individuals, particularly data analysts and land managers, to accurately interpret monitoring objectives and data.

Table 4. Expected changes in Ecological and Silvicultural monitoring indicators for the first two monitoring periods.

Indicator	Anticipated Change	
	Baseline to 1 year post-treatment	Post-treatment year 1-5
Mean tree density	Decrease	No change or slight decrease
Coefficient of variation of tree density	Increase	No change or slight decrease
Mean tree DBH	Increase	Increase
Mean tree radial growth rate	N/A	Increase or no change
Crown ratio	N/A	Increase
Mean tree height	N/A	Increase
Mean canopy cover	Decrease	Increase
Epicormic branch abundance	N/A	Increase
Epicormic branch size	N/A	Increase
Conifer seedling/sapling density	Decrease	Increase
Conifer seedling/sapling height growth	Decrease	Increase
Shrub cover	Decrease	Increase
Shrub height	Decrease	Increase
Shrub diversity	Decrease or no change	Increase or no change
Herb cover	Decrease	Increase
Herb diversity	Decrease or no change	Increase or no change

Social and Economic Monitoring Plan

This section includes a monitoring design and specific indicators that can be used to evaluate the effectiveness the Cat Creek Stewardship Project in achieving social and economic objectives. As mentioned earlier, an indicator is a "unit of information measured over time that documents changes in a specific condition." The Partnership is interested in how projects like Cat Creek affect change in social and economic conditions.

The social and economic monitoring plan is modeled after guidelines provided by several sources including the USDA Forest Service Southwest Region's *Multiparty Monitoring and Assessment Guidelines*[7] as well as the *Guidebook for Multiparty Monitoring for Sustainable Natural Resource Management,* a publication of the Ecosystem Workforce Project of the University of Oregon and the Watershed Research and Training Center in Hayfork CA.[8] We recommend that monitoring team members acquire both documents as they provide step by step methods for collecting, analyzing, and communicating social data.

This section includes information on sampling design – including data collection and analysis. All data should be collected post-project implementation. Collecting pre-project data for Cat Creek is probably not feasible, although the Partnership should consider collecting baseline data on socio-economic indicators if the group begins to conduct multiple projects (program monitoring). Although specific interview guides have not been created under this protocol and are subject to the discretion of the monitoring teams, questions and subject areas should be apparent from the "learning questions". Monitoring team members should feel enabled to design surveys and questionnaires that probe on particular issues of interest.

Social and Economic Objectives

As mentioned earlier, the Partnership presented the design team with a broad set of social and economic goals. Recall that the initial Partnership mission included the achievement of "community health." An additional Partnership goal was "learning." All project–level objectives thus can also be

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[7] See http://www.fs.fed.us/r3/spf/cfrp/monitoring/
[8] See http://ewp.uoregon.edu/guidebook/

considered as "learning questions" or "learning opportunities." The design team worked with Partnership members to fine-tune programmatic goals into the project-level objectives. The team also relied upon existing literature and case studies to provide project-level objectives. These project-level objectives, presented earlier in Chapter 2, are:

1) Produce and develop:
    a. Local employment opportunities
    b. New and useful skills and experience for contractors/workers
    c. Income/wages for local contractors/workers
    d. A diversity of wood products
    e. Net revenue
2) Compare the effectiveness of Cat Creek silviculture operations and innovative contracting mechanisms to standard operations and contracting methods
3) Assess effectiveness of collaborative processes, including decision-making, project design and multiparty monitoring. Also improve intra Partnership communication, participation and group learning.

Objectives were designed to be representative of the broad goals outlined by the Partnership. Certainly, other objectives could have been included; in fact there is a significant literature dedicated to the topic (see references in Donoghue and Haynes (2002) for a good review of the "community well-being" literature.)

Objectives and Indicators

The design team, after formulating the objectives, set out to create indicators that could measure achievement of those objectives. Again, existing literature and case studies were utilized to generate ideas. (Several excellent examples are borrowed from the USFS source cited earlier in this section.) Program evaluation methods were also applied to the indicator design.

Objectives are presented here with the associated learning questions, indicators, as well as notes on data collection methods, analysis and other comments. Learning questions frame the objectives, and contain a sampling of the type of information that may be collected in qualitative interviews.

Multiple indicators allow opportunities for "triangulation", often combining quantitative and qualitative methods. A rationale for the indicator may not be clear, and a note is provided.

Objective 1 – Produce and develop:

- Local employment opportunities
- New and useful skills and experience for contractors/workers
- Income/wages for local contractors/workers
- A diversity of wood products
- Net revenue

Learning Question(s) – What is the economic impact of the Cat Creek Stewardship project? Did Cat Creek employ local workers?[9] How does Cat Creek compare to other GPNF thinning projects, in terms of economic impacts (i.e. jobs, volume, types of products, etc.)? Are contractors developing new skills implementing variable density thinning? Would contractors bid on this type of project again? Why or why not? Did Cat Creek "make" or "lose" money? Can the costs be lowered? How?

Indicators

- # of local workers/contractors employed
- Contact duration (days, weeks, months)
- # and description of new skills/experiences
- Earnings/wages/ "quality" for contractors/workers
- Volume and types of wood products
- Project costs and revenues

Collection Methods

- USFS Project documentation should include information on volume and types/grades of wood products as well as information on project costs and revenues. The Partnership may have documentation on project costs as well.

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[9] It is up to the monitoring team to define "local." Our team considered Lewis and Skamania counties to be local. Workers from the Cowlitz Valley would be "more" local.

- Interviews (individual or focus group interviews) with contractors, workers and USFS planners are perhaps the best way to gather and assess employment information.[10]
- Surveys of contractors and workers can take the place of interviews, or focus groups.

Analysis Notes

- As more projects are implemented analysis can include % change in indicators over time. For example, "There was a 20% increase in local jobs between 2005 and 2007."
- A simple "economic impacts" spreadsheet, or something similar, should be produced to illustrate the economic statistics.
- Team members could compare project costs to economic indicators to produce useful metrics (i.e. jobs created per $$ invested, cost per acre treated, etc.).

Comments

- Focus group interviews may be more efficient than individual interviews or written surveys.
- "Quality" jobs are defined by the Ecosystem Workforce Program as those that provide family-supporting wages and benefits, a healthy and safe workplace, skill standards and opportunities for advancement, job durability, and the chance to work close to home. These elements should be included in interview guides and surveys to assess the "quality" of project related jobs.
- The "pilot status" of Cat Creek may create unusually high project costs; this type of project, with these types of authorities has not been attempted on the GPNF.

Objective 2 – Compare the effectiveness of Cat Creek silviculture operations and innovative contracting mechanisms to standard operations and contracting methods

Rationale: The Partnership is curious if Cat Creek, as a "new business model", is superior to standard thinning and restoration projects. Cat Creek contains innovations in terms of harvest operations, prescription and contracting mechanisms. For the most part, these innovations have been untested on the GPNF. Thus, Cat Creek acts as an experimental comparison to standard practices.

[10] There are a number of good resources on qualitative data collection and analysis methods. See: Bradburn (2004), Dillman (2000), Frankfort-Nachmias (2000), Miles (1994), Patton (2002), Robson (2002), and Rubin (2005).

Learning Question(s) – Is variable density thinning an effective and efficient way to conduct restoration-based forestry? Or, are standard FS thinning projects more effective and efficient? Do contractors and workers find the prescription and guidelines operationalizable and "user-friendly"? Do FS planners? What were the planning costs of the Cat Creek project? How do those compare to planning costs in standard FS thinning projects? What was the utility of the innovative Stewardship Contracting mechanisms? Are they more efficient than standard contracting methods? Why or why not? Could they be improved? Did *Best Value Contracting* attract experienced local bidders? Was the "*goods for services*" provision utilized, and did it allow for more efficient contract implementation? Were contractors comfortable using *designation by prescription* and did the mechanism make the project more efficient?[11] Were there any barriers to implementing the Cat Creek project? Can those barriers be addressed and overcome? Would participants do a Cat Creek-like project again? What would they change?

Indicators

- Quantitative – Project revenues/costs
- Qualitative – Perceptions of workers, contractors and USFS planning staff

Collection Methods

- USFS Project and Partnership documentation
- Interviews with contractors/workers, USFS planning staff, Partnership
- Surveys of contractors/workers, USFS planning staff, Partnership

Analysis Notes

- USFS should produce project benefit/cost summary for Cat Creek.
- "Perception" responses should be written up in report format and analyzed for themes and patterns. See the qualitative references for good guides.

Comments

- Qualitative interviews may be best way to compare perceptions of Cat Creek to standard projects. Some contractors may not have previously worked on FS projects.

[11] See: Moseley, *A Survey of Innovative Contracting for Quality Jobs and Ecosystem Management*, for more information on assessing innovative contracting.

- Selecting past projects for comparison may be a challenge, as there is no one "standard" project. Cat Creek should be compared, as much as possible, to similar type treatments in the Cispus AMA. It should be noted that Cat Creek costs may be unusually high due to the "pilot status" of the project.

Objective 3 – Assess effectiveness of collaborative processes, including decision-making, project design and multiparty monitoring. Also improve intra Partnership communication, participation and group learning.

Rationale: Partnership participants are interested if the decision-making and other group processes are functioning well for members. This information will allow the group to make improvements in process, and perhaps improve participation and group effectiveness. Group learning is a primary goal of the Partnership. Collective learning and communication will lead to improved decision-making and reduced conflicts. Conflict reduction is a primary goal of the Partnership.

Learning Question(s): How did Partnership participants perceive the decision-making process associated with the Cat Creek project? How could the process be improved? Were participants involved in making decisions related to Cat Creek? If not, why not? Did Partnership members contribute to project design? Why or why not? How many Partnership members participated in multiparty monitoring? Did multiparty monitoring team members find the experience useful? Why or why not? How could multiparty monitoring processes be improved? Did members participate in field tours/meetings/or other Partnership functions? If not, why not? How could communication be improved? What did members learn through the Cat Creek process?

Indicators

- Qualitative – Perceptions of Partnership members and other process participants
- Appeals – Was the project appealed through administrative channels?

Collection Methods

- One-on-one interviews
- Surveys

Analysis Notes.

- "Perception" responses should be written up in report format and analyzed for themes and patterns. Qualitative data can be transformed into descriptive statistics if the monitoring team chooses. See the qualitative references for good guides on qualitative analysis and reporting.

- The presence or absence of an appeal indicates a level of controversy. There is no indication that the Cat Creek project will be appealed. The indicator should be retained for future projects.

Comments

- Surveys or one-on-one interviews with someone from outside the Partnership may be best for this objective. Participants should be assured confidentiality in their responses. Information should be presented in a constructive manner.

- Qualitative surveys that go to Partnership members should be consolidated. For example, Objectives 2 and 3 include questions for members. One questionnaire should be sent to Partnership members and members can select which questions are relevant.

Methodology and data storage common to both protocols

Arrangements should be made to ensure the long-term nature of this monitoring plan. Protocols and data management must be well documented, standardized and safely stored in order to maintain continuity of the monitoring effort through organizational restructuring and personnel changes. It is important to maintain original paper records of field data, surveys, questionnaires, summary reports and other relevant documents. Original data sources allow for quality control/assurance of data entry into an electronic data storage system and also provide a physical back-up in case digital records are lost. Original paper records of field (including surveys and questionnaires) data and notes for every remeasurement period should be maintained in a single file with a copy of the original monitoring plan and field protocol (this document with all appendices and any updated field protocol). The original field data sheets should be backed-up with duplicate photocopies, with records for each measurement period also kept in a single file, stored in a separate building to protect against loss due to fire, flooding or vandalism.

Collaboration with the USFS or another stable organization with technological resources will be necessary to ensure long-term electronic data storage. For the ecological silviculture monitoring data, a single database will be set up as part of the initial monitoring implementation process in which values for every measurement collected in each measurement period are stored. With this system all of the project data is stored in a single file, but measurements can then be sorted, summarized and compared according to a measurement period, plot number or even individual tree. The database is easily updated with new data from remeasurements; a single file database structure also helps ensure that data from individual remeasurement periods are not lost or excluded from the final analysis. Electronic data should be backed-up according to standard information technology protocol.

Funding and Resources

Long-term monitoring projects require adequate, reliable resources in order to guarantee continued and consistent implementation. To some extent, costs associated with the monitoring program can be defrayed by recruiting volunteers for fieldwork and collaboration with organizations such as the US Forest Service and the University of Washington, College of Forest Resources or Evans School of Public Affairs. However, an individual will need to be hired to oversee data entry and analysis and data storage following each remeasurement. This individual should also have field crew leadership responsibilities in order to ensure the highest level of data quality. Many natural resource consulting firms should be able to provide this service. Additionally, it is very likely that a qualified data analyst or statistician will need to be hired in the future to produce a final report at the end of the monitoring program. The GPCWG should develop a long-term strategic plan for securing the funds and resources necessary to maintain a successful monitoring program.

Chapter 4 – From Project to Program

Measuring the broad socioeconomic and environmental impacts of a single project can be challenging due to limited scale and associated generalization issues. For example, it is unlikely that either of the projects detailed in this document will have measurable impacts on the base social and economic fabric of a community like Packwood. With this in mind, the monitoring team has designed monitoring indicators (for the socio-economic objectives, as well as the ecological silviculture objectives) that can be "scaled-up" in the future. In other words, as similar projects are developed and implemented within the Cispus AMA, we will be able to replicate the monitoring steps in order to create a larger data set. The analysis of this expanding data set over time will provide more representative information – information that can then be applied to new projects. This is the essence of adaptive management and systemic "learning by doing." However, it is not necessary for every restoration or thinning project implemented in the Cispus AMA to be monitored. Indeed, monitoring every project would be cost-prohibitive. However, program-scale monitoring and evaluation is vitally important to assessing cumulative socio-economic impacts and landscape scale ecological objectives.

Given program-level information requirements, monitoring efforts undertaken on future projects should employ a uniform monitoring plan within management activity classes (e.g. thinning, culvert replacement, stream restoration). Standardizing monitoring protocols within management activity classes, including sampling design, indicators and measurements, facilitates comparison of results between individual projects and aggregation of monitoring data across projects in a program level summary. In some instances, there will be project-specific restoration objectives and measurements that do not fit into a standardized monitoring plan. These project-specific objectives and associated indicators should be included as additions to a general, standardized monitoring protocol used across projects within a particular project type.

The usefulness of this document to serving other audiences is proportional to the ability to "scale-up" or "scale-out" the project-level objectives, monitoring indicators, and data reporting sections detailed above. One of the objectives for the Cat Creek monitoring plan is to develop a monitoring protocol that it transferable to other thinning projects within the Cispus AMA. In the remainder of this section we discuss how the Cat Creek monitoring plan can be used as a template for future monitoring in the Cispus AMA, and the benefits of standardizing project-level monitoring protocols within a forest management program.

Programmatic Ecological and Silvicultural Monitoring

The ecological monitoring protocol developed for the Cat Creek Stewardship Project was designed to be portable enough to be used as a general ecological silviculture monitoring protocol for other variable density and commercial thinning projects implemented in the Cispus AMA. The size of the circular tree plot may need to be increased in some instances where prescriptions result in relatively low stem densities, in order to ensure adequate overstory-tree sample sizes on each plot. Otherwise, the ecological silviculture monitoring protocol should transfer directly between projects. For some projects it will be desirable to add specific components to the standardized monitoring program in order to evaluate site-specific prescriptions. One example is monitoring decay rates and wildlife usage of artificially created snags. This example is not a component of the Cat Creek prescriptions or monitoring protocol, but could easily be incorporated in future projects, particularly projects in slightly older stands with larger trees.

The overall credibility and statistical rigor of the ecological silviculture protocol will be improved if it is applied in other thinning projects. By using a standardized sampling and measurement protocol in a monitoring program, some of the statistical benefits of a replicated experimental design can be realized in program level evaluations. This is a noteworthy benefit, since it will allow rigorous evaluation of thinning as forest restoration tool and adds credibility to the overall monitoring program. A standardized monitoring and sampling design across projects will also help legitimize formal statistical hypothesis testing for restoration treatment effects at the program level. Including a paired treatment and control, or a blocked (multiple treatments with control) design in as many units as possible, is imperative for these benefits to be realized. This should be no trouble in future projects; it is only due to the small treatment unit acreage that this design (treatment with control) was not used for Cat Creek.

Data storage and management will become increasingly important as additional monitoring is implemented on future projects in the Cispus AMA. A standardized protocol will greatly enhance data management and storage, as well as data analysis. Long-term data management is discussed in greater detail in section three.

Conclusions

This document has set forth the rationale and methodology to create and implement a multiparty monitoring protocol for the Cat Creek Stewardship Project as part of a larger forest restoration program in the Gifford Pinchot National Forest. Conceived through the efforts of a diverse group of forest stakeholders who have come together as the Pinchot Partnership, this project is both the first to emerge from this partnership and a potential model for future projects that this group or other groups may undertake.

Utilizing the latest forest science, the Cat Creek Stewardship Project seeks to transform a relatively young, monocultural stand into one that exhibits, or is likely to more quickly exhibit, late-successional characteristics. The project strives to improve habitat for wildlife while generating revenue for the local community, increasing both the economic and environmental value of the stand. Perhaps most importantly, this project attempts to sidestep the contentious and much-litigated issues that have emerged as the result of the "forest wars" and which the Northwest Forest Plan proved unable to adequately address. The collaborative nature of this project has led to the discovery of wide swaths of agreement among various stakeholders who previously had seen themselves on opposite sides of a debate. The shared-decision making process ensures that a wide range of voices are heard and that competing interests are addressed.

To a certain extent the Cat Creek Stewardship Project was designed as a "proof of concept" that thinning operations of this kind, specifically variable density thins focused on creating late-successional forest characteristics, can be both environmentally beneficial and economically viable for the contractors involved. Toward this end, monitoring for ecological conditions will be conducted at the site, and objectives for economic development will be measured over the life of the project. By developing the monitoring protocol in such a way that it may be scaled to the programmatic level, we hope to aid in the creation of other thinning projects that build upon this model.

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Appendices

APPENDIX A: Ecological Silviculture Monitoring Indicators

APPENDIX B: Silvicultural Prescription

APPENDIX C: Field Methods

APPENDIX D: Rural Technology Initiative Fact Sheet #24

Appendix A: Ecological Silviculture Monitoring Indicators

Ecological silviculture monitoring indicators for the Cat Creek Thinning Project.

Objective	Indicator
1. Maintain or increase growth rates of dominant and co-dominant trees	Current 10 year radial growth; Mean tree dbh, Basal area growth; Volume growth, height growth
2. Promote the development of structurally complex, decadent individual trees	Crown ratio, epicormic branches development, decadence (rot) and damage
3. Maintain and increase horizontal spatial variability	Histograms of tree density and Curtis Relative Density
4. Provide for future large diameter snag and CWD recruitment	Diameter growth, volume growth, tree mortality
5. Accelerate the development of multiple tree canopy layers	Seedling and sapling density, shade-tolerant tree recruitment into larger size classes, height growth
6. Promote understory shrub and herb growth and diversity	Herb cover and diversity, shrub cover, height and diversity
7. Maintain approximately 70%+ canopy closure	Canopy closure estimates derived from stocking, dbh, height, and crown volume measurements
8. Preserve options for future harvesting and increase the future timber value of the stand	Diameter class distribution, species distribution, stocking densities. Current 10 year radial growth, height growth, stand level basal area and volume growth, amount of defect
9. Protect and minimize damage to existing snags, CWD, wildlife trees, and rare species during harvest operations.	Harvest damage to existing structures. Comments on effectiveness of different strategies and associated costs from operator and sale administrator in post harvest surveys.
10. Minimize long-term soil and understory vegetation impacts due to logging operation	% exposed mineral soil, soil displacement, rill erosion, Herb cover and diversity, shrub cover, height and diversity

Appendix B: Silvicultural Prescription

SILVICULTURE INTEGRATED RESOURCE PRESCRIPTION

CAT CREEK STEWARDSHIP PROJECT

UPPER CISPUS UNIT 30, STANDTAG 540503
TOWNSHIP 10N, RANGE 10 E, SECTIONS 7 & 18

CISPUS ADAPTIVE MANAGEMENT AREA
COWLITZ VALLEY RANGER DISTRICT
GIFFORD PINCHOT NATIONAL FOREST

JUNE, 2004

Authors:
Derek Churchill
Andrew Larson
Peter Nelson

Introduction

The Cat Creek Stewardship Project Thin is a forest restoration project proposed and funded under the Secure Rural Schools and Community Self-Determination Act of 2000, Title II. It was developed through a collaboration of diverse interests with a stake in the management of the Cispus Adaptive Management Area, working with the Cowlitz Valley Ranger District and the GP Supervisor's office. It will be implemented in accordance with guidelines and recommendations set forth in the Cispus AMA Guide and Watershed Analysis for the Cat Creek Watershed.

The stand proposed for treatment is a 45 acre Douglas fir / Hemlock stand originated in 1957. It includes level 3 recreation (Hamilton Buttes Trail #118), use of which is characterized by hiking and motorized ORV activities. It is in the Cat Creek basin, tributary to the Upper Cispus River. It is classified as Managed Habitat/Habitat Development under the Cispus AMA landscape analysis design (LAD). Although the stand is 46 years old, it is adjacent to old-growth stands to the NE, SE, and WSW.

The project consists of a variable density thinning entry. The chief objectives of the thinning entry are to accelerate the development of late seral structures and habitats, produce wood and local employment, and serve as a learning opportunity for multiparty, collaborative decision making processes and monitoring as well as alternative methods of timber sale contracting. The timber sale will produce an estimated net volume of 440 mbf or 85,000 cubic feet and require a combination of ground-based and cable yarding systems. Approximately 4000 lineal feet of road 78-638 will be reconstructed and then decommissioned after the project, and existing skid trails will be used to the fullest extent possible.

Based on field reviews, stand inventories, and analysis of the physical characteristics, the stand is suitable for silvicultural treatments that remove timber volume and accelerate the achievement of the desired future conditions of late seral structure and habitat. A short and long term monitoring plan will be implemented to evaluate the effectiveness of the project and provide learning opportunities for adaptive management.

Physical and Ecological Conditions

Physical Characteristics

The stand is located on the toe and mid slope of the southwest ridge of Hamilton Butte and approximately ½ mile from the confluence of Cat Creek and Upper Cispus River. The elevation ranges from 2800 – 3400 feet. Approximately 40% of the 45 acre stand is relatively flat (0-25% slope) while 60% of the stand is steep (25-45% slope) with a south to southwest aspect.

The soils within the stand are SMU 16 (60%) and 41T18 (40%) according to the Soil Resource Inventory for the Gifford Pinchot National Forest (6/1992). It is also likely that part of the stand has SMU 15 soils in the relatively flat, southern portion. SMU 15 soils are very similar to SMU 16, but on gentle slopes.

SMU 16 and 15 are very deep soils with a depth to bedrock of greater than 12 feet. Bedrock is Breccia or Andesite. These soils are derived from colluviums and till and contain a high percentage of pumice and volcanic ash. Surface horizons are very thin coarse sands and lower horizons are very thick and range from gravelly clay loam to gravelly sandy loam. The soils are moderately fertile supporting site class III and IV. The soils are classified as Andisols (USDA Soil Classification: Typic udivitrand, pumiceous, mixed frigid).

SMU 41T18 is comprised of 60% SMU 41T and 40% SMU 18. SMU 18 is very similar to SMU 16, but occurs at higher elevations with lower temperatures and fertility. SMU 41T is similar to SMU 18, but is shallower and derived from residuum and colluvium.

In general, these course textured soils are well drained with rapid surface permeability and high water holding capacity in subsurface layers. The high content of ash and pumice make these soils moderately succeptible to surface erosion on steep slopes and compaction and displacement on more gentle slopes that are suitable for ground-based equipment. The soils are stable and not prone to slumps, slides, or other deep-seated failures. Management activities are unlikely to increase risk of slope failures.

All 4 soil types are suitable for timber management. SMU 15 is suitable for tractor logging. SMU 16, 18 and 41T are suitable for high lead yarding on slopes up to 60% and for suspended logging on slopes from 60%-100%. Regeneration potential is low to moderate.

Vegetation

The stand is situated at the upper elevational bound of the Western Hemlock (*Tsuga heterophylla*) /Douglas-fir *(Pseudotsuga menziesii*) zone and supports a Western Hemlock/Oregon Grape (*Berberis nervosa*) plant association. Douglas-fir site index is 95 (McArdle, 1961). While Douglas-fir is the dominant species, western hemlock and western red cedar (*Thuja plicata*) are moderately abundant in the overstory and understory. Minor trees species include silver fir (*Abies amabilis*), noble fir (*Abies procera),* western white pine (*Pinus monticola*), pacific yew (*Taxus brevifolia*), cottonwood (*Populus tricocarpa*), and red alder (*Alnus rubra)*. Tables 1-2 and figure 1 present inventory information from the 10 stand exam plots. Several minor species and significant amounts of overstory western red cedar were not observed in the plots but observed during field reconnaissance. Vine maple (*Acer circinatum*) is the dominant understory shrub and large individuals are present throughout the stand. Other understory plant species are listed in table 2.

Table 1: Inventory Summary

Species	TPA	% of Total	DBHq	AveDBH	AveHt	TBA	SDI	CurtisRD	BF/Ac	Cubic Ft/Ac*	Merch CubicFt /Ac*
DF	394	63%	9.1	8.1	54.2	178	339	59	22074	5376	4476
RC	90	14%	1.7	1.37	8.9	1	5	1	0	6	0
CW	9	1%	9.2	9.2	69	4	8	1	798	153	164
WH	128	21%	6.5	5.26	35	30	64	12	3203	813	574
TOTAL	621		7.9	6.55	43.9	213	428	76	26075	6348	5214

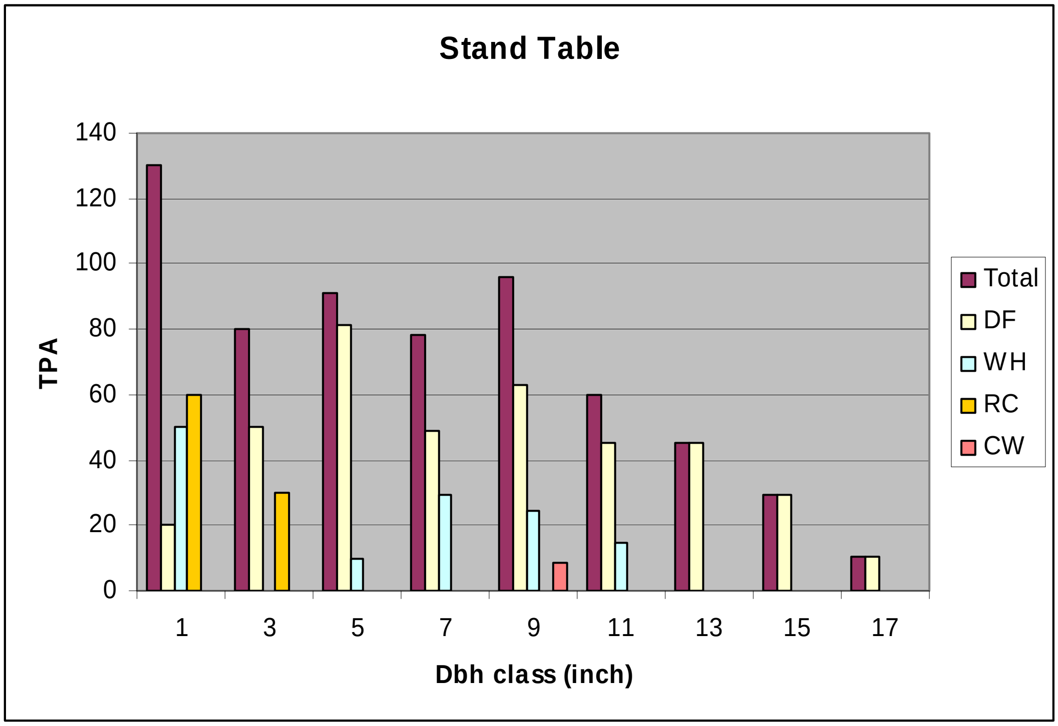
* Volumes are calculated based on Scribner to a 4” top, 40’ log.

Table 2: Shurb and Herb abundance and cover

Shrubs and ferns	Common Name	% of plots	Average % cover	Average height (ft)
Berberis nervosa	*Oregon grape*	90	18.8	1.0
Acer circinatum	*vine maple*	60	12.5	7.8
Gaultheria shallon	*salal*	20	40.0	2.0
Polystichum munitum	*Sword fern*	20	5.5	3.5
Rosa sp.	*Rose*	20	1.5	2.0
Pachystima myrsinites	*Oregon boxwood*	10	1.0	1.0
Rubus lasiococcus	*Cloud berry*	10	1.0	1.0
Rubus ursinus	*Trailing bl. berry*	10	1.0	1.0
Vaccinium membranaceum	*Black huckleberry*	10	2.0	3.0
Vaccinium parvifolium	*Red huckleberry*	10	2.0	1.0

Herbs				
Linnaea borealis	*Twin flower*	40	39.0	2.0
Chimaphila umbellate	*Princess pine*	10	1.0	2.0
Cornus Canadensis	*Bunch berry*	10	2.0	1.0
Xerophyllum tenax	*Bear grass*	10	20.0	1.0

Figure 1: Trees per acre by species and Dbh class



Stand density is high with a Curtis relative density of 76. Competition from high density is causing significant suppression of growth in all crown classes, crown ratios less than 40% in intermediate and some co-dominant Douglas-fir, as well as some western red cedar and western hemlock. Competition is also causing high height to diameter ratios in intermediate and some co-dominant trees and significant suppression mortality in intermediate and suppressed Douglas-fir.

The stand is near the end of the stem exclusion stage and beginning understory re-initiation. The majority of co-dominant and some intermediate trees have crowns ratios of 40% or greater due to moderately developed crown class differentiation. Horizontal spatial variability is high for a stem exclusion stand. Curtis relative density ranges from 40 to 120 in the 10 plots inventoried and has a co-efficient of variation of 36%. Gaps, dense thickets, and widely spaces areas exist throughout the stand and create a relatively heterogeneous understory light environment for a young stand. A cohort of western red cedar and western hemlock advanced regeneration is moderately abundant, but is generally small (less than 4’ in height) and growing slowly.

Legacies from the previous old growth stand provide significant structural complexity. A component of large pacific yew exists and is providing a seed source for new colonization. Large (3-5’ diameter) course woody debris (CWD) is moderately abundant throughout the stand and is in a decay class of 3-4. A few large diameter, decay class 4-5, snags are also present.

Suppression mortality is creating abundant small diameter (<10”dbh) CWD and snags.. Blowdown and laminated root rot (caused by the fungus *Phellinus weiri)* are causing mortality in a few pockets and creating larger diameter (10”+ dbh), decay class 1-2 snags and CWD. Other than extensive cavity creation on numerous overstory western red cedar, few live trees containing decadence were observed. Dwarf mistletoe is moderately abundant on overstory and understory western hemlock in most areas of the stand. Infection levels of individual trees vary from low to very high.

Landscape Features

The unit is bordered by an old growth forest to the north and southeast. Dwarf mistletoe infection is high in these old growth stands and potential exists for inputs of large CWD into the stand. Recreational use of the Hamilton Buttes trail that cuts through the stand as well as several dispersed camp sites within the stand and adjacent to it appears to be high, especially by ORV users. Although separated from a late seral riparian forest along Cat Creek by road 78, harvest activities within the stand have the potential to affect Cat Creek, especially through sedimentation. The Watershed Analysis for the Cat Creek basin identified the need to maintain adequate levels of canopy cover in the watershed to minimize risk of major resource damage from rain on slow flood events. A threshold level of 70% was defined as a guideline.

Management Objectives

The stand is classified as Managed Habitat/Habitat Development under the Cispus AMA landscape analysis design (LAD). This designation accommodates moderate harvest but emphasizes the restoration, maintenance and connectivity of late successional forest.

Using the LAD objectives as a starting point, the Gifford Pinchot Collaborative Working Group and its monitoring advisory team have identified the following management objectives:

1) Accelerate the development of late-successional forest structure and habitat. This includes:

- Large trees (>40” dbh) with complex crowns
- Wildlife trees: live trees with decadence and/or habitat structures
- Large snags (>10” dbh)
- Large course woody debris (CWD) (>12” larger end diameter and >15’ in length)
- Multiple canopy layers, including shrub and herbaceous layers.
- Horizontal heterogeneity
- A diverse plant community including hardwood and conifer trees, tall shrubs, low shrubs, herbs, epiphytes, lichens, fungi, herbs, etc.

2) Produce local employment, wood, and revenue in the short term as well as in the future. Preserve options for future harvesting and increase the future timber value of the stand.

3) Maintain and enhance recreational opportunities within the stand.

4) Minimize damage and disturbance to riparian areas and soils.

5) Restore landscape connectivity in terms of habitat, hydrologic function, aesthetics, and recreation.

6) Provide successful examples of and learning opportunities for:

- Alternative operational and contractual methods of implementing variable density thinning
- Multi-party collaborative decision making processes.
- Multi-party monitoring.

Prescription

Rationale & Summary

Existing natural processes will create desired late-successional forest structure and habitat over time. These processes include: natural disturbance agents (laminated root rot, wind, and dwarf mistletoe, etc); colonization and establishment of understory trees, shrubs, and herbs from within the stand and adjacent old growth; and natural stand development processes: self-thinning, crown class differentiation, and understory re-initiation.

However, the timeframe required for late-seral characteristics to develop can be accelerated through thinning. As late-seral structures are in short supply in the Cat Creek and Cispus watersheds, accelerating their development is desirable from both a stand level and landscape perspective. Also, competition from high density is currently causing low crown ratios and high height to diameter ratios in intermediate and co-dominant western red cedar, western hemlock, and other minor species. Without thinning, a significant portion of this component will not survive and the stand will decline in tree diversity. Although maintaining a moderate level of dwarf mistletoe in the stand is important for wildlife, it is very prevalent in some areas and will significantly slow the development of existing and future overstory and mid-story.western hemlock without treatment.

This thinning entry has been designed with the understanding that the stand may be entered again in the next 15-30 years for a second thinning if deemed necessary to reach ecological goals. The stand will be managed to create late-successional structure and habitat in a 100+ year time frame.
Due to the high degree of variability and diversity within the stand, the long-range management timeframe, and the opportunity for future entries, this thinning entry will attempt to work with the existing stand conditions and natural development processes to encourage structural and species diversity, rather than impose a set level of density, spacing, or variability. Instead of density or spacing targets, thinning guidelines will be based on removing 50% of trees within each 1/20 acre area of the stand.

The primary goals of this entry are to reduce stocking levels and open up sufficient growing space to:

- Significantly increase growth rates of dominant and co-dominant trees
- Accelerate the growth and continued establishment of advanced regeneration
- Prevent stagnation and mortality of intermediate and co-dominant western red cedar, western hemlock, minor conifer species, and hardwoods.
- Increase horizontal spatial variability by creating additional gaps and leaving skips

The thinning treatment will reduce stand density to an average of Curtis RD of 35-40. The post treatment co-efficient of variation and distribution of plot RD's will be similar to what currently exists within the stand. Douglas-fir will be the primary species selected, although a significant amount of western hemlock will be harvested by removing trees infected with dwarf mistletoe. Proportional thinning will be used to ensure that enough co-dominants are removed to maintain crown class differentiation and allow understory and mid story shade tolerant trees to occupy released growing space. Although canopy cover is estimated to drop to 68%, which is just below the 70% level recommended in the Watershed Analysis, crown expansion after thinning will move the stand back above this level within a few years.

Slash should be left on site and used to cover skid trails, cable yarding corridors, landings, and scattered on the forest floor to protect from soil erosion and retain soil nutrients and organic matter. This is necessary due to the steep slopes and moderate erosion potential, moderate compaction potential, and low nitrogen content of the volcanic soils. Retaining slash will increase fuel loading and risk of a crown fire. However, the stand is located within a low frequency/ high severity fire regime. The young age of the stand and abundant ground and ladder fuels already make the stand susceptible to a high severity crown fire. Additional slash will not substantially increase this risk for a significant period of time.

As root rot pockets are relatively scarce within the stand and are the chief source of large snags, CWD and openings within the stand, treatments to significantly reduce them will not be part of this entry. Instead pockets will either be left alone or thinned according to the general thinning guidelines. More intensive treatments may be undertaken during future thinning entries. Dwarf mistletoe will be significantly reduced during this entry to ensure development of the western hemlock component. However, it will not be eliminated from the stand to provide for wildlife habitat.

Ground based harvest systems will be required on approximately 40% of the stand. No restrictions are necessary as to the type of ground based equipment that could be used (tractor, skidder, harvester, etc) as long as skid trails are covered with slash to reduce compaction and prevent excessive exposure of mineral soil. Cable-yarding will be necessary on the remaining 60%. Full suspension is not necessary as long as yarding corridors are covered with sufficient slash to prevent excessive exposure of mineral soil.

To allow for greater complexity and flexibility in the prescription, to explore the potential of increased marketing opportunities for small diameter and marginally valuable timber, and to allow for an economic, silvicultural, and ecological comparison with lump sum bid sales, a service stewardship contract, designation by prescription, and a scaled sale method will be used.

Thinning guidelines

A) Trees under 8” dbh:

- Fell all Douglas-fir
- Fell hemlock if crown ratio is less than 30% or if infected with dwarf mistletoe.

- Fell western white pine if infected with white pine blister rust.
- Do not fell any other species.
- Do not fell trees if damage potential to critical retention features (see below) is high.
- This material and may be removed or lopped and scattered in the forest. If left in the forest, 75% or more of each stem must be touching the ground.

B) Trees 8-15” dbh:

- Thin to leave 50% of stems by 1/20th acre area. Count all species
- Thin proportionally using operator’s preference. Proportional is defined as leaving a similar dbh range and distribution as existed before thinning.
- Remove Douglas-fir, prioritizing trees with shorter and smaller crowns.
- Remove hemlock only if crown ratio is less than 30% or if infected with dw. mistletoe.
- Fell western white pine if infected with white pine blister rust.
- Do not fell any other species, unless marked in blue. If felled, these species should be left on the ground and may not be merchandized.
- Do not remove any tree over 15” dbh, unless within a marked gap, marked in blue, or necessary for skid trails, landings, or yarding corridors.

C) Gaps

- Approximately 10%, including existing openings, of the stand will be left in gaps of 1/20th - 1/4 acre.
- Location of new gaps will be marked with flagging in the center or determined by contractor after approval by sale administrator. The color will indicate gap size.
- All trees, unless marked in orange, will be removed from gap.
- Gaps will be placed in the following locations:
    - In areas with existing small gaps with no rot root
    - Along and off of yarding corridors
    - To create and expand landings
    - In areas where hardwoods or other species would benefit from release.
    - In a few areas of high density near cable yarding landings.

D) Skips

- Approximately 10% of the stand will not be entered and left in 1/20th – ¼ acre patches.

- Some skips will be marked with a perimeter of pink flagging. Location of a specified number and size of additional skips will be determined by the contractor and approved by the sale administrator.
- Skips will be placed in:
- Areas of high stem density and suppression mortality to ensure a source of small diameter snags, cwd, and thickets for wildlife.
    - Root rot pockets
    - Areas with mistletoe
    - Around critical retention features or smaller snags

Projected harvest volumes and post treatment stand conditions.

Table 3: Pre & post treatment stand conditions (Post treatment is shaded)

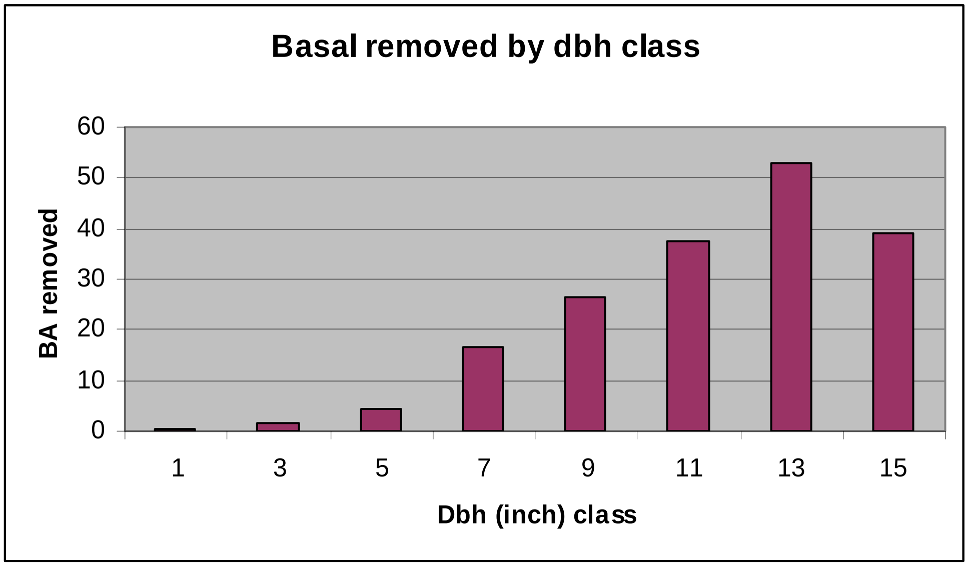
Species	TPA	% of Total	TPA	% of Total	TPA >8" Dbh	% of Total	DBH q	DBH q	TBA	TBA	Curtis RD	Curtis RD
DF	394	63%	108	37%	108	79%	9.1	12.46	178	92	59	26
RC	90	14%	90	31%	0	0%	1.7	1.72	1	1	1	1
CW	9	1%	9	3%	9	6%	9.2	9.2	4	4	1	1
WH	128	21%	83	29%	20	15%	6.5	5.62	30	14	12	6
TOTAL	621		290		137		7.9	8.4	213	111	76	39

Table 4: Pre and Post Treatment volumes*

	Pre-treatment				Removed				Remaining		
Species	BF/Ac	Cubic Ft/Ac	Merch CubicFt /Ac		BF/Ac	Cubic Ft/Ac	Merch CubicFt /Ac		BF/Ac	Cubic Ft/Ac	Merch CubicFt /Ac
DF	22074	5376	4476		8450	1958	1710		13628	3419	2767
RC	0	6	0		0	0	0		0	6	0
CW	798	153	164		0	0	0		798	153	164
WH	3203	813	574		1376	344	249		1828	469	325
TOTAL	26075	6348	5214		9826	2302	1959		16254	4047	3256

* Volumes based on Scribner, 4” top, 40’ log.

Figure 2: Basal Area removed



<u>Operational Guidelines</u>

A) <u>Protection of critical retention features</u>

- Special care will be taken to protect the following rare species and habitat structures. Many, but not all, of these items will be marked with orange flagging or paint
    - Large cedar trees with woodpecker cavities
    - Red alder and cottonwood
    - Western white pine free from White Pine Blister Rust
    - Pacific yew over 5’ in height.
    - Snags over 6’ high and 24” diameter (Legacy snags from previous stand)
- Wildlife trees: Defined as live trees over 10” dbh with broken tops, forked stems, cavities, large platform branches, or other forms of stem defect.
- Blow downs over 12” dbh.
    - Any other feature marked with orange flagging or paint.

-. Protecting these items has priority over any other instructions in the contract

- Significant damage to over 5% of these items will result in penalties
    - If felling is necessary, approval from sale administrator is required.

B) <u>Snags</u>

- 10” dbh or greater: leave where safe and feasible.
- Under 10”: Leave approximately 25%. Contractors choice to fell, remove, or leave the rest. 75% of stem of each stem must be touching the ground.

C) Course woody debris (CWD)

- Existing CWD: Do not remove. Avoid lifting, moving, or cutting CWD as much as practical. Skirt skid trails around CWD or cut through CWD where expansion of skid trail coverage can be kept to a minimum.
- New CWD: leave all pulp logs, butts, or un-merchantable sections over 8” small end diameter in forest.

D) Residual Damage

- Residual trees shall be protected from unnecessary injury.
- Penalties will occur if residual damage is over 5%.
- Damage is defined as a bole scar greater than 50^2 inches (the size of an outstretched hand).

E) Creation of wildlife trees or snags

- Contractor is encouraged to create significant damage to 1-2 Douglas-fir trees over 10” dbh per acre during normal logging operations. Significant damage is defined as a broken top or large bole scar, above 30’ in height.
- Contractor should mark these trees and they will not be counted in damage estimates.
- Additional wildlife trees, snags, or CWD will be created after logging operation under a separate contract if deemed necessary.

F. Slash

- Tops and limbs will be left on the forest floor in such a manner as to cover skid trails and cable yarding corridors, or be scattered to disperse the fuels for fire prevention.
- If trees are processed in the landing, slash should be hauled out and scattered on skid trails, cable yarding corridors or on forest floor.
- In cable yarding areas, trees should be topped and limbed in the forest.

F. Root Rot Pockets

- Protect snags and regeneration (other than D-fir or hemlock) in root rot pockets.

- In general, root rot pockets will be marked as a skip or thinned through according to the thinning guidelines.
- Any control of root rot will be left to the next entry.

G. <u>Dwarf Mistletoe</u>

- Mistletoe will be retained in the stand in skips and by marking specific trees for retention. Retention will be in areas where spread to other hemlock is minimal.

H) <u>Skid trails</u>

- Existing and old trails should be used as mush as possible, especially for main haul trails.
- The Hamilton Buttes hiking/ORV trails may be used as a skid trail
- Minimum spacing is 50', except where necessary to avoid moving large (over 30" diameter) CWD or damaging other critical retention features.
- Trails should not be wider than 12'
- Ghost trails are not required
- Contractor will flag in approximate location of trails and sale administrator will approve of location

I) <u>Yarding Corridors</u>

- Contractor will flag in approximate location of corrid
ors and sale administrator will approve of location.
- Minimum spacing ?? (I've seen 125-150 feet elsewhere)
- Full suspension is not necessary as long as yarding corridors have sufficient slash to prevent excessive exposure of mineral soil.

J) <u>Landings</u>

- Contractor will select location of landings in consultation with sale administrator.

E) <u>Clean up</u>

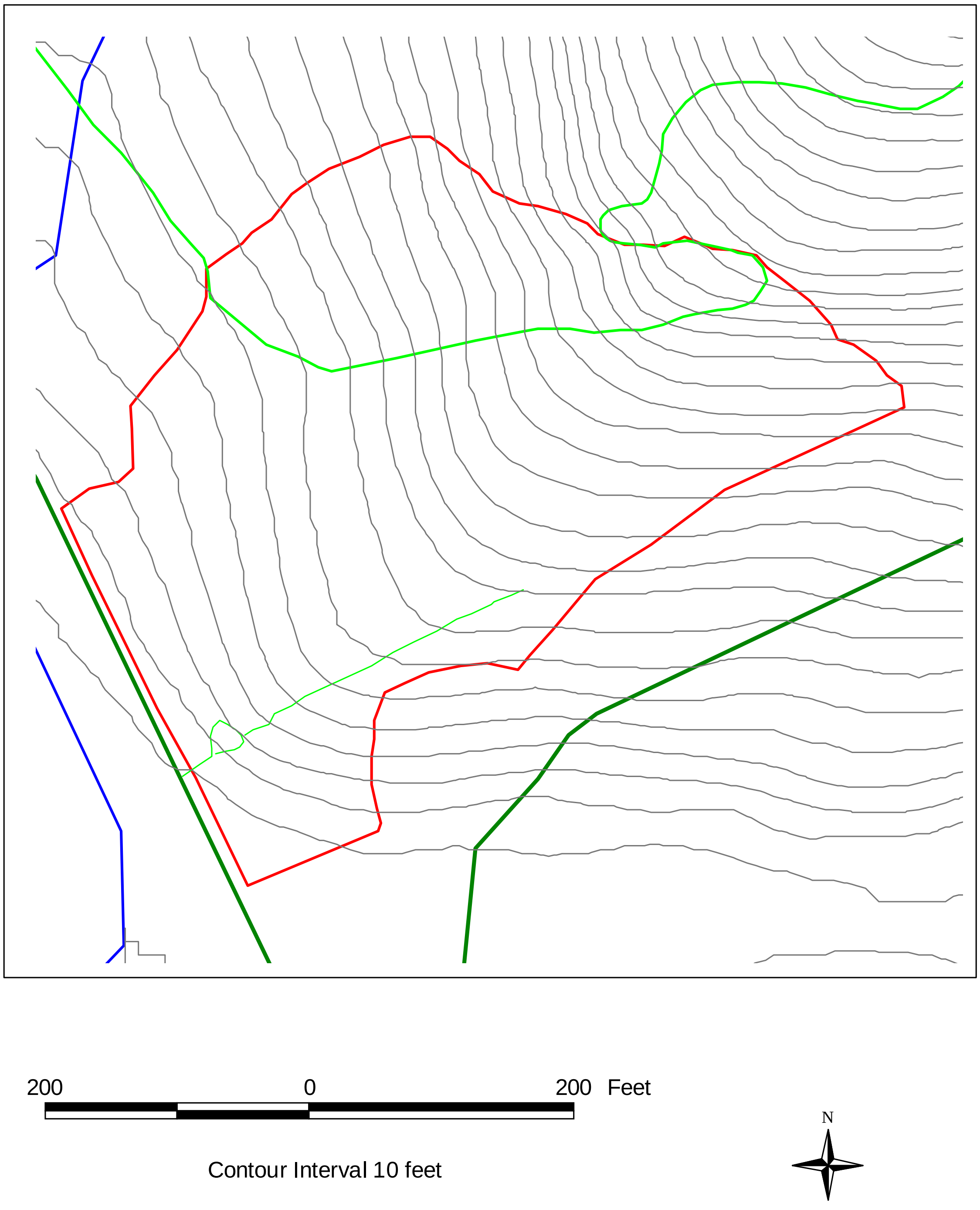
- Skid trails, corridors, and landings shall be covered with slash and new CWD during or after operation as much as possible.
- The Hamilton butte trail will be left open and not covered in slash.

- Un-merchantable butts and other pulp logs left on the landing at end of operation may be offered as firewood for the local community.

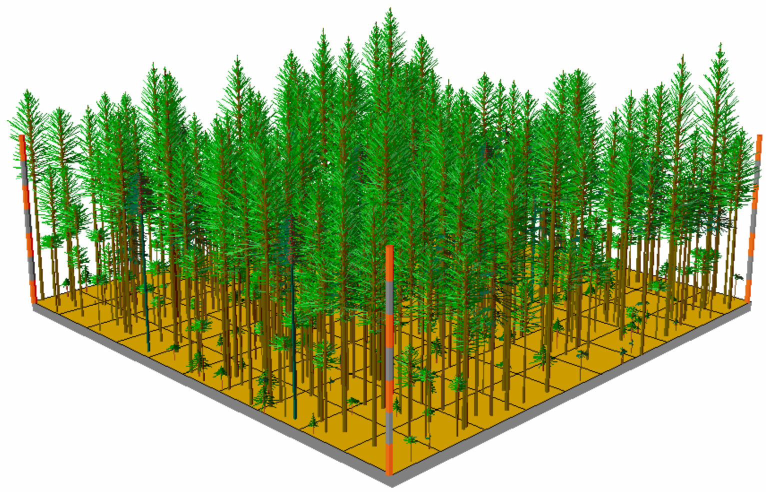
Post Sale Activities

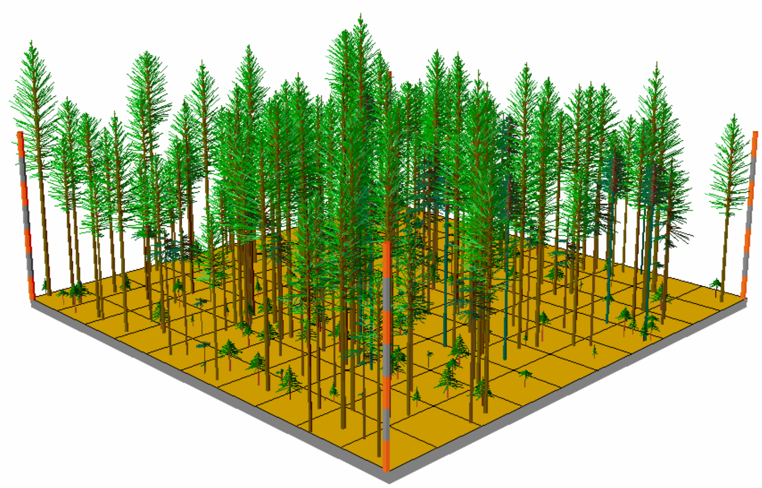
To reduce overall project time and costs, all of the objectives of the prescription should be met within the primary thinning contract. However, additional creation of wildlife trees, snags, or CWD may be necessary to meet habitat objectives. This will be determined after analysis of data from post thinning field reconnaissance monitoring plots. Underplanting will not be necessary due to the high level of existing diversity and abundance and recruitment potential from adjacent old growth stands.

Cat Creek Stand



Appendix 2: Pre and Post Treatment Stand Visualizations





Appendix C: Field Methods

Ecological Monitoring Plots

1. Navigate to Plot Center

Load known coordinates of each plot into a GPS data logger and use for navigation with backpack GPS unit.
If it is not possible to use the GPS for navigation (e.g., dense tree canopy precludes obtaining signals) use standard field methods from last GPS reading (using a map and compass).

2. Plot Center

Place 5’ length of PVC pipe over 4’ rebar driven into the ground to mark plot center.
Label PVC monument with the appropriate plot identification number.
Take a digital photograph in each of the four cardinal directions, starting with due north, then proceeding east, south, and west.
Record slope (%) and aspect.
Mark reference trees: Attach aluminum tags to 2 healthy dominant or co-dominant trees close to plot center, with the tag facing plot center. Scribe onto the tag azimuth from reference tree to plot center, distance to plot center, and PSP identification number.

3. Shrub Transects (line intercept)

Establish a transect oriented East-West and passing through plot center by stretching a 100’ tape. The transect should extend 37.24’ from plot center in both directions for a total length of 74.5’. Monument both ends of the transect with a 2’ length of PVC pipe placed over a 1.5’ length of rebar driven into the ground.
Measure along tape in tenths of feet, any shrub foliage/branches/stem that overlaps the tape. Visually project the tape as a plane that extends from the ground to the top of the highest shrub along the transect. Record all parts of shrubs that intersect this plane.
Measure to nearest 0.1’, ignore gaps in foliage of same plant of 0.1’ (i.e. treat as if the foliage was continuous). If have gaps in foliage > 0.1’ measure the foliage separately.
Do not record vine maple (*Acer circinatum*) along shrub transects.

4. Canopy Cover

Take readings using a *convex* spherical densiometer at plot center and 20’ from plot center in both directions along the shrub transect. At each location, take four canopy cover measurements, one in each of the cardinal directions (they will be averaged).

5. Herb Plots

Establish 6 plots, each 3’ X 3’ (9.0 ft^2) along the shrub transect (10, 20, and 30 feet from plot center), offset 3’ to the right, as you walk away from plot center (see plot layout diagram).
Mark corner closest to plot center (lower left corner) with 1.5’ tall rebar and 2’ PVC pipe.
Identify to species and count all tree seedlings < 6” tall.
Estimate percent cover of all non-woody vegetation, ‘sub-shrubs’ or small woody vegetation by species. Use percent cover categories: <1%, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%.

Estimate % cover by substrate/ground cover (moss, duff, rock, bare soil, tree bole, CWD). Use percent cover categories: <1%, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%. For logs, record percent of plot they cover. For moss on ground and logs, estimate amount of cover. Don't measure moss on live tree boles. Estimate visible duff and bare soil only (not under the moss, but look under herbaceous plants).

6. Belt Transects

6' X 74.5', centered on the shrub transects (use a yard-stick to visualize the belt transect)
Count number of live trees by species in each size class:

- 6"-4.5'
- >4.5', 1-3"dbh
- >4.5' 3-5" dbh

Estimate average height of each sapling strata
Estimate percent cover of vine maple in each belt transect (may have to look overhead).
Estimate average height of vine maple in the belt transect

7. Tree Plot

Circular, 1/10th acre plot, 37.24' radius
If there's a question about whether a tree is in or out of the plot, measure to the tree.
Tag all live trees ≥5.0 inches dbh with a pre-numbered tag at breast height on uphill side of the tree. Tree Number 1 is the first tree east of due north (from plot center); proceed in a clockwise direction marking all remaining trees.
Record species, dbh (to 0.1 inch), presence/type of damage, presence of dwarf mistletoe (western hemlock only), presence and max length of epicormic branches (Douglas-fir only), total height, height to base of continuous live crown and height to lowest live branch for each tagged tree.
Core the 1st, 3rd, 5th and 7th tagged trees and record 10 year radial growth increment to the nearest 1/20th inch. These same trees, tracked by tag number, should be remeasured in subsequent measurement cycles.
Measure and record dbh, estimated height (ft), decay class, and wildlife usage for all snags ≥5.0 inches dbh. Do not tag snags.
Record species code of all vascular plant species occurring in the tree plot
Slope correct plot if slope is greater than 10 degrees

Field Methods: Soil Disturbance Transects

1. Navigate to Transect Origin

Transect Establishment
Subjectively locate transect in desired area to be monitored
Record transect origin (start point) with a GPS unit
Record transect orientation (azimuth)
Remeasurement
Load known coordinates of each transect origin into a GPS data logger and use for navigation with backpack GPS unit.
If it is not possible to use the GPS for navigation (e.g., dense tree canopy precludes obtaining signals) use standard field methods from last GPS reading (using a map and compass).

2. Shrub Transect

Establish 30’ shrub transect with a
Monument both ends of the transect with a 2’ length of PVC pipe placed over a 1.5’ length of rebar driven into the ground.
Measure along tape in tenths of feet, any shrub foliage/branches/stem that overlaps the tape.
Visually project the tape as a plane that extends from the ground to the top of the highest shrub along the transect.
Measure to nearest 0.1’, ignore gaps in foliage of same plant of 0.1’ (i.e. treat as if the foliage was continuous). If have gaps in foliage > 0.1’ measure the foliage separately.
Do not record vine maple (*Acer circinatum*) along shrub transects.

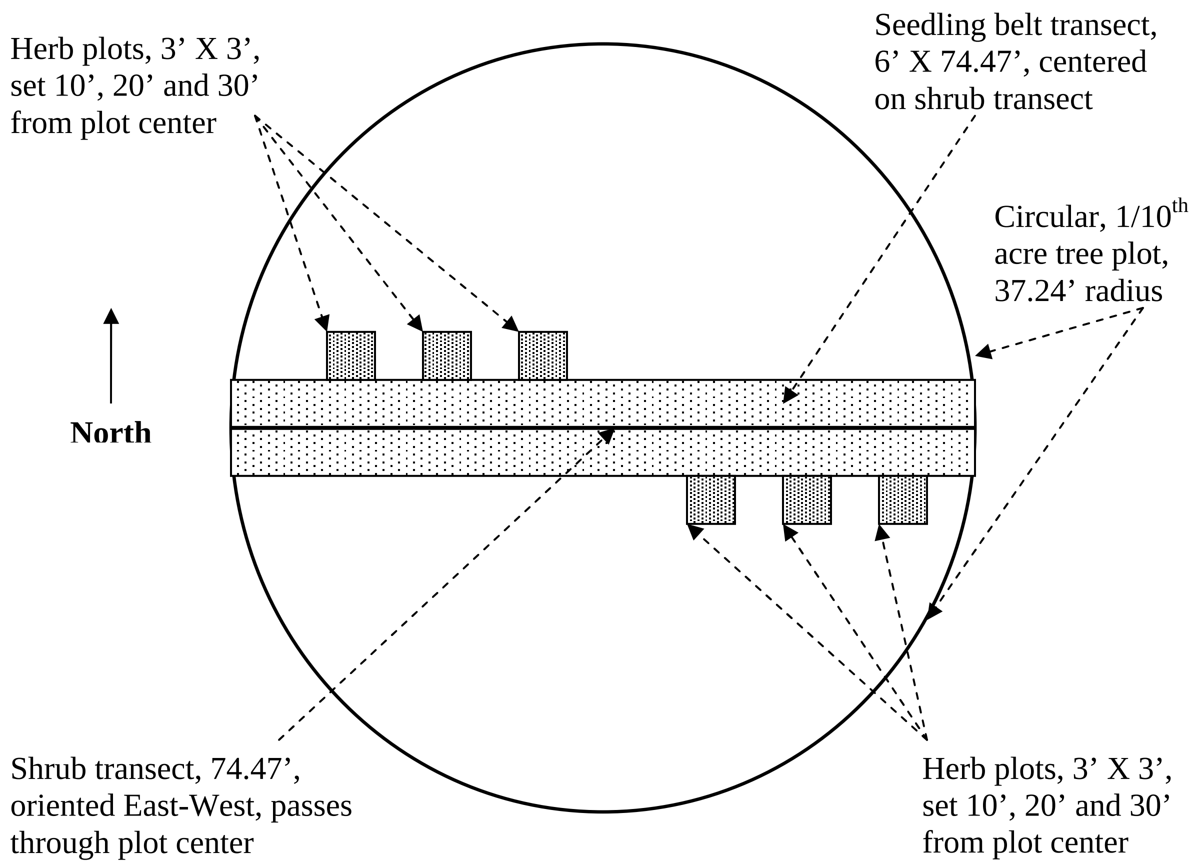
3. Soil Disturbance/Herb Plots

Establish 4 plots, each 3’ X 3’, (9.0 ft^2) at 0’, 9’, 18’ and 27’ along the shrub transect (see transect layout diagram).
Mark corner closest to the shrub transect origin (lower left corner) with 1.5’ tall rebar and 2’ PVC pipe.
Identify to species and count all tree seedlings < 6” tall.
Estimate percent cover of all non-woody vegetation, ‘sub-shrubs’ or small woody vegetation by species. Use percent cover categories: <1%, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%.
Estimate % cover by substrate/ground cover (moss, duff, rock, bare soil, tree bole, CWD). Use percent cover categories: <1%, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%. For logs, record percent of plot they cover. For moss on ground and logs, estimate amount of cover. Don’t measure moss on live tree boles. Estimate visible duff and bare soil only (not under the moss, but look under herbaceous plants).

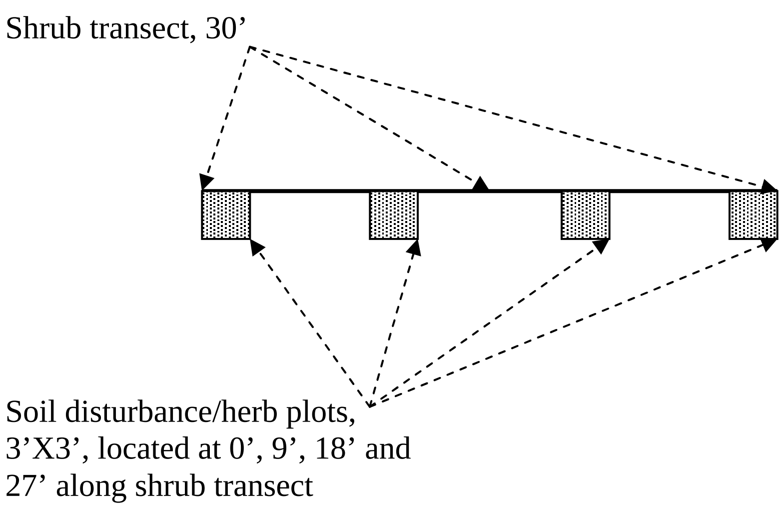
Equipment List

Backpack GPS unit (with waypoints loaded)
Laser Rangefinder (for measuring tree heights)
Compass
100 foot tape marked in feet and tenths of feet
Numbered tags (bring >50 tags per plot)
Nails
Hammer
10 unmarked aluminum tags (for marking reference trees, replacing damaged tags, etc.)
Digital Camera
Clinometer
DBH tapes (2)
Spherical Densiometer with convex mirror (1)
3’ folding frame or two yard-sticks (for delineating herb plots)
Increment Borer
Data sheets and clipboard
Field protocol
Backup rite-in-rain notebook/pencils
Plant ID book
Sample bags for unknown plants

Ecological Monitoring Plot Layout



Soil Disturbance Transect Layout



Appendix D: Rural Technology Initiative Fact Sheet #24

The Emerging Consensus for Active Management in Young Forests

There has been increasing regulatory pressure on public and private forestlands to provide for the ecological benefits associated with oldgrowth forests. Whether in riparian zones or habitat areas, the result has been that thousands of acres of previously harvested forestlands are no longer being managed. Recent attention, however, has questioned the ability of these young forests to provide old growth functionality without management to reduce stem densities (Muir et. al. 2002, Rapp 2002, Hunter 2001). Scientific evidence has shown that thinning of younger forests can accelerate the development of old growth characteristics (Acker et. al 1998, Tappeiner et. al. 1997, Carey et al. 1999, Muir et. al. 2002, Bailey & Tappeiner 1998, Garman 2003). Scientists, environmentalists, and forest managers are recommending more active management in young stands (Curtis et. al. 1998, Franklin et. al. 2002, Carey et. al. 1998, Heiken 2003, Spies et al. 2002).

It is commonly understood that west side old growth forests in the Pacific Northwest are highly variable (Spies & Franklin 1991) and developed from multiple growth pathways as a result of varying starting conditions and disturbance patterns (Spies et. al. 2002). Underlying these different pathways is an approximate south to north and east to west gradient of decreasing fire frequency and increasing fire size (Morrison and Swanson 1990, Spies et. al. 2002). Localized disturbance agents, such as wind, root diseases, insect outbreaks, floods, and ice storms interact over time with fire regimes to create a dynamic environment that results in the development of the complexity inherent in many natural old forests.

In the past, small frequent fires contributed to development of heterogeneous natural forests with wide Douglas-fir age distributions, often in discrete age classes in the southern and central Oregon Cascades (Morrison & Swanson 1990, Spies & Franklin 1991). A temporal pattern of long Douglasfir establishment periods (60-200+ years), multiple low-to-moderate severity fires, seed source deficiencies, low initial tree densities and little competitive exclusion has been linked to the development of old growth forest conditions in this southern, drier part of the

Pacific Northwest (Oliver & Larson 1996). Two recent studies of 38 old growth stands in the Oregon Cascades and Coast Range support this hypothesis (Tappeiner et. al. 1997, Poage & Tappeiner 2002).

Comparisons of the growth rates in the first 50 years of old growth stands with growth rates of young stands of known densities on similar site classes, suggest that these old growth stands started at densities of 40 - 52 trees per acre (tpa). Tree sizes at ages 100, 200, and 300 years were found to be much more positively correlated with early growth rates than with site or climatic factors, suggesting that widely-spaced early stocking density, associated with a wide range of establishment periods (100-420 years), was the principal factor in the growth trajectory of individual trees (Poage & Tappeiner 2002).

In the wetter, northern part of the region, a history of larger and less frequent fires may have resulted in more homogeneous forests with narrower age distributions, which developed after large fires 500 and 700 years ago in the Cascade and Olympic Mountains (Agee 1991). It is hypothesized that at least some of these forests developed at high densities with understory exclusion and growth reduction from stocking competition (Spies et. al. 2002). Winter (2002) found evidence of this pathway in a 500-year-old stand in the southern Cascades of Washington. Using a similar comparison technique to Poage & Tappeiner (2002), she estimated a density at crown closure of 320 tpa and an establishment period of 21 years dominated by Douglas-fir. Although anecdotal evidence of this higher density pathway has been reported (Spies et. al 2002), no other published reconstruction studies have found quantitative verification of similar stand origin characteristics. While a young forest density of 320 tpa is not dissimilar to that of some planted forests, the establishment period, although much shorter than that found by Poage & Tappeiner (2002), is much longer than that of a plantation.

These investigations suggest that many of today's young, previously harvested forests may be on developmental pathways that are very different from those that resulted in natural old growth stands. Young planted forests, established at high densities in very short time periods with the expectation of pre-commercial and commercial thinnings, are typically uniform and dense with little differentiation. Without density reductions, planted forests eventually evidence suppressed growth, high height to diameter ratios, and short crowns; conditions that have been shown to make stands susceptible to windthrow and inhibit the development of the large trees associated with old growth forests (Wilson & Oliver 2000).

Although some researchers theorize that young stands will eventually develop old growth characteristics regardless of early establishment conditions, it will take much longer. Heavy or repeated thinning of dense young forests has been proposed as a way to silviculturally shift these stands onto a development pathway more likely to produce old forest structure with large diameter trees (Poage & Tappeiner 2002). Researchers, however, also stress the importance of creating variability by using a mix of thinning densities within stands and across the landscape (Carey et. al.1999a, Garman 2003, Hunter 2001, Muir et. al. 2002, Franklin et. al. 2002, Spies et. al. 2002).

Several studies have found that thinning accelerates the development of other old growth characteristics in addition to diameter growth. Three major research projects, the Managing for Biodiversity in Young Forests Project in western Oregon (Muir et. al. 2002), the Forest Ecosystem Study in western Washington (Carey et. al. 1999a), and the Young Stand Thinning Study on the Willamette National Forest (Hunter 2001), have undertaken comprehensive investigations into the effects of thinning. Results of these studies show that understory vegetation, shade tolerant tree regeneration, and the vertical distribution of the canopy in thinned stands tend to be more similar to old growth conditions than in un-thinned stands (Acker et. al 1998, Tappeiner et. al. 1997, Muir et. al. 2002, Bailey & Tappeiner 1998). Wildlife and plant diversity, including birds, macrolichens and bryophytes, fungi, small mammals, and bats, have also been shown to be greater in thinned stands (Carey et al. 1999, Hayes et al. 1997, Muir et. al. 2002, Hunter 2001).

Different thinning strategies appear to produce different results. Thinning from below that strives for regular spacing may create a uniform light environment that leads to a thick understory of shade tolerant species with little diversity that shades out forest floor vegetation. Development of coarse woody debris, decadence, and cavities may also be delayed by heavy thinning. Removing hardwood species, wildlife trees, and snags may limit many of the habitat gains from thinning (Muir et. al. 2002). On the other hand, thinning that retains at least some of these structures and leaves patches of variable densities has been shown to increase plant and wildlife diversity even further. Underplanting shade tolerant conifers, hardwoods, and native shrubs, as well as augmenting coarse woody debris and snags can increase similarity to old-growth structure (Rapp 2002, Carey et. al. 1999a). However, even a simple thin-from-below, designed to create uniform available growing space and favor dominant crop trees, has been shown to increase wildlife and plant diversity when compared to a no action management alternative (Tappeiner 1997, Muir et al. 2002).

Regulatory constraints intended to protect sensitive species and provide riparian function, as well as the economic costs of selectively harvesting low value trees, presently limit the potential for some thinning activities. However, current research suggests that a significant portion of young stands will need active management if forest habitats suitable to old growth dependent species are to be developed in the next 25-150 years. Replication of the complexity and variability found in oldgrowth forests, thought to exist at the landscape level prior to commercial harvest, will require intervention to diversify the developmental pathways of young uniformly planted forests (Heiken 2003, Spies et. al. 2002). Studies have suggested that customized harvests designed to achieve variable densities within stands and augment snags, understory species, and coarse woody debris may be ecologically preferable to commercial thin-from-below alternatives (Carey 1999a, Muir et. al. 2002). Without incentives, however, the economic costs will likely restrict such ecological thinning activities to small areas and public forestlands. Even on public lands, the more standardized thin-from-below approach, with the possibility for both positive economic and environmental outcomes, has greater likelihood of application on a broader scale given current market conditions and government funding levels.

Whether on National Forest lands, State Forests, Tribal lands, or private lands, an ecological paradigm shift is occurring (Heiken 2003). A growing body of scientists, environmentalists and forest managers are recommending that in many forests with a prior history of harvest, continued management will be necessary to avoid the development of stagnant, overstocked stands that provide few old-growth habitats, are more susceptible to disturbance and disease, and fail to achieve the variability of pre-settlement forests.

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