# BLM Density Management and Riparian Buffer Study: Establishment Report and Study Plan

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In cooperation with the Bureau of Land Management, the Pacific Northwest Research Station, Oregon State University, and the Cooperative Forest Ecosystem Research Program.

Scientific Investigations Report 2006-5087

**U.S. Department of the Interior**
**U.S. Geological Survey**

**U.S. Department of the Interior**
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Cover photo of Southern Torrent Salamander by William P. Leonard.

Suggested citation:
Cissel, J.H.; Anderson, P.D.; Olson, Deanna; Puettmann, Klaus; Berryman, Shanti; Chan, Samuel; and Thompson, Charley. 2006, BLM Density Management and Riparian Buffer Study: Establishment Report and Study Plan, U.S. Geological Survey, Scientific Investigations Report 2006-5087, 151 pages.

# Acknowledgements

Many individuals have contributed time, energy, and support to the Density Management and Riparian Buffer Study. We thank John Tappeiner for his scientific leadership and vision as the initiator of the study. Charley Thompson and Larry Larsen provided the leadership and support needed from the BLM to get the study implemented. A Core Team of BLM specialists gave freely of their time and ideas to help develop the early study plan. A site coordinator leads each site and relies on resource specialists, planners, operations specialists, and GIS specialists to make the study happen on the ground. Mark Koski has contributed many weeks of his time to coordinate development of GIS databases. Managers in the BLM have seen the study as a priority worth funding and supporting. We benefited from our interactions with scientists who participated in collaborative studies and field tours. Field crews and research assistants spent countless hours climbing over steep slopes collecting data in weather both ideal and miserable. Still others have cleaned up the data and created large, complex databases. To each of these folks, and to all who have helped move the Density Management Study forward, we heartily thank you. Specific individuals that have contributed to the study include:

Collaborating scientists - Bruce McCune, Andy Moldenke, Pat Muir, Lorelei Norvell, and Rob Progar

Data management - Maureen Duane, Loretta Ellenburg, Melissa Hamar, Joe Hanus, Robin Hibbs, Dylan Keon, David Larson, George Lienkaemper, Kathleen Maas-Hebner, Kevin Nelson, Kate Norman, Sherry Pittam, Cindy Rugger, Cheryll Solomon, and Rebecca Thompason

Field crew leadership - Laurie Abernathy, Valerie Banner, Loretta Ellenburg, Ron Exeter, Bob Fahey, Jay Flora, Emmalie Goodwin, David Larson, Dan Mikowski, Estella Morgan, Stafford Owen, and Mark Yeiter.

Graphic support - Kelly Christiansen, Kathryn Ronnenberg, and Kirsten Schumaker

Map development - Jeremy Hruska and Jeanne Keyes

Planning and implementation - David Harden, Alan James, Rick Kottke, Roger Monthey, Phil Redlinger, Rick Schultz, Steve Weber, and Steve Yates

Site coordinators - Floyd Freeman, Craig Kintop, Peter O'Toole, Sharmila Premdas, Frank Price, and Hugh Snook

Statistical analysis - Lisa Ganio, Manuela Huso, David Larson, Cindy Rugger, David Rundio, and George Weaver

Steering committee - Jamie Barbour, Julia Dougan, John Hayes, and Nancy Molina

Study plan development - John Applegarth, Pete Bisson, Bruce Bury, Linda Conley, Stan Gregory, Bruce Hansen, Dave Hohler, Larry Jones, Larry Larsen, Yuman Lee, Don Major, Brenda McComb, Peter O'Toole, Gordie Reeves, Jim Sedell, and Craig Snider

We also thank Steve Acker, John Bailey, Janet Erickson, and Rob Pabst for their helpful review comments, and John Ame and Angel Dawson for their editorial assistance.

Lastly, we want to thank all the people we forgot to mention above.

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## Tables

# Conversion Factors

English to Metric

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| inch (in.) | 2.54 | centimeter (cm) |
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| mile, nautical (nmi) | 1.852 | kilometer (km) |
| yard (yd) | 0.9144 | meter (m) |
| | Area | |
| acre | 4,047 | square meter ($m^2$) |
| acre | 0.4047 | hectare (ha) |
| acre | 0.4047 | square hectometer ($hm^2$) |
| acre | 0.004047 | square kilometer ($km^2$) |
| square foot ($ft^2$) | 929.0 | square centimeter ($cm^2$) |
| square foot ($ft^2$) | 0.09290 | square meter ($m^2$) |
| square inch ($in^2$) | 6.452 | square centimeter ($cm^2$) |
| section (640 acres or 1 square mile) | 259.0 | square hectometer ($hm^2$) |
| square mile ($mi^2$) | 259.0 | hectare (ha) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |

Metric to English

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| centimeter (cm) | 0.3937 | inch (in.) |
| millimeter (mm) | 0.03937 | inch (in.) |
| meter (m) | 3.281 | foot (ft) |
| kilometer (km) | 0.6214 | mile (mi) |
| kilometer (km) | 0.5400 | mile, nautical (nmi) |
| meter (m) | 1.094 | yard (yd) |
| | Area | |
| square meter ($m^2$) | 0.0002471 | acre |
| hectare (ha) | 2.471 | acre |
| square hectometer ($hm^2$) | 2.471 | acre |
| square kilometer ($km^2$) | 247.1 | acre |
| square centimeter ($cm^2$) | 0.001076 | square foot ($ft^2$) |
| square meter ($m^2$) | 10.76 | square foot ($ft^2$) |
| square centimeter ($cm^2$) | 0.1550 | square inch ($ft^2$) |
| square hectometer ($hm^2$) | 0.003861 | section (640 acres or 1 square mile) |
| hectare (ha) | 0.003861 | square mile ($mi^2$) |
| square kilometer ($km^2$) | 0.3861 | square mile ($mi^2$) |

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

# BLM Density Management and Riparian Buffer Study: Establishment Report and Study Plan


## Abstract

The Bureau of Land Management (BLM), Pacific Northwest Research Station (PNW), US Geological Survey (USGS), and Oregon State University (OSU) established the BLM Density Management and Riparian Buffer Study (DMS) in 1994 to demonstrate and test options for young stand management to meet Northwest Forest Plan objectives in western Oregon. The primary objectives of the DMS are to evaluate the effects of alternative forest density management treatments in young stands on the development of important late-successional forest habitat attributes and to assess the combined effects of density management and alternative riparian buffer widths on aquatic and riparian ecosystems.

The DMS consists of three integrated studies: initial thinning, rethinning, and riparian buffer widths. The initial thinning study was installed in 50–80-year-old stands that had never been commercially thinned. Four stand treatments of 30–60 acres each were established at each of seven study sites: 1) unthinned control, 2) high density retention (120 trees per acre (TPA)), 3) moderate density retention (80 TPA), and 4) variable density retention (40-120 TPA). Small (1/4 to 1 acre in size) leave islands were included in all treatments except the control, and small patch cuts (1/4 to 1 acre in size) were included in the moderate and variable density treatments. An eighth site, Callahan Creek, contains a partial implementation of the study design.

The rethinning study was installed in four 70–90-year-old stands that previously had been commercial thinned. Each study stand was split into two parts: one part as an untreated control and the other part as a rethinning (30-60 TPA).

The riparian buffer study was nested within the moderate density retention treatment at each of the eight initial thinning study sites and two rethinning sites. Alternative riparian buffer widths included: 1) streamside retention (one tree canopy width, or 20–25 ft), 2) variable width (follows topographic and vegetative breaks, 50 ft slope distance minimum), 3) one full site-potential tree height (approximately 220 ft), and 4) two full tree heights (approximately 440 ft).

A second round of density management manipulations are now being planned for implementation beginning in 2009. Stem density will be reduced in the high, moderate, and variable density treatments and most existing riparian buffers, leave islands, and patch cuts will remain in place.

Remeasurement, data management, and analysis are ongoing for three long-term, core components of the DMS: vegetation, microclimate, and aquatic vertebrates. In addition, several short-term collaborative studies have been completed on these sites including leave island effectiveness as refugia, treatment response of terrestrial and aquatic arthropods, and smaller-scale studies of fungal, lichen, and bryophyte community response. Additional collaborative studies are encouraged on DMS sites.



**Key Words:** forest density management, thinning, riparian buffer, aquatic habitat, microhabitat, microclimate, late-successional habitat.

# Introduction

The Bureau of Land Management (BLM) manages a significant amount of forested land in western Oregon (approximately 2,200,000 acres), much of which occurs on productive, low-elevation sites. Historically, most of these lands have been managed primarily for sustained timber production to meet the objectives of the Oregon and California (O&C) Railroad Act of 1937, the primary legislation authorizing management of O&C lands. Until approximately 1950, seed tree harvest with natural regeneration was the primary silvicultural practice. Seed trees were usually removed once regeneration was established. Since then, spatially dispersed clearcut harvests with subsequent artificial regeneration and intensive stand management have been the dominant forms of silviculture practiced on these lands. Regeneration harvests, wildfire, and blowdown events have resulted in young forests on approximately half of the BLM-managed lands (1,139,000 acres (52 percent) are less than 80 years of age, Fig. 1). Douglas-fir is the dominant tree species on most sites, both because of its competitive ability in early-successional environments and because management has favored Douglas-fir through reforestation and thinning operations.

Forest management on federal lands in western Oregon and Washington changed dramatically with the listing of the northern spotted owl as a threatened species under the Endangered Species Act in 1990 and with the development of an owl recovery plan in 1992. The BLM responded in 1991 by initiating a process to revise the Resource Management Plans (RMPs) for management districts within the range of the owl. Draft plans were issued that included a range of new and untested silvicultural approaches intended to foster development of structurally complex late-successional habitat. In 1993, prior to issuance of final RMPs for these districts, federal scientists were directed by President Clinton to produce a regional plan to protect and restore late-successional forest habitat and species, while simultaneously providing for a sustainable level of timber production (FEMAT 1993). The results were incorporated into the Northwest Forest Plan (NFP; USDA and USDI 1994), which formally modified existing BLM RMPs and national forest plans. Subsequently, the BLM issued revised RMPs for the districts within the range of the owl in 1994 and 1995 that fully incorporated the NFP. These plans rely heavily on the application of new silvicultural systems to hasten development of late-successional habitat from existing young, structurally simple forests.

In response to these developments, BLM foresters, biologists, and botanists worked with Dr. John Tappeiner (former research scientist for the USGS and professor at the College of Forestry, Oregon State University; now retired) to create the BLM Density Management and Riparian Buffer Study (DMS). The broad goal of the DMS is to test silvicultural options intended to develop complex late-successional habitat from even-aged young (less than 80 years of age) forests. The purpose of this report is to describe the design and plan for conduct and maintenance of the study, and document the establishment of treatments across study sites.

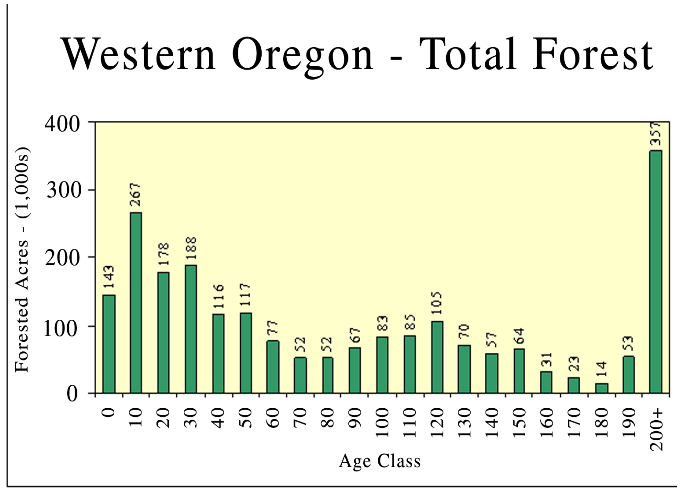


Figure 1. Western Oregon BLM forest age distribution.

## History

In the late 1980s Dr. John Tappeiner recognized that forest stand management on federal lands in western Oregon needed to change in response to new knowledge regarding ecosystem structure and function and a shift in federal land management priorities (personal communication). His experience leading other silvicultural studies in western Oregon and as lead author of the silviculture chapter in the Northern Spotted Owl Recovery Plan (USDI, Tappeiner and others, 1992) helped clarify key questions needed for successful forest stand management to meet these challenges.

In consultation with BLM foresters, Dr. Tappeiner drafted a study plan (February 1, 1993; on file at the BLM Oregon State Office, final version contained in Appendix D) intended to help the BLM manage for new objectives. This draft contained the first outline of the DMS. The draft plan also identified existing studies and sources of information that could be used to help test new prescriptions for BLM lands and listed reasons why these studies were insufficient (for example, sites were not adequately representative of BLM-managed lands, studies did not test prescriptions anticipated in BLM RMPs, plot or stand size was insufficient to sample wildlife populations, and ongoing studies did not represent the planning and implementation skills of BLM personnel.)

Concurrently, a retrospective study was initiated by Dr. Tappeiner and a graduate student (John Bailey) that examined older commercially thinned sites on BLM-managed lands and compared them with nearby unthinned stands that shared a common history, and with nearby older forests located on sites with similar characteristics. The goal of these studies was to get an early look at the response of overstory and understory vegetation to thinning, recognizing it would take considerable time for experimental treatments to be implemented and for responses to become evident. Results from these studies were published (Bailey 96, Bailey and Tappeiner 98, and Bailey et al. 98) and helped shape the concepts underlying the DMS study plan and site selection.

Formal direction to undertake the new study from the BLM Oregon State Office was issued to the BLM west-side and Lakeview districts on June 25, 1993 (OR-93-145; Appendix A). The memo announced the intention of the BLM to establish a group of active, recognized study sites on BLM-administered lands where complementary research and monitoring activities could be conducted. It also scheduled a meeting of district silviculturists and wildlife biologists to help shape the study. Shortly thereafter, Charley Thompson (forester, BLM Salem District) was designated as the BLM Project Coordinator and site selection criteria were developed. Later in 1993 the study was renamed the Density Management Study, an interdisciplinary study team was formed, and the first two sites for implementation were picked, one in the Cascade Range (Keel Mountain, Salem District) and one in the Coast Range (Bottomline, Eugene District).

The BLM Oregon State Office issued further guidance to the BLM west-side and Lakeview districts on March 29, 1994 (OR-94-317; Appendix B). The memo clarified that the study would proceed despite the reorganization of the BLM Cooperative Research Unit into the National Biological Survey (eventually to become part of the US Geological Survey (USGS)). The memo stated that study implementation would initially focus on the Cascade and Coast Ranges, that implementation would be delayed on the Medford and Lakeview districts, and that each affected district and resource area should expect a significant commitment of time to plan, implement, and monitor study sites. The interdisciplinary team also reviewed revised study plans in 1994 and suggested ways to integrate concerns and opportunities regarding plants, wildlife, and prescribed fire into the study plan as funds allowed.

A major event in the history of DMS occurred later in 1994 when Pacific Northwest Research Station (PNW) scientists began discussions with Dr. Tappeiner and Charley Thompson about integrating a riparian buffer study into the DMS. Subsequently, study plans were written by Dr. Deanna Olson (aquatic vertebrates) and Samuel Chan (microclimatic gradients) that included an alternative riparian buffer design to be nested within one of the DMS treatments. These plans were refined and accepted as the Riparian Buffer Study.

Additional collaboratie studies were added to the DMS in 1994, including a planting study developed by Dr. Peyton Owston (PNW). Epiphytic lichen (Dr. Bruce McCune, Oregon State University (OSU)) and forest floor bryophyte (Dr. Patricia Muir, OSU) studies designed to characterize pre-treatment conditions of these taxa were also initiated in 1994. Shortly thereafter, Dr. Andrew Moldenke (OSU) and Dr. Robert Progar (PNW) initiated aquatic and terrestrial arthropod studies. Beginning on page 41 of this report, DMS collaborative studies are summarized with lists of publications resulting form this work.

The BLM submitted a request to the Regional Ecosystem Office (REO), an interagency body created with the Northwest Forest Plan, for review and concurrence of five DMS sites in early 1995. Concurrence by the REO was deemed necessary under the Northwest Forest Plan because timber harvest activities were planned within riparian reserves and late-successional reserves, even though the harvests were thinnings planned in young stands. The process involved discussions and deliberations over an 18-month period involving the Research and Monitoring Committee and the Late-Successional Reserve Committee of the REO. Study site selection was an ongoing process throughout this time period (see Study Sites, page 13) and sites were proposed to the REO in three groups. Ultimately, concurrence with findings of consistency with the Northwest Forest Plan were issued for all proposed DMS sites in the form of three memoranda from the REO to the BLM (June 21, 1995; May 24, 1996; and August 12, 1996; on file at the BLM Oregon State Office).

Timber sale planning to implement study treatments began in earnest once REO approval was granted. Timber harvests were phased in over a five-year period (1996-2000) across twelve sites. Measurement plots and transects were established on all sites as documented in the study plan (see Component Studies, page 15 and Treatment and Measurement Schedule, page 47). Planning is now underway for a second round of manipulations, as described in this report and directed by the BLM State Office (IM OR-05-083, Appendix C). Detailed information describing each site and its management history was prepared by the site coordinators and is included as Appendix E.

Additional collaborative studies were established on some sites including a leave island study (Stephanie Wessell (OSU), Dr. Deanna Olson (PNW), and Dr. Richard Schmitz (OSU)); a fungi biodiversity and community study (Dr. Lorelei Norvell (Pacific Northwest Mycology Service) and Ron Exeter (Salem BLM)); a bryophyte study (Hugh Snook (Salem BLM)); a songbird study (Jennifer Weikel (OSU) and Dr. Dan Edge (OSU)); an understory shrub study (Dr. John Tappeiner (OSU)), and additional bryophyte studies by Dr. Patricia Muir (OSU) and Tom Rambo (OSU).

Changes have occurred in science leadership over time as scientists have retired or moved into new positions. Dr. John Tappeiner retired in 2002 as the silviculture and vegetation principal investigator (PI) and was succeeded by Dr. Klaus Puettmann. In 2002, John Cissel (Oregon State Office, BLM) succeeded Charley Thompson as Study Coordinator, and Site Coordinators were established for all study sites. Dr. Paul Anderson assumed leadership of the Microclimate and Microsite Component when Samuel Chan moved into a new position in 2004.

## Partnerships

From its inception, the DMS has been perceived and operated as a broad partnership. The study was initiated as a collaboration between the USGS Forest and Rangeland Ecosystem Science Center and the BLM, and quickly expanded to include the PNW and OSU. The BLM has planned and implemented the treatments, administered site use and management, provided overall study coordination, organized outreach activities, and installed vegetation monitoring plots. The USGS provided the initial science leadership and study plan and supports website development and data delivery. PNW and OSU provide science leadership, collect and manage data, conduct analyses, report results, participate in outreach activities, and provide administrative support. The Cooperative Forest Ecosystem Research (CFER) program, a collaboration among USGS, OSU, BLM, and the Oregon Department of Forestry, supports DMS outreach activities and products. The Pacific Northwest Mycology Service, a private consulting firm, supports research on fungal response to DMS treatments. Each of these partners has provided substantial financial support, skills, and personnel to support the DMS.

# Objectives

## Science and Management

- Evaluate effects of alternative forest density management treatments on important stand and habitat attributes (large trees; standing and down dead wood; understory trees, shrubs, and herbs; vertical distribution of tree canopy; and spatial distribution of trees, shrubs, herbs, and dead wood)
- Determine treatment effects on selected plant and animal taxa (amphibians, arthropods, mollusks, nonvascular plants, and fungi)
- Assess the combined effects of density management and alternative riparian buffer widths on aquatic and riparian ecosystems
- Use DMS sites to develop operational approaches to implement new prescriptions and improve methods for effectiveness monitoring of plant and animal taxa
- Use DMS sites to share results of on-the-ground practices and findings with land managers, regulatory agencies, policy-makers, and the public
- Use results from DMS to conduct a long-term adaptive management process where management implications and policy changes are regularly evaluated and changed as needed

## Desired Future Stand Conditions

The essential long-term goal of the DMS is to accelerate development of late-successional characteristics in these younger forests. To a significant extent, habitat requirements of the northern spotted owl underlie this goal. Stands with late-successional characteristics provide better habitat for spotted owls as they appear to prefer stands with large diameter trees for nesting (Perkins 2000, Courtney et al. 2004). Preferred habitat attributes include vertical canopy layering, tree height or diameter diversity, high canopy closure and volume, large trees, and large snags. All of these variables showed a positive relationship with owl habitat (Courtney et al. 2004). Accelerating development of habitat characteristics may be crucial in maintaining viable owl populations, especially in regions dominated by young, even-aged stands.

When treated stands reach 120-150 years of age, the desired stand conditions are as follows:

Large green conifer trees

- >8 Douglas-fir per acre >30 in
- 2-6 trees per acre (TPA), diameter >50 in
- 1 TPA, diameter >50 in with a broken top

Enhanced species and structural diversity

- 25-35 TPA, diameter 15-30 in, hardwoods and conifers
- 100-200 TPA, diameter <15 in, hardwoods and conifers
- Two or more species to include at least one shade tolerant species, and two or more age cohorts

Snags

- 8-12 snags/acre, 50 percent diameter 10-25 in, 50 percent diameter >25 in
- All decay classes present

Downed logs

- 900 linear ft/acre of well-dispersed logs
- 1/3 of logs >24 in diameter
- 2/3 of logs 10-24 in diameter
- All decay classes present

# Study Design

Design of the DMS occurred in two distinct phases. The initial study design was developed in 1993-1995 and documented in 2001 (Appendix D). This design was used to install the first phase of the treatments in 1996-2000. Post-treatment measurements and observations led to new questions regarding the long-term trajectory of study stands and potential future treatments. The study plan was revised in 2004 in response to these questions and documented herein. Similar to the initial study plan, the revision was developed by the principal investigators with iterative input by BLM field staff and others through field tours, document reviews, and meetings.

The DMS consists of three related studies. The primary design was intended for 50- to 80-year-old forests that had not been previously thinned and was termed the "Initial Thinning" Study. Four distinct treatments (High Density, Moderate Density, Variable Density, and Control) were applied to seven sites in the Initial Thinning Study. An eighth initial thinning site, Callahan Creek, contains a partial implementation of the study design. A second study, the “Riparian Buffer” Study, was nested within the Moderate Density treatment at these sites. Two to four alternative riparian buffer widths were applied at each site depending on the types and positions of streams within the study units. The third study is the “Rethinning” Study. This design was intended for 70- to 100-year-old forests that had been previously thinned. Two treatments (Rethin and Control) were applied to four sites in the Rethinning Study.

## Initial Thinning Study

The Initial Thinning Study was designed to obtain information relevant to developing late-successional habitat that was not available from previous studies of even-aged, Douglas-fir silviculture (see Appendix D; and USDI, Tappeiner and others, 1992). Unique characteristics of late-successional habitat include development of understory and midstory canopies, high spatial heterogeneity of trees and understory vegetation, and provision of large dead wood, both standing and down. Exploration of approaches to rapidly create high spatial heterogeneity and support development of understory and midstory vegetation drove the design of treatments. Dead wood management is only addressed indirectly in this study because approaches to managing for large dead wood depend on developing and sustaining sources of large live trees, a primary desired future stand condition.

### Phase One

The initial thinning study was installed in 50 to 80-year-old stands that had never been commercially thinned. Four treatments of 30-60 acres each were established within each of seven study sites:

1. **Unthinned control.** 200–350 TPA.
2. **High density (HD) retention.** 70–75 percent of the stand thinned to 120 TPA, 20–30 percent left unthinned in riparian buffers or leave islands of three sizes (0.25, 0.5, and 1.0 acres).
3. **Moderate density (MD) retention.** 60–65 percent of the stand thinned to 80 TPA, 10 percent of the stand cut in circular patch openings (0.25, 0.5, and 1.0 acres), 10 percent left in circular leave islands (0.25, 0.5, and 1.0 acres), and 15–20 percent left unthinned in riparian buffers.
4. **Variable density (VD) retention.** 10 percent thinned to 40 TPA, 25–30 percent thinned to 80 TPA, 25–30 percent thinned to 120 TPA, 10 percent left in leave islands (0.25, 0.5, and 1.0 acres), 10 percent cut in circular patch openings (0.25, 0.5, and 1.0 acres), and 15–20 percent left unthinned in riparian buffers.

Within the control, high density, and moderate density treatments, nine 1-acre areas were underplanted with western hemlock and western redcedar. Western hemlock, Douglas-fir, western redcedar, and grand fir were planted in all patch openings and in the 40 TPA areas of the variable density retention treatment.

At Callahan Creek the control and moderate density treatments were installed, primarily to facilitate the riparian buffer study.

Figure 2 depicts a representative layout of an initial thinning study site with the four subtreatments (control, HD, MD and VD).

The HD retention treatment most closely resembles a traditional commercial thinning for timber production. While effects of accelerating the development of forest structure may be short-lived, this treatment retains options for later stand entries. The MD retention treatment allows more growing space for understory trees, shrubs, and herbs, and reduces competition among overstory trees for a longer period of time. Openings and islands create complexity within the stand. The VD retention treatment results in a highly diverse mix of conditions over a small spatial scale, providing the highest level of spatial heterogeneity among the treatments.

### Phase Two

A second round of thinnings is being planned for implementation in 2009-2011. With this second round of thinnings study treatments are now viewed as silvicultural systems involving multiple stand treatments over time as described below.

**Table 1.** Residual live tree target densities for the Initial Thinning Study treatments. Second and third entries will be implemented 12 and 24 years after the first entry, respectively.

| Treatment | First entry | Second entry | Third entry |
|---|---|---|---|
| Unthinned Control | No treatment | No treatment | No treatment |
| High Density | 120 TPA | 60 TPA | 30 TPA |
| Moderate Density | 80 TPA | 30 TPA | No treatment |
| Variable Density | 120/80/40 TPA | 60/30/20 TPA | Evaluate following second entry |

1. **Unthinned Control** will provide data on development of unmanaged forests and will provide information about the benefits and costs of treatments. Controls provide baseline information crucial for comparison of the treatments on the different study sites, especially because only one replication of each treatment is present on a site. Controls will remain intact for the duration of the study.

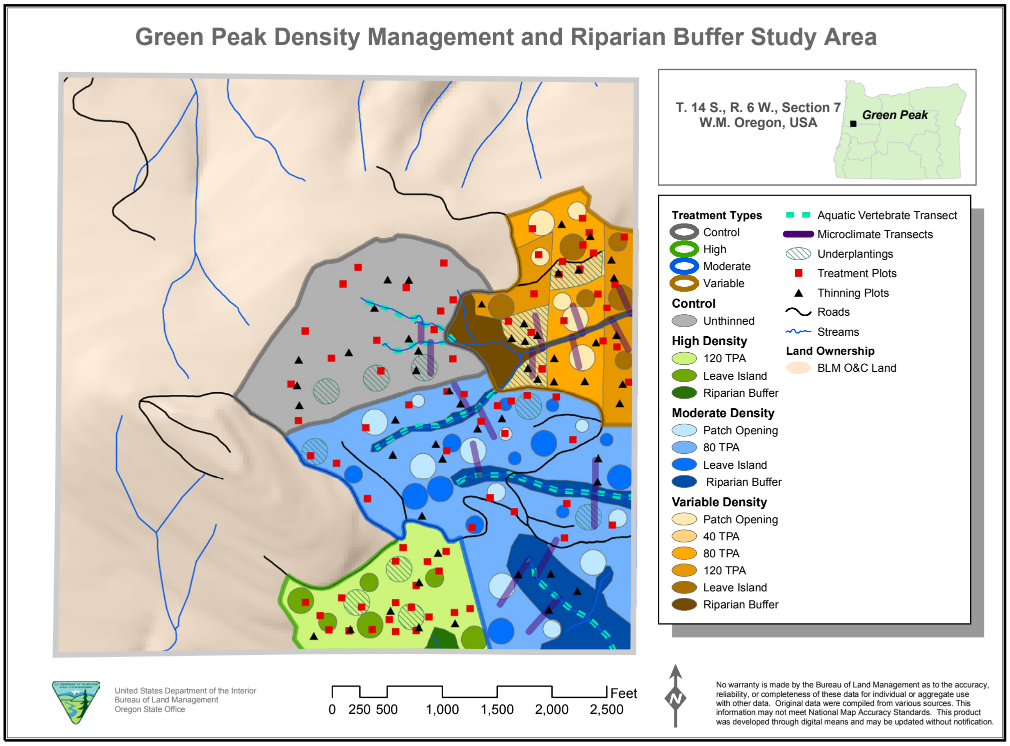


Figure 2. Layout of treatments in the Green Peak study site in the Oregon Coast Range.

2. **High Density (HD) Retention**, or three-step conversion, includes multiple thinnings aimed at opening the overstory canopy gradually. The first entry opened the canopy to 120 TPA; the second is proposed to occur 12 years later to 60 TPA, and the third, at a time to be determined, to 30 TPA.

3. **Moderate Density (MD) Retention**, or two-step conversion, includes two intensive thinnings. The overstory will be thinned in two steps with the first entry to 80 TPA and the second to 30 TPA proposed to occur 12 years later. No further entries are planned with one exception described in the riparian buffer section.

4. **Variable Density (VD) Retention** provides the highest heterogeneity within a stand. It provides a cornerstone of what can be achieved with intensive forest management. The next rethinnings for the 120 TPA and 80 TPA treatment components mimic the thinnings described above in the HD and MD treatments. We propose to thin the 40 TPA areas to 20 TPA at the next entry (12 years after the initial thinning). Areas currently thinned to 120 TPA will be rethinned again to 30 TPA at a time to be determined.

Residual density targets given above are for live trees; five additional trees per acre will be left for future snag recruitment. Thus, for marking purposes, the residual density after thinning will be higher – 65 TPA, 35 TPA, and 25 TPA. (See "Snags" on page 11.)

The Riparian Buffer Study nested within the MD treatment will be retained and expanded. Existing buffers will remain with the exceptions described below (See "Riparian Buffer Study" on page 8).

The HD, MD, and VD treatments also provide a continuing opportunity to evaluate the effects of leave islands and patch cuts in the context of a managed stand. Existing leave islands and patch cuts will remain through the second round of treatments.

Other management considerations, such as downed wood and treatment of understory vegetation and regeneration, are applied consistently across all treatments and described below.

## High Density Treatment Prescription

This prescription will reduce tree density in areas initially thinned to 120 TPA down to 60 TPA (65 TPA with snag allowance) 12 years after the initial thinning (see table 11 on page 38 for the thinning schedule). Future plans include a third thinning lowering the density to 30 TPA (35 TPA with snag allowance).

The HD treatment is aimed at converting an even-aged, single-story stand structure to a more complex late-successional habitat by employing multiple, low-intensity thinnings. Our preliminary assessments indicate that the overstory and understory development resulting from the initial HD thinning are not very different from control stands. Consequently, we view the initial thinning as conservative, and view repeated thinnings as necessary to ensure stands develop towards a diverse structure characteristic of late-successional forests. However, this treatment provides a high amount of protection for plants and animals that require overstory cover.

The initial HD treatment was originally designed to reflect "conventional" management strategies. Current practices on federal lands include thinning to densities lower than the 120 TPA initially left, even in stands managed for timber production. However, a slow, three-step treatment provides information for strategies where protection of interior stand conditions is important during the conversion of even-aged stands into late-successional habitat, such as in areas with wildlife sensitive to open conditions.

We plan to thin to 60 TPA (65 TPA with snag allowance) with the second thinning. This entry will allow crown and stem form (taper) condition to adjust to more open canopy conditions and improve tree stability for the third thinning, which will open the stand to 30 TPA (35 TPA with snag allowance) and provide "open" growing conditions for the residual trees.

In summary, this treatment will provide information about a conservative management approach aimed at converting homogenous stands to diverse stand structure. The information will apply to stands that have been thinned conservatively in the past. The low-intensity repeated thinnings will allow trees to adjust fairly slowly to more open conditions. This treatment provides information directly usable in stands where multiple entries are economical, access is fairly easy, risk of windthrow is high, and continuous protection by overstory trees is desirable.

### Moderate Density Treatment Prescription

This presecription will reduce tree density in areas initially thinned to 80 TPA down to 30 TPA (35 TPA with snag allowance) 12 years after the initial thinning (see table 11 on page 38 for the thinning schedule). This will be the last thinning for this treatment. It will retain existing riparian buffers, except as described below.

This prescription was selected to maximize the scientific value of the DMS. Preliminary results of vegetation and other analyses indicate that the Phase One thinnings were fairly conservative. In hindsight it is clear that a wider range of treatments is desirable to bracket the possible range of conditions. Traditionally, the choice of thinning intensities was influenced by growth-growing stock relationships and stand stability considerations. The proposed thinning to 30 TPA goes below "conventional" density levels. The site will not likely be fully occupied by overstory trees, and the treatment will result in lower growth (per acre) of the overstory. Thinning to levels below full site occupation provides a scientific baseline for conditions where lack of a closed canopy changes microclimatic conditions and a large amount of site resources are available for other (than overstory) stand components, such as understory vegetation or regeneration.

This proposed action represents an attempt to accelerate the development of late-successional habitat in two thinning entries. Even though not originally envisioned as such, the original entry can be viewed as a "preparation cut." The stands grew at a fairly high density and trees had low live crown ratios and high height-to-diameter ratios. Concerns about tree stability after exposure by a single high intensity thinning were addressed by first "opening up" the stand to 80 TPA and allowing the residual tree crowns to recover and height-to-diameter ratios to decrease. At the same time, our measurements and observations indicate that understory vegetation did not respond significantly to the original thinning. Because tree architecture has had 12 years to adjust to more open conditions, rethinning to 30 TPA (35 TPA with snag allowance) in one thinning entry should not substantially degrade stability. However, we expect the understory vegetation, which has developed rather slowly during the first 12 years, to respond quickly to the increased resources after the second thinning, and the stands should start providing components of late-successional habitat fairly quickly.

From this treatment we expect to gain information useful for management on a wider range of stand conditions, including cases where stands are opened up with a single intensive thinning. For example, in young or low density stands with high stability, (that is, high live-crown ratios and lower height-to-diameter ratios), the initial entry may not be necessary to improve tree stability. While we will not be able to do replicated comparisons of a single entry with multiple thinnings, the treatment response may provide useful information to assess potential outcomes when dense stands are opened up with a single, very intensive thinning. The conversion of the two-tree height riparian buffers to a streamside riparian buffer (see below) will provide complementary information for these conditions.

A third reason for this treatment is the location of alternative riparian buffers within the MD treatment areas. Initial analyses of microclimate and amphibian habitat found few effects of varying riparian buffer widths; they did buffer the impact of thinning the upland area to 80 TPA (85 TPA with snag allowance). Lowering the upland density to 30 TPA (35 TPA with snag allowance) will result in a higher contrast between upland areas and riparian buffers. We expect more differences regarding the effectiveness of the riparian buffers to become evident under these conditions.

### Variable Density Treatment Prescription

This prescription will provide another cornerstone of information by creating a very high level of structural diversity within a stand. It will be used to investigate the relative importance of various sub-treatments (for example, patch cuts and leave islands) and provide a reference for evaluating spatial scale relationships found in the other treatments. Thus, future thinning densities should be comparable to rethinnings in the

HD and MD treatments. We plan to duplicate the prescriptions listed above for the variable density treatment in areas currently with 120 TPA and 80 TPA, respectively. In addition, we plan to thin the area currently in 40 TPA to 20 TPA (25 TPA with snag allowance). Thus, we maintain within-stand structural diversity while enhancing differences within this treatment over time. A decision concerning whether or not to conduct a further thinning in the high density portion of this treatment will be made after the second round of thinnings are completed and assessed.

### Provisions Common To All Treatments

#### Patch Cuts

We intend to maintain but not increase the existing openings created with patch cuts in the Phase One thinning in all proposed rethinnings. Although created openings are steadily shrinking as stands develop, further manipulation, for example, enlarging openings or feathering opening edges, would be confounding with the thinnings. In addition, the ability to increase opening size is very limited in most DMS stands due to space constraints. Information from other studies about survival of conifer seedlings under various light conditions can be used in conjunction with our light measurements in the openings to make some prediction about the impact of opening size on tree regeneration.

Existing openings span a range of opening sizes and environmental effects. Ongoing spatial analysis of opening size and neighborhood conditions will be enhanced and extended as the neighboring stand is thinned to a lower residual density. Rethinning will provide new data on gap closure rates, the effects of gap closure on vegetation, and gap edge response to changing light environments. These data will facilitate predictions about the effects of creating openings of alternative sizes and spatial arrangements and their effect on the development of late-successional habitat.

#### Leave Islands

We plan to maintain the leave islands created in the Phase One thinning in all proposed rethinnings for reasons similar to those outlined above for openings. Initial analyses (Wessell, 2005) of the effects of leave island size on low-mobility species indicate that small (0.25- to 0.5-acre) leave islands may not be very effective in providing refugia or other benefits of dense forest cover. However, the value of these features may increase over time as stands are opened up through repeated thinnings. In addition, leave islands will likely experience some density-dependent tree mortality and thus provide a future source of smaller snags.

#### Understory Trees, Shrubs, and Herbs

Understory vegetation contributes to species richness in the short term and to desired stand structure in the long term. Development of diverse and well-established understory vegetation to support a variety of arthropod and wildlife species is one of the main goals of the overstory thinnings. Many of the openings created through patch cutting are also sources of abundant shrubs and hardwood trees. Conifer seedlings of several species were planted in the gaps soon after the initial patch cuts to ensure that conifers were also present.

We do not plan any manipulations of shrub and herb components within gaps because gaps are sources of biodiversity, gaps have a limited spatial extent (10 percent or less of the treated stands), observations to date indicate conifers will persist as a component of gap vegetation, and understory competition control treatments intended to promote conifers would reduce or eliminate desirable stand components that contribute to species and structural diversity. We will continue to monitor vegetation within gaps and assess the need for futher manipulation to ensure conifer emergence.

Some areas within the treatments support dense patches of conifer reproduction. Dense conifer regeneration reduces understory vegetation, potentially leading to a depauperate understory. At this stage no manipulation of understory regeneration is planned. We expect seedling and understory mortality from logging damage due to the harvesting activities planned for 2009-2011. Development of tree regeneration will be monitored, and the need for future thinning will be assessed following these harvests. Precommercial thinning will be prescribed and implemented in thinned areas and gaps where large patches greater than 1 acre of conifer reproduction exceed 80 TPA. Conifer understory density following precommercial thinning should be between 50 TPA and 60 TPA.

## Riparian Buffer Study

Within the context of the Density Management Study, the Riparian Buffer Study is designed to characterize 1) interactive effects of upland density management treatments and riparian buffers, 2) effects of streamside no-harvest zones of different widths on spatial and temporal variation in forest microclimate, vegetation structure and composition, and 3) associated habitat values for aquatic and riparian dependant organisms. Four riparian buffer configurations, differentiated by width, are being compared (Fig. 3):

**Two site-potential tree heights:** This is the largest buffer width to be examined in our study. It is measured as a slope distance from the stream. In the NFP, this buffer is applied, as the interim default width, along fish-bearing streams until watershed analysis is conducted. Buffer widths can be modified on a case-by-case basis using information and interpretations in a watershed analysis. In our study, this buffer is generally applied to first- or second-order streams that may or may not have fish.

**One site-potential tree height:** This buffer also is measured as slope distance from the stream. In the NFP, this buffer is applied to all non fish-bearing streams with a definable channel and evidence of annual scour or deposition. It is an interim default width used prior to watershed analysis. In our study, this buffer is generally applied to first- or second-order streams that may or may not have fish.

**Variable width:** This buffer is not based on a fixed slope distance from the stream, but rather, its boundary depends upon on-site streamside ecological breaks in vegetation and slope character. Adjustment of riparian buffers to on-site ecological conditions is a concept consistent with the NFP and naturally follows from watershed analyses and on-site evaluations. This buffer is delineated during on-site activities. Where steep slopes, slumps, surface seeps, or distinct riparian vegetation occur, wider boundaries are marked. Where gentler slopes occur and upslope forest conditions extend to the stream, narrower buffers are used. A minimum slope distance of 50 ft is used to ensure a high degree of stream and streamside shading, and litter and wood inputs. This buffer is applied to intermittent, first- and second-order streams, that may or may not have fish.

**Streamside retention:** This buffer is the narrowest riparian buffer examined. The streamside retention does not have a single fixed distance, and hence the buffer width varies along the stream reach. This buffer retains trees that directly confer both streambank stability by their rooting position next to streams and overhead shading by their crowns extending over the channel. Retained trees are visually determined by examining overstory crown widths. In this study streamside retention delineation has resulted in retention of one to two standing trees away from the channel or at minimum those trees within approximately 20 ft of the channel. Buffers were extended to include unstable slopes or unique tree species in streamside areas. In this study, streamside retention buffers are used primarily in intermittent and first-order perennial channels, and sometimes along second-order perennial streams.

**Control:** Control stream reaches are identified at each study site. Streams and upslope areas adjacent to controls are left untreated, that is, no density management. The assumption underlying the uncut control is that reserve designation and the explicit passive management represents the most likely alternative to active management in the form of riparian buffer delineation and density management in adjacent upslope forest stands. The uncut controls provide characterization of interior forest conditions for stands having similar pretreatment characteristics as those being thinned.

All four riparian buffer treatments are intended to moderate stream and channel microclimate and microhabitat responses to density management treatments imposed on adjacent upslope forests. However, the rationale for buffer delineation varies among the four buffer types. Buffers based on site-potential tree heights stem from the interim guidelines for riparian management under the NFP. Use of site-potential tree

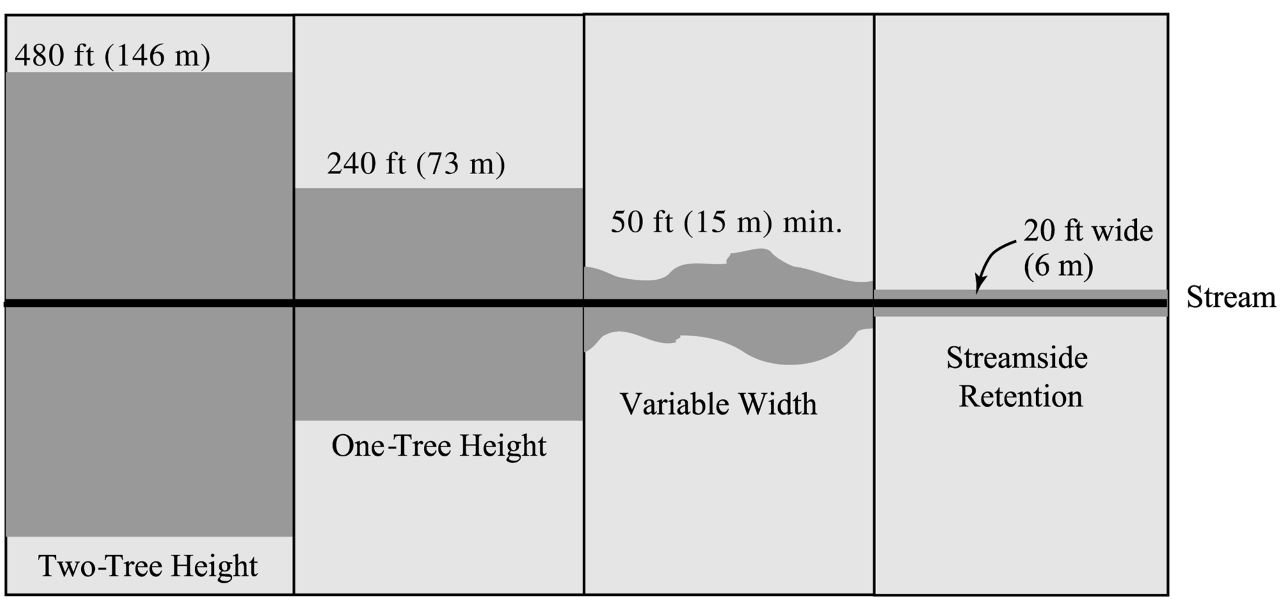


Figure 3. Conceptual representation of riparian buffer treatments being evaluated: 2 site-potential tree heights, 1 site-potential tree height, variable break, and streamside retention.

heights was developed primarily due to the potential benefits of wood and litter inputs to streams, and the effects of shading and other moderating influences on microclimate. Wide riparian buffers also ensure that debris torents entrain and deliver large wood to streams. The upslope extent of these buffers also reflects uncertainty about the degree to which the stream and riparian microclimate can be influenced by harvesting operations in adjacent stands. The two-tree-height buffer is a conservative guideline designed to minimize risks for altering stream and riparian habitats due to potential changes in light, temperature, relative humidity or wind velocity that may result from upslope density management. The one-tree-height buffer recognizes a lower risk associated with harvest adjacent to non-fish-bearing streams. This buffer can predictably provide substantial moderation of microclimate perturbation at the stream. Trees within this buffer zone potentially provide direct recruitment of coarse wood to the channel in the absence of large transport events.

The variable width and streamside retention buffers being tested in this study likewise are based on ecological rationale and are narrower than one site-potential tree height. The variable width buffer represents a more literal delineation between riparian and upland forest. Operative assumptions of the variable width buffer are that riparian areas have an inherent ability to buffer streams and habitats against adjacent upslope harvest effects, and that the riparian zone is the most important source of coarse wood to maintain channel processes and habitat quality. Variable width buffers were often delineated at vegetation or topographic "breaks" and may reduce land slide occurrence. The streamside retention buffer delineation is based on the premise that dominant values of riparian buffers in non-fish-bearing headwaters streams include maintenance of bank stability, stream shading, and direct recruitment of vegetative litter and coarse wood. Depending on local features and adjacent stand conditions, the streamside retention buffers may or may not provide substantial stream-side amelioration of microclimate perturbations associated with density management, even though they may effectively buffer changes in stream water temperature. Documenation of microclimate effects associated with these buffer widths is a specific study objective.

At the onset of our study, very little was known about forested headwaters. In the design of the riparian buffer study, we applied different buffer widths to first- and second-order headwater streams occurring at our selected study sites with the assumption that the basic character of headwater streams was similar among reaches. However, stream reach character was not assessed a priori and was not a condition for reach inclusion in the buffer study. During our study design, we recognized the general lack of information on headwaters by including characterization of instream conditions and fauna as a specific study objective. We anticipated detection of species-specific habitat associations within our headwater stream sample, and consequently planned species-specific analyses of treatment effects to help control for the potentially different types of streams encountered. Results have indicated our sample includes perennial and spatially intermittent stream types, and fauna have strong associations with these hydrological classes. In our analyses of treatment effects on habitat conditions, we included some parameters that were specific to these hydrological types.

The basic design of the Riparian Buffer Component is focused on the MD treatment and will not be altered during the second round of treatments. However, all riparian buffers should be viewed in the context of upland management. Rethinning in upland areas will greatly enhance the contrast between the buffer and the thinned areas and significantly alter edge conditions. Thus, by rethinning the uplands we will gain additional information about the importance and effects of leaving unthinned areas near streams (see discussion about riparian buffers under the MD treatment).

Based on strong feedback from scientists and managers, we are also planning more active management in areas near a limited number of stream reaches. We propose thinning down to 60 TPA (65 TPA with snag allowance) through the existing two-tree height buffers within the MD treatment at two study sites (Callahan Creek and Keel Mountain). In addition, we plan to thin through half of the existing variable-width riparian buffers in the HD treatment, also down to 60 TPA (65 TPA with snag allowance), and retain half of the variable-width buffers in the HD treatment. These thin-through areas will not have any special riparian buffer and will help frame interpretation of results. Selection of buffers to thin will be random unless operational constraints can not be mitigated. We are also exploring the potential to add five to six new sites in the Oregon Coast Range to test the thin-through approach.

The thinning of the two stream reaches with two-tree height buffers provides a case study of how stands may respond when only a single entry is used to convert dense stands to open conditions potentially favorable for development of late-successional habitat. We realize that reducing stand density to 60 TPA (65 TPA with snag allowance) in unthinned areas may increase the potential for blowdown. However, the limited blowdown observed in the study sites, combined with the relatively protected landscape position of these sites, has led us to conclude that the potential for producing useful information merits the increased risk.

## Rethinning Study

The Rethinning Study should be viewed in conjunction with the Initial Thinning Study. A primary goal of the Rethinning Study is to provide a context for predicting future response of the initial thinning sites. Thus, matching the prescriptions to the Initial Thinning Study is very important. While a direct comparison is not possible, that is, the rethinning sites do not have patch cuts and leave islands, the rethinning sites provide information about long-term development of various stand structural components. For example, the continuous "recovery" of live crown ratio or stem taper can be assessed on the rethinning sites and helps put the initial thinning treatments in perspective. We will use the response on the rethinning sites as a reference or validation point when we predict development of the initial thinning sites or use growth models to simulate overstory development of alternative treatments.

While a number of studies investigate development of young seedlings under various overstory densities, this information cannot be directly used to predict long-term future development. Seedlings are expected to become more light demanding as they get older and few studies investigate the growing conditions of saplings as they transition to the overstory. Thus, the rethinning sites are also very helpful in predicting future development of advanced regeneration and understory vegetation.

Rethinning Study treatments include:

1. Control (CON): a control with a single commercial thinning that reduced overstory density to 100+ TPA 25 - 30 years ago. A preliminary assessment indicated that the development of overstory and understory conditions necessary to create late-successional habitat is not accelerated appreciatively at this stage. However, this treatment provides baseline data. We feel this baseline information is necessary as it links the different study sites in the statistical analysis. This is especially important because the study was replicated across sites, that is, each site has only one replication of the treatments. Because of the relatively high residual density of overstory trees, we are not planning to thin the understory.

2. Rethin (RET): This treatment includes the original thinning to 100+ TPA and a second thinning conducted as part of the DMS that reduced the density to a clumpy distribution of 30 to 60 TPA. We are planning a third thinning to reduce the overstory to 30 TPA, plus an additional five trees left for snag recruitment. This treatment is "paired" with the MD and HD treatments on the initial thinning sites in that the final residual density target (30 TPA) is the same in all three treatments. This pairing will facilitate analysis and modeling of future stand trajectories.

   The primary goal of the treatment is to maintain and encourage the development of structural diversity, especially in the understory layers. The two thinnings already implemented facilitated understory regeneration of various species, including Douglas-fir and western hemlock. To maintain growth of advanced regeneration and avoid unstable conditions, such as unfavorable height/diameter ratios of seedlings, requires more growing space. Advanced regeneration is clumpy and dense in many spots. The additional thinning is intended to open the canopy to a level that advanced regeneration can maintain strong growth and vigor.

   Thinning the stand again will damage some seedlings, especially seedlings of larger size classes. However, with careful logging we expect that the advanced regeneration will still be sufficient to provide a significant component of future stand structure. The precommercial thinning prescription will take harvesting damage into account.

### Understory Trees, Shrubs, and Herbs

Understory vegetation contributes to floral and faunal species richness in the short term and to desired stand structure in the long term. Development of diverse and well-established understory vegetation is one of the main goals of the overstory thinnings and patch cuts. Because of the importance of shrubs and herbs as sources of biodiversity and because tree regeneration has become established in many portions of the stands, we do not plan any direct manipulations of shrub and herb components of the understory. Understory competition control activities intended to promote conifers, for example, removing hardwoods, would reduce or eliminate desirable stand components that contribute to species and structural diversity.

Natural regeneration on rethinning sites ranges from very dense to very sparse. Dense conifer regeneration, particularly of western hemlock, reduces understory vegetation, potentially leading to a depauperate understory. We also expect seedling and understory mortality in seedling patches from logging damage due to the harvesting activities planned for 2009-2011. The status of tree regeneration will be monitored immediately following the third thinning and the need for precommercial thinning will be assessed. Precommercial thinning will be prescribed and implemented in large patches (greater than 1 acre) of dense conifer reproduction that exceeds 80 TPA. Conifer understory density following precommercial thinning should be between 50 TPA and 60 TPA. To ensure tree species diversity, thinning will focus on cutting "majority" and retaining "minority" species (see "Species Choice" on page 13).

## Provisions Common to all Studies

### Snags

Large snags are an important characteristic of late-successional habitat and are typically in short supply in young managed forests. Several considerations complicate decisions regarding snag recruitment and management in young stands. Snags will likely form immediately following timber harvest due to harvesting damage, increased respiration demands on residual trees, sudden exposure to direct sun of needles formed in the shade, and other factors such as bark beetles. The extent of harvest induced mortality varies, but should subside within three to five years. Chronic tree mortality will contribute a low level of snags throughout the life of the stand as a result of competition, root pathogen pockets, and other sources.

**Table 2.** Study Sites

| Site | Province | BLM District | Study type(s) | Year selected |
|---|---|---|---|---|
| Bottomline | Coast Range | Eugene | Initial thinning, riparian buffer | 1993 |
| Keel Mountain | Cascade Range | Salem | Initial thinning, riparian buffer | 1993 |
| OM Hubbard | Coast Range | Roseburg | Initial thinning, riparian buffer | 1994 |
| North Soup | Coast Range | Coos Bay | Initial thinning, riparian buffer | 1995 |
| Green Peak | Coast Range | Salem | Initial thinning, riparian buffer | 1995 |
| Ten High | Coast Range | Eugene | Initial thinning, riparian buffer | 1995 |
| Delph Creek | Cascade Range | Salem | Initial thinning, riparian buffer | 1995 |
| Perkins Creek | Cascade Range | Eugene | Rethinning, riparian buffer | 1995 |
| Little Wolf | Coast Range | Roseburg | Rethinning | 1995 |
| Blue Retro | Coast Range | Coos Bay | Rethinning | 1995 |
| Sand Creek | Coast Range | Salem | Rethinning | 1995 |
| Callahan Creek | Coast Range | Salem | Riparian buffer | 1996 |

Episodic mortality will also contribute to the total snag pool through periodic blowdown, snow and ice breakage, insect or pathogen outbreaks, or fire. Although the likelihood of episodic mortality over the life of the stand is high, snag recruitment from such sources is highly variable and unpredictable. In addition, trees killed to provide snags at or near the time of thinning, when the trees are 10-16 in diameter, are not available later as larger diameter snags that supply greater ecological and habitat values.

Because of the importance of snags to late-successional habitat and substantial deficits of snags in the existing stands, we established a goal of five large snags per acre in the thinned areas ten years after timber harvest. Large snags will also form over time in control areas and within leave islands and stream buffers, but we have not established specific numerical objectives for these unthinned areas. Thus, thinning prescriptions call for leaving five additional TPA to ensure the snag goal can be attained (for a total of 25, 35 or 65 TPA corresponding with the 20, 30, or 60 TPA live tree targets). We will monitor whether mortality in the residual overstory meets this objective within ten years. If snag objectives are not met we plan to create sufficient large snags to fill the deficit. We expect that in many treatments natural mortality will provide for snags and no further snag creation will be needed. By documenting which snags were “natural” versus “created,” we will be able to quantify natural snag recruitment and compare development, usage, and longevity of the two types of snags.

Small snags also contribute to wildlife habitat and ecological functions. Control areas, leave islands, stream buffers, and other unthinned areas contain a range of tree sizes at fairly high densities, likely leading to high mortality in the smaller size classes. We anticipate that abundant small snags will be created through competition and other factors in these areas, and have not established numerical objectives for smaller snags. We will monitor the number and development of small snags as part of our overstory monitoring protocol.

The final residual live tree density target following commercial thinning of 30 TPA in the moderate and high density treatments, and in most of the variable density treatment, also provides a pool of trees for potential long-term snag recruitment. These trees function as live and dead tree habitat, as sources of regeneration and as future snags and downed wood. We plan an analysis comparing the amount of snags present relative to desired future stand conditions at every re-measurement. Additional snags can be created in the future if needed to achieve the desired future stand conditions. However, we expect that in most cases natural mortality processes will provide sufficient large snags over the next 50 to 100 years.

## Downed Wood

Downed wood is generally lacking in intensively managed landscapes and is a crucial part of late-successional habitat. Many of the same considerations discussed above under “Snags” apply to the discussion of downed wood. The DMS “Desired Future Stand Conditions” call for 900 linear ft of logs, 1/3 greater than 24 in diameter and the rest coming from logs 10-24 in diameter when the stands are 120-150 years old. All decay classes are to be represented. While some ecological values are associated with small logs, larger logs provide habitat for a greater range of organisms and support more ecological functions. Stands in the DMS have not yet attained sufficient diameter to provide logs of 24 in diameter, although the rethinning sites are approaching this target. Our primary approach is to target attainment of the downed wood objective later in stand development. The study objective is to reach half of the Desired Future Stand Condition targets at year 100, and full attainment by year 150. Analysis of remeasurement data will determine if additional logs will need to be created by management actions to meet this objective.

In addition to measurements and actions aimed toward reaching the downed wood targets in the long term, we also prescribe a minimum level of downed wood in the short term. Two dominant or co-dominant TPA should be felled from thinned areas as downed wood during thinning operations. Existing, recently downed trees (class 1 or 2 logs) can be used to satisfy this requirement. Current downed wood levels vary across and within sites, and additional logs will be created naturally from snag fall, storm damage, or other sources over time. These factors combine to create spatially and temporally variable levels of downed wood in keeping with the high variability in dead wood found in natural stands. Provision of two additional logs per acre also applies to the third thinning in the HD treatment and in the high density portions of the VD treatment during future operations.

### Species Choice

To ensure maximum tree species diversity, thinning will focus on cutting “majority” and retaining “minority” species. Thinning operations should not remove any tree species that make up less than 10 percent of the overstory. Overstory tree species greater than 10 percent of the overstory should generally be removed in proportion to their abundance. Residual overstory trees of all conifer species, but not hardwood species, will be counted toward target tree density.

## Treatment Assignment

A primary limitation of the Initial Thinning and Riparian Buffer studies is that treatments were not assigned completely randomly. For the most part this was due to the necessity of having multiple stream reaches available for the Riparian Buffer Study in the MD and control treatments of the Initial Thinning Study. Thus, the presence of streams dictated where the MD and Control treatments could be located. On most sites, the assignment of these two treatments to two units with streams was done randomly, and the assignment of the HD and VD treatments to the two other units was done randomly. However, on some sites, other operational factors also constrained treatment assignment, for example, road construction costs and effects. The Site History appendix (Appendix E) gives the details of treatment assignment for each site. Nonrandom treatment assignment may or may not have biased some of our results and therefore limits our ability to apply and interpret inferential statistics. These limitations are discussed in the Scope of Inference section for each component study.

# Study Sites

## Site Selection Process

Study sites were initially intended to be broadly representative of forest lands managed by the BLM in western Oregon and to include sites in the Cascade, Coast, and Klamath provinces. A decision was made to focus first in the Cascade province because it was believed that implementation would be less complex than in other provinces. Site selection began in 1993 and was completed in 1995. Eventually, BLM silviculturists and Dr. Tappeiner realized that the study design was not feasible for the Klamath province, and a decision was made to drop further consideration of the Klamath province in 1996. The high heterogeneity of forest stands in southern Oregon and site conditions that were significantly different from other study sites in the Cascade and Coast provinces led to this decision. This decision resulted in twelve study sites broadly representative of mesic, low-elevation forests in the Cascade and Coast provinces of western Oregon (table 2).

Each west-side BLM district was provided site selection criteria for the Initial Thinning Study and asked to screen their upcoming thinning sales for potential study sites. Although there were minor changes over time, the criteria attached to the March 29, 1994 BLM State Office directive (Appendix B) were widely used for site selection. These criteria included:

1. Preference for sites that are in the General Forest and Connectivity land use allocations in the BLM resource management plans
2. Stands should be between 30-50 years old
3. Sites should be at least 200 acres in size and capable of subdivision into four 50 or more acre units
4. Stand conditions should be relatively homogeneous
5. Avoid Tier One Key Watersheds and watersheds where watershed analysis has not been completed
6. Presence of streams is a positive factor since streams are necessary to implement the Riparian Buffer Study
7. Avoid stands that have experienced or are likely to experience significant wind damage
8. Avoid stands with extensive root disease

Criteria used for the Rethinning Study were similar, but tailored to the Rethinning Study design. Sites were selected from the pool of study sites used in a prior retrospective young stand biodiversity study conducted on BLM-managed lands (Baily 96, Bailey and Tappeiner 1998). These criteria included:

1. Prefer sites that are in the General Forest and Connec-

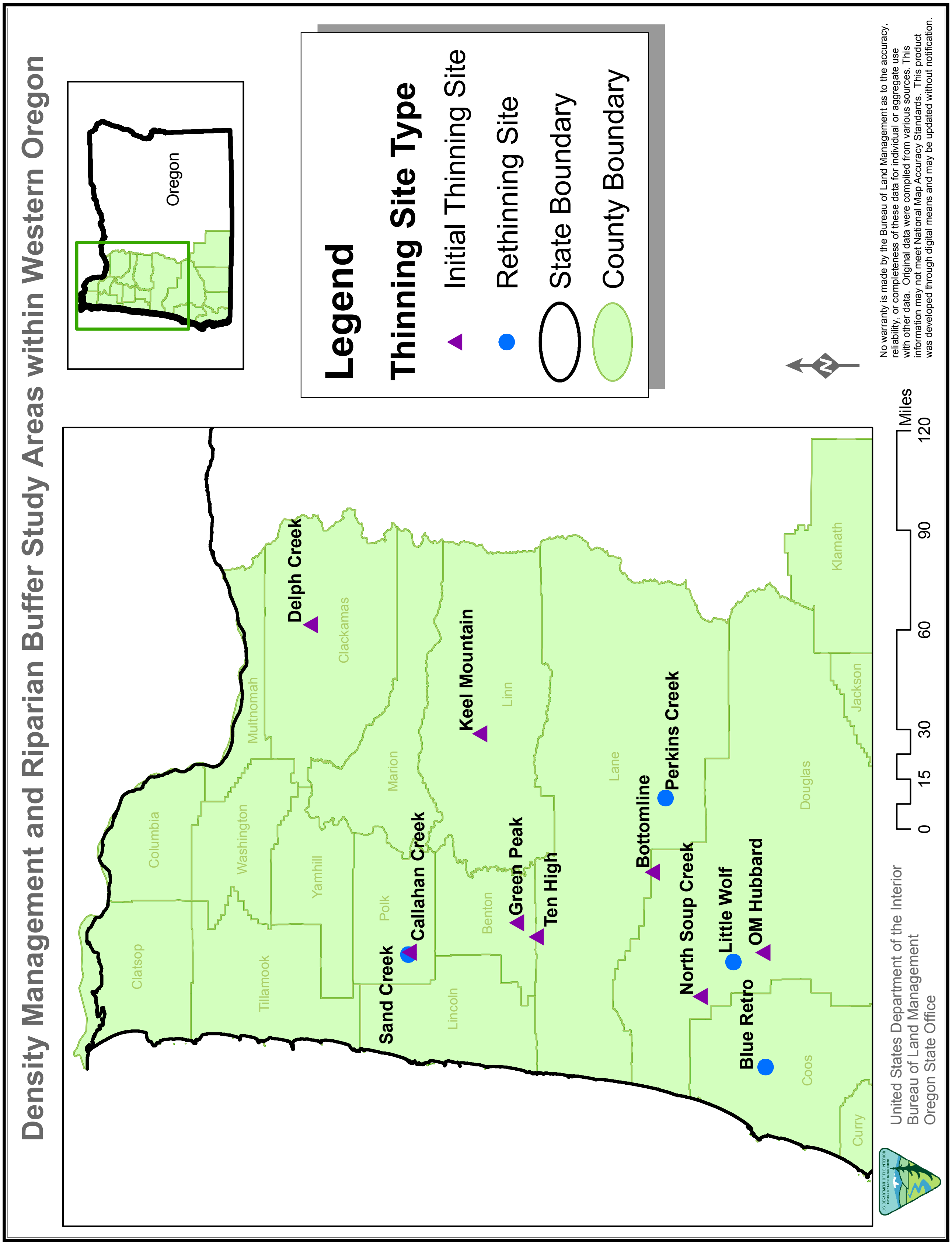


Figure 4. Study sites

tivity land allocations in the BLM resource management plans

2. Stands should be between 50-80 years old and previously commercially thinned

3. Sites should be at least 40 acres in size and capable of subdivision into two, 20 or more acre units

4. Stand conditions should be relatively homogeneous

5. Avoid Tier One Key Watersheds and watersheds where watershed analysis has not been completed

6. Avoid stands that have experienced or are likely to experience significant wind damage

7. Avoid stands with extensive root disease

8. Stands should show evidence of understory development following the first commercial thinning.

Resource specialists evaluated sites based on the criteria above, ranked sites considering all criteria, and selected study sites in consultation with Dr. John Tappeiner (study PI), Charley Thompson (study coordinator), and local decision-makers. Selected sites met these criteria, although the initial thinning study sites are somewhat older (50-80 years) than originally sought.

## Study Locations

Seven sites host a full set of the DMS Initial Thinning Study Treatments (three in the BLM Salem District, two in the BLM Eugene District, and one each in the BLM Roseburg and BLM Coos Bay Districts; Fig. 4 on page 14). An eighth site, Callahan Creek on the BLM Salem District, contains a partial implementation of the Initial Thinning Study Treatments sufficient to support the Riparian Buffer Study design. In addition, three similar sites in the Siuslaw National Forest contain thinned stands with alternative riparian buffers. Although these sites are not considered part of the DMS, they expand the scope of the Riparian Buffer Study in the Coast Range. Rethinning treatments are located on four sites (one each in Eugene, Roseburg, Salem, and Coos Bay Districts; Fig. 4). Site location and summary information is contained in Fig. 4 and table 2; detailed site histories are in Appendix E.

# Component Studies

## Vegetation Response - Klaus Puettmann and Shanti Berryman (OSU)

### Introduction

The foundation underlying the DMS lies in findings that old-growth forests may have developed differently than current young managed stands (Tappeiner et al. 1997; Bailey and Tappeiner 1998; Poage and Tappeiner 2001). Many old-growth stands apparently initiated at relatively low densities, as evident by rapid diameter rates of growth over the first 100 years (Poage and Tappeiner 2001; Tappeiner et al. 1997; but see Winter et al. 2002). In contrast, trees in current young managed stands tend to grow more slowly at high densities.

The effects of thinning on various ecosystem responses have been the subjects of multiple studies, most of them focused on timber productivity. Residual overstory trees respond to thinning by increasing crown, branch and diameter growth (Marshall and Curtis 2002). It is important to note that different stand components, such as dominant versus understory trees, may respond differently to thinning operations (Miller and Williamson 1974; Oliver and Murray 1983). However, over time, overstory trees may “close in” and increasing competition slows the growth of residual trees.

Opening the canopy increases light availability in the understory (Parker et al. 2001) and, especially on drier sites, may increase soil moisture (Everett and Sharrow 1985). These altered conditions, if they persist through time, may allow establishment of a multi-layered canopy by encouraging crown extension and development of advanced tree regeneration (Bailey et al. 1998), and may encourage more abundant and diverse understory vegetation layers (Alaback and Herman 1988; Carey and Johnson 1995; Gilliam et al. 1995; Klinka et al. 1996; Qian et al. 1997; Bailey et al. 1998; Thomas et al. 1999; Thysell and Carey 2000; Parker et al. 2001; Thysell and Carey 2001; Muir et al. 2002; Lindh and Muir 2004). Well-developed and diverse understory layers offer more suitable habitat for several species commonly found in late-successional forests (McComb et al. 1993; Carey and Johnson 1995; Hayes et al. 1997; Franklin et al. 2002).

The structure and composition of understory layers is important as the disturbances related to thinning may facilitate invasion by exotic species (Bailey et al. 1998; Mack et al. 2000; Thysell and Carey 2000; Beggs 2005), and may lead to dominance of certain clonal shrub species (Tappeiner and Zasada 1993; Messier and Mitchell 1994; Huffman and Tappeiner 1997; Thomas et al. 1999; He and Barclay 2000). Reduction of clonal species dominance after thinning may be achieved by considering both absolute density and vertical and horizontal structure of the overstory as it may impact understory composition (Berger and Puettmann 2000; Franklin et al. 2002; Franklin and Van Pelt 2004).

It is important to distinguish among studies that investigate ecosystem response to thinning intended to enhance timber production (for example, Bailey et al. 1998; Thomas et al. 1999; Thysell and Carey 2000) from studies that use thinning to accelerate late-successional habitat. Residual thinning densities in timber production thinning studies are aimed at ensuring that the overstory tree layers are fully occupying the sites. These densities are usually too high to allow development of a diverse, well-developed understory. These thinnings usually favor crop trees (for example, Douglas-fir on most low elevation sites in western Oregon). Thinning aimed at increasing species diversity in the over- and understory would instead discriminate against the major crop species and would ensure the maintenance or increased presence of minor species, especially hardwoods (as in the DMS treatments). Thinning for timber production typically does not consider impacts on advanced regeneration which can be damaged by the harvesting operation, or indirectly through thinning shock and/or higher mortality upon partial canopy removal (Tucker and Emmingham 1977; Tucker et al. 1987).

Timber production thinning prescriptions usually call for homogenous densities of residual trees, ignoring the importance of variation on small spatial scales (Franklin and Van Pelt 2004). The inclusion of treatments that address small-scale variation may enhance overall structural and habitat diversity. For example, small gaps may provide open conditions, including high resource levels and altered microclimate conditions (Moore and Vankat 1986; Gray et al. 2002). This, in combination with the physical harvesting disturbance, may lead to recruitment and growth of early-seral herbs and shrubs in small gaps (Beggs 2005). These conditions are very different from the surrounding stands with lower light availability, which favor species that can tolerate shade (Tappeiner and Alaback 1989; Huffman and Tappeiner 1997; Beggs 2005). Alternatively, the inclusion of leave islands as part of management prescriptions will provide areas without soil disturbance or other harvesting disturbance, which allows species sensitive to these disturbances to persist (Beggs 2005, Wessell 2005). Leave islands also ensure the maintenance of dense conditions, thus ensuring variability of environmental and resource conditions within a stand (Franklin and Van Pelt 2004).

The DMS is unique as it includes treatments specifically aimed at increasing within-stand diversity of overstory conditions. The design allows for comparisons of overall stand responses and allows evaluation of the contribution of different stand components (such as stand matrix, gaps and leave islands) to the overall stand response. Thus, the DMS contributes to a basic understanding of ecosystem development and provides information that can be used directly by forest managers.

## Objectives

A primary objective of the DMS is to evaluate if alternative thinning treatments accelerate development of late-successional stand characteristics and vegetation communities (for example, large trees, late-seral understory species) in young Douglas-fir forests of the Cascade foothills and Coast Range in western Oregon. This objective is being met through two related sets of permanent plots. The first set, termed “Treatment Monitoring Plots,” is intended to document vegetation dynamics and average conditions across the entire treatment for the Initial Thinning Study Sites. They encompass the patch cuts and leave islands as well as the thinned areas, and will help determine the relative influence of each on the overall vegetation response to the treatments. A second set of plots, termed “Thinning Monitoring Plots,” is intended to evaluate overstory response and overstory/understory relations at the prescribed thinning densities. Plots are located only in areas where target thinning densities were achieved without influence from patch cuts and leave islands. In addition, plots were located to evaluate whether responses to thinning varied by location within a Riparian Reserve compared to areas outside of Riparian Reserves.

**Table 3.** Number of thinning plots (0.25-acre) at each site for the initial thinning and rethinning studies, separated by uplands and Riparian Reserves.

| Site | Uplands | Riparian-Reserves | Total |
|---|---|---|---|
| **Initial thinning sites** | | | |
| Bottomline | 29 | 17 | 46 |
| OM Hubbard | 28 | 23 | 51 |
| Keel Mountain | 20 | 28 | 48 |
| North Soup | 22 | 30 | 52 |
| Green Peak | 27 | 20 | 47 |
| Ten High | 24 | 29 | 53 |
| Delph Creek | 34 | 17 | 51 |
| Total | 184 | 164 | 348 |
| **Rethinning sites** | | | |
| Sand Creek | 10 | 8 | 18 |
| Little Wolf | 15 | 8 | 23 |
| Blue Retro | 13 | 5 | 18 |
| Perkins Creek | 12 | 12 | 24 |
| Total | 50 | 33 | 83 |

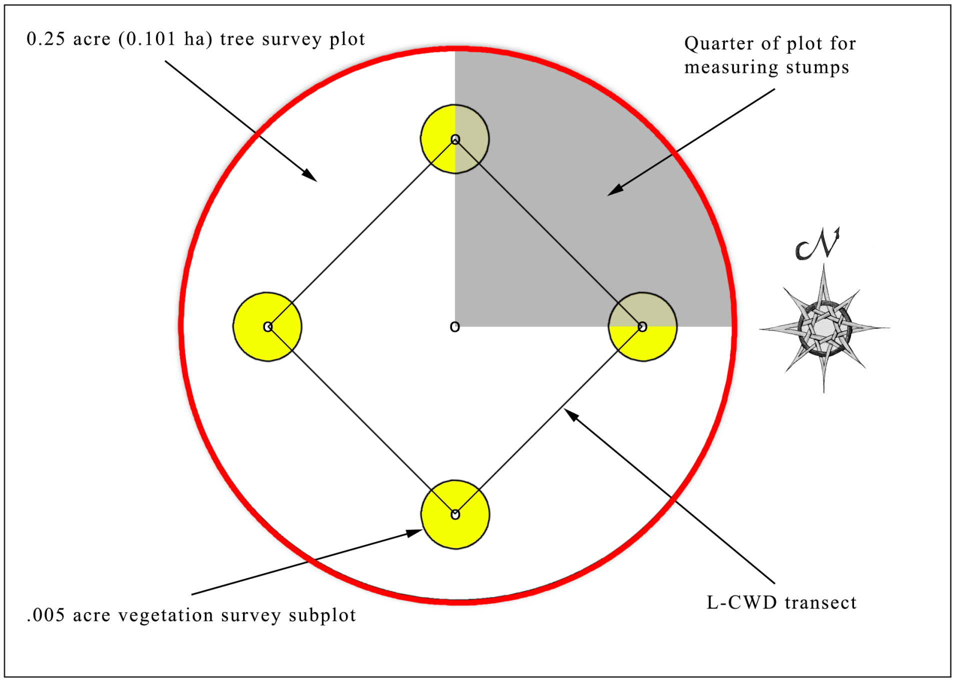


Figure 5. Sampling schematic for the treatment plot vegetation survey showing the 0.25-acre plot (red line circle) and the 0.005-acre nested subplots (yellow circles). Large coarse woody debris (LCWD) transects are shown connecting the subplot centers and the NE quarter section (gray) for stump measurements is also delineated. Diagram from Harmon & Sexton (1996).

## Methods

### Study Sites

Vegetation plots are established on seven of the initial thinning sites (all except Callahan Creek) and all four rethinning sites. Two initial thinning sites (Keel Mountain and Delph Creek), and one rethinning site (Perkins Creek) are in the foothills of the Cascades, while all other sites are in the Oregon Coast Range.

### Sampling Design

Vegetation response to the treatments is characterized by repeated sampling. The sites are treated as replicates (or blocks) in the study. The sampling design varies for the two sets of monitoring plots. These two plot networks were initiated at different times and have different research objectives. Consequently, the sampling protocols vary (see details in Sampling Methods and Sampling Protocol; http://ocid.nacse.org/nbii/density/).

#### Treatment Plots

The treatment monitoring plots were installed six years post-harvest at initial thinning sites to represent the entire treatment area. At each site, locations of these plots were randomly selected within the four initial thinning treatments (control, HD, MD, VD). Twenty-one new plots were installed and sampled within each of the high density, moderate density, and variable density treatments. Fourteen new plots were installed and sampled within the control treatment. This resulted in 77 treatment plots sampled at seven initial thinning sites.

Random location of plots was performed using GIS site maps. Treatment boundaries were buffered so that plot boundaries are at least 50 ft from treatment boundaries. Plots were not accepted if they overlapped. In this case, new random points were generated until there was no overlap in plot locations. Plots were excluded from all riparian buffers, except the streamside retention buffer, and from active roads. Plots that landed on active roads or skid trails were shifted so they were not in the middle of the road, but next to the road. Plots that fell on inactive roads were included in the study.

Treatment plots were 0.25-acre circular plots (58.9 ft radius; Fig. 5). Plot center was located using GPS and/or pacing along an azimuth from known points using maps and aerial photos for reference. Plot center was marked with 4.5 ft PVC pipe and flagging. The PVC pipe was labeled with the following: treatment, plot number and “center.” Four subplots were installed at 30 ft from plot center in each cardinal direction (north, south, east and west). Subplots were 0.005-acre circular plots (8.32 ft radius; Fig. 5) and sub-plot centers were marked with 2.5 ft PVC pipe and flagging. The PVC pipe was labeled with plot number, treatment and the cardinal direction. All distances for plot layout and measurements were slope-corrected (that is, horizontal distance).

## Thinning Plots

Thinning plots were installed at initial and rethinning sites following harvest (1-3 years post-harvest; table 3). Quarter-acre circular vegetation plots (58.9 ft radius) were established in each of the treatments. At each plot, a live overstory tree was selected as the plot center with the pith of the tree representing the exact center point. Within each 0.25-acre plot, four circular sub-plots (0.005-acre) were established 50 ft from the plot center at the four cardinal directions (north, south, east and west). Subplot centers were permanently marked with plastic stakes. Five circular subplots were installed at the Bottomline site (plot center, north, south, east and west). The center subplot was not measured at the other sites and, therefore, data for the Bottomline center subplots were dropped for data consistency. All plot layout distances were slope-corrected.

Quarter-acre vegetation plots were established in both uplands and in Riparian Reserves. Riparian Reserves are a land allocation under the Northwest Forest Plan and are delineated at a fixed distance from stream center (one or two site-potential tree heights). Riparian Reserves were not always present in each treatment. The number of vegetation plots varied by treatment and by site (table 3). Plot location differed for the initial thinning and rethinning sites.

### Initial Thinning Sites

Thinning plots were established in the thinned portions of the high density, moderate density, and variable density treatments (three target densities), and in the unthinned control. Plots in the initial thinning sites were located only where tree density was ± 20 percent of the treatment prescription (except at Bottomline, the first site sampled). Monitoring plots were not established in gaps or leave islands. Plot locations were mapped to fit on paper and were then located in the field. Plot centers were adjusted until the target density criterion was met. Only trees greater than 7 inches diameter at breast height (dbh) were considered when estimating the target densities. In addition, plots were located within the treatments to maximize spatial dispersion over the treatment area.

Plots were established in Riparian Reserve areas that were thinned and in unthinned areas. Riparian Reserve widths were usually one site-potential tree height (Riparian Reserves, as defined by the Northwest Forest Plan; USDA & USDI 1994). Plots established in unthinned Riparian Reserves were in the control treatments and in the unthinned riparian buffers in other treatments. Plots never straddled the Riparian Reserve boundary. This plot selection procedure was not in place when the Bottomline plots were installed.

### Rethinning Sites

Plots in the rethinning sites were established on a systematic grid in upland and riparian areas in the unthinned control and rethinning treatments. Grid spacing varied by site and was intended to achieve between 20-25 plots per site, if feasible. Riparian plots were located within Riparian Reserves, and did not straddle the Riparian Reserve boundary.

## Response Variables and Measurements

Many variables are being measured and monitored over the long-term at these plots (table 4), including plot characteristics, overstory and understory vegetation structure and composition, volume of coarse woody debris, and substrate conditions. Variables collected at each plot differ slightly for the two studies. For specific differences see the Sampling Methods and Sampling Protocol (http://ocid.nacse.org/nbii/density/).

## Treatment Plots

### Overstory Stand Structure

All live trees and snags with dbh >2.0 in within the 0.25-acre plot were included in the tree survey. Snags were standing dead trees >4.5 ft tall. Trees were considered “in” the plot boundary if the center of the tree bole at breast height was within the 58.9 ft-radius plot. Each tree was tagged at breast height (metal tag facing plot center) with a number unique to the plot. All live and dead tree species were identified. Horizontal distance and azimuth from plot center to each tree bole were recorded. Measurements for each tree followed those in table 4. Live crown ratio, crown class and tree damages and condition were only recorded for live trees. Decay condition and wildlife usage were only recorded for snags.

### Understory Vegetation

Understory vegetation (<20 ft tall), seedlings, and saplings were sampled in the 0.005-acre subplots (see table 4 for measurements). Estimates of absolute cover for individual plant species and life-form groups were made in the 0.005-acre subplots using cover classes: 1 percent = trace, 5 percent, 10 percent, then continuing in 10 percent increments to 100 percent. Species identifications were made following Pojar & Mackinnon (1994) and Hitchcock & Cronquist (1973).

### Coarse Woody Debris

Large coarse woody debris was measured along four directional transects, connecting the centers of the 0.005-acre subplots (Fig. 5). Transects were northeast, southeast, southwest, and northwest. Logs positioned parallel to transects were ignored. Small coarse woody debris was measured within the 0.005-acre subplots. All measured logs were >1 ft in length and were identified to species if possible (see table 4 for measurements). Logs at >45 degree angles above the ground were not considered down woody debris (pers. com. M. Harmon).

### Stumps

All stumps in the northeast quarter section of the 0.25-acre plot (or straddling the boundaries) were measured (Fig.

**Table 4.** Response variables and descriptions for the vegetation monitoring plots. Specific sampling details and codes (for example, decay condition codes) can be found online in the detailed Sampling Methods and Sampling Protocol (http://ocid.nacse.org/nbii/density/).

| Variable | Description |
|---|---|
| **Physiography** | |
| Slope | % slope |
| Aspect | degrees east of north, using a compass |
| Elevation | taken from GPS units or digital elevation model |
| Topographic position | plot position in context of local relief (for example, ridge-top, slope, bench, toe, and floodplain) |
| **Overstory (trees >2 in dbh)** | |
| Number of trees | number of trees per unit area, stratified by conifers and hardwoods and by individual species |
| Basal area | stand basal area per unit area of trees, stratified by conifers, hardwoods, live and dead trees and by crown class |
| Diameter at breast height (dbh) | diameter at breast height (4.5 ft above ground on uphill side) for all trees 2 in dbh on the plot |
| Tree health | healthy tree (yes or no)? Healthy = normally developed tree. Unhealthy = sickly or diseased tree (for example, bark or needles are sickly or not developed correctly); a damage code is recorded to indicate the cause of an unhealthy tree. A tree can be healthy if damages exist. |
| Height | total height for a sub-sample of conifer and hardwood trees |
| Live crown ratio | the ratio of live crown to the total tree height; based on height to live crown measurements: the point where the crown covers 2/3 of the tree bole |
| Crown class | position of tree in the canopy |
| Tree damages and condition | healthy or damaged: forked crown, broken crown, logging damage, fire scars, leaning tree, etc. |
| Decay condition | characterized decay condition of snags |
| Wildlife usage | characterized wildlife usage of snags based on size of excavations if present |
| **Understory** | |
| Density of seedlings and saplings | number of conifer and hardwood seedlings and saplings per unit area, measured in 0.005-acre subplots; seedlings = stem height between 6.0 in and 4.5 ft; saplings = stem height 4.5 ft in height and diameter <2.0 in; seedlings and saplings were recorded by species and included planted and natural regeneration |
| Cover of individual plant species | absolute % cover of each plant species in the 0.005-acre subplots; cover did not exceed 100% for a given species |
| Cover of life form groups: shrubs, forbs, ferns, grasses (including sedges/rushes), hardwood and conifer trees | absolute percent cover of each group in the 0.005-acre subplots; cover did not exceed 100% for a given group |
| Frequency of early seral, late seral and persistent forest understory species | derived from individual plant species data |

**Table 4.** Response variables and descriptions for the vegetation monitoring plots. Specific sampling details and codes (for example, decay condition codes) can be found online in the detailed Sampling Methods and Sampling Protocol—Continued

| Variable | Description |
|---|---|
| Cover of exotic species` | absolute percent cover of exotic species in the 0.005-acre subplots; averaged from individual plant species data |
| Height of individual plant species | average height of understory species |
| Understory vegetation composition | presence and abundance (% cover) of vascular plants per plot |
| Beta diversity | vascular plant species turnover between plots; calculated from individual plant species data |
| Alpha diversity | species richness of vascular plants by plot; calculated from individual plant species data |
| **Coarse Woody Debris (CWD) and Stumps** | |
| Decay condition | characterized decay condition of coarse woody debris and stumps |
| Number of stumps | stump tally |
| Volume of CWD | based on length and diameter estimates of large and small coarse woody debris. Small coarse woody debris logs were measured if the large end was >3 in and <10 in. in diameter and was within the subplot perimeter. Large coarse woody debris logs were >10 in. in diameter. |
| **Substrate** | |
| Cover of stumps, boles, litter, logs, duff, bare soil, rocks, moss | absolute percent cover measured for substrate in 0.005-acre subplots (treatment plots only) |

5). Stumps were <4.5 ft tall (measured on the up-hill side) and >2 in diameter at the top end. Stumps were either new man-made stumps from harvest, remnant stumps from before harvest, or natural stumps from blow down. Stumps were identified to species if possible and measured for diameter and height.

### Substrate

Estimates of absolute cover for substrate groups were made using cover classes: 1 percent = trace, 5 percent, 10 percent, then continuing in 10 percent increments to 100 percent.

## Thinning Plots

### Overstory Stand Structure

All live trees with dbh >2.0 in within the 0.25-acre plot (58.9 ft radius) were included in the tree survey. All snags (standing dead trees >4.5 ft tall) and remnant stumps (old stumps from before the initial thin 10.0 in dbh and 1 ft tall) within the 0.25-acre plot were also included in the survey. Remnant stumps were not recorded at the Bottomline site, but the protocol was amended and crews began sampling remnant stumps at all other sites.

Trees were considered "in" the plot boundary if the center of the tree bole at breast height was within the 0.25-acre plot. Each tree was tagged at the base (metal tag facing plot center) with a unique number. All live and dead tree species were identified. Distance and azimuth from plot center to each tree bole were recorded. Measurements for each tree followed those in table 4. Live crown ratio, crown class and tree damages and condition were only recorded for live trees. Decay condition and wildlife usage were recorded only for snags.

One Douglas-fir tree per plot was selected arbitrarily (usually the largest tree on the plot, maximum dbh of 30 in) as the "site tree." In addition to measurements listed in table 4, height, live crown height, age at breast height (years), and growth increments at 5 and 10 years (1/20 in) were measured for the site tree. In many cases, the site tree was the plot center tree.

Swiss needle cast monitoring was implemented at the Keel Mountain and Sand Creek sites only, in which estimates were made for crown density, foliage transparency and crown dieback (following FHM protocol; see FIA Field Measurements for Phase 3 2003, "Crown Condition Classifications" at http://fia.fs.fed.us/library.htm#manuals). Estimates were made for the "height" trees at each plot. These measurements are in Excel spreadsheets, but are not included in the overall database because the data are not consistently collected.

Hardwood Clumps

Hardwood clumps were tagged at each plot (each clump received a clump tag number). The clump measurement procedure was changed after the Bottomline site was sampled. Thus, clump measurements at Bottomline are not consistent with other sites. A clump was defined as stems originating from a stump with a common root system and individual crowns were not discernable. The parent stump was not always evident; however, the clump generally had a circular arrangement around a central point. Clump species were identified, azimuth and distance to plot center was recorded and the following measurements were taken: mean stem height, mean clump width, number of stems <2 in. in the clump, and stem damages or condition. Individual stems in the clump >2.0 in dbh were individually tagged and measured as trees, described above.

The clump data were not consistently collected across sites and sometimes the method of collection varied within sites. Therefore, subsequent visits to the sites will not include remeasurements of clumps. However, the tagged trees >2 in. in the clumps are included in the overstory tree data and will be remeasured upon future visits. These trees >2 in. in the clump will receive a "CL" in the remarks section, indicating that it is a tree part of a hardwood clump. Clump data are stored in Excel spreadsheets but are not included in the DMS vegetation database.

Understory Vegetation

Understory vegetation, seedlings and saplings were sampled in the 0.005-acre subplots (see table 4 for measurements). Conifer seedlings and saplings were always tallied; however, hardwood seedlings and saplings were not consistently recorded at each site.

Estimates of absolute cover for individual plant species (no height limit) and life form groups were made in the 0.005-acre plots. Plant identifications for all plots followed Hitchcock & Cronquist (1973), Pojar & Mackinnon (1994) and the Jepson Manual (Hickman 1993). *Cornus nuttallii, Prunus emarginata, Rhamnus purshiana*, *Salix* spp., *Lithocarpus* spp. and *Malus fusca* were originally considered hardwood trees in 1997 measurements (Bottomline, OM Hubbard, Keel Mountain and Sand Creek sites). These species were later considered understory shrubs in subsequent site measurements and consequently, were edited out of the overstory data sets for Bottomline, OM Hubbard, Keel Mountain and Sand Creek for consistency with the revised sample method.

Presence of vascular plant species associated with late-successional/old-growth forests (USDA and USDI 1993) was recorded for the 0.25-acre plot. The species monitoring was included in the study to specifically evaluate the effects of this treatment on late-successional species.

Coarse Woody Debris

All large coarse woody debris logs were measured in the 0.25-acre plot. Small coarse woody debris was measured within the 0.005-acre subplots. All logs >1 ft in length were measured and identified to species (see table 4).

Stumps

All newly cut stumps (from the harvest) in the 0.25-acre plot were tallied in 2 in diameter classes. Stumps were <1 ft tall (no minimum diameter cut-off). At rethinning sites, both stumps from the initial thinning and rethinning (that is, new and old stumps) were counted. Stumps were identified to species if possible. Stumps were considered "in" the 0.25-acre plot if the center of the stump was within the plot boundary.

## Measurement Schedule

Remeasurements of both plot types are scheduled in five-year increments (see measurement schedule, tables 13 and 14, page 47). Coarse woody debris and stumps are being remeasured every 10 years because they change slowly in the forest. Evaluation of the current data and future follow-up treatments may result in some modifications in the future remeasurement schedule at the thinning plots.

## Data Management

Data are either entered directly into a computerized format using electronic polycorders or palm pilots in the field, or recorded on paper data sheets. Electronic polycorder data collectors use error-checking routines built into the data collection system to catch invalid or missing data while the crews are still on the plot. Data entered on data sheets are proofed in the field and later entered into a spreadsheet and crosschecked for data entry errors. All data sets are quality checked for errors by conducting summary statistical analysis and by graphing the results (following standard data-cleanup procedures). Erroneous data are field verified and corrected, or deleted from the data set (that is, only deleted when data are time-sensitive and clearly incorrect). Clean data will then be imported into the DMS vegetation database.

All clean data are in Microsoft Excel spreadsheets and in an Access database that is still undergoing development. Excel spreadsheets of the raw data are retained. All data are currently stored on the Oregon State University server, which is backed up off site every night. The vegetation data ultimately will be stored in the Oregon State University Forest Science Data Bank.

A data management protocol has been developed to maintain consistency and quality control for data collected and entered into the database each year. A metadata specialist with the National Biological Information Infrastructure (NBII; http://www.nbii.gov) has developed the project metadata following NBII standards. Metadata will be updated on a yearly basis. In addition, The Northwest Alliance for Computational Science and Engineering, a partner with NBII, is assisting with the development of the DMS vegetation database. Datasets from the DMS Vegetation Study will be available through the DMS website (http://ocid.nacse.org/nbii/density/).

## Analysis

Data analyses will assess initial vegetation response to the thinning treatments within the first years following harvest (thinning plot data: one to three years; treatment plot data: six years). Subsequent analyses will evaluate changes in vegetation response over time (using repeated measurements taken at five-year increments). The analysis approaches will follow a randomized block design, where treatments were replicated across sites (that is, blocks = sites; seven blocks in the Initial Thinning Study; four blocks in the Rethinning Study). Treatment averages will be calculated to evaluate differences in overstory and understory vegetation dynamics and conditions in the thinning treatments (that is, the treatment plots including gaps and leave islands) and in homogenous thinning conditions (that is, the thinning plots, only where target densities were achieved).

Analyses will evaluate effects of the treatments on various aspects of overstory and understory vegetation structure and composition. Pre-harvest data are not available for these sites; therefore, all thinning treatments will be compared to the unthinned controls to evaluate treatment effects. Analysis of variance (ANOVA) and multiple comparison tests (that is, predetermined contrasts: thinned versus unthinned; and contrasts comparing thinned treatments) will be used to assess differences in vegetation responses among treatments. Sites are random effects and treatments are fixed effects in the ANOVA analyses. When evaluating thinning effects on vegetation dynamics over time, initial overstory conditions (from the first measurement date) will be used as covariates in the ANOVA models. All ANOVA statistical procedures will be performed using SAS software (SAS Institute Inc. 2001).

### Overstory

All evaluations of treatment effects for overstory vegetation will be made using ANOVA. Overstory tree growth (average tree growth and growth per hectare) will be compared among thinning treatments (for selected species where degrees of freedom >20). Differences in growth of dominant trees (for example, 10 or 20 largest trees/ha) will also be compared among treatments to determine if the DMS thinning treatments are accelerating large tree development. Crown development of overstory trees will be compared among treatments using average crown ratio or percent live crown of selected species where degrees of freedom >20.

### Understory

Treatment averages will be calculated for understory vegetation cover, variability (coefficient of variation for mean cover) and frequency for life-form groups, seral groups and exotic species. ANOVA and multiple comparison tests (described above) will be used to determine differences in understory vegetation cover among the thinning treatments.

Patterns of community composition within and among sites will be evaluated using non-metric multidimensional scaling (NMS; Kruskal 1964; Mather 1976) ordination and will be related to stand and site characteristics (for example, physiography, overstory structural characteristics, initial site condition factors, seedling and sapling density, and harvest disturbance factors) and treatments (thinning treatments and sub-treatments, patch cuts and leave islands). Multiple response parametric procedure (MRPP; Berry et al. 1983; Mielke 1984) and indicator species analysis (ISA; Dufrêne and Legendre 1997) will be used to determine potential differences in understory communities among treatments and to identify indicator species driving these differences. Evaluation will be made on how sub-treatments (patch cuts and leave islands) contribute to overall treatment variation in understory vegetation communities using NMS ordination, MRPP and ISA analyses. Frequency distributions of species in the gaps, leave islands and forest matrix areas will also be evaluated. NMS ordination, MRPP and ISA analyses will be performed using PCORD software (McCune and Mefford 1999).

Plant communities will be analyzed in the riparian and upslope locations with the thinning plots to help assess the impact of less intensive sampling schemes for the thinning plots (that is, possibly reducing sample size for 0.25-acre thinning plots or dropping some Riparian Reserve plots).

Summaries of coarse woody debris (large and small) will be made at the treatment level for all sites and will be monitored through time. We will determine if the amount and characteristics of the coarse woody debris meet the late-successional objectives of the DMS.

## Application of Results

### Scope of Inference

The inference scope of any experiment is defined as the range of conditions to which the study results are applicable. Consequently, applicability of study results will vary with the study component and with the degree of confidence required for managers to derive or justify their decisions. The range of study locations and stand conditions defines the inference scope of the DMS. While study sites were not selected randomly, they are representative of a large portion of BLM lands in western Oregon. The site locations range from just south of Mt. Hood to north of Coos Bay, from the western slopes of the Cascades to the central Coast Range. No study sites were located in southwestern Oregon (Medford district of the BLM). The sites cover a range of ecological conditions as they represent a wide gradient in latitude, elevation, soil and climate conditions. The experimental design does not include replications within a site; thus, sites have to be considered case studies for their specific conditions. However, replications across sites allow statistical analysis within the larger inference scope (defined by the range of site conditions, see site history tables, Appendix E).

A second dimension of inference scope includes the stand conditions represented on the study sites. Sites were selected to be homogenous, fully stocked with conifers (mainly Douglas-fir), within a narrow age range (50-90 years), and without major disease issues. All of these constraints define the stand conditions to which the results may be applicable. The minimum size criterion (that is, ~200 acres) for selection of the study sites has to be considered an artifact of the experiment. The minimum treatment area of approximately 25+ acres (target area was 50 acres for the DMS initial thinning treatments) is sufficient to characterize "within-stand conditions" and stand-level results can be scaled up to larger areas. On the other hand, small-scale results, (for example, information about gap partitioning) may apply at a sub-stand scale.

Further analysis will provide more information about the proper inference scope of these findings. For example, trends that are consistent across all initial and rethinning sites are likely so robust that the inference scope of the results includes the full range of conditions covered by the study. With lack of alternative information sources, managers may even feel comfortable applying these results beyond the conditions represented in the study. Other results may show inconsistent responses across study sites. Analysis of these trends may indicate whether they vary along moisture, climate, soil, stand age or other conditions specific to the sites. This information will help managers decide whether their local conditions fall within the inference scope of the study.

The inference scope of specific responses, such as absolute growth of individual species, is very limited (in most cases) to the study sites. Other information (for example, whether the understory vegetation responds to reduction in overstory density) is more general and most managers may feel very comfortable expanding the inference scope beyond the specific study site conditions. Lastly, judgments as to whether extrapolation of our results to other conditions is acceptable will also benefit from consideration of other related studies, such as the Young Stand Thinning and Diversity Study (Willamette National Forest).

### Expected Outcomes

While numerous thinning studies in the PNW provide basic information about effects of density management on timber growth and yield, we lack an understanding of the effects of thinning practices on other ecosystem structures, processes and dynamics. This is especially crucial because, under the Northwest Forest Plan, the area with regeneration harvests has substantially declined on Federal lands, and thinning provides a significant portion of the harvested timber. Thus, we expect to develop information on how various components of late-successional habitat are influenced by alternative thinning practices. Standard thinning operations aimed at maximizing economic return will not accelerate or provide for aspects of late-successional habitat. As part of this study, we will also determine the impact of modifying "traditional" thinning practices. These modifications include variable density thinnings, harvesting gaps, and leaving reserve islands of various sizes. By separating the ecosystem responses to the various components, we will provide the information necessary for managers to assess what combination of management practices (that is, homogenous thinnings, gaps, leave islands, plantings) best fit their local conditions and management objectives.

We expect to provide basic information about the impact of thinning on growth and yield of residual trees. In addition, the residual trees will be stratified to match different late-successional characteristics, such as large-super-dominant trees and small trees that provide lower canopy layers. We will document how thinning effects canopy layering and crown sizes and development.

We will provide data to predict the impact of overstory manipulations on understory vegetation. Together with other studies, we hope to assess the relative impact of pre-treatment conditions, direct disturbance effects (for example, harvesting traffic), and altered environmental and resource conditions after the harvesting treatments. Hereby, we plan to describe both the abundance and the species composition of these structural components.

At the same time, we provide the basic vegetation response that can be used by other researchers to characterize the impact of density management on visual quality or habitat conditions. We hope to facilitate the development of a predictive model that integrates these aspects and simulates the response of various ecosystem components to alternative thinning treatments.

Already, the exposure of field managers to the DMS sites and information from the DMS and related studies has resulted in a shift in application of thinning treatments on Federal lands. Observations to date indicate that, in most cases, thinning to the prescribed initial densities will not cause high levels of stand damage due to storms or other events. This has already resulted in a shift toward lower densities in many federal thinning operations.

## Aquatic Habitats and Vertebrate Diversity - Deanna H. Olson

### Introduction

There is a critical need for greater understanding of aquatic-dependent faunal communities in Pacific Northwest forest ecosystems. First, many fishes and amphibians are strongly associated with habitat conditions occurring in older forests (for example, Thomas et al. 1993, FEMAT 1993; Amphibians: Blaustein et al. 1995, papers in Ruggiero et al. 1991 and Szaro et al. 1988; Fish: see Nehlsen et al. 1991, papers in Meehan 1991), which have diminished substantially over the last century.

Second, although their general habitat requirements are known (for example, stream habitat conditions, forest age class and stand moisture associations), there is little understanding with regard to much of their ecology, such as their associations with watershed-level characteristics, their responses to the variety of microhabitats occurring in forests and streams across a landscape, and their community organization. For example, although the general ties to water for many amphibians are known, there is little understanding of the effect of specific terrestrial moisture gradients or aquatic conditions on different amphibian species and life-history stages.

Third, expanded knowledge of forest amphibians, in particular, is needed because both aquatic and terrestrial forest amphibians potentially can represent significant ecological components of forests with regard to trophic networks and biomass: they can occupy a central position in food webs (for example, Pough et al. 1987), can be a dominant predator in some systems (for example, headwaters: Rundio and Olson 2001), and may comprise the majority of the biomass of vertebrate fauna in both terrestrial and aquatic habitats within forests (for example, Burton and Likens 1975, Pough et al. 1987, Bury and Corn 1991).

Lastly, the status of many fish and amphibian populations and species occurring in Pacific Northwest forests is of concern (for example, Marshall et al. 1992, Blaustein et al. 1995, Nehlsen et al. 1991, and Nickelson et al. 1992). In a quantitative vulnerability analysis of non-fish vertebrates associated with older forests, several forest amphibians were found to be among those with the highest risk of extinction, higher than more publicized species such as the northern spotted owl and the marbled murrelet (Lehmkuhl and Ruggiero 1991). A recent global amphibian assessment reported 57 percent of Pacific Northwest amphibians occurring in western forests were of concern (IUCN Red List category: Endangered, 1 sp.; Vulnerable 4 sp.; Near Threatened, 11 sp.; IUCN et al. 2004 and Stuart et al. 2004). Risk of extinction to fish is also pervasive; over 300 stocks of anadromous fishes are identified to be at risk within the range of the northern spotted owl in the Pacific Northwest (FEMAT 1993), and several populations are candidates for federal listing as Threatened and Endangered. Successful management of these species requires increased knowledge of their specific requirements, from microhabitat to landscape spatial scales, and with regard to levels of biological organization from the individual to the community.

Although the detrimental effects of clearcutting to various fauna are recognized and many species have clear associations with forest age and moisture regimes (for example, papers in Ruggiero et al. 1991, early papers in de Maynadier and Hunter 1995, Ash 1997, Rafael et al. 2002), the impacts of alternative forest practices on aquatic fauna are not well-studied. In retrospective studies, Bisson et al. (2002), Raphael et al (2002), and Stoddard and Hayes (2005) found that certain forest management activities, including past clearcutting without stream buffers, were associated with reduced stream-associated amphibian occupancy patterns. Pough et al. (1987) suggested that small-scale modification of forests may have little detrimental effect on terrestrial amphibians if microhabitats near the soil-litter interface are retained. Likewise, other studies (for example, Bury and Corn 1988) suggested that management retaining existing microhabitats and microclimate conditions on the forest floor can benefit amphibians. Conversely, forest disturbances altering interior microclimate conditions may have cascading effects on amphibian life-history functions such as foraging and reproduction (Welsh and Droege 2001). Forest thinning practices can have a reduced effect on hydrologic processes in comparison to clearcutting and may likewise have a reduced impact on aquatic vertebrate assemblages, especially if additional mitigation measures to preserve microhabitats and microclimates such as retention of downed wood or streamside trees are also imposed. Thinning prescriptions have been recommended to accelerate late-successional characteristics of managed forest stands, yet the predicted positive response of various “old-growth associates” including aquatic-riparian dependent vertebrates to such density management remains to be studied. Stream buffers have been established to protect stream function and habitats and as mitigation for amphibians and fish (for example, Welsh 1990, Bury 1988, FEMAT 1993, USDA and USDI 1994). The role of buffer zones in the maintenance of forest characteristics and its potential tempering influence on riparian microclimate have been recognized (see discussion in FEMAT 1993) and could benefit riparian and aquatic-riparian dependent organisms in any part of the drainage. However, the influences of buffer widths on aquatic fauna are unstudied.

In forested ecosystems, headwater areas and associated fauna are of particular concern to both land managers and scientists. Historically, these areas have had minimal protection from management activities such as timber harvest, yet they may be pivotal for maintenance of the ecological function and integrity of a watershed (for example, Beschta et al. 1987, Bisson et al. 1987, Naiman et al. 1992) and for the life-history of several aquatic-dependent vertebrates (for example, amphibians: Blaustein et al. 1995, Sheridan and Olson 2003). However, basic knowledge is lacking of the ecology of most of these species, their reliance on headwater areas, and, in particular, their use of streams and streamside refuges within headwaters. Their responses to streamside buffer zones with upslope thinning are unknown; however, buffers are assumed to offer protection to a variety of taxa (for example, Olson et al. 2002).

## Objectives

1) Characterize stream habitats and aquatic-dependent vertebrate diversity patterns in headwater stream networks.

2) Examine effects on headwater aquatic vertebrate assemblages and their habitats of different riparian buffer widths within young forests subject to upslope timber thinning treatments.

3) Examine findings of Objectives 1 and 2, above, in light of Chan and Anderson’s study of streamside-to-upslope vegetation, microhabitat, and microclimate regimes (this volume).

4) Develop inventory and monitoring methods for headwater habitats and assemblages.

**Table 5.** Stream reaches per riparian buffer treatment type.

| Stand age (yrs) | Site | Stream Reaches (N) | | | | |
|---|---|---|---|---|---|---|
| | | Streamside Retention | Variable Width | One Tree Height | Two Tree Heights | Control |
| 30-50 | Bottom Line | | 2 | | | 2 |
| | Delph Creek | 1 | 1 | | | 1 |
| | Green Peak | 1 | 1 | 1 | | 2 |
| | Keel Mountain | 2 | 1 | 1 | 1 | 3 |
| | OM Hubbard | 1 | 2 | 0 | | 2 |
| | North Soup | 1 | 1 | 1 | | 2 |
| | Ten High | 2 | 3 | 1 | | 2 |
| | Cougar (USFS) | 1 | 1 | 1 | 1 | 2 |
| | Grant (USFS) | 2 | 1 | | | 3 |
| | Schooner (USFS) | 1 | 4 | | | 1 |
| 70-80 | Callahan Creek | 3 | 2 | 1 | 1 | 1* |
| | Perkins Creek | 2 | 2 | | | 2/2* |

* Indicates never-thinned reaches of older stands.

## Methods

### Study Sites

One upslope thinning treatment was used for the Riparian Buffer Study Component addressing aquatic habitats and vertebrates: the moderate density treatment (80 TPA). This treatment was chosen because in comparison to the variable upslope treatment it reflected a more homogeneously applied upslope condition, and in comparison to the high retention treatment, it was a more severe harvest. Both young (30-50 years) and older (70-80 years) stands were included in the study. To be selected as a site, headwater (1st and 2nd order) stream reaches needed to occur in this treatment, and comparable headwater stream reaches needed to occur in the untreated control area. Headwater characterization was a study objective; stream reaches selected for study were not fully assessed by habitat type beforehand. In addition, reaches needed to be at least 2.5 times the height of a site-potential tree to be eligible for this study. Some sites had >1 replicate buffer treatment due to the occurrence of multiple stream reaches for inclusion in the study (table 5). An example of the layout of one study site, Green Peak (Fig. 2), shows that stream buffer replication at a site was driven by the geometry of stream reaches occurring within the site boundaries. At this site, three stream reaches occurred in the moderate upslope thinning area. Three stream buffer widths were applied to these reaches. Comparable headwater stream reaches occurred in the untreated control area.

This study component was implemented on 12 study sites. Most study sites were part of the BLM Density Management Study, however, three sites on USDA Forest Service lands also were implemented (table 5). The upslope pre-treatment forest conditions and post-treatment thinning density were similar on Forest Service lands, however, the leave islands and small patch cuts were not installed.

### Sampling Design

Habitat conditions and the aquatic-riparian vertebrate fauna were examined in and along all stream reaches (table 5). At two sites, Green Peak and Keel Mountain, the basic study of instream-riparian fauna was augmented by conducting surveys for amphibians and mollusks latitudinally to streams into the upslope forest.

Stream habitat was inventoried along the entire reach, starting at the downstream end. In wetted stream channels that were walkable, an adapted Hankin and Reeves (1988) habitat survey was conducted. Habitat units were typed as pool, riffle, or dry. Units having mixed types were identified as the dominant type and percent of the subdominant type was recorded. During habitat typing, units that were unsampleable for vertebrates (that is, inaccessible) were identified. Numerous habitat data elements were collected during stream surveys (table 6).

### Response Variables and Measurements

Instream habitat parameters included the stream size metrics, microhabitat types, and substrate and down wood characteristics (table 6). Field data were collected on a per unit basis, while subsequent reach-scale parameters were derived.

Per unit visual estimates were made of several habitat elements. These included stream gradient, average depth, dominant bank overstory tree species, dominant bank shrub species and dominant bank herb species. Substrate composition was visually estimated per unit as percentages of six categories (table 6). Measured habitat elements included unit length, width and maximum depth.

Downed wood was characterized per unit. Wood pieces were counted, measured (length and diameter), characterized

**Table 6.** Habitat variables collected along streams.

| Habitat Variable | Description |
|---|---|
| Estimated gradient | Estimated trend in gradient by categories |
| Measured length | Measured length of the unit |
| Measured width | Measured width of the unit at the bottom |
| Average depth | Estimated average depth of the unit |
| Maximum depth | Measured maximum depth of the unit |
| Overstory vegetation | Estimated dominant species of vegetation in the overstory layer |
| Shrub vegetation | Estimated dominant species of vegetation in the shrub layer |
| Herb vegetation | Estimated dominant species of vegetation in the herb layer |
| Other | Other features that influence the stream (tribs, seeps, slides, springs, slumps, etc.) |
| **Substrate** | |
| % substrate size 0 | Percent of substrate in the unit that is <3 mm diameter (sand, silt, clay, organic matter) |
| % substrate size 5 | Percent of substrate in the unit that is between 3-10 mm diameter (small gravel) |
| % substrate size 6 | Percent of substrate in the unit that is between 10-30 mm diameter (large gravel) |
| %substrate size 7 | Percent of substrate in the unit that is between 30-100 mm diameter (cobble) |
| % substrate size 8 | Percent of substrate in the unit that is between 100-300 mm diameter (boulder) |
| % substrate size 9 | Percent of substrate in the unit that is larger than 300 mm diameter (Bedrock) |
| By category the estimated dominant and subdominant substrate for the banks adjacent to the unit (within 2 m) | |
| **Wood** | |
| No. pieces | Number of pieces represented by this line of data |
| Form | Description of wood characteristics (log, root wad, etc.) |
| Estimated length | Estimated length of a piece of wood |
| Estimated diameter | Estimated diameter of a piece of wood (at approx. 1/3 the distance from the largest end) |
| Verified length | Measured length of a piece of wood |
| Verified diameter | Measured diameter of a piece of wood |
| Percent in Zone 1 | Percentage of a piece of wood that is located within the wetted channel |
| Percent in Zone 2 | Percentage of a piece of wood located within the active channel excluding the wetted channel |
| Percent in Zone 3 | Percentage of a piece of wood that is located vertically above the active channel |
| Percent in Zone 4 | Percentage of wood outside of the wetted, active or plane above the active channel |
| Decay class | Decay class of a piece of wood |

by form such as root wad or log, decay class determined, and their location was estimated by zone. Zones were determined by proximity in or over the unit (table 6).

Several reach-scale variables were determined subsequent to habitat unit typing of the reach. These were used in reach-level analyses of habitat and species-habitat associations. "Hydrotype" characterized the extent of water flow in the reach during the two sampling seasons, spring and summer. Seven hydrotypes were classified varying from perennial flow (water present in entire channel in both spring and summer), to discontinuous in one or both seasons (flow going subsurface in part of reach), to dry channels with no surface flow. Pool-riffle ratios, total channel dimensions (for example, length and area), percent dry channel, and number and length of flow interruptions (flow going subsurface) were determined, per reach. Reach-scale summaries of other elements such as substrate and downed wood were also calculated.

## In-Channel Vertebrate Sampling

Within each stream reach, 10 stream sites were selected for sampling of vertebrates using a random systematic approach. Sampleable pool and riffle units were surveyed in proportion to their availability as determined by habitat typing. Units within approximately 15 m of reach edges were not sampled to avoid boundaries (also termed unsampleable units). The first unit to be sampled was randomly determined in the downstream portion of the reach. Systematic sampling of every $n^{th}$ sampleable unit thereafter was conducted upstream, where n = the number of sampleable pools or riffles in the reach divided by 10. This spread the sampled units along the entire reach section.

Two sampling methods were used for instream vertebrates, electroshocking and hand searches. While electroshocking is a standard research methodology, the potential for low levels of lethal or sub-lethal effects on amphibians and fishes is unknown and is a subject of ongoing research. Electroshocking was used to effectively sample the fishes. Electroshocking likely underestimates the numbers of amphibians potentially occurring within stream substrates, however, the relative abundances of amphibians among reaches could be gauged if standard methods and equal effort were applied. If fishes were not apparent within a reach then electroshocking was not used. Entire pool units were shocked, whereas representative 2-m sections of riffle units were shocked. When electroshocking, the upper and lower ends of habitat units were blocked to allow for capture and measurement of fish and amphibians. Two or more passes of the electroshocker through a unit were conducted to achieve a 75 percent reduction in all species or to achieve a pass with no fish or amphibians. If the fifth pass did not achieve this, the survey crew moved to the next sample site.

During hand searches, the area to be surveyed was approached from the downstream end and a dipnet, aquarium net, or seine was placed downstream of the area searched to catch drifting animals. This net was flush with or within the substrate to prevent the escape of drifting animals. The surveyor proceeded upstream, first visually surveying the unit (for example, looking for salamander/tadpole tails), then removing potential cover for amphibians. An aquarium dipnet was placed immediately downstream of an object intended for removal. Surveyors removed larger unembedded objects (wood, rocks) from the stream channel first, then removed smaller objects; they looked for animals on the undersides of objects and in the water, and used both a hand and dipnet to catch animals. Lastly, they removed loosely embedded objects and raked the substrate. If the unit clouded with silt, they visually searched while waiting for visibility to return. They scooped fine gravels with a dipnet to look for smaller animals. They replaced all substrate and cover when unit sampling was completed.

### Streambank Time-Constrained Searches

Streambanks adjacent to the instream vertebrate surveys were searched on each side of the stream for 5 minutes within approximately 2 m of the water. Searches concentrated on suitable amphibian habitats, such as potential cover objects (rocks, vegetation, leaf litter, downed wood and in talus substrate) and in wet areas. Cover objects were peeled away in layers, while the surveyor looked underneath and within interstitial spaces. Woody material, litter, and substrate were further searched subsurface by hand or carefully using a potato rake. Vegetation, cover, and substrate were replaced and care was taken to reduce impact on habitat. Handling, identification, and measuring of animals were not included in the survey time period.

### Upslope Time-Constrained Searches

Limited funding and low upslope capture rates initially restricted this portion of the study. However, as time permitted within the constraints of the study or collaborative field crews could be arranged, this aspect was pursued to address amphibian and mollusk use of upslope areas and treatment effects.

Terrestrial amphibians and mollusks were censused in the spring along transects that began at the stream edge and extended uphill, perpendicular to the stream through the riparian buffer and into the upslope forest. These trans-riparian buffer transects were located nonrandomly near the center of the riparian buffer treatments to avoid edge effects due to neighboring treatments in areas of relatively uniform topography from stream to ridge and away from patch openings and leave islands. Transects were co-located with those used by the Microhabitats and Microclimates Component (this volume) to promote integration of studies. Each transect consisted of four 2 m-wide parallel lines arrayed within 15 m either side of transect center (that is, Chan and Anderson transect line). Line locations were offset by 1-2 m among sampling years to avoid sampling previously disturbed areas. Transect length varied according to constraints such as the distance from stream to ridge and road locations, but extended about 100 m.

Hand-sampling methods were used. Cover objects (including branches, logs, bark, rocks, moss, and litter) were peeled away in layers, while the surveyor looked underneath and within interstitial spaces. Woody material, litter, and substrate were further searched subsurface by hand or by carefully using a potato rake. Vegetation, cover, and substrate were replaced and care was taken to reduce impact on habitat. A single case study of the efficacy of artificial cover boards for amphibian sampling was conducted at Green Peak (table 7b).

### Handling of Animals

Instream and bank animal captures were reported per unit sampled. Upon capture, species, body length, distance to stream (if on bank or upslope), and the cover object and substrate at capture sites were recorded. Care was taken to minimize stress to animals, including possible desiccation and heat stress of amphibians during handling.

### Sampling Schedule

Pre-treatment ($P_0$) data were collected during one wet season and one dry season to assess the range of seasonal differences in animal numbers, aquatic habitat use, and habitat availability. When feasible, due to survey crew logistics and annual workload, a second year of pre-treatment surveys were conducted. Spring and summer post-treatment surveys were conducted for year one ($P_1$), two ($P_2$) and five ($P_5$) after the completion of timber harvest. An attempt was made to enter the site for post-treatment surveys in the spring as soon as the moderate thinning was complete, regardless of ongoing harvest activities in other upslope treatment units. In some cases the moderate thinning unit was harvested first, and early entry of our field crews for spring surveys was permitted. Thus, the $P_1$ calendar date used for this study may vary from the date of final harvest for the entire site. Implementation was staggered over several years among the 12 study sites (tables 7a and 7b), with pre-treatment surveys ($P_0$) conducted in 1994-1999 and $P_1$-$P_5$ surveys conducted in 1998-2006.

### Data Management

Field data were recorded on paper forms and checked in the field to ensure correctness of header, page, and protocol information. Original forms were bound and entered into spreadsheets at the office. All data entry was subjected to 100 percent visual inspection for errors. An audit trail is kept with the bound hard copy.

Electronic data management procedures included Excel file data entry, editing, quality assurance and quality control procedures, compilation of files into directories and Access database directory archiving. Data processing and quality control consisted of queries and graphs for range checks and proper coding in addition to automated checks using customized programs for data file format consistency, completeness, and correct data types for each variable. After individual spreadsheets were processed, they were merged using a customized program into annual files for each site and/or data format before uploading into a database. Multiple copies of the study database are kept to provide data security. These copies are kept both on and off-site and include CDs, a network server, and work station hard drives.

Two other documents provide additional study detail, such as site maps and driving directions, description of stream reach monument procedures (including GIS coordinates), deviations from study design or survey protocol, and metadata documentation (http://ocid.nacse.org/nbii/density/).

### Analytical Approach

From pre-treatment and post-treatment surveys, channel habitats, species, and assemblages will be described and compared relative to numerous site conditions, including stream/vegetative/geomorphic strata at the stream reach level. Assessment of variability within and among reaches will be one point of emphasis. Models of habitats, species, and assemblages relative to strata will be examined. Qualitative and quantitative patterns will be assessed. Where appropriate, a variety of univariate and multivariate statistics will be used. Multivariate analyses to characterize headwater assemblages and species-habitat associations (Objective 1) include canonical correlation and poisson regression. More stream reaches were included in analyses of pre-treatment data to characterize headwaters, due to inclusion of zero-order basin dry channel segments above water flow. These segments may or may not have had evidence of scour or deposition, and often were not included within buffer zones applied to wetted reaches.

Treatment effects (Objective 2) on spring season species abundances and habitat parameters will be examined using analysis of variance, trend pattern analyses and pairwise comparisons. Stream reaches used in analyses will have perennial or intermittent flow, riparian buffers implemented on both sides of the stream, and upslope thinning on both sides. Treatment effects will be analyzed with $P_0$ and $P_1$ data, $P_0$ and $P_2$ data, $P_0$ and most comparable year of post-treatment year one and two data among sites, and $P_0$ and $P_5$ data. The most comparable year analysis will merge year one and two data due to offset implementation schedule timing. For example, at some sites $P_1$ data were collected several days post harvest, while other sites $P_1$ data were collected 12 months after harvest. In these cases, the most comparable years of surveys for inclusion in analyses across all sites may be $P_2$ (12 months + a few days) from the first site and $P_1$ (12 months) from the second site. Many analyses will be conducted both separately and together for species abundances collected with hand searching and electroshocking techniques.

In analyses of treatment effects, sample sizes were anticipated to be an issue in several regards. First, the small number of two-tree height buffers were expected to constrain our ability to detect potential patterns related to treatment effects from these wider buffers. Second, low or patchy species occurrences were anticipated to be problematic and were expected to reduce the number of taxa we could analyze.

Key findings from each Riparian Buffer Study Component will be compiled within a synthesis paper on headwater streams (Objective 3). A more quantitative integration of findings is planned, contingent on funding, using upslope data at Green Peak and Keel Mountain study sites. The integration will include instream-riparian species-habitat analyses with derivation of reach-level microsite and microclimate characterizations.

Species occupancy and abundance patterns, and variability therein, will be examined in order to explore development of streamlined headwater survey methodology. Plots of species abundance distributions and presence/absence will be grouped by different spatial scale measures (basin, stream segment within basin, site within stream segment) and plots will be examined which show changes in the average density by basin and season. Further description of variability patterns will be made using estimates of variance components for the relative abundance in total and by species. Maximum likelihood procedures with SAS, PROC, and VARCOMP statistical programs will be used to obtain estimates of these variance components.

## Application of Results

### Scope of Inference

Study sites included in this project were selected based on nonrandom criteria including homogeneous forest structure of particular ages and composition and the practicality of implementation scheduling. They are a collection of case studies, extending from Mount Hood to Coos Bay, Oregon. The scope of inference is limited to these selected sites. However, these sites were, in part, chosen to be representative of federal forests across low elevations in western Oregon and results may be highly relevant to neighboring lands. In several regards, there are analogous forested systems extending north into British Columbia and south to northwest California.

Streams in this study were located in forested headwaters and range from zero to second order. In some cases, it was possible to randomly apply riparian buffer treatments to stream reaches per site. However, in other cases, treatments were restricted by the number and proximity of reaches available, such that a random application of buffers was not possible. Thus, at the reach level, overall results will apply only to the reaches examined. Again, however, these streams are expected to represent headwater networks in nearby forest landscapes, and analogous headwater systems may be found from British Columbia to northern California. Thus, the findings of this study are relevant to this larger landscape. Results of this study should not be considered for application to larger streams or to headwaters with significantly different geologies (for example, gradient, topography, and parent geology) in which different processes and species-assemblages may occur.

Over 15 species of amphibians and fishes have been encountered in this study. Species detected in small numbers likely have limited analytical value; treatment effects may not be possible to detect. For more commonly found taxa, the scope of inference of species-specific results is only to

Table 7a. Pre-treatment implementation schedule for the aquatic habitat and vertebrate component of the Riparian Buffer Study.

**Key:** s = stream surveys, u = upslope transects, m = mollusk surveys, b = cover boards

| Stand Age (yrs) | Site | Pre-treatment Surveys | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
| 30-50 | OM Hubbard | | s | | | | |
| | Keel Mountain | | s | | su | | |
| | North Soup | | | s | s | | |
| | Grant | | | s | | | |
| | Ten High | | | | s | | |
| | Green Peak | | | | | s | su |
| | Delph Creek | | | | s | | |
| | Schooner * | | | | s | s | |
| | Cougar | | | s | | | |
| | Bottom Line | su | | | | | |
| 70-80 | Callahan Creek | | | s | | | |
| | Perkins Creek | | | | s | | |

Table 7b. Post-treatment implementation schedule for the aquatic habitat and vertebrate component of the Riparian Buffer Study.

**Key:** s = stream surveys, u = upslope transects, m = mollusk surveys, b = cover boards

| Stand Age (yrs) | Site | Post-treatment Surveys | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 30-50 | OM Hubbard | s | s | | | s | | | | |
| | Keel Mountain | | su | sum | | | sum | | | |
| | Soup Creek | | s | s | | | s | | | |
| | Grant | | s | s | | | s | | | |
| | Ten High | | | | s | s | | | s | |
| | Green Peak | | | sumb | sumb | | | sumb | | |
| | Delph Creek | | | | s | s | | | s | |
| | Schooner * | | | | s | s | s | | s | s |
| | Cougar | | s | s | | | s | | | |
| | Bottom Line | s | s | | | s | | | | |
| 70-80 | Callahan Creek | s | s | | | s | | | | |
| | Perkins Creek | | | s | s | | | s | | |

* Buffer treatments were implemented across two years, requiring 2-years to complete year 1, 2, and 5 post-treatment surveys. For example, year 1 post treatment surveys were conducted in 2001 and 2002, year 2 in 2002 and 2003, and year 5 surveys will be completed in years 2005 and 2006

the reach and sites studied. However, results generated in this study are viable hypotheses for patterns occurring elsewhere in the ranges of these species. Many of these species occur in similar forests from British Columbia to northern California, west of the Cascade Range. This is the extent to which our findings may have relevance.

### Expected Outcomes

We lack an understanding of the effects of alternative riparian management practices on aquatic habitat and species. Interim Riparian Reserves, as established in the Northwest Forest Plan, provide buffer zones to conservatively protect a variety of ecological values from the impacts of timber harvest. Data addressing the risks and benefits of alternative riparian buffer boundaries and of forest management within delineated Riparian Reserves are needed to provide rationale for management decisions. This study is specifically designed to advance our knowledge of the effects on aquatic resources of thinning with riparian buffer zones of various widths. We expect to provide data to address the level of risk associated with alternative riparian buffers along headwater streams when forest thinning is proposed.

This study will integrate abiotic and biotic headwater features sampled at multiple western Oregon study sites from Mt. Hood to Coos Bay to classify headwater stream networks. This classification, which incorporates variability among ecologically distinct forested provinces (that is, the central Oregon Coast Range and the western Oregon Cascade Range), will aid resource assessments prior to site-level field verification and guide resource managers with regard to the physical and biological values of these portions of watersheds. For example, definitive ecological values of headwaters may be tied to elements named in the Aquatic Conservation Strategy Objectives of the Northwest Forest Plan. A characterization scheme for headwater streams and identifiable associations of vertebrate fauna with stream characterizations will help evaluate their potential biological resources allowing for more appropriate land management. Early results of our study have been used to this end. Our identification of discontinuous streams as habitat for a sensitive amphibian species is being incorporated into resource specialist surveys as habitat to identify during field reconnaissance prior to the design of management proposals.

Development of standardized approaches for field inventory and monitoring of headwater stream systems and their vertebrate fauna is a high priority in the Pacific Northwest. A large proportion of managed watersheds are in headwater Riparian Reserves. These approaches should incorporate streamlined reconnaissance-level methodologies to field-validate physical and biological resources. Such methodologies can be used to inventory habitats and species to aid management decisions, and also can be used for implementation, effectiveness, and validation monitoring.

This expected outcome has been partially realized. Our bank survey methodologies were integrated into the Northwest Forest Plan Aquatic and Riparian Effectiveness Monitoring Protocol.

In summary, relative to the Record of Decision (ROD, USDA and USDI 1994) for the Northwest Forest Plan, results of this project are expected to:

- Aid decisions for delineation of, and management within, Riparian Reserves (ROD B12-17)
- Develop better understanding of aquatic-dependent resources named in elements of Aquatic Conservation Strategy Objectives (ROD B-11)
- Understand impacts of management within Riparian Reserves on elements of Aquatic Conservation Strategy Objectives (ROD B9-12)
- Develop methodologies, guidelines, and project sites for monitoring of aquatic-dependent resources (ROD E5-10, ROD B32-34)

An incidental outcome of this project has been the development of partnerships among clients and collaborators. Improved relationships among researchers in agencies and industry, and between the forest research and management communities, provide opportunities for future collaborations. This project involves a large amount of coordination within and among agencies and forest managers. Primary clients and collaborators number over forty, and consultations through outreach activities have reached hundreds of natural resource personnel. International consultations have been requested and are resulting in new global liaisons relative to forest management.

## Related Studies

Two additional studies have been conducted to address Objective 1, characterization of headwater habitats and vertebrates. They are directly related to this study component, but were implemented in neighboring drainages to fill information gaps that we were unable to address at DMS riparian buffer study sites.

First, Sheridan and Olson (2003) and Sheridan and Spies (2005) characterized habitats, amphibians and plants in unmanaged headwater basins near the North Soup study site. This work fills the knowledge gap of what headwater conditions may be like in unmanaged forests, although the scope of inference is restricted to forests near Coos Bay, Oregon. We initially sought unmanaged “control” sites near all riparian buffer study sites but were unable to adequately match elevation, stand size or condition, or stream character near most locations.

Second, characterization of headwater vertebrates includes understanding their ecological role in the forest system. This includes interspecific interactions, which may have a profound influence on species’ distribution patterns. Using an experimental approach, Rundio and Olson (2001) and Rundio and Olson (2003) examined interactions among three dominant species occurring in headwater streams at the riparian buffer sites.  Strong interactions were detected. Due to the manipulative nature of this work, it was not conducted at DMS riparian study sites, but in neighboring basins.

## Microhabitats and Microclimates of Riparian and Adjacent Upland Areas - Samuel Chan and Paul Anderson (PNW)

### Introduction

The Riparian Microclimate and Microsite Component is intended to characterize the interactive effects of riparian buffer delineation and associated upland thinning treatments. These treatments influence microclimate, light conditions, understory vegetation and other site characteristics important to ecosystem function, habitat quality and forest productivity.

A primary management objective for young even-aged Douglas-fir forests on federal lands being managed under the Northwest Forest Plan (NFP, USDA and USDI 1994) is the restoration and maintenance of watershed ecological functions. Two strategies to meet this objective are the establishment of Riparian Reserves and the implementation and monitoring of aquatic and riparian restoration projects. Continued widespread application of even-aged management practices will likely maintain these forests in the stem exclusion stage of development (Oliver and Larson 1996) for several decades to come. Setting aside these dense stands as unmanaged reserves to achieve biodiversity goals will potentially delay, perhaps a century or longer (Andrews et al. 2005), development of late-successional stand structures while also forgoing the potential production of wood and other forest products compatible with attainment of ecological objectives.

Various forms of thinning and density management are being widely employed, however, information is lacking on the effects of density management practices in riparian areas, especially along intermittent streams and headwalls that are prevalent features of the mountain landscape in western Oregon and Washington. Riparian areas are integrally linked with upland forests (Reeves et al. 1995) through vegetation that regulates the exchange of energy, nutrients and matter (Swanson et. al. 1982, Gregory 1997). The degree to which vegetation management, within and adjacent to riparian zones, influences these linkage processes is largely unknown. The efficacy of Riparian Reserves for sustaining riparian functions and their compatibility with producing wood and other commodity values from riparian zones has not been rigorously tested (Olson et al. 2002).

Thinning is a silvicultural practice designed to increase the amount of site resources available to the residual vegetation in a forest stand. Perhaps the most obvious effect of thinning is the increase in light available to overstory and understory vegetation. In the relatively moist climate of western Oregon it is common to think of thinning in relation to alterations of the light regime. However, thinning can also influence many other microclimate parameters by altering the energy balance, radiation regime, interception of precipitation, air flow and soil water regime (Landsberg 1986, Chen et al. 1999). Depending on the intensity and configuration, thinning is one approach to moving a stand from the stem exclusion phase, either temporarily or permanently, by creating opportunities for understory regeneration, improved growth and vigor of advanced regeneration, delaying senescence of lower canopy limbs and increasing the diameter growth of lower branches (Bailey and Tappeiner 1998).

Variation in stand structure resulting from competition, disturbances, and management practices leads to variation in microclimate and microhabitat (Oliver and Larson 1996). Gaps in the canopies of late-successional Douglas-fir/western hemlock forests facilitate development of multi-layered and patchy stand characteristics (Spies and Franklin 1991; Gray and Spies 1992, Gray 1995). In contrast, canopy gaps created in young Douglas-fir stands are often quickly occupied by crown expansion of adjacent trees, providing limited opportunity for understory regeneration and development of a multi-layered canopy. Given the greater plant diversity and interactions with complex environments and edges in riparian areas, competition between plants may be even more intense than in uplands (Hayes et al. 1996, Newton et al. 1996). Thus, openings in riparian areas are likely to be closed more rapidly by existing plants but not necessarily by trees (Hayes et al. 1997, Chan 1994, Hibbs and Giordano 1996, Spies et al. 1994, Minore and Weatherly 1994).

The conceptual basis defining the potential role of Riparian Reserves in moderating microclimate developed in FEMAT (USDA and USDI 1993) was the subject of studies by Chen, Franklin and Spies (Chen et al. 1993a, 1993b,

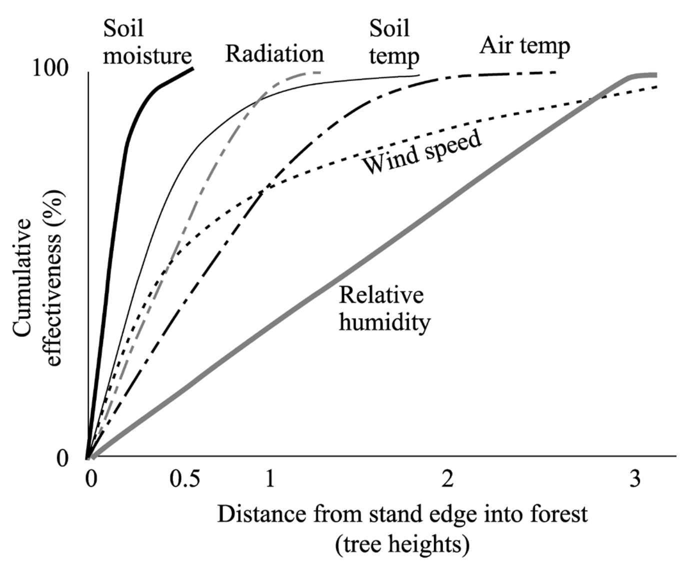


Figure 6. Cumulative effectiveness of an old-growth stand in mitigating microclimatic changes associated with clearcutting. Adapted from FEMAT (1993).

1995). Their examination of microclimate conditions along gradients from a clearcut into an old-growth Douglas-fir forest demonstrated that microclimate, particularly solar radiation and air temperature near the ground surface, is very sensitive to changes in canopy cover and is highly variable in space and time (Chen et al. 1999). Their work also demonstrated substantial differences among microclimatic parameters in spatial and temporal responses to different forest structures. The distance from cut edge to forest interior in which microclimatic perturbation could be detected varied from tens of feet (for example, soil moisture) to hundreds of feet (for example, wind velocity) (Fig. 6).

Subsequent to FEMAT, two studies have been conducted that examine microclimate gradients associated with riparian buffers and upslope forest management. Brosofske et al. (1997) demonstrated in uncut forests that, for most parameters, microclimate approached interior forest conditions within 30-60 m (100-200 ft) upslope from stream center for steeply constrained, 2-4 m (7-13 ft) wide stream channels in the west-side Cascades of Washington. Exceptions to this generalization included solar radiation and wind speed, which attained interior forest conditions at distances in excess of 100 m (325 ft) from stream center. They also observed little influence of buffer width when the uplsope was clearcut on air temperature or wind speed at stream center. Solar radiation was negatively correlated with, and relative humidity was positively correlated with, width of buffer. Danehy and Kirpes (2000) demonstrated similar spatial relationships for relative humidity for riparian-upland transects in east-side Cascade forests that had been partially harvested (selective harvest) with no uncut buffer. Relative humidity gradients were strong from stream center to 5 m (15 ft) upslope, with little change in relative humidity with increasing distance beyond 10 m (35 ft) from stream center. There was also greater diurnal and spatial variation in relative humidity with partial overstory removal.

## Objectives

1) Describe the spatial and temporal variability in microsite (stand canopy, vegetation, forest floor and topography), microclimate (temperature and humidity) and light conditions (canopy transmittance) in riparian and adjacent upland forests.

2) Evaluate microclimate, microsite and light condition responses to upland density management treatments and riparian buffers of different widths.

3) Determine potential linkages among commonly measured microclimate and microsite attributes with a) density management and different riparian buffer strategies, b) understory vegetation development and tree regeneration, and c) diversity of aquatic dependent vertebrates and the presence and development of lichens and bryophytes (as measured by other investigators).

4) Develop methods for monitoring spatial and temporal variation in riparian microclimate and microsite responses to forest management practices in riparian and adjacent upslope forests.

## Methods

### Study Sites

The Riparian Microclimate and Microsite Studies were installed at seven DMS locations (table 8). Six sites have all four upland density management treatments installed, while Callahan Creek has only the 32 TPH (80 TPA) thinning treatment. Callahan Creek also differs from the other DMS sites in that the stand age was approximately 80 years at the time of study initiation (contrast to 35-40 years for the other initial thinning sites). Delph Creek is unique from other DMS sites as it includes areas of very low density (8 TPA, 20 TPA). A limited number of transects were installed at Delph Creek to characterize light conditions within this very low density area. However, microsite and understory vegetation data were not collected on the Delph Creek transects.

**Table 8.** Geographic locations and BLM administrative jurisdictions for sites in the Riparian Microclimate and Microsite Component.*

| Site | BLM District | Resource Area | T-R-S | Latitude | Longitude |
|---|---|---|---|---|---|
| Green Peak | Salem | Marys Peak | 14S-6W-7 | 44° 22’00” | 123° 27’30” |
| Callahan Creek | Salem | Marys Peak | 8S-7W-31 | 44º50’05.0” | 123º35’26.0” |
| Keel Mountain | Salem | Cascades | 12S-1E-13 | 44° 31’41” | 122° 37’55” |
| Delph Creek | Salem | Cascades | 03S-05E-35 | 45º15’56.0” | 122º9’33.0” |
| Bottomline | Eugene | South Valley | 21S-5W-1 | 43° 46’20” | 123° 124’11” |
| O.M. Hubbard | Roseburg | Swiftwater | 26S-8W-24 | 43° 17’36” | 123° 35’05” |
| North Soup Creek | Coos Bay | Umpqua | 23S-9W-16 | 43° 33’57” | 123° 46’38” |

* Complete site history information available in Appendix E

**Table 9.** Riparian buffer and density management treatments by site. Parentheses indicate more than one transect per treatment combination at a given site.

| | Density Management Treatment | | | | | | |
|---|---|---|---|---|---|---|---|
| **Riparian Buffer Type** | **0.4-hectare Patch Opening** | **16 TPH (40 TPA)** | **32 TPH (80 TPA)** | **48 TPH (120 TPA))** | **0.4-hectare Leave Island** | **Unthinned Control** | **Buffer Type Total** |
| **Unthinned Control (C)** | | | | | | BL<br>CC(2)<br>GP(2)<br>KM(2)<br>MH<br>NS(2) | 10 |
| **2-Site Potential Tree Heights (B2)** | BL | | BL<br>CC(2)<br>KM(2) | | | | 6 |
| **1-Site Potential Tree Height (B1)** | BL<br>GP<br>KM<br>NS | | BL<br>CC(2)<br>GP(2)<br>KM<br>NS(2) | BL<br>KM | KM[1] | | 15 |
| **Variable Break (VB)** | BL<br>GP(2)<br>GP[2]<br>KM<br>MH(2)<br>NS(2) | BL(2)<br>KM<br>MH<br>NS | BL<br>BL[3]<br>CC(2)<br>GP(4)<br>KM(2)<br>MH<br>NS | BL<br>GP<br>MH(2) | GP | | 31 |
| **Streamside Retention (SR)** | | | CC(2)<br>GP(2)<br>KM(2)<br>NS(3)[4] | | KM | | 10 |
| **Density Management Treatment Total** | 14 | 5 | 34 | 6 | 3 | 10 | 72 |

[1]B1-L1 thru 80 TPA; [2]VB-P1 thru 80 TPA; [3]VB-80 thru P1; [4]Thin-through 80 TPA

BL = Bottomline

CC = Callahan Creek

GP = Green Peak

KM = Keel Mountain

NS = North Soup Creek

OM = O.M. Hubbard

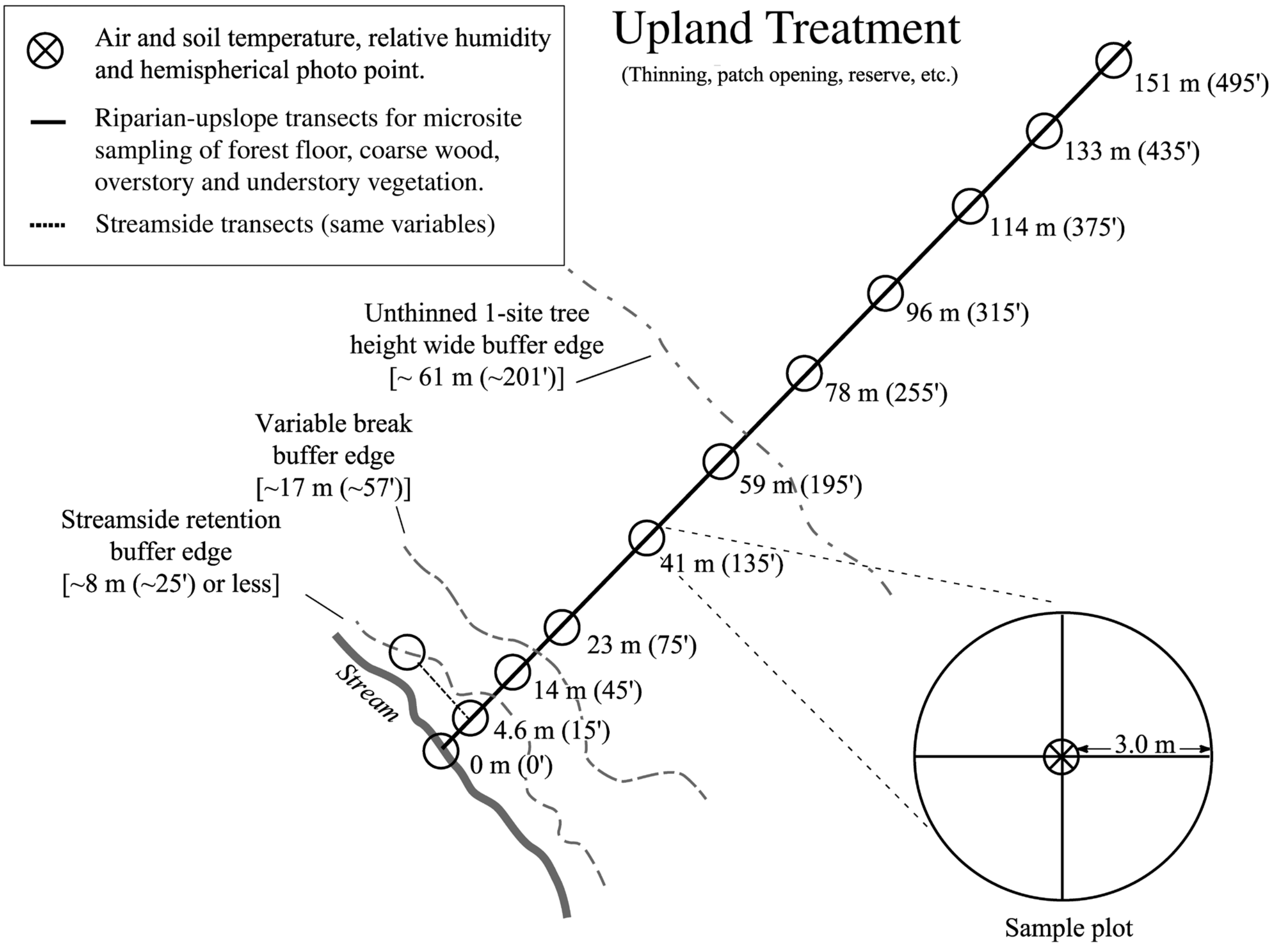


Figure 7. Transect and sample-plot layout for microclimate and microsite sampling.

## Sampling Design

Effects of the experimental treatments on microsite and microclimate are being characterized through repeated sampling of the treatment units. Sampling is based on two types of transects: 1) riparian-upland transects, which extend perpendicular to the stream, from the stream center, through the riparian buffer and into the adjacent upland density treatment and 2) streamside transects, which run parallel to the stream 4.6 m (15 ft) from stream center. Riparian-upland transects are the principal focus of the study and represent a majority of the research effort. Streamside transects provide an opportunity for integration with other study components but represent a relatively small research effort.

Co-location of sample plots along transects has been undertaken by various researchers to facilitate integration among component and collaborative studies within the DMS.

### Riparian-Upland Transects

Each riparian-upland transect samples one of twenty possible combinations of four buffer widths (two site-potential tree height, one site-potential tree height, variable width, and streamside retention) with overstory retention of 16 TPH (40 TPA), 32 TPH (80 TPA), 48 TPH (120 TPA), 0.4-ha (1.0-acre) leave island, and 0.4-ha (1.0-acre) patch, or unthinned control stands. A maximum of nine riparian-upland transects were established at each site based on the specific combinations of density management and riparian buffers represented at each site (table 9). Priority was given to locating transects in the unthinned controls and in the variable and moderate density treatments. The intent is to focus the sampling effort on treatments hypothesized to demonstrate the largest gradients in microclimate. The variable density treatment units contain elements of all the residual density conditions included in the DMS. The moderate density treatments (32 TPH, 80 TPA) are a focus of this study because they allow comparison of the full range of buffer width delineations in association with a common upslope treatment. Also, much of the aquatic vertebrate research of Olson et al. (1996) is being conducted in the moderate density treatments. Focused sampling of the variable and moderate density treatments permits more efficient characterization of the environmental gradients associated with buffer width and overstory retention.

Riparian-upland transects are initiated at stream center and extend perpendicular to the stream through the riparian zone and a minimum of 72 m (234 ft) into the adjacent upland treatment. The minimum 72 m extension into the upland beyond the riparian buffer edge is based on the diameter of a 1-acre patch opening, the smallest upland unit being monitored. Thus, transect lengths range from 72 m (234 ft) (unthinned control treatment) to as long as 225 m (740 ft) (two site-potential tree height buffer into a 32 TPH thin) depending on the combination of buffer treatment and the potential height of dominant trees. Transects on opposite sides of the stream may be offset from one another to ensure that transects traverse the interior of an upland treatment and, thus, minimize edge effects along the transect length.

Permanent sample points are established along each riparian-upland transect and marked with a 1.2 m (4 ft) tall fiberglass rod labeled with the transect number, distance from the stream center and the associated overstory treatment. Spacing among sample points varies with inter-point distances being shorter near the stream and longer at greater distances from the stream. Relative to stream center, the first terrestrial sample plot is located 4.6 m (15 ft) distant. From a 4.6 to 23 m (15 to 75 ft) distance from stream center, sample points are spaced 9.1 m (30 ft) apart. Beyond 23 m (75 ft) from stream center, plots are spaced 18 m (60 ft) apart. The greater near-stream sampling intensity is intended to better capture the spatial variation in conditions that exhibit an initially strong gradient with increasing distance from stream center.

### Streamside Transects

The explicit purpose of monitoring streamside transects is to provide riparian microsite and microclimate data that are complimentary to faunal abundance, diversity and habitat quality data being collected for amphibians and arthropods in the studies of Olson et al. (1996) and Moldenke (Furnish et al. 1997).

Streamside transects are oriented parallel to stream center at a distance of 4.6 m and consists of two sample points. The streamside transects are initiated at the 4.6 m point of riparian/upland transects and extend either 4.6 m or 9 m. Sample points are located at the ends of the streamside transect; the 4.6 m point of the riparian/upland transect is shared as a sample point with the streamside transect.

### Nested Sample Plots

Nested sample plots are associated with each sample point along each transect (Fig. 7). The sample point serves as plot center and is the location at which microclimate, light and canopy closure are measured. Overstory and understory

**Table 10.** Descriptive and response variables measured or monitored as part of the Microsite and Microclimate Component.

| Variable | Description |
|---|---|
| **Physiography** | |
| Aspect | Azimuth of transect line |
| Plot aspect | Azimuth of slope at plot along transect |
| Topographic position | Position of plot in context of local relief: Ridge-top, slope, bench, toe, floodplain |
| Slope | Gradient in elevation between successive plots |
| Distance from stream | Slope distance from stream center to plot – measured along the transect parallel to the ground surface |
| Height above stream | Elevation of plot above the stream center within a transect |
| **Overstory** | |
| Density | Number of trees per unit area greater than 12 cm (4.7 in) dbh stratified by conifer and hardwood |
| Basal area | Stand basal area per unit area of trees greater than 12 cm (4.7 in) dbh stratified by conifer and hardwood |
| Diameter breast height | Mean diameter at breast height for subsample of trees greater than 12 cm (4.7 in) dbh per plot |
| Height | Mean height for subsample of trees greater than 12 cm (4.7 in) dbh per plot |
| Live crown ratio | Mean depth of live crown as a % of total tree height |
| Snag density | Number per unit area of standing dead trees greater than 12 cm (4.7 in) dbh |
| Windthrow density | Number per unit area of overturned trees greater than 12 cm (4.7 in) dbh |
| **Understory** | |
| Density of small trees | Number of natural (not planted) trees per unit area greater than 1.5 m (4.9 ft) height and less than 12 cm (4.7 in) dbh |
| Woody species cover | % plot cover by woody species less than 2 m (6.6 ft) height |
| Dominant woody species | The woody species having the greatest cover per plot |
| Height of dominant woody species | Maximum height of the dominant woody species per plot |
| Density of natural seedlings | Number of natural (not planted) trees per unit area less than 1.5 m (4.9 ft) height |
| Herbaceous cover | % plot cover by herbaceous species |
| Dominant herb species | Herbaceous species having the greatest % cover per plot |
| Height of dominant herbaceous species | Maximum height of dominant herbaceous species per plot |

**Table 10.** Descriptive and response variables measured or monitored as part of the Microsite and Microclimate Component. — Continued

| Variable | Description |
|---|---|
| **Forest Floor** | |
| DWM cover | % ground covered by downed woody material stratified by diameter class: diameter class: <5 cm; 5-30 cm; >30 cm (<2 in; 2-11.8 in; >11.8 in) |
| DWM depth | Depth of downed woody material stratified by diameter class |
| Litter cover | % ground covered by litter |
| Litter depth | Depth of litter |
| Moss/bryophyte cover | % ground covered by moss and/or other bryophytes |
| Bare ground | % ground uncovered (bare mineral soil) |
| **Microclimate and Light** | |
| Air temperature | Air temperature 1 m (3.3 ft) above ground at plot center |
| Soil temperature | Soil temperature 15 cm (6 in) below ground at plot center |
| Streambed temperature | Temperature 15 cm (6 in) beneath surface of channel substrate at stream center; often saturated by stream water |
| Relative humidity | Humidity 1 m (3.3 ft) above ground surface at plot center |
| Percent canopy light transmittance | Diffused visible light 1 m above ground at plot center as a percentage of estimated diffused light above the overstory canopy |

vegetation conditions are sampled within a 3-m (9.8 ft) radius (0.003 ha, 0.007 ac) plot centered on each sample point. Two perpendicular 6-m (19.7 ft) transects centered at each sampling point are used to survey downed woody material and forest floor conditions.

## Response Variables and Measurements

A broad suite of variables is being measured or monitored. These include descriptors of physiographic conditions, vegetation composition and structure, microclimate and light regimen (table 10). With the exception of static physiographic features, the variables being measured and monitored are individually of potential interest as responses to the applied density management treatments, as well as covariates explaining the treatment responses of other variables. Although this study focuses on interactions among physiography, vegetation and microclimate, there is an explicit interest in the implications of these interactions for riparian and aquatic habitat quality. Ideally, the variables monitored in this component study are directly relevant to responses of other organisms to the density management and riparian buffer treatments.

### Overstory Stand Structure

Stand-level variables such as density, basal area, relative density and mean tree diameter are being measured to characterize stand structure dynamics in relation to the buffer and density management treatments. Basal area and relative density are estimated using a variable-radius-plot sampling technique based on a 20-factor angle gauge (either a prism or a Spiegel-Relaskope). Stand basal area (BA) is calculated from the tally of "in trees" with each tallied tree representing 4.6 $m^2$ $ha^{-1}$ (20 $ft^2$ $ac^{-1}$) basal area. Diameter at breast height and species of each tallied tree is recorded and used to estimate quadratic mean diameter ($D_q$). Relative Density (RD), an index of site occupancy, is calculated from BA and $D_q$ (Curtis 1982). Stand metrics are stratified between conifer and hardwood species classes and also between live and dead classes.

In addition to stand metrics describing basal area and relative density, tree height and live crown ratio are determined on a sub-sample of trees tallied in the variable radius plots. Distances from plot center to the nearest tree, and to that tree's nearest neighbor, are also recorded to facilitate analysis of spatial variation in the horizontal distribution of overstory trees (Ludwig and Reynolds 1988).

### Canopy Cover and Light Conditions

Vertically oriented hemispherical photographs of the forest canopy are taken from 1 m above ground, near the center of the sample plot. These provide a permanent record (analog and digital) of canopy condition. They also allow an estimation of the percent light transmittance of the canopy (gap fraction) and the probability and duration of direct and indirect solar radiation. Hemispherical photographs are made using a tripod mounted 35-mm SLR camera with a hemispherical lens having a 180° field of view. Images are recorded on high contrast black and white film. To minimize potential errors associated with light reflectance from boles, branches and foliage, images are recorded during early morning or evening when the sun is low to the horizon (low solar angle), or when the sky is uniformly overcast. Commercially developed black and white negatives are digitized and analyzed using CANOPY (Rich 1989) software. Specific hemispherical photographic procedures are likely to change in the future with the adoption of a digital camera and newer graphical interface software. Although the tools of image capture and analysis will change, fundamentals of the procedure, data reduction and variable estimation will remain the same.

Image processing using CANOPY provides estimates of gap fraction and leaf area index (LAI). Gap fraction is a measure of canopy light transmittance that is defined as the amount of light measured beneath the canopy as a fraction of the incident light above the canopy. In CANOPY, gap fraction is estimated by dividing values for unweighted openness by those for a blank negative for each of 160 image segments (eight azimuth sectors x 20 zenith classes). LAI is then estimated by one-dimensional inversion modeling for each of eight azimuth sectors and then averaged for the image estimate (Rich 1989, Martens et al. 1993).

Early in the study, gap fraction and LAI were measured using the LI-2000 Plant Canopy Analyzer (Licor Inc., Lincoln NE), in addition to hemispherical photography. Use of paired instruments, one sensor/detector set located under the canopy at transect sample points, and the other placed simultaneously in a nearby clearing permits calculation of gap fraction. Gap fraction estimates are then used to estimate LAI by applying the same single-dimension inversion modeling technique as described above for hemispherical photographs.

Additional direct measurements of photosynthetically active radiation (PAR) and total radiation have been made using quantum sensors and pyranometers, respectively. Both the quantum and pyranometer sensors are connected to data loggers equipped with humidity, air and soil temperature sensors. These sensor packages are then transported plot to plot along each transect to obtain instantaneous measurements of light and microclimate conditions. In addition to plot measurements, two additional sensor packages collect concurrent reference data: one sensor package located at stream side and the other in a nearby upland opening (typically a clearcut or landing).

### Microclimate

Three microclimate variables are monitored at each plot center along each transect. These include air temperature and relative humidity 1 m (3.3 ft) above the ground and soil temperature 15 cm (6 in) below ground, or, if the plot is at stream center, stream substrate temperature 15 cm below the surface of the streambed. While soil and streambed temperatures are measured essentially the same way, the often water-saturated conditions make the latter a measurement of hyporheic zone temperature and will strongly reflect the thermal influence of stream water. It is also noted whether the soil temperature was measured in mineral soil or in decomposing organic matter.

As described above for the measurement of PAR and total radiation, pre-treatment and first post-treatment microclimate conditions were recorded with sensors attached to a portable data logger. Air, soil and streambed temperatures were measured using thermisters. Relative humidity was measured using thin capacitance sensors. As with the light measurements, two sensor packages were located to provide streamside and open reference conditions while a third sensor package was carried from plot to plot along the transect to make instantaneous microclimate measurements. Synchronization of the timers among the three data loggers permits direct comparison of data collected at the plots and each reference location.

Simultaneous, continuous microclimate monitoring was undertaken beginning in 2000 for the first post-harvest measurement period ($P_1$). This was in contrast to instantaneous measurements of microclimate made pre-treatment ($P_0$). Self-contained data logger and sensor units are deployed at each plot along transects. Each 3-channel unit records air temperature, relative humidity and soil or streambed temperature at hourly intervals over a pre-programmed period of days. The units are shielded from rain and direct sunlight with 1-liter (32 oz) ventilated white plastic cups. Typically the sensors are deployed at all plots for all transects within a site for continuous monitoring over a two-week period. Limitations in the number of available sensors result in sensors necessarily being rotated among sites in any given season of a sampling year.

### Microsite

Topographic variables measured include, aspect, slope position, percent slope, and elevation above the stream. Transect and plot aspects have been measured by hand-compass. Percent slope at each plot has been determined by either clinometer or Abney level. Plot elevation above the stream has been calculated from the slope angle and slope distance between subplots.

### Understory Vegetation

Cover and composition of understory vegetation is measured at each subplot. Understory vegetation is stratified into shrub, herbaceous, and moss classes. Percent cover is determined by measuring total length of cover for each stratum along two permanently marked 6 m (19.7 ft) transects centered within each subplot. The two transects are perpendicularly oriented with one having been established along a random azimuth from plot center. In addition to percent cover, the dominant shrub species and the dominant herbaceous species within each subplot are noted. The maximum height of both the dominant shrub and dominant herbaceous species are measured.

### Forest Floor

Forest floor conditions were characterized by percent cover and depth of litter, slash, and coarse wood; and percent bare ground. Coarse wood was further stratified into three diameter classes: <5.0 cm, 5 to 30 cm, and >30 cm (<2 in; 2-11.8 in; >11.8 in) as measured at the point of transect intersection. Cover estimation is based on the same 6 m transects used to quantify understory vegetation cover. Slash and coarse wood depth measurements are made where the specified forest floor component is judged to be deepest. Litter depth is measured at five points. The decay status of woody material >30 cm (11.8 in) in diameter is also recorded.

## Sampling Schedule

### Periodicity

Initial harvest schedule and logistical constraints associated with instrumentation and measurement protocols dictate that the timing of sampling varies over years among sites, and over seasons within sites (table 11).

Transects and plots were installed at least one year prior to initial harvesting to quantify pre-treatment ($P_0$, baseline) conditions. Pre-treatment data are used as a reference to assess the effectiveness of thinning treatments in modifying stand and site conditions and to characterize the longer term temporal dynamics of overstory and understory vegetation dynamics and associated changes in microsite and microclimate.

Post-treatment data were collected twice in the first five years following harvest (table 11). The first post-harvest periodic measurement ($P_1$) occurred within two years of harvest to characterize initial post-harvest conditions. The second post-harvest periodic measurement ($P_2$) occurred three to five years after harvest to characterize initial post-harvest dynamics. Subsequent periodic measurements are intended to occur at five-year intervals.

### Seasonality

Sampling of microsite and microclimate parameters is performed in the summer. Summer vegetation surveys facilitate accurate identification and abundance estimation of herbaceous vegetation. Density management treatment effects on microclimate are expected to be greatest during the summer period, which is characterized by large diurnal amplitude in air temperature and humidity.

Assessments of canopy cover and canopy light transmittance are made in both summer and winter corresponding to respective leaf-on and leaf-off conditions for deciduous trees. Difference in light transmittance estimates for leaf-on and leaf-off seasons provides an indication of the relative influence of hardwoods to overall canopy structure. Seasonal differences in canopy coverage will also influence the relative proportions of direct and indirect light reaching the understory. This seasonal variation in light regimen may have an important influence on understory development and species composition.

Integration among disciplines is also considered in the seasonality of microclimate and microsite surveys. The protocol developed by Olson and the BLM (Olson et al. 1996) for monitoring amphibians calls for surveys of terrestrial amphibians during the spring and fall and surveys of aquatic amphibians during the summer. BLM survey protocols are microclimate driven and are conducted during periods of high relative humidity with ambient air temperatures between 4 and 16 °C (39° and 61 °F). Microsite characteristics such as downed woody material, forest floor condition and understory vegetation are important to defining microhabitat quality and may potentially be important to explaining responses of amphibians, arthropods and other organisms to the density management and riparian buffer treatments.

## Data Management

Microsite data are collected on portable electronic data recorders. Microclimate sensor arrays are calibrated according to manufacturer specifications. Sensors are checked and recalibrated as necessary prior to each deployment. Upon retrieval, sensors are checked under uniform conditions to assess potential sensor drift or malfunction. Sensor calibration data are stored in either logbooks (early in the study) or electronically (current practice).

Field crews receive training in standardized data collection techniques with emphasis on vegetation cover estimation, line intercept sampling of downed woody material, and decay classification of downed woody material. Training includes evaluation of variability among observers. Field crews follow standardized recording procedures and data are field-checked by a crew supervisor. A data manager further checks data accuracy employing various arithmetic, graphic, and statistical procedures.

**Table 11.** Schedule of major harvest and measurement events by site for the Riparian Microsite and Microclimate Component. Numbers in parentheses indicate the number of years post-treatment. $P_0$ through $P_2$ have been conducted according to the year indicated. The third post-treatment measurement event ($P_3$) is planned.

| | Measurement/Harvest Event | | | | |
|---|---|---|---|---|---|
| Site | Pre-treatment ($P_0$) | Initial Harvest ($H_1$) | First post-treatment ($P_1$) | Second post-treatment ($P_2$) | Third post-treatment ($P_3$) |
| Bottomline (BL) | 1996 | 1997 | 1999 (+2) | 2002 (+5) | 2007 (+10) |
| Callahan Creek (CC) | 1996 | 1997 | 1999 (+2) | 2002 (+5) | 2007 (+10) |
| Green Peak (GP) | 1998 | 2000 | 2001 (+1) | 2003 (+3) | 2010 (+10) |
| Keel Mountain (KM) | 1997 | 1997-98 | 1999 (+1) | 2003 (+5) | 2008 (+10) |
| OM Hubbard (OM) | 1996 | 1996-98 | 1999 (+1) | 2002 (+4) | 2008 (+10) |
| North Soup Creek (NS) | 1998 | 1998-99 | 2001 (+2) | 2003 (+4) | 2009 (+10) |

Data are currently stored as Microsoft Excel spreadsheets. As resources permit, an ACCESS database will be developed to provide more efficient data handling into the future. Both raw and reduced forms of the data are being maintained. The primary data sets are stored on a server at the USFS Pacific Northwest Research Station, Forestry Sciences Laboratory in Corvallis, Oregon. A complete backup of the data is being stored on a server at Oregon State University in Corvallis. Database structure and access are coordinated through a database manager employed by the Forest Service.

Database documentation follows metadata standards promulgated by the National Biological Information Infrastructure, a broad, collaborative program to provide increased access to data and information on the nation's biological resources (http://www.nbii.gov). The Northwest Alliance for Computational Science and Engineering (NACSE*)*, an interdisciplinary research coalition located at Oregon State University, is dedicated to improving the usability of advanced information technology applications for practicing scientists and engineers. NACSE is a partner with the PNW NBII node and is participating in web and database development for the DMS and component studies.

## Analytical Approach

Although the DMS was laid-out as a complete block design with four treatments each repeated at seven sites, the distribution of riparian buffer treatments among the sites is both imbalanced and incomplete and does not lend itself to a typical analysis as a randomized complete block design. Thus, rather than explicitly evaluating stand-averaged responses to the treatments, our assessments focus on 1) patterns of variation in conditions along transects representing a wide array of buffer width and density management treatment combinations and 2) specific treatment combinations represented by sufficient numbers of transects, treatment differences to discern the effectiveness of buffer width and the influences of thinning intensity.

The experimental units consist of transects spanning a combination of buffer type and upslope density management treatment features (thinned matrix, patch opening, or leave island). This is in contrast to the complimentary aquatic vertebrate studies of Olson for which the experimental unit is the stream reach. As such, two transects spanning a common buffer type and extending into different elements of the same upslope thinning treatment (for example, a thinned matrix versus a patch opening) are considered samples of two different experimental treatments. The nested sample plots located along transects are spatially dependent repeated measures.

Analyses of treatment effects are built around three hypotheses, referred to as tests:

1) Microclimate/microsite conditions do not differ among transects defined by different levels of upslope thinning adjacent to one site-potential tree height riparian buffers or with respect to unthinned controls;

2) Microclimate/microsite conditions do not differ among transects defined by different levels of upslope thinning adjacent to variable-break riparian buffers or with respect to unthinned controls;

3) Microclimate/microsite conditions do not differ among transects defined by varying buffer widths adjacent to upslope stands thinned to moderate density or with respect to unthinned controls.

We evaluate these three hypotheses from four perspectives representing different spatial and resource contexts. A

**Table 12.** Single-degree-of-freedom contrasts to evaluate differences among riparian buffer/density management treatments.

| Test | Interpretation |
|---|---|
| 1: Test among upslope density management treatments for a 1 site-potential tree height buffer | Harvested (thin and patch opening) vs. unthinned |
| | Light & moderate (48 & 32 TPH) vs. heavy thin (16 TPH) |
| | Heavy (16 TPH) vs. moderate thin (32 TPH) |
| 2: Test among upslope density management treatments for a variable-break buffer | Harvested vs. unthinned |
| | Light & moderate vs. heavy thin |
| | Heavy thin vs. patch opening |
| | Light thin vs. unthinned |
| 3: Test among riparian buffer widths for an 80-TPA residual density thinning | Wide (one or two site-potential tree heights) vs. narrow (variable width and streamside retention) buffers |
| | Wide buffers vs. unthinned |
| | Narrow buffers vs. unthinned |
| | Variable break vs. streamside retention buffers |

* - The contrasts listed have been applied to analyses of all microsite variables. Due to the inclusion of fewer treatments in the analyses, the contrasts applied in the analyses of light and microclimate are reduced in scope but followed the basic construct as outlined above.

fundamental interest is whether or not effects of the various buffer/thinning treatments are manifest as variation in microclimate/microsite conditions as detected at a) the stream center, b) within the buffer, c) within the upslope thinning, or d) over the combined buffer/upslope thinning transect. From a fisheries or water quality perspective there may be a discrete stream-centric interest in knowing whether or not the prescribed stand treatments influence potentially important stream conditions. Broader concerns regarding treatment effects on associated riparian values are also of interest to managers. To evaluate the efficacy of riparian buffers, it is beneficial to know the degree of upslope perturbation being moderated by the buffers. Finally, there may be interest in a basic test of the buffer/thinning treatments.

The majority of our analysis is based on a univariate linear modeling approach to detect treatment effects. Mean values calculated for three transect zones are used for data: stream center, buffer, and upslope. These zone values are means of individual point values weighted by the proportional length of transect zone each point represents. Buffer width and density management treatment are fixed effects. Sites are random effects. Microclimate, light, understory vegetation, woody debris, ground disturbance, and stand structure variables (for example, density, basal area, relative density, and canopy cover) are the principal response variables.

Linear models are fitted using SAS Proc Mixed software (SAS Institute, Carey, NC). Observations for stream center, buffer, and upslope zones are repeated measurements of transect and therefore, transects are subjects. Pre-defined contrasts are used to evaluate significant buffer/density management treatment main effects according to the three tests described above (table 12).

For all analyses we consider sources of variation significant if the probability for factor mean values to be the same as the general mean is 0.10 or less. We have adopted this significance level in the recognition that we have relatively few replicates and within- and among-site variation is high. Contrast comparisons among treatments will be considered significant based on a Bonferonni adjustment of probability level to maintain an experiment-wide error rate within the p=0.1 level

To further elucidate potential associations among vegetation, microclimate, light and topography, linear regression and multivariate analytical procedures may be employed. The relationships among overstory density, as measured by basal area and relative density, and understory light levels have been quantified via linear regression using SAS PROC Mixed. Additional analyses are focused on discerning plots having similar vegetation features and identifying the microclimatic and topographic variables having the greatest influence on vegetation stratification. These multivariate analyses are conducted using PC-ORD software (MJM Software Design, Glendenon Beach, OR).

## Application of Results

### Scope of Inference

The inference scope of this study is confined to microsite and microclimate conditions represented by six adaptive management study sites in western Oregon. The findings may have broader relevance to managers of west-side Cascade and Coastal range forests throughout Oregon, parts of Washington and beyond. Given the potential for thinning projects over the next few decades, both in terms of geographic area and number of acres treated, this study may greatly impact forest management activities on federal lands in the Pacific Northwest.

This study is based on application of buffer delineations and thinning treatments to 40- to 80-year-old, second-growth Douglas-fir/hemlock forests. These forests were typically fully stocked and within the stem-exclusion phase of stand development (Oliver and Larson 1996) prior to implementation of the DMS thinning treatments. The DMS includes stands that were previously thinned and stands that were previously unthinned prior to implementation of the density management and riparian buffer treatments. The Riparian Buffer Component of the study addresses only those stands that were previously unthinned.

The riparian zones investigated are those associated with headwater streams. These streams are generally small and of low flow, some being intermittent and only a few bearing populations of fishes. The observed interactions among forest vegetation, microclimate, hydrology and water quality may be substantially different from those of larger streams lower in the drainage network (Ice et al. 2004).

Our assessment of riparian functionality is limited to those processes associated with microclimate, coarse wood, and dominant vegetative species. We recognize that there are numerous physical and biotic factors important to ecosystem function that are not being monitored in this study. Thus, any inferences about the efficacy of buffers or influences of density management are made only in the contexts of the measured parameters and across the range of site conditions and treatments observed.

### Expected Outcomes

Riparian areas are capable of supporting highly diverse and dynamic plant communities. Their structure and composition affect water quality and habitat for fish and wildlife. Riparian areas can also be a sustainable source of timber or fiber products. Consequently, vegetation management in integrally linked riparian and upland forests can have major effects on the productivity of fish, wildlife, and timber.

This study will generate basic and applied knowledge about temporal and spatial variability of microclimate, vegetation, and habitat of riparian and associated upland forests. The information generated will elucidate relationships among overstory thinning, microclimate, and riparian vegetation dynamics. It will be useful to the development or refinement of riparian zone functional definitions. The data may be useful to the development of conceptual or quantitative models linking upslope management to riparian zone productivity or habitat suitability. The study results will help scientists develop and test hypotheses about forest management and its effects on riparian structure, processes, and function.

There will likely be multiple ramifications of such knowledge. It may be used by managers to define the extent of riparian management zones. A policy outcome might be the adoption of guidelines for the use of riparian buffers that extends beyond interim guidelines in the NWFP. Other government or private entities may choose to apply buffers to small headwater streams for which buffers are not currently prescribed. Applied information linking riparian forest conditions to upland thinning treatments will assist managers in developing adaptive management strategies for headwaters forests. The study will be particularly useful to foresters and aquatic biologists considering thinning adjacent to or within riparian reserves prescribed in the Northwest Forest Plan. Depending on conclusions drawn regarding the extent of riparian buffers needed, the study could have significant impact on the proportion of headwater forest area that may be considered for thinning. From a federal land management perspective this potentially would impact the number and distribution of acres thinned to meet restoration and production objectives. Ideally, the results of this study would lead to management decisions that sustain essential riparian functions.

# Collaborative Studies

Short-term studies that use a subset of DMS sites are termed collaborative studies. These studies take advantage of the diverse conditions imposed by the DMS treatments or capitalize on other datasets characterizing response variables of interest to address important science and management questions. Collaborative studies are usually funded on an opportunistic basis and are encouraged as long as they do not conflict with ongoing studies or other objectives for the site. Potential collaborators are encouraged to contact the study coordinator or any of the scientists or site coordinators involved with the study for further information. Brief summaries of past and ongoing collaborative studies follow.

**Lichens** - Peter Neitlich (National Park Service), Bruce McCune (Oregon State University)

| | |
|---|---|
| **Objectives** | 1. Quantify the range of variability of lichen diversity in young managed forest stands<br>2. Quantify the relationship between lichen diversity and selected stand structural features<br>3. Determine whether “hotspots” of lichen diversity can be readily identified from the presence of indicator species or certain stand structural features |
| **DMS study sites** | Bottomline, Lookout Mountain (not currently part of the DMS) |
| **Study design** | Plots were installed in each treatment unit, and in four units of a site (Lookout Mountain) that was being considered for inclusion in the DMS but was later dropped; Forest Health Monitoring (FHM) Program protocols were followed for plot design; data have been added to the national FHM database |
| **Primary response variables** | Species richness, number of species, and species change as measures of lichen diversity; lichen community structure assessed through nonmetric multidimensional scaling |
| **Status** | Completed prior to implementation of initial DMS treatments<br>Post-treatment measurements planned prior to the second round of DMS treatments |
| **Products** | Results published (Neitlich and McCune 1997, see Appendix F) |

**Leave Islands** - Stephanie Wessell (Oregon State University), Deanna Olson (Pacific Northwest Research Station), and Richard Schmitz (Oregon State University)

| | |
|---|---|
| **Objectives** | The primary study objective was to compare the role of leave islands and moderately thinned forest as habitat for taxonomic groups that are potentially sensitive to ground-disturbing activities (vascular plants, amphibians, mollusks, and soil arthropods). Specifically, our study objectives were to:<br>1. Compare the composition and abundance of low-mobility, ecologically sensitive species between five forest types: thinned, unthinned, 1/4-acre leave islands, 1/2-acre leave islands, and 1-acre leave islands<br>2. Characterize microclimate and forest stand structure<br>3. Relate gradients in biotic communities to measured environmental variables |
| **DMS study sites** | Bottomline, Delph Creek, Green Peak, Keel Mountain |
| **Study design** | Study design surveyed biota and habitat within five forest types: unthinned forest, thinned forest, and 0.1-, 0.2-, and 0.4-ha leave islands. Three replicates of each forest type were randomly selected at each of the four study sites (n=60) |
| **Primary response variables** | Biotic response variables included vascular plant, amphibian, mollusk, and arthropod abundance and diversity. Habitat response variables included microclimate, downed wood volume, substrate, and forest structure and composition |
| **Status** | Master's thesis defended in June 2005<br>Manuscripts will be submitted for publication in September 2005 |
| **Products** | 1. Wessell, Stephanie J. 2005. The role of leave islands for biodiversity and habitat in managed forests of the Pacific Northwest, U.S.A. Master's thesis, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon<br>2. Wessell, Stephanie, Deanna Olson, and Richard Schmitz. 2005 submission. The role of upslope leave islands for low-mobility species and habitat in western Oregon managed forest landscapes. Ecological Monographs<br>3. Wessell, Stephanie J., Deanna H. Olson, and Richard A. Schmitz. 2005. Leave islands as refugia for low-mobility species in managed forests, p 379. In C. Peterson and D. Maguire, editors. Balancing ecosystem values: innovative experiments for sustainable forestry. Proceedings. PNW-GTR, p 635. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon<br>4. Wessell, Stephanie J., Deanna H. Olson, and Richard A. Schmitz. 2005. Effects of thinning on microclimate, plants, and low-mobility animals in managed Oregon forests. Abstract. Northwestern Naturalist. In press<br>5. Posters and oral presentations |

**Fungi** - Lorelei Norvell (Pacific Northwest Mycology Service), Ron Exeter (BLM Salem District)

| | |
|---|---|
| **Objectives** | Inventory macrofungal response to five density management treatments: three thinning levels, a 1-acre patch opening, and a 1-acre leave island |
| **DMS study sites** | Green Peak |
| **Study design** | All target and unknown species were collected in strip transects in each treatment |
| **Primary response variables** | Species richness of all ectomycorrhizal epigeous basidiomycetes and 40 non- ectomycorrhizal epigeous basidiomycetes, soil temperature |
| **Status** | Pre-treatment and years 1-5 post-treatment data have been collected and analyzed<br>Additional post-treatment measurements are planned |
| **Products** | Initial results published (Norvell and Exeter 2004), see Appendix F |

**Bryophytes** - Pat Muir (Oregon State University), Tom Rambo (Oregon State University)

| | |
|---|---|
| **Objectives** | 1. Compare the diversity, abundance, and community composition of forest floor bryophytes in both young and old-growth stands, and between “diversity” plots and “matrix” plots for each stand type<br>2. Quantify relationships of bryophytes to large log substrates by decay class in both young and old-growth stands<br>3. Infer changes in bryophyte community associations over time as related to large log decay class |
| **DMS study sites** | Bottomline, Lookout Point (not currently part of DMS) |
| **Study design** | Prior to treatment, 24 plots were established in a young stand and 6 plots were located in an old stand at each site. Half of the plots were located in “diversity” areas and half in “matrix” areas |
| **Primary response variables** | Bryophyte species cover, log and humus decay class, and other environmental variables |
| **Status** | Completed |
| **Products** | Results published (Rambo and Muir 1998a, Rambo and Muir 1998b, see Appendix F) |

**Songbirds** - Jennifer Weikel (Oregon State University), Dan Edge (Oregon State University)

| | |
|---|---|
| **Objectives** | Evaluate the response of songbirds to the DMS treatments |
| **DMS study sites** | Bottomline, OM Hubbard, Green Peak, Ten High |
| **Study design** | Fixed-radius point counts along transects |
| **Primary response variables** | Nesting songbird abundance |
| **Status** | Pre-treatment and immediate post-treatment data collected<br>Follow-up post-treatment planned for 2007-2008 |
| **Products** | Results summarized in the 2000 CFER (Cooperative Forest Ecosystem Research) annual report |

**Understory Vegetation Patterns Across Canopy Gaps** - Robert Fahey (Oregon State University), Klaus Puettmann (Oregon State University)

| | |
|---|---|
| **Objectives** | Evaluate whether canopy gaps created with small patch cuts enhance small-scale heterogeneity and diversity in understory vegetative community composition and structure |
| **DMS study sites** | Bottomline, Keel Mountain, North Soup, OM Hubbard |
| **Study design** | Three or four gaps of each size (0.25 and 1.0 acres) were sampled per site with small quadrats along transects that spanned the gap and extended into the surrounding thinned forest. Plots characterizing the thinned forest without gap influence were also used. |
| **Primary response variables** | Percent cover for all vascular plant species, growth form types, and substrate surface types; light availability |
| **Status** | Complete |
| **Products** | Fahey, Robert T. 2005. Patterns in understory vegetation communities across canopy gaps in young, Douglas-fir forests of western Oregon. Masters thesis on file at Oregon State University, 153 p.<br><br>Additional manuscripts are in preparation. |

**Understory Shrubs and Trees** - John Tappeiner (Oregon State University)

| | |
|---|---|
| **Objectives** | 1. Assess year-to-year variation in flower or fruit production for five shrub species<br>2. Assess the effects of four overstory treatments on flower or fruit production for five shrub species |
| **DMS study sites** | Bottomline, OM Hubbard |
| **Study design** | Suitable patches or individual shrubs were randomly selected from a population of identified suitable patches or individual shrubs for each of the four treatments |
| **Primary response variables** | Basal diameter, height, crown diameter, stem density, flower racemes, fruit production |
| **Status** | Complete |
| **Products** | Published (BAiley and Tappeiner 1998; Bailey et al. 1998; Wender, Harrington, and Tappeiner 2004, see Appendix F) |

**Aquatic and Riparian Functions** - Samuel Chan (Oregon State University), Robert Danehy (Weyerhaeuser Corporation), Maryanne Reiter (Weyerhaeuser Corporation)

| | |
|---|---|
| **Objectives** | 1. Characterize headwater stream environments and aquatic ecosystem characteristics<br>2. Describe the relationships among stand density, understory vegetation, riparian environment, and stream flow and water quality in forested headwater streams |
| **DMS study sites** | Green Peak, Sand Creek, Ten High, Hammer Creek (non DMS site) |
| **Study design** | Riparian characteristics measured along five riparian area transects oriented perpendicular to the stream and running from the stream upslope for each study stream reach; in-stream characteristics measured at fixed intervals along each 100-meter study reach |
| **Primary response variables** | Riparian: basal area, tree density, overstory cover, composition, live crown ratio, light, air and soil temperature, humidity, soil water potential, dead wood.<br>In-stream: physical habitat, water temperature, macroinvertebrate community structure and biomass, periphyton community structure and biomass, water quality (nutrients, turbidity, conductivity) |
| **Status** | Data collection complete<br>Analysis ongoing |
| **Products** | Posters; manuscripts in preparation |

**Arthropods** - Andrew Moldenke (Oregon State University)

| | |
|---|---|
| **Objectives** | 1. To evaluate the effects of density management and riparian buffer width on the total density, species richness, and biomass of ground-dwelling terrestrial arthropods adjacent to headwater streams<br>2. To evaluate the effects of density management and riparian buffer width on the species richness and biomass of aquatic invertebrate species in headwater streams<br>3. To determine whether thinning changes the flight patterns of emergent aquatic adult insects |
| **DMS study sites** | Delph Creek, Green Peak, Keel Mountain |
| **Study design** | 1. Terrestrial species - thinned areas and gaps are compared to two controls: unthinned DMS control treatments and nearby clearcuts; sampling is by pitfall traps<br>2. Aquatic species - streams in thinned areas with alternative riparian buffer widths will be sampled and compared to stream reaches in untreated control areas; sampling is by emergence tent traps<br>3. Flight patterns - flight patterns in thinned and control areas will be sampled with flight-intercept and malaise traps placed in arrays perpendicular to streams (Green Peak only) |
| **Primary response variables** | 1. Total density, species richness, and biomass of ground-dwelling terrestrial arthropods<br>2. Species richness and biomass of aquatic invertebrate<br>3. Total density of flying insects |
| **Status** | Sampling complete<br>Species identification and database development complete<br>Analyses underway<br>Publications in development |
| **Products** | Final reports and published manuscripts are planned for each topic:<br>1. The effects of density management and riparian buffer width on the total density, species richness, and biomass of ground-dwelling terrestrial arthropods adjacent to headwater streams<br>2. The effects of density management and riparian buffer width on aquatic insect emergence from headwater streams<br>3. The seasonal and geographic distribution of flighted insect biomass in forests and the effects of thinning<br>Also,<br>A joint manuscript oriented to managers that integrates the invertebrate responses to alternative riparian buffer widths with the microclimate and aquatic vertebrate components<br>Contribute toward development of an automated aquatic invertebrate identification system (separately funded by NSF) |

# Treatment and Measurement Schedule

Study treatments are now defined by multiple, sequential manipulations. Ecosystem responses measured after the second round of treatments scheduled for 2009-2011 can not be attributed to a single management activity, but will be the result of a set of manipulations. To minimize problems due to confounding effects, we plan to document response to the initial manipulations 11 years after implementation. These measurements will also be used to characterize the study site prior to the second round of treatments. The second entry is planned twelve years after the initial manipulation. Delay will lead to lower data quality and should be avoided.

The current measurement schedule standardizes field measurements to the same year of post-treatment development so that measurements are comparable across study components (table 13 and table 14). Vegetation measurements have been collected and are planned on a five-year re-measurement schedule (years 1, 6, and 11 post-treatment). Other measurements (for example, aquatic vertebrates and microhabitat) were not taken on the same schedule for a variety of reasons (for example, study initiation date or funding availability), but will follow the same schedule in the future, pending funding availability.

**Table 13.** Initial Thinning Sites

| Site name | Majority first treatment complete | Initial vegetation measurement (date/ growing seasons post harvest) | Second vegetation measurement (year/ growing seasons post harvest) | Third vegetation measurement (year/growing seasons post harvest) | Second treatment (year) |
|---|---|---|---|---|---|
| Bottomline | 11-1997 | 09-1998/1 | 2003/6 | 2008/11 | 2009 |
| OM Hubbard | 11-1997 | 09-2000/3 | 2003/6 | 2008/11 | 2009 |
| Keel Mountain | 12-1997 | 09-1999/2 | 2003/6 | 2008/11 | 2009 |
| Callahan Creek | 04-1998 | Not taken | Not taken | Not planned | 2009 |
| North Soup | 08-1998 | 09-2000/2 | 2004/6 | 2009/11 | 2010 |
| Green Peak | 01-2000 | 04-2002/2 | 2005/6 | 2010/11 | 2011 |
| Ten High | 01-2000 | 04-2002/2 | 2005/6 | 2010/11 | 2011 |
| Delph Creek | 04-2000 | 03-2003/3 | 2005/6 | 2010/11 | 2011 |

NOTE: Vegetation plots are not established at the Callahan Creek site, though it will be re-treated and re-measured as part of the riparian buffer studies

**Table 14.** Rethinning Sites

| Site name | Majority first treatment complete | Initial vegetation measurement (date/ growing seasons post harvest) | Second vegetation measurement (year/ growing seasons post harvest) | Third vegetation measurement (year/growing seasons post harvest) | Second treatment (year) |
|---|---|---|---|---|---|
| Sand Creek | 11-1997 | 09-1998/1 | 2003/6 | 2008/11 | 2009 |
| Little Wolf | 09-1998 | 07-2000/2 | 2004/6 | 2009/11 | 2010 |
| Blue Retro | 03-1999 | 08-1999/1 | 2004/6 | 2009/11 | 2010 |
| Perkins Creek | 03-2000 | 10-2000/1 | 2005/6 | 2010/11 | 2011 |

**Table 15.** Roles.

| DMS Coordinator |
|---|
| Serves as the primary point of contact for the DMS |
| Coordinates response to internal or external information requests |
| Ensures adequate communication among all parties involved in the DMS |
| Resolves DMS issues |
| Identifies budget needs and formulates an annual budget strategy |
| Works with BLM Oregon State Office (OSO) program leads to procure needed BLM funds |
| Works with DMS Principal Investigators (PIs) to ensure study plans are feasible and that BLM information needs are addressed as practicable |
| Coordinates with the PIs on science issues, opportunities, and synthesis |
| Works with Site Coordinators to ensure DMS PIs needs are met as feasible |
| Coordinates planning for future treatments |
| Coordinates implementation of future treatments |
| Works with BLM OSO procurements and agreements staff and PIs to develop and process agreements and procurements |
| Works with CFER outreach staff and others to develop DMS products and information-sharing events (for example, tours, workshops) |
| Serves as primary contact for DMS website hosted by the National Biological Information Infrastructure |
| Works with others to identify needs and opportunities for additional collaborative studies to meet BLM needs |

| Site Coordinators |
|---|
| Reviews DMS study plans to ensure operational feasibility and that BLM management needs are considered |
| Ensures that DMS treatments are implemented in a timely manner according to the study plan |
| Ensures that DMS treatment areas are adequately marked on the ground |
| Coordinates and maintains DMS GIS databases |
| Provides information to support DMS website development |
| Serves as primary point of contact for the DMS site at the district and resource area |
| Keeps staff at the district and resource area informed of DMS direction, needs, and opportunities |
| Keeps the DMS Coordinator informed of issues and opportunities |
| Provides information to support development of DMS outreach products such as field tours |
| Informs the DMS coordinator of local needs to develop additional collaborative studies |
| Ensures road and trail access to study sites is maintained |

| Principal Investigators (PIs) |
|---|
| Implements the work described in study plans and related agreements and contracts |
| Develops reports and publications for broad dissemination |
| Keeps the DMS Coordinator informed of the status of DMS measurements, analysis, reporting and outreach activities |
| Works with the DMS Coordinator and the Site Coordinators to integrate BLM information needs into study plans as feasible |
| Keep DMS study plans current, and obtains reviews of changes to study plans from the DMS Coordinator |
| Identify opportunities for additional collaborative studies |
| Keeps the DMS Coordinator informed of funding needs and opportunities |
| Works with the DMS Coordinator to develop outreach products and participates in outreach events (for example, tours and workshops) |
| Provides information and data to support the DMS website |

| DMS Steering Committee (BLM OSO science program branch chief, BLM district manager, CFER program manager, PNW program manager, USGS FRESC research manager) |
|---|
| Stays informed of DMS status, needs, and opportunities |
| Identifies trends and future information needs that could be addressed in the DMS |
| Advises the Study Coordinator on strategies for resolving major issues and obtaining funds |

| BLM Program Leads (silviculture, timber, wildlife) |
|---|
| Stays informed of DMS status, needs, and opportunities |
| Works with the DMS Coordinator and PIs to ensure that BLM management needs are addressed in the DMS |
| Works with the DMS Coordinator to obtain funds to support the DMS |
| Identifies trends and future information needs that could be addressed via additional collaborative studies |

| District Management |
|---|
| Ensure that provision of necessary funds and work months are consistent with the State Office budget directives and priorities |
| Assist the site coordinators with local resource support necessary for DMS planning, implementation, and monitoring activities |
| Keeps informed of the status of the DMS |
| Participates in local field tours as appropriate to provide a management perspective on the value of these studies |
| Provides a strategic perspective to the site coordinator concerning the potential future value of the DMS site(s) |

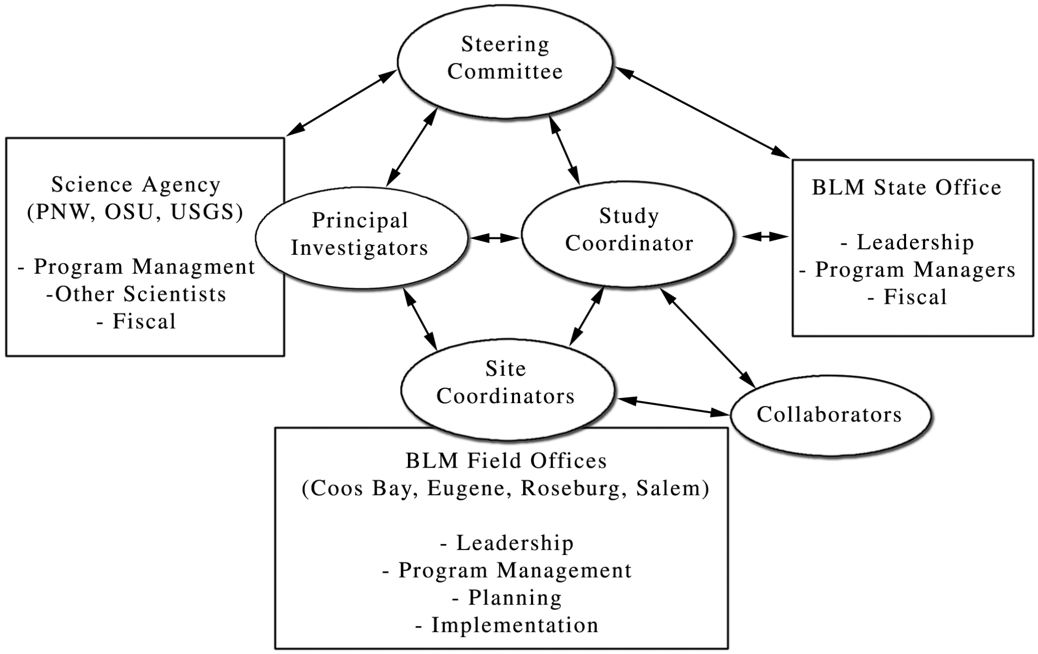


Figure 8. Principal lines of communication

# Study Administration

Successful administration of the DMS requires consideration of the information needs and roles filled by key individuals within each of the partner organizations. Each partner makes decisions and allocates resources at multiple levels and evaluates project success, in part, by client satisfaction with project products. Thus, multiple pathways of information flow and decision-making are in play.

The DMS Study Coordinator, Principal Investigators, and Site Coordinators play the principal roles in developing and coordinating the study and in communicating about study progress and needs (Fig. 8 and Table 15). The Study Coordinator has the primary responsibility for maintaining the flow of information among all study participants, for coordinating planning and development of the study, and for briefing the BLM State Office on the status of the study and needs for support. The Principal Investigators (PIs) provide science leadership and methods development and ensure their home institutions are well informed. Each study site has a designated Site Coordinator who serves as the primary point of contact with the field units. Regular communication is maintained through email and two annual meetings among PIs, Site Coordinators, BLM State Office staff and the Study Coordinator.

Decision making follows multiple channels, primarily through each institutions' normal processes. Major decisions require more complex processes to ensure that short- and long-term needs from all partners can be met and that resources are likely to be available to successfully follow through on data collection, analysis, and publication. The DMS Steering Committee serves as a body of well-placed advisors helping guide the study through complex, multi-institutional issues. For example, the decision to undertake a second round of treatments was made following an extended process that included a field trip among study participants to clarify information needs and treatment opportunities, several iterations of proposal development by DMS principle investigators with field review, a workshop and fieldtrips by BLM managers and resource specialists, review and advice by the DMS Steering Committee, and briefings for both BLM and PNW leadership.

In addition to designation of a Study Coordinator and Site Coordinators, the BLM has taken a number of steps to "institutionalize" the study in an effort to ensure long-term continuity and study site maintenance. Study sites will be recognized in the new Resource Management Plans as special areas dedicated to the DMS, and study sites are integrated into the BLM corporate spatial database. The State Office periodically issues formal direction memos to the field (Appendices A, B, and C) regarding major study activities, and includes DMS budget direction to the field units in each years program of work. At the field level, subtreatment locations are marked with signs and plot locations are recorded with GPS units.

**Table 16.** DMS Funding Sources (in thousands of dollars)

| | Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
| **Vegetation** | | | | | | | | | | | | |
| **- BLM** | | | | | 48 | 52 | 117 | 14 | 88 | 171 | 355 | 108 |
| **Microclimate** | | | | | | | | | | | | |
| **- PNW** | | 63 | 83 | 83 | 83 | 109 | 109 | 277 | 279 | 191 | 101 | 203 |
| **- BLM** | | | | | | | | 50 | 50 | 50 | 63 | |
| **Aquatic Vertebrates** | | | | | | | | | | | | |
| **- PNW** | | 83 | 83 | 130 | 200 | 200 | 200 | 281 | 240 | 240 | 27 | 10 |
| **- BLM** | | | | | | | | | | | 72 | 72 |
| **Arthropods** | | | | | | | | | | | | |
| **- BLM** | 33 | 33 | 33 | 33 | 27 | 20 | | | 37 | 50 | 50 | |
| **Leave Islands** | | | | | | | | | | | | |
| **- PNW** | | | | | | | | 66 | 60 | 11 | 23 | 3 |
| **Fungi** | | | | | | | | | | | | |
| **- PNW Mycology Service** | | | | | | 13 | 13 | 13 | 13 | 12 | 12 | 12 |
| **- BLM** | | | | | | 13 | 13 | 13 | 13 | 12 | 12 | 12 |
| **Lichens** | | | | | | | | | | | | |
| **- OSU** | 10 | | | | | | | | | | | |
| **- BLM** | 10 | | | | | 17 | | | | | | |
| **- USGS** | | | | | | | | | | | | |
| **Bryophytes** | | | | | | | | | | | | |
| **- OSU** | 6 | 8 | | | | | | | | | | |
| **- BLM** | 6 | 8 | | | | | | | | | | |
| **- USGS** | | | | | | | | | | | | |
| **Understory Regeneration** | | | | | | | | | | | | |
| **- USGS** | | | | | | 12 | 12 | 12 | 12 | | | |
| **Songbirds** | | | | | | | | | | | | |
| **- USGS** | | | | | 10 | 10 | 10 | | | | | |
| **Website** | | | | | | | | | | | | |
| **- USGS** | | | | | | | | | 15 | 15 | 15 | 30 |
| **Project Coordination** | | | | | | | | | | | | |
| **- BLM** | | | 12 | 26 | 53 | 57 | 60 | 64 | 67 | 65 | 61 | 69 |
| **- USGS** | 44 | 47 | 36 | 26 | | | | | | | | |
| **Supplies** | | | | | | | | | | | | |
| **- BLM** | | | | | | | 20 | 22 | 20 | 12 | 6 | 5 |
| **Total** | 109 | 242 | 247 | 298 | 421 | 503 | 554 | 812 | 894 | 829 | 797 | 524 |

Notes:

1. Responsibility for vegetation plot installation and measurements were switched from a BLM district responsibility to OSU through a BLM-funded agreement after 2002.

2. Funds for the Leave Island Study were procured by PNW from the interagency (Forest Service and BLM) Survey and Manage fund.

3. Project coordination includes Study Coordinator salary at 12 months/year from 1994 through 2002, and Study Coordinator salary at 6 months/year and Site Coordinator salary at one month/year for each from 2003 through 2005.

4. Funds displayed in the table are only for readily measured out-of-pocket costs; many in-kind contributions are difficult to estimate and are not displayed.

5. Federal funds are shown in the year in which they are obligated.

**Table 17.** Direct funding contributions by organization (in thousands of dollars)

| | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
| **BLM** | 49 | 33 | 45 | 59 | 128 | 142 | 210 | 163 | 275 | 360 | 619 | 266 | 2,349 |
| **OSU** | 16 | 8 | | | | | | | | | | | 24 |
| **PNW** | | 146 | 166 | 213 | 283 | 309 | 309 | 624 | 579 | 442 | 151 | 216 | 3,438 |
| **PNW Mycology Service** | | | | | | 13 | 13 | 13 | 13 | 12 | 12 | 12 | 88 |
| **USGS** | 44 | 55 | 36 | 26 | 10 | 39 | 22 | 12 | 27 | 15 | 15 | 30 | 331 |
| **Total** | 109 | 242 | 247 | 298 | 421 | 503 | 554 | 812 | 894 | 829 | 797 | 524 | 6,230 |

## Funding

Funding for the DMS has been contributed by several partners and has varied over time (table 16). Funds have been allocated out of base funding from each agency to support salary costs of scientists, research assistants, site coordinators, and the study coordinator. In addition, supplemental funds have been procured from grants and other agency funding processes to pay for assistance agreements with OSU and the Pacific Northwest Mycology Services (PNWMS). Scientists with OSU and PNWMS have contributed significant portions of their time to help advance the DMS.

Start-up funding was provided by USGS through the Forest and Rangeland Ecosystem Science Center to initiate study planning and implementation. Several small case studies were also begun with USGS funding (lichens, bryophytes, understory regeneration, and songbirds). Beginning in 2002, DMS website development has been funded through the National Biological Information Infrastructure, a national program of USGS intended to increase access to scientific information.

The BLM and PNW Research Station have supplied the majority of the financing (table 17). The PNW Research Station has contributed over three million dollars through 2005, primarily for the Riparian Buffer Study Components. Data collection and management have consumed most of this funding. Roughly 60 percent of these funds derived from base funds with the remainder coming from internal competitions. The BLM has provided supplemental funds through inter-agency agreements to support these studies, particularly in years where there have been greater funding needs or less financial support from PNW.

The BLM has provided salary support for the study coordinator and for site coordinators for each study site. The BLM has also assumed responsibility for funding the vegetation work. Vegetation plot installation and measurements were the responsibility of BLM field units through 2002 when these responsibilities were transferred to OSU through a Cooperative Ecosystem Studies Unit agreement funded by the BLM. The unusually large amounts of funds for the vegetation work in 2004 is due to a decision to advance the funding cycle by one year to avoid timing problems encountered by time lags in budgeting and procurement. Hence two years of work were funded in one year. OSU has contributed substantial in-kind resources to support this work.

## Outreach

Since its inception, interest in the DMS has been high. A range of media and activities has been used to share information and to promote awareness and discussion of DMS treatments and findings. Field tours enable researchers and forest managers to visualize the effects of various silvicultural prescriptions on forest structure and composition, and to discuss the potential effects of different management practices on future stand conditions. They are an effective mechanism to exchange information and views, and are a mainstay of the DMS outreach program. Field tours are conducted as part of workshops and symposia, for university classes, and on request. Short administrative trails have been built at the Delph Creek, Green Peak, and Keel Mountain sites to support field tours. Care is taken to use these trails and other locations to avoid measurement plots.

Oral and poster presentations of DMS findings are frequently given at workshops and symposia. These presentations have been part of both science- and management-oriented events and are an efficient means to share information. Talks and posters have been given at regional, national, and international proceedings and have served to highlight current thinking regarding density management and riparian objectives.

Written materials are a key component of DMS outreach and include both traditional outlets and electronic formatting and access through the DMS website (http://ocid.nacse.org/nbii/density/). Manuscripts have been published in agency science publications, symposia proceedings, science journals, and as book chapters. Many of these publications and additional progress reports, proposals, study plans, and notes are available through the DMS website. Access to DMS vegetation datasets is also possible through the website. Website development has been supported by funding through the National Biological Information Infrastructure, a program of USGS, and implemented by the Northwest Alliance for Computational Science and Engineering (NACSE). Appendix F lists DMS papers, posters, abstracts, and reports.

In combination, these media and activities reach an extensive number of interested individuals. For example, in 2003 approximately 1,125 individuals were exposed to the DMS through ten field tours and ten presentations at workshops and symposia, and in 2004 approximately 995 individuals participated in nine field tours and five oral presentations.

# Opportunities and Needs

The DMS provides an experimental template suitable for studying many aspects of young stand ecology and management. The BLM and collaborating scientists are very interested in maximizing the potential of these sites to contribute new knowledge. New collaborative studies are encouraged and supported as feasible, provided they will not conflict with ongoing or future planned work. Potential subjects of interest suitable for additional collaborative studies on the DMS sites include:

## Stand and Habitat Development

- What stand structures and spatial patterns resulting from thinning favor the development and persistence of ecologically significant levels of hardwood tree and shrub communities?
- How thinning and small patch cuts affect changes within crown structures and habitats, especially in terms of platforms for wildlife and branch-size effects on wood quality?
- How does the choice of logging system affect habitat development?
- Do the particular arrangements of riparian buffers and upslope features (thinned patches, leave islands, small patch openings) at a stand scale significantly affect the habitat of terrestrial vertebrates?
- How do various density management and riparian buffer approaches affect reciprocal aquatic-terrestrial subsidies in headwaters? For example, does thinning influence aquatic invertebrates that are food for birds, bats, etc.?

## Effects of Young Stand Management

- How does density management affect fruit and seed consumption by wildlife?
- What is the response of deer forage to thinning?
- What are the effects of density management with contemporary logging practices on surface erosion, soil compaction, stream temperature, and hydrology?

## Landscapes

Landscape issues increasingly influence management considerations and objectives for young stand management. Research needs include both questions of how the broader landscape influences specific stand responses and what the landscape response might be if these stand management practices were implemented across broad landscapes. For example:

- Are there significant landscape influences on stand-scale responses (for example, sources of plant or animal immigrants, connectivity of stream network)?
- Can wildlife responses to landscape-scale young stand management be discerned through retrospective studies?
- What are effective scales for designing variable density thinning?

Landscape models will often be used to address these types of questions because of the difficulties involved with conducting landscape research. Landscape models can also help frame and synthesize hypotheses and data needed to answer these questions. Although many managers and investigators are interested in large landscape questions, fundamental knowledge is often lacking at the patch-to-patch scale. A next step at scaling up could involve investigating landscape functions at the patch-to-patch scale, for example, flows of exotic plant propagules or dispersal of amphibians across patch types. This kind of information could help develop and validate landscape models.

While the DMS is not designed to address these landscape issues, scientists and managers involved with the study are keenly interested in young-stand landscape issues.

## Integration

The DMS and other young stand studies in the region have been established for over a decade and offer an opportunity to integrate results. Integration can produce new insights into the linkages among response variables, and lead to new hypotheses regarding system performance. Integration can occur at multiple scales. For example, at the treatment scale, microsite and microclimate responses to treatment could be linked to amphibian habitat suitability or abundance through joint analyses of data sets developed from an overlapping sampling scheme. At the regional scale, there is potential for integration among young-stand studies by evaluation of response patterns across the range of treatments in existing studies. Some of this work has been initiated through an OSU-PNW synthesis project using a Bayesian model (verHoef 1996, Borsuk et al. 2004) to link wildlife, vegetation, and other response variables to overstory thinning. The emphasis is on defining common trends in response rather than absolute responses, and to quantifying the level of certainty associated with response estimates. There is great potential to bring additional sources of data and to expand the range of linkage functions in this analysis.

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# Appendices

## Appendix A. BLM Oregon State Office Directive IM OR-93-145

**UNITED STATES DEPARTMENT OF THE INTERIOR**
**BUREAU OF LAND MANAGEMENT**
**Oregon State Office**
**P.O. Box 2965 (1300 N.E. 44th Ave.)**
**Portland, Oregon 97208**

**In Reply Refer to:**
**5700 (931.6)**

**June 25, 1993**

**Instruction Memorandum No. OR—93—145**
**Expires 9/30/94**

**To:** DMs: Coos Bay, Eugene, Lakeview, Medford, Roseburg, and Salem

**From:** State Director

**Subject:** Silviculture System Experiments - Co-op Unit Project

The Bureau of Land Management is implementing studies of silvicultural systems that will produce old-growth characteristics on selected land uses as quickly as possible. These plans are part of the adaptive management found in the Resource Management Plans. As part of the studies, each District will potentially provide one or more areas in which to carry out these experiments.

Initial installations are to serve as demonstrations and trials for BLM resource specialists and for our publics in order to learn and demonstrate our ability to implement this type of stand management, and to verify that they are an adequate means of attaining the desired objectives of ecosystem-based management.

Attached is a study plan for an experiment in density management of forest stands. This will be a cooperative effort coordinated jointly by the Oregon State Office and the Co-op Unit. Projects will be initiated on a province basis (Cascade, Coastal, and Klamath) with cross-District planning/implementation teams. We are asking each District to select representatives for determining potential locations and for the coordination of these studies.

The first study area is projected for the Cascade Province, and we plan to coordinate with the U.S. Forest Service to sample stands across the province. Implementation of study projects is expected to occur in the fall of 1993. Similar studies are planned for “adaptive areas” in the Coastal and Klamath

**Provinces laser in FY 1994.**

**We realize there are many issues involved in the location of the study sites in the Cascade Province and hope to begin planning the process now, so that units can be located and implemented in early FY 1994.**

**The Salem, Eugene, Roseburg, and Medford Districts should each designate a wildlife biologist and a silviculturist to attend a meeting to discuss the Cascade Province project. The meeting is scheduled for July 21, 1993, at 9:00 a.m. in the Willamette Room of the Eugene District Office. Please give the names of your district's representatives to Larry Larsen (OR-931.6) at (503) 280-7080.**

**A research ecologist from the Co-op Unit will be available to help plan the integration of studies and to locate study sites.**

**/s/ Elaine Y. Zielinski**

**Elaine Y. Zielinski**
**Deputy State Director for**
**Lands and Renewable Resources**

## Appendix B. BLM Oregon State Office Directive IB OR-94-317

**UNITED STATES DEPARTMENT OF THE INTERIOR**
**BUREAU OF LAND MANAGEMENT**
**Oregon State Office**
**P.O. Box 2965 (1300 N.E. 44th Ave.)**
**Portland, Oregon 97208**

**March 29, 1994**

**In Reply Refer to:**
**5600 (936)(931.6)**

**Information Bulletin No. OR-94- 317**

**To:** District Managers: Coos Bay, Eugene, Lakeview, Medford, Roseburg, and Salem

**From:** State Director

**Subject:** Density Management Study - National Biological Survey/BLM Project

As of November 14, 1993, our Cooperative Research Unit based at Oregon State University in Corvallis was absorbed into the National Biological Survey (NBS). Most of the personnel who formerly worked for OR-936 now work for the NBS. This change will not affect the status of existing cooperative agreements, including the Density Management Study now in progress.

The Density Management Study was formerly known as the "Silvicultural Systems Experiment." This study provides us with the opportunity to test the use of alternative silvicultural systems to accelerate the development of old-growth characteristics in young forest stands. Procedures for monitoring the response of botanical, wildlife, and riparian resources to the various silvicultural treatments will be tested; thereby providing a basis for adaptive management. Similar studies have been started in other parts of the Pacific Northwest.

The study is being initiated in the Cascades Province because its forest management picture is less complex than that of either the Coast Range or Klamath Province. Site selection for the first blocks of treatment replications in even-aged, 50-year-old stands is nearly complete. Two 200-acre study blocks will be the primary focus for FY 1994 - one each in the Salem and Eugene Districts.

We will also begin the process of expanding the study to the rest of the westside Districts. NBS personnel will look along the Coos Bay/Roseburg District boundary for a suitable group of study sites. Both Districts will have a study block identified, and these two sites will be the initial focus for the study in the Coast Range Province. A list of site selection criteria for the Coast Range Province is attached.

OSO and NBS personnel would like to screen each District's timber sale plan for possible study sites. They will work with the District Silviculturist to get the necessary information. Potential study sites may be at a point in the timber sale planning process where it is not too late to select them for the study. This would not necessarily delay implementation of a given sale.

**Study blocks will be replicated across the landscape in groups of three or more, providing as much overlap and replication among Districts or Resource Areas (RAs) as possible. The study design for the first group of Cascades Province installations is being developed, and the same design is projected for use in the Coast Range Province. The design will be modified as needed as the study is expanded to include older stands, other plant associations or habitat types, and as we move into other Land Use Allocations such as Late Successional Reserves or Adaptive Management Areas.**

**Both the study design and the timeline for implementation will need to be different for the Klamath Province, and Medford District is preparing a study proposal.**

**Each RA containing a project area selected for the study will need to identify a silviculture forester to work with NBS personnel as needed. These people do not need to be formally designated until that time.**

**Before these sales are harvested, permanent understory vegetation monitoring plots will be installed by NBS personnel. These plots will be remeasured by RA personnel in each of the first five years following treatment, and every five years thereafter. Our regular stand exam will be used to track the development of the overstory vegetation, and the RAs will do this in years 1 and 5 following treatment, and every five years thereafter. The planting of seedlings to create another canopy layer will be a standard practice, and this will also be the responsibility of the RAs. Each RA with a project area will require about 4 workmonths of work in years 1 and 5 following treatment, with 2 workmonths being needed in years 2-4.**

**NBS personnel will soon begin working with the appropriate people to identify potential study blocks along the Coos Bay/Roseburg boundary. At the same time, layout of the Salem and Eugene blocks is beginning; with marking of these two blocks planned for this summer. NBS personnel will assist in the actual marking of these sales.**

**The OSO will coordinate the rate of development of this study so that a positive momentum is maintained. NBS personnel intend to accommodate as many RAs with prospective density management sales-as time and logistics allow, but they can only handle a few project areas in this early phase of implementation. Limiting the number of project areas will help assure a credible and high-quality product.**

**Management recognizes that research projects such as this study represent an important opportunity to demonstrate to managers, resource specialists, and our various interested publics that we can implement ecosystem-based stand management objectives as described in our various draft District RMPs and the Forest Plan. Your continued cooperation is appreciated.**

**Please direct any questions/comments/feedback to Charley Thompson at 280-7076 in Portland or John Tappeiner at 750-7359 in Corvallis.**

**/s/ Terry Nichols**
**Acting Associate Director**

## Appendix C. BLM Oregon State Office Directive IM OR-05-083

# United States Department of the Interior

**BUREAU OF LAND MANAGEMENT**
**Oregon State Office**
**P.O. Box 2965**
**Portland, Oregon 97208**

**In Reply Refer to:**
5610 (OR-933) P

August 12, 2005

EMS TRANSMISSION 8/16/2005
Instruction Memorandum No. OR-2005-083
Expires: 9/30/2006

To: District Managers: Coos Bay, Eugene, Roseburg, Salem
From: State Director, Oregon/Washington
Subject: Density Management Studies

**Purpose:** This Instruction Memorandum provides direction for the next phase of the Density Management and Riparian Buffer Study (DMS).

**Policy/Action:** To begin out-year planning to implement the next phase of the DMS according to the revised DMS Study Plan. The DMS Site Coordinator for each site should work with the local field manager and employees responsible for the necessary contract work to ensure that this schedule can be met and to resolve difficulties. The DMS Study Coordinator should be kept informed and involved as necessary to help keep necessary actions on schedule.

**Timeframe:** The schedule for on-the-ground treatment implementation is as follows:

| Site Name | District | Implementation Year | Site Coordinator |
|---|---|---|---|
| Bottomline | Eugene | 2009 | Peter O'Toole/Shami Premdas |
| OM Hubbard | Roseburg | 2009 | Craig Kintop |
| Keel Mountain | Salem | 2009 | Charley Thompson |
| Sand Creek | Salem | 2009 | Hugh Snook |
| Callahan Creek | Salem | 2009 | Hugh Snook |
| North Soup | Coos Bay | 2010 | Frank Price |
| Little Wolf | Roseburg | 2010 | Craig Kintop |
| Blue Retro | Coos Bay | 2010 | Frank Price |
| Green Peak | Salem | 2011 | Hugh Snook |
| Ten High | Eugene | 2011 | Peter O'Toole/Shami Premdas |
| Delph Creek | Salem | 2011 | Charley Thompson |
| Perkins Creek | Eugene | 2011 | Peter O'Toole/Shami Premdas |

**NOTE:** Implementation year means the year that the activity happens on the ground. Every effort should be made to ensure the DMS units are treated in the one-year window assigned above.

**Budget Impact:** Funding to support contract development and implementation for the next round of treatments will come out of normal operating budgets, and achievements will contribute to normal accomplishment reporting. The Study Coordinator and other individuals in the State Office are evaluating the feasibility of funding post-treatment monitoring through contract receipts, either through stewardship contracting and/or use of the 5900 forest health funds. Additional funding of post-treatment monitoring may be needed and will be funded out of 6320, 6334, and/or 6310 subactivities, as has been the case for the last 10 years. Total funding needs for post-treatment monitoring will range from $100,000 to $300,000 annually depending on scheduling and partner funding contributions. Partner contributions have exceeded Bureau of Land Management (BLM) study funding to date.

**Background:** Initial direction to implement the DMS was provided through two State Office directives (Instruction Memorandum OR-93-145, Information Bulletin OR-94-317) over ten years ago. Since then, treatments implementing the study have been completed, over a thousand plots have been established, measurements for a wide variety of responses have been conducted, initial results have been reported, and a wide range of outreach and education activities have been conducted on DMS sites or with DMS information. Several manuscripts officially reporting five-year post-treatment results are scheduled for publication within the year. A strong partnership among Pacific Northwest Research Station, Oregon State University, US Geological Survey, and the BLM has supported these accomplishments.

An extensive effort was made over the past year to develop a revised DMS Study Plan (Cissel et al. in review) to address key information needs of the BLM. Proposal development steps included:

- DMS scientists and site coordinators developed initial ideas for the revised study plan and reviewed proposals in the field
- Revised study plan was reviewed and discussed with a wide range of field practitioners and managers at the DMS Workshop and Field Trips in June, 2004
- The DMS Study Coordinator reviewed the proposal with affected field managers
- Revised study plan proposal was distributed to westside field units for review
- Revised proposal was reviewed and approved by the interagency DMS Steering Committee (includes BLM district manager and branch chief)

The BLM State Office leadership and Pacific Northwest Research Station Leadership Team were briefed and concurred on study plans and direction.

**Manual/Handbook Sections Affected:** None

**Coordination:** Development of these instructions was coordinated with District Management, DMS Coordinators, and OR-930 Management and staff.

**Contact:** Contact the DMS Study Coordinator John Cissel, at (541) 683-6410 with questions, or for a copy of the revised study plan.

**Districts with Unions** are reminded to notify their unions of this Instruction Memorandum and satisfy any bargaining obligations before implementation. Your servicing Human Resources Office or Labor Relations Specialist can provide you assistance in this matter.

| | |
|---|---|
| Signed by | Authenticated by |
| Kathy Eaton<br>Acting Associate Director | Mary O'Leary<br>Management Assistant |

## Appendix D. Final Initial Study Plan

# U. S. Bureau of Land Management - Density Management Studies

Prepared by John Tappeiner and Charley Thompson

February 3, 2000

**Table of Contents**

# PART I - INTRODUCTION

## Summary

This is a plan for an adaptive study of silvicultural systems that will be used under the new U.S. Bureau of Land Management (BLM) Resource Management Plans. These plans call for Density Management for some stands to achieve old-growth characteristics such as large trees and multiple understory layers as quickly as possible. Other stands are to be managed primarily for wood production, while still maintaining large conifers and hardwoods, in them in order to provide structure and habitat for a variety of wildlife species.

These silvicultural systems differ in two major respects from the evenage systems that are commonly used in western Oregon forests. They require: a) the regeneration of conifers and hardwood species beneath an overstory of conifers and/or hardwoods; b) the management of overstory density to grow large trees; provide snags and logs on the forest floor, and to regulate canopy density so that understory conifers will survive and grow. These silvicultural systems are new for western Oregon forests. There is, however, considerable information from research and implementation programs about thinning conifer stands and conifer regeneration that provide a basis for the work outlined here.

The purpose of this plan is to outline study objectives and protocols to test these new silvicultural systems. There are thousands of acres of stands 30 to 70 years old in the Salem and Eugene BLM Districts for which thinning and density management are appropriate. In addition, there are many more thousands of acres of plantations less than 30 years old in these Districts and in Roseburg and Coos Bay Districts as well. There is significant variation in forest species composition throughout the forests on these Districts. Therefore response to these systems will need to be monitored carefully throughout the forests on BLM lands in western Oregon. It will be necessary to insure silviculture systems being studied are appropriate given the ecosystem variables and specific management objectives for each District. Consequently, particular studies may be designed for each District but the overriding objective is to provide as much overlap and replication among Districts or Resource Areas as possible.

In order to understand how these systems will work in the management of forest lands, it is important to test them operationally. This means that treatments should be established as part of management programs, and that they be installed on large tracts of land, not uniform research plots. Therefore, there is likely to be considerable variation among study sites and treatment replications. Nevertheless, an experimental approach and scientific rigor is needed to evaluate these systems across all BLM lands, if meaningful inferences are to be drawn from the results, and if the results are to provide a basis for adaptive management.

In this study, we will establish study sites on which the response of a range of taxa to stand density management can be evaluated. In this plan, we focus on the response of vascular plants to density management. Studies on other species will be established under separate study plans.

## Past Research and New Information and Approaches Needed

There is considerable published information and practical experience on which to base these new silvicultural prescriptions. Much of the literature has been reviewed recently for the Final Recovery Plan for the Northern Spotted Owl (U.S.D.I., Tappeiner and others, 1992). The density management prescriptions called for in RMPs are similar to those suggested for managing stands to produce spotted owl habitat in the Final Draft Recovery Plan. Briefly, there has been considerable research on the effects of thinning on the growth and yield of Douglas-fir and hemlock stands (King 1986, Ruth and Harris 1979). This research includes response of very young stands (Reukema 1975), stands over 100 years of age (Williamson 1982), and a rather thorough study in stands from about 25 through 50 years of age (Curtis and Marshall 1986, Marshall et al 1992). These studies all show that Douglas-fir trees respond well to thinning and that they can be grown at a wide range of densities. For example, the levels of growing stock studies documents stand growth at stocking levels ranging from 50 to 400+ trees per acre. They also indicate that stands grown at these densities are not prone to windthrow, although assessing how thinning effects windthrow was not one of the objectives of the studies, and windthrow will likely vary from site to site. See the Final Recovery Plan for a more thorough review of research (U.S.D.I., Tappeiner and others, 1992).

Artificial regeneration methods for reforesting clearcuts with Douglas-fir have been well researched. There are successful procedures in place for nursery production of seedlings, site preparation, planting, shrub and herb control, and protection from wildlife damage (Cleary et al 1978, Hobbs et al 1992). This research and management experience strongly suggests that if healthy seedlings are properly planted, they will survive and grow. However, control of herbs and shrubs is often needed to insure satisfactory tree growth and plantation establishment. Control of competition is often of more concern on dry sites in southwestern Oregon than on moister sites to the north.

What remains is to combine these two areas of information and experience into silviculture systems to produce or maintain structures that provide for wildlife habitat, and for other resources while producing wood. Thus, as mentioned above, stand density management or thinning has the objective of not only producing large trees, snags, and wood volume, but also enabling the establishment of multiple layers of trees, shrubs, and herbs in the understory. Reforestation practices must insure seedlings produced in nurseries or advanced natural regeneration will survive and grow beneath larger trees. These practices must take into account competition to seedlings from both understory species and overstory trees. Also, it is anticipated that seedlings in an understory may be more susceptible to animal damage than seedlings growing in clearcuts since they might be less vigorous and growing more slowly.

Other aspects of the studies outlined here are different from past thinning and regeneration studies. They should be done on fairly large tracts (30 to 50+ acres) so that wildlife use of the different stand management systems can be evaluated. Adequate tree response data can be obtained from small, well-monitored plots (0.2+ acres), but entire stands on a variety of sites are needed to evaluate response of multiple resources and to evaluate costs and implementation of these new systems.

Finally, these studies should provide a basis for monitoring and adaptive management. Scientists from the Biological Resources Division (BRD) of the U. S. Geological Survey will play the lead role in analyzing and interpreting initial results; they are based at the Forest and Rangeland Ecosystem Science Center (FRESC) in Corvallis, OR. Personnel from Districts, Resource Areas, the Pacific Northwest Research Station (PNW), Oregon State University (OSU), and other agencies should collaborate in these studies. Once these systems are begun, they should provide a basis for learning how to monitor new stand and landscape management systems and thus proceed with adaptive management. They should also provide the basis for studying a variety of ecosystems and management variables, such as site productivity, root disease effects, wildlife response, economics, etc.

## Other Related Studies

There are other studies proposed or underway that are related to the work proposed here and will contribute to development of the silvicultural systems in the RMP. See Hunter (1995) for a recent summary of related studies. Following are examples of studies of active management of trees and understory vegetation.

1. Comparison of wildlife communities and tree response among three silvicultural systems in the east-central Coast Range, Oregon - OSU McDonald-Dunn Research Forest

   An integrated study documenting the response of vegetation, wildlife and conifer regeneration in three different systems: a) clearcutting with 2 trees/acre retained; b) two-story stand development - 8 to 12 trees/acre left at a uniform spacing after harvest; natural regeneration and planted seedlings; c) “group selection or group shelterwood” - one-third of the stand is being regenerated in 1/2-acre openings; and d) no treatment. Study installed beginning in 1991 in 120-year-old Douglas-fir.

2. Young stand thinning and diversity study - Willamette National Forest

   Documenting vegetation, wildlife and conifer regeneration response to: a) no treatment; b) spacing to 100-120 trees/acre; c) wide spacing of 50 trees/acre and underplanting; d) thinning to 100-120 trees/acre plus 1/2-acre openings planted with conifer seedlings. Study established in 30-40-year-old Douglas-fir plantations or naturally regenerated stands; bird and small mammal monitoring was completed prior to treatment. Logging is scheduled for 1993 and 1994. Each treatment to include 50+ acres.

3. Commercial thinning and understory regeneration in young western hemlock - Siuslaw National Forest-OSU

   Stand densities or stocking levels of 30 year old hemlock range from about 30 trees per acre to an uncut control. Natural regeneration and planted seedlings will be monitored. Treatment units about 5 acres.

4. OSU and the Forest and Rangeland Ecosystem Science Center - Stand Reconstruction

   Stands on BLM lands that have been thinned 10-30 years previously, unthinned stands, and old-growth stands will be inventoried to compare overstory stand structure, species composition, and growth rates. The species composition, density, and growth of understory trees, shrubs, and herbs will also be measured. Information from this work will help design future stand management systems and predict response of understory trees and shrubs and overstory trees in stands whose canopy has been regulated by commercial thinning. Work began in June 1993.

5. OSU and Forest and Rangeland Ecosystem Science Center - Understory Regeneration

   A study to determine how to establish a conifer understory by planting. Douglas-fir, western hemlock, grand fir, and western redcedar will be planted under a range of overstory densities with and without vegetation control and protection from animal damage. Study to be conducted on east and west Coast Range sites. Overstory thinning done fall 1993, planting done spring 1994.

6. A Demonstration of Ecosystem Management Options (DEMO) - Gifford Pinchot and Umpqua National Forests, Washington State Department of Natural Resources

   This study will evaluate various silvicultural systems designed to sustain or develop late-successional forest attributes in managed forest ecosystems. To be implemented by the USFS and Washington DNR in conjunction with PNW and the Ecological Framework for Management Partners, which includes the USFS, OSU, the Ecosystem Research Group at the University of Washington, the Cascade Center for Ecosystem Management, and the Aerial Forest Management Foundation. Six treatments representing the full range of green-tree retention levels will be implemented. The biological and operational feasibility of the various green-tree retention designs will be evaluated, as will their economic and social acceptability.

7. Influence of commercial thinning intensity on stand structure and wildlife abundance. Two stand densities and a control on 60+ acre sites. In the Coast Range near Tillamook, OR - COPE and Oregon Department of Forestry.

8. Olympic habitat development study. Variable density treatments on small patches 0.1 to 0.5 acres to create variable stand structures. Installed on 6 sites on the Olympic Peninsula.

These studies will all provide information that will help with the design and implementation of the prescriptions called for in the RMPs. However, they alone will not provide sufficient information for the following reasons:

1. The sites studied do not adequately represent those managed by BLM, especially the numerous young stands. Therefore, they will not provide a basis for BLM monitoring and adaptive management.

2. They are not exactly compatible with prescriptions called for by the RMPs. For example, only treatment (2) in study one is similar to a GFMA prescription. But it includes only one leave tree number and pattern.

3. Plot or stand size is often not large enough to provide a basis for sampling wildlife populations.

4. They do not represent the planning analysis, prescriptions, and implementation skills of BLM personnel and are being implemented on research forests or on specially selected sites.

# PART II - DENSITY MANAGEMENT STUDY PLAN

## Objectives

1. General Scientific Objectives

    - Test the working hypothesis that "regulation of stand density will enhance stand structural and species diversity."

    - Evaluate several density management regimes to enhance species diversity as described in the proposed action. Test the null hypothesis that among the regimes there are no differences in structural characteristics and species diversity within 5, 10, or 15+ years following treatment.

    - Provide a basis and experimental design for evaluating the response of various taxa to density management.

2. Management Objectives

    - Begin to implement the density management program called for in the BLM's Resource Management Plans and the Record of Decision for the Northwest Forest Plan.

    - Demonstrate the immediate and long-term effects of density management.

    - Learn to integrate riparian and upland stand management prescriptions to achieve multiple species/stand structure objectives.

    - Develop a basis for learning how to monitor populations of plants and animals.

## Desired Future Condition at Age 120-150 Years

The following are the future stand goals that the treatments are intended to produce. They are taken from Spies and Franklin (1991), and represent a wide range of old-growth stand characteristics. Wherever possible, we will measure the characteristics of nearby old-growth stands and use them to guide stand development. The initial treatments will be similar for all stands, however.

1. Large green trees to be developed from the current stand

    - 20 (range 10-30) trees/acre greater than 30" DBH

    - 4 (range 2-6) trees per acre greater that 50" DBH

    - 1 tree per acre greater than 50" DBH - with a broken top

2. Enhancement of species and structural diversity - this will be done through thinning the current stand, reserving the minor species that are already present, and by regenerating conifers and other plants in the understory.

    - 30 (range 25-35) trees/acre between 15 and 30" DBH. These trees would be a mixture of hardwoods, Douglas-fir, western redcedar, and western hemlock. They would include trees currently in the stand plus trees regenerated in the understory.

    - 150 (range 100-200) tree/acre less than 15" DBH. If natural regeneration is not present, one to three cohorts of a mixture of hemlock and cedar will be underplanted.

3. Snags

    - 10 (range 8-12) snags/acre with half greater than 25" DBH and half from 10 - 25" DBH. All decay classes would be represented.

4. Logs on the forest floor

    - 900 linear feet of well-dispersed down logs per acre

        - 1/3 of the logs would be 24" DBH or greater

        - 2/3 of the logs would be 10-24" DBH

        - All decay classes would be represented.

## Study Design and Analysis of Results

The study will be replicated in blocks consisting of a control and three density management treatments. To the extent possible, each block will have a uniform forest cover of about 200 acres, and treatments will be assigned randomly to 50-acre parcels. Large treatment units are necessary in order to study the response of some wildlife populations to density management, and to evaluate the effects of operational treatments on stand structure. Within a block, the treatment units because of their size will generally not be homogenous or similar. For example, some will include streams and riparian buffers; others will include large trees from the previous stand; and understory vegetation will vary among and within treatment units. Nevertheless, our experience with stand reconstruction work in thinned, unthinned, and old-growth stands suggests the treatment effects on overstory trees and understory vegetation can be analyzed using regression to relate understory development to overstory density, and using analysis of variance with a block design to compare differences among treatments.

Analysis of the response of individual plant species such as native shrubs and herbs as well as lichens and bryophytes may be more difficult to assess, and less amenable to rigorous statistical analysis. These species are not likely to be uniformly distributed throughout blocks, among blocks, or within stands. Therefore, we will have to do analyses on a site-by-site basis using appropriate techniques among treatments and blocks. In some cases, this may mean simply reporting the presence or absence, relative abundance, or means and standard errors. In other cases, testing for significant treatment effects may be possible.

The experience gained by monitoring these density management studies can be directly applied to the monitoring and adaptive management called for in the Northwest Forest Plan. By replicating density management studies across many sites and systematically monitoring for "survey and manage" species, riparian zone characteristics, and stand growth and structure development, we expect to be able to document the responses of a range of taxa to density management.

## Treatments to Achieve Desired Future Conditions

1. Stand Treatments

   See Figure 1 and Table 1 in the appendix for the projected effects of these treatments on the size of overstory trees.

   High density - vertical structural development only

   - About 70-75% of the stand will be thinned to a density of 120 TPA to provide a moderate rate of understory development and growth in tree diameter.

   Moderate density (with openings) - vertical structure and some horizontal structure

   - About 60-65% of the stand will be thinned to a density of 80 TPA.

   - About 10% of the stand will consist of well-dispersed circular patch cuts ranging from .25 - 1.0 acre in size (see below)

   Variable density - rapid, "maximum" development of vertical and horizontal structure

   - A highly variable (light to heavy) opening of the canopy that will provide an opportunity for the most rapid development of species and structural diversity.

   - each thinning will be implemented in three or more areas of about the same size:

     - 10% of the stand will be thinned to a density of 40 TPA

     - 25 - 30% of the stand will receive the high density treatment (120 TPA left)

     - 25 - 30% of the stand will receive the moderate density treatment (80 TPA left)

   - in 10% of the stand there will be well-dispersed circular openings ranging from .25 - 1.0 acre in size (see below)

   The complement of patch cuts to be implemented in the moderate and variable density treatments is as follows:

   3 or more .25-acre patches (59-ft radius) = .75 acre

   3 or more .5-acre patches (83-ft radius) = 1.5 acres

   3 or more 1-acre patches (118-ft radius) = 3 acres

   For example, 5.25 acres or 10.5% of a 50-acre unit would be in patch cuts. They should be located in spots conducive to the growth of planted seedlings.

   Control

   - The control unit will provide a means of comparing stand development and species response in treated versus untreated stands. Stand development will occur slowly through such natural processes as self-thinning, root disease, and wind. See Figure 1 to see how the projected diameter distributions in the control at stand age 120 compare with those in the treated stands.

2. Riparian Zones

Streamside treatment unit boundaries will be adjusted from the one- and two- site-potential tree height buffers set forth in the ROD, as appropriate pending the results of watershed analysis and environmental assessment development. Riparian ecologists from the Aquatic-Lands Interaction Group of the PNW Research Station in Corvallis, OR have described two additional buffer widths that they are examining with the Riparian Buffer Component of the Density Management Study. These are:

Variable-width: varies with ecological breaks of vegetation (composition, age) and slope character (stability, gradient). Minimum width is 50 feet, measured as slope distance from the edges of the active channel, to ensure shading and wood/litter input to the stream.

Streamside Retention: maintains trees directly contributing to streambank stability and overhead shading. A streamside tree is reserved if a branch crosses a plane extending vertically from an edge of the active channel. Generally, trees within 20-30 feet of the stream are considered for retention.

At some sites, these same PNW riparian ecologists will install studies to evaluate the effects of thinning within Riparian Reserves on the populations and habitats of aquatic-dependent species such as fish and amphibians. PNW personnel will work directly with the Resource Area as riparian treatment boundaries are located on the ground during sale layout. For study sites or treatment units where PNW activity is absent, the local Interdisciplinary Team will employ either the variable-width or streamside retention concept when adjusting the buffer widths, consistent with the outcome of the watershed analysis.

3. Marking Guidelines

Marking criteria will be developed for each study block. Following are general criteria that may be modified for a given block:

- thinning will generally be "from below." Leaving the largest trees will result in a somewhat clumpy distribution of overstory trees.
- retain all hardwoods.
- retain conifers that are minor species for that stand.
- retain all understory conifers less than 5.0 inches in diameter.
- retain all residual overstory trees from the previous old-growth stand.
- retain all existing large down logs and snags from trees in the previous stand.
- retain limby/wolf trees from all canopy levels.
- select larger trees on the margins of root disease centers to thin around for coarse woody debris recruitment.
- maintain or enhance species diversity. Vary spacing or marking guidelines as needed to retain desired species or even to retain a single tree.

4. Reserve Areas

There will be aggregated green tree retention or "leave islands" in each of the thinning treatments. They help increase horizontal structural diversity and provide suitable microclimates for many organisms. They may be located around known populations of certain plant species, and can be used with adjacent thinned areas to determine how species respond to the direct effects of overstory thinning.

- About 20-30% of the area will be left untreated, with riparian reserve acres contributing to this component. Generally, circular leave islands will be left as follows:
    - 3 or more .25-acre areas (59-ft radius) = .75 acre
    - 3 or more .5-acre areas (83-ft radius) = 1.5 acres
    - 3 or more 1-acre areas (118-ft radius) = 3 acres

In treatment units with low amounts of riparian reserve acres, we will use 2.5-acre leave islands (186-ft radius) to arrive at the desired percentage.

5. Regeneration

Both outplanting and natural regeneration will contribute to the development of additional canopy levels. As stated on Page 7, the stand development goal is to have about 150 trees per acre less than 15" dbh in the understory at stand age 120-150.

Areas to be planted:

- all patch openings
- underplant all areas of 40 TPA in the variable density unit
- underplant 3 1-acre areas (circles, squares, or rectangles) in the moderate and high density treatments, and the control

The planting scheme outlined below should be used in all areas to be planted:

- planting at a 15 X 15 spacing will result in about 200 TPA. Spacing may vary by 20%, i.e. from 12-18 feet.

- The planting rows may be oriented in any direction, although planting at right angles to the contour seems to make the rows easier to re-locate. One species should be planted per row, with no two adjacent rows containing the same species. To make the planting outcome somewhat random, we would use the following process when there are four species. Randomly assign a species to Row # 1. Then randomly assign any of the remaining three species to be in Row # 2. Then randomly assign either of the remaining two species to Row # 3, leaving only one species choice to be in Row # 4. At this point, the only species we don't want in Row # 5 is whatever species was in Row # 4 (so that no two rows of the same species are adjacent). Row # 5 would then be assigned any one of the species that were in Rows # 1, 2, or 3; etc. In like fashion, Row # 9 would be assigned any of the species that didn't end up in Row # 8. The planters should adhere as well as they can to the established transects and spacing, regardless of existing regeneration or overstory trees.

Species to be planted in the patch openings and underplanted in 40 TPA: western hemlock, western redcedar, and Douglas-fir.

- a fourth conifer or hardwood species appropriate for a given site could be planted at the Resource Area's option.

Species to be underplanted in 80 TPA, 120 TPA, and the control: western hemlock and western redcedar.

- a third conifer or hardwood species appropriate for a given site could be planted at the Resource Area's option.
- these areas should be placed where the seedlings are likely to succeed, and it is preferrred that they be at least 50-100 feet from roads.

Site preparation, manual planting spot preparation, protective action such as vexar tubing, and follow-up stocking maintenance would occur at the Resource Area's option as needed for growth and survival. To date the western redcedar have been tubed.

Since advanced natural regeneration has generally been retained in these study sites, there may be clumps of these trees that will need thinning in the future.

Any formal monitoring of seedling growth and survival after planting will be the responsibility of the BRD Unit in Corvallis.

6. Future Treatments

We are examining the process of stand development towards achieving old growth structure and species diversity under varying stand densities. Each treatment or overstory density represents a different way to achieve old forest characteristics.

Residual stand density in the high retention treatment will likely develop a level of competition that reduces vigor and causes suppression mortality to occur within 10-20 years. Such a degree of competition for growing space will inhibit growth and slow progress towards the desired future condition. A similar stand development scenario will occur in the moderate retention treatment, but at a later time. Additional intermediate harvests are planned to maintain growth and vigor by reducing stocking in order to achieve structural objectives. For example, old-growth stands commonly have only 10-60 large trees per acre. The only density management prescription which will reduce stocking to this level, e.g. 40 trees per acre, is on about 10% of the study area in the variable density treatment. Part of the variable treatment may also be thinned in the future.

Future thinnings and the number of trees per acre to be left are outlined in Table 1. Potential results of these treatments on tree size are shown in Figure 1. For example, the high density treatment (2) may be considered for additional density management in 10-20 years. The monitoring of overstory and understory development will indicate when to treat. In addition, planting or releasing established understory trees may be done to increase vertical or horizontal diversity along with these future thinnings.

## Rethinning

Many stands on BLM and Forest Service lands have been thinned when they were 30 to 60+ years of age. Recent work by the BRD research staff at Corvallis suggests that these thinnings often stimulate initiation of conifer and shrub seedlings in the understory and development of trees with full crowns and large branches - all of which could lead to the development of old-growth characteristics. After these initial commercial thinnings the stand is often stocked with 80 to 100+ trees per acre at regular spacing. Old-growth stands often have a variable stocking of approximately 10 to 60 large trees per acre at irregular spacing. Thus it appears that rethinning may help promote old forest characteristics by further reducing overstory density while creating an irregular distribution of overstory trees. It will also promote continued development of 1), a second layer of conifers or hardwoods; 2), a shrub and herb understory; and 3), fuller crowns, larger branches, and furrowed bark on overstory trees.

Rethinning may be done in stands that have been commercially thinned. It is also part of the studies on density management in young stands described above (Table 1). As with the younger stands the goal is the same: development of old-growth characteristics while producing yields of commercial wood.

> Treatments - will be done to enable large trees to continue their growth, and to promote the establishment of a multi-storied stand. Thinning will be "from below," generally resulting in a clumpy distribution of the 30 to 60 trees per acre to be left. Thinning will be heavier around clumps of understory conifers and hardwoods, thus promoting their release. Site-specific marking guidelines to be developed for each project area may vary from those found on P. 10. For example, we intend to reserve from thinning all stems contributing to additional canopy layers; so for each site we will need to set a diameter limit, below which all trees left undamaged by logging are reserved from thinning. This could be as much as 8-10 inches dbh.
>
> Installation - where possible, it is desirable to rethin 50+ acres, while retaining at least 15 acres as a once-thinned control. These acreages will vary among sites, but at each study site there will be a block of a rethinned stand with a once-thinned control. In some cases, the unthinned control area from the Stand Reconstruction study can be retained as well. These controls need to be left intact for about 15 years after the rethinning to allow us to get enough of a data set for vegetation analysis purposes.
>
> Regeneration - one of the criteria for selecting these six study sites was that a significant amount of advanced regeneration resulted from the previous thinning. We do not propose to do any planting in these areas, however a management unit may decide to plant an unstocked area or introduce a species lacking in the stand. In some cases, it may be necessary to perform stocking control on the understory to maintain the growth and development of this canopy layer.

## Vegetation Variables

The primary variable to be studied on all sites is the response of vegetation to density management. Studies of other species will be initiated on a case-by-case basis. Following are general outlines of the variables that should be quantified on each District, or set of studies.

1. Overstory tree response to density management (See Part III)

   - subsequent growth rates of trees and stands
   - cause of mortality (wind, insects, diseases, etc.)
   - snag recruitment rates

2. Response of shrubs and herbs (and lichens, bryophytes, and fungi if possible) to overstory density, and to treatments controlling competition to conifer seedlings (See Part III)

   - species composition
   - cover and height

3. Effects of trees, shrubs, and herbs on conifer regeneration (planted; new and advanced natural regeneration)

   - survival
   - growth
   - competition management

4. How well can these prescriptions be implemented using BLM procedures?

   - success of prescription implementation evaluated by achieving designated tree and snag retention, stand density, low levels of damage to trees, regeneration survival and growth
   - cost of implementation

5. Procedures for monitoring

   - data collection procedures for objectives 1-4 will be used to develop District-wide monitoring methods

- data summary, analysis, and review for objectives 1-4 will be used to evaluate the need for adaptive management

6. Other objectives will become apparent as this plan is reviewed and other information needs surface. These study sites will create opportunities for wildlife ecologists to evaluate the response of some wildlife species (such as amphibians, small mammals, and some birds) to several density management regimes which will have been replicated at least twelve times on a representative set of young forests on four BLM Districts. Particular studies and variables to measure will be decided study by study. For example, underburning is being considered as a part of stand management by some Districts or Resource Areas. Evaluation of underburning could be incorporated in these studies.

## Monitoring Plot Installation and Measurement

We propose to install about 60 of the quarter-acre plots described below at each of the density management study sites. Rethinning study sites will likely need closer to 20 plots. The total number of plots for a given site will depend on the number of strata, with probably 3-6 plots per strata. Strata may derive from different Land Use Allocations, different thinning densities, and different riparian buffer widths. Four sites have been measured, and Kathleen Maas-Hebner of OSU Forest Science is doing statistical analysis of this data now, with results due 4/1/00.

These plots should be established and measured within two years following harvest, and subsequent measurements should occur at roughly five-year intervals. This data on vegetation response and stand development is essential for determining how well density management prescriptions such as these can create the desired stand structural characteristics, and will facilitate the use of these sites by other researchers.

The FRESC Unit in Corvallis has an ongoing commitment to assist and guide the BLM in analyzing this monitoring plot data. The FRESC Unit cannot commit to any significant amount of the data gathering effort, so individual Districts and Resource Areas will need to install and remeasure these plots if the monitoring component of the study is to be fully implemented. Some amount of State Office guidance and oversight is expected to continue into the foreseeable future.

### Overview of Plot Design

.25-acre fixed-radius (58.9') plot

- record and number all live trees that are ≥2.0 inches dbh

- record and number all dead trees that are ≥10.0 inches dbh and are ≥1 foot high. This definition of a dead tree will allow the tracking of old-growth stumps.

- record presence for all vascular plant species identified as late-successional/old-growth associates, e.g. those listed in the FEMAT report (1993).

- in thinned areas, record diameter (2-inch classes) and species of stumps in order to estimate basal area & number of trees per acre removed in thinning.

Four 8.33 ft. (.005 acres) fixed-radius subplots

- 4 satellites located 50 feet from plot center at the four cardinal directions.

- seedling count: for each tree species (conifers and hardwoods), tally the total number of stems that are 6 inches to 4.5 feet in height.

- sapling count: for each conifer tree species, tally the total number of stems that are ≥4.5 feet in height and <2.0 inches in diameter.

- record average height and absolute per cent cover for all vascular plant species. Height is recorded to the nearest foot for shrubs, and to the nearest 0.1 foot for herbs.

Coarse woody debris sampling

- 100% sample of the .25-acre plots for pieces that are ≥10.0 inches in diameter at the large end, when the large end of the piece is within the perimeter of the plot. To observe this tally rule, we will often need to determine which end is the large end. Record length, species, condition class, and large- and small-end diameters.

- 100% sample of the .005-acre plots for pieces that are 3.0 - 9.9 inches in diameter at the large end and when the large end of the piece is within the perimeter of the plot.

Data Recording and Storage

The Polycorder 2000 is intended to hold all the field data, to be downloaded to a PC for storage and editing. Data sheets have been developed in the event that field data should need to be recorded by hand. A spreadsheet application of the DataPlus software has been developed for this project for use on the Polycorders. Once downloaded, the data can be manipulated by software such as Lotus or Excel.

Salem District is hosting a training in March 2000 on the DataPlus Professional software, which will be used to develop a better handheld data recorder application for this year's field measurements.

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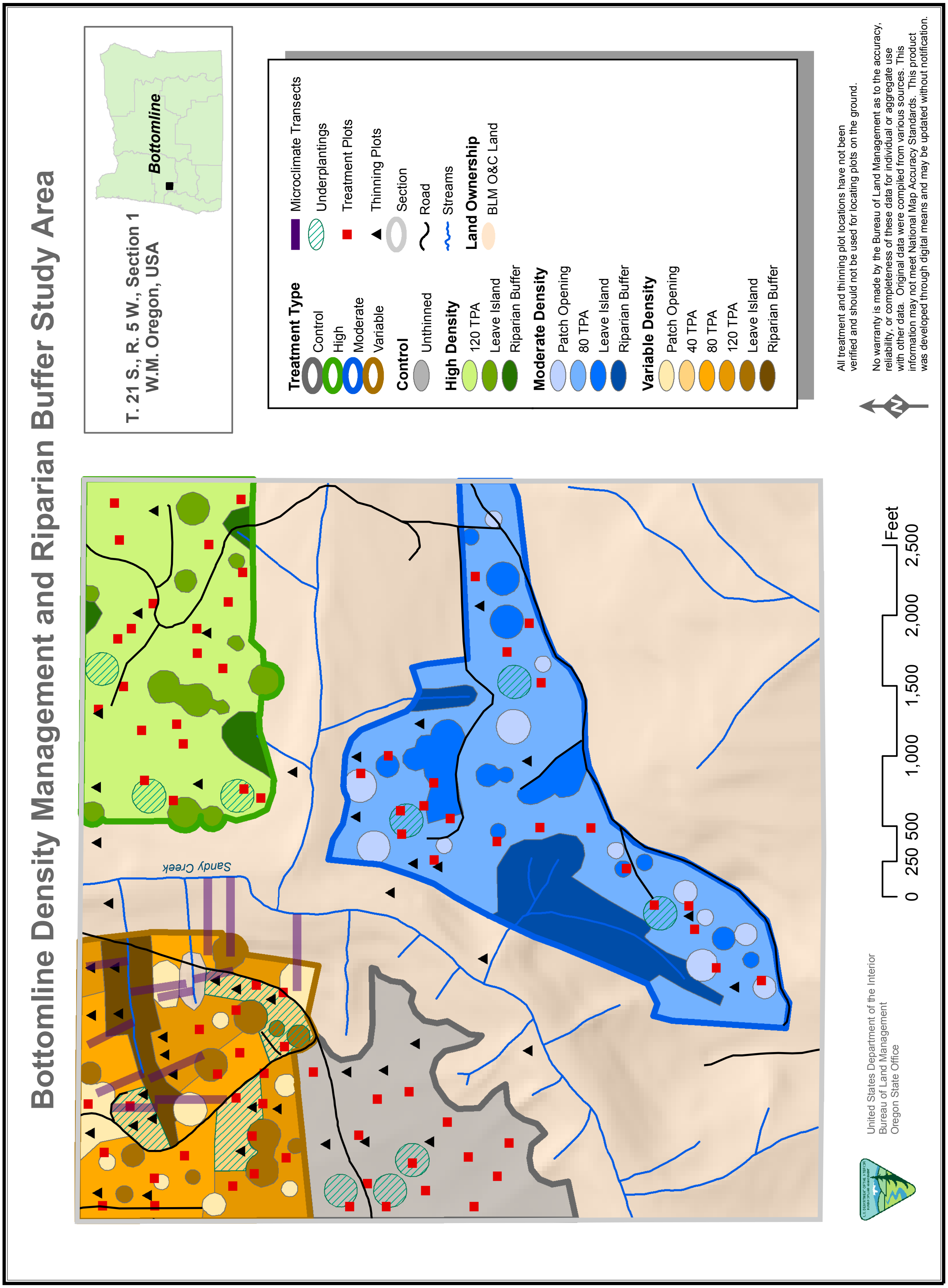

Bottomline Density Management and Riparian Buffer Study Area
T. 21 S., R. 5 W., Section 1
W.M. Oregon, USA
Bottomline
Treatment Type
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Riparian Buffer
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Riparian Buffer
Microclimate Transects
Underplantings
Treatment Plots
Thinning Plots
Section
Road
Streams
Land Ownership
BLM O&C Land
Sandy Creek
0 250 500 1,000 1,500 2,000 2,500
Feet
All treatment and thinning plot locations have not been verified and should not be used for locating plots on the ground.
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.
United States Department of the Interior
Bureau of Land Management
Oregon State Office

# Appendix E. Site Histories and Maps (site maps on left-facing page preceeding site description.)

## Initial Thinning Sites

### Bottomline

Compiled by: Peter O'Toole (BLM, Eugene District), Sharmila Premdas (BLM, Eugene District)

1. Site location

| | |
|---|---|
| Township | 21 South |
| Range | 05 West |
| Section | 01 |
| Latitude | N43º46'20.0" |
| Longitude | W123º14'11.0" |
| BLM District | Eugene |
| BLM Resource Area | Siuslaw |
| County | Douglas |

2. Site environment

| | |
|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | |
| - Control | - Tyee formation (100%) |
| - High density treatment | - Tuffaceous siltstone and sandstone (100%) |
| - Moderate density treatment | - Tuffaceous siltstone and sandstone (52%); Tyee formation (48%) |
| - Variable density treatment | - Tyee formation (100%) |

| | |
|---|---|
| Elevation range (feet, (meters)) | |
| - Control | 846 - 1,089 (258 - 332) |
| - High density treatment | 863 - 1,148 (263 - 350) |
| - Moderate density treatment | 801 - 1,211 (244 - 369) |
| - Variable density treatment | 774 - 1,181 (236 - 360) |

| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| - Control | 0 | 9 | 35 | 37 | 17 | 2 | 0 | 0 |
| - High density treatment | 8 | 7 | 2 | 3 | 45 | 16 | 10 | 9 |
| - Moderate density treatment | 19 | 4 | 2 | 2 | 3 | 5 | 24 | 41 |
| - Variable density treatment | 16 | 39 | 27 | 14 | 2 | 0 | 0 | 2 |

| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% |
|---|---|---|---|
| - Control | 91 | 9 | 0 |
| - High density treatment | 82 | 18 | 0 |
| - Moderate density treatment | 88 | 12 | 0 |
| - Variable density treatment | 80 | 20 | 0 |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Windygap (97%); Other (3%) |
| - High density treatment | - Windygap (61%); Honeygrove (23%); Orford (15%); Other (1%) |
| - Moderate density treatment | - Honeygrove (80%); Orford (17%); Other (3%) |
| - Variable density treatment | - Honeygrove (71%); Windygap (23%); Other (6%) |
| NOTE: soil series and complexes are defined in the Douglas County Soil Survey | |
| Mean annual precipitation (inches) | 50 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Achlys triphylla-dry (71%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (29%) |
| - High density treatment | - Tsuga heterophylla/Oxalis oregana (38%); Tsuga heterophylla/Achlys triphylla-dry (25%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (13%); Pseudotsuga menziesii/Toxicodendron diversilobum (13%); Pseudotsuga menziesii/Holodiscus discolor-Whipplea modesta (13%) |
| - Moderate density treatment | - Tsuga heterophylla/Achlys triphylla-dry (73%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (18%); Other (9%) |
| - Variable density treatment | - Tsuga heterophylla/Achlys triphylla-dry (60%); Abies grandis/Mahonia nervosa-Gaultheria shallon (25%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (10%); Other (5%) |
| Site index (Kings) | 138 |

3. Site planning

| | |
|---|---|
| RMP (name and date) | Eugene District Record of Decision and Resource Management Plan, June 1995 |
| RMP land use allocations | Matrix (General Forest), Riparian Reserve |
| Watershed analysis (name and date) | Siuslaw, 1996 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | Bottomline Density Management |
| - Number | OR090-94-28 |
| - Date decision document signed | 08/28/1995 |
| Site potential tree height (feet) | 210 |
| Aerial photography (years available) | Standard (1:12000) - 1984, 1995, 2000, 2002 |

4. Study design

| | |
|---|---|
| Site selection criteria | Site met minimum unit size and age range criteria, economically viable, and was already being evaluated for commercial thinning |
| Treatment assignment rationale | |
| - High retention unit | Random |
| - Moderate retention unit | Random |
| - Variable retention unit | Random |
| - Control | Random |
| Subtreatment location rationale | |
| - Leave islands | One-acre leave areas selected to protect habitat features thought to benefit lichens and bryophytes (large remnant live and dead trees, large logs, hardwood patches); ½ and ¼ acreleave areas placed along unit edges to minimize logging conflicts |
| - Patch cuts | Patch cuts were interspersed throughout the treatment block with consideration of logging feasibility |
| - Variable density areas | Low retention areas were placed in areas of low existing stem density to enhance tree stability; high retention areas were placed in areas of high existing stem density to enhance tree stability |
| Nonstandard treatments (type, location, rationale) | Two small reserve islands were left in the high retention treatment to protect two species:<br>*Buxbaumia piperi*: one 80' radius island<br>*Orobanche pinorum*: one 30' radius island |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Seed tree harvest (1939); most seed trees subsequently removed (date unknown), although a few scattered residual trees remain on site |
| Regeneration method | Natural |
| Post-harvest slash treatment | None |
| Precommercial thinning | None |
| Prior commercial thinning | None |
| Comments | None |

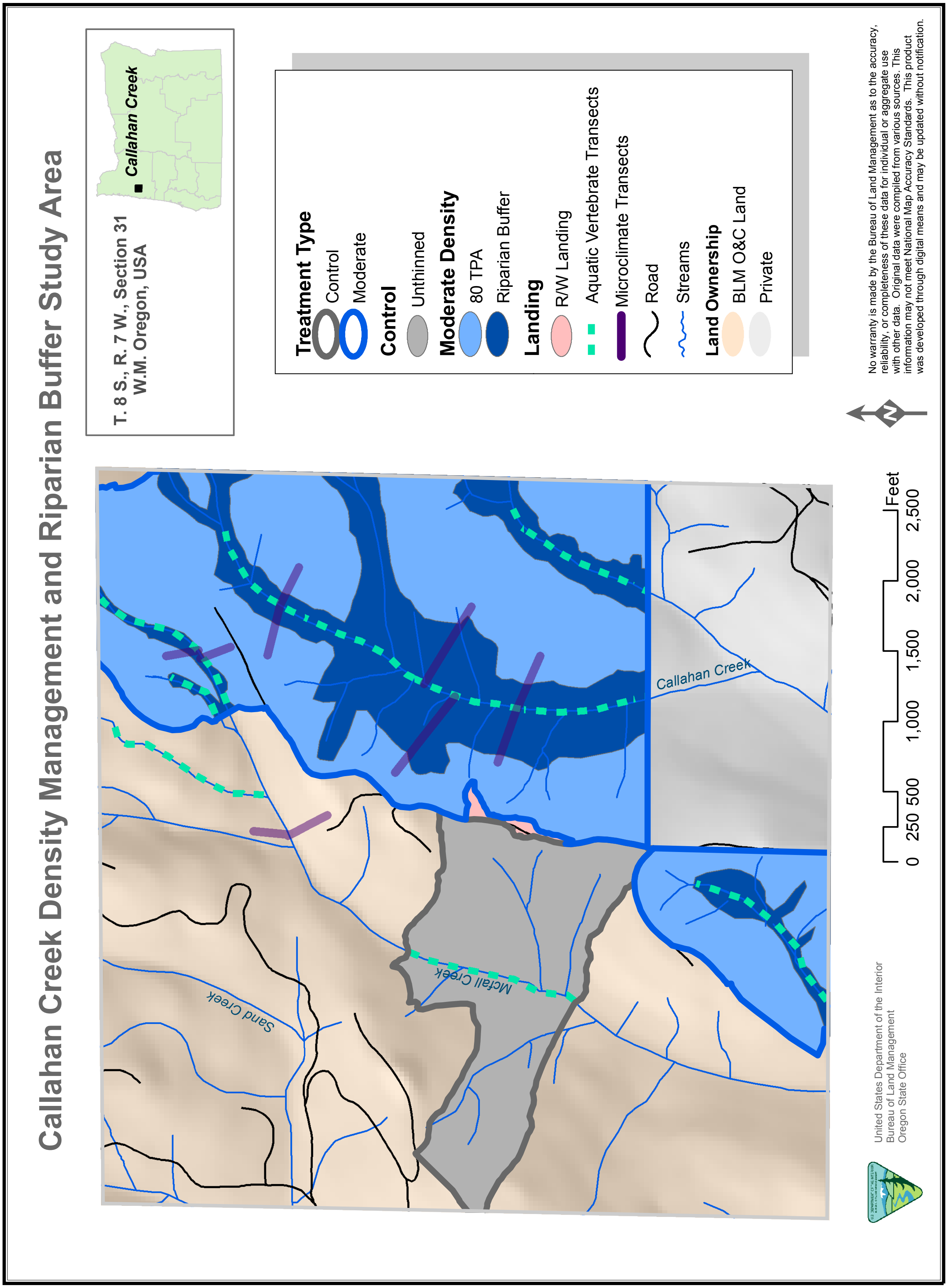
B. DMS - first treatment

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) |
| Timber sale | |
| - Sale name | Bottomline |
| - Sale number | ORO90-TS95-357 |
| - Sale award date | 10/18/95 |
| - Sale closing date | 10/18/97 |
| - Sale price for all study units (total for all species and sizes) | $999,218 |
| Logging dates | |
| - High retention unit | 12/1995-10/1997 |
| - Moderate retention unit | 07/1997-09/1997 |
| - Variable retention unit | 09/1997-11/1997 |
| Logging systems | |
| - High retention unit | Cable yard |
| - Moderate retention unit | Cable yard |
| - Variable retention unit | Cable yard |
| Merchantability standards | Purchaser option to leave or take all designated trees above 6” DBH |
| Slash treatment | None |
| Underplanting date | 02/1998 |
| Comments | None |

6. Acreage Table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 46.3 (18.7) | 100.0 |
| High density | | |
| - Thinned (120 TPA) | 59.5 (24.1) | 84.2 |
| - Leave islands | 7.4 (3.0) | 10.5 |
| - Riparian buffer | 3.7 (1.5) | 5.3 |
| Total | 70.6 (28.6) | 100.0 |
| Moderate density | | |
| - Thinned (80 TPA) | 72.8 (29.5) | 66.6 |
| - Leave islands | 11.9 (4.8) | 10.8 |
| - Patch cuts | 6.6 (2.7) | 6.1 |
| - Riparian buffer | 18.0 (7.3) | 16.4 |
| Total | 109.3 (44.2) | 100.0 |

| | | |
|---|---|---|
| Variable density | | |
| - Thinned (120 TPA) | 16.4 (6.7) | 22.3 |
| - Thinned (80 TPA) | 20.8 (8.4) | 28.2 |
| - Thinned (40 TPA) | 10.4 (4.2) | 14.1 |
| - Leave islands | 7.6 (3.1) | 10.3 |
| - Patch cuts | 8.5 (3.5) | 11.6 |
| - Riparian buffer | 10.0 (4.0) | 13.5 |
| Total | 73.7 (29.8) | 100.0 |
| Total | 299.8 (121.3) | |


Callahan Creek Density Management and Riparian Buffer Study Area
T. 8 S., R. 7 W., Section 31
W.M. Oregon, USA
Callahan Creek
Treatment Type
Control
Moderate
Control
Unthinned
Moderate Density
80 TPA
Riparian Buffer
Landing
R/W Landing
Aquatic Vertebrate Transects
Microclimate Transects
Road
Streams
Land Ownership
BLM O&C Land
Private
Callahan Creek
Mcfall Creek
Sand Creek
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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## Callahan Creek

**Compiled by:** Hugh Snook (BLM, Salem District)
(Note: Callahan Creek is an anomaly and does not have all the treatments and subtreatments.)

1. Site location

| | |
|---|---|
| Township | 08 South |
| Range | 07 West |
| Section | 31 |
| Latitude | N44º50’05.0” |
| Longitude | W123º35’26.0” |
| BLM District | Salem |
| BLM Resource Area | Mary’s Peak |
| County | Polk |

2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Tyee formation (100%) | | | | | | | |
| - Moderate density treatment | - Tyee formation (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 1,263 - 1,608 (385 - 490) | | | | | | | |
| - Moderate density treatment | 1,263 - 1,893 (385 - 577) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 1 | 1 | 26 | 13 | 13 | 14 | 30 | 3 |
| - Moderate density treatment | 1 | 4 | 16 | 22 | 14 | 16 | 20 | 7 |
| Slope steepness (% area in each slope class) | 0%-30% | | 30%-60% | | | >60% | | |
| - Control | 67 | | 33 | | | 0 | | |
| - Moderate density treatment | 58 | | 41 | | | 1 | | |
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Bohannon (99%); Other (1%) | | | | | | | |
| - Moderate density treatment | - Astoria (77%); Bohannon (22%); Other (1%) | | | | | | | |
| NOTE: soil series and complexes are defined in the Polk County Soil Survey | | | | | | | | |
| Mean annual precipitation (inches) | 115 | | | | | | | |
| Plant association group (% area in each group that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Data unavailable | | | | | | | |
| - Moderate density treatment | - Data unavailable | | | | | | | |
| Site index (Kings) | 130 | | | | | | | |

3. Site planning

| | |
|---|---|
| RMP (name and date) | Salem District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | North Coast Adaptive Management Area |
| Watershed analysis (name and date) | Upper Siletz, 1996 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | Callahan Creek Adaptive Management Project |
| - Number | OR-080-96-12 |
| - Date decision document signed | 03/11/96 |
| Site potential tree height (feet) | 220 |
| Aerial photography (years available) | Standard (1:12000) - 1977, 1982, 1988, 1998, 2003; orthophotos - 1994, 2000 |

4. Study design

| | |
|---|---|
| Site selection criteria | Densely stocked stand regenerated following a 1920 fire and suitable for thinning; in adaptive management area appropriate for study objectives; one unit of a larger thinning project, including Sand Creek; economically viable |
| Treatment assignment (rationale) | |
| - High retention unit | Not included at this site |
| - Moderate retention unit | Only unit suitable for multiple riparian buffers |
| - Variable retention unit | Not included at this site |
| - Control | Stream reach in McFall Creek within same stand type |
| Subtreatment location (rationale) | None included at this site |
| Nonstandard treatments (type, location, rationale) | 1. Only a subset of treatments are included at this site: moderate retention with alternative riparian buffers and a control; site is included only for the riparian buffer studies<br>2. Moderate retention unit does not include any leave islands or patch cuts<br>3. The portion of the control unit that also serves as the Sand Creek control was previously thinned (1975) |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut postfire, approximately 1920 |
| Regeneration method | Natural |
| Post-harvest slash treatment | Unknown |
| Precommercial thinning | None |
| Prior commercial thinning | None |
| Comments | Stand had approximately 175 TPA prior to thinning |

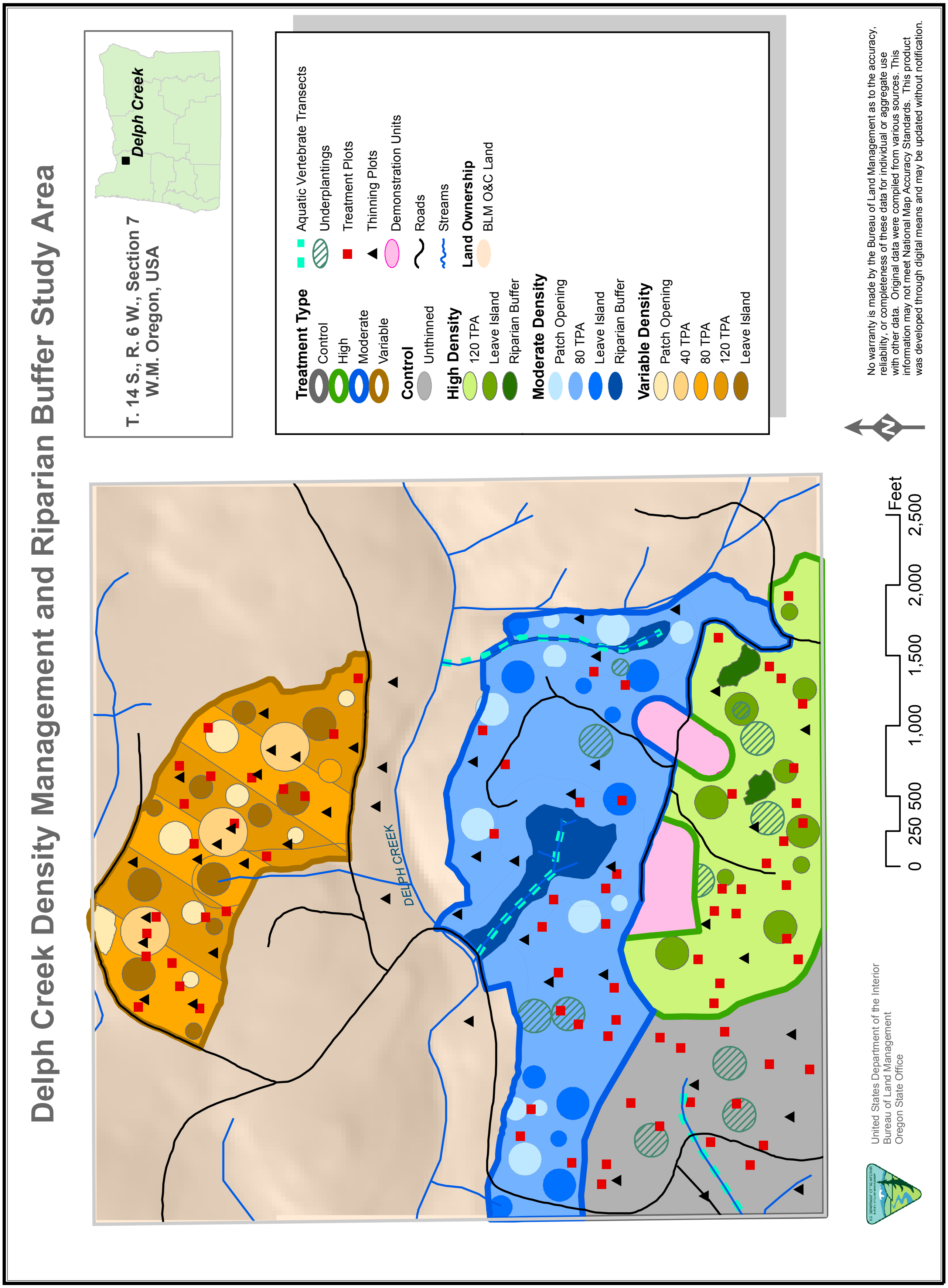
B. DMS - first treatment

| | |
|---|---|
| Marking guidelines | Thin from below to leave 80 dominant and co-dominant trees per acre, at an approximate spacing of 23 feet, leaving approximately 133 $ft^2$ basal area; do not mark conifers as leave trees in root rot pockets; leave all cull trees, multiple top trees, wolf trees or other wildlife habitat trees; leave snags, overstory hardwoods, and Pacific yew; favor hemlock and cedar for leave trees |
| Timber Sale | |
| - Sale name | Callahan Creek Thinning |
| - Sale number | 97-301 |
| - Sale award date | 02/27/97 |
| - Sale closing date | 06/24/98 |
| - Sale price for study units, total for all species and sizes | $707,496 |
| DMS treatment date | 01/1998-04/1998 |
| Logging systems | Helicopter |
| Merchantability standards | All designated trees down to 7.0 inches DBH were required to be removed |
| Slash treatment | Slash concentrations on landings were burned (11/1998) |
| Underplanting date | Not applicable |
| Comments | 1. Entry permits required in the Luckiamute Closure and Cooperative Travel Management Area<br>2. Two genetic program “superior” trees in thinning area reserved: near center of section 31 just east of the 9-7-6 road, and in Unit 1 on the ridge above McFall Creek |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned.36 | 56.5 (22.9) | 100.0 |
| Moderate density | | |
| - Thinned (80 TPA) | 151.0 (61.1) | 67.7 |
| - Riparian buffers | 71.9 (29.1) | 32.3 |
| Total | 223.0 (90.2) | 100.0 |
| Total | 279.5 (113.1) | |

Note: Callahan Creek is unique among the initial thinning study sites in that only the moderate density and control treatments were implemented, and only the thinning portion of the moderate density treatment was implemented (i.e., no leave islands or patch cuts). Callahan Creek is included as a DMS study site because it is part of the riparian buffer study.


Delph Creek Density Management and Riparian Buffer Study Area
T. 14 S., R. 6 W., Section 7
W.M. Oregon, USA
Delph Creek
Treatment Type
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Riparian Buffer
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Aquatic Vertebrate Transects
Underplantings
Treatment Plots
Thinning Plots
Demonstration Units
Roads
Streams
Land Ownership
BLM O&C Land
DELPH CREEK
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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## Delph Creek

**Compiled by:** Charley Thompson (BLM, Salem District)

### 1. Site location

| | |
|---|---|
| Township | 03 South |
| Range | 05 East |
| Section | 35 |
| Latitude | N45º15’56.0” |
| Longitude | W122º9’33.0” |
| BLM District | Salem |
| BLM Resource Area | Cascades |
| County | Clackamas |

### 2. Site environment

| | |
|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | |
| - Control | - Undifferentiated flows and clastic rocks (100%) |
| - High density treatment | - Undifferentiated flows and clastic rocks (79%); basalt and andesite (21%) |
| - Moderate density treatment | - Undifferentiated flows and clastic rocks (56%); basalt and andesite (44%) |
| - Variable density treatment | - Undifferentiated flows and clastic rocks (88%); basalt and andesite (12%) |

| | |
|---|---|
| Elevation range (feet, (meters)) | |
| - Control | 1,916 - 2,106 (584 - 642) |
| - High density treatment | 2,083 - 2,365 (635 - 721) |
| - Moderate density treatment | 1,827 - 2,310 (557 - 704) |
| - Variable density treatment | 1,919 - 2,080 (585 - 634) |

| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| - Control | 1 | 1 | 3 | 4 | 14 | 21 | 41 | 14 |
| - High density treatment | 9 | 0 | 0 | 0 | 7 | 19 | 33 | 33 |
| - Moderate density treatment | 33 | 2 | 0 | 0 | 1 | 7 | 21 | 37 |
| - Variable density treatment | 0 | 2 | 2 | 3 | 17 | 42 | 25 | 8 |

| Slope steepness (% area in each slope class) | 0%-30% | 30%-60% | >60% |
|---|---|---|---|
| - Control | 97 | 3 | 0 |
| - High density treatment | 100 | 0 | 0 |
| - Moderate density treatment | 77 | 23 | 0 |
| - Variable density treatment | 100 | 0 | 0 |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Kinney (90%); Other (10%) |
| - High density treatment | - Wilhoit-Zygore (80%); Zygore (18%); Other (2%) |
| - Moderate density treatment | - Aschoff (35%); Wilhoit-Zygore (33%); Kinney (26%); Other (6%) |
| - Variable density treatment | - Wilhoit-Zygore (57%); Klickitat-Kinney (42%); Other (1%) |
| NOTE: soil series and complexes are defined in the Clackamas County Soil Survey | |
| Mean annual precipitation (inches) | 75 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Oxalis oregana (83%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (17%) |
| - High density treatment | - Tsuga heterophylla/Oxalis oregana (80%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (20%) |
| - Moderate density treatment | - Tsuga heterophylla/Oxalis oregana (100%) |
| - Variable density treatment | - Tsuga Heterophylla/Oxalis oregana (56%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (44%) |
| Site index (Kings) | 122 |

3. Site planning

| | |
|---|---|
| RMP (name and date) | Salem District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | Matrix (General Forest), Riparian Reserve |
| Watershed analysis (name and date) | Eagle Creek, 1995 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | Delph Creek Density Management Project |
| - Number | # OR080-97-21 |
| - Date decision document signed | 8/17/98 |
| Site potential tree height (feet) | 200 feet |
| Aerial photography (years available) | Standard (1:12000) - 1956, 1967, 1970, 1977, 1982, 1988, 1993, 1998, 2003; low-elevation (1:2400) 2002 |

4. Study design

| | |
|---|---|
| Site selection criteria | Selected as a back-up site after the initial site for the northern Cascade Range in Oregon (Lookout Point, TRS 1S-5E-13) was dropped due to concerns from the City of Portland; site met minimum unit size and age range criteria, economically viable |
| Treatment assignment (rationale) | |
| - High retention unit | Random assignment to one of two available units |
| - Moderate retention unit | Random assignment to one of two units suitable for the riparian buffer studies |
| - Variable retention unit | Random assignment to one of two available units |
| - Control | Random assignment to one of two units suitable for the riparian buffer studies |
| | Note: Two units with streams were suitable for the riparian buffer studies and assigned to the moderate and control treatments; the two remaining units without streams were available for the high and variable treatments |
| Subtreatment location (rationale) | |
| - Leave islands | Primary goal was to maximize post-treatment horizontal diversity; some leave areas were selected to protect late-successional habitat features (large remnant live and dead trees, large logs, hardwood patches) |
| - Patch cuts | Patch cuts were interspersed throughout the treatment block to maximize post-treatment horizontal diversity |
| - Variable thinning density areas | A unique layout design was used with the internal unit boundaries parallel to one another for the 120 TPA and 80 TPA areas, and circular 40 TPA areas distributed among both the 120 TPA and the 80 TPA areas |
| Nonstandard treatments (type, location, rationale) | 1. A single two-acre 40 TPA area and three two-acre 20 TPA areas were placed near the road separating the moderate and high density treatments for demonstration and field tour purposes; these areas were subsequently excluded from the formal measured treatments<br>2. Following harvest, 352 trees were treated under a service contract to create snag habitat; all trees were located in riparian buffers and were at least 20 inches DBH; 86 trees were topped and 133 were top-girdled 20 feet from the top, or at a 6-inch minimum top diameter; another 133 trees were girdled 60 feet from the ground; this work began in October 2002 and was completed in March 2003<br>3. An unknown number of yarding corridor trees were left on the ground as fresh log habitat; these trees were at least 20 inches DBH and most were located near the end of yarding corridors close to riparian buffers<br>4. Two ¼-acre areas along the field tour trail were planted with western hemlock and western redcedar for demonstration purposes; these underplanted areas are in the thinned portion of the moderate treatment unit, and in the middle of a one-acre leave island (A-11) in the heavy treatment |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut (1935-38), seed trees may have been left and subsequently removed |
| Regeneration method | Natural |
| Post-harvest slash treatment | On-the-ground evidence indicates broadcast burning, unconfirmed |
| Precommercial thinning | 1974, 14 x 14 spacing |
| Prior commercial thinning | None |
| Comments | Evidence of steam donkey logging on site |

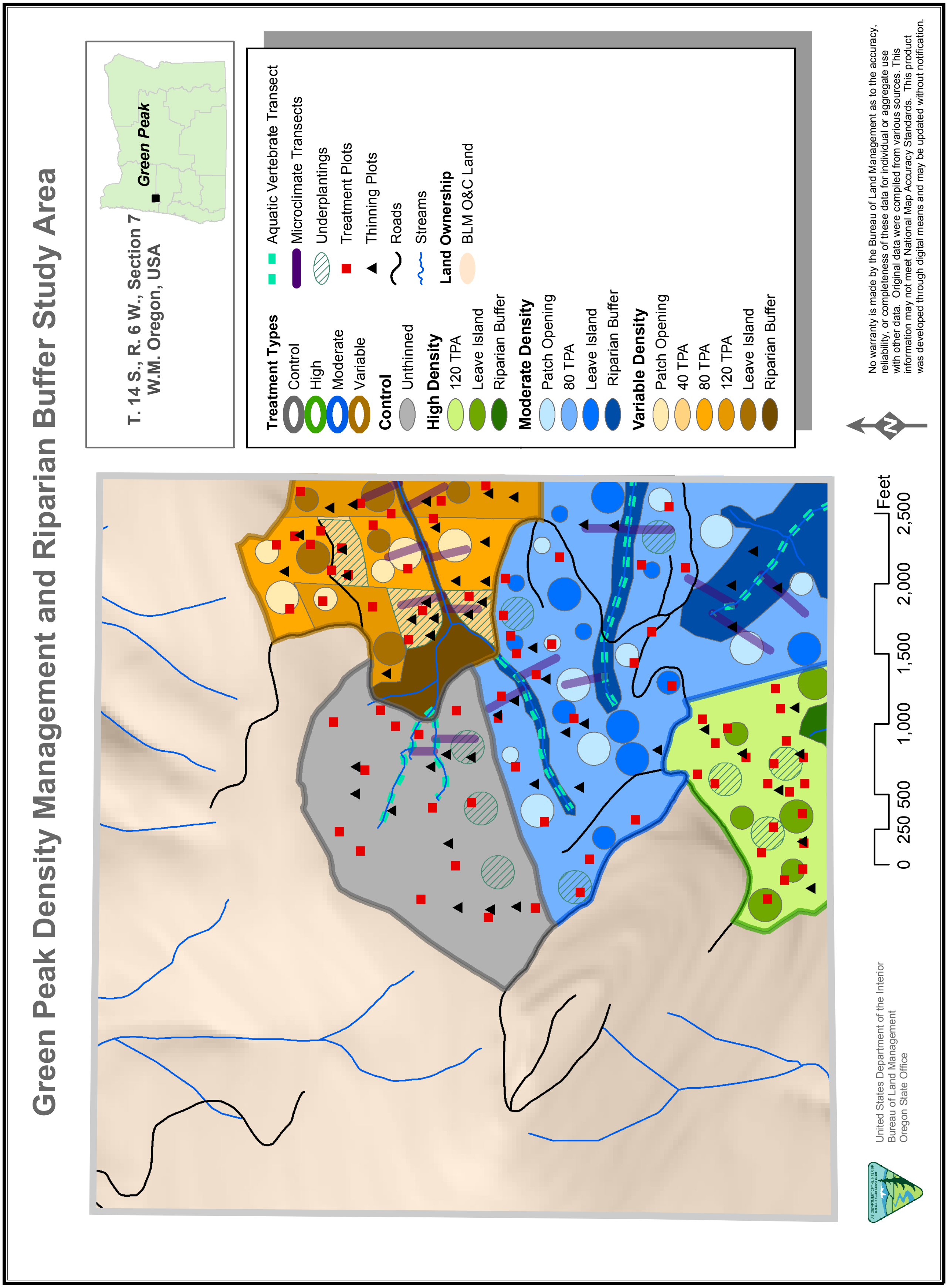
B. DMS - first treatment

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) with the following specifications:<br>- merchantable dead, down, and dying trees less than 20 inches in diameter (DBH) were marked for removal; larger dead, down, and dying trees were reserved<br>- all tree species other than Douglas-fir were favored for retention within 50 feet of root rot infection centers<br>- all trees in the genetics program ("Plus trees") were reserved |
| Timber sale | |
| - Sale name | Delph Creek |
| - Sale number | 98-501 |
| - Sale award date | 12/09/98 |
| - Sale closing date | 12/11/01 |
| - Sale price for all study units (total for all species and sizes) | $576,800 |
| Logging dates | |
| - High retention unit | 01/00 - 03/00 |
| - Moderate retention unit | 01/00 - 04/00 |
| - Variable retention unit | 01/00 - 07/00 |
| Logging systems | |
| - High retention unit | cable yarding |
| - Moderate retention unit | tractor yarding |
| - Variable retention unit | tractor yarding |
| Merchantability standards | All marked trees greater than 7 inches DBH were elgible for removal; all trees less than 7 inches DBH were retained |
| Slash treatment | Lop and scatter slash within 25 feet of Road 4-5E-3.0 (main road that crosses Delph Creek); slash on landings was piled, some piles were burned and some remain on site |

| | |
|---|---|
| Underplanting date | 03/2001 (high and moderate units), 03/2002 (variable density unit) |
| Comments | None |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 55.1 (22.3) | 100.0 |
| High density | | |
| - Thinned (120 TPA) | 54.6 (22.1) | 86.4 |
| - Leave islands | 6.7 (2.7) | 10.7 |
| - Riparian buffers | 1.8 (.7) | 2.9 |
| Total | 63.1 (25.6) | 100.0 |
| Moderate density | | |
| - Thinned (80 TPA) | 89.7 (36.3) | 78.1 |
| - Leave islands | 7.3 (2.9) | 6.3 |
| - Patch cuts | 7.2 (2.9) | 6.3 |
| - Riparian buffers | 10.7 (4.3) | 9.3 |
| Total | 114.8 (46.5) | 100.0 |
| Variable density | | |
| - Thinned (120 TPA) | 24.8 (10.0) | 37.6 |
| - Thinned (80 TPA) | 22.6 (9.1) | 34.2 |
| - Thinned (40 TPA) | 6.5 (2.6) | 9.9 |
| - Leave islands | 7.2 (2.9) | 11.0 |
| - Patch cuts | 4.8 (1.9) | 7.2 |
| Total | 65.8 (26.6) | 100.0 |
| Total | 298.9 (121.0) | |


Green Peak Density Management and Riparian Buffer Study Area
T. 14 S., R. 6 W., Section 7
W.M. Oregon, USA
Green Peak
Treatment Types
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Riparian Buffer
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Riparian Buffer
Aquatic Vertebrate Transect
Microclimate Transects
Underplantings
Treatment Plots
Thinning Plots
Roads
Streams
Land Ownership
BLM O&C Land
N
0 250 500 1,000 1,500 2,000 2,500
Feet
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## Green Peak

**Compiled by:** Hugh Snook (BLM, Salem District)

### 1. Site location

| | |
|---|---|
| Township | 14 South |
| Range | 6 West |
| Section | 7 |
| Latitude | N44º22’00.0” |
| Longitude | W123º27’ 30.0” |
| BLM District | Salem |
| BLM Resource Area | Marys Peak |
| County | Benton County |

### 2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Tyee formation (62%); mafic intrusions (38%) | | | | | | | |
| - High density treatment | - Tyee formation (100%) | | | | | | | |
| - Moderate density treatment | - Tyee formation (51%); mafic intrusions (49%) | | | | | | | |
| - Variable density treatment | - Tyee formation (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 1,860 - 2,510 (567 - 765) | | | | | | | |
| - High density treatment | 1,719 - 2,352 (524 - 717) | | | | | | | |
| - Moderate density treatment | 1,549 - 2,431 (472 - 741) | | | | | | | |
| - Variable density treatment | 1,657 - 1,991 (505 - 607) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 18 | 37 | 29 | 14 | 1 | 0 | 0 | 1 |
| - High density treatment | 0 | 1 | 33 | 57 | 9 | 0 | 0 | 0 |
| - Moderate density treatment | 14 | 27 | 26 | 28 | 2 | 1 | 0 | 2 |
| - Variable density treatment | 33 | 10 | 18 | 32 | 2 | 0 | 0 | 5 |
| Slope steepness(% area in each slope class) | 0%-30% | | 30%-60% | | >60% | | | |
| - Control | 40 | | 58 | | 2 | | | |
| - High density treatment | 12 | | 83 | | 6 | | | |
| - Moderate density treatment | 57 | | 42 | | 1 | | | |
| - Variable density treatment | 66 | | 31 | | 2 | | | |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Fiverivers-Grassmountain-Chintimini (35%); Oldblue-Burntwoods (23%); Burntwoods-Oldblue (22%); Murtip-Giveout-Laderly (11%); Other (9%) |
| - High density treatment | - Fiverivers-Grassmountain-Chintimini (67%); Caterl-Murtip-Laderly (27%); Other (6%) |
| - Moderate density treatment | - Burntwoods-Oldblue (32%); Fiverivers-Grassmountain-Chintimini (22%); Murtip-Giveout-Laderly (15%); Shivigny-Honeygrove (15%); Caterl-Murtip-Laderly (10%); Other (6%) |
| - Variable density treatment | - Murtip-Giveout-Laderly (58%); Oldblue-Burntwoods (22%); Klistan-Harslow (17%); Other (3%) |
| NOTE: soil series and complexes are defined in the Benton County Soil Survey | |
| Mean annual precipitation (inches) | 55 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Oxalis oregana (44%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (33%); Tsuga heterophylla/Achlys triphylla-dry (11%); Tsuga heterophylla/Vaccinium alaskense-Oxalis oregana (11%) |
| - High density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (67%); Tsuga heterophylla/Oxalis oregana (33%); |
| - Moderate density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (57%); Tsuga heterophylla/Achlys triphylla-dry (21%); Tsuga heterophylla/Oxalis oregana (21%) |
| - Variable density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (61%); Tsuga heterophylla/Achlys triphylla-dry (22%); Tsuga heterophylla/Oxalis oregana (17%) |
| Site index (Kings) | 123 |

## 3. Site planning

| | |
|---|---|
| RMP (name and date) | Salem District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | Late-Successional Reserve, Riparian Reserve |
| Watershed analysis (name and date) | Benton Foothills, 1997 |
| LSR assessment (name and date) | Oregon Coast Province – Southern Portion, 1996 |
| Environmental assessment | |
| - Name | Green Peak Density Management |
| - Number | OR-080-97-25 |
| - Date decision document signed | 09/24/98 |

| | |
|---|---|
| Site potential tree height (feet) | 220 |
| Aerial photography (years available) | Standard (1:12000) - 1977, 1982, 1988, 1998, 2003; orthophotos - 1993, 2002 (Weyerhaeuser Company provided) |

4. Study design

| | |
|---|---|
| Site selection criteria | Placed in a late-successional reserve because of limited suitable lands elsewhere; site met minimum unit size and age range criteria, economically viable |
| Treatment assignment (rationale) | |
| - High retention unit | Assigned by default, no streams present or needed |
| - Moderate retention unit | Unit best for alternative riparian buffer treatments because of multiple independent streams |
| - Variable retention unit | Placed where a stream is present to create additional sampling opportunities for the microclimate study |
| - Control | Unit contains streams for the riparian buffer studies and avoids road construction<br><br>Note: First priority was to select two units with streams for the moderate and control treatments to accommodate the riparian buffer studies |
| Subtreatment location (rationale) | |
| - Leave islands | Several islands were used to protect species under the "Survey and Manage" guidelines in effect at the time of the timber sale (see below); otherwise islands were distributed to promote horizontal diversity and to facilitate logging operations |
| - Patch cuts | Distributed to promote horizontal diversity and to facilitate logging operations |
| - Variable thinning density areas | Located to create sampling opportunities for the microclimate study |
| Nonstandard treatments (type, location, rationale) | 1. Leave island locations were located to protect identified "Survey and Manage" species<br><br>- Leave island #8 in moderate density treatment moved to include: *Craterellus neotubaeformis, Cantharellus formosus, Galerina atkinsoniana, Galerina uiltiformis, Stropharia olbivelata*, and *Gyromitra esculenta*<br>- Leave island #13 in moderate density treatment was moved to include *Phaeocollybia* sp. and *Gomphus clavatus*.<br>- Leave island #3 in moderate density treatment moved to include lichens: *Sticta limbata, Nephroma laevigatum, Peltigera collina, Peltigera pacifica, Fuscopannaria saubinetti, Lobaria oregana, Lobaria pulmonaria, Pseudocyphellaria anthraspis*.<br>- Leave island #12 in moderate density treatment was moved to include *Sarcosoma mexicana*.<br>- *Otidea onotica* protected by reserving several trees around site. |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut (1933-1935), seed trees may have been left and subsequently removed; area was grazed for several years after timber harvest; a forest fire burned the area in 1943 |
| Regeneration method | Natural |
| Post-harvest slash treatment | None, though a forest fire burned the area in 1943 |
| Precommercial thinning | None |
| Prior commercial thinning | None |
| Comments | Cattle grazing occurred in the early years of stand establishment; concrete watering trough found on site |

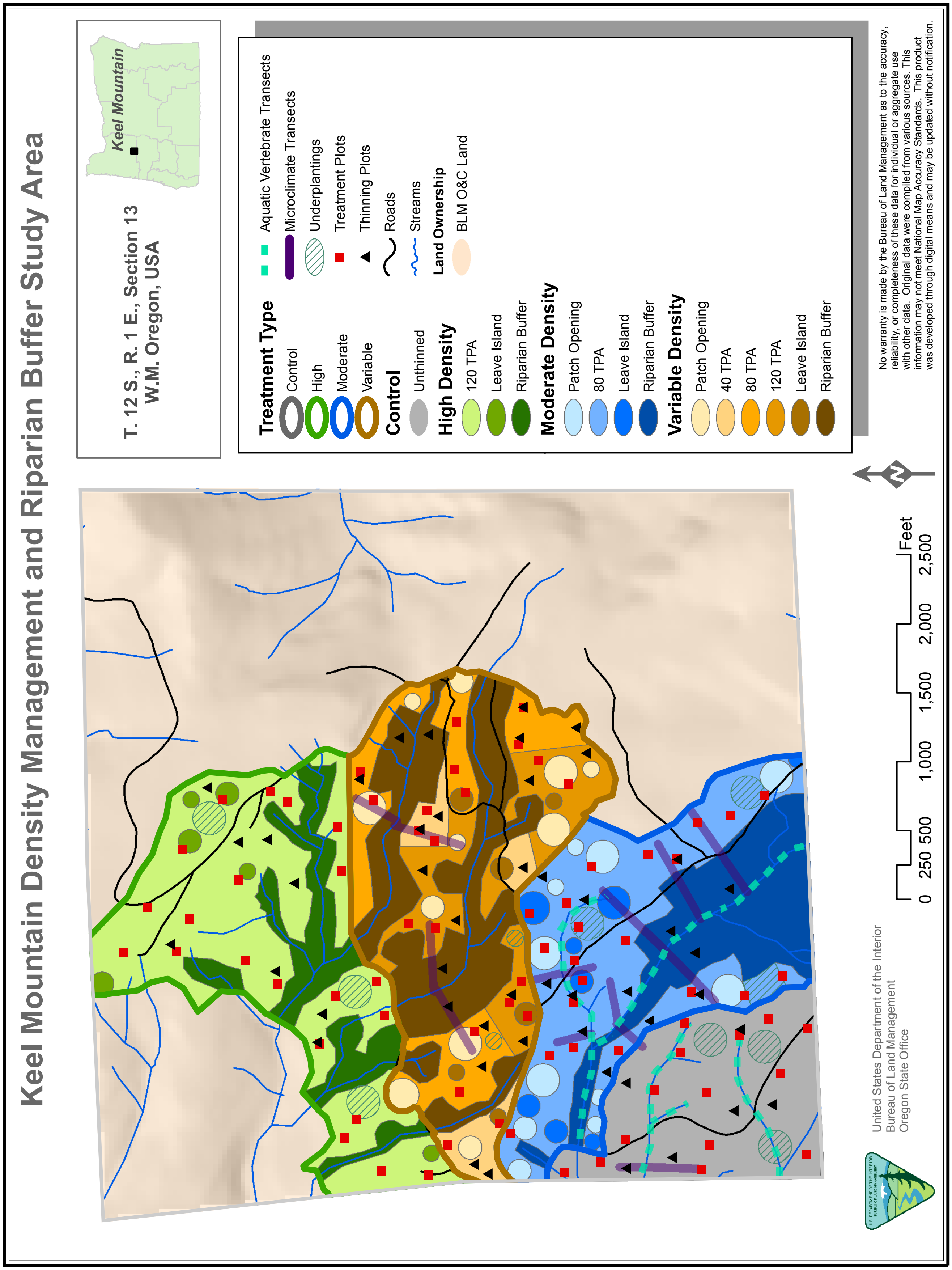
B. DMS - first treatment

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) with the following specifications:<br>- trees <5 inches DBH were reserved from cutting or damage<br>- trees ≥30 inches DBH were reserved<br>- genetic program “plus” tree was reserved ( one occurs in the northwest corner of the Variable Density treatment) and protected with a two-tree wide buffer |
| Timber Sale | |
| - Sale name | Green Peak |
| - Sale number | OR080-TS99-302 |
| - Sale award date | 10/30/99 |
| - Sale closing date | 06/29/00 |
| - Sale price for study units, total for all species and sizes | $638,765 |
| Logging dates | |
| - High retention unit | 10/1999-02/2000 |
| - Moderate retention unit | 10/1999-02/2000 |
| - Variable retention unit | 10/1999-11/1999 |
| Logging systems | |
| - High retention unit | Cable yarding |
| - Moderate retention unit | Cable yarding, except for ground-based yarding between Forest Road 14-6-17.1 and Forest Road 14-6-7.4, and on the lower half of the ridge between the variable width-buffered stream and the streamside retention-buffered stream |
| - Variable retention unit | Cable yarding, except for ground-based yarding above Forest Road 14-6-7.5 |
| Merchantability standards | Minimum diameter limit set at 5 inches DBH |
| Slash treatment | Slash within 30 feet of landings was piled (01/2000) and burned (11/2001) |

| | |
|---|---|
| Underplanting date | 03/2000 |
| Comments | 1. Adjacent private land in section 14-6-18, along south boundary, and 14-6-8, southwest quarter section along east boundary, was clearcut harvested in 2003<br>2. A snow and ice storm in January 2004 resulted in significant top snap, breakage, and downed trees in the moderate unit; effects were concentrated at upper unit edge and on both sides of the 14-6-7.4 road.<br>3. South slope below 14-6-7.5 road contains relatively shallow soils, and is rockier and drier with a component of golden chinkapin (*Castanopsis chrysophylla)*) |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 57.0 (23.1) | 100.0 |
| High density | | |
| - Thinned (120 TPA) | 28.3 (11.5) | 83.4 |
| - Leave islands | 4.5 (1.8) | 13.2 |
| - Riparian buffers | 1.2 (.5) | 3.4 |
| Total | 34.0 (13.8) | 100.0 |
| Moderate density | | |
| - Thinned (80 TPA) | 76.5 (31.0) | 67.0 |
| - Leave islands | 7.8 (3.1) | 6.8 |
| - Patch cuts | 7.3 (2.9) | 6.4 |
| - Riparian buffers | 22.7 (9.2) | 19.9 |
| Total | 114.2 (46.2) | 100.0 |
| Variable density | | |
| - Thinned (120 TPA) | 14.4 (5.8) | 27.1 |
| - Thinned (80 TPA) | 14.3 (5.8) | 27.0 |
| - Thinned (40 TPA) | 7.3 (3.0) | 13.8 |
| - Leave islands | 4.5 (1.8) | 8.5 |
| - Patch cuts | 4.5 (1.8) | 8.5 |
| - Riparian buffers | 8.0 (3.3) | 15.2 |
| Total | 53.0 (21.4) | 100.0 |
| Total | 258.1 (104.5) | |


Keel Mountain Density Management and Riparian Buffer Study Area
T. 12 S., R. 1 E., Section 13
W.M. Oregon, USA
Keel Mountain
Treatment Type
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Riparian Buffer
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Riparian Buffer
Aquatic Vertebrate Transects
Microclimate Transects
Underplantings
Treatment Plots
Thinning Plots
Roads
Streams
Land Ownership
BLM O&C Land
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0 250 500 1,000 1,500 2,000 2,500
Feet
N
United States Department of the Interior
Bureau of Land Management
Oregon State Office

## Keel Mountain

**Compiled by:** Charley Thompson (BLM, Salem District)

1. Site location

| | |
|---|---|
| Township | 12 South |
| Range | 01 East |
| Section | 13 |
| Latitude | N44º31’41.0” |
| Longitude | W122º37’55.0” |
| BLM District | Salem |
| BLM Resource Area | Cascades |
| County | Linn |

2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Undifferentiated tuffaceous sedimentary rocks, tuffs, and basalt (100%) | | | | | | | |
| - High density treatment | - Undifferentiated tuffaceous sedimentary rocks, tuffs, and basalt (100%) | | | | | | | |
| - Moderate density treatment | - Undifferentiated tuffaceous sedimentary rocks, tuffs, and basalt (100%) | | | | | | | |
| - Variable density treatment | - Undifferentiated tuffaceous sedimentary rocks, tuffs, and basalt (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 2,146 - 2,421 (654 - 738) | | | | | | | |
| - High density treatment | 2,024 - 2,434 (617 - 742) | | | | | | | |
| - Moderate density treatment | 2,162 - 2,520 (659 - 768) | | | | | | | |
| - Variable density treatment | 2,162 - 2,480 (659 - 756) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 2 | 0 | 0 | 0 | 2 | 28 | 50 | 18 |
| - High density treatment | 6 | 0 | 0 | 0 | 22 | 28 | 13 | 31 |
| - Moderate density treatment | 18 | 2 | 0 | 0 | 6 | 45 | 19 | 10 |
| - Variable density treatment | 15 | 0 | 0 | 0 | 9 | 10 | 21 | 44 |
| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% | | | | | |
| - Control | 97 | 3 | 0 | | | | | |
| - High density treatment | 83 | 16 | 0 | | | | | |
| - Moderate density treatment | 91 | 9 | 0 | | | | | |
| - Variable density treatment | 89 | 10 | 0 | | | | | |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Blachly (99%); Other (1%) |
| - High density treatment | - Kinney (62%); Harrington- Klickitat (38%) |
| - Moderate density treatment | - Kinney (65%); Blachly (22%); Other (13%) |
| - Variable density treatment | - Kinney (100%) |
| NOTE: soil series and complexes are defined in the Linn County Soil Survey | |
| Mean annual precipitation (inches) | 65 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Oxalis oregana (100%) |
| - High density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (50%); Tsuga heterophylla/Oxalis oregana (38%); Tsuga heterophylla/Achlys triphylla-dry (13%) |
| - Moderate density treatment | - Tsuga heterophylla/Oxalis oregana (77%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (23%) |
| - Variable density treatment | - Tsuga heterophylla/Oxalis oregana (76%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (24%) |
| Site index (Kings) | 127 |

3. Site planning

| | |
|---|---|
| RMP (name and date) | Salem District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | Matrix (General Forest), Riparian Reserve |
| Watershed analysis (name and date) | Hamilton Creek, 1995 |
| Environmental assessment | |
| - Name | Keel Mountain |
| - Number | OR080-96-28 |
| - Date decision document signed | 11/4/96 |
| Site potential tree height (feet) | 240 |
| Aerial photography (years available) | Standard (1:12000) - 1956, 1959, 1967, 1977, 1982, 1988, 1993, 1998, 2003 |

4. Study design

| | |
|---|---|
| Site selection criteria | Picked from one of three sites under consideration because it had multiple streams suitable for the riparian buffer study; site met minimum unit size and age range criteria, economically viable |
| Treatment assignment (rationale) | |
| - High retention unit | Default after the other three treatments were assigned |
| - Moderate retention unit | Unit best for alternative riparian buffer treatments because of multiple stream reaches |
| - Variable retention unit | Unit assigned because flatter ground made it much easier to lay out this complex treatment |
| - Control | Unit contained a stream suitable for the riparian buffer studies, and the location facilitates field tours |
| | Note: First priority was to select two units with streams for the moderate and control treatments to accommodate the riparian buffer studies |
| Subtreatment location (rationale) | |
| - Leave islands | One-acre leave areas selected to protect habitat features thought to benefit lichens and bryophytes (large remnant live and dead trees, large logs, hardwood patches); ½ and ¼ acreleave areas were located to protect tree improvement parent trees, or to maximize horizontal variability; logging systems constrained locations |
| - Patch cuts | Patch cuts were located in *Phellinus weirii* infection centers, or to promote horizontal variability; logging systems and plots from the collaborative lichen study constrained locations |
| - Variable thinning density areas | Thinned areas were interspersed throughout the unit to maximize horizontal diversity<br>Note: there is a five–page description in the files describing Keel Mountain leave island and patch cut layout in detail |
| Nonstandard treatments (type, location, rationale) | 1. The collaborative lichen study resulted in additional one-acre leave islands (one additional in the high retention unit, two additional in the moderate retention unit, two additional in the variable retention unit), and forced some patch cuts to be located adjacent to each other |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut (1949-53), seed trees may have been left and subsequently removed |
| Regeneration method | Natural regeneration, except that approximately 12 acres in the eastern portions of the moderate and variable density units were planted in 1958-59 |
| Post-harvest slash treatment | None; general area was extensively “desnagged” around 1960 as part of a fire hazard reduction effort resulting in an abundance of large logs on site |
| Precommercial thinning | PCT on a 14 x 14 spacing in 1971-72 |
| Prior commercial thinning | None |
| Comments | Tractor yarding; some evidence of railroad yarding also, unconfirmed |

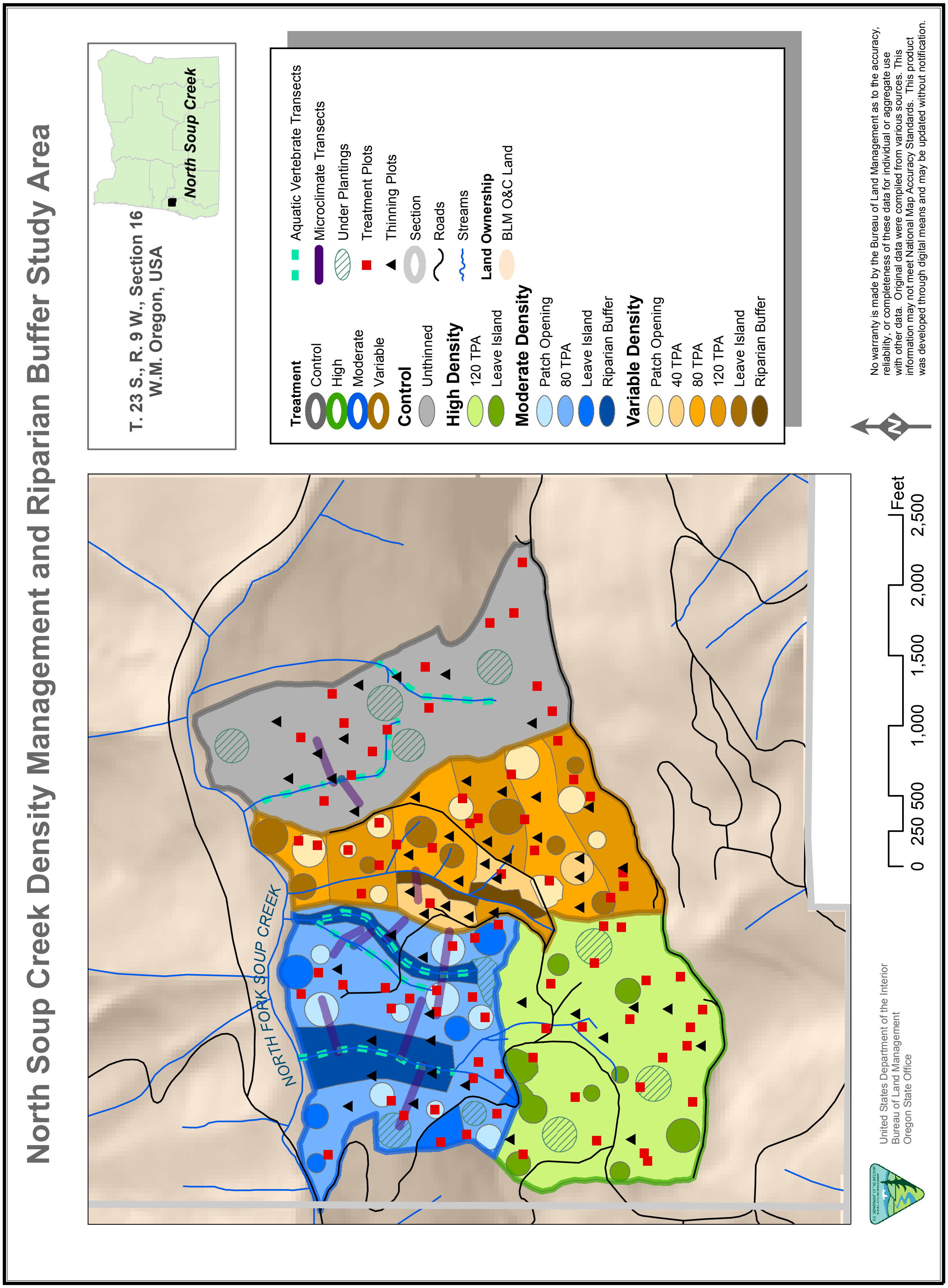
B. DMS - first treatment

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) with the following specifications:<br>- reserve genetics program parent trees<br>- reserve trees should have crown ratios of at least 40%<br>- mark western hemlock infected with dwarf mistletoe to cut<br>- leave extra growing space around western redcedar and hardwoods |
| Timber Sale | |
| - Sale name | Keel Mountain |
| - Sale number | OR080-TS7-507 |
| - Sale award date | 01/23/97 |
| - Sale closing date | 09/27/00 |
| - Sale price for study units, total for all species and sizes | $623,798 |
| Logging dates | |
| - High retention unit | 07/1997-02/1998 |
| - Moderate retention unit | 07/1997-09/1998 |
| - Variable retention unit | 07/1997-09/1998 |
| Logging systems | |
| - High retention unit | Cable yarding |
| - Moderate retention unit | Ground-based yarding |
| - Variable retention unit | Ground-based yarding |
| Merchantability standards | All marked trees greater than 7 inches DBH were elgible for removal; all trees less than 7 inches DBH were retained |

| | |
|---|---|
| Slash treatment | Lop and scatter slash within 25 feet of Road 12-1E-14.03 (main road thru middle of sale area); slash on landings was piled, some piles were burned and some remain on site |
| Underplanting date | 03/1999 |
| Comments | |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 44.9 (18.1) | 100.0 |
| High density | | |
| - Thinned (120 TPA) | 62.1 (25.1) | 71.8 |
| - Leave islands | 2.3 (0.9) | 2.7 |
| - Riparian buffers | 22.1 (8.9) | 25.6 |
| Total | 86.4 (35.0) | 100.0 |
| Moderate density | | |
| - Thinned (80 TPA) | 44.7 (18.1) | 51.4 |
| - Leave islands | 4.3 (1.7) | 5.0 |
| - Patch cuts | 7.1 (2.9) | 8.2 |
| - Riparian buffers | 30.8 (12.5) | 35.4 |
| Total | 87.0 (35.2) | 100.0 |
| Variable density | | |
| - Thinned (120 TPA) | 17.6 (7.1) | 17.9 |
| - Thinned (80 TPA) | 19.3 (7.8) | 19.6 |
| - Thinned (40 TPA) | 7.9 (3.2) | 8.0 |
| - Leave islands | 2.3 (0.9) | 2.3 |
| - Patch cuts | 7.4 (3.0) | 7.5 |
| - Riparian buffers | 44.0 (17.8) | 44.6 |
| Total | 98.6 (39.9) | 100.0 |
| Total | 316.9 (128.2) | |


North Soup Creek Density Management and Riparian Buffer Study Area
T. 23 S., R. 9 W., Section 16
W.M. Oregon, USA
North Soup Creek
Treatment
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Riparian Buffer
Aquatic Vertebrate Transects
Microclimate Transects
Under Plantings
Treatment Plots
Thinning Plots
Section
Roads
Streams
Land Ownership
BLM O&C Land
NORTH FORK SOUP CREEK
0 250 500 1,000 1,500 2,000 2,500
Feet
N
United States Department of the Interior
Bureau of Land Management
Oregon State Office
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## North Soup

**Compiled by:** Frank Price (BLM, Coos Bay District)

### 1. Site location

| | |
|---|---|
| Township | 23 South |
| Range | 09 West |
| Section | 16 |
| Latitude | N43º33’57.0” |
| Longitude | W123º46’38.0” |
| BLM District | Coos Bay |
| BLM Resource Area | Umpqua |
| County | Douglas |

### 2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Elkton formation and related rocks (100%) | | | | | | | |
| - High density treatment | - Elkton formation and related rocks (100%) | | | | | | | |
| - Moderate density treatment | - Elkton formation and related rocks (100%) | | | | | | | |
| - Variable density treatment | - Elkton formation and related rocks (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 587 - 1,345 (179 - 410) | | | | | | | |
| - High density treatment | 807 - 1,335 (246 - 407) | | | | | | | |
| - Moderate density treatment | 522 - 991 (159 - 302) | | | | | | | |
| - Variable density treatment | 577 - 1,348 (176- 411) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 23 | 1 | 0 | 1 | 1 | 0 | 7 | 66 |
| - High density treatment | 26 | 12 | 1 | 0 | 0 | 0 | 5 | 56 |
| - Moderate density treatment | 33 | 17 | 0 | 0 | 0 | 0 | 20 | 29 |
| - Variable density treatment | 12 | 8 | 0 | 1 | 0 | 0 | 37 | 41 |
| Slope steepness(% area in each slope class) | 0%-30% | | 30%-60% | | >60% | | | |
| - Control | 47 | | 46 | | 6 | | | |
| - High density treatment | 58 | | 32 | | 10 | | | |
| - Moderate density treatment | 53 | | 40 | | 7 | | | |
| - Variable density treatment | 35 | | 50 | | 15 | | | |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Absaquil-Blachly-McDuff (56%); McDuff-Absaquil-Blachly (22%); Digger-Bohannon-Umpcoos (15%); Other (7%) |
| - High density treatment | - Absaquil-Blachly-McDuff (60%); Digger-Bohannon-Umpcoos (25%); Digger-Bohannon (15%) |
| - Moderate density treatment | - Absaquil-Blachly-McDuff (28%); Digger-Bohannon-Umpcoos (26%); McDuff-Absaquil-Blachly (25%); Preacher-Bohannon-Blachly (21%) |
| - Variable density treatment | - Absaquil-Blachly-McDuff (44%); Digger-Bohannon-Umpcoos (32%); Preacher-Bohannon-Blachly (21%); Other (3%) |
| NOTE: soil series and complexes are defined in the Douglas County Soil Survey | |
| Mean annual precipitation (inches) | 85 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Oxalis oregana (60%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (30%); Tsuga heterophylla/Rhododendron macrophyllum-Mahonia nervosa (10%) |
| - High density treatment | - Tsuga heterophylla/Oxalis oregana (63%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (38%); |
| - Moderate density treatment | - Tsuga heterophylla/Oxalis oregana (92%); Other (8%) |
| - Variable density treatment | - Tsuga heterophylla/Oxalis oregana (59%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (27%); Tsuga heterophylla/Rhododendron macrophyllum-Mahonia nervosa (14%) |
| Site index (Kings) | 132 |

## 3. Site planning

| | |
|---|---|
| RMP (name and date) | Coos Bay District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | Late-Successional Reserve |
| Watershed analysis (name and date) | Mill Creek, 1995 |
| LSR assessment (name and date) | South Coast - Northern Klamath, 1998 |
| Environmental assessment | |
| - Name | North Soup Density Management Study |
| - Number | OR125-96-08 |
| - Date decision document signed | 07/22/96 |
| Site potential tree height (feet) | 200 |
| Aerial photography (years available) | Standard (1:12000) - 1952, 1960, 1965, 1970, 1981, 1986, 1992, 1997, 2002 |

4. Study design

| | |
|---|---|
| Site selection criteria | Site met minimum unit size and age range criteria, economically viable; streams and streamside vegetation suitable for the riparian buffer studies; candidate sites were very limited due to fragmentation from past timber harvests and highly dissected landforms |
| Treatment assignment (rationale) | |
| - High retention unit | The high retention treatment does not require streams for the riparian buffer studies and was assigned to a unit without streams |
| - Moderate retention unit | The selected unit had sufficient streams to accommodate a one site-potential-tree width buffer, a variable-width buffer with a patch cut on either side, and a streamside buffer |
| - Variable retention unit | This unit contains a stream to provide additional sampling opportunities for the microclimate study |
| - Control | This unit contains a stream for the riparian buffer studies, and would have required significant logging road construction costs if it were selected for an active treatment |
| | Note: First priority was to select two units with streams for the moderate and control treatments to accommodate the riparian buffer studies |
| Subtreatment location (rationale) | |
| - Leave islands | Dispersed throughout units; located to avoid yarding corridors; some islands were located to protect wet areas |
| - Patch cuts | Dispersed throughout units; two patch cuts were located next to the variable-width riparian buffer in the moderate treatment unit to accommodate the microclimate study |
| - Variable thinning density areas | Goal was to maximize structural and compositional diversity; high (120 TPA) and medium (80 TPA) density areas were placed on opposing sides of draws, and low density (40 TPA) areas were interspersed where they would fit |
| Nonstandard treatments (type, location, rationale) | 1. Three seed trees in the tree improvement program were left in the high retention unit and marked with red paint, tags, and painted orange above and below stump height |

5. Unit history

A. Pre-DMS

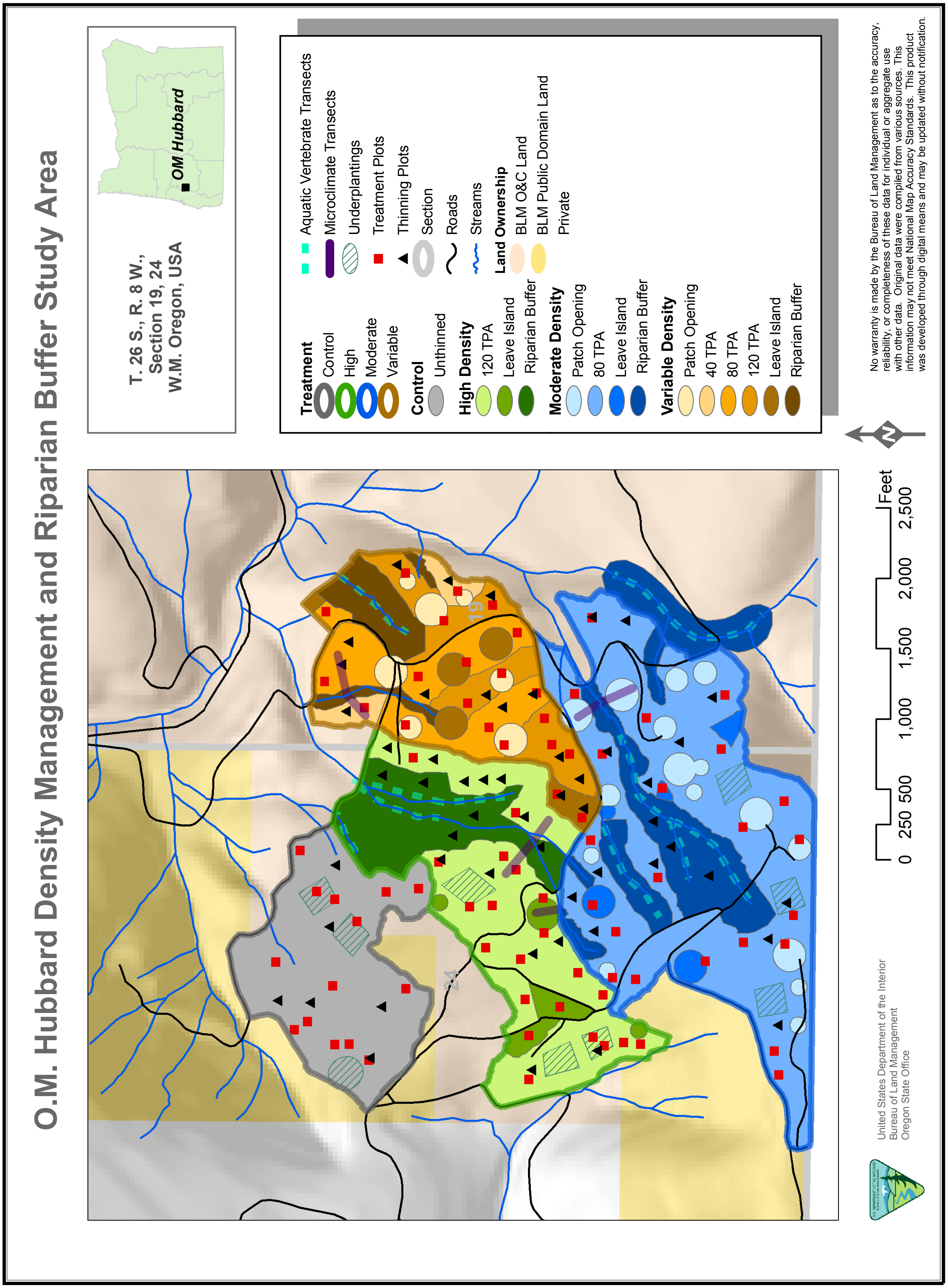
| | |
|---|---|
| Regeneration harvest method | Seed tree (prior to 1948); seed trees were likely removed during salvage sales in the project area in 1954 and/or 1956 |
| Regeneration method | Natural |
| Post-harvest slash treatment | Unknown |
| Precommercial thinning | None |
| Prior commercial thinning | None |
| Comment | BLM assumed management responsibility for this section in a 1948 land exchange |

B. DMS

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) |
| Timber Sale | |
| - Sale name | North Soup Density Management |
| - Sale number | OR120-TS96-09 |
| - Sale award date | 10/8/96 |
| - Sale closing date | 03/06/00 |
| - Sale price for study units, total for all species and sizes | $335,379 |
| Treatment date | |
| - High retention unit | North half - 08/1998; south half - 09/1999 |
| - Moderate retention unit | 08/1998 |
| - Variable retention unit | North of road - 08/1998; south of road - 09/1999 |
| Logging systems | |
| - High retention unit | Cable yard, one-end suspension |
| - Moderate retention unit | Cable yard, one-end suspension |
| - Variable retention unit | Cable yard, one-end suspension |
| Merchantability standards | Minimum TOP diameter limit set at 6 inches |
| Slash treatment | Slash within 20 feet of roads was piled and burned |
| Underplanting date | 02/2000 |
| Comments | 1. All new roads were blocked following slash disposal to reduce risks to aquatic ecosystems and reduce disturbance to wildlife<br>2. A snow, ice, and wind storm in early 2004 resulted in top and stem breakage and blowdown of scattered patches and individual trees throughout the study site |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 58.3 (23.6) | 100.0 |
| | | |
| High density | | |
| - Thinned (120 TPA) | 54.5 (22.1) | 91.0 |
| - Leave islands | 5.4 (2.2) | 9.0 |
| Total | 59.9 (24.3) | 100.0 |
| | | |
| Moderate density | | |
| - Thinned (80 TPA) | 33.6 (13.6) | 58.4 |
| - Leave islands | 5.3 (2.1) | 9.2 |
| - Patch cuts | 5.8 (2.3) | 10.0 |
| - Riparian buffers | 12.9 (5.2) | 22.4 |
| Total | 57.6 (23.3) | 100.0 |
| | | |
| Variable density | | |
| - Thinned (120 TPA) | 21.2 (8.6) | 36.9 |
| - Thinned (80 TPA) | 16.7 (6.8) | 29.1 |
| - Thinned (40 TPA) | 6.0 (2.4) | 10.5 |
| - Leave islands | 5.6 (2.3) | 9.8 |
| - Patch cuts | 5.6 (2.3) | 9.8 |
| - Riparian buffers | 2.2 (0.9) | 3.9 |
| Total | 57.3 (23.2) | 100.0 |
| | | |
| Total | 233.0 (94.3) | |


O.M. Hubbard Density Management and Riparian Buffer Study Area
T. 26 S., R. 8 W.,
Section 19, 24
W.M. Oregon, USA
OM Hubbard
Treatment
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Riparian Buffer
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Riparian Buffer
Aquatic Vertebrate Transects
Microclimate Transects
Underplantings
Treatment Plots
Thinning Plots
Section
Roads
Streams
Land Ownership
BLM O&C Land
BLM Public Domain Land
Private
19
24
0 250 500 1,000 1,500 2,000 2,500
Feet
N
United States Department of the Interior
Bureau of Land Management
Oregon State Office
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## OM Hubbard

**Compiled by:** Craig Kintop (BLM, Roseburg District)

### 1. Site location

| | |
|---|---|
| Township | 25 South/26 South |
| Range | 7 West/8 West |
| Section | 19/24 |
| Latitude | N43º17’30.0” |
| Longitude | W123º35’00.0” |
| BLM District | Roseburg |
| BLM Resource Area | Swiftwater |
| County | Douglas |

### 2. Site environment

| | |
|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | |
| - Control | - Tyee formation (100%) |
| - High density treatment | - Tyee formation (100%) |
| - Moderate density treatment | - Tyee formation (100%) |
| - Variable density treatment | - Tyee formation (100%) |

| | |
|---|---|
| Elevation range (feet, (meters)) | |
| - Control | 1,430 - 2,024 (436 - 617) |
| - High density treatment | 1,434 - 2,133 (437 - 650) |
| - Moderate density treatment | 1,411 - 2,569 (430 - 783) |
| - Variable density treatment | 1,293 - 1,713 (394 - 522) |

| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| - Control | 25 | 71 | 0 | 1 | 0 | 0 | 0 | 3 |
| - High density treatment | 14 | 46 | 5 | 1 | 0 | 9 | 15 | 10 |
| - Moderate density treatment | 28 | 44 | 15 | 1 | 0 | 0 | 3 | 8 |
| - Variable density treatment | 31 | 44 | 16 | 5 | 0 | 0 | 0 | 5 |

| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% |
|---|---|---|---|
| - Control | 37 | 61 | 2 |
| - High density treatment | 49 | 51 | 0 |
| - Moderate density treatment | 24 | 69 | 8 |
| - Variable density treatment | 75 | 24 | 1 |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Orford (72%); Gustin-Orford (20%); Other (8%) |
| - High density treatment | - Gustin-Orford (43%); Orford (24%); Fernhaven (23%); Other (10%) |
| - Moderate density treatment | - Preacher-Bohannon-Digger (27%); Gustin-Orford (24%); Orford (20%); Fernhaven (17%), Digger-Bohannon-Umpcoos (12%) |
| - Variable density treatment | - Gustin-Orford (91%); Other (98%) |
| NOTE: soil series and complexes are defined in the Douglas County Soil Survey | |
| Mean annual precipitation (inches) | 70 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Oxalis oregana (50%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (33%); Abies grandis/Toxicodendron diversilobum (17%) |
| - High density treatment | - Abies grandis/Toxicodendron diversilobum (50%); Abies grandis/Mahonia nervosa-Gaultheria shallon (31%); Tsuga heterophylla/Achlys triphylla-dry (13%); Other (6%) |
| - Moderate density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (31%); Tsuga heterophylla/Oxalis oregana (25%); Pseudotsuga menziesii/Holodiscus discolor-Whipplea modesta (13%); Abies grandis/Toxicodendron diversilobum (13%); Abies grandis/Mahonia nervosa-Gaultheria shallon (13%); |
| - Variable density treatment | - Abies grandis/Mahonia nervosa-Gaultheria shallon (54%); Abies grandis/Toxicodendron diversilobum (31%); Other (15%) |
| Site index (Kings) | 120 |

## 3. Site planning

| | |
|---|---|
| RMP (name and date) | Roseburg District Record of Decision and Resource Management Plan, June 1995 |
| RMP land use allocations | Matrix (General Forest), Riparian Reserve |
| Watershed analysis (name and date) | Upper Umpqua, 2003 |
| LSR assessment (name and date) | South Coast-Northern Klamath, May 1998 |
| Environmental assessment | |
| - Name | O.M. Hubbard |
| - Number | OR104-95-10 |
| - Date decision document signed | 09/26/1995 |

| | |
|---|---|
| Site potential tree height (feet) | 180 |
| Aerial photography (years available) | Standard (1:12,000) - 1964, 1970, 1978, 1983, 1989, 1994, 1999; Large scale - 2000 |

## 4. Study design

| | |
|---|---|
| Site selection criteria | Large (>200 acres), relatively uniform conifer stand, 40-50-years-old with no past commercial thinning, economically viable, streams available for riparian buffer studies |
| Treatment assignment (rationale) | |
| - High retention unit | Assigned by default, no streams present or needed |
| - Moderate retention unit | Assigned because unit contains streams for alternative riparian buffer treatments |
| - Variable retention unit | Placed where a stream is present to create additional sampling opportunities for the microclimate study; gentle topography facilitated implementation of this complex treatment |
| - Control | Unit contains streams for the riparian buffer studies and avoids road construction |
| | Note: First priority was to select two units with streams for the moderate and control treatments to accommodate the riparian buffer studies |
| Subtreatment location (rationale) | |
| - Leave islands | Placed to avoid logging conflicts |
| - Patch cuts | Placed to facilitate first entry, but placement of some patch cuts near landings may have rendered future entries more difficult |
| - Variable thinning density areas | Placed to facilitate efficient logging |
| Nonstandard treatments (type, location, rationale) | 1. Three sets of paired plots (1/10 acre each) from an old BLM precommercial thinning study (established 1970) are present in the study area, one pair in each of the variable, moderate and control treatments; trees are marked with one inch circular metal tags; plots were treated as leave islands |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut (1953-1955) following wildfire (August 1951) |
| Regeneration method | Artificial regeneration:<br>- 1955, Douglas-fir and ponderosa pine (off-site) in section 24 & north half of section 19<br>- 1956, Douglas-fir and ponderosa pine (off-site) in south half of section 19<br>- 1960, Douglas-fir in south half of section 19 (54 acres within the study site)<br>- 1963, spot seeding of ponderosa pine (off-site) in south half of section 19 (14 acres within the study site) |
| Post-harvest slash treatment | None |
| Precommercial thinning | 1970, 12’ x 12’ spacing |
| Prior commercial thinning | None |
| Comments | |

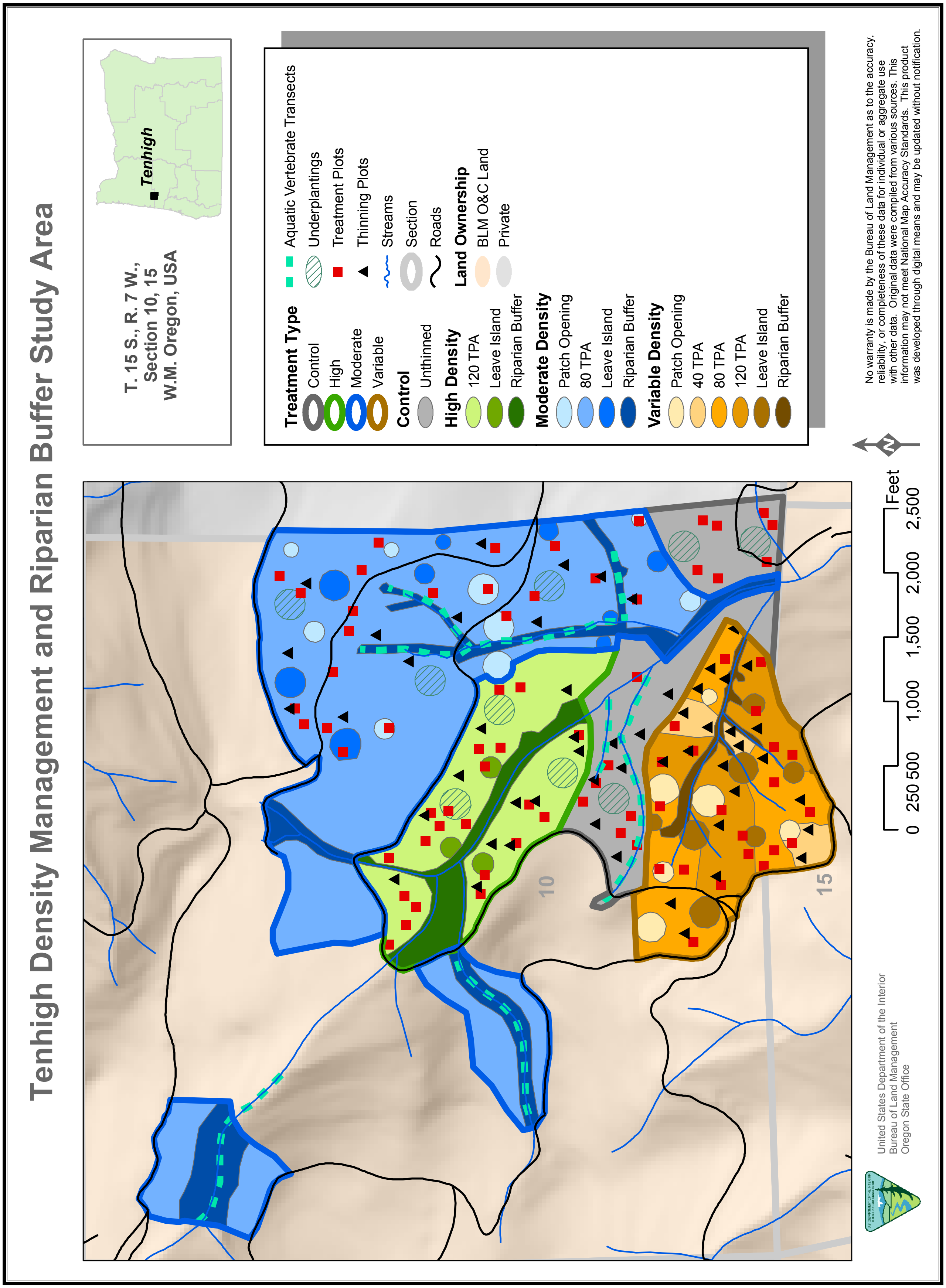
B. DMS - first treatment

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) with the following specifications:<br>- Largest, best-formed conifers were left on the spacing necessary to achieve the target density regardless of species |
| Timber Sale | |
| - Sale name | O.M. Hubbard Thinning |
| - Sale number | OR100-TS96-41 |
| - Sale award date | 11/03/95 |
| - Sale closing date | 12/14/98 |
| - Sale price for study units, total for all species and sizes | $422,742 |
| Logging dates | |
| - High retention unit | 07/1997 - 11/1997 |
| - Moderate retention unit | 07/1997 - 11/1997 |
| - Variable retention unit | 07/1997 - 11/1997 |
| Logging systems | |
| - High retention unit | Cable (80%), tractor (20%) |
| - Moderate retention unit | Cable (85%), tractor (15%) |
| - Variable retention unit | Tractor (85%), cable (15%) |
| Merchantability standards | Minimum diameter limit set at 6 inches DBH; purchaser was allowed but not required to cut submerchantable trees |
| Slash treatment | Slash within 25 feet of roads and in patch cuts was piled 01/1998 and burned in 12/1998; some patch cuts that had already been planted were not burned |

| | |
|---|---|
| Underplanting date | 12/1998 |
| Comments | Although there are no designated off-road vehicle trails, such vehicles are occasionally driven through the study site |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 38.8 (15.7) | 100.0 |
| High density | | |
| - Thinned (120 TPA) | 39.1(15.8) | 64.4 |
| - Leave islands | 4.3 (1.7) | 7.1 |
| - Riparian buffers | 17.3 (7.0) | 28.5 |
| Total | 60.7 (24.5) | 100.0 |
| Moderate density | | |
| - Thinned (80 TPA) | 64.9 (26.2) | 66.6 |
| - Leave islands | 3.2 (1.3) | 3.3 |
| - Patch cuts | 9.0 (3.6) | 9.2 |
| - Riparian buffers | 20.4 (8.3) | 20.9 |
| Total | 97.4 (39.4) | 100.0 |
| Variable density | | |
| - Thinned (120 TPA) | 12.6 (5.1) | 25.6 |
| - Thinned (80 TPA) | 15.4 (6.2) | 31.2 |
| - Thinned (40 TPA) | 3.4 (1.4) | 6.9 |
| - Leave islands | 4.9 (2.0) | 10.0 |
| - Patch cuts | 4.5 (1.8) | 9.2 |
| - Riparian buffers | 8.4 (3.4) | 17.1 |
| Total | 49.4 (20.0) | 100.0 |
| Total | 246.2 (99.6) | |


Tenhigh Density Management and Riparian Buffer Study Area
T. 15 S., R. 7 W.,
Section 10, 15
W.M. Oregon, USA
Tenhigh
Treatment Type
Control
High
Moderate
Variable
Control
Unthinned
High Density
120 TPA
Leave Island
Riparian Buffer
Moderate Density
Patch Opening
80 TPA
Leave Island
Riparian Buffer
Variable Density
Patch Opening
40 TPA
80 TPA
120 TPA
Leave Island
Riparian Buffer
Aquatic Vertebrate Transects
Underplantings
Treatment Plots
Thinning Plots
Streams
Section
Roads
Land Ownership
BLM O&C Land
Private
10
15
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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United States Department of the Interior
Bureau of Land Management
Oregon State Office

## Ten High

**Compiled by:** Peter O'Toole (BLM, Eugene District), Sharmila Premdas (BLM, Eugene District)

### 1. Site location

| | |
|---|---|
| Township | 15 South |
| Range | 07 West |
| Section | 10, 15 |
| Latitude | N44º16'50.0" |
| Longitude | W123º31'06.0" |
| BLM District | Eugene |
| BLM Resource Area | Siuslaw |
| County | Lane, Benton |

### 2. Site environment

| | |
|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | |
| - Control | - Tyee formation (100%) |
| - High density treatment | - Mafic intrusions (63%); Tyee formation (37%) |
| - Moderate density treatment | - Mafic intrusions (66%); Tyee formation (34%) |
| - Variable density treatment | - Tyee formation (100%) |

| | |
|---|---|
| Elevation range (feet, (meters)) | |
| - Control | 1,263 - 2,064 (385 - 629) |
| - High density treatment | 1,480 - 1,998 (451 - 609) |
| - Moderate density treatment | 1,260 - 2,854 (384 - 870) |
| - Variable density treatment | 1,322 - 2,123 (403 - 647) |

| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| - Control | 1 | 26 | 21 | 14 | 20 | 16 | 2 | 0 |
| - High density treatment | 8 | 28 | 5 | 14 | 43 | 3 | 0 | 0 |
| - Moderate density treatment | 5 | 4 | 6 | 29 | 45 | 11 | 0 | 1 |
| - Variable density treatment | 15 | 34 | 26 | 20 | 4 | 0 | 0 | 1 |

| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% |
|---|---|---|---|
| - Control | 29 | 66 | 5 |
| - High density treatment | 18 | 38 | 45 |
| - Moderate density treatment | 36 | 48 | 16 |
| - Variable density treatment | 34 | 56 | 11 |

| | |
|---|---|
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | |
| - Control | - Blachly-Kilowan (97%); Other (3%) |
| - High density treatment | - Blachly-Kilowan (40%); Harslow-Klistan-Rock (29%); Caterl-Laderly-Romanose (26%); Other (5%) |
| - Moderate density treatment | - Laderly-Murtip-Giveout (30%); Caterl-Laderly-Romanose (22%); Blachly-Kilowan (21%); Caterl-Murtip-Laderly (21%); Other (6%) |
| - Variable density treatment | - Blachly-Kilowan (64%); Honeygrove-Peavine (20%); Chintimini-Grassmountain (16%) |
| NOTE: soil series and complexes are defined in the Lane County and Benton County Soil Surveys | |
| Mean annual precipitation (inches) | 95 |
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (57%); Tsuga heterophylla/Oxalis oregana (43%) |
| - High density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (55%); Tsuga heterophylla/Achlys triphylla-dry (27%); Tsuga heterophylla/Oxalis oregana (18%) |
| - Moderate density treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (67%); Tsuga heterophylla/Achlys triphylla-dry (33%) |
| - Variable density treatment | - Tsuga heterophylla/Oxalis oregana (67%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (33%) |
| Site index (Kings) | 125 |

## 3. Site planning

| | |
|---|---|
| RMP (name and date) | Eugene District Record of Decision and Resource Management Plan, June 1995 |
| RMP land use allocations | Matrix (General Forest), Riparian Reserve |
| Watershed analysis (name and date) | Upper Lake Creek, 1995 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | The Ten High Density Management Study and Commercial Thinning |
| - Number | OR090-98-11 |
| - Date decision document signed | 04/14/1998 |
| Site potential tree height (feet) | 200 |
| Aerial photography (years available) | Standard (1:12000) - 1984, 1990, 1995, 2000, 2002 |

4. Study design

| | |
|---|---|
| Site selection criteria | Site met minimum unit size and age range criteria, economically viable; streams available for the riparian buffer studies; met goal for an interior Coast Range site in the matrix land use allocation |
| Treatment assignment (rationale) | |
| - High retention unit | Default after the other three treatments were assigned |
| - Moderate retention unit | Unit best for alternative riparian buffer treatments because of multiple stream reaches |
| - Variable retention unit | This unit contains a stream to provide additional sampling opportunities for the microclimate study |
| - Control | This unit contains a stream for the riparian buffer studies, and would have resulted in significantly greater soil disturbance if it were selected for an active treatment |
| | Note: First priority was to select two units with streams for the moderate and control treatments to accommodate the riparian buffer studies |
| Subtreatment location (rationale) | |
| - Leave islands | Distributed throughout study units to maximize horizontal diversity and facilitate efficient logging |
| - Patch cuts | Distributed throughout study units to maximize horizontal diversity and facilitate efficient logging; two one-acre patch cuts in the moderate density unit, and two ½-acre patch cuts in the variable density unit, were placed for the microclimate study |
| - Variable thinning density areas | Interspersed to maximize horizontal diversity and facilitate efficient logging |
| Nonstandard treatments (type, location, rationale) | 1. Two riparian buffer treatments (one-tree height, and streamside) are located in two different thinning units to the west of the primary study units; units do not contain leave islands or patch cuts and are only being sampled as part of the riparian buffer studies |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut (1946) |
| Regeneration method | Natural |
| Post-harvest slash treatment | None |
| Precommercial thinning | 1972 |
| Prior commercial thinning | None |

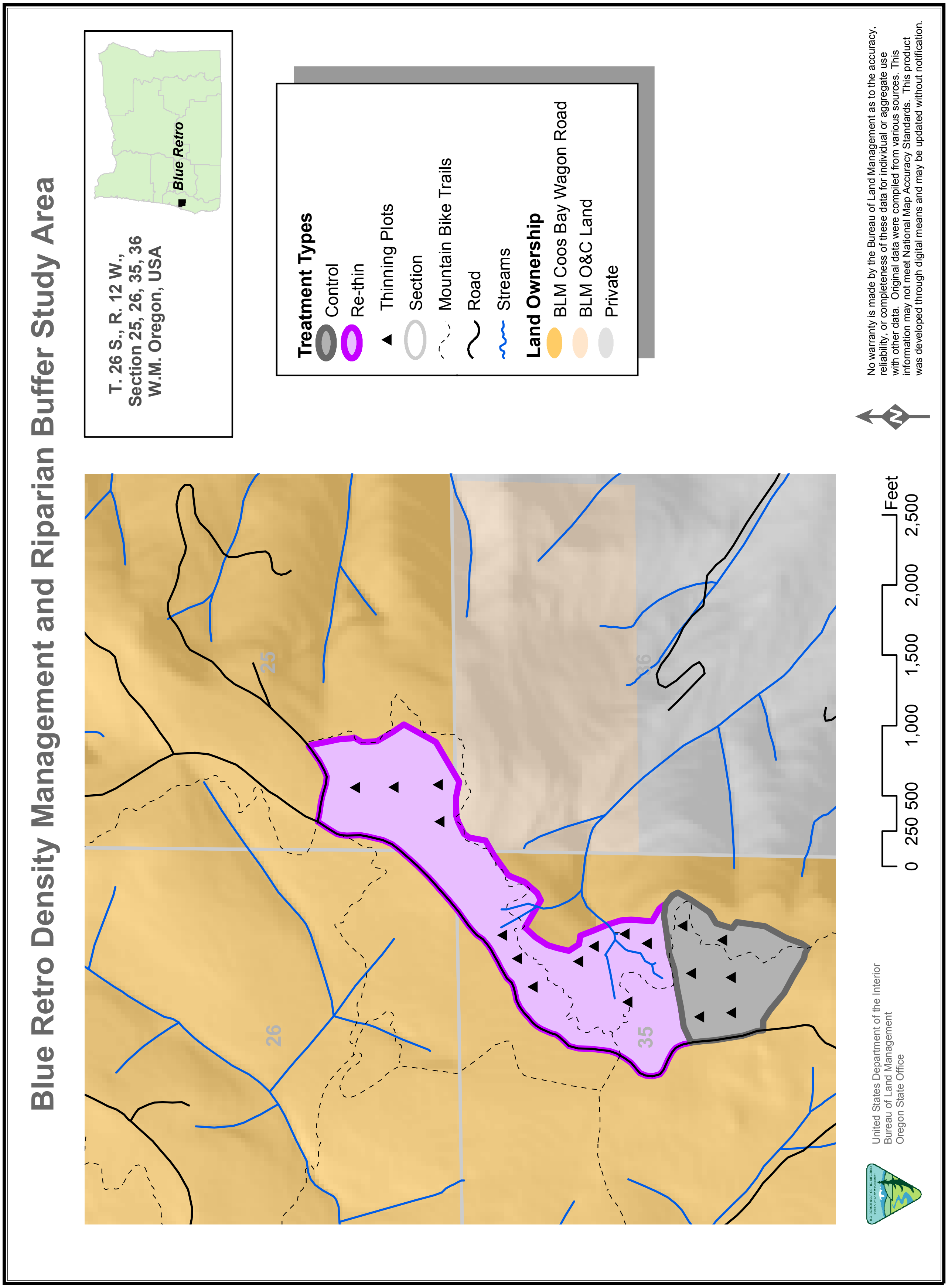
B. DMS

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) |
| Timber sale | |
| - Sale name | Ten High |
| - Sale number | ORO90-TS98-118 |
| - Sale award date | 08/13/1998 |
| - Sale closing date | 09/08/2004 |
| - Sale price for study units, total for all species and sizes | $888,053 |
| Treatment date | |
| - High retention unit | 04-08/1999 |
| - Moderate retention unit | 05-07/1999 |
| - Variable retention unit | 01-03/2000 |
| Logging systems | |
| - High retention unit | Cable yard |
| - Moderate retention unit | Cable yard |
| - Variable retention unit | Cable yard |
| Merchantability standards | Purchaser option to leave or take all designated trees above 6” DBH |
| Slash treatment | Slash piles were burnt on landings and in the patch cuts |
| Underplanting date | 02/2001 |
| Comments | None |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Unthinned | 42.5 (17.2) | 100.0 |
| High density | | |
| - Thinned (120 TPA) | 41.0 (16.6) | 75.9 |
| - Leave islands | 1.5 (0.6) | 2.7 |
| - Riparian buffers | 11.6 (4.7) | 21.4 |
| Total | 54.0 (21.9) | 100.0 |

| | | |
|---|---|---|
| Moderate density | | |
| - Thinned (80 TPA) | 134.5 (54.5) | 79.0 |
| - Leave islands | 5.3 (2.1) | 3.1 |
| - Patch cuts | 5.2 (2.1) | 3.0 |
| - Riparian buffers | 25.3 (10.2) | 14.9 |
| Total | 170.3 (68.9) | 100.0 |
| Variable density | | |
| - Thinned (120 TPA) | 18.1 (7.3) | 31.7 |
| - Thinned (80 TPA) | 21.2 (8.6) | 37.1 |
| - Thinned (40 TPA) | 5.2 (2.1) | 9.1 |
| - Leave islands | 4.7 (1.9) | 8.2 |
| - Patch cuts | 4.4 (1.8) | 7.6 |
| - Riparian buffers | 3.6 (1.5) | 6.3 |
| Total | 57.2 (23.2) | 100.0 |
| Total | 324.0 (131.1) | |


Blue Retro Density Management and Riparian Buffer Study Area
T. 26 S., R. 12 W.,
Section 25, 26, 35, 36
W.M. Oregon, USA
Blue Retro
Treatment Types
Control
Re-thin
Thinning Plots
Section
Mountain Bike Trails
Road
Streams
Land Ownership
BLM Coos Bay Wagon Road
BLM O&C Land
Private
25
26
35
36
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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# Rethinning Sites

## Blue Retro

Compiled by: Frank Price (BLM, Coos Bay District)

### 1. Site location

| | |
|---|---|
| Township | 26 South |
| Range | 12 West |
| Section | 25, 26, 35, 36 |
| Latitude | N43º16’49.0” |
| Longitude | W124º04’57.0” |
| BLM District | Coos Bay |
| BLM Resource Area | Umpqua |
| County | Coos |

### 2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Volcanic member of the Roseburg formation (100%) | | | | | | | |
| - Rethin treatment | - Volcanic member of the Roseburg formation (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 1,499 - 1,588 (457 - 484) | | | | | | | |
| - Rethin treatment | 1,385 - 1,585 (422 - 483) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 17 | 43 | 11 | 0 | 0 | 0 | 12 | 17 |
| - Rethin treatment | 10 | 16 | 25 | 11 | 5 | 7 | 18 | 8 |
| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% | | | | | |
| - Control | 98 | 2 | 0 | | | | | |
| - Rethin treatment | 94 | 6 | 0 | | | | | |
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Blachly (100%) | | | | | | | |
| - Rethin treatment | - Blachly (95%); Other (5%) | | | | | | | |
| NOTE: soil series and complexes are defined in the Coos County Soil Survey | | | | | | | | |
| Mean annual precipitation (inches) | 60 | | | | | | | |

| | |
|---|---|
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (67%); Tsuga heterophylla/Rhododendron macrophyllum-Mahonia nervosa (33%) |
| - Rethin treatment | - Tsuga heterophylla/Oxalis oregana (50%); Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (42%); Other (8%) |
| Site index (Kings) | 133 |

## 3. Site planning

| | |
|---|---|
| RMP (name and date) | Coos Bay District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | Matrix (General Forest) |
| Watershed analysis (name and date) | North Fork Coquille, 2002 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | Blue Retro CT |
| - Number | OR125-97-19 |
| - Date decision document signed | 07/17/97 |
| Site potential tree height (feet) | 220 |
| Aerial photography (years available) | Standard (1:12000) - 1950, 1959, 1964, 1970, 1976, 1981, 1986, 1992, 1997, 2002; Panorama - 1936 (Osborne photo from Blue Ridge Lookout shows the project area after logging but before the Fairview Fire) |

## 4. Study design

| | |
|---|---|
| Site selection criteria | Approximately 50-acres of relatively homogenous, contiguous conifers; stand must have been commercially thinned previously, and sufficiently dense to merit a second commercial thinning |
| Treatment assignment (rationale) | |
| - Rethin unit | Random |
| - Control | Random |
| Nonstandard treatments (type, location, rationale) | None |

5. Unit history

A. Pre-DMS

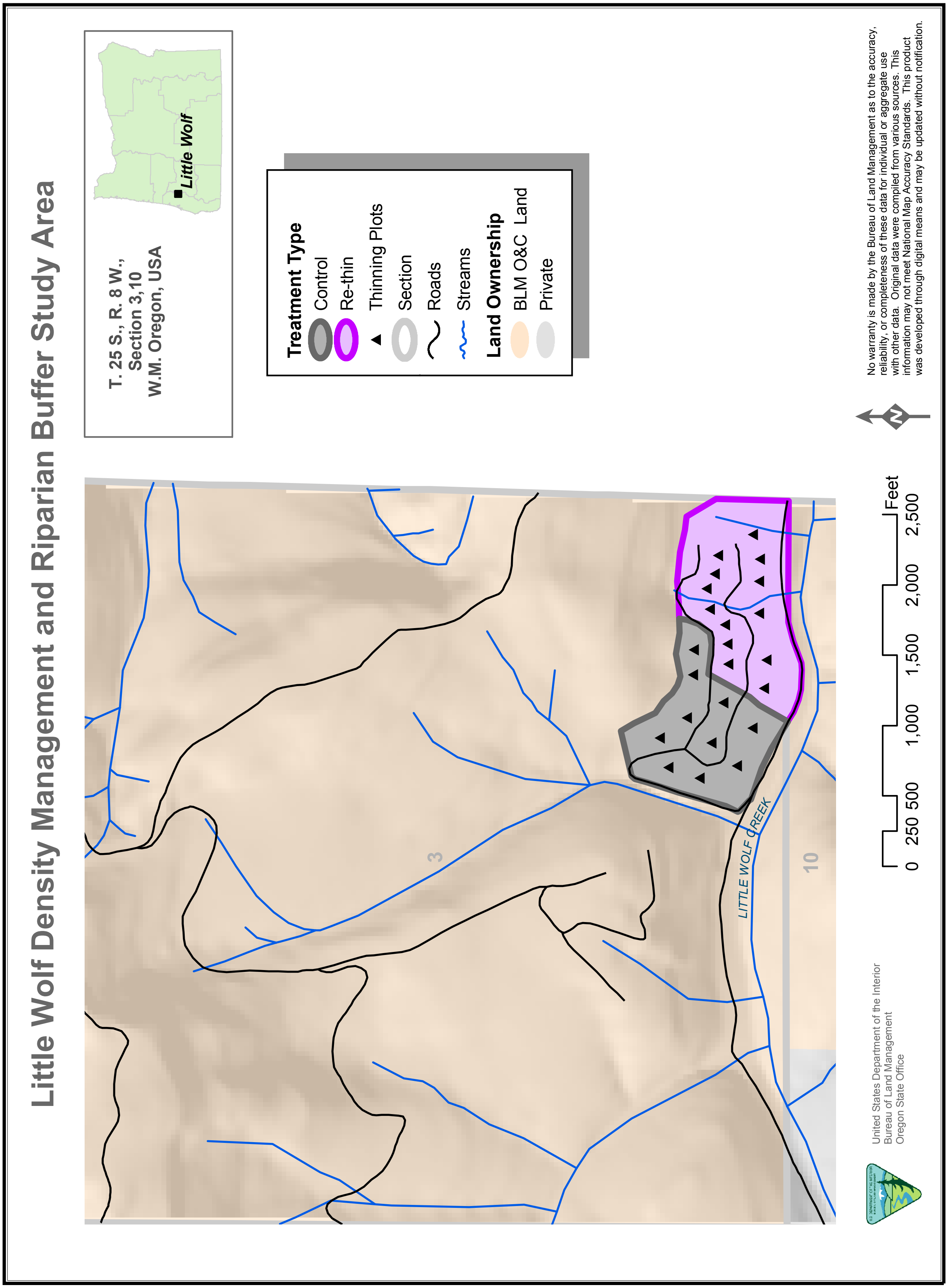
| | |
|---|---|
| Regeneration harvest method | Exact logging methods and dates are unknown, although photography shows railroad logging was complete by 1936. Timber in section 35 was sold under a timber patent in 1926; timber in section 25 was sold under timber patent in 1931; sale dates for sections 26 and 36 are unknown |
| Regeneration method | Natural, established in the 1940s |
| Post-harvest slash treatment | Not known |
| Precommercial thinning | None |
| Prior commercial thinning | Blue Ridge Eastside Thinning sale (TS80-16), logging completed in 1982 by tractor; trees were thinned from below retaining the best-formed conifers; an average of 59 trees per acre were removed averaging 7.7 MBF/acre; hardwoods were only retained where there were no suitable conifers on the desired spacing |
| Comments | The project area burned in 1936 during the Fairview Fire; the federal government received sections 26 and 36 through a land exchange in 1948 |

B. DMS

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C), except that all Douglas-firs 10” or less were reserved from cutting |
| Timber Sale | |
| - Sale name | Blue Retro |
| - Sale number | OR120-97-07 |
| - Sale award date | 08/27/97 |
| - Sale closing date | 08/17/99 |
| - Sale price for study units, total for all species and sizes | $266,935 |
| Treatment date | 01-03/1999 |
| Logging system | Cable yard |
| Merchantability standards | Minimum diameter limit set at 10 inches DBH |
| Slash treatment | Hand pile and burn all logging debris 0.5 inches to 3.0 inches in diameter within 25 feet of road 26-12-25.0 and road 26-12-35.4 |
| Comments | 1. All minor tree species, and all existing snags and down wood were reserved from cutting to provide structural diversity;<br>2. Felling and yarding operations were not permitted from March 1 to June 30, when the bark is most vulnerable to logging damage |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Once thinned area | 15.4 (6.2) | 100.0 |
| Rethin | | |
| - Rethinned area | 47.6 (19.3) | 100.0 |
| Total | 63.0 (25.5) | |


Little Wolf Density Management and Riparian Buffer Study Area
T. 25 S., R. 8 W.,
Section 3,10
W.M. Oregon, USA
Little Wolf
Treatment Type
Control
Re-thin
Thinning Plots
Section
Roads
Streams
Land Ownership
BLM O&C Land
Private
3
10
LITTLE WOLF CREEK
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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Oregon State Office

## Little Wolf

**Compiled by:** Craig Kintop (BLM, Roseburg District)

### 1. Site location

| | |
|---|---|
| Township | 25 South |
| Range | 08 West |
| Section | 3, 10 |
| Latitude | N43º25’20.0” |
| Longitude | W123º37’45.0” |
| BLM District | Roseburg |
| BLM Resource Area | Swiftwater |
| County | Douglas |

### 2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Yamhill formation and related rocks (100%) | | | | | | | |
| - Rethin treatment | - Yamhill formation and related rocks (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 538 - 896 (164 - 273) | | | | | | | |
| - Rethin treatment | 525 - 938 (160 - 286)) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 0 | 0 | 0 | 6 | 60 | 30 | 4 | 0 |
| - Rethin treatment | 0 | 0 | 0 | 37 | 57 | 6 | 0 | 0 |
| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% | | | | | |
| - Control | 43 | 44 | 13 | | | | | |
| - Rethin treatment | 18 | 63 | 20 | | | | | |
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Rosehaven-Atring (54%); Rosehaven (46%) | | | | | | | |
| - Rethin treatment | - Rosehaven (81%); Rosehaven-Atring (16%); Other (3%) | | | | | | | |
| NOTE: soil series and complexes are defined in the Douglas County Soil Survey | | | | | | | | |
| Mean annual precipitation (inches) | 70 | | | | | | | |

| | |
|---|---|
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Achlys triphylla-dry (40%); Abies grandis/Mahonia nervosa-Gaultheria shallon (20%); Pseudotsuga menziesii/Holodiscus discolor-Whipplea modesta (20%); Pseudotsuga menziesii/Toxicodendron diversilobum (20%) |
| - Rethin treatment | - Pseudotsuga menziesii/Toxicodendron diversilobum (54%); Abies grandis/Mahonia nervosa-Gaultheria shallon (23%); Abies grandis/Toxicodendron diversilobum (15%); Other (8%) |
| Site index (Kings) | 105 |

## 3. Site planning

| | |
|---|---|
| RMP (name and date) | Roseburg District Record of Decision and Resource Management Plan, June 1995 |
| RMP land use allocations | Late-Successional Reserve, Riparian Reserve |
| Watershed analysis (name and date) | Upper Umpqua, 2003 |
| LSR assessment (name and date) | South Coast-Northern Klamath, May 1998 |
| Environmental assessment | |
| - Name | Little Wolf Density Management |
| - Number | OR104-97-03 |
| - Date decision document signed | 04/29/1997 |
| Site potential tree height (feet) | 180 |
| Aerial photography (years available) | Standard (1:12000) - 1964, 1970, 1978, 1983, 1989, 1994, 1999; Large scale - 2000 |

## 4. Study design

| | |
|---|---|
| Site selection criteria | Approximately 50-acres of relatively homogenous, contiguous conifers; stand must have been commercially thinned previously, and sufficiently dense to merit a second commercial thinning; one of the young stand retrospective study sites (Bailey and Tappeiner) |
| Treatment assignment (rationale) | |
| - Rethin unit | Random |
| - Control | Random |
| Nonstandard treatments (type, location, rationale) | None |

5. Unit history

A. Pre-DMS

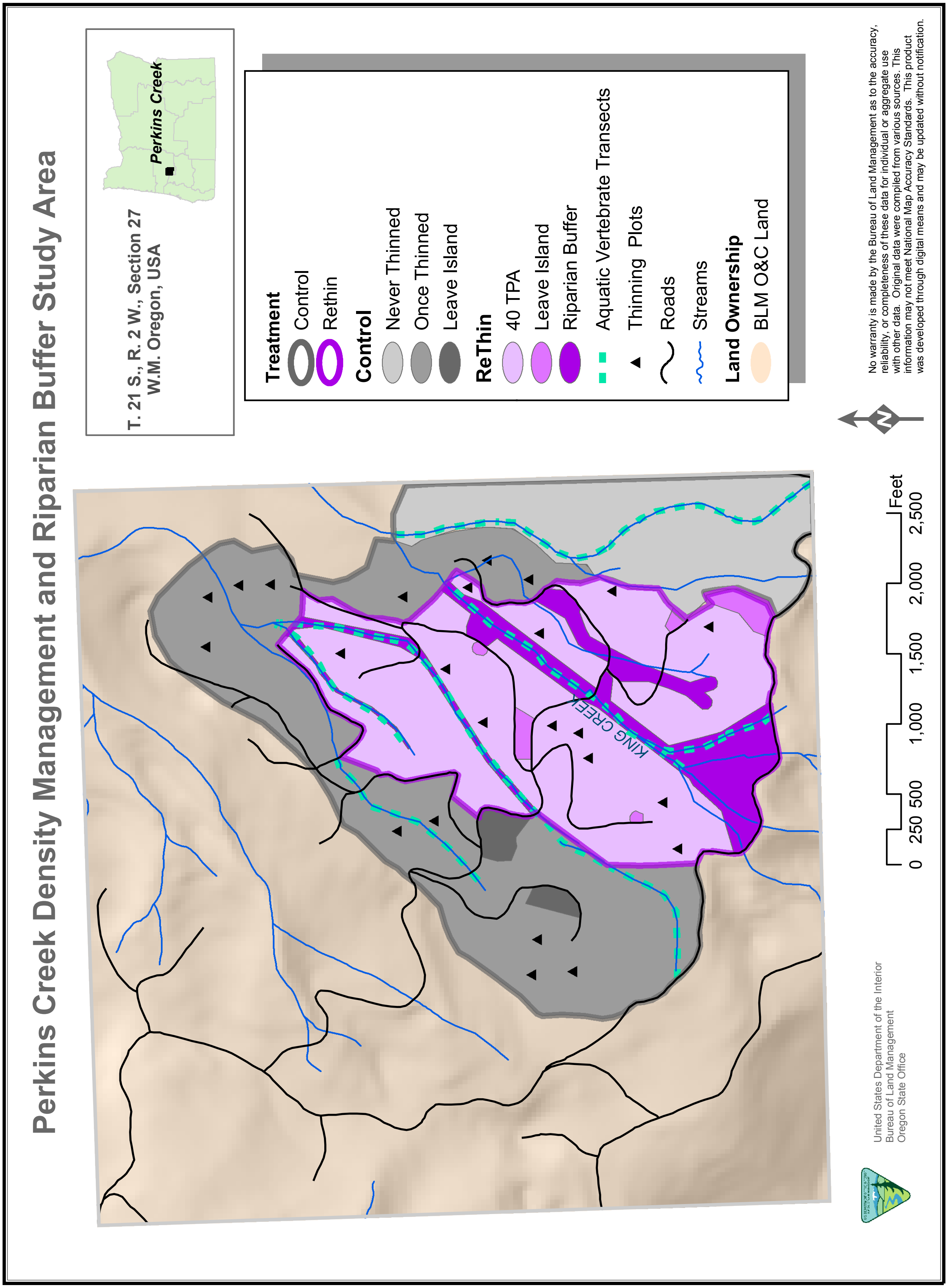
| | |
|---|---|
| Regeneration harvest method | Wildfire origin between 1900 and 1914 (exact date unknown) |
| Regeneration method | Natural |
| Post-harvest slash treatment | None |
| Precommercial thinning | None |
| Prior commercial thinning | Little Wolf Thinning, Sale (OR100-TS8-20); awarded February 1978, terminated December 1981; prescription was to thin from below and remove approximately 40% of the basal area; an additional 15% of the basal area was removed due to excessive logging damage; many sub-merchantable trees (<6 inches DBH) survived logging and remain in the stand; due to a drop in the market conditions near the end of the contract a small area along the east section line was never logged; 85% of removed trees were less than 12 inches DBH |
| Comments | None |

B. DMS

| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) |
| Timber Sale | |
| - Sale name | Little Wolf O.M. Hubbard Thinning |
| - Sale number | OR100-TS97-09 |
| - Sale award date | August 22, 1997 |
| - Sale closing date | October 19, 1998 |
| - Sale price for study units, total for all species and sizes | $31,161 |
| Treatment date | 07/1998-08/1998 |
| Logging system | Cable yard |
| Merchantability standards | Minimum diameter limit set at 6 inches DBH |
| Slash treatment | None |
| Comments | None |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Once thinned area | 18.4 (7.5) | 100.0 |
| Rethin | | |
| - Rethinned area | 22.9 (9.3) | 100.0 |
| Total | 41.3 (16.7) | |


Perkins Creek Density Management and Riparian Buffer Study Area
T. 21 S., R. 2 W., Section 27
W.M. Oregon, USA
Perkins Creek
Treatment
Control
Rethin
Control
Never Thinned
Once Thinned
Leave Island
ReThin
40 TPA
Leave Island
Riparian Buffer
Aquatic Vertebrate Transects
Thinning Plots
Roads
Streams
Land Ownership
BLM O&C Land
KING CREEK
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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## Perkins Creek

Compiled by: Peter O'Toole (BLM, Eugene District), Sharmila Premdas (BLM, Eugene District)

### 1. Site location

| | |
|---|---|
| Township | 21 South |
| Range | 02 West |
| Section | 27 |
| Latitude | N43º42'51.0" |
| Longitude | W122º54'47.0" |
| BLM District | Eugene |
| BLM Resource Area | Upper Willamette |
| County | Lane |

### 2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Fischer and Eugene formations and correlative rocks (100%) | | | | | | | |
| - Rethin treatment | - Fischer and Eugene formations and correlative rocks (90%); sedimentary and volcaniclastic rocks (10%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 1,467 - 2,093 (447 - 638) | | | | | | | |
| - Rethin treatment | 1,519 - 2,133 (463 - 650) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 24 | 28 | 28 | 7 | 0 | 0 | 1 | 12 |
| - Rethin treatment | 25 | 19 | 15 | 0 | 0 | 0 | 1 | 40 |
| Slope steepness(% area in each slope class) | 0%-30% | 30%-60% | >60% | | | | | |
| - Control | 83 | 16 | 1 | | | | | |
| - Rethin treatment | 79 | 21 | 0 | | | | | |
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Peavine (92%); Other (8%) | | | | | | | |
| - Rethin treatment | - Peavine (79%); Honeygrove (16%); Other (5%) | | | | | | | |
| NOTE: soil series and complexes are defined in the Lane County Soil Survey | | | | | | | | |
| Mean annual precipitation (inches) | 57 | | | | | | | |

| | |
|---|---|
| Plant association group (% area in each group that occupies >10% of the treatment area) | |
| - Control | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (58%); Tsuga heterophylla/Oxalis oregana (25%); Other (17%) |
| - Rethin treatment | - Tsuga heterophylla/Mahonia nervosa-Oxalis oregana (67%);Tsuga heterophylla/Oxalis oregana (17%); Tsuga heterophylla/Achlys triphylla-dry (17%) |
| Site index (Kings) | 107 |

3. Site planning

| | |
|---|---|
| RMP (name and date) | Eugene District Record of Decision and Resource Management Plan, June 1995 |
| RMP land use allocations | Matrix, Riparian Reserve |
| Watershed analysis (name and date) | Row River, 1995 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | Perkins Creek Density Management |
| - Number | OR090-98-9 |
| - Date decision document signed | 08/30/1998 |
| Site potential tree height (feet) | 200 |
| Aerial photography (years available) | Standard (1:12000) - 1995, 2000, 2002 |

4. Study design

| | |
|---|---|
| Site selection criteria | Approximately 50 acres of relatively homogenous, contiguous conifers; stand must have been commercially thinned previously, and sufficiently dense to merit a second commercial thinning; one of the young stand retrospective study sites (Bailey and Tappeiner) |
| Treatment assignment (rationale) | |
| - Rethin unit | Unit had multiple stream reaches for the riparian buffer study |
| - Control | Default unit |
| Nonstandard treatments (type, location, rationale) | 1. Unthinned reserves in rethin treatment - *Prophysaon dubium* – reserve three of four sites with ¼-acre leave patch; *Prophysaon coeruleum* – reserve one of two sites with ¼-acre leave patch; *Pityopus californica* – 60 foot radius buffer; Achlorophyllous plants – maintain closed canopy with two ½-acre leave patches<br>2. There is an additional adjacent area from the same initial stand that has never been thinned and is considered part of this study site; contains vegetation plots<br>3. Rethin treatment contains alternative riparian buffer widths for the riparian buffer study |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Seed tree harvest occurred in one or more entries (1920s); seed trees removed in 1980 |
| Regeneration method | Natural |
| Post-harvest slash treatment | None |
| Precommercial thinning | None |
| Prior commercial thinning | Perkins Creek Thinning (1980); thin from below to approximately 100 Douglas-fir per acre (120 square feet of basal area), evenly spaced, hardwoods retained |

B. DMS

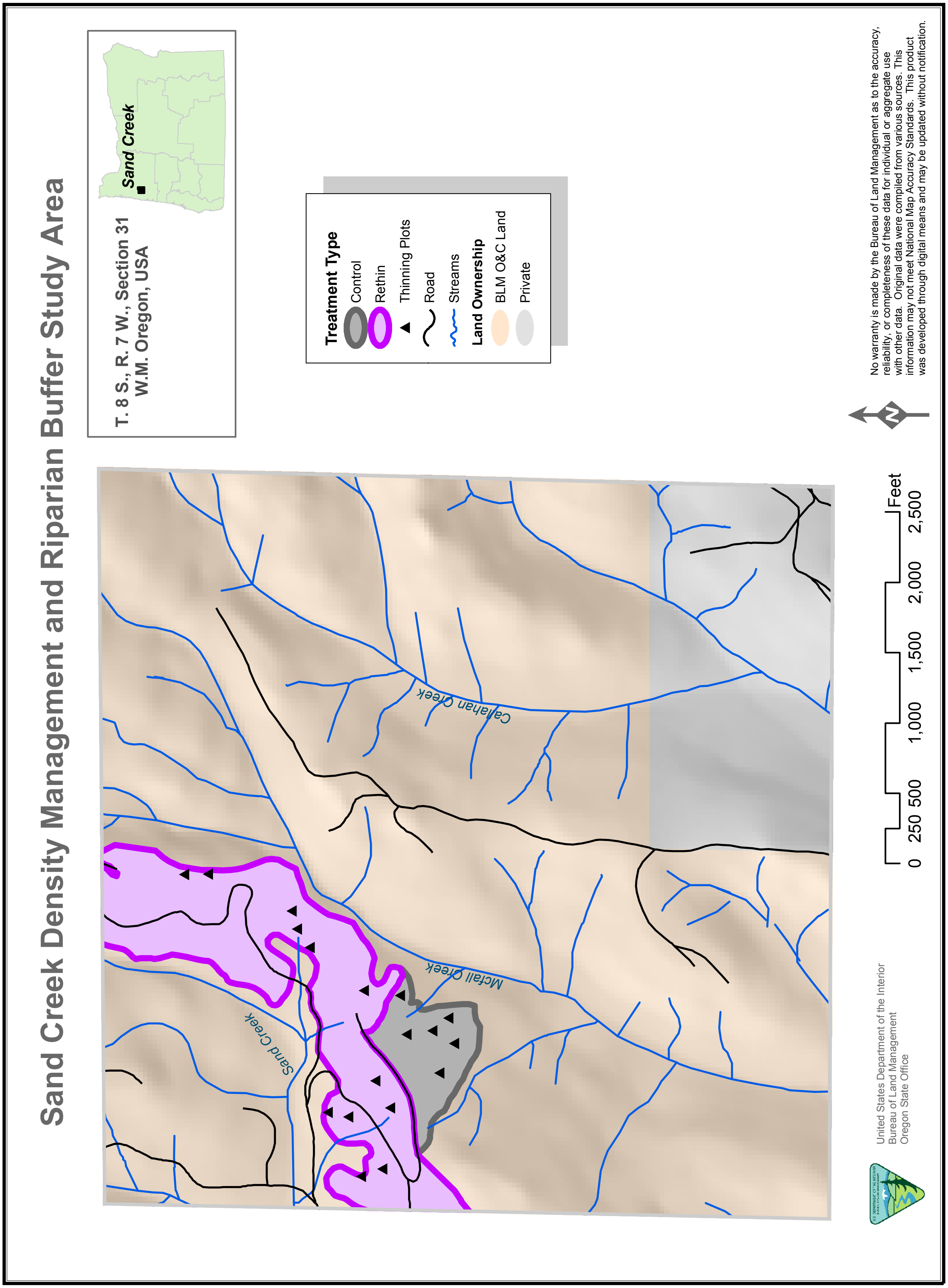
| | |
|---|---|
| Marking guidelines | Standard DMS (see initial study plan, Appendix C) |
| Timber Sale | |
| - Sale name | Perkins Creek |
| - Sale number | ORO90-TS98-352 |
| - Sale award date | 12/98 |
| - Sale closing date | 12/28/00 |
| - Sale price for study units, total for all species and sizes | $283,108 |
| Treatment date | 12/1999 - 03/2000 |
| Logging system | Cable yard |
| Merchantability standards | Purchaser option to leave or take all designated trees above 6” DBH |

| | |
|---|---|
| Slash treatment | Slash piles were burnt on landings |
| Comments | None |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Once thinned area | 99.3 (40.2) | 96.6 |
| - Leave islands | 3.5 (1.4) | 3.4 |
| Total | 102.8 (41.6) | 100.0 |
| Rethin | | |
| - Rethinned area | 89.5 (36.2) | 77.0 |
| - Leave islands | 3.4 (1.4) | 2.9 |
| - Riparian buffers | 23.4 (9.5) | 20.1 |
| Total | 116.2 (47.0) | 100.0 |
| Total | 219.0 (88.6) | |

Note: Perkins Creek is unique among the rethinning sites in that it had leave islands left unthinned when the initial thin was implemented; Perkins Creek is also a riparian buffer study site.


Sand Creek Density Management and Riparian Buffer Study Area
T. 8 S., R. 7 W., Section 31
W.M. Oregon, USA
Sand Creek
Treatment Type
Control
Rethin
Thinning Plots
Road
Streams
Land Ownership
BLM O&C Land
Private
Callahan Creek
Mcfall Creek
Sand Creek
0 250 500 1,000 1,500 2,000 2,500
Feet
N
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## Sand Creek

Compiled by: Hugh Snook (BLM, Salem District)

### 1. Site location

| | |
|---|---|
| Township | 08 South |
| Range | 07 West |
| Section | 31 |
| Latitude | N44º50'05.0" |
| Longitude | W123º35'26.0" |
| BLM District | Salem |
| BLM Resource Area | Mary's Peak |
| County | Polk |

### 2. Site environment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface geology (% area in each type that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Tyee formation (100%) | | | | | | | |
| - Rethin treatment | - Tyee formation (100%) | | | | | | | |
| Elevation range (feet, (meters)) | | | | | | | | |
| - Control | 1,375 - 1,611 (419 - 491) | | | | | | | |
| - Rethin treatment | 1,339 - 1,697 (408 - 517) | | | | | | | |
| Aspect (% area in each aspect class) | N | NE | E | SE | S | SW | W | NW |
| - Control | 3 | 4 | 41 | 44 | 4 | 2 | 2 | 1 |
| - Rethin treatment | 3 | 1 | 7 | 12 | 11 | 17 | 14 | 35 |
| Slope steepness(% area in each slope class) | 0%-30% | | 30%-60% | | >60% | | | |
| - Control | 56 | | 40 | | 4 | | | |
| - Rethin treatment | 53 | | 47 | | 1 | | | |
| Soil series (% area in each soil series or complex that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Bohannon (100%) | | | | | | | |
| - Rethin treatment | - Bohannon (76%); Astoria (24%) | | | | | | | |
| NOTE: soil series and complexes are defined in the Polk County Soil Survey | | | | | | | | |
| Mean annual precipitation (inches) | 115 | | | | | | | |
| Plant association group (% area in each group that occupies >10% of the treatment area) | | | | | | | | |
| - Control | - Tsuga heterophylla/Vaccinium alaskaense-Oxalis oregana (67%); Tsuga heterophylla/Oxalis oregana (33%) | | | | | | | |
| - Rethin treatment | - Tsuga heterophylla/Rubus spectabilis-Acer circinatum (33%); Tsuga heterophylla/Vaccinium alaskaense-Oxalis oregana (33%); Tsuga heterophylla/Oxalis oregana (25%); Other (9%) | | | | | | | |

| | |
|---|---|
| Site index (Kings) | 130 |

3. Site planning

| | |
|---|---|
| RMP (name and date) | Salem District Record of Decision and Resource Management Plan, May 1995 |
| RMP land use allocations | North Coast Adaptive Management Area |
| Watershed analysis (name and date) | Upper Siletz, 1996 |
| LSR assessment (name and date) | N/A |
| Environmental assessment | |
| - Name | Callahan Creek Adaptive Management Project |
| - Number | OR-080-96-12 |
| - Date decision document signed | 03/11/96 |
| Site potential tree height (feet) | 220 |
| Aerial photography (years available) | Standard (1:12000) - 1977, 1982, 1988, 1993, 1998, 2003; orthophoto - 1993, 2002 (Weyerhaeuser Company provided) |

4. Study design

| | |
|---|---|
| Site selection criteria | Approximately 50 acres of relatively homogenous, contiguous conifers; stand must have been commercially thinned previously, and sufficiently dense to merit a second commercial thinning; North Coast Adaptive Management Area land use allocation encourages research; part of a larger thinning project (Callahan Creek) |
| Treatment assignment (rationale) | |
| - Rethin unit | Random |
| - Control | Random |
| Nonstandard treatments (type, location, rationale) | None |

5. Unit history

A. Pre-DMS

| | |
|---|---|
| Regeneration harvest method | Clearcut, approximately 1920 |
| Regeneration method | Natural |
| Post-harvest slash treatment | Unknown |
| Precommercial thinning | None |

| | |
|---|---|
| Prior commercial thinning | Thinned from below in 1975, leaving approximately 114 TPA (approximately 139 TPA were removed with an average DBH of 10 inches); few remaining legacy trees were also removed in this sale |
| Comments | None |

B. DMS

| | |
|---|---|
| Marking guidelines | Thin from below to leave 45 dominant and co-dominant TPA; thinning to be patchy, removing more trees where understory exists, and leaving more trees where there the understory is sparse; where possible, mark groups of trees around snags to protect them during logging; do not mark conifers as leave trees in root rot pockets; leave all cull trees, multiple top trees, wolf trees or other wildlife habitat trees; leave snags, overstory hardwoods, and Pacific yew; favor hemlock and cedar to leave |
| Timber Sale | |
| - Sale name | Sand Creek |
| - Sale number | 96-313 |
| - Sale award date | 09/25/96 |
| - Sale closing date | 07/14/98 |
| - Sale price for study units, total for all species and sizes | $736,564 |
| Treatment date | 07/29/97-12/12/97 |
| Logging system | Skyline yarding (44 acres), tractor yarding (7 acres) |
| Merchantability standards | Minimum diameter limit set at 7 inches DBH |
| Slash treatment | All slash within 30 feet of landings was piled (fall 1997) and burned (fall 1998) |
| Comments | 1. Entry permits required in the Luckiamute Closure and Cooperative Travel Management Area |

6. Acreage table

| Treatment and subtreatment | Acres (Hectares) | % Treatment Area |
|---|---|---|
| Control | | |
| - Once thinned area | 11.1 (4.5) | 100.0 |
| Rethin | | |
| - Rethinned area | 49.9 (20.2) | 100.0 |
| Total | 61.0 (24.7) | |

# Appendix F. Density Management and Riparian Buffer Study Publications

## Brochures

Olson, D.H. 2005 submitted. Riparian areas. In: Pilliod, D. and E. Wind (eds.). Habitat Management Guidelines for Amphibians and Reptiles in the Pacific Northwest. Partners in Amphibian and Reptile Conservation, brochure and web publication.

Olson, D.H. 2005 submitted. Moist coniferous forest. In: Pilliod, D. and E. Wind (eds.). Habitat Management Guidelines for Amphibians and Reptiles in the Pacific Northwest. Partners in Amphibian and Reptile Conservation, brochure and web publication.

Olson, D. and B. Hansen. 1999. Aquatic vertebrates and habitats: Keel Mountain Density Management Study, in: Littlefield, B. and K. Searl (eds.). 1999. Young Stand Diversity Studies: Interpretive Guides for the Keel Mountain Density Management Study. USGS Biological Resources Division, CFER publication. 2 p.

## Journal Articles And Book Chapters

Chan, Samuel, P. Anderson, J, Cissel, L. Larsen, C. Thompson. 2004. Variable density management in riparian reserves: lesson learned from an operational study in managed forests of western Oregon, USA. Forest Snow and Landscape Research 78(1/2):151-172.

Cunningham, Patrick G. 2002. A survey of research on riparian responses to silviculture. In: Johnson, A.C.; Haynes, R.W.; Monserud, R.A.; eds. Congruent Management of Multiple Resources: Proceedings from the Wood Compatibility Initiative Workshop; December 5-7, 2001, Skamania Lodge, Stevenson, WA. Gen. Tech. Rep. PNW-GTR-563. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 73-79.

Hohler, David, James Sedell, and Deanna Olson. 2001. Aquatic conservation strategy. pp30-39 In: Richard W. Haynes and Gloria E. Prez (tech. eds.). Northwest Forest Plan Research Synthesis. Gen. Tech. Report, PNW-GTR-498, USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Nauman, R., D.H. Olson, L. Ellenburg, and B. Hansen. 1999. *Plethodon dunni* (Dunn's salamander). Reproduction. Herpetological Review 30: 89-90.

Neitlich, Peter N., Bruce McCune. 1997. Hotspots of epiphytic lichen diversity in two young managed forests. Conservation Biology 11(1):172-182.

Norvell, Lorelei L, R. Exeter. 2004. Ectomycorrhizal epigeous basidiomycete diversity in Oregon Coast Range *Pseudotsuga menziesii* forests - preliminary observations. In Fungi In Forest Ecosystems: Systematics, Diversity, and Ecology, ed. by Cathy L. Cripps. The New York Botanical Garden, p. 159-189.

Norvell, Lorelei L; Redhead, Scott A. 2000. *Stropharia albivelata* and its basionym Pholiota albivelata. Mycotaxon 76: 315-320.

Olson, D.H., S.S. Chan, P. Cunningham, B. Hansen, A. Moldenke, R. Progar, P.S. Muir, B. McCune, A. Rosso, E.B. Peterson. 2000. Characterizing managed headwater forests - integration of stream, riparian, and upslope habitats and species in western Oregon: Companion projects to the BLM Density Management Studies. p. 539-540 In: Proceedings of the Society of American Foresters 1999 National Convention, 11-15 September, Portland, OR. SAF Publication 00-1, Bethesda, MD; ISBN 0-939970-81-3.

Olson, Deanna H., Samuel S. Chan, and Charles R. Thompson. 2002. Riparian buffers and thinning designs in western Oregon headwaters accomplish multiple resource objectives. In: Johnson, A.C.; Haynes, R.W.; Monserud, R.A.; eds. Congruent Management of Multiple Resources: Proceedings from the Wood Compatibility Initiative Workshop; December 5-7, 2001, Skamania Lodge, Stevenson, WA. Gen. Tech. Rep. PNW-GTR-563. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 81-91.

Olson, D.H., S.S. Chan, G. Weaver, P. Cunningham, A. Moldenke, R. Progar, P.S. Muir, B. McCune, A. Rosso, E.B. Peterson. 2000. Characterizing stream, riparian, upslope habitats and species in Oregon managed headwater forests. Pp. 83-88 In: Wiggington, J. and R. Beschta (eds.). Riparian Ecology and Management in Multi-Land Use Watersheds. International conference of the American Water Resources Association, 30 August, Portland, OR. AWRA Publication TPS-00-2, Middleburg, VA. 616 pp.

Olson, Deanna H., Richard S. Nauman, Loretta L. Ellenburg, Bruce P. Hansen, and Samuel S. Chan. 2005. *Ensatina eschscholtzii* nests at a managed forest site in Oregon. Northwestern Naturalist.

Pilz, David, Lorelei Norvell, Eric Danell, and Randy Molina. 2003. Ecology and management of commercially harvested chanterelle mushrooms. PNW-GTR-576. Portland, OR: etc., 83 p.

Progar, R. A., A. R. Moldenke. 2002. Insect production from temporary and perennially flowing headwater streams in western Oregon. Journal of Freshwater Ecology 17(3):391-407.

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