December

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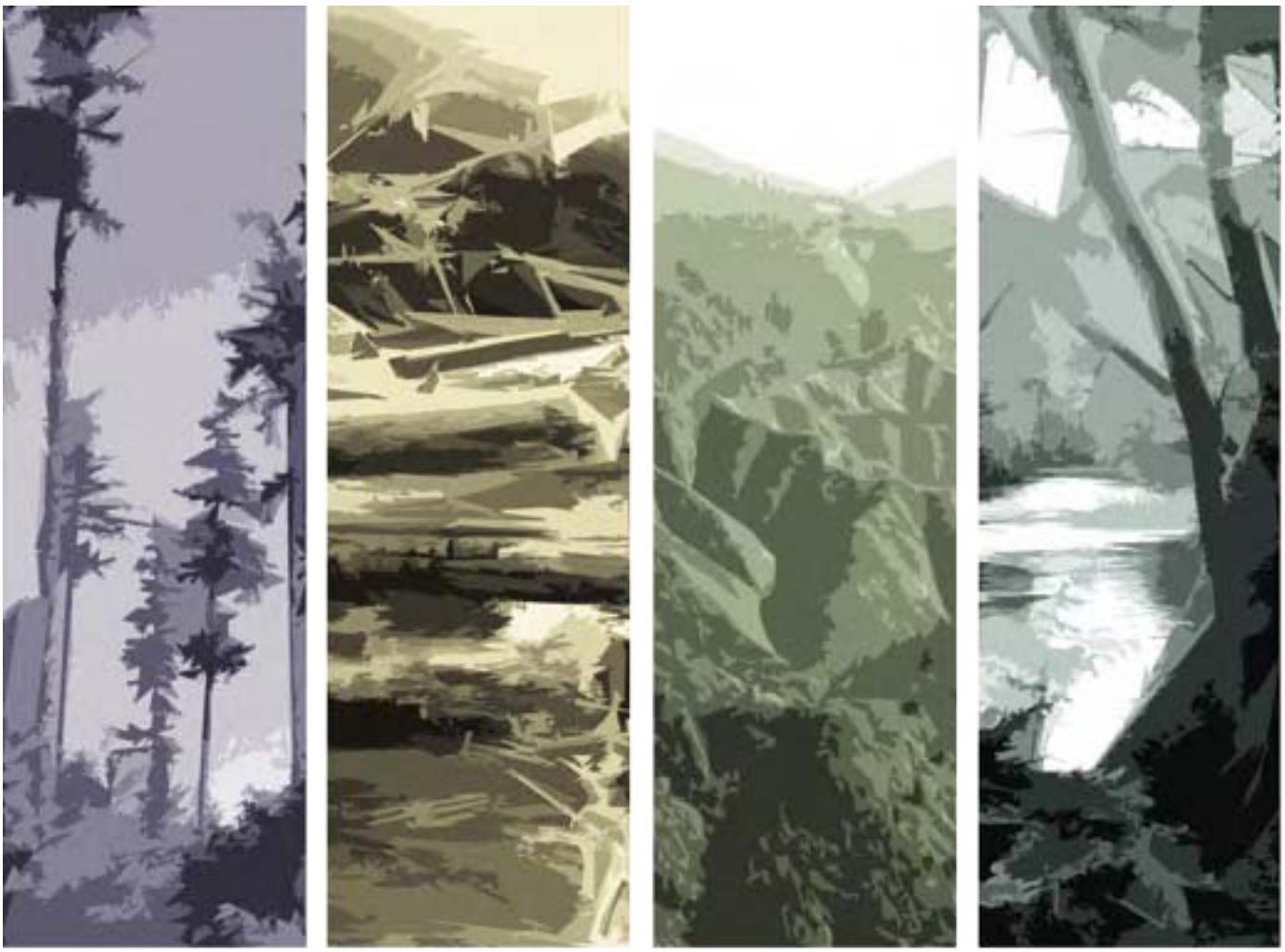

2004 Annual Report

USGS science for a changing world
USGS Forest and Rangeland Ecosystem Science Center

Oregon Department of Forestry

Bureau of Land Management

Oregon State University
College of Agricultural Sciences and College of Forestry

The Cooperative Forest Ecosystem Research (CFER) program was developed to facilitate sound management of forest ecosystems, with emphasis on meeting priority research information needs of the Bureau of Land Management (BLM) and the Oregon Department of Forestry (ODF) in western Oregon.

Mission

The CFER program will work closely with resource managers, researchers, and decision-makers to develop and convey information needed to successfully implement ecosystem-based management at forest stand and watershed scales, especially on lands dominated by young forests and fragmented by multiple ownership.

Goals

- To provide forest managers with new information to evaluate current and proposed strategies and practices associated with management of forest ecosystems
- To facilitate development of sustainable forest practices through team-oriented, integrated research

Objectives

- To further the understanding of ecological relationships in forest ecosystems with special emphasis on biodiversity and its management in young forest stands and riparian zones
- To deliver information to cooperators, forest managers, and the general public in a timely and responsive manner

Cooperators

The CFER program cooperators provide financial support, faculty and staff to conduct research and information exchange, study sites, assistance with project installations, and in-kind support as needed.

Program cooperators include:

Bureau of Land Management

Oregon Department of Forestry

Oregon State University
College of Agricultural Sciences and College of Forestry

USGS
science for a changing world
USGS Forest and Rangeland Ecosystem Science Center

THE COOPERATIVE FOREST ECOSYSTEM RESEARCH PROGRAM

Annual Report 2004

Janet Erickson, Editor, CFER Information Specialist
Gretchen Bracher, Graphic Artist
Nancy Creel, CFER Administrative Assistant

December 2004
Corvallis, OR

Chronology and Highlights of Program (1995–2004)

1995
- Initial cooperative agreement signed with BLM, OSU, and USGS FRESC

1996
- Scoping meetings held with BLM to determine information needs

1997
- CFER Problem Analysis completed
- Initial CFER research team established

1998
- ODF became a cooperator
- Information exchange specialist and administrative assistant hired
- Pilot studies and preliminary field work conducted

1999
- Three integrated projects developed:
  - Biotic responses to changes in stand structure
  - Production and function of large wood in the riparian zone
  - Effects of landscape pattern and composition on species
- Integrated projects and field work underway

2000
- Continued research on the three integrated research areas
- Program web site established
- Meetings with focus group and district contacts on future research directions

2001
- Completion of several studies within the three integrated project areas
- Development of a new research initiative examining the influences of riparian vegetative community composition on animal community response
- First issues of the program's quarterly newsletter, CFER News, distributed

2002
- Drs. Judith Li and Christian Torgersen joined the CFER research team
- Four issues of the quarterly newsletter, CFER News, were produced and circulated to 1000 people and organizations
- The semi-technical report titled "Managing for Biodiversity in Young Douglas-fir Forests of Western Oregon" was published
- Workshop held to convey results of the Tillamook Thinning Project

2003
- Scope of CFER research and information exchange program expanded to include the BLM Density Management Study
- Landscape Scenario Analysis Project initiated to evaluate alternative forest management scenarios
- A 5-year review of the CFER program conducted

2004
- Co-sponsorship of the Density Management Study Workshop and Field Tour
- Two USGS/CFER fact sheets developed summarizing completed research
- Final report completed for the Landscape Scenario Analysis Project

In 1996 Bob Gresswell, Jeff Smith, and I sat around a small table on the campus of Oregon State University and began the process of gathering information on the informational needs of the BLM in western Oregon as one of the first steps in the process of building a cooperative research and information exchange program. Since that time CFER has grown into a significant program with a substantial list of accomplishments. Over the years the program has evolved to address new research and information needs of the program's cooperators and in response to the changing careers of CFER personnel.

This Annual Report marks change in the leadership of the program and the assignments of three CFER scientists. Beginning January 2005 I will assume the position of Associate Dean for International Programs in the College of Forestry at Oregon State University. With my new assignment, I will be stepping down from my position as Program Coordinator for CFER. Though I will no longer serve as the program's coordinator, my new assignment retains a significant allocation of time for research activities, and I look forward to continuing to serve as a member of the CFER Science Team and close involvement in research activities concerning forest management issues in western Oregon. I will certainly miss many aspects of the CFER coordinator position, and I thank all of you who have made the position so interesting, productive, and enjoyable.

Dave Hibbs, one of the original members of the CFER team, has accepted the role of Program Coordinator for CFER. In addition to the long involvement that Dave has had with the program's research and information exchange programs, Dave served as interim program coordinator during my sabbatical leave in 2002. Because of Dave's history with the program, I expect the transition to his new position as Program Coordinator to be a seamless one.

Bob Gresswell has also transitioned to another phase of his career. Earlier in 2004 Bob accepted a position with the USGS Northern Rocky Mountain Science Center in Bozeman, Montana. During Bob's transition he will continue to play an important leadership role with CFER, especially in the area of aquatic ecology and fish biology. Nevertheless we will miss his great sense of humor and the ecological insight that regular interactions with Bob have brought us. We wish him the best of luck in his new position.

In programs like CFER, we frequently focus on products such as technical publications published, newsletters distributed, workshops conducted, and seminars presented, as these are an important measure of the program's productivity. Indeed, CFER has produced an impressive quantity and array of these products, as outlined in the information exchange accomplishments of the program (p. 88). An equally important measure of productivity, and one that will certainly be among the long-term legacies of CFER's work, is the training of graduate students. This year four CFER students (Troy Guy, Shami Premdas, Nico Romero, and Emily Scott) received M.S. degrees and one (Daniel Sarr) received his Ph.D. from Oregon State University, bringing the total number of degrees fostered by the CFER program to 17, including 12 M.S. and 5 Ph.D. degrees. The students trained under the CFER program are making important contributions to furthering our understanding of the science underlying management of natural resources and to the management of forests and the environment. Over half of the students trained by CFER (ten) are currently working for federal natural resources agencies, two have gone on to pursue Ph.D. degrees at other institutions, one is a post-doctoral fellow at Berkeley, one is a research assistant in Louisiana, and two are doing biological consulting and contract work in western Oregon. This impressive cadre of professionals represents the future of natural resources management, and we are honored to have played some part in their professional development and training.

I hope you enjoy reading about CFER's activities and research in this report. Please feel free to contact the CFER program office if you need additional information or if you would like to be added to our mailing list. Also, I encourage you to take a look at the program's web page (http://www.fsl.orst.edu/cfer) to keep abreast of program developments.

John P. Hayes
Professor of Forest Science
CFER Program Coordinator

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Preface

This publication is a compilation of research activities occurring during the year under report. The information is preliminary in nature and has not been peer-reviewed. The study summaries are provided with the understanding that the data are not guaranteed to be correct or complete. Users are cautioned to consider carefully the provisional nature of the information.

Current Research

Research Direction

The Northwest Forest Plan and state forest management plans provide approaches for regional-scale management of forest ecosystems that attempt to accommodate human resource needs, sustain critical ecosystem functions, and maintain native biodiversity. Additional research is needed to assess the efficacy of the management approaches and to refine specific management directions.

Information needs of resource managers are inherently complex and integrative, and many of the issues extend over many years and a broad geographic area. Accordingly, CFER has designed its research to answer questions at different scales of time and space.

Research Themes

Currently, there are four research themes that focus CFER research activities.

- Stand Structure and Biotic Responses to Changes in Structure of Young Forests of Western Oregon (*Stand Structure*)
- Large Woody Debris in the Terrestrial and Aquatic Riparian Zone: Production, Recruitment, Retention, and Function (*Riparian Wood*)
- Influence of Landscape Pattern and Composition on Species in Forested Ecosystems of Western Oregon (*Landscape Pattern*)
- Influences of Riparian Vegetative Community Composition on Animal Community Response (*Riparian Linkages*)

Integration

The CFER program is designed to be integrated at various levels to produce a body of knowledge that will address complex scientific and management information needs that span multiple disciplines, spatial scales, and geographic regions in western Oregon. It is our hope that the significance of the results will be enhanced through the integrated nature of our studies. Integration is planned to occur during multiple stages of research: planning, data collection, interpretation, and presentation and synthesis of results.

Planning

During the research planning process, efforts are made to define a broad, interrelated, and integrated set of questions pertaining to a particular research theme. As a result of this planning process, a series of individual studies are identified. Each study is designed to address a key element of the larger set of questions and to address multiple objectives. For example, information on the development of understory vegetation and stand structure is collected at several sites along with terrestrial vertebrate responses. These data sets will allow development of models that simultaneously predict the response of several plant and animal species and communities to management of young forest stands.

Data collection

Whenever possible, data sets for multiple studies are collected at the same sites using multidisciplinary crews. This allows for efficient use of programmatic resources, but more importantly facilitates integration. Multidisciplinary crews help ensure that data collected for different components of a research theme will be interpreted in the context of the broader set of questions being posed.

Interpretation

Following collection and analysis of data from individual studies, CFER team members will discuss results during regularly scheduled meetings and through periodic programmatic review of written materials. When possible, attempts will be made to broaden these discussions to include additional scientists in other pertinent disciplines. This will help ensure that interpretation of results from an individual study will be made in the broader context of the questions being addressed by a research theme and the CFER program as a whole.

Presentation and synthesis

Presentation and synthesis is probably the most important aspect of the plan for integration. During this step, results from each individual study and each major research theme will be synthesized to provide answers to questions concerning multidisciplinary resource management questions. Although the most appropriate mechanisms for transmitting this information are still being formulated, it is anticipated that this will involve production of white papers, review articles, and summary documents, as well as participatory events, such as field tours, symposia, and roundtable discussions. CFER's principal investigators will meet regularly to provide a programmatic forum to further develop these mechanisms for integration.

Stand Structure and Biotic Responses to Changes in Structure of Young Forests of Western Oregon

Understanding the relationships among stand structure, management activities, and ecological responses is central to wise management of forest systems. Among the primary management activities in young forest stands are density management and fuels management. Changes in forest structure resulting from these activities can affect plant and animal communities. Although some of the general relationships of structural features to stand density are well established, significant gaps in our understanding remain in some areas. In addition, the responses of plant and animal species to structural changes in young forests are poorly understood. This research examines some of these relationships for plant and animal species that are of concern to forest managers.

Goals

The two interrelated goals of this research theme are:

- to understand changes in stand structure that result from management and
- to understand some of the more important biotic responses to changes in forest structure.

2004 Highlights

- Former graduate student Jeff Manning and Dan Edge published their research results in the *Journal of Mammalogy* with the title "Small mammal survival and downed wood at multiple scales in managed forests."
- The BLM's Density Management Workshop and Field Tour were cosponsored and hosted by the CFER program
- The research theme was expanded to include three new projects:
  - Influences of Post-fire Salvage Logging on Wildlife Populations: The Timbered Rock Integrated Project
  - Tree Species Controls on Nutrient Cycling in the Oregon Coast Range
  - Contrasting Fire Severity between Riparian and Upslope Forests in the Biscuit Fire of Southwestern Oregon

Continuing studies during the year under report are summarized in the following section.

Population and Behavioral Responses of Small Mammals to Silviculture and Downed Wood Treatments in the Oregon Coast Range

David L. Waldien and John P. Hayes

Small mammals are an important component of forest ecosystems and in the Pacific Northwest function as prey for species such as the northern spotted owl and marten. Further, several species of small mammals forage upon hypogeous fungi and are hypothesized to play an important role in the dispersal of sporocarps. Other species of small mammals forage on insects, seeds, and vegetation, and in some cases are considered forest pests because of the damage they can cause to both saplings and older trees.

Historically, much of the research on habitat use by small mammals in the Pacific Northwest has addressed differences in communities between older forest (often old-growth) and recently harvested clearcuts or young stands that regenerated following clearcut harvest. Only recently has research addressed the response of wildlife to alternative silvicultural practices to determine their potential for active management of forest stands for timber while maintaining or enhancing habitat for wildlife. Various silvicultural methods (e.g., thinning, shelterwood, green-tree retention, group- and single-tree selection) can be employed as alternatives to traditional clearcut systems to promote structural diversity within forest stands and to provide commodity production and revenue generation. However, our understanding of the responses of wildlife in general, and small mammals in particular, to alternative silvicultural approaches is poorly developed.

In addition, there has been increased interest in retaining dead wood on the forest floor to promote biodiversity and other ecological values. Small mammals use downed wood for nest and den sites, travel paths, and forage sites. Research on how small mammals respond to downed wood in stands harvested with alternative silvicultural systems is lacking but would enable managers to more effectively manage stand density and downed wood volumes to meet multiple objectives, including timber and wildlife.

The objectives of this study are to determine the influence of silviculture treatments (henceforth the silviculture objective) and downed wood (henceforth the downed wood objective) on aspects of population demographics (e.g., abundance, survival, age and sex ratios, reproductive condition) of small mammals. We also examined how individual Townsend's chipmunks (*Tamias townsendii*) use downed wood for movement.

Methods

This study was located on the McDonald-Dunn Research Forest at the eastern edge of the Oregon Coast Range. Forests in this area are dominated by Douglas-fir (*Pseudotsuga menziesii*). Other tree species in the area include grand fir (*Abies grandis*), bigleaf maple (*Acer macrophyllum*), Oregon white oak (*Quercus garryanna*), Pacific madrone (*Arbutus menziesii*), Pacific dogwood (*Cornus nuttallii*), red alder (*Alnus rubra*), Oregon ash (*Fraxinus latifolia*), and bitter cherry (*Prunus emarginata*).

To meet the silviculture objective, two stands of four silvicultural treatments (clearcut, group-selection, two-story, and control) located in three geographic blocks were selected for study (24 stands total). Silvicultural treatments were applied to the stands between 1989 and

1991. Clearcuts retained 0.5 green trees/acre (1 acre = 0.405 ha); group selection cuts removed one-third of the volume in 1/2-acre circular plots; two-story stands uniformly removed three-quarters of the volume; and control stands did not receive any treatment. Prior to treatment, stands were 90 to 130 years old.

To meet the downed wood objective, one clearcut and one group-selection stand within each block were randomly selected to receive approximately 600 ft^3/acre of downed wood (six stands total). This volume of wood is similar to volumes found in core areas of western red-backed voles (*Clethrionomys californicus*) and reflects levels used in management of state forestlands and levels needed to achieve downed wood management objectives for some areas of the MacDonald-Dunn Research Forest. Eleven logs were added to each of three clearcuts within 98.4 ft (1 ft = 0.305 m) of the trap grid (grid + 98.4 ft buffer = 2.97 acres) in February 2001 (average volume = 1,593 ft^3, SE = 53.6 ft^3). Five trees were felled within 98.4 ft of the trap grid in each of three group-selection stands (mean volume = 1,933 ft^3, SE = 175.4 ft^3) in March 2001.

An 8 x 10 trap grid (32.8-ft spacing between grid points) was randomly located within each stand with a buffer of at least 115 ft maintained between the outer set of traps and the edge of the stand. Grids in group-selection stands were located to represent the overstory composition of the stand (ca. 33% cut and ca. 66% uncut). One large, collapsible Sherman live-trap was placed within 3.3 ft of each trap station (80 Sherman traps per trap grid). Starting spring 2000, one additional Tomahawk live trap (16 in x 5 in x 5 in) was placed at each of 20 stations (65.6-ft spacing) in each grid.

Three trap sessions were conducted each year (1999–2002) during spring (April and May), summer (July and August), and fall (October and November); the first trapping session was conducted in summer 1999. Research to examine the influence of silviculture treatments on small mammals was conducted in all four-stand types, and trapping for this objective was completed fall 2000. Research to examine the influence of downed wood on small mammals was conducted only in clearcut and group-selection stands, and field work for this objective was initiated summer 1999 and was completed fall 2002. Data for both the silviculture and the downed wood objectives were analyzed with a repeated measures analysis of variance.

During summer and fall 2001, we evaluated use of downed wood by Townsend's chipmunks in six group-selection stands by attaching lightweight spools of thread to the tails of chipmunks (spool-and-line tracking). The degree that chipmunks used downed wood was evaluated at 6.6-ft intervals along the trail from the release point. We used an information theoretic approach to evaluate the influence of downed wood and the diameter and elevated status of wood on path selection for each chipmunk. We used logistic regression to evaluate selection for and the influence of the elevated status of wood on path selection and linear regression to evaluate the influence of diameter on path selection.

Research Results

During the 91,200 trap nights of the entire project, we captured 22 species of small mammals a total of 35,138 times. Deer mice (*Peromyscus maniculatus*) and Townsend's chipmunks were the most abundant species and represented 69.5% and 18.5% of the captures, respectively.

For the investigation of influences of silvicultural treatments on small mammals, we completed 5 seasons of trapping (1999 and 2000). In 55,200 trap nights, 7,024 individuals of 20 species of mammals were captured. The deer mouse was the most abundant species (63% of captives) and Townsend's chipmunk and Trowbridge's shrew (*Sorex trowbridgii*) were the next most common species (13% and 9%, respectively). For our investigation of the response of small mammals to downed wood in group-selection and clearcut stands, we completed 11 seasons of trapping (1999, 2000, 2001, and 2002). In 63,600 trap nights, we captured 8,080 individuals of 22 species of small mammals. The deer mouse was the most abundant species (54% of captives) and Townsend's chipmunk and Trowbridge's shrew were the next most common species

(16% and 12%, respectively).

In both the silviculture and downed wood objectives, seasonal cycles were apparent for most species ($P < 0.05$). In general, densities of open-canopy species were similar among controls and all three treatments with a trend for greater densities in harvested stands (e.g., vagrant shrews, *S. vagrans*; Figure 1). Densities of adult female ($F_{3,6} = 13.52$, $P < 0.01$; Figure 1) and reproductive female ($F_{3,6} = 5.33$, $P = 0.04$) deer mice were greatest in harvested stands although other measures (e.g., total density, density of adults, density of males, and sex ratios) for deer mice and Townsend's chipmunks, and density measures for Oregon voles (*Microtus oregoni*) and Pacific shrews (*S. pacificus*) were not significantly different among stand conditions ($P > 0.05$; Figure 1). Measures for Trowbridge's shrews were variable among treatments with a time and block interaction ($P < 0.01$). Similar patterns were apparent in the downed wood objective although most measures were not statistically significant ($P > 0.05$). Vagrant shrews were more abundant in clearcuts (captures in group-selection stands were excluded from analyses due to small sample size) and densities did not respond to the wood addition ($F_{1,2} = 0.99$, $P = 0.42$; Figure 2). Conversely, Pacific shrews were more abundant in group-selection stands (captures in clearcuts were excluded from analyses due to small sample size) and densities did not respond to the wood addition ($F_{1,2} = 0.01$, $P = 0.95$). Total density and density of reproductive deer mice, and density of male reproductive chipmunks exhibited a silviculture x wood x time interaction with no consistent pattern in the effects ($P < 0.05$). All other measures (e.g., total density, density of adults, density of males, and sex ratios) in the wood study were not statistically significant ($P > 0.05$; Figure 2).

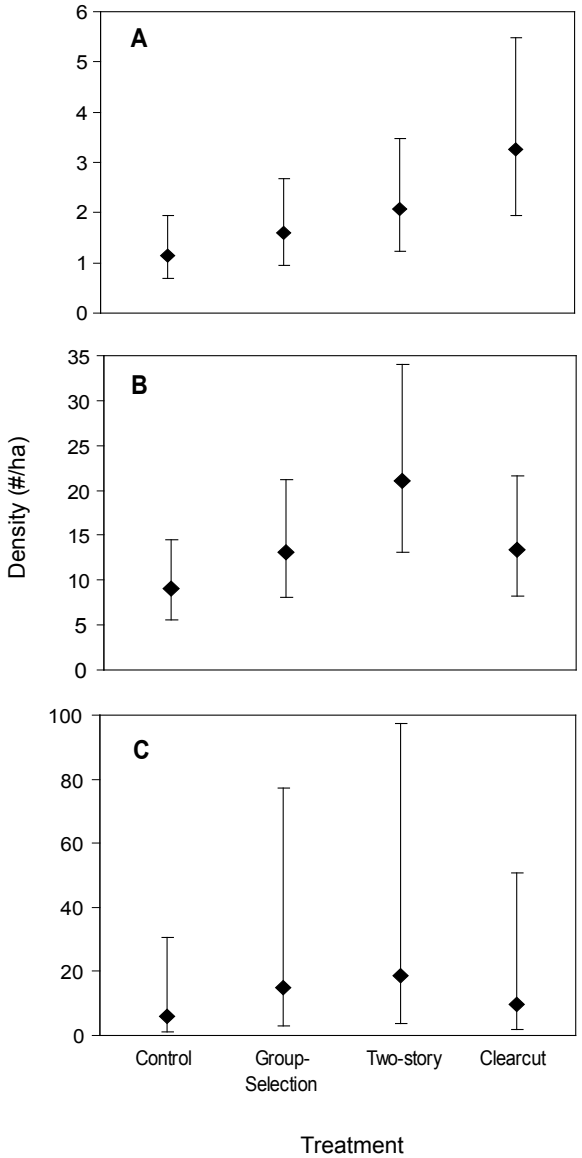

Figure 1. Examples of the response in the density of selected species of small mammals [A) vagrant shrews, B) adult female deer mice, and C) Townsend's chipmunks] to three silviculture treatments in western Oregon.

Although statistical analyses were not conducted on the California ground squirrel (*Spermophilus beecheyi*), Douglas' squirrel (*Tamiasciurus douglasii*), dusky-footed woodrat (*Neotoma fuscipes*), northern flying squirrel (*Glaucomys sabrinus*), Pacific jumping mouse (*Zapus trinotatus*), and western red-backed vole for either the silviculture or downed wood objectives (due to limited captures or absence of a species in a block), the general pattern in the number of individuals captured among the treatments warrants mention. Group-selection stands were more similar to control stands in that they had similar numbers of Douglas' squirrels, flying squirrels, and red-backed voles. These species had reduced numbers or were absent in two-story and clearcut stands. Conversely, two-story and clearcut stands were similar in that they had the greatest number of captures of California ground

squirrels, jumping mice, and dusky-footed woodrats relative to captures in control or group-selection stands.

Using spool-and-line tracking, we tracked 41 Townsend's chipmunks for a total of 16,709 ft. In all but one case, Townsend's chipmunks disproportionately selected points with downed wood relative to its availability (Figure 3). There was strong evidence that chipmunks disproportionately selected paths with downed wood and that the quantity of wood in the environment influenced path selection. At average wood densities (26% of path), a chipmunk path was 3 times as likely to be associated with downed wood (95% CI = 2.5-3.5) and a decrease of 10% of wood in the environment resulted in an increase in the relative odds of wood use between 6% and 36%. However, the probability of downed wood being on a chipmunk path was always greater than the availability of downed wood across the range of our data (Figure 3). Chipmunks used downed wood that was 1.2 times larger in diameter than wood in random plots (95% CI = 1.1-1.3) but did not disproportionately select paths with elevated wood (relative odds = 1.1; 95% CI = 0.8-1.5).

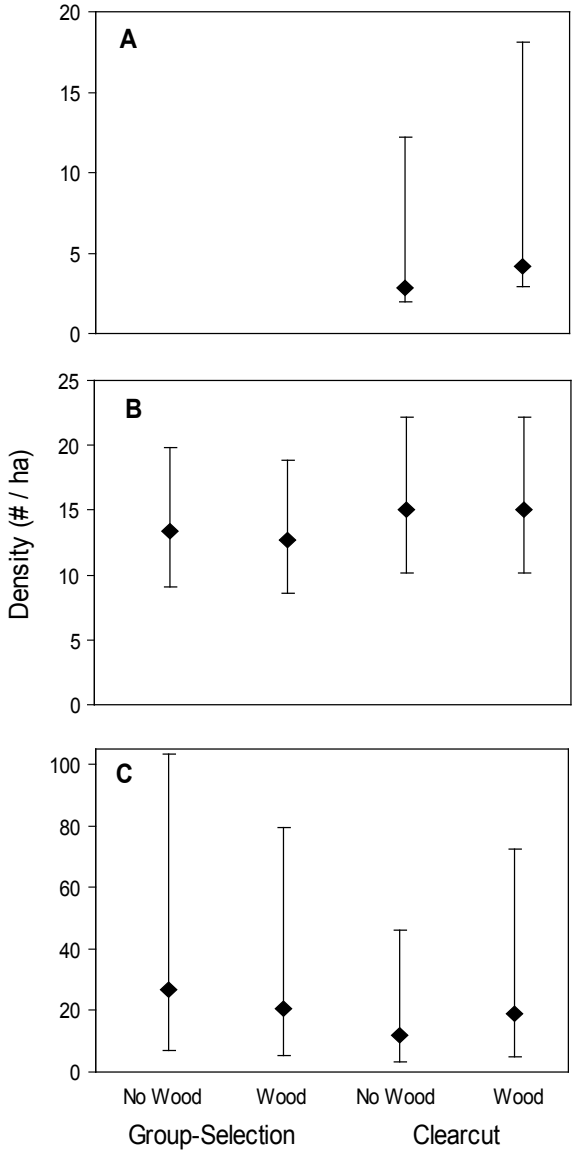

Figure 2. Examples of the response in the density of selected species of small mammals [A) vagrant shrews, B) adult female deer mice, and C) Townsend's chipmunks] to the addition of downed wood in group-selection and clearcut stands in western Oregon. Vagrant shrews were not abundant enough in group-selection stands to include in the analysis.

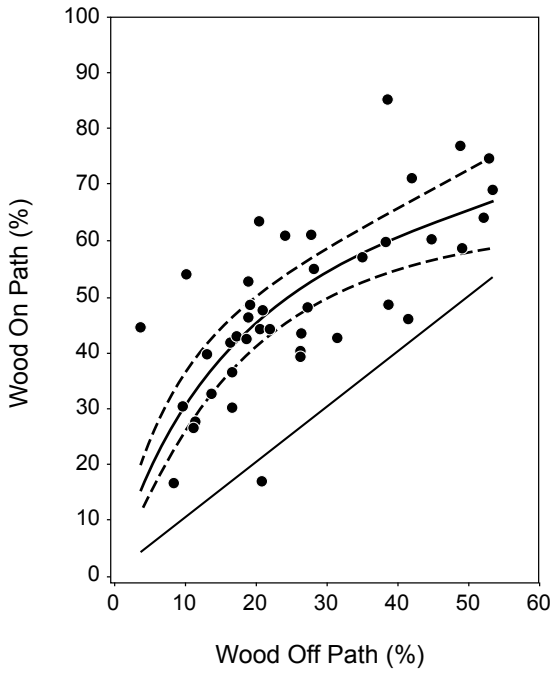

Figure 3. Percentage of used versus random plots with downed wood for 41 Townsend's chipmunks in western Oregon, 2001. The solid line represents equal percentage of used and random plots having wood. Values located below this line indicate a greater percentage of random plots with wood than used plots; values above the line indicate a greater percentage of used plots with wood than random plots. The dashed line represents the predicted probability and a 95% Confidence Interval (CI) of a chipmunk's path having wood.

Management Implications

Selection of harvest systems has strong implications on economic return and can influence a number of ecological patterns and processes. Open-canopy species and generalists (e.g., deer mice, Townsend's chipmunks) tend to benefit from timber harvest. However, there are thresholds in how other species respond to timber harvest that should be considered. The removal of too much of the overstory from a stand can negatively impact or eradicate species that need a fairly contiguous overstory (e.g., flying squirrels or red-backed voles). Alternatively, not adequately opening the canopy may prohibit other species (e.g., dusky-footed woodrats, jumping mice) from successfully establishing populations in the stand. In our study, we found a threshold for closed-canopy species that lies between the group-selection treatment, which removed ca. 33% of the canopy in patches, and the two-story treatment, which uniformly removed ca. 75% of the canopy; the group-selection treatment favors closed-canopy species whereas the two-story treatment favors open-canopy species. Understanding the tradeoffs among different management options in both economic and ecological terms will guide and facilitate decision-making by land managers.

The group-selection harvest system is a management option that provides timber revenue from a stand while maintaining many desirable ecological values. Forests with gaps can provide both forest habitat while enhancing habitat for gap specialists and early successional species. Small mammals associated with an overstory canopy can be maintained in forests with gaps and early-successional species (e.g., dusky-footed woodrat, Oregon vole) may positively respond to the gaps if the gaps are of adequate size. In general, if no critical thresholds are crossed during harvest, the creation of gaps through group-selection harvest may enhance the habitat and increase resources for many forest species with minimal negative impacts.

In the short-term, densities of deer mice and Townsend's chipmunks do not appear to respond to the addition of relatively large amounts of large diameter wood (without decay) in either group-selection or clearcut stands. In contrast, selection of downed wood by Townsend's chipmunks can be high, suggesting that downed wood may be important for the quality of habitat for individuals. Our data demonstrate that Townsend's chipmunks have a relatively large and positive response to even small amounts of wood. We also have demonstrated selection for larger diameter wood as travel paths. Insight into minimum thresholds of downed wood needed to elicit a response by chipmunks and upper limits where chipmunks no longer respond to or have a change in their response to downed wood would enable resource managers to more effectively implement conservation and management efforts.

Our research provides managers with an assessment of the response of small mammals to different silvicultural treatments and insight into a potentially important threshold for management of closed-canopy species. We also have demonstrated that Townsend's chipmunks select downed wood for travel paths although the density of chipmunks did not appear to respond to downed wood. Although density measures of small mammal populations did not appear to respond to our downed wood addition, we have implemented an experiment that will facilitate future research on how small mammals respond to large volumes of downed wood as it decays though time.

Study Timeline

This project was initiated in 1999 and all objectives of the study have been completed. Two years of sampling (summer and fall 1999; spring, summer, and fall 2000) have been completed to evaluate the response of species to silvicultural treatments. Two years of pre-treatment and two years of post-treatment sampling to evaluate small mammal response to downed wood also have been completed. The final report in the form of a Ph.D. dissertation will be on file with the CFER office winter 2005.

Influences of Post-fire Salvage Logging on Wildlife Populations: the Timbered Rock Integrated Project

John P. Hayes and Tom Manning

Recent fires throughout the western states have heightened interest in the influences of post-fire management activities on a variety of ecological processes, social goods and services, and forest attributes, including forest health, ecosystem integrity, future management options, and wildlife habitat. Post-fire salvage harvest of dead and damaged trees has been of particular interest because of an array of potential benefits including commodity production and economic gain, decreased fuel loads reducing risk of future fires, and reduction in future insect infestation. However, post-fire salvage may also carry significant environmental risks to soil, water, and biodiversity. Key concerns related to biodiversity center on wildlife response, especially related to species associated with dead wood, both standing dead wood (such as cavity-nesting birds) and fallen dead wood (such as several species of small mammals).

As a consequence of the potential societal benefits and possible environmental impacts, post-fire salvage is becoming an increasingly contentious issue. Social conflict surrounding the issue is high, as evidenced by the interest and concern expressed by environmental organizations and by litigation surrounding proposed salvage activities. Despite considerable interest and concern, however, relatively little work has been conducted to investigate environmental effects of post-fire logging. McIver and Starr (2001, *Western Journal of Applied Forestry* 16:159–168) conducted an extensive review of all studies published through February 2000 evaluating the environmental effects of post-fire logging. They found only nine studies worldwide that included unlogged controls and evaluated the ecological impacts of post-fire salvage logging. Of these, seven evaluated influences on wildlife populations (five studies of birds, two of mammals). Only four were replicated field studies, and only three of these (all studying bird response) were conducted in the United States. We are aware of one additional study on the influences of post-fire logging on birds in the Canadian boreal forest (Morissette et al. 2002, *Canadian Journal of Forest Research* 32:2169–2183) published since the completion of the assessment by McIver and Starr.

Lack of information will undoubtedly fuel the social controversy surrounding this issue. Until adequate information is available to evaluate actual consequences of post-fire salvage logging, anecdotal and philosophical perspectives uninformed by scientific evidence will largely drive the debate over this issue.

The Record of Decision (ROD) for the Northwest Forest Plan provides basic guidelines for the conditions under which salvage may occur in Late-Successional Reserves. The ROD allows for salvage to prevent negative effects on late-successional habitat and to facilitate habitat recovery. The ROD specifically addresses the potential use of salvage to reduce catastrophic insect, disease, and fire threats. However, the ROD restricts activities that diminish habitat suitability in Late Successional Reserves now or in the future. Unfortunately information that would allow full evaluation of the influences of salvage activity on habitat restoration and the short- and long-term impacts of salvage on habitat suitability is not available.

To help elucidate the influences of salvage operations on wildlife habitat quality, we have begun sampling of bird and small mammal communities in 12 research units occupying the area burned by the Timbered Rock Fire in July 2002. These stands are located in the southern Cascades near Medford in Jackson County. Four blocks of replicated treatments (representing uncut controls and two different intensities of salvage) will be compared after

salvage operations have been completed. Pre-treatment sampling took place between April and July of 2004, and the initial post-treatment sampling is expected to take place in the spring and summer of 2005.

Our work at Timbered Rock will provide information on the influences of salvage and salvage intensity on habitat quality and abundance of wildlife species. The experimental, manipulative approach, combined with random allocation of treatments to stands provides the framework for inference of causality with minimal bias. In contrast, observational research is correlative in nature and cannot be used to infer causality, and research that does not invoke randomization of treatments and controls is subject to potential sampling biases. As a result, very strong inference can be gained from this experimental research, and it is likely to impact post-fire management on other public and private lands in southwestern Oregon and throughout the western states.

Studies of wildlife response to fire suggest that habitat conditions during the first few years following fire are especially important for a number of species. As a consequence, understanding the short-term effects of salvage, such as those that will be revealed in this study, can provide important information for management of forest stands. In addition, this study will provide an important foundation for future work on this topic, and we anticipate follow-up studies using the same sites.

Methods

In collaboration with staff of the Medford District of the Bureau of Land Management (BLM), potential study sites within the Timbered Rock Fire were identified. Sites meeting the following criteria were considered to be potential sites for study: 1) the site had burned with a high fire intensity, 2) the site was at least 12 (preferably at least 16) ha in size and was not exceptionally sinuous in shape or did not include elongate extensions, 3) the site consisted of a good stocking of conifers ≥100 cm diameter-at-breast-height (DBH), 4) the site could accommodate at least three nonoverlapping 80-m radius bird survey circles, and 5) it was logistically feasible and reasonable to assign any treatment to any site.

Prior to the fire, forest stands were dominated by Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) with scattered sugar pine (*Pinus lambertiana*), incense-cedar (*Libocedrus decurrens*), and ponderosa pine (*Pinus ponderosa*) in the overstory. Understory vegetation included the same species of conifers, as well as madrone (*Arbutus menziesii*), chinquapin (*Castanopsis chrysophylla*), and canyon live oak (*Quercus chrysolepis*). Baldhip rose (*Rosa gymnocarpa*), dwarf Oregongrape (*Mahonia nervosa*), poison oak (*Toxicodendron diversiloba*), creambush oceanspray (*Holodiscus discolor*), deerbrush ceanothus (*Ceanothus integerrimus*), and creeping snowberry (*Gaultheria hispidula*) occurred in the shrub layer.

Stand treatments

Three treatments were randomly assigned to stands:

1) Control. No salvage activity will occur on control sites.
2) Moderate salvage. Salvage activities will occur on 70% of the site. In the salvaged area, 15 trees per hectare (TPH) >50 cm DBH will be retained. Retained snags will be dispersed throughout the salvaged area. The remaining 30% of the site will not be subjected to any salvage activity. If riparian areas are present, the unsalvaged area will be oriented to include the riparian habitat. This prescription is designed to emulate likely salvage activities on BLM lands in the region, where sensitive areas, such as riparian areas or small patches of trees, are left unsalvaged for wildlife habitat or other environmental considerations.
3) Heavy salvage. The entire site will be salvaged. Fifteen TPH >50 cm DBH will be retained throughout the site. Retained snags will be dispersed throughout the site.

Salvage will occur during a relatively narrow window of time to minimize impacts of salvage on data collection and to maintain the integrity of the research design. Salvage treatments will be installed before 15 May 2005 to avoid activity during the breeding bird season. Aside from salvage activities, all management activities will be identical among treatments. To the extent that activities undertaken on the sites do not impact the field experiment, all management activities conducted on the sites will be as similar to typical operational practices as possible.

Bird sampling

During spring of 2004, we established three bird-sampling points in each of the 12 experimental stands. Sampling points were chosen so that the distance between points was at least 160 m and arranged so as to maximize distance between sampling points and stand boundaries. In moderate salvage stands, point counts were established so as to cover salvaged and unsalvaged areas roughly in proportion to their occurrence in the stand. Sampling began 24 May and concluded on 1 July. This timing will be approximated in the post-treatment years. Each point was visited a minimum of four times in 2004. Bird sampling was conducted for an 8-minute period at each point between 0.5 hour before and 3 hours after sunrise. Distances from the observer to each bird were estimated. We plan to analyze bird data using both distance techniques and double-observer approaches.

Small mammal sampling

Trapping was conducted with two different sizes of live traps to maximize the diversity of animals captured. In each of the 12 research units, we established a 10 x 10 grid of Sherman live traps with 10 m between each trap station. Separate grids (6 x 15 with 25 m spacing) of Tomahawk 201 cage traps were established in six of the units, representing two blocks of each treatment. All traps were baited with a mixture of peanut butter and rolled oats. Each trap was covered with a small waterproof shelter, and cotton fiber was provided inside the traps for insulation. Trapping in 2004 began 10 May and was finished by 28 June. During each trapping session, traps were opened for eight consecutive days. Captured animals were identified to species, weighed, sexed, assessed for reproductive status, and individually marked. Dead animals were necropsied to confirm field data, and will be sent to a qualified vertebrate museum to serve as voucher specimens. We will use program CAPTURE to analyze mark-recapture data and to estimate abundance of small mammal populations.

Data analysis

We will use an information-theoretic approach (Burnham and Anderson 2002, *Model Selection and Multi-Model Inference: a Practical Information-Theoretic Approach*. Springer-Verlag. 488 p.) to statistically evaluate influences of salvage harvest on wildlife using a general strategy used by Hayes et al. (2003, *Ecological Applications* 13:1222–1232) to evaluate influences of thinning on bird populations. Using this approach, we will evaluate four *a priori* hypotheses of response to treatments: 1) population parameters (abundances for birds and small mammals, amount of activity for bats) in controls, moderate salvage, and heavy salvage stands are the same (the null model); 2) population parameters in moderate salvage and heavy salvage stands are the same, but differ from the controls (the salvage effect hypothesis); 3) population parameters in the controls and moderately salvaged stands are the same, but differ from the heavily salvaged stands (the unsalvaged refuge hypothesis); or 4) population parameters differ in all three treatments (the salvage intensity hypothesis). We will also consider temporal trends in the responses of species during the first 2 years following salvage and evaluate differences in trends among treatment types.

The combination of treatment effects and temporal trends results in nine *a priori* models that will be evaluated (Table 1). We will then construct a set of quantitative models representing each of the nine conceptual models. Each quantitative model will include a term for the categorical effect of year; as sampling for bat activity will follow a randomized block design, we will also include a term for the categorical effect of block for models of bat responses. We will evaluate the likelihood of each *a priori* model given the data that we collect us-

Table 1. Models to be evaluated. C = Control stand; M = Moderate salvage; H = Heavy salvage.

Model	Treatment Effect	Temporal Effect
1	C = M = H	C = M = H
2	C ≠ (M = H)	C = M = H
3	C ≠ (M = H)	C ≠ (M = H)
4	(C = M) ≠ H	C = M = H
5	(C = M) ≠ H	(C = M) ≠ H
6	C ≠ M ≠ H	C = M = H
7	C ≠ M ≠ H	C ≠ (M = H)
8	C ≠ M ≠ H	(C = M) ≠ H
9	C ≠ M ≠ H	C ≠ M ≠ H

Table 2. Bird species detected at sampling points at Timbered Rock, spring 2004.

Species	Detections
American Kestrel	3
American Robin	48
Ash-throated Flycatcher	1
Black-capped Chickadee	1
Black-headed Grosbeak	93
Brown Creeper	68
Blue Grouse	23
Bullock's Oriole	4
Cassin's Vireo	4
Chestnut-backed Chickadee	9
Chipping Sparrow	4
Common Raven	16
Dark-eyed Junco	185
Hairy Woodpecker	151
Hermit Thrush	17
Hermit Warbler	29
House Wren	209
Lazuli Bunting	475
Lesser Goldfinch	11
MacGillivray's Warbler	6
Mourning Dove	28
Mountain Quail	38
Nashville Warbler	14
Northern Flicker	20
Olive-sided Flycatcher	37
Peregrine Falcon	1
Pine Siskin	10
Pileated Woodpecker	17
Pacific-slope Flycatcher	82
Purple Finch	8
Red-breasted Nuthatch	74
Rock Wren	2
Rufous Hummingbird	25
Spotted Towhee	13
Steller's Jay	97
Townsend's Solitaire	59
Turkey Vulture	3
Unidentified Hummingbird	1
Unidentified raptor	3
Unidentified sapsucker	1
Unidentified sparrow	1
Unidentified warbler	4
Unidentified woodpecker	34
Warbling Vireo	4
White-breasted Nuthatch	12
White-crowned Sparrow	19
Western Bluebird	42
Western Tanager	52
Winter Wren	8
Western Wood Pewee	25
Yellow-rumped Warbler	10

ing an information-theoretic approach. We will calculate AIC_c for models for species or taxa that follow a lognormal or Poisson distribution and $QAIC_c$ for those that follow an overdispersed Poisson distribution. Our evaluation of models will be based on ΔAIC_c or $\Delta QAIC_c$ and generalized Akaike weights (w_i) of each model. For taxa demonstrating a response to the treatments, size of effect of the treatments will be evaluated based on model-averaged parameter estimates.

Preliminary Research Results

We recorded 2,101 detections of breeding birds, representing 52 species (Table 2). We captured 899 individual small mammals a total of 2,115 times, representing 14 species (Table 3). Trap mortalities have been necropsied. All data have been entered into spreadsheets and proofread and are awaiting analysis. No further results are available at this time.

Study Timeline

Data collection for 2004 has been completed, and we expect to complete preliminary analyses (to examine pre-treatment differences among stands) during January 2005 and submit a preliminary report to BLM in March 2005. If salvage activities are completed before May 2005, we will begin our first season of post-treatment sampling at that time. We expect to complete the initial post-treatment work in the spring of 2006 and submit a final report to the BLM no later than March 2007.

Table 3. Mammal species captured at Timbered Rock, spring 2004.

Species	Common Name	Total Captures	Total Individuals
Peromyscus maniculatus	Deer mouse	1890	557
Tamias townsendii	Townsend's chipmunk	153	73
Clethrionomys californicus	Western red-backed vole	18	13
Neotoma fuscipes	Dusky-footed woodrat	20	11
Spermophilus beecheyi	California ground squirrel	16	9
Neotoma cinerea	Bushy-tailed woodrat	5	4
Microtus sp.	Unidentified *Microtus* vole	5	3
Sorex vagrans	Vagrant shrew	3	3
Microtus longicaudus	Long-tailed vole	2	1
Spilogale gracilis	Spotted skunk	2	1
Mephitis mephitis	Striped skunk	1	1
Mustela frenata	Long-tailed weasel	1	1
Microtus oregoni	Creeping vole	1	1
Sylvilagus bachmani	Brush rabbit	1	1
Total		**2118**	**679**

Response of Birds to Fire Mosaics

Michelle Donaghy Cannon and John P. Hayes

Wildfire is one of the most important natural disturbances in forests of the western United States. Fires alter forest developmental trajectories and change the plant and animal communities in the affected areas. In the first few years after a fire, the flush of new vegetation can increase the abundance and diversity of wildlife, particularly those species associated with early successional habitats.

Bird species respond positively or negatively to fire depending primarily on their foraging strategies. Studies of bird populations in fire-altered forests generally show a shift in the composition of the avian community from foliage- and bark-gleaners to shrub-foragers, tree-drillers, and cavity-nesters (Kotlier et al. 2002, *Studies in Avian Biology* 25:49–64). Approximately 78% of bird species that frequent burns are insectivores (Hutto 1995, *Conservation Biology* 9:1041–1058). Some granivores also take advantage of the seed crops provided by annual and perennial grasses. The large number of snags created by severe fires may benefit cavity-nesting species. Populations of many species of woodpeckers typically increase after fires because of the enhanced foraging, roosting, and nesting opportunities in the dead and dying trees resulting from fire. Aerial and shrub insectivores also tend to increase following fire because of flushes in volant insects and increases in herbs and shrubs following stand-replacing fires.

Because of environmental, topographic, and anthropogenic factors, wildfires burn across landscapes with differing intensities, typically creating landscapes with a mosaic of severely burned, partially burned, and unburned patches. The response of the avian community is determined by fire size and severity and by proximity to remnant, unburned forest. Anecdotally, some researchers have reported that bird activity appeared to be concentrated near burn edges (Hutto 1995; Murphy and Lehnhausen 1998, *Journal of Wildlife Management* 62:1359–1372).

Rigorous evaluation of alternative post-fire management activities, including salvage logging, requires an understanding of the ecological responses to fire. Although studies in other regions have led to an understanding of general patterns of bird population response to fire, region-specific information for western Oregon is lacking. Moreover, the spatial context of bird response to fire is poorly understood, and the influences of the mosaic of burned and unburned patches and distance from unburned forest on bird populations are unknown.

During the summer of 2002, wildfires burned hundreds of thousands of hectares in southwest Oregon. The largest of these fires, the Biscuit Fire, was located in and around the Siskiyou National Forest. It is estimated that this fire covered nearly 200,000 ha, of which nearly 40% was classified as being of moderate or high severity. A large-scale mosaic of severely burned patches interspersed with underburned and unburned patches was created. Because of the size and severity of this fire, this site offers an excellent opportunity for investigating how bird communities respond to the juxtaposition of burned and unburned patches of forest.

Here we report on progress to date on the second year of a 3-year study investigating how birds are distributed in large, severely burned patches relative to remnant, unburned or low intensity burned forest. Specifically, we are examining potential relationships between the diversity, richness, and composition of bird communities

within severely burned patches and proximity to green forests. In addition, we are examining the distribution and abundance of individual breeding bird species that are associated with burned forest. Our initial predictions were 1) that species that are associated with burns, but rely on forest habitat for nesting or cover, will be more likely to be associated with the edge of green forest; and 2) that species associated with open and burned forest will show no relationship with proximity to unburned forest.

Methods

Study sites

Our study sites are located on the east-central edge of the Kalmiopsis Wilderness in the Siskiyou National Forest, southwest Oregon, within the burn perimeter of the Biscuit Fire. The dominant overstory trees are Douglas-fir (*Pseudotsuga menziesii*), sugar pine (*Pinus lambertiana*), and ponderosa pine (*Pinus ponderosa*). The mid-canopy and understory are composed of conifers such as incense-cedar (*Calocedrus decurrens*), white fir (*Abies concolor*), and grand fir (*Abies grandis*), along with hardwoods such as black oak (*Quercus kelloggii*), Pacific madrone (*Arbutus menziesii*), tanoak (*Lithocarpus densiflorus*), and canyon live oak (*Quercus chrysolepis*). We targeted study sites within the Biscuit Fire boundary that were dominated by mature conifer forest types. Study sites were located in severely burned forest (≥75% canopy death) and low to moderately underburned forest patches (≤25% canopy death). We randomly chose points within these areas stratified by distance from forest-severe burn edges. We placed points from 50 to several hundred meters from the severe burn-forest interface. In 2003, we placed 45 points in severely burned patches and added seven more in 2004. In addition, we placed points at 26 forest sites within the unburned/underburned forest patches between 50 and >200 m from the burn edge for a total of 78 point-count sites. Forty-six of these points are between 900 m and 1350 m in elevation, and 33 are between 300 and 800 m in elevation. All points were a minimum of 250 m from all others and will be treated as independent in analyses.

Point-count surveys

We conducted point counts for birds at each point, using a variable-radius counting method during point counts. A single observer spent 8 minutes at each point and recorded species, sex, and activity (when possible) of all birds seen or heard, and estimated their distances from the observer. In 2003 and 2004, we surveyed each point three times during the peak nesting period in June and early July. All surveys were conducted between 0530 and 1100 hours. Two observers sampled 68 points in 2003 and four observers sampled 78 points in 2004. Each point was surveyed by at least two observers each season to minimize observer bias.

Nest searching

In addition to point-count sampling, we searched for nests on 35 burn plots. Plots were 4 ha in size and were centered on point-count sites. To facilitate searching, plots were divided into 16 50-m^2 subplots with flagging and/or wooden stakes (Figure. 1). Two observers surveyed each 4-ha plot twice per season, spending

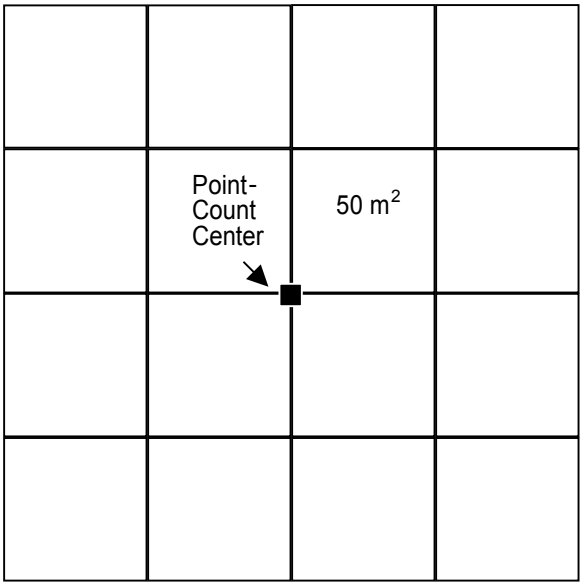

Figure 1. Four-ha nest searching plots were established at 35 point-count sites in burned stands. To facilitate searching and recording of nests and birds within plots, plots were further divided into 16 50-m^2 subplots.

between 2 and 3 hours during each survey period (approximately 30 minutes per 50-m^2 subplot).

Observers recorded birds encountered in plots and recorded their positions on the map. Species, sex, age, and activity were recorded whenever possible. Adult males were observed for 10 minutes, or until the bird went to a nest or was lost from view. Adult females encountered on the plots were observed until they either went to a nest or were lost from view. Observers also searched for nests by scanning substrates and by observing adult bird behavior for parental cues, including carrying food, nesting material, or fecal sacs, and antagonistic behavior towards conspecifics or other species, including alarm calls and chases. Bird observations and nests were recorded on a grid for later analysis of patterns of bird use and nest placement in burned stands.

Vegetation sampling

In 2003, vegetation and stand structure were sampled at the 68 point-count centers by using modified BBIRD protocols (Martin et al. 1997, *BBIRD Field Protocol*, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana, USA). In 2004 we resampled understory vegetation at the original 68 sites and completely sampled the 10 new sites. In addition, we measured vegetation characteristics at nests. At each nest site we described the nest substrate(s), recorded species, diameter at breast height (DBH), and decay class of all snags and live trees >8 cm DBH located within 11.3 m of the nest. Within 5 m of nests, we estimated percent cover of shrubs, herbaceous vegetation, and bare ground, counted all live stems ≥0.5 m high, and recorded all live trees >8 cm DBH. Live foliage associated with resprouting hardwood trees was included in the percent shrub cover estimate in sampling plots.

Preliminary Research Results

Excluding birds flying over stands during surveys, we detected 2,294 individuals of 59 bird species on 78 sites in 2004. Thirty-eight percent of individuals were detected within 50 m and 56% of birds were detected within 75 m of observers, respectively. Unidentified birds comprised approximately 4% of the total. Singing males comprised 55% of all detections.

Analyses of bird abundance and distribution patterns for 2003 and 2004 are currently being conducted. In 2004, the Dark-eyed Junco (*Junco hyemalis*) was the most common species encountered within 50 m of observers in point-count surveys (69%) followed by Hairy Woodpeckers (*Picoides villosus*) and Lazuli Buntings (*Passerina amoena*) (45% and 40%, respectively). Hermit Warblers (*Dendroica occidentalis*), Yellow-rumped Warblers (*Dendroica coronata*), and Red-breasted Nuthatches (*Sitta canadensis*) were detected on at least 30% of the sites within 50-m of point-count centers.

In 2003, mean species richness was highest in the forest interior and lowest at points in the burn farthest from unburned forest edge. There was no evidence that overall abundance or species richness of birds differed between the forest interior and points close to the edge of the burn, but forest sites on average had higher overall abundance and species richness than burned sites (see the 2003 CFER Annual Report). Analyses of patterns of abundance and richness in burned and forested sites in 2004 will be completed later this year.

On 30 burned sites where nest searching was conducted, we found 120 nests of 29 species (Table 1), with evidence of eight more species breeding on or near search plots. During nest searching efforts, we detected an average of 5.4 species breeding per plot. We did not find any nests on five of the sites; however, we detected fledglings on all plots. Nests of all species were not observed during the survey period in June and July, as reflected by the relatively low numbers of Dark-eyed Junco, Yellow-rumped Warbler, and Hairy Woodpecker nests compared to the number of breeding groups (Table 1). These species were some of the earliest nesters in the plots and many already had fledglings in early and mid-June. Therefore, observations of parental behavior and fledglings also will be analyzed for each plot to provide a more comprehensive picture of breeding bird use.

The resprouting hardwood species, tanoak, Pacific madrone and black oak provided important nesting substrates for Lazuli Buntings and Black-headed Grosbeaks;

Table 1. Breeding groups and nests detected on 35 4-ha plots in burned stands (25 May–7 July 2004). Each plot was visited twice per season and searched by two observers. The number of plots represents the total of 35 plots searched where at least one nest or fledgling of a particular bird species was detected. The number of breeding pairs denotes the total number of pairs for which either a nest or fledglings were detected on plots.

Avian Family	Species	No. Plots Breeding Detected	No. Breeding Pairs	No. Nests	Primary Nesting Substrates
Picidae	Hairy Woodpecker (*Picoides villosus*)	25	25	6	Conifer/Hardwood snags
	Northern Flicker (*Colaptes auratus*)	8	8	6	Conifer/Hardwood snags
	White-headed Woodpecker (*Picoides albolarvatus*)	1	1	1	Large conifer snag
	Red-breasted Sapsucker (*Sphyrapicus ruber*)	1	1	1	Hardwood snag
	Downy Woodpecker (*Picoides pubescens*)	2	2	0	N/A
Columbidae	Mourning Dove (*Zenaida macroura*)	1	1	1	Conifer snag
Accipitridae	Red-tailed Hawk (*Buteo jamaicensis*)	1	1	1	Large conifer snag
	Cooper's Hawk (*Accipiter cooperii*)	1	1	1	Nest off-plot in live conifer
Falconidae	American Kestrel (*Falco sparverius*)	2	2	2	Large conifer snags
Tyrannidae	Dusky Flycatcher (*Empidonax oberholseri*)	2	2	2	Branches of Douglas-fir snags
	Pacific-slope Flycatcher (*Empidonax difficilis*)	2	2	2	Log/cutbank
	Olive-sided Flycatcher (*Contopus cooperi*)	1	1	1	Live Douglas-fir
	Western Wood Pewee (*Contopus sordidulus*)	2	2	1	Branch of Douglas-fir snag
Corvidae	Steller's Jay (*Cyanocitta stelleri*)	2	2	0	N/A
Muscicapidae	Townsend's Solitaire (*Myadestes townsendi*)	7	7	2	Ground
	Western Bluebird (*Sialia mexicana*)	11	15	15	Conifer/Hardwood snags
	Mountain Bluebird (*Sialia currucoides*)	1	1	1	Conifer snag
	American Robin (*Turdus migratorius*)	9	11	11	Conifer/Hardwood snags
Sittidae	Red-breasted Nuthatch (*Sitta canadensis*)	7	7	5	Large conifer snags
Certhiidae	Brown Creeper (*Certhia americana*)	4	4	2	Large conifer snags
Troglodytidae	House Wren (*Troglodytes aedon*)	10	10	7	Conifer/Hardwood snags
Aegithalidae	Bushtit (*Psaltriparus minimus*)	1	1	1	Hardwood (live)
Hirundinidae	Tree Swallow (*Tachycineta bicolor*)	1	1	1	Large conifer snag
Fringillidae	Black-headed Grosbeak (*Pheucticus melanocephalus*)	12	15	8	Hardwood resprout/branches dead hardwoods
	American Goldfinch (*Carduelis tristis*)	2	2	2	Hardwood resprouts
	Pine Siskin (*Carduelis pinus*)	2	2	0	N/A
	Purple Finch (*Carpodacus purpureus*)	1	1	0	N/A
Parulidae	Yellow-rumped Warbler (*Dendroica coronata*)	15	16	5	Conifer snags (80%)
	Black-throated Gray Warbler (*Dendroica nigrescens*)	2	2	1	Live oak (live)
	Nashville Warbler (*Vermivora ruficapilla*)	1	2	1	Ground under live shrub/cover
	MacGillivray's Warbler (*Oporornis tolmiei*)	2	2	0	N/A
Emberizidae	Dark-eyed Junco (*Junco hyemalis*)	29	41	11	Ground, under live shrubs
	Lazuli Bunting (*Passerina amoena*)	15	30	21	Hardwood resprouts (86%)
	Western Tanager (*Piranga ludoviciana*)	4	5	1	Hardwood resprout
	Rufus-sided (Spotted) Towhee (*Pipilo maculatus*)	3	3	0	N/A
	Song Sparrow (*Melospiza melodia*)	1	1	0	N/A
	White crowned Sparrow (*Zonotrichia leucophrys*)	1	1	0	N/A
	Totals		**231**	**120**	

Lazuli Buntings in particular tended to be concentrated in areas with high densities of large re-sprouting hardwoods. American Robins and Yellow-rumped Warblers are generally identified as mid-story/canopy nesters but were found associated with conifer and hardwood snags on burned sites (see photo, p. 19). Analyses of patterns of nesting activities in burned areas relative to stand vegetation characteristics will be conducted. We also will compare point-count detections and presence of breeding individuals in the 35 sites where both were conducted to examine how well point-count sampling, which is biased towards singing males, reflects the presence of breeding females and nesting efforts.

Study Timeline

We completed the vegetation sampling for the 78 point-count sites in late September. Data entry and analysis of the second year's data on breeding bird distribution and abundance and vegetation patterns will be completed this fall and winter 2004/2005. Additional field work will be conducted in summer 2005. Final analysis of results will occur in fall and winter of 2005/2006. Preparation of publications describing the research and its results is anticipated in the spring of 2006.

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Tree Species Controls on Nutrient Cycling in the Oregon Coast Range

Alison Cross and Steven Perakis

Plants, generally and as individual species, are among the important controls on nutrient cycling in terrestrial ecosystems. Trees may influence soil nutrient cycling via various mechanisms, including nutrient uptake, alteration of precipitation chemistry, root turnover, and litter inputs. Leaf litter is a substantial nutrient input to surface soils. Because leaf litter chemistry varies with tree species, these inputs may be an important mechanism of tree species control on soil nutrient cycling.

An understanding of the effects of plant species on nutrient cycling should improve our ability to predict ecosystem response to perturbations such as climate change or invasion by exotic species. Such knowledge may also aid in guiding ecosystem management and restoration of late-successional composition and function of forests in addition to structural characteristics. Most information on effects of tree species on soils, however, is derived from highly controlled garden studies or field studies where land-use history, air pollution, or other human perturbation may confound ecological response. Old-growth forests of the Pacific Northwest provide a unique opportunity to examine tree species effects on soils in a wide range of ecosystems that developed with minimal anthropogenic disturbance. Information on species effects on soils should be useful in both Late-Successional Reserves (LSRs) and young stands.

In this region, compositional shifts through succession toward forests dominated by western hemlock (*Tsuga heterophylla*) may result in altered soil nutrient dynamics, with implications for ecosystem management. Additionally, fire suppression in coastal Pacific Northwest forests is predicted to increase western hemlock dominance in LSRs that are managed for old-growth structural characteristics. Such ecosystem simplification is of particular concern where important species differences in nutrient cycling would be eliminated.

The overall objective of this research is to explore the relationship of forest ecosystem structure and composition with function. In particular, this project addresses the following questions:

- How do individual tree species differ in their influence on soils of mixed old-growth forests of the Oregon Coast Range?
- How important are tree species effects across a broad geographic area?
- What are some potential mechanisms by which tree species influence soil properties and nutrient cycles?

In an observational study, soil and foliar properties are being quantified and compared among tree species within and across mixed old-growth stands. A manipulative study tests the leaf-litter leachate mechanism of tree species influence on soils in the laboratory.

Methods

Eight old-growth forest sites in the Oregon Coast Range were chosen for having four common tree species, Douglas-fir *(Pseudotsuga menziesii)*, western hemlock, western redcedar *(Thuja plicata),* and bigleaf maple *(Acer macrophyllum)*, well represented in the canopy (Figure 1). Four of the sites have soils derived from sedimentary rocks, primarily sandstone and siltstone, and the remaining four have soils derived from mixed sedimentary and volcanic rock. The Bureau of Land Management manages seven of the eight sites (Figure 2).

Field survey

During summer 2003, we selected six replicate trees of each of the four species at each site for sampling.

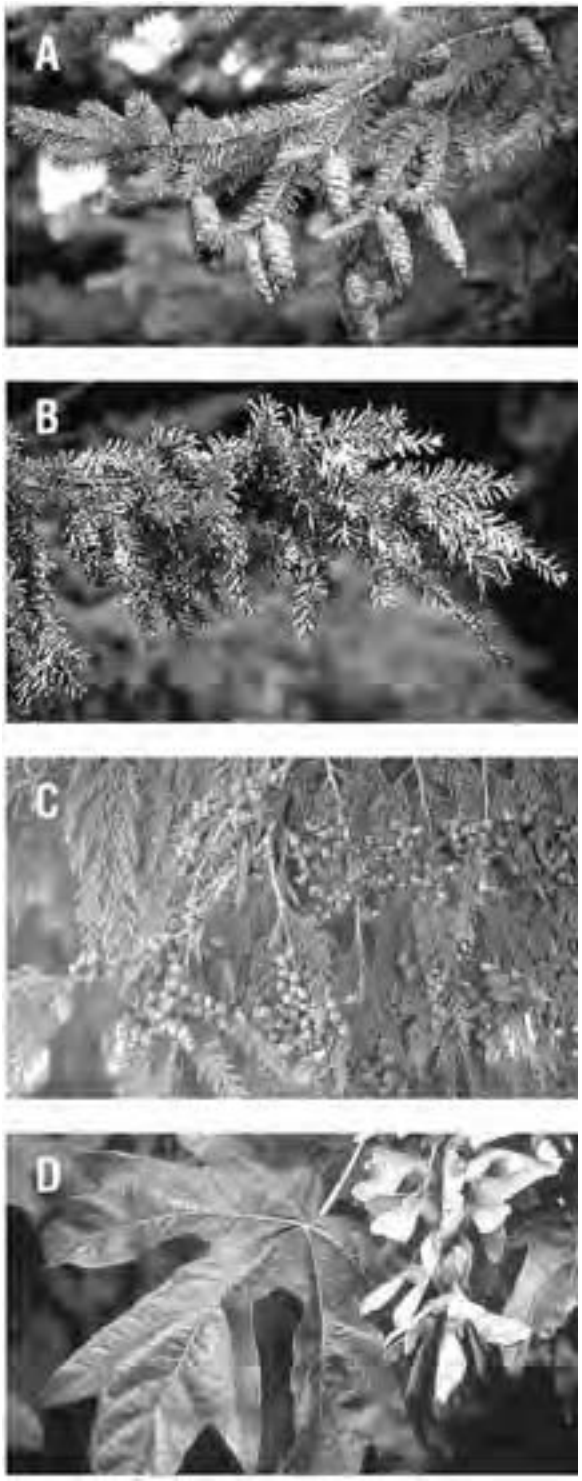


Figure 1. Foliage of A) Douglas-fir, B) western hemlock, C) western redcedar, and D) bigleaf maple. Photos courtesy of the Bureau of Land Management.

Selected individuals were large canopy trees in upland areas away from stand edges, large gaps, and draws. Immediate neighbor trees were not sampled. Aspect was recorded and diameter at breast height was measured from the upslope side of each tree. Within a 30- x 30-cm template placed beneath each tree, recently fallen (Oi) and decomposing (Oe/Oa) forest floor layers were measured for depth and removed. Underlying soils were collected at depths 0–10 cm and 10–20 cm and sieved through 2-mm mesh. Subsamples of the <2-mm soil fractions were analyzed for pH in a 2:1 water:soil solution. Soil pH is directly influenced by plant nutrient uptake, respiration, exudates, throughfall, stemflow, and litter leachates. Soils were analyzed for Bray-extractable phosphorus, and separate subsamples were fumigated with chloroform and extracted as above to determine microbial pools of carbon, nitrogen, and

Figure 2. Map of field survey sample locations in the Oregon Coast Range (courtesy of George Lienkaemper, USGS-FRESC.)

phosphorus. Analyses are ongoing for exchangeable ammonium, nitrate, organic carbon, and exchangeable base cations (calcium, magnesium, potassium, and sodium). These nutrient pools are those readily available to plants and microbes. Soils were also analyzed by dry combustion to determine total pools of nitrogen and carbon.

We returned to the sites in July 2004 to collect foliage from six trees of each species. Foliage samples were retrieved from the canopy using a 0.12-gauge shotgun loaded with steel turkey shot. Samples were then frozen and later sorted, ovendried, and ground prior to analysis for carbon and nitrogen by dry combustion and for phosphorus and base cations by acid digest.

A total of 384 samples are being analyzed in each assay (4 species x 6 replicates x 2 depths x 8 sites = 384). Site and species effects will be analyzed in a nested two-way ANOVA, and changes with depth will be tested by two-tailed paired t-test. Significant effects will be reported at the $\alpha = 0.05$ level.

Litter extract experiment

To test the litter leachate mechanism of tree species controls on soil nutrient cycling, we will treat soils in chambers with either extracts of each species' leaf litter or a deionized water control and track changes in soil microbial respiration and biologically available nutrient pools. In mid-August 2004, we installed 18 litter traps at a site near Honey Grove Creek sampled in the field survey. Traps consisted of two layers of 1-mm mesh suspended above the understory by stakes; each covered approximately 1.8 m^2 (Figure 3). Litter samples will be collected from traps biweekly through early November. Samples will then be ovendried, and leaves will be sorted to species (Douglas-fir, western hemlock, western redcedar, or bigleaf maple) and composited across all traps and collection dates. Litter extracts, created by soaking leaf litter of each species with deionized water, will be analyzed for carbon, nitrogen, phosphorus, and base cation concentrations. In addition, litter samples for each species will be analyzed for nutrient content as described above for foliage.

In early November 2004, multiple 0–10 cm soil samples will be collected from beneath each tree species and composited. After adjustment to 60% water holding capacity, the soils will be divided among Falcon filters modified for laboratory incubation including leachate and gas sampling ("chambers"). Twenty chambers will be analyzed for headspace CO_2 concentration and then leached with deionized water to establish baseline levels of respiration and available nutrients (4 soils x 5 replicates = 20). Another 100 chambers will be treated with a litter extract or deionized water, sampled periodically for headspace CO_2 concentration over 4 weeks, and then leached with water to determine post-treatment levels of respiration and available nutrients (4 soils x 5 treatments x 5 replicates = 100).

Figure 3. Litter collection at Honey Grove Creek.

Treatment response, as mineralization of carbon and nitrogen or alterations in other nutrient pools, will be compared to controls and to baseline measurements. The full factorial design will allow for two-way ANOVA of tree species effects via litter extract, soil source, and any interactions of the two. As in the field survey, significant effects will be reported at the $\alpha = 0.05$ level.

Preliminary Research Results and Management Implications

Preliminary results from the field survey suggest that tree species differentially affect soil phosphorus and

pH. Species effects were significant within sites, despite considerable background variation across sites. Figures 4 and 5 show mean pH and phosphorus values for the four species at two depths. Soil pH varied significantly with species at both depths ($P < 0.001$) and followed the general order western hemlock < Douglas-fir < western redcedar < bigleaf maple. Effects of bigleaf maple and western redcedar on pH were most apparent at low-pH sites. Species differences in pH appeared to be greater at the surface, where biological activity is highest, and smaller at 10–20 cm, where weathering is likely to be more important. These trends may have important implications for activity of litter- and soil-dwelling organisms known to be sensitive to pH variations.

Available phosphorus pools showed species differences ($P < 0.001$ at 0–10 cm depth, and $P = 0.013$ at 10–20 cm depth). These pools were lowest beneath western redcedar, but the overall species ordering varied by site. In addition, these pools were greater near the surface, where trees are actively cycling phosphorus. Phosphorus decreased with depth beneath all species and decreased significantly with depth under Douglas-fir ($P = 0.05$). These species-level variations in soil properties of current late-successional forests in the Oregon Coast Range may contribute to local biodiversity in soil- and litter-dwelling organisms by creating heterogeneous habitats at scales of one to several square meters, the projected zones of influence of individual trees. Such variations may, however, decrease in the future as continued fire suppression promotes dominance by shade-tolerant western hemlock in LSRs.

Study Timeline

For the field survey, soils were sampled during July and August 2003 and foliage was collected in July 2004. For the experiment, litter collection began in mid-August 2004 and will continue through early November, when soils will be gathered. Laboratory work is ongoing and projected to conclude by April 2005. Data analysis will continue through June 2005, and a final report, manuscripts, and a Master's thesis will be completed by October 2005.

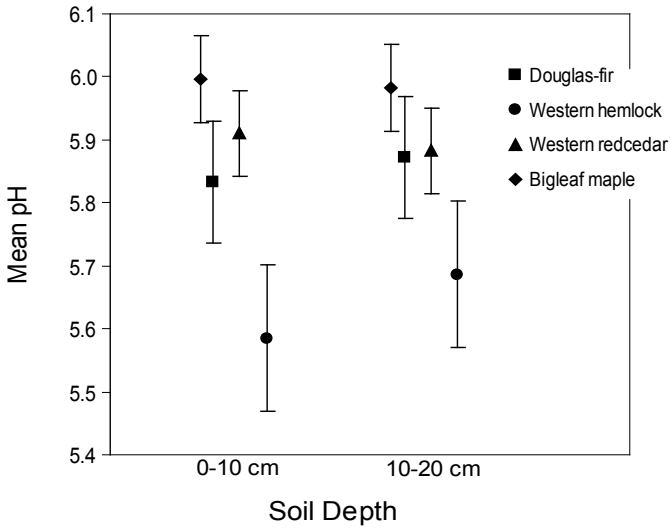


Figure 4. Mean soil pH (± SE) for each species and depth across all sites.

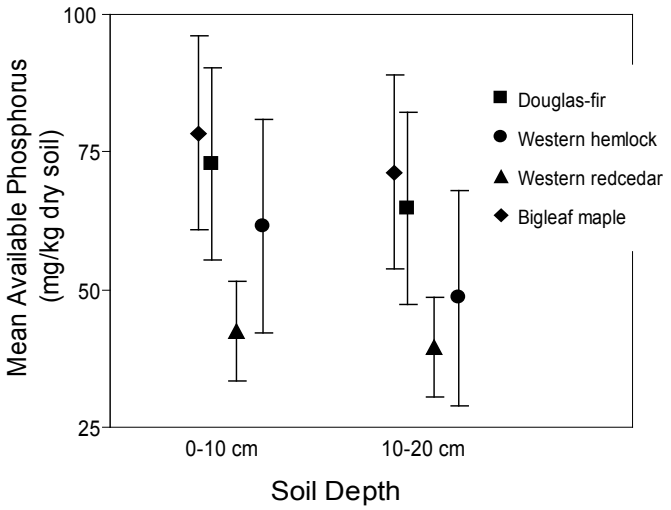


Figure 5. Mean soil phosphorus (± SE) for each species and depth across all sites.

Contrasting Fire Severity between Riparian and Upslope Forests in the Biscuit Fire of Southwestern Oregon

Jessica Halofsky and David E. Hibbs

Riparian zones have great ecological importance relative to the area they occupy in the landscape. Although natural disturbances, such as fire and landslides, are integral in the dynamics of riparian systems, very little is known about the history and role of fire in riparian areas. Riparian zones have unique physical characteristics, as well as unique vegetation structure and composition, which have the potential to influence fire behavior in riparian zones. There is no consensus, however, on how fire behaves in riparian areas compared to uplands; some researchers have found that fire is less frequent and less severe in riparian areas than in uplands, whereas others have found that fire is more severe in riparian areas. There is also very little information on vegetation recovery patterns in riparian areas following fire.

The present study was initiated in two watersheds of the 2002 Biscuit Fire in the Siskiyou National Forest of southwest Oregon. Two objectives of the study are to determine 1) how the severity of fire in riparian areas compares to that in uplands and 2) what factors affect the severity of fire in riparian areas. Fire severity class of uplands, forest basal area, species composition, pre-fire stand age, valley floor width, and topographic variables were measured factors. It is also possible that forest productivity is a potential organizing principle explaining the discrepancies in theories on how fire behaves in riparian areas compared to uplands, because differences in fuel composition, structure, and configuration in systems of varied productivity may affect how fires burn in riparian versus adjacent upland areas. Thus, Watershed 1 and 2 investigated in this study represent relatively low and high productivity levels, respectively. A third objective of this study is to determine what factors affect post-fire recovery patterns in riparian zones. To meet this objective, we measured fire severity, abundance of resprouting hardwoods and shrubs, and width of floodplains/terraces, among other factors.

Information on the behavior of fire in riparian systems will lead to a greater understanding of the role of fire as a disturbance process in riparian areas of southwestern Oregon and will aid in the understanding of how environmental factors related to riparian zones can affect fire regimes at local and landscape scales in this region. Information gained in this study will also aid in setting pre- and post-fire management goals for riparian areas of southwest Oregon.

Methods

Study sites

Two watersheds in the Biscuit Fire area, each approximately 90 ha in size, were selected for study. The first watershed (Watershed 1), on the east side of the fire, is characterized by relatively low forest productivity. Dominant overstory species include Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), Port-Orford-cedar (Chamaecyparis lawsoniana), and western hemlock (*Tsuga heterophylla*). Common midcanopy species include tanoak (*Lithocarpus densiflorus*), canyon live oak (*Quercus chrysolepis*), Sadler oak (*Quercus sadleriana*), and golden chinquapin (*Chrysolepis chrysophylla*), and the understory is characterized by Pacific rhododendron (*Rhododendron macrophyllum*), salal (*Gaultheria shallon*), dwarf Oregon-grape (*Mahonia nervosa*), and wild blackberry (*Rubus ursinus*). The second

watershed (Watershed 2), on the west side of the fire, is characterized by relatively high forest productivity. Dominant overstory species include Douglas-fir, sugar pine (*Pinus lambertiana*), western hemlock, and Port-Orford-cedar. Common midcanopy species include California laurel (*Umbellularia californica*), tanoak, golden chinquapin, and canyon live oak. The understory is characterized by evergreen huckleberry (*Vaccinium ovatum*), Pacific rhododendron, salal, wild blackberry, and dwarf Oregon-grape.

Sites were selected in each watershed to incorporate a range of broad fire severity classes, stand ages, and stream sizes. Within a geographic information system (GIS), a fire severity map created by the U.S. Forest Service was used to separate each watershed into three broad fire severity categories (low, moderate, and high severity). For a given severity class, first-, second-, and third-class stream segments were identified. Once stream segments were selected in each fire severity class, points were randomly selected in a GIS to incorporate a range of forest stand ages (early-, mid-, and late-seral stage). Approximately 25 points were sampled in each watershed.

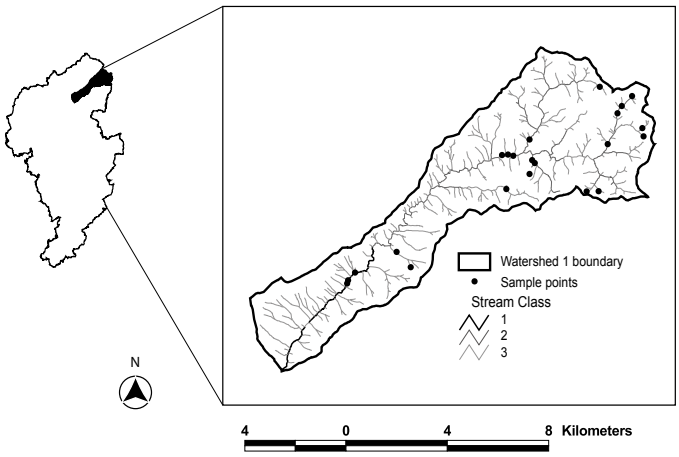


Figure 1. Watershed 1 (low-productivity watershed) location in the Biscuit Fire.

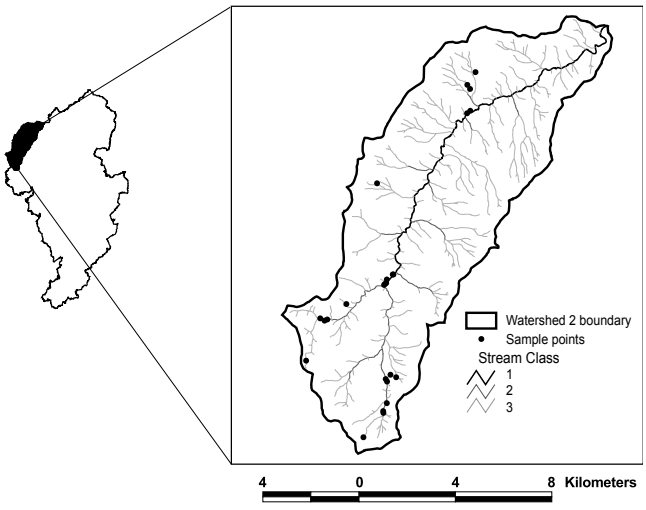


Figure 2. Watershed 2 (high-productivity watershed) location in the Biscuit Fire.

Vegetation sampling

At each randomly selected point, four plots were established: two 5- x 25-m plots were placed directly adjacent to the stream, and one 10- x 25-m upland plot was placed at 25 m of elevation above the riparian area on each side of the stream. In each plot, an assessment of fire severity was done. Fire severity measures taken in each plot included scorch height and pre- and post-fire percent live crown of the three tallest trees in each plot. These measurements were done with a hypsometer. Percent exposed mineral soil and percent oxidized soil were visually assessed in each plot. This assessment of soil damage was conducted by the same two individuals throughout data collection, and an average of the estimates for each individual was used for each plot in order to reduce bias. Basal area mortality and live basal area were approximated in each plot by measuring the diameter at breast height (DBH) of all trees greater than 5 cm DBH and recording whether the individual trees were living or dead. The species of each individual was recorded. All individual trees less than 5 cm DBH were counted by species. Dead shrub stems were also counted by species, and the percent cover of all live shrub species was visually assessed to approximate former shrub cover by species. Aspect and elevation were recorded for each plot.

In addition to the above methods, further measurements were taken in riparian plots. These measurements included stream slope within the plots, percent slope to each of the upland plots, bank-full width, and valley floor width. For the purposes of assessing recovery of riparian vegetation, all live and dead trees in the plot measured within 2 m of the stream were recorded separately. In addition, all regeneration of trees and shrubs was recorded in the 2-m band. It was noted whether regeneration was by seed or sprouting. All riparian plot centers were permanently marked with rebar, and GPS coordinates of the markers were taken for future measurement purposes.

Analysis of variance (ANOVA) will be used to determine if there is significant variation in fire severity in riparian versus upland plots. A multivariate regression analysis will be done to determine the variables that are most important in explaining variation in fire severity in riparian areas. ANOVA will also be used to determine whether there are significant differences in riparian recovery patterns in areas of varied fire severity and stream size.

Preliminary Research Results and Management Implications

No results are available at this time.

Study Timeline

Data collection in the Biscuit Fire was completed in September 2004. Further data collection will be done in the summer of 2005. Final analysis of results is expected to occur in the fall of 2005 and winter of 2006.

Bureau of Land Management Density Management Study

John Cissel, Paul Anderson, Shanti Berryman, Sam Chan, Deanna Olson, Klaus Puettmann

The Bureau of Land Management (BLM), Pacific Northwest Research Station (PNW), U.S. Geological Survey (USGS), and Oregon State University (OSU) established the Density Management Study (DMS) in 1994 to develop and test options for young stand management to meet Northwest Forest Plan objectives in western Oregon. The DMS demonstrates and evaluates alternative approaches to managing 40- to 70-year-old forest stands on low-elevation sites in western Oregon to create and maintain late-successional forest characteristics.

Scientific and management objectives of the DMS include the following:

- evaluate effects of alternative forest density management treatments on important late-successional 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 resources
- use DMS sites to develop operational approaches to implementation of 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 study findings with land managers, regulatory agencies, and policy-makers
- 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

Methods

Study treatments

The DMS consists of three sets of treatments: initial thinning, rethinning, and riparian buffer widths (see http://www.fsl.orst.edu/cfer/pdfs/DMS.pdf for more details).

The initial thinning treatments were installed in 40- to 60-year-old stands that had never been commercially thinned. Four stand treatments of 30–60 acres each (1 acre = 0.405 ha) 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 (0.25 to 1 acre) leave islands were included in all treatments except the control, and small patch cuts (0.25 to 1 acre in size) were included in the moderate and variable density treatments.

Alternative riparian buffer treatments were nested within the moderate density retention treatment at each of the seven initial thinning study sites. Alternative riparian buffer width treatments included 1) streamside retention (one tree canopy width, or 20–25 ft [1 ft = 0.305 m], 2) variable width (follows topographic and vegetative breaks, approximately 70 ft), 3) one full tree height (approximately 220 ft), and 4) two full tree heights (approximately 440 ft). Physical limitations at each site usually prevented installation of all four treat-

ments, and the two-tree-height treatment fit the ground on only two sites.

The rethinning treatments were installed in four 60- to 70-year-old stands that had been previously commercial thinned. Each study stand was split into two parts: one, an untreated control, and the other, a rethinning (30–60 TPA). The rethinning treatment was intended to represent a potential future option for a second entry thinning 15–25 years after an initial thinning.

Location

Study sites were selected on BLM lands to be broadly representative of mesic, low-elevation forests in western Oregon. Sites are located in both the Coast Range and the Cascade Range (Figure 1).

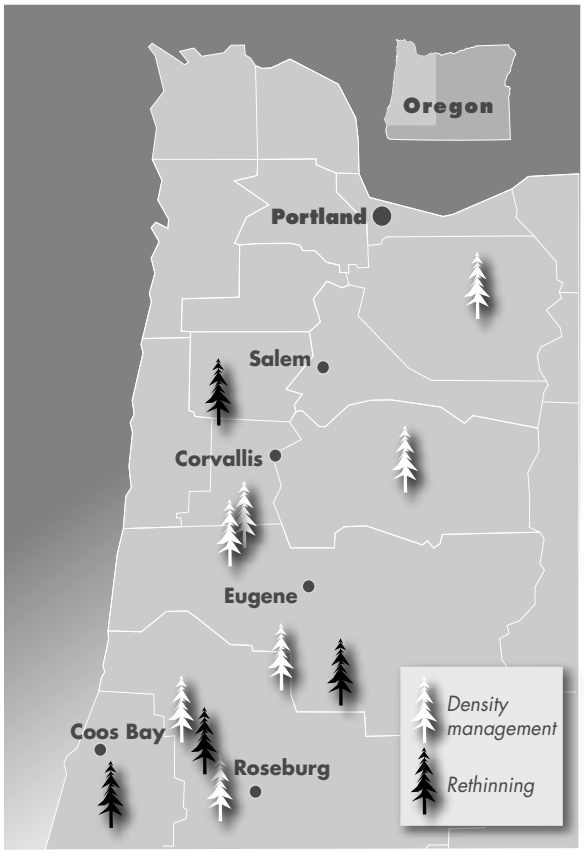


Figure 1. Location of the Density Management Study sites.

Component studies

Several component studies are currently underway addressing DMS objectives. Measurement, remeasurement, data management, and analysis were ongoing for each of these components in 2004.

Vegetation

Randomly allocated plots are scattered across all treatment areas to characterize treatment implementation and whole-treatment vegetation response. These plots also provide information about the influence of overstory conditions on understory vegetation diversity and development. Transects across patch-cut boundaries are being used to measure patch dynamics as affected by patch size and neighborhood. A full suite of overstory and understory tree, shrub, herb, and dead wood variables are being monitored. Klaus Puettmann (OSU) is the lead investigator for this component.

Microclimate and microhabitat

Microclimate and microhabitat gradients due to density management practices and alternative riparian buffer widths are being monitored at seven DMS sites along transects oriented perpendicular to streams and extending from stream center to approximately 240 ft past the end of the riparian buffer. Available light, air and soil temperature, streambed temperature, relative humidity, vegetation, and overstory trees are measured at points distributed along these transects. Paul Anderson (PNW) and Samuel Chan (OSU) are the lead investigators for this component.

Aquatic vertebrates

DMS sites are being used to assess potentially unique aquatic resources in managed headwaters and evaluate the effects of thinning in riparian reserves. Pre- and post-treatment surveys along streams with alternative riparian buffer widths and moderate retention thinning measure fish and amphibian abundances and their habitats. Terrestrial salamanders and mollusks are being monitored on two sites. Deanna Olson (PNW) is the lead investigator for this component.

Arthropods

Aquatic and terrestrial arthropods add significantly to the beauty and biodiversity of forest and stream ecosystems, are significant links in many food chains, and are important regulators of nutrient cycling processes. The biodiversity and biomass responses of aquatic and terrestrial arthropods to thinning and to alternative riparian buffer widths are being evaluated on three DMS sites using data collected with pitfall and emergence traps. Andrew Moldenke (OSU) leads this component.

Leave Islands

Retention of leave islands during forest harvest operations has emerged as an important strategy to maintain plant and animal diversity. The objective of this component is to evaluate the relative effectiveness of leave islands in providing refugia for low mobility species including vascular plants, amphibians, mollusks, and arthropods. Species abundance and diversity in leave islands of different sizes are being compared to thinned areas and to unthinned controls. Stephanie Wessell (OSU), working under the direction of Deanna Olson and Richard Schmitz (OSU), is leading this component of the study.

2004 Highlights

Overall study accomplishments

- Organized and hosted the first DMS findings workshop (165 participants, mostly BLM); PowerPoint presentations with initial results are available online (http://ocid.nacse.org/nbii/density/)
- Hosted eight DMS field tours, including two for national symposia (ESA and IUFRO)
- Developed DMS poster and brochure
- Developed GIS database template and metadata and created GIS databases for seven DMS sites
- Developed proposal for new study treatments to be implemented in 2009–2011
- Completed site histories for all 11 sites
- Developed draft DMS establishment report and study plan
- Manuscript describing the DMS and riparian buffer study published (Chan et al. 2004, Variable density management in Riparian Reserves: lessons learned from an operational study in managed forests of western Oregon, USA. *Forest Snow and Landscape Research* 78: 151–172)
- Book chapter describing the initial findings of the effects of thinning on aboveground fungi published (Norvell and Exeter 2004, Ectomycorrhizal epigeous basidiomycete diversity in Oregon Coast Range *Pseudotsuga menziesii* forests preliminary observations *in* C.L. Cripps, editor. Fungi in Forest Ecosystems: Systematics, Diversity, and Ecology. The New York Botanical Garden Press. Bronx, NY.)
- Manuscript describing the effectiveness of leave islands for low-mobility species submitted

Vegetation

- Developed the vegetation database with associated metadata
- Documented DMS vegetation sampling protocol for BLM plots
- Analyzed the response of overstory and understory vegetation to the thinning treatments 5 years post harvest at three sites (Keel Mountain, Bottomline, OM Hubbard)
- Field survey of overstory and understory vegetation and coarse woody debris at 77 new plots at North Soup
- Remeasurement field survey of understory vegetation at 256 BLM monitoring plots at seven sites (Keel Mountain, OM Hubbard, Bottomline, North Soup, Sand Creek, Little Wolf, and Blue Retro)
- Remeasurement field survey of overstory trees at 93 BLM monitoring plots at three sites (North Soup, Blue Retro, Little Wolf)

- Installation and vegetation survey of 22 permanent gradient transects in gaps (0.25 and 1 acre) at four sites (Keel Mountain, Bottomline, North Soup, OM Hubbard)
- Poster displaying study methods and initial results developed

Microclimate and microhabitat

- Field survey of stand density, basal area, and mean tree diameter; data collection at 283 plots over five sites (Green Peak, Keel Mountain, OM Hubbard, North Soup, Bottomline)
- Analyses of microclimate data for six sites (those listed above plus Callahan Creek)
- Development and submission of Interim Report on the microclimate component of the DMS-Riparian Buffer Study (http://ocid.nacse.org/nbii/density/)
- Analysis of relationships between measures of overstory structure (density, basal area, relative density) and canopy light transmittance
- Poster displaying study methods and initial results developed

Aquatic vertebrates

- Field surveys of stream habitats and vertebrates were conducted in spring and summer at three sites (BLM sites: Perkins Creek, Green Peak; Forest Service site: Schooner Creek)
- Site monumenting and metadata documentation completed for most sites
- Data entry and quality control completed for pre-treatment data and years 1 and 2 post-treatment data
- Analyses of years 1 and 2 post-treatment vertebrate data completed in comparison to pre-treatment conditions
- Analyses of years 1 and 2 post-treatment habitat data initiated in comparison to pre-treatment conditions, including instream substrate, flow conditions, and down wood
- Report to site coordinators submitted, including detailed maps of stream reaches included in the study and species inventories derived from pre- and post-treatment sampling
- Poster displaying study methods and initial results developed

Arthropods

- Field data for terrestrial arthropods collected in patch openings, thinned and unthinned areas, and three riparian buffer widths on three DMS sites (27 plots per site)
- Field data for aquatic arthropods collected for three riparian buffer widths on three DMS sites (15 sample points per site)
- Sorting, identification, data management, and analysis completed for the terrestrial arthropods and in progress for the aquatic arthropods

Leave islands

- Arthropod and vascular plant species identification completed for all sites
- Arthropod and vascular plant functional groups determined
- Analyses completed of comparisons among five treatment types (unthinned forest, thinned forest (80 TPA), and circular leave islands of 0.25 acre, 0.5 acre, and 1 acre) of arthropod, mollusk, amphibian, and vascular plant abundance
- Multivariate analyses of community organization and habitats completed
- Initial results presented at the Ecological Society of America annual meeting
- Poster displaying study methods and initial results developed

Preliminary Research Results: Microclimate

Microclimate is an important element of ecosystem function, as it influences biological processes, such as primary production and decomposition, and the physical environment determining habitat suitability for many organisms. Basic knowledge of spatial and temporal variation in microclimate of riparian and adjacent upland forests of western Oregon is lacking. Further, the influence of forest management practices, particularly overstory thinning and riparian buffer delineation, on microclimate conditions of riparian zones is generally unknown. Given that much of the active management on federal lands occurs in headwater forests, it is important that relationships between silvicultural treatments and microclimate be characterized for riparian and adjacent upslope forests.

The microclimate study component included the following objectives: 1) describe microclimate gradients associated with riparian and adjacent upland forests in both thinned and unthinned stands, and 2) evaluate potential differences in microclimate gradients among alternative buffer widths.

For each site and treatment combination, canopy cover, understory light, air and soil temperature, and relative humidity were measured or monitored prior to and following implementation of the commercial thinning treatments. Spatial variation in cover, light, and microclimate was characterized by repeated sampling along transects originating at stream center and extending perpendicular to the channel through the riparian zone and into the adjacent upland forest (Figure 2).

While most transects extended about 200 ft upslope, a few extended in excess of 700 ft, depending on buffer width and topography. Observations of canopy cover and light transmittance were made at 3.3 ft above ground. Air temperature and relative humidity were measured at heights of 0.7 ft (near-ground) and 3.3 ft above ground (understory). Light and microclimate were sampled at six of the seven BLM sites, five in the Coast Range and one in the Cascade Range. Results are reported for observations made during the summer when treatment effects were expected to be most pronounced.

Commercial thinning substantially increased understory light when stand density was decreased to a basal area (BA) less than 120 ft^2, or in other terms, below a relative density (RD) of 30. At higher residual densities, light transmittance values were very similar to those of unthinned stands, being about 10% of light in the open (Figure 3). Increased thinning intensity to a moderate level of 80 TPA (BA of ca. 100 ft^2 or RD 20) resulted in average light levels of 25% of open conditions. The heaviest thinning, to 40 TPA (BA of ca. 60 ft^2 or RD 15), resulted in light levels averaging about 30% of that in the open, only a 5% increase for a doubling of thinning intensity over the 80 TPA treatment. Light conditions within 1-acre patch openings averaged about 57% of open conditions as a result of light interception by the surrounding trees. With respect to riparian buffers, increased light transmittance resulting from thinning adjacent stands was generally limited to 60 ft from the buffer-upland forest edge.

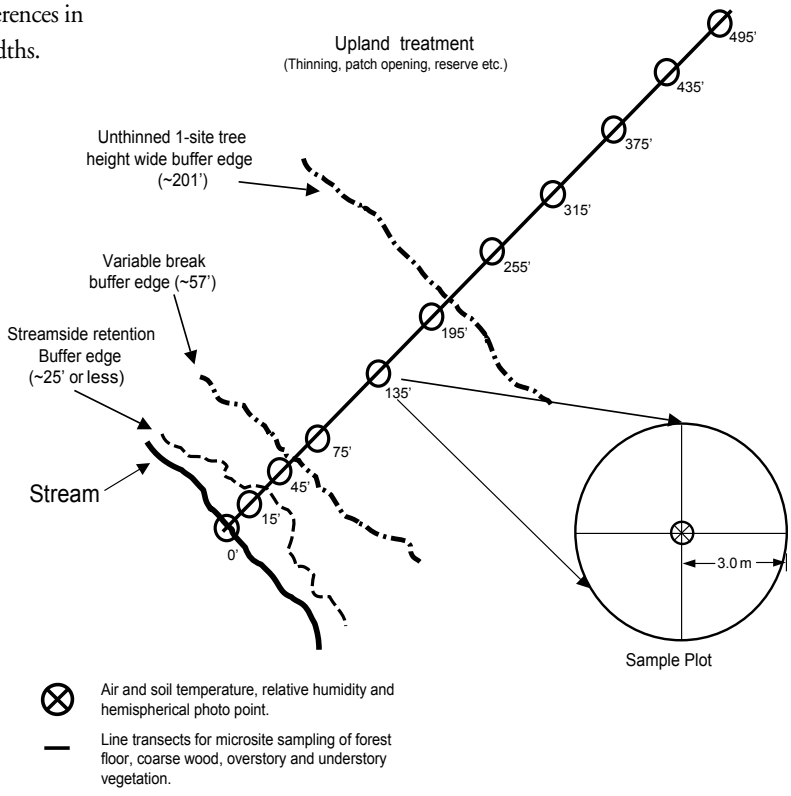


Figure 2. Transect and sub-plot layout for microclimate and microsite sampling in the riparian buffer component of the Density Management Studies.

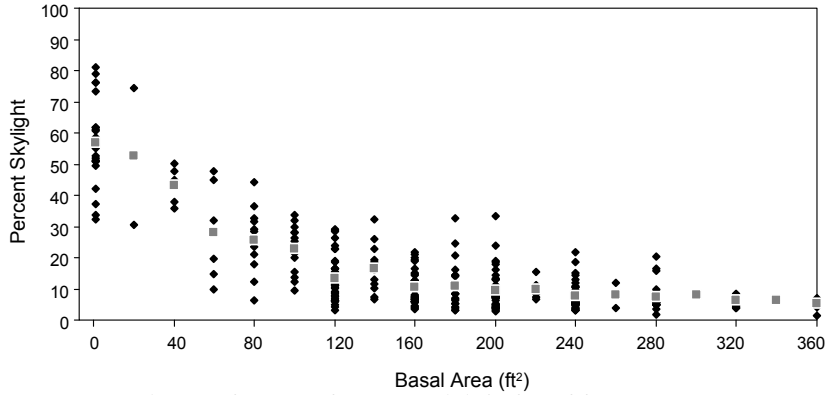


Figure 3. Basal area and corresponding percent skylight derived from six Density Management Study sites during summer conditions. Scatter points represent individual plot values while squares represent means.

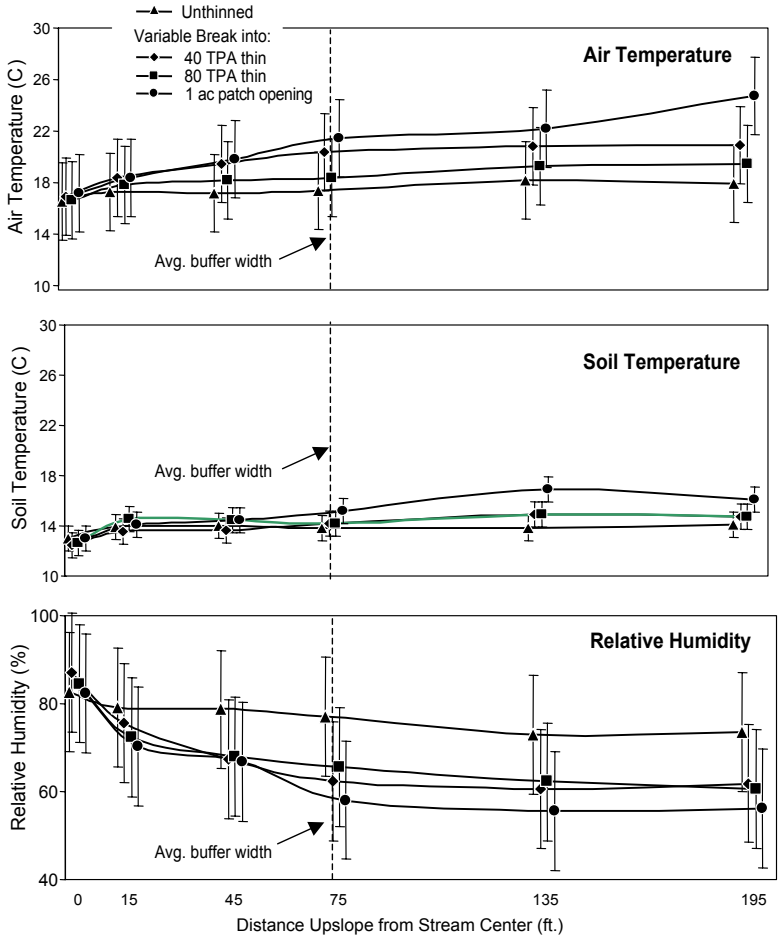


Figure 4. Spatial variation in microclimate at 4 pm; variable break (approximately 73 ft) buffers into 80 TPA thinned stand, 40 TPA thinned stand, and 1-acre patch opening; and an unthinned stand.

Microclimate gradients at 4 pm, the warmest and driest part of the day, indicated a significant influence of the stream extending about 75 ft outward from stream center. The strongest influence of the stream on microclimate, as indicated by steepness in temperature and relative humidity gradients, occurred within 15 ft of the stream (Figure 4). Microclimates differed significantly among upslope treatment areas during the peak stress period at 4 pm. Patch openings tended to be warmer and drier than thinned stands, which in turn were warmer and drier than unthinned stands. Among stands thinned to various densities, however, microclimates on average were not significantly different. There was considerable overlap in observed temperatures and humidities between thinned and unthinned stands, suggesting that these stands provide a wide-range of microclimates. Microclimate differences associated with buffer width or density management were not evident between 6 pm and 6 am.

At the stream we were unable to detect significant effects of either buffer width or upland density management on streambed water temperature or air temperature and relative humidity within the first 15 ft of the stream center.

Study Timeline

Thinning treatments were implemented on the 11 study sites between 1997 and 2002. Permanent vegetation plots were established in each stand soon thereafter. Remeasurement of permanent plots is scheduled to occur periodically on a 5-year cycle. Each component study follows a similar timeline. Major analyses and reports are expected on a 5-year cycle. A second round of treatments is proposed to begin in 2009.

For more information on the current status of these studies, please contact John Cissel, DMS Coordinator (jcissel@or.blm.gov, 541-683-6410).

Large Woody Debris in the Terrestrial and Aquatic Riparian Zone: Production, Recruitment, Retention, and Function

Large wood in streams is important because it affects stream function. This wood also provides habitat for aquatic and terrestrial organisms. Although the role of large wood as a structural feature of coastal streams is known, the processes that control recruitment, retention, and redistribution of woody debris at broad spatial and temporal scales remain poorly understood.

Goal

The goal of this research theme is to develop a basin-level understanding of large woody debris, which includes:

- examining the processes and conditions that regulate input and
- examining the movement and removal of large woody debris.

2004 Highlights

- Former doctoral student Christine May and Robert Gresswell co-authored a publication in the journal *Geomorphology* titled "Spatial and temporal patterns of debris-flow deposition in the Oregon Coast Range, USA." A summary of these findings was published as a USGS/CFER fact sheet.
- Daniel Sarr completed his Ph.D. dissertation titled "Multiscale Controls on Woody Riparian Vegetation: Distribution, Diversity, and Tree Regeneration in Four Western Oregon Watersheds."

Continuing studies during the year under report are summarized in the following section.

Large Woody Debris Production and Input

Jeff Shatford and David E. Hibbs

Headwater streams comprise a large proportion of the riverine systems that run through western Oregon. Forest management and restoration activities in and around headwater streams can therefore affect a large percentage of the system and have effects that cascade up and down the network. Impacts on stream temperature are a common example, but other impacts to stream networks relate to inputs of leaf litter and woody debris. An understanding of the natural patterns of riparian forest composition is therefore useful in guiding management decisions and understanding how forest management activities may impact ecosystem function.

Most research on riparian forests comes from lowland rivers, which are characterized by large floodplains and meandering channels. The low-order (1st–3rd) streams that are typical of steep mountainous landscapes in western Oregon are more often constrained, with relatively narrow valley floors, terraces, and, often, steep side slopes. Along such streams, forest composition is influenced by biotic and abiotic factors common to upland sites (e.g., fire, insect infestation, root rot, wind), but also factors unique to stream networks (e.g., flooding, debris flow, bank cutting). The resulting riparian forests can be very heterogeneous as the floodplain narrows and widens along the channel, intersecting with various slope processes and upland disturbances. This heterogeneity can be seen as bands of vegetation that trace the stream channel and extend upslope. The degree to which streamside and upslope forest types overlap is affected, in part, by this streamside topography. Shallow surface topography will be subject to flooding (floodplains), whereas steep slopes will elevate trees and tree roots above floodwaters and seasonally saturated soils.

We investigated how tree species composition varied at different scales of reference. At a large scale, we summarized the abundance of the common tree species occupying riparian forests within distinct ecoregions of western Oregon. At a smaller scale, we investigated how forest composition changed with distance from stream edge and how composition differed between floodplains and side slopes.

Methods

Sampling was conducted in unmanaged forested watersheds throughout western Oregon (Figure 1), west of the Cascade crest and below 1,300 m (i.e., below elevations dominated by true fir and alpine forests). Sampling was stratified into five ecoregions, the Klamath, south Cascades, north Cascades, Coast Range, and coastal fog belt, having 84, 28, 89, 68 and 45 vegetation sampling transects, respectively. Stream reaches were selected that 1) had no prior farming, grazing, hydraulic mining, or tree cutting; 2) were at least 600 m in length; and 3) were unroaded from creek to ridge on both stream sides. A roughly equal number of first- through third-order streams were sampled that ranged in elevation from sea level to 1,300 m.

Sampling began at a random location along the stream 200 m or more above the boundary between managed and unmanaged forests. Sampling sites were established on one side of the stream with subsequent sites established 200 m apart on alternating sides. Belt transects (15 m × 50 m) began at the stream edge and ran upslope with the long axis of the transect perpendicular to the valley axis. For all trees encountered in a transect, we recorded species, diameter at breast height (DBH), and distance to stream. Stream and topographic information were recorded to characterize each site, including aspect, stream width, gradient, percent slope,

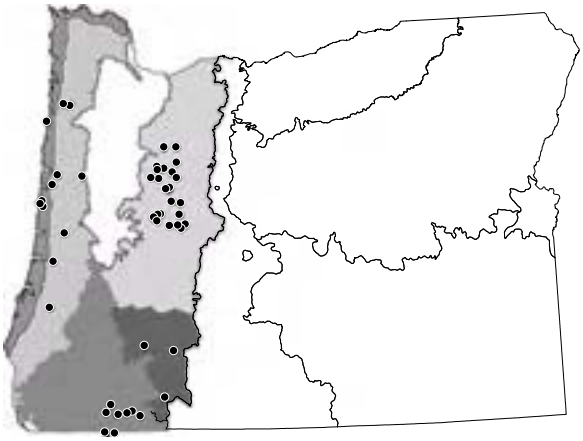


Figure 1. Map of western Oregon showing the location of transects sampled within five ecoregions (clockwise from top right: N. Cascades, S. Cascades, Klamath, Coast Range and Fog Belt.

and valley width. Stream width ranged from 0.5 to 45 m wide ($\bar{x}$ = 7.3 m) and floodplains ranged from 0 to 100 m wide ($\bar{x}$ = 7.1 m).

We calculated the average basal area/ha of each tree species in a given ecoregion. This is reported as the percent basal area/ha per species, given the total basal area/ha of each ecoregion. We analyzed changes in species composition from streamside to side slope, e.g. from trees 0 to 50 m from the stream, in two separate analyses. First, we dissected each transect into three subplots of equal area and determined how frequently a species occurred at a range of distances from the stream edge. This is reported as the percent of subplots occupied. Second, we were interested in how breaks in topography would influence forest composition. For each stream-side transect, we determined a breakpoint between floodplain trees and side-slope trees and compared the species composition of these two geomorphic settings. For both the approaches described above, we summarized the results by ecoregion.

Research Results and Management Implications

Regional variation

Riparian forest composition varied both at the large scale (within and among ecoregions) and the local scale (between floodplain and side-slope plots). This suggests that management options and restoration goals should vary among ecoregions. Species abundance followed a gradient from the moist north coast to the dry southwest (Figure 2). Douglas-fir (*Pseudotsuga menziesii*) comprised a large percentage of the basal area of the region (~50%) and dominated most ecoregions. One exception was the coastal fog belt, where Sitka spruce (*Picea sitchensis)* dominated and Douglas-fir comprised only 2% of the basal area (Figure 2). There was a shift in dominance from Sitka spruce and western hemlock (*Tsuga heterophylla*) in the moister part of the region to ponderosa pine (*Pinus ponderosa*) and oaks (*Quercus spp*.) at the drier end. The abundance of bigleaf maple (*Acer*

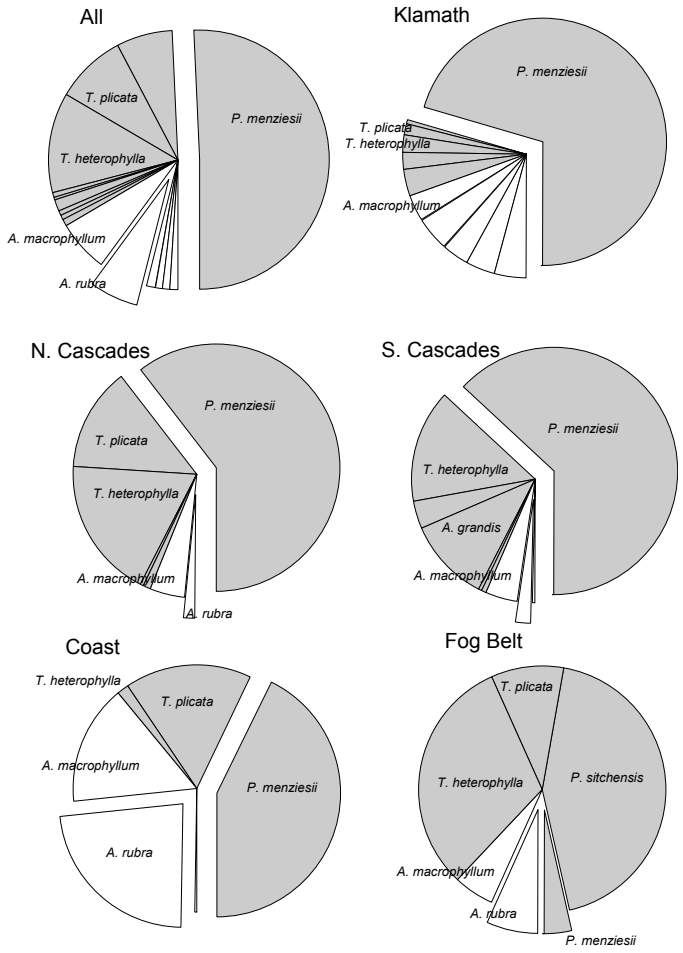


Figure 2. Riparian forest composition summarized by percent basal area for each of five ecoregions sampled in western Oregon. Conifers are presented as shaded and hardwoods as unshaded.

Table 1. Percent occupancy of dominant tree species recorded at three distances (meters) from low-order streams in unmanaged watersheds of western Oregon.

	Klamath				S. Cascades				N. Cascades				Coast				Fog belt			
	0-10	10-20	20-30		0-10	10-20	20-30		0-10	10-20	20-30		0-10	10-20	20-30		0-10	10-20	20-30	
Douglas-fir	80	83	83		68	68	64		45	61	63	▲	15	24	25	▲	-	2	4	▲
Western redcedar	-	-	-		36	36	29	▼	28	29	28	■	10	12	13	▲	2	4	9	▲
Western hemlock	-	-	-		-	-	-		57	67	66	▲	1	6	4	▲	36	31	56	▲
Sitka spruce	-	-	-		-	-	-		-	-	-		-	-	-		31	24	38	■
Yew	13	7	5	▼	21	18	21	▼	12	10	12	▼	-	-	-		-	-	-	
Bigleaf maple	39	15	11	▼	29	29	25	▼	34	26	21	▼	22	19	28	▲	7	4	4	▼
White alder	2	1	-	▼	4	-	-	▼	-	-	-	▼	-	-	-		-	-	-	
Red alder	7	-	-	▼	21	21	-	▼	27	10	6	▼	42	37	37	▼	51	29	33	▼
Grand fir	8	12	15	▲	54	50	50		-	-	-		-	-	-		-	-	-	
Pacific silver fir	-	-	-		-	-	-		3	7	6	▲	-	-	-		-	-	-	
Madrone	6	25	32	▲	-	7	4		-	-	-		-	-	-		-	-	-	
Canyon live oak	11	30	24	▲	-	-	-		-	-	-		-	-	-		-	-	-	
Black oak	7	18	19	▲	-	-	-		-	-	-		-	-	-		-	-	-	
Oregon white oak	11	13	19	▲	-	-	-		-	-	-		-	-	-		-	-	-	
Ponderosa pine	6	11	13	▲	-	-	-		-	-	-		-	-	-		-	-	-	

▲= apparent increase, ▼ = decrease, and ■ = no change with distance from stream.

macrophyllum) was fairly consistent in each ecoregion, while red alder showed a maximum abundance in the Coast Range ecoregion and was at a minimum in the Klamath ecoregion. The abundance of hardwoods, therefore, peaked in the Coast Range, due to the abundance of red alder, and in the Klamath, where hardwood diversity increased to include three oak species.

Distance from stream (percent of subplots occupied)

Species presence increased, remained the same, or, for some species like the early seral red alder, decreased with distance from stream. In the Klamath, the driest ecoregion in western Oregon, red alder, bigleaf maple, and western yew presence decreased with increasing distance from the stream (Table 1). In contrast, the presence of several species increased with distance from the stream, including grand fir, madrone (*Arbutus menziesii*), ponderosa pine, black oak (*Q. kelloggii*), white oak (*Q. garryana*), and canyon live oak (*Q. chrysolepis*). The presence of Douglas-fir was both extremely high and fairly constant across the range of transects.

In the north Cascades ecoregion, the presence of alder and bigleaf maple decreased with distance from the stream, while Douglas-fir and, to some degree, western hemlock increased. Patterns in the Coast Range differed somewhat from other ecoregions. For example, presence of bigleaf maple tended to increase, rather than decrease, with distance from the stream. Likewise, the presence of alder was fairly constant across the range of subplots. Here, as in the Cascades, Douglas-fir presence increased with distance from stream.

Floodplain vs. side-slope composition

Although all tree species in a given ecoregion could be found within the floodplain as well as on side slopes, there were obvious shifts in the relative abundance between these two surfaces. At the moist end of the gradient, broadleaved species, especially alder, reached their highest abundance. Within the floodplains of the coastal mountains and coastal fog belt, more than 70% of the trees were hardwoods (Figure 3). In the middle of the gradient, hardwoods were common only on the fluvially disturbed stream edge. At the dry end of the gradient, broadleaved species again became important in

all topographic positions. In the Klamath region, however, many of the hardwoods in or near the floodplain were not typical wetland species, but included oaks and madrone. Douglas-fir was dominant on floodplains and hill slopes in the Klamath, but became less common on floodplains at the moist end of the regional gradient (Figure 3).

Conclusions

- Recognition of the distinct ecoregions of western Oregon is an important step in understanding riparian forest composition and for developing sound forest management practices and restoration goals.
- The abundance of a given tree species can vary considerably with distance from stream edge. For some species, the pattern was consistent across ecoregions, whereas for others the type of pattern varied among ecoregions.
- Douglas-fir was a dominant species along many headwater streams, but its ability to dominate the near-stream environment varied among ecoregions.
- The relative proportion of other species and the divide between hardwood and conifer composition were also important distinctions among ecoregions.
- Alder and bigleaf maple were more common in the near-stream plots than upslope except in the Coast Range, where alder was common at all three distances and bigleaf maple appeared to increase with distance from the stream, at least at the scale of 0–50 m from stream edge.
- The break between floodplain and side slope surfaces was a useful means to highlight compositional differences and, again, provide insights into variation among ecoregions.

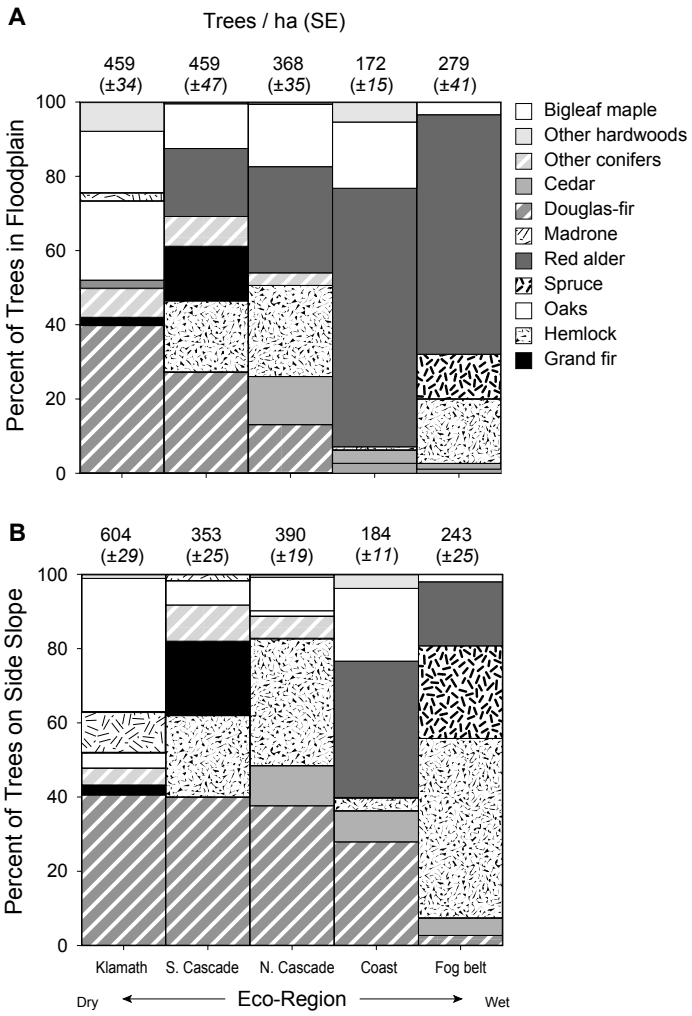
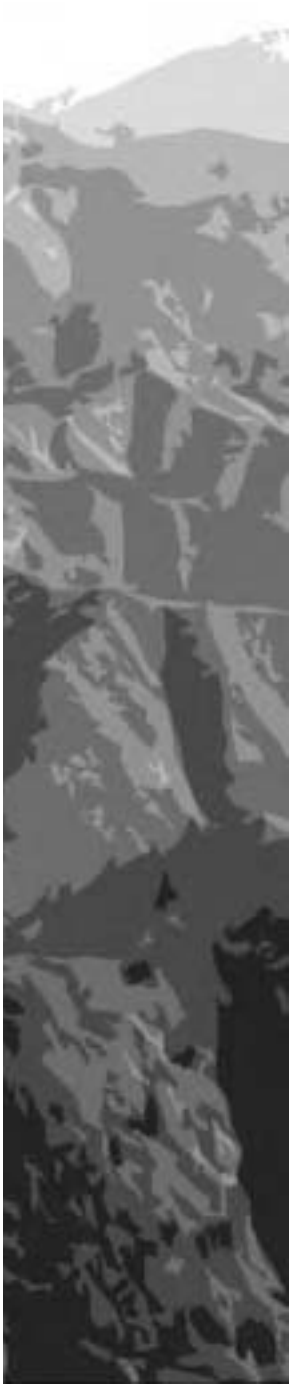


Figure 3. Percent of trees on A) floodplain and B) side-slope surfaces within five ecoregions of western Oregon. Tree density (per ha) provided as a measure of absolute abundance.

Study Timeline

Field research for this project commenced in 1998 and was completed in 2001. Two manuscripts, one on patterns of wood input and one on forest composition, are currently in preparation and will be submitted for review. Additional manuscripts on analysis of this data examining plant community composition and the diversity of shrub and herb species in the Cascades and Klamath are planned.

Influence of Landscape Pattern and Composition on Species in Forested Ecosystems of Western Oregon



Understanding effects of management at landscape scales is critical to managing for habitat and biodiversity. However, knowledge of the influence of landscape effects on many species is lacking. There is growing consensus that knowledge of the form, function, and historical context of landscapes is essential to research and management of ecosystems at a variety of temporal and spatial scales.

Goal

The goal of this research theme is to investigate the relationships among aquatic and terrestrial organisms, instream habitat, and riparian-area and upslope conditions across broad geographic areas in western Oregon.

2004 Highlights

- Master's student Troy Guy completed his thesis titled "Landscape Scale Evaluation of Genetic Structure among Barrier-isolated Populations of Coastal Cutthroat Trout, *Oncorhynchus clarki clarki*."
- Master's student Nico Romero completed his thesis titled "Seasonal Influences on Food Availability and Diet of Coastal Cutthroat Trout in Relation to Riparian Vegetation."
- A final report was completed on a collaborative landscape-modeling project funded by the BLM that evaluated responses of forest ecosystems to alternative forest management scenarios.
- The research theme was expanded to include two new projects:
  - Influences of Landscape Variables on Age and Growth of Coastal Cutthroat Trout in Headwater Streams
  - Effects of Wildfire on Growth and Demographics of Coastal Cutthroat Trout in Headwater Streams

New and continuing studies during the year under report are summarized in the following section.

Effects of Landscape Patterns on Fish Distribution

Robert E. Gresswell, Christian E. Torgersen, Douglas S. Bateman, and David P. Hockman-Wert

Numerous studies have examined the relationships between physical stream habitat and the distribution and abundance of anadromous salmonids. It is difficult, however, to relate these interactions to fitness because anadromous fishes spend some part of their lives in a marine environment, where they are affected by a much different array of environmental variables, including shifts in ocean currents and commercial harvesting. In contrast, salmonids that migrate only in freshwater (potamodromous salmonids, including some populations of coastal cutthroat trout, *Oncorhynchus clarki clarki*) are dependent on suitable stream habitats throughout their lives. Therefore, it may be possible to relate variations in fluvial freshwater habitats to the ecology of potamodromous salmonids.

Changes in aquatic habitats resulting from land-management activities may be especially relevant for coastal cutthroat trout. During the last century, both the abundance and the distribution of this subspecies have declined across its entire range. Aquatic habitat degradation associated with timber harvest, road building, agriculture, and development has been identified as one of the potential causes of this decline. To date, however, most research on relationships between coastal cutthroat trout and freshwater habitat has been conducted on anadromous populations. Little effort has been expended on describing potamodromous populations or their linkages with aquatic habitat. This study examines the relationships between stream habitats and populations of potamodromous coastal cutthroat trout across broad spatial scales in western Oregon.

Methods

Study site selection and barrier database

Beginning in 1999, watersheds were randomly selected from a known population of streams in western Oregon. First, the population of mid-size watersheds (500–1,500 ha) west of the Cascade Range divide was derived from watershed delineations by using 30-m digital elevation models (DEM) and tools from the U.S. Geological Survey (USGS) GIS Weasel application (see Gresswell and Bateman, 2001 CFER Annual Report). Initial watershed size was set at 500 ha, and the ultimate size was determined by the location of the next downstream tributary junction.

Because a database with locations of isolated, potamodromous populations of coastal cutthroat trout did not exist, a sampling frame of isolated watersheds meeting this criterion had to be developed. Information obtained from an Oregon Department of Fish and Wildlife (ODFW) database and interviews with field biologists (active and retired) from ODFW, U.S. Forest Service (USFS), and the Bureau of Land Management (BLM) were used to locate barriers to upstream fish movement. After the sampling frame of watersheds was established, isolated watersheds with coastal cutthroat trout were stratified by ecoregion and erosion potential based on dominant bedrock lithology (i.e., sedimentary and igneous). A stratified random sample of 40 watersheds was selected with proportional allocation in each stratum.

Logistical constraints of field sampling limited the maximum basin area to 1,000 ha; therefore, in cases where a watershed exceeded 1,000 ha, the area above each tributary junction (moving progressively farther upstream) was estimated until at least one of the subwatersheds had an area of 1,000 ha or less. The portion of the watershed upstream from this point was then sampled. If

watersheds contained two or more basins between 500 and 1,000 ha, one subwatershed was randomly selected to represent the watershed.

Instream habitat evaluation and fish surveys

Prior to initial surveys, stream segments were identified in each watershed by using existing databases, topographic and geologic maps, aerial photographs, and field reconnaissance. During field surveys, geomorphic stream reaches were classified in each segment, and channel units were delineated in each geomorphic reach. Stream habitat was inventoried with methodology developed in 1998 (see Gresswell and Bateman, 1999 CFER Annual Report). Physical variables that describe habitat unit size (e.g., length, depth, and width), substrate size class, channel type, valley segment type, and woody debris were estimated or measured for all sampled habitat units. To investigate interannual variation in habitat characteristics and coastal cutthroat trout distribution, Camp Creek, a tributary of the Umpqua River, has been resampled annually from 1998 through 2004 (see Gresswell et al., 2003 CFER Annual Report).

Estimating fish abundance and distribution

Following habitat-unit mapping of a study basin, the relative abundance of fish in all pools and cascades was assessed by one of two methods, depending on stream size and accessibility: 1) a single-pass removal using electrofishing to collect fish, or 2) visual estimation of fish numbers by snorkeling. The upstream extent of fish distribution in a tributary was determined by electrofishing in an upstream direction until a minimum of 10 pools containing no fish had been sampled. In each stream segment, 100 fish were measured (fork length to ±1 mm) and weighed (±0.1 g). Scale samples were collected for age determination from up to five fish in each 10-mm length category (see Rehe and Gresswell, this report).

To determine the feasibility of using sampling protocols to assess fish abundance and distribution, relative abundance estimates from the complete census from 1998 were compared to simple random and systematic samples of the census data. Initial evaluation suggested that estimates of mean number of fish per channel unit, mean channel unit area, and the correlations between these two variables were similar between the complete census and simple random samples of the units; however, distribution patterns of fish abundance from either of the samples lacked specificity necessary to detect longitudinal distribution of fish (see Gresswell et al., 2000 CFER Annual Report). Because it appeared that spatial patterns of fish distribution were directly linked to habitat characteristics, it was determined that the continuous assessments of relative abundance would be conducted in all of the sample watersheds. Subsequent research in 2001 suggested that the results of estimating relative abundance of coastal cutthroat trout on the basis of single-pass electrofishing were highly correlated with those from more labor-intensive multiple-pass removal techniques (see Bateman et al., 2002 CFER Annual Report). In combination, these results provided information necessary to assess distribution patterns of coastal cutthroat trout in watersheds of western Oregon in an economical and logistically efficient manner.

Watershed database development

Digital data layers for ecoregions, geology, elevation, vegetation, and hydrography were obtained for geographic information system (GIS) processing from numerous sources (e.g., BLM, USFS, ODFW, Oregon Department of Forestry [ODF], and Oregon State University [OSU]). Using dynamic segmentation methodology in Arc/Info GIS allowed stream survey data to be georeferenced to the stream network for the construction of a spatially explicit, relational database for each watershed. Landmarks, such as bridge crossings and tributary junctions, were used for calibrating the digital stream length to the actual surveyed stream length. Consecutively numbered habitat units and associated attributes, including habitat dimensions, wood, substrate, and fish numbers, were then joined to the calibrated stream network in a GIS database.

Three-dimensional maps of landscape terrain and subwatershed boundaries were generated for each watershed by using 10-m DEMs. Overlays of fish distribution

and stream habitat data on the three-dimensional terrain provided a means of assessing patterns of fish abundance and channel morphology in a landscape context (see Gresswell et al., 2002 CFER Annual Report). Longitudinal elevation profiles have been developed from field measurements of stream channel slope. Landscape metrics (e.g., valley form, aspect, slope, and upslope disturbance potential) and channel slope are all being used as explanatory variables in statistical models of fish–habitat relationships.

Spatial data on forest stand characteristics, road density, landslide potential, and land ownership (federal, state, and private) have been entered into the GIS and are being analyzed in statistical models to investigate the relationship between management activities and fish distribution. Land use, landslide risk, and road coverages have also been included in these analyses. Forest cover and vegetation classifications from Landsat satellite imagery were obtained from the Coastal Landscape Analysis and Modeling Study (CLAMS) and the Interagency Vegetation Mapping Project (IVMP). Historical management information for each sample watershed was summarized from time-series satellite imagery (Stand Replacement Disturbance 1972–2002; S. Healey and W. Cohen, USFS, Corvallis, Oregon) to provide a temporal context concerning forest disturbance from timber harvest and fire.

Quantifying spatial variability in fish distribution and landscape pattern

Fish abundance (by age group) and physical habitat characteristics are being used to explore relationships between fish and aquatic habitat at stream reach, segment, and watershed scales. Effort has been focused on three-dimensional visualization techniques and semivariograms for detecting patterns and determining the spatial scales at which landscape characteristics influence fish distribution within and among watersheds (see Gresswell et al., 2002 CFER Annual Report).

Patterns of spatial variability in coastal cutthroat trout abundance were evaluated by comparing variograms among watersheds. Semivariograms were developed by using network distance (measured along the stream channel) as opposed to traditional Euclidean distance (i.e., the shortest distance between two points). Characteristics of the variogram, including the shape and the distance over which fish abundance was autocorrelated (i.e., the range of a variogram that fit a spherical model), were compared among watersheds with respect to landscape characteristics such as erosion potential, geology, ecoregion, and watershed characteristics (elevation, slope, and drainage density) (see Gresswell et al., 2003 CFER Annual Report). To evaluate distributional patterns and spatial dependence in fish abundance, semivariogram models were compared by using spatially continuous datasets and simulated data based on random resampling of original data.

Landscape influences on the spatial extent of fish distribution

Fish distribution in each study basin was calculated in a GIS and normalized by watershed area (km/km^2). This variable, representing the length of stream occupied by coastal cutthroat trout, was compared among watersheds to identify broad-scale physiographic and climatic patterns that influence distribution. Multiple linear regression and Akaike's Information Criterion (AIC) were used to identify a set of best approximating models that predicted fish distribution based on landscape explanatory variables derived from GIS layers (road density, geology, DEMs, spatially explicit climate models, and satellite imagery). Predictor variables in the regression analysis included mean stream slope (%), stand replacement disturbance (percent of watershed that has been clearcut since 1972), mean annual temperature (°C), mean annual precipitation (cm), land ownership (percent private/public), forest vegetation type (percent broadleaf/conifer), and geologic rock type (resistant/weak).

Preliminary Research Results and Management Implications

Investigation of coastal cutthroat trout distribution in 40 headwater streams revealed pronounced differences

in the spatial extent of coastal cutthroat trout distribution in watersheds (Figure 1). Model selection with AIC indicated that channel slope, annual precipitation, and stand replacement disturbance were the primary landscape variables associated with fish distribution. Basin shape (length/area), ecoregion (Coast Range/Cascades), and residual topography (basin volume/surface area) were also important predictor variables, but they were not included in the most parsimonious regression model. The best approximating regression model explained 73% of the variation in coastal cutthroat trout distribution and was validated with an independent data set representing coastal cutthroat distribution in eight headwater watersheds in western Oregon (Figure 2).

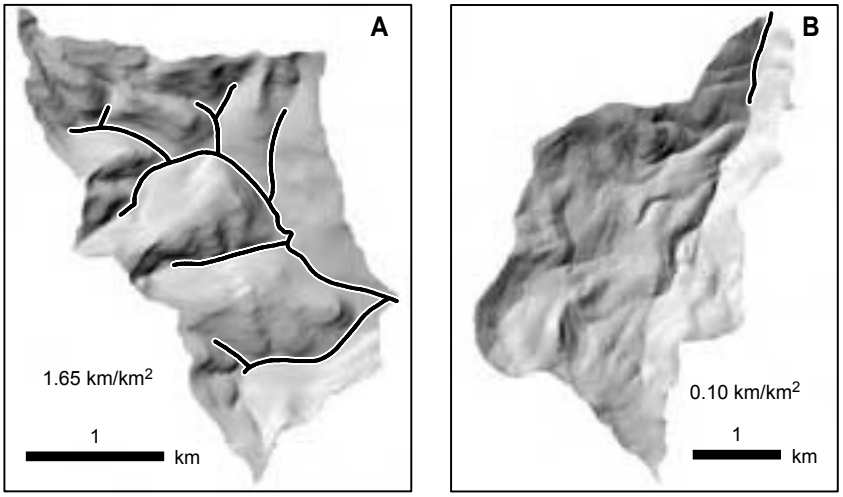


Figure 1. Spatial extent of coastal cutthroat trout distribution in contrasting headwater basins. Fish distribution as a proportion of watershed area (km/km^2) is greater in (a) Racks Creek in the Coast Range than in (b) Nevergo Creek in the Cascade Range, Oregon.

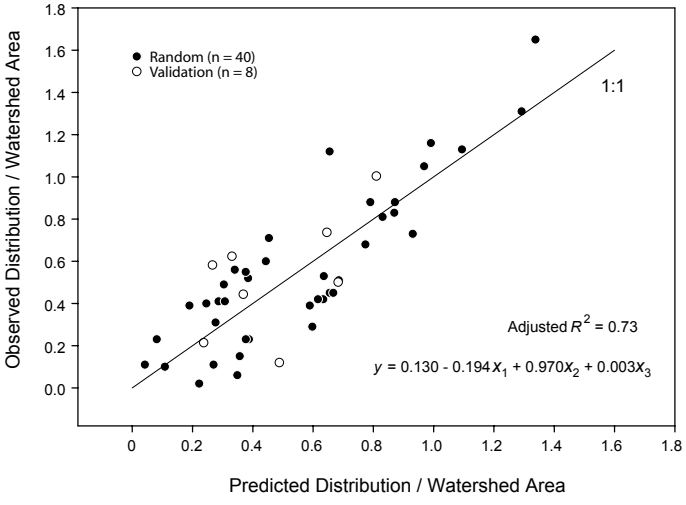


Figure 2. Multiple linear regression model predicting the spatial extent of coastal cutthroat trout distribution based on landscape variables. Explanatory variables include mean channel slope (x_1), mean annual precipitation (x_2), and stand replacement disturbance (x_3).

Although the distribution of coastal cutthroat trout and other stream fishes has previously been described in relation to barriers to movement associated with high stream slope, the results of this analysis represent a unique attempt to predict the spatial relationship between stream fish distribution and broad-scale landscape and climate patterns. The positive relationship between mean annual precipitation and coastal cutthroat trout distribution is believed to be related to increased accessibility of the stream network to fish in relation to water yield and discharge. The positive relationship between fish distribution and stand replacement disturbance (percent of the basin that has been clearcut or burned in the last 30 years) is more difficult to explain because it suggests interactive effects between land management practices and hydrologic, geomorphic, and biological processes. For example, the effects of timber harvest on forest vegetation, hydrology (water yield and discharge), geomorphology, and stream temperature occur simultaneously and are difficult to isolate in a landscape context. In addition, the biological responses of coastal cutthroat trout to changes in forest vegetation, prey availability, and physical constraints to movement are highly context dependent both spatially and temporally. It is especially interesting that the spatial extent of fish distribution in a watershed was not directly related to the relative abundance of coastal cutthroat trout in the drainage. In other words, even when fish become more broadly distributed, it does not necessarily mean that the number of fish will increase.

Understanding the broad-scale factors influencing the distribution of coastal cutthroat trout is important

for advancing ecological science, which has traditionally been conducted at the scale of forest stands or individual study plots. Resource management decisions made at the scale of entire landscapes or watersheds must be matched to ecological research that can address management issues over an entire region such as western Oregon. Models that predict the distribution of organisms over large areas provide initial, coarse-filter information on habitat associations and set the context for more detailed studies of biological processes. For example, further understanding the cumulative effects of stand replacement disturbance on fish abundance and distribution requires spatially explicit studies of fish movement and growth in conjunction with watershed-scale manipulations, such as those currently being conducted in Hinkle Creek, Umpqua River basin, Oregon (see Gresswell et al., 2003 CFER Annual Report).

Study Timeline

Database development has been completed, and manuscripts are currently in press, submitted, or are being prepared for publication. Three papers, one on the development of a sampling frame of watersheds, one on geospatial techniques for quantifying spatial variability in the distribution of stream fishes, and one on the genetic structure of coastal cutthroat trout within barrier-isolated watersheds, are currently in press. Five additional papers on 1) monitoring coastal cutthroat trout at the watershed scale, 2) comparing single-pass and multiple-pass electrofishing, 3) geostatistical analysis in stream networks, 4) genetic structure of coastal cutthroat trout in 29 watersheds in western Oregon, and 5) population-scale movement of coastal cutthroat trout in an isolated stream network were submitted to peer-reviewed journals in 2004. Two more manuscripts on landscape influences on the spatial extent and variability of coastal cutthroat trout in headwater streams are in preparation and will be submitted in 2005. Analysis of habitat relationships of coastal cutthroat trout at multiple spatial scales will continue in 2004, and four manuscripts summarizing this work will be submitted for publication in spring 2005.

Cumulative Effects of Contemporary Timber Harvest on Fish Abundance and Distribution

Robert E. Gresswell, Douglas S. Bateman, Judith L. Li, Marc Novick, Christian E. Torgersen, and David Hockman-Wert

On public lands, restoration activities addressing the effects of land-use activities on aquatic habitats rely increasingly on ecosystem principles across large spatial scales. In western Oregon, however, public lands often occur in a matrix of private timberlands where harvest activities are subject to other regulations. These industrial forest systems have rarely been considered in the integrated management of forested landscapes. Our goal is to expand the understanding of physical and biological processes in streams subjected to contemporary forest harvest in western Oregon. This study will initiate a long-term program examining fish and riparian invertebrates associated with temporally varying harvest activities.

Critical questions concerning contemporary timber harvest practices remain unanswered. Fundamental to answering these questions is determining how harvest activities in headwaters affect fish assemblages and behavior across the stream network. We anticipate that changes in habitat, water quality, or food supply will affect fish in a dynamic way, and we propose to address the following questions: 1) How do changes in physical and biological characteristics of tributaries without fish seasonally influence habitat quality in other portions of the stream network? 2) How do seasonal hydrologic changes in headwater streams affect fish abundance and distribution? 3) Does the abundance or diversity of fish fauna decline in response to changed habitat quality, or do organisms seasonally move to areas where habitat quality remains high?

It is difficult to understand the relationships among physical, chemical, and biological characteristics of terrestrial, riparian, and aquatic systems on aquatic habitat, and, ultimately, on aquatic organisms. Because interpretation of results can be highly context-dependent, it is important to collect data across a variety of temporal and spatial scales. Here we use passive integrated transponder (PIT) tags with both mobile and fixed site antennas, in conjunction with electrofishing, to characterize fish distribution and abundance at time scales of continuous, seasonal, and yearly at spatial scales from individual habitat units to multiple watersheds.

Methods

During the 2003/2004 season, summer electrofishing and winter, spring, and early summer mobile antenna PIT-tag surveys were performed as in 2002/2003 (Gresswell et al., 2003 CFER Annual Report). In addition, relative abundance estimates were collected from every tenth riffle/rapid in both the North and South Forks of Hinkle Creek. These data were combined with relative abundance data collected from riffle/rapids in Camp Creek during summer 2002 and used to compare relative abundance estimates of age-1+ cutthroat among riffle/rapids, a habitat type which we have not typically sampled, and cascades and various types of pools. Other aspects of summer electrofishing remained unchanged, and all captured salmonids ≥100 mm fork length received a 23-mm PIT tag.

Stationary PIT-tag antennas were installed at all junctions between fish-bearing tributaries and mainstem Camp Creek, replicating the antenna network present in both forks of Hinkle Creek (Figure 1). Stationary antennas provide continuous temporal data on fish

movement across stream segment boundaries. An additional 24 stationary PIT-tag antennas were installed in South Fork Hinkle Creek. These antennas are being used in conjunction with existing stream-segment-scale stationary antennas to provide continuous data on fish movement between habitat patches consisting of multiple habitat units (Figure 1). A total of 17 mainstem and six tributary habitat patches have been bracketed by these additional antennas. Habitat patches were identified during the electrofishing survey in summer 2003 as having relatively high or low densities of salmonids. All antennas were positioned perpendicular to stream flow and located in high-velocity habitats to minimize multiple PIT-tag readings related to fish holding behavior.

Additional invertebrate sampling sites were added in both forks of Hinkle Creek during 2004, allowing comparisons among invertebrate abundance, size, and community structure at sites representing 1) logged vs. unlogged, 2) fish vs. no fish, and 3) high relative fish abundance vs. low relative fish abundance (Figure 1). Fish diet information was collected during spring, summer, and fall in conjunction with invertebrate sampling in all sites where fish were present. Invertebrate sampling was limited to Hinkle Creek.

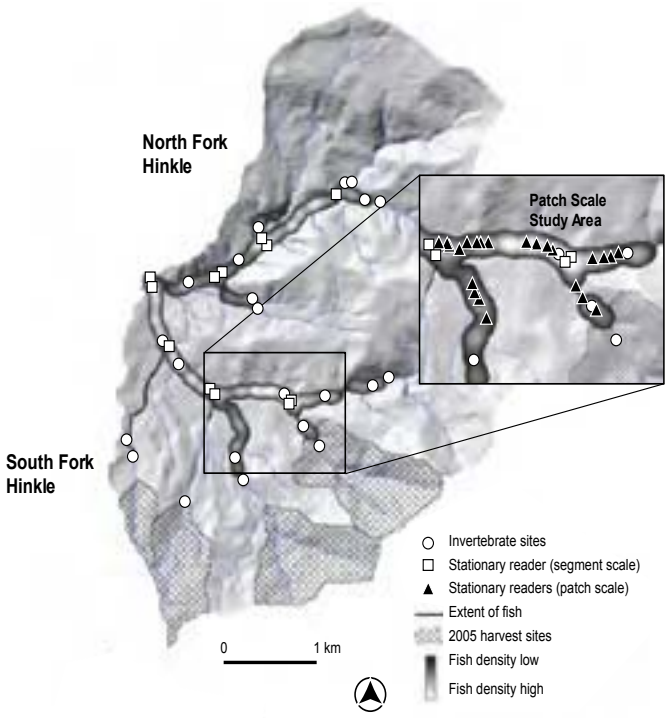


Figure 1. Hinkle Creek study site. Inset portion depicts upper portion of South Fork Hinkle Creek where patch-scale work is located. The portion of the drainage network in bold or with heavy fish density line indicates the total known extent of coastal cutthroat trout in this study area. Density gradient represents relative abundance.

Preliminary Research Results and Management Implications

A total of 1,077 cutthroat trout were PIT tagged during November of 2003 in Camp Creek. In August of 2004 the watershed was again electrofished, and a total of 1,148 fish ≥100 mm were collected. Of these fish, 868 were previously untagged fish (new fish); the 280 remaining individuals were fish originally tagged in November 2003 (recaptures). Approximately 31% of these fish had shed their PIT tag. In South Fork Hinkle Creek, where a total of 493 new fish were PIT tagged in summer 2003, 543 fish ≥100 mm were collected in summer 2004. Of these, 430 were new captures and 113 were recaptures. Only 18% of the recaptured fish had shed their PIT tag. During summer 2003, 307 new fish were PIT tagged in North Fork Hinkle Creek. Subsequently, 46 of these fish were recaptured during summer of 2004. The PIT-tag loss rate was 15% for these individuals. Only 191 new fish were tagged in North Fork Hinkle Creek during summer 2004.

An evaluation of relative abundance of age-1+ cutthroat in different habitats indicated that abundance was lowest in riffle/rapids, followed by cascades. Both fast-water habitat types always had lower abundance estimates than any pool type with the exception of isolated pools (Table 1). Riffle/rapids contained 55% and 50% of the fish per meter relative to cascades in South and North Fork Hinkle creeks, respectively. When both age-1+ steelhead and cutthroat were considered, riffles had relative abundance estimates of 76% and 58% of those found in cascades in the South and North Forks of Hinkle Creek, respectively. South Fork Hinkle Creek had considerably more age-1+ steelhead than North Fork Hinkle Creek,

Table 1. Number of age- 1+ coastal cutthroat trout per meter for cascade (CA), riffle/rapid (RR), isolated pool (IP), plunge pool, (PP), scour pool (SP), and dam pool (DP) habitats.

Stream	CA	RR	IP	PP	SP	DP
S.F. Hinkle	0.084	0.046	NA	0.571	0.186	0.594
N.F. Hinkle	0.052	0.026	0.106	0.441	0.166	0.313
Camp	0.081	0.028	0.037	0.345	0.161	0.292

and these data would indicate that a higher percentage of steelhead than of cutthroat resided in riffle habitat. This may be an artifact of fish distribution in South Fork Hinkle Creek where steelhead are generally confined to the lower stream segments, in which riffle/rapid habitat is much more common than cascade habitat. In Camp Creek, where steelhead are not present, riffle/rapid habitats contained only 35% of the number of fish per meter found in cascades, and pools also had higher relative abundances than either fast-water habitat type.

At the basin scale, few data collected by stationary antennas have been processed (Gresswell et al., 2003 CFER Annual Report). Progress has been made, however, with regard to these types of data at the patch scale in South Fork Hinkle Creek. The most striking response to date has been the variation in movement between mainstem and tributary patches. Median extent of movement (i.e., difference between most upstream and downstream locations) and variation in the extent of movement were significantly different between fish of mainstem and tributary origin. In addition, differences in the median extent of movement and variance for fish originating below and above Tributary 2 were significant. Two fish tagged in Tributary 2 during the spawning season subsequently moved >190 habitat units and were detected in the mainstem South Fork of Hinkle Creek (Figure 2).

Most coastal cutthroat trout moved during periods of low to moderate discharge (Figure 3). Approximately 57% (270/452) of longer distance "between-habitat patch" movements occurred at moderate stage heights, and 55% (353/640) of shorter distance "within-habitat patch" movements occurred during periods of low stage height. Sixty-one percent (279/457) of stationary behavior events (i.e., maintaining position within the detection field of an antenna for a minimum of 15 minutes) occurred during moderate stage levels. There was a two-fold increase in the median duration of stationary behavior events during times of high stage height (median = 3.8 hours) as compared to similar events at moderate (median = 1.6 hours) or low (median = 1.9 hours) stage heights. Movements from mainstem habitats to tributaries increased during periods of high stage height.

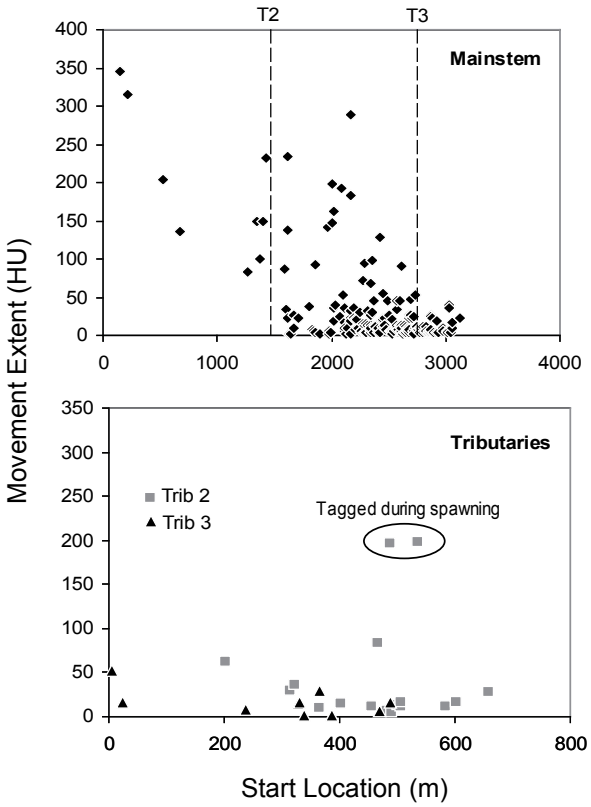


Figure 2. Movement extent (i.e., difference between most upstream and downstream locations in habitat units) for individual fish based on starting location from the mouth of South Fork Hinkle Creek. Lines labeled T2 and T3 show tributary locations.

Understanding how coastal cutthroat trout use available habitat at multiple spatial and temporal scales will aid managers in evaluating risk associated with fragmentation and disturbance from both anthropogenic and natural sources. The data reported here 1) confirm previous findings that age-1 + cutthroat trout are more abundant in pool habitats relative to fast-water habitats,

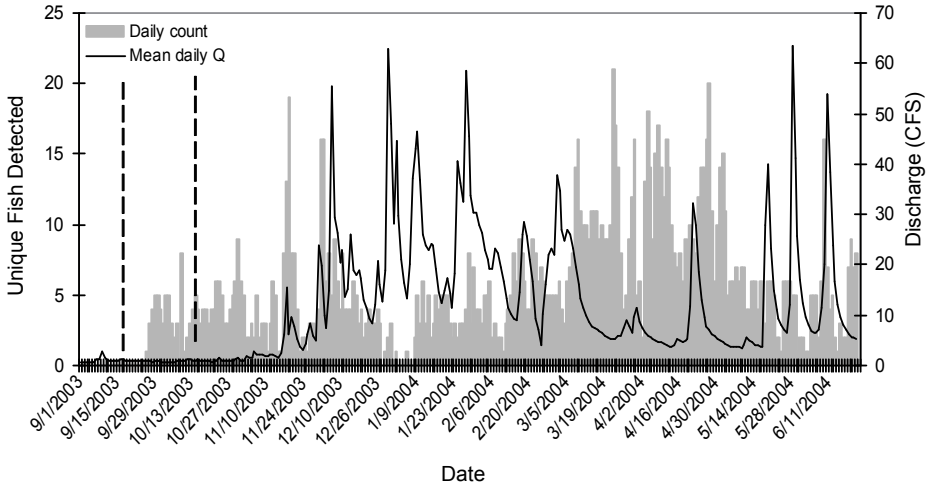


Figure 3. Time series plot of stream discharge superimposed on a frequency distribution of unique fish detections at stationary antenna sites. Detections are based on the first detection of individual fish for each day. Both mainstem and tributary detections are represented.

2) provide practical information on retention rates of PIT tags that have been surgically implanted in the body cavity of small fish, and 3) suggest that coastal cutthroat trout may express multiple life-history types within a relatively small watershed.

Study Timeline

Sampling is scheduled to continue in Hinkle Creek until 2012. Initial timber harvest will begin in 2005. Sampling in Camp Creek will continue as funding allows. Fish distribution and relative abundance will continue to be evaluated four times per year with one basin-wide electrofishing effort during the summer low flow period, and three portable PIT tag reader surveys will be conducted corresponding to winter, spring, and early summer. A final report in the form of a master's thesis on patch-scale fish movement is due in early summer 2005.

Influences of Landscape Variables on Age and Growth of Coastal Cutthroat Trout in Headwater Streams

William G. Rehe and Robert E. Gresswell

The coastal cutthroat trout (*Oncorhynchus clarki clarki)* has the largest geographic range of any native western trout, extending from the Kenai Peninsula, Alaska, to the Eel River, California, and inland about 150 km. Like other native trout of western North America, the coastal cutthroat trout has undergone substantial population declines resulting from habitat alterations associated with land-use practices (e.g., logging, dams, mining, urbanization, and irrigation withdrawals). Declines are especially apparent in California and Oregon where habitat degradation has been substantial. In the northern portion of their range, available information suggests that stocks are declining in parts of Washington and coastal British Columbia, and increasing in Alaska.

In order for populations of coastal cutthroat trout to recover and persist, diverse habitat for all developmental stages must be preserved or restored. It has been suggested that habitat simplification has caused widespread alteration of life-history diversity among Pacific salmonid populations, and remaining healthy and intact habitat should be protected. Furthermore, restoration of degraded habitat should rely more on ecosystem-based approaches that focus on land-water interactions and less on engineered short-term solutions.

For restoration and preservation of cutthroat trout habitat to be successful, managers must understand the interactions between environmental factors and trout distribution. The absence of quantitative data on habitat interactions can complicate management of imperiled populations of salmonids. The relationship between stream fish and habitat is scale-dependent; however, the most effective scale to study fish populations has not been determined. Most studies examining the association of trout and environmental features have used a fine-scale approach focused at stream reach or habitat type. In contrast broad-scale geomorphic variables could be used to predict potential trout habitat. For example, drainage geomorphic characteristics, such as elevation, channel gradient, and watershed size, can influence trout growth in both lentic and lotic systems.

Unfortunately, scientific understanding concerning habitat requirements of coastal cutthroat trout is incomplete, and there is an information gap concerning disturbance and its influence on trout habitat and growth rates. If imperiled populations of fish are to be managed properly, it is important to assess age structure and growth characteristics. These important population parameters can be used to evaluate recovery efforts, monitor environmental conditions, and formulate effective management strategies. Collecting life-history data and evaluating the influence of environmental factors across a broad spatial scale will assist in answering questions such as 1) to what extent age structure and growth vary within and among basins in isolated headwater streams, and 2) which drainage characteristics influence growth of coastal cutthroat trout.

Methods

To address these objectives, 40 watersheds were randomly selected from 269 western Oregon headwater streams that are located above barriers to migration of anadromous fishes and contain non-migratory and potamodromous (freshwater migratory) coastal cutthroat trout. Other aquatic species that are found in some of these systems include sculpin (*Cottus* sp.), Pacific giant

salamander (*Dicamptodon tenebrosus*), tailed frogs (*Ascaphus truei*), and crayfish (Family Astacidae).

Sampling occurred during summer low flows from 1998 through 2001. Fish were captured by electrofishing (Smith-Root Model #15-B) and anesthetized with clove oil or tricaine methanesulfonate (Finquel® MS222). Each fish was measured to the nearest millimeter and weighed to the nearest gram, and scales were removed and adhered to gum cards. The habitat in all study basins was characterized using a nested hierarchical system of stream classification.

Coastal cutthroat trout in each watershed were grouped by 10-mm size groups between 80 mm and 200 mm, and 10 fish from each group were randomly selected for age and growth determination. Camp Creek, a stream in the Coast Range of Oregon, was chosen to investigate within-watershed variation of age and growth rates. Additional scales were randomly selected from fish from each of the 11 stream segments in Camp Creek by the same size criteria as the other study sites. Age of individual coastal cutthroat trout is being estimated by scale-reading, and length at annulus formation will be estimated by back-calculation using the direct-proportion method. Scales that lack a first-year annulus will be identified and age will be adjusted upward when necessary.

Watershed-scale environmental variables (from data collected in the field, published literature, and state, federal, and non-governmental databases) that characterize the 40 study watersheds will be compiled and evaluated. The influence of environmental factors on age structure and growth characteristics for both the within- and among-basin study sites will be investigated by statistical approaches such as multiple regression, stepwise regression, or multivariate regression. Response variables will include relative growth, proportional stock density (PSD), and index of growth performance.

Research Results and Management Implications

To date, approximately 4,800 scale samples have been processed, and age analysis is nearing completion. The results of this study will assist resource managers, planners, and community stakeholders by identifying critical environmental variables that may influence growth and persistence of isolated populations of coastal cutthroat trout. By identifying habitat features associated with different ontological periods in the life of coastal cutthroat trout, managers can make informed decisions on how to best manage resource extraction, recreation, and community expansion. This study will assess the natural range of variation in age structure and growth rates, demonstrate the relationship between environmental factors and population dynamics, and provide baseline information on a wide spatial range of coastal cutthroat trout populations.

Study Timeline

The age and growth analysis of the scale samples was completed during October 2004. Data analysis was scheduled to begin in October 2004 and will be completed by December 2004. The final report and a manuscript for publication will be completed by April 2005.

Effects of Wildfire on Growth and Demographics of Coastal Cutthroat Trout in Headwater Streams

Michael Heck and Robert E. Gresswell

In stochastic environments such as streams, fishes must persist under a range of environmental conditions. When factors in the stream environment suddenly change following a disturbance, a new environmental state is realized. Fishes generally respond at both the individual and population level, and biological systems with the capacity to survive under the new environmental conditions persist. These biological responses to the changed environment provide insights about the relative state of the ecosystem. For example, in headwater streams, isolated populations of coastal cutthroat trout (*Oncorhynchus clarki clarki*) reflect conditions in their environment. Growth of individuals and population demographics are two characteristics that can shift in response to environmental change. Growth of an individual fish is determined by the difference between the amount of energy consumed in food resources and the amount of energy expended through metabolism and gamete production, all of which are influenced by a suite of abiotic variables. Demographics also reflect the relative state of the ecosystem following exogenously driven changes in the age structure, abundance, and distribution of a population.

Wildfire, a largely terrestrial perturbation, is broadly recognized as an agent of disturbance and ecological change in forested biomes, but the links to subsequent changes in aquatic systems are less well documented. Wildfire causes a number of changes in stream environments, including increased solar radiation, increased water temperatures, change in water chemistry, increased erosion and sedimentation, and increased water yields. At the basin scale, the influence of wildfire is theoretically most profound in headwater streams because of the tight linkage between aquatic and terrestrial ecosystems. These abiotic changes resulting from wildfire will elicit biological responses, many of which are poorly understood.

Current wildfire management plans are often based solely on theories, models, and extrapolation of forest management data. In fact, there is little empirical information about responses of stream fishes to wildfire. The majority of studies have focused on direct mortality, extirpation, recolonization, and change in relative abundance. Studies that relate post-fire environmental conditions to ecological responses of stream fishes are lacking, although the two are hypothesized to be strongly connected. These gaps in understanding impede our ability to formulate comprehensive management plans. By observing growth and demographics of coastal cutthroat trout, we are attempting to understand how post-fire conditions influence fish in headwater streams at the basin scale. Specific objectives of this study are to investigate 1) the relationships between wildfire severity, abiotic stream characteristics, and relative growth rates of coastal cutthroat trout at the landscape scale, and 2) annual trends in the distribution, relative abundance, and population age structure of coastal cutthroat trout following wildfire.

Methods

Four small watersheds in the headwaters of the North Umpqua River basin of western Oregon were

selected for this study. During the late summer of 2002, wildfire in three of the watersheds resulted in a mosaic of burn severities. A fourth watershed was selected as a control. Sampling is being conducted upstream of migration barriers to anadromous fishes (i.e., waterfalls) where coastal cutthroat trout are the only species of salmonid present. The drainage area above the migration barriers ranges from 804 ha to 1,489 ha.

Stream habitat inventories are being conducted during summer low-flow periods according to methods developed by Gresswell and Bateman (see 1999 CFER Annual Report). Stream habitat has been hierarchically classified into geomorphic segments, reaches, and habitat units. Severity of wildfire has been estimated for each watershed and for the riparian areas adjacent to each of the study streams from aerial photographs (USFS). In addition, abiotic variables such as solar input, water temperature, water chemistry, and discharge are being monitored in each stream.

All fish-bearing streams within these watersheds are being censused with a single-pass electrofishing method (see Bateman et al., 2002 CFER Annual Report). In each geomorphic stream segment, scales from a minimum of 10 fish (when possible) per 10-mm size group are collected annually. In one of the burned streams, which consists of a single segment, scales from 30 fish per 10-mm size group are being collected annually.

After field collection, up to 10 scales in each 10-mm size group are being analyzed to determine the age of fish in each stream. A random sample will determine which scales are to be read in each size group. Relative growth rates will be derived from scales by back-calculation of age at length. If there is evidence of selected mortality (Lee's phenomenon), only the last complete year of growth will be used to calculate relative growth rates. Statistical analyses will focus on the effects of severity of wildfire, stream of origin, habitat, solar influx, water temperature, and water chemistry on mean relative growth rates of coastal cutthroat trout. To detect changes in population age structure, age-length keys will be constructed for each stream and sample period. Population-scale changes in the relative abundance and distribution of coastal cutthroat trout will be monitored on an annual basis. Relative growth rates of coastal cutthroat trout from this study will be compared to relative growth rates of coastal cutthroat trout from 40 other watersheds in western Oregon (see Rehe and Gresswell, this report).

Preliminary Research Results and Management Implications

In 2003, 1,080 scale samples were collected from coastal cutthroat trout in the four study watersheds. In 2004, another 1,387 scale samples were collected. Relative summer densities (fish/unit area sampled) of coastal cutthroat trout ranged from 0.48 to 0.69 fish/m^2 in 2003 and 0.41 to 0.97 fish/m^2 in 2004. Between 2003 and 2004, relative summer densities changed in the three burned watersheds (from -0.01 to 0.28 fish/m^2); in the unburned control watershed, relative density declined 0.07 fish/m^2.

Water temperatures have been monitored continuously since June 2003. Maximum water temperatures in 2003 ranged from 13.5 °C in the unburned control watershed to 24.2 °C in the most severely burned watershed.

Study Timeline

Fish sampling and stream habitat inventories for 2003 and 2004 have been completed. A final field season will take place in June 2005. Age and growth analyses of scale samples will be completed by September 2005. Data analysis will continue through December 2005, and a final report and manuscript for publication will be submitted in March 2006.

Influence of Landscape Characteristics on Presence and Use of Habitat by Bat Communities in the Central Oregon Cascades

Ed Arnett and John P. Hayes

Twelve species of bats occur in Douglas-fir (*Pseudotsuga menziesii*) forests of western Oregon, and nine are known to roost in tree cavities and crevices. Availability, distribution, and quality of roosts are thought to be critical factors influencing population size and distribution of some species. Relationships of spatial distribution and availability of habitat features (e.g., roost structures, watering sites) to community richness, abundance, and habitat use by bats are poorly understood. Further investigation of these relationships could provide information to improve management prescriptions for providing habitat for bats through space and time.

This study was initiated in 1999 to evaluate the influence of availability of snags and roost trees on presence, relative abundance, and use of habitat by bats in managed forests of the western Oregon Cascades. Specifically, this study evaluated the influence of availability of roosts on presence and relative abundance of bats; the types of structures used for roosting by female and male long-eared myotis (*Myotis evotis*), female long-legged myotis (*Myotis volans*), and female big brown bats (*Eptesicus fuscus*); use of roost structures among species and among landscapes with various availabilities of roosts; and influences of characteristics of structures used as day roosts by bats at multiple spatial scales.

Cooperators for the project included Bat Conservation International, Bureau of Land Management (BLM; Eugene and Roseburg Districts), The Campbell Group, the Cooperative Forest Ecosystem Research program, Giustina Land and Timber Company, Jeff Allen Conservation Fund, National Council for Air and Stream Improvement, National Fish and Wildlife Foundation, Oregon Department of Fish and Wildlife, Oregon State University, Oregon Zoo Foundation, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Forest Service (USFS; Willamette National Forest), USGS Forest and Rangeland Ecosystem Science Center, and Weyerhaeuser Company.

Methods

The study area is located along the west slope of the Cascade Range between the Calapooya River north of Marcola, Oregon, and south into the North Umpqua River basin east of Roseburg, Oregon. This area encompasses lands managed by two federal agencies (BLM and USFS) and forests owned and managed by Weyerhaeuser Company and other private landowners. A diversity of habitat conditions and management histories occurs in this area.

Landscapes offering a range of snags and residual old-growth trees available for roosting by bats were randomly selected for sampling (n = 36). Bats were captured with mist nets placed over ponds within landscapes having low, medium, and high availability of roosts (12 ponds in each category of roost availability). Between six and nine surveys were completed at each pond between 1999 and 2001. Radio transmitters were attached to a sample of individuals of the three target species. We attached radio transmitters to 163 bats: 50 female big brown bats, 28 female long-eared myotis, 31 male long-eared myotis, and 54 female long-legged myotis. Roosts were located via radiotelemetry and recorded with a global positioning system. At each roost, we collected information of habitat characteristics to evaluate relation-

ships between habitat characteristics and use of roosts at multiple spatial scales.

Randomly selected structures and snag availability were sampled in landscapes surrounding each capture site. The distance from each day roost to the capture site where each bat was marked was quantified, and it was determined that >85% of all roost sites for all three species studied occurred within 4.8 km (3 mi) of a capture site. Thus, a 4.8 km-radius buffer around each capture site was considered to be "available" to bats in this study. For our analyses, we assumed that any bat radio-tagged at a capture site had an equal chance of flying in any direction up to 4.8 km to direct its selection toward a particular roost structure. We identified 250 random points from a 20-m grid overlaying each landscape. Random points were located in the field by pacing along compass bearings taken from the nearest known location to a given random point. Once at the point, an azimuth was obtained from a random numbers table, and random roosting structures were searched along a transect 100 m long by 40 m wide. This procedure was repeated up to three times until a random structure was located; if one was not encountered, the point was discarded and the next point in the random order was sampled. We collected data on the first of any of the four possible structure types (snag, tree, stump, log) encountered at each random point, using the same variables and procedures as for used structures. In addition, we quantified characteristics of all available snags >20 cm DBH for each transect.

Relationships between availability of roosts, bat community richness and abundance, and patterns of roost-site utilization will be analyzed during this study. To date, we have analyzed relative abundance data (based on mist-netting data), using multiple regression and Akaike's Information Criterion as a model selection tool. We modeled the number of bat captures per visit in relation to three predictor variables: snag density in the landscape, linear kilometers of medium and large streams in a landscape (as a surrogate for riparian foraging habitat), and elevation at the capture site.

Research Results and Management Implications

Final analysis of data has not yet been conducted. Therefore, all information in this report should be considered preliminary pending further analysis.

Relative abundance of bats

A total of 1,342 bats of nine species were captured during simultaneous mist-net surveys between 1999 and 2001. Silver-haired bats (*Lasionycteris noctivagans*; n = 350), big brown bats (n = 289), long-eared myotis (n = 259), long-legged myotis (n = 220), and California myotis (*Myotis californicus*; n = 137) were the most frequently captured species.

We found a positive relationship between number of captures of all bats with both elevation and snag density. Similarly, number of captures of all male bats was positively related to elevation and to snag density. Conversely, number of captures of female bats was negatively related to elevation. This finding is consistent with other studies that have demonstrated negative relationships between capture of female bats and increasing elevation. Snag density was not an important variable in models of female bat relative abundance, but this lack of association appeared to be strongly influenced by capture site location in relation to elevation. Snag-rich landscapes sampled during this study were biased towards higher elevation sites located on public lands. Males and females have different physiological requirements during the summer months and may partition their use of landscapes based on the influence of elevation on microclimatic conditions and food availability. Patterns emerging from these data suggest that managing for maternity roosts for bats at lower elevations may be important for conservation of bats in managed forests.

Use of day roosts

Female big brown bats and long-legged myotis selected snags used as day roosts that were larger in diameter than those randomly available. In contrast, mean

diameter of snags used by male and female long-eared myotis was less than mean size of snags used by other species and than randomly available snags, although the confidence intervals for diameter of snags used by long-eared myotis and randomly available structures overlap and differences are likely not statistically significant (Figure 1).

Snags used as day roosts by females of all three species and male long-eared myotis had more snags 10–50 cm DBH and snags >50 cm DBH within 20 m of the roost site than did randomly available snags (Figures 2 and 3). Additionally, snags used as day roosts by females of all three species and male long-eared myotis were closer to edges (defined as a gap >20 x 20m or a change in forest-age class) than were randomly available snags, but the confidence intervals for snags used by both genders of long-eared myotis and randomly available structures overlap (Figure 4).

Relative to physical position in the landscape, snags that were selected by females of all three species and male long-eared myotis were closer to the capture site than were randomly available snags (Figure 5). Female big brown bats and long-legged myotis also selected snags used as day roosts that were closer to small and large streams (Figures 6 and 7). Male long-eared myotis selected snags as day roosts that were significantly farther from small and large streams than those selected by female long-eared myotis, but not different from randomly available snags (Figures 6 and 7).

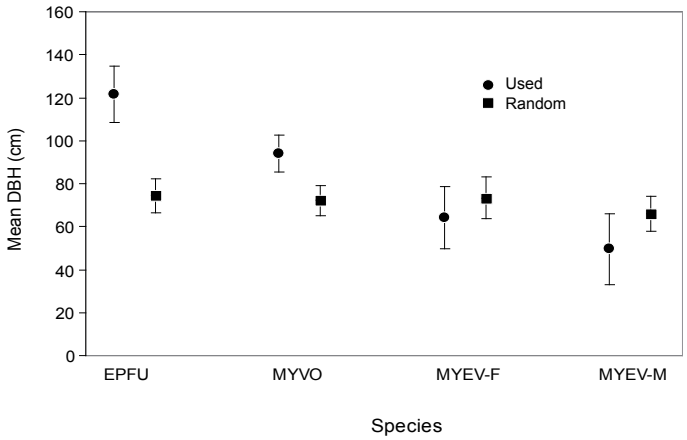


Figure 1. Mean diameter at breast height (DBH) and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

Although definitive conclusions await final analysis of the data, patterns emerging from these preliminary analyses suggest that managing for a range of sizes of snags is important when providing day roosts for sympatric species of bats, but larger bats (big brown bat and long-legged myotis) prefer larger diameter trees. As these large-diameter roosting structures are often uncommon in managed landscapes, management should focus primarily on retention and development of large snags in the future in situations where providing habitat for bats is a management goal. Retaining patches of snags appears to be an important consideration when managing snags for forest-roosting bats in this region. Finally, it appears that snags managed as day roosts for bats need to be in close proximity to open water and foraging habitat (e.g., riparian areas).

Study Timeline

All field data have been gathered, and we are currently finalizing GIS data and analyzing habitat relationships. Data analysis will be finalized in winter 2004/2005, with an expected completion and distribution of a final report in June 2005.

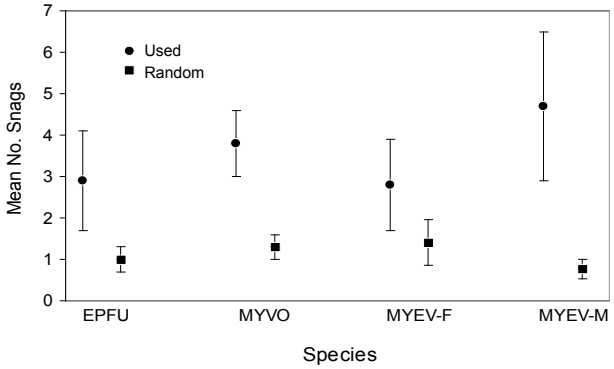


Figure 2. Mean number of snags 10–50 cm DBH within a 20-m radius plot and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

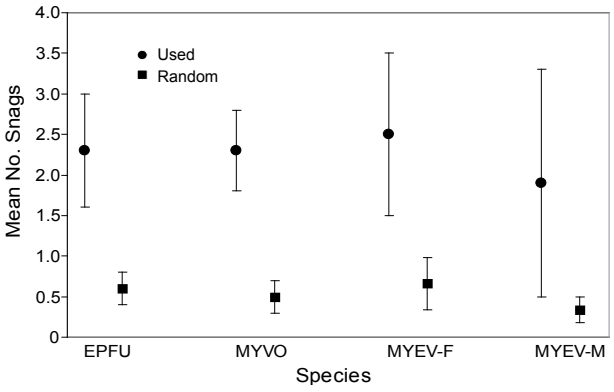


Figure 3. Mean number of snags >50 cm DBH within a 20-m radius plot and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

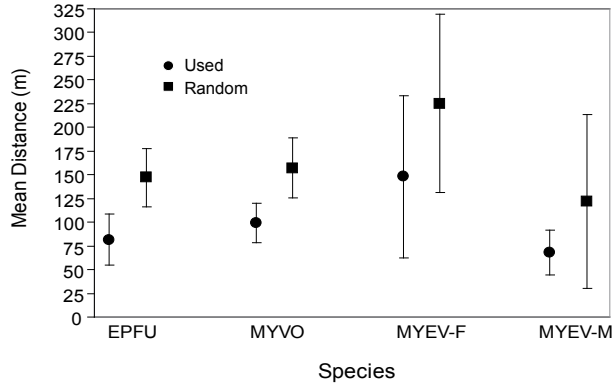


Figure 4. Mean distance to edge (>20 x 20m gap or change in forest type) and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

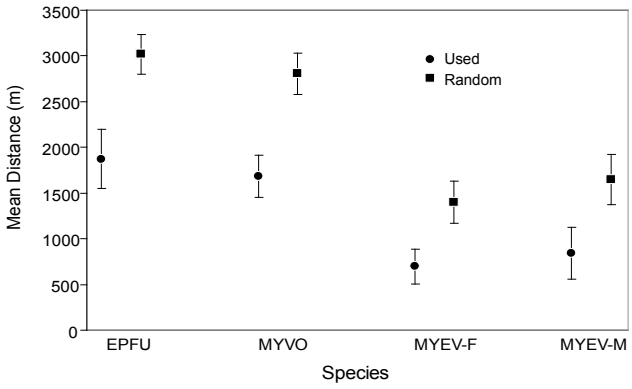


Figure 5. Mean distance to capture site and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

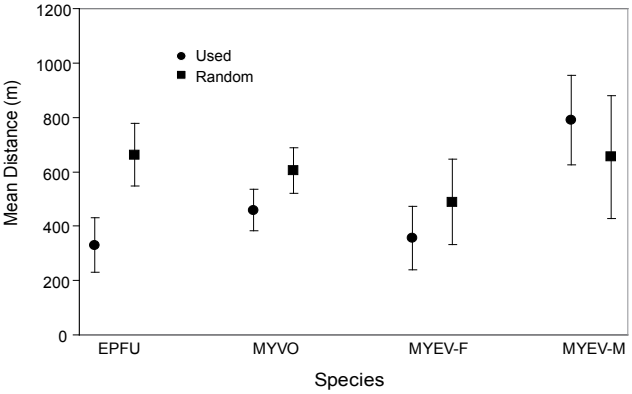


Figure 6. Mean distance to small stream and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

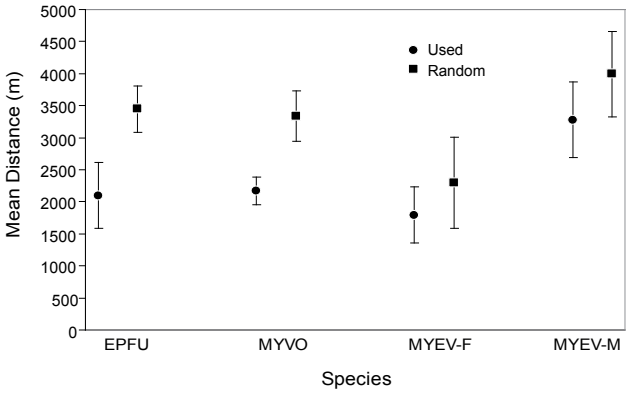


Figure 7. Mean distance to large stream and 95% confidence intervals for snags used as day roosts by each species of bat compared to snags randomly available in landscapes (EPFU = big brown bat, MYVO = long-legged myotis, MYEV = long-eared myotis females [F] and males [M]).

Spatially Explicit Landscape Modeling of Alternative Forest Management Scenarios in Western Oregon

Christian E. Torgersen, David P. Hockman-Wert, John H. Cissel, Chris D. Sheridan, and John H. Guetterman

Forest ecosystems in the Pacific Northwest represent a dynamic convergence of terrestrial and aquatic ecosystems within a shifting mosaic of natural and anthropogenic influences. Because forested landscapes are spatially complex and temporally variable, it is difficult to interpret scientific results and make management decisions based on site-specific analysis without considering the spatial and temporal context of potential future management activities and ecosystem patterns and processes, such as forest succession and landscape disturbance. Recognizing the need to understand pathways of forest succession under different management scenarios across a patchwork of forest types (riparian and upslope), researchers and managers have begun to use spatially explicit tools for visualizing and understanding the impacts of human and natural disturbances on forest ecosystems at a landscape scale. Spatial modeling with alternative management scenarios can be an effective tool for understanding landscape dynamics and balancing multiple land uses (e.g., timber harvest, recreation, and aquatic conservation) in a complex matrix of public and private lands.

The primary goals of this project were to develop a landscape scenario modeling and analysis capability within the Cooperative Forest Ecosystem Research (CFER) program at Oregon State University and the Forest and Rangeland Ecosystem Science Center (FRESC) and to provide science support to initial BLM landscape scenario analyses. Landscape scenarios were developed in coordination with the BLM Coos Bay District, which is currently engaged in landscape analysis for an environmental assessment (EA) of activities designed to enhance late-successional reserves (LSR) in the Brummit Creek study area in the East Fork Coquille watershed. The objectives of the project were to 1) facilitate integration and synthesis of CFER data, models, and expertise in a landscape context, 2) provide a vehicle for ongoing interaction with BLM districts regarding the implications of alternative landscape management approaches, and 3) explore the capability of landscape modeling for evaluating broad-scale impacts of management actions on forest ecosystems. Spatial and tabular data generated in the project will be used by the BLM Coos Bay District to evaluate the potential effects of wind disturbance, density management thinning, and other forest and riparian treatments on forest cover and structural characteristics. The models described in this report should be viewed as a first step towards evaluating potential impacts of various management scenarios and are intended to be a tool for visualizing landscape change and generating discussion on management options. In this sense, the models are not predictive of actual future conditions because they are dependent on assumptions specific to the goals of the project. It is expected that model development will proceed beyond the initial analyses presented in this report. Through continued cooperation among CFER and BLM ecologists and resource managers, the models will be modified iteratively and incrementally, with capabilities and improvements added over time.

Methods

Spatially explicit landscape modeling consists of four basic components: a geographic information system (GIS), stakeholder involvement (i.e., managers and

scientists), alternative scenario analysis, and evaluation and monitoring. Links between scientists and managers in landscape scenario modeling ensure that information flows freely among all parties involved. Spatial modeling with a GIS is a key component in the system because it provides a visual, intuitive interface that makes it possible for scientists to 1) present different management options and 2) demonstrate how these scenarios play out in a dynamic landscape. The landscape modeling approach allows scientists and managers to provide feedback both in the development of alternative management scenarios and in the refinement of the spatial models.

We used TELSA/VDDT in this project because of its focus on landscape pattern, its ease of use and flexibility, and its greater capability to represent interactions of disturbance and management at landscape scales. The tools provided in TELSA/VDDT are designed to address management questions at these intermediate scales, and thus they offer managers and scientists the opportunity to bridge the gap between regional landscape models and site-specific scientific research. Models in TELSA/VDDT represent landscape management scenarios as combinations of stand types, successional pathways, management regimes, and disturbance regimes. Stands are represented as polygons in ArcView GIS Version 3.x (Environmental Systems Research Institute [ESRI]), and pathways describing changes in stand type over time and in response to management and disturbance are defined for each stand type. The TELSA/VDDT software package also contains numerous mechanisms to control management and disturbance at landscape scales based on mapped characteristics (e.g., fire regime, rain-on-snow zone, Northern spotted owl home range, aquatic large wood source area). Landscape scenarios can be represented at a very coarse resolution initially and then refined over time as skills and insight are acquired.

Study Area

Modeling was conducted at two spatial scales in the East Fork Coquille study area, located southeast of Coos Bay in the Oregon Coast Range. The larger of the study areas, the E.F. Coquille, covers 42,591 ha and extends 3 km north of the actual E.F. Coquille watershed boundary. The additional area north of the E.F. Coquille watershed boundary was included to encompass wildlife habitat that occurred on both sides of the watershed divide. The smaller Brummit EA study area is nested within the E.F. Coquille boundary and has an area of 11,603 ha.

The E.F. Coquille study area ranges in elevation from sea level to 900 m and is located in the midcoastal sedimentary subdivision (level IV ecoregion) of the Coast Range ecoregion (level III). This region of western Oregon is underlain by massive beds of siltstone and sandstone. The steep, dissected topography of the region is prone to mass movement and high fluvial erosion rates when vegetative cover is removed. Forest vegetation in the study area is a mix of two types: Douglas-fir (*Pseudotsuga menziesii*)/deciduous and Douglas-fir/western hemlock (*Tsuga heterophylla*). Land ownership in the E.F. Coquille study area is primarily BLM LSR (32%) and matrix land (25%) interspersed in a checkerboard pattern with nonfederal (42%) lands consisting mainly of privately owned industrial forest. The Brummit EA is composed of BLM LSR (61%) and privately owned industrial forest (39%).

Successional Pathways

Forest vegetation cover types, structural stages, and successional pathways were derived from the literature and from field observations of existing vegetation in the E.F. Coquille study area. Cover types were identified based on the dominant overstory tree species, where dominance was defined by percent canopy cover. A secondary species was included in the cover type if it constituted greater than 20% of the total cover. Structural stages were based on local knowledge of existing vegetation in the study area (C. Sheridan and F. Price, BLM Coos Bay District, Oregon, unpublished data) and on literature for forests of the Pacific Northwest. To represent existing forest vegetation as accurately as possible, 22 cover types and 29 structural stages were combined to create 56 state classes (i.e., unique cover type and structural stage combinations). Nonforest state

classes (shrub, agricultural, urban, water, and barren lands) were included in the model as static variables for map display only (i.e., no changes in size or cover class over time).

In TELSA/VDDT, successional pathways specify the natural progression of forest vegetation cover type/structural stage (state class) over time in the absence of natural disturbance (e.g., fire, wind, or landslides) and timber harvest. The pathways developed for the E.F. Coquille and Brummit EA study areas represent an extensive effort by BLM Coos Bay District forest ecologists to synthesize field observations and published literature on forest vegetation in the Pacific Northwest. Successional pathways employed in the model were categorized into six pathway types: 1) traditional, semi-open pathway; 2) open conifer pathway; 3) open conifer with legacies; 4) dense pathway (plantations); 5) red alder/conifer pathway; and 6) western hemlock pathway. Transitions from one state class to another occurred in a linear fashion with the passage of time.

Spatial Data Layers

Spatial data with forest attributes (state class, stand age, and years in state class) are required to model spatial patterns of forest vegetation change in TELSA. Multiple spatial data products were used to create a map of landscape units (a polygon shape file in ArcView) for the E.F. Coquille study area. Information on forest cover type, stand age, and structural characteristics was obtained from the BLM Forest Operations Inventory (FOI) database. Because these data were only available for BLM lands, forest cover type data for nonfederal lands were evaluated from four Landsat Thematic Mapper (TM) image products: 1) the Interagency Vegetation Mapping Project (IVMP) (1996), 2) the Western Oregon Digital Imagery Project (WODIP) (1993), 3) the Coast Landscape Modeling Study (CLAMS) (1996), and 4) the Stand Replacement Disturbance Mapping Project (SRD) (1972–2002). Data on stand age for nonfederal lands were interpreted from aerial photographs and mapped in a GIS by the BLM Coos Bay District.

To determine the most appropriate imagery to use in creating a forest cover map for nonfederal lands in the study area, vegetation classifications from IVMP, WODIP, and CLAMS imagery were compared to vegetation data in BLM FOI polygons. The strengths and weaknesses of the various image products varied, depending on the purpose for which they were developed. Because the cover types we used in TELSA/VDDT were based on dominant canopy cover, the imagery was used to determine only the dominant vegetation signature. This information was then compared to the vegetation data derived from the BLM FOI polygons. Although the vegetation classifications of IVMP, WODIP, and CLAMS were not developed to provide detailed information at a local scale, all three image types performed remarkably well at detecting the amount of conifer-dominant cover.

The IVMP was very good at quantifying conifer cover but not at separating broadleaf cover from recently cut areas. In contrast, WODIP imagery was good at quantifying conifer cover, adequate at quantifying broadleaf cover, and very good at separating broadleaf cover from recently cut areas. Vegetation classes in CLAMS imagery were very different from IVMP and WODIP. The CLAMS imagery was developed with the gradient-nearest-neighbor approach and probably represented vegetative conditions the most accurately of the three image products. It was difficult, however, to compare CLAMS to the other imagery because CLAMS data provided much more information on mixed cover types (conifer/broadleaf).

After comparing the three forest cover data sources, we concluded that CLAMS provided the most useful representation of forest cover type on private lands. The WODIP imagery also provided very good information on forest vegetation; it has the added advantage of being available outside of the CLAMS study area, which is limited to the central and northern portion of the Coast Range. However, the statistical rigor of the vegetation classification method and the more recent image acquisition date of the CLAMS imagery (1996 as opposed to 1993 for WODIP) made it preferable for modeling vegetation in the E.F. Coquille study area.

The final steps in building a spatial data layer of forest cover type involved updating the FOI stand ages with the SRD imagery and developing crosswalks from the FOI polygons and the CLAMS imagery to the state classes. The SRD imagery provided information on stand replacement disturbance from clearcuts and fire during a 30-year period (1972–2002). No significant fires had occurred in the study areas, so all stand replacement disturbances were from clearcuts. Landscape units (polygons) that did not have young stand ages in the FOI but were depicted as clearcuts in the SRD were updated based on the year of disturbance specified in the imagery.

Scenario Development

Landscape management scenarios were developed through discussions between CFER and BLM landscape ecologists, forest ecologists, and resource managers. The first landscape model encompassed the entire E.F. Coquille study area and evaluated three management scenarios: 1) succession only (no management actions; provided a basis for comparison with subsequent scenarios), 2) management similar to the Northwest Forest Plan (NWFP) with density management thinning and hardwood conversion on LSR stands 25–50 years of age, and 60-year regeneration harvest rotations with full riparian reserves on BLM matrix lands, and 3) management roughly patterned after natural disturbance by fire (landscape dynamics) with a 300-year rotation on north-facing slopes, 150-year rotation on south-facing slopes (both with 15–20% retention of live trees), and reduced (33 m) riparian reserves (Table 1). In all three scenarios, timber harvest on private lands was modeled on 40-year rotations with a minimum age of 35 years at first cut. These three scenarios provided an opportunity to evaluate broad-scale patterns of forest change in response to management approaches.

The second landscape model focused more on the specific management needs of the BLM Coos Bay District to develop an EA in the Brummit study area, which is currently managed by the BLM for late-successional forest characteristics. The goals of this model were to evaluate the effectiveness of density management and

Table 1. Alternative landscape management scenarios for the E.F. Coquille and Brummit Environmental Assessment (EA) study areas in the BLM Coos Bay District, Oregon.

Scenario	Natural disturbance	Management
E.F. Coquille		
1. Succession (no action)	None	No action on BLM land; clearcut private lands with 40-year rotation; 35-year minimum age at first cut; harvest on private lands same in all scenarios.
2. Less intensive (NWFP)[1]	None	Density management (DMT) and hardwood conversion in all 25-50-year-old stands in late-successional reserves (LSR); 60-year rotation on BLM matrix lands; full riparian reserves; no management on Research Natural Areas.
3. Landscape dynamics	None	Different rotation lengths based on slope aspect (i.e., presumed historical fire frequency): 300 years (north-facing) and 150 years (south-facing); BLM lands (LSR and matrix) clearcut with 15-20% overstory retention; private lands managed with traditional clearcut.
Brummit EA		
1. Succession (no action)	None	No action on BLM land; clearcut private lands with 40-year rotation; 35-year minimum age at first cut; harvest on private lands same in all scenarios.
2. More intensive (preferred)	None	DMT and hardwood conversion in *all* EA units (individual prescriptions); thinning in first- and second-order riparian reserves; management on stands only up to 80 years of age.
2a. Wind #1	Wind	Same as scenario 2 but with wind and delayed DMT. [2]
2b. Wind #2	Wind	Same as scenario 2 but with wind and delayed DMT.
2c. Secondary disturbance	None	Same as scenario 2 but with delayed DMT and no wind.
3. Less intensive	None	Same as scenario 2 but only has DMT and hardwood conversion in *some* EA units (individual prescriptions), and includes a no-thinning zone (red alder/conifer >20 TPA cover type and/or stands greater than or equal to 60 years of age).
3a. Full riparian reserves	None	Same as scenario 3 but includes full riparian reserve buffers (i.e., no thinning in first- and second-order riparian reserves).
4. Full DMT	None	Density management thinning and hardwood conversion on all eligible BLM land, including riparian reserves (EA units not considered).

[1] Scenario similar to Northwest Forest Plan management.

[2] Delayed DMT is a management type in which all non-EA units become eligible for thinning after the model has run for 10 years.

hardwood conversion prescriptions for creating late-successional forest structure and to examine potential spatial and temporal interactions of wind disturbance with various thinning activities. Detailed descriptions of the eight different Brummit scenarios are provided in Table 1. As in the E.F. Coquille model, the succession-only scenario provided a basis against which various management options could be compared.

Various management types and one type of natural disturbance (wind) were evaluated in the model. Thinning prescriptions were complex and case-specific in the Brummit scenarios because they reflect actual management actions considered by the BLM Coos Bay District. The majority of the 20 management types were applied in the Brummit scenarios. The E.F. Coquille scenarios were relatively simple. Wind damage that occurred as a result of the ice storm during winter 2004 provided the impetus to incorporate natural disturbance patterns in the Brummit model. In the scenarios with wind (see Table 1), 10% of the study area experienced wind disturbance (heavy wind disturbance) over the 100-year modeling horizon, in which 90% of the disturbance events were 10–100 ha in size and 10% were 100–1,000 ha in size. Wind was used in a limited number of scenarios (Brummit study area only) because initial model runs indicated that wind had a visual impact equaling the effects of different management scenarios, which confounded the primary goal of seeing differences among management practices.

Spatially Explicit Landscape Modeling

The spatial component of landscape modeling was done in TELSA, which is a software program that links ArcView maps of forest vegetation characteristics and management areas (planning zones and withdrawn areas) with successional pathway information in a relational database in Microsoft Access. Input maps in the Brummit and E.F. Coquille models included withdrawn areas (nonforest, protected areas for wildlife and research, and riparian buffers), and planning zones (land ownership boundaries, management areas such as BLM matrix and LSR, and fire-prone areas on south-facing slopes). The spatial module in TELSA uses Avenue scripts in ArcView to carve the landscape into polygons along all boundaries of the input maps. The landscape was then tessellated into smaller irregularly shaped polygons that determine the spatial grain (approximately 9 ha) at which natural disturbances occur across the landscape. Spatial and tabular output data were displayed in classes indicating cover type (conifer, broadleaf, and nonforest) and structural stage: early (ecosystem initiation, competitive exclusion, canopy closure, and biomass accumulation); mid (understory reinitiation, developed understory, botanically diverse, and maturation); and late (vertical diversification, fully functional, horizontal diversification, and pioneer cohort loss).

Research Results and Management Implications

Maps generated by the models were useful for visualizing the effects of natural and anthropogenic disturbances on forest stand structure and for generating discussion among scientists and managers regarding the implications of management actions. Patterns resulting from the three alternative landscape management scenarios in the E.F. Coquille model showed that a timber harvest regime patterned after potential natural disturbances (landscape dynamics scenario) created a patchier landscape with smaller areas of late-successional forest than did the NWFP scenario (Figure 1).

A key difference between the two scenarios was the distribution and extent of mid-successional forest on BLM matrix lands. The overall "darker" impression of the NWFP scenario derived from the extensive late-successional forest cover within the Brummit study area. In contrast, the landscape dynamics scenario resulted in a more balanced distribution of mid- and late-successional forest within and outside the LSR. The succession-only scenario yielded the greatest amount of mid- and late-successional forest after 200 years. A comparison of temporal trends in forest characteristics by scenario revealed that, although the NWFP initially developed more mid- and late-successional forest after 100 years,

the landscape dynamics scenario eventually surpassed the NWFP after 200 years (Figure 2).

In the Brummit study area, the more intensive scenario generated forest patterns that were not noticeably different at a coarse scale from the succession-only scenario (Figures 3 and 4). Even the more dramatic effects of secondary disturbance (wind #1 and secondary disturbance) and full DMT were difficult to detect when they were compared to forest patterns resulting from the succession-only scenario. Thus, the effects of various thinning approaches had a limited effect on the visual appearance of the landscape in the Brummit study area, particularly when management was limited to only the Brummit EA harvest units, which made up only 10% of the total land area. However, closer examination of temporal trends in stand composition and structure revealed that the proposed management actions of the more intensive scenario resulted in faster transition rates to mid- and late-successional stages than the succession-only scenario, particularly after 40 to 80 years (Figure 5). The fastest transition to mid- and late-successional forest structure occurred under the full DMT, wind #1 (wind and secondary disturbance), and secondary disturbance scenarios, with the fastest rate of change occurring between 40 and 80 years (Figures 5 and 6).

Spatially explicit landscape modeling provided a means to evaluate what landscapes may look like under different natural and anthropogenic disturbance regimes. The information generated by the models was useful for visualizing the general direction of landscape change in response to management actions and for promoting discussion among scientists and resource managers. Maps depicting various scenario outcomes were helpful for comparing alternative management scenarios, but the conditions of the scenarios should be considered carefully

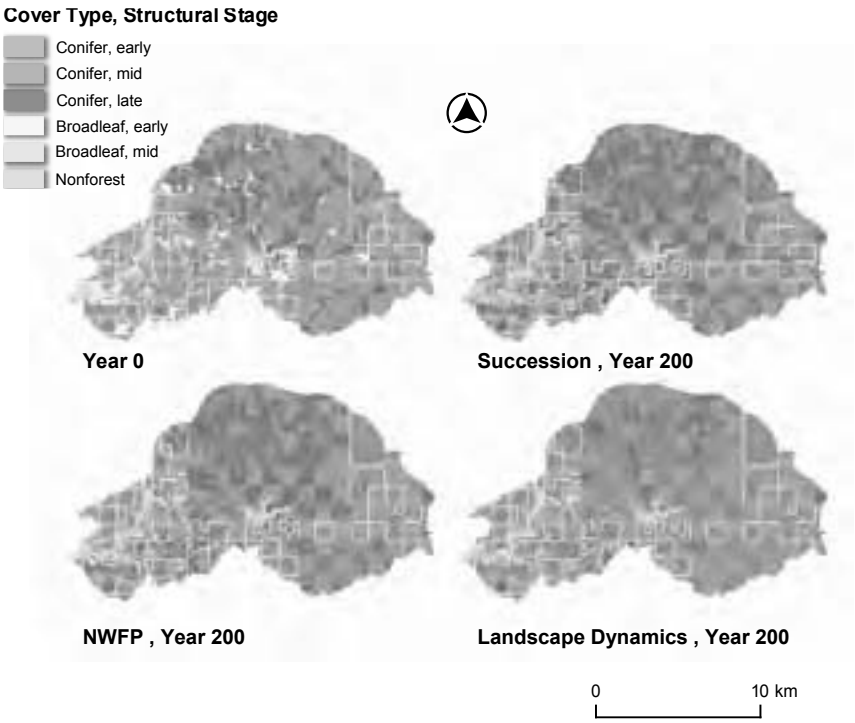


Figure 1. Alternative landscape management scenarios and initial forest vegetation conditions (year 0) in the E.F. Coquille study area (see Table 1 for scenario descriptions). The scenarios simulate natural disturbance and timber harvest over a 200-year period. White outlines indicate BLM matrix land boundaries.

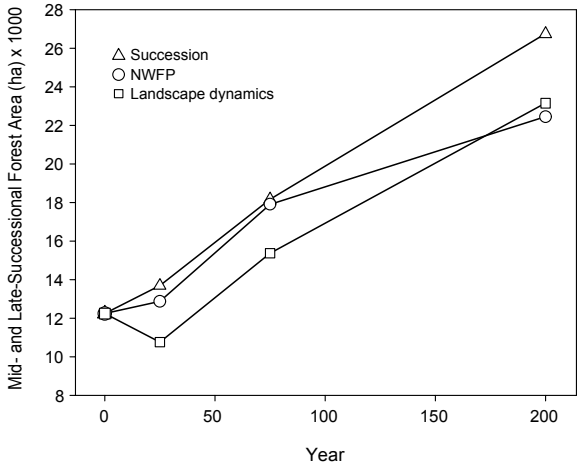


Figure 2. Temporal trends and transition rates to mid- and late-successional stages under different landscape management scenarios in the E.F. Coquille study area (see Table 1 for scenario descriptions).

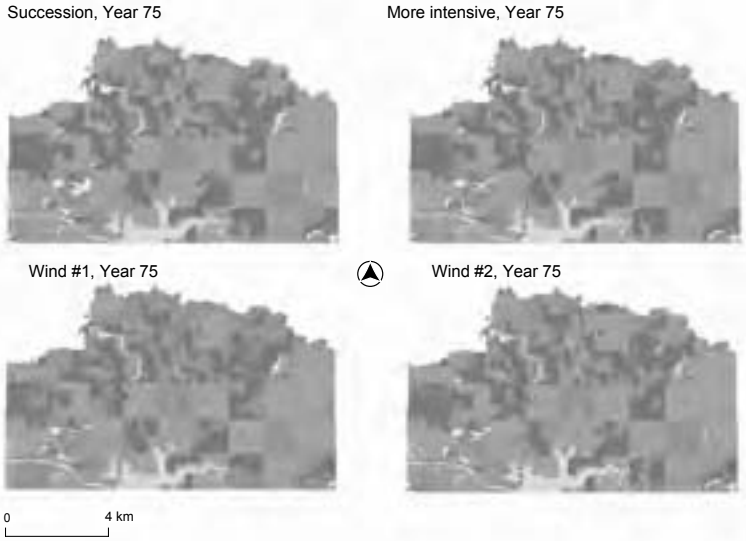


Figure 3. Alternative landscape management scenarios in the Brummit study area (see Table 1 for scenario descriptions). The scenarios simulate natural disturbance and timber harvest over a 100-year period.

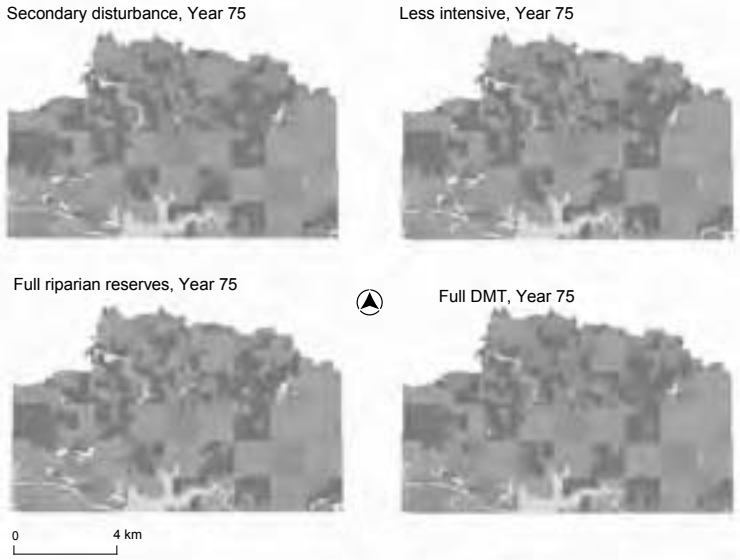


Figure 4. Additional alternative landscape management scenarios in the Brummit study area (see Table 1 for scenario descriptions). The scenarios simulate natural disturbance and timber harvest over a 100-year period.

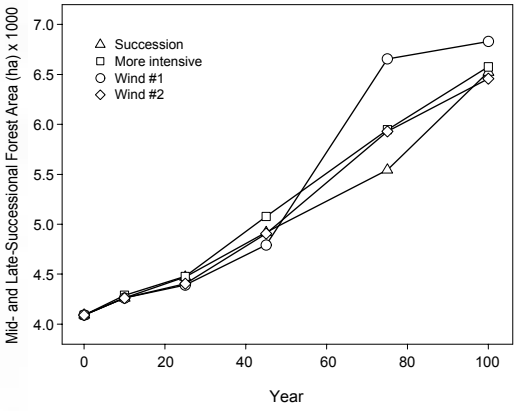


Figure 5. Temporal trends and transition rates to mid- and late-successional stages under landscape management scenarios 1-2b in the Brummit study area (see Table 1 for scenario descriptions).

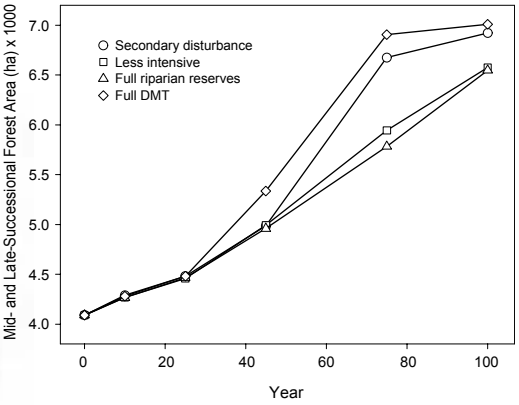


Figure 6. Temporal trends and transition rates to mid- and late-successional stages under landscape management scenarios 2c-4 in the Brummit study area (see Table 1 for scenario descriptions).

before generalizations can be made about management actions. For example, direct comparison of the NWFP and landscape dynamics scenarios in the E.F. Coquille study area was complicated by the different proportions of LSR and matrix lands in the two scenarios. The NWFP scenario differentiated between BLM LSR and matrix lands, whereas the landscape dynamics scenarios did not. Thus, the spatial distribution of forest cover types after 200 years of management was expected to be quite different under the two scenarios, given the pattern of LSR and matrix lands in the study area. Underlying model assumptions and patterns of land ownership need to be taken into account when comparing the results of different landscape management scenarios.

Spatially explicit landscape models are only approximations of complex natural systems and, therefore, vary in their realism, precision, and generality depending upon the purpose for which they were developed. The goal of modeling alternative landscape scenarios in this project was to achieve a general understanding of ecological patterns that are difficult or impossible to quantify over broad spatial and temporal scales. Given the uncertainties involved with forecasting future conditions over large areas, landscape modeling provided a qualitative assessment of planning alternatives. More rigorous, quantitative comparisons of ecological effects of landscape alternatives are difficult to obtain because knowledge is incomplete.

For more information on this project, the final report titled "Modeling responses of forest landscapes to alternative management scenarios in the East Fork Coquille watershed, Oregon" can be downloaded from http://oregonstate.edu/~torgersc/pub/LSAP_Torgersen_etal_2004.pdf.

Influences of Riparian Vegetative Community Composition on Animal Community Response

Riparian management objectives in forests of the Pacific Northwest have diversified considerably over the last two to three decades, from a primary focus on strictly utilitarian interests to goals that encompass a broader set of objectives that include conservation and restoration. Although this shift has yet to settle on clear statements of objectives for many ownerships, the transition in management directions has heightened the importance of scientific information about riparian areas.

Because the primary issues of concern for riparian areas are stream temperature and in-stream structural wood, regulations tend to promote the retention of existing conifers and conversion of hardwood-dominated areas to conifers. Because these regulations are relatively new, it is unclear how successful they will be in increasing riparian conifer dominance. However, the potential is great, and this has raised questions concerning the effect this conversion may have on habitat quality for both fish and wildlife. This research will examine the influences of woody plant community composition in riparian areas on food chains and response of consumer organisms of interest.

Goals

The three interrelated goals of this research theme are:

- to determine the influence of riparian woody plant community composition on in-stream productivity, aquatic vertebrate populations and communities, and terrestrial vertebrate communities;
- to determine the interactions among these components of the riparian ecosystem; and
- to predict the influence of riparian forest management practices on riparian aquatic and terrestrial vertebrate communities as mediated through food chains.

2004 Highlights

- Master's student Sharmila Premdas completed her thesis titled "Influence of Canopy Type and Seasons on Adult Aquatic Insect Emergence and Riparian Spiders in the Oregon Coast Range."
- Master's student Emily Scott completed her thesis titled "The use of δ15N and δ13C to Analyze Food Webs and Identify Source-Sink Relationships in Riparian Canopy Vegetation of the Oregon Coast Range."
- The research theme was expanded to include a new study titled "Litter Decomposition in Terrestrial and Aquatic Habitats of Managed Coast Range Riparian Forests."

New and continuing studies during the year under report are summarized in the following section.

Influence of Riparian Vegetation on Amphibian Communities and Amphibian Diet in the Oregon Coast Range

Paula Graff and W. Daniel Edge

In the Pacific Northwest, high amphibian densities and biomass have been recorded for terrestrial and aquatic systems, particularly riparian zones. These areas provide important biotic and abiotic features, such as logs, thermal cover, and abundant invertebrate prey, that benefit many amphibian species. In spite of reported high densities, the role of amphibians in riparian food webs is not well known. It is likely that amphibians provide an important trophic link between terrestrial and aquatic systems because they exploit terrestrial and aquatic prey and are prey for other vertebrates. Plant species composition in riparian zones may influence the availability and types of invertebrate prey for aquatic and riparian amphibian communities. In low-order streams, allochthonous inputs, such as leaf litter and invertebrates, provide much of the energy at the base of the food web. Vegetation composition may influence the invertebrate prey available to amphibians and other vertebrates because the diversity of invertebrates falling from some tree species is higher than from others (Southwood 1961, *Journal of Animal Ecology* 30(1):1–8; Mason and MacDonald 1982, *Freshwater Biology* 12:305–311). It has been suggested, however, that vegetation composition is important only for providing thermal cover or microhabitat sites and plays no role in amphibian diet. Soil moisture, soil temperature, air temperature, and humidity may limit foraging opportunities for terrestrial amphibians, potentially restricting activities to times when soil moisture, soil temperature, or humidity levels are high. Few studies on amphibian diet address habitat influences or seasonality of prey sources.

Current management practices that promote retention of conifer trees over hardwoods in riparian forests in the Oregon Coast Range may unintentionally affect other species, such as amphibians. The goal of this project is to examine the relationships among riparian vegetation and aquatic and terrestrial riparian amphibian assemblages and their invertebrate prey. We will identify habitat components that may be correlated with the occurrence and distribution of aquatic and terrestrial amphibians found in streams and riparian zones in the Oregon Coast Range. We will also compare amphibian diet and invertebrate prey availability in these habitats. Seasonal differences in amphibian diet and prey availability and an evaluation of fitness through relative size indices and a measure of stomach fullness will be qualitatively and quantitatively described. Amphibians offer an excellent opportunity to assess prey differences between habitats because they swallow their prey whole and have low metabolic rates, so items remain intact in their stomachs for extended periods. Additionally, many amphibians are relatively long-lived, have small home ranges, show strong site fidelity, are not highly mobile, and do not move away from areas after handling. The information gained can be used to evaluate the influence of different riparian vegetation on prey sources and amphibian communities. Understanding these relationships is important for providing baseline information for assessing potential impacts of vegetation alteration in riparian management areas on amphibians.

Methods

Terrestrial and aquatic amphibian, vegetation, and wood surveys were completed in August 2003. Study

sites were located on 2nd- and 3rd-order streams in second growth Douglas-fir (*Pseudotsuga menziesii*) in the Oregon Coast Range that reflected a range of conifer- and hardwood-dominated riparian conditions. A study site consisted of a 150-m stream length and the adjacent 30-m upslope area. We used pitfall traps, artificial cover objects, and area-constrained searches to capture terrestrial amphibians. We used randomly located 1- by 2-m quadrats for area-constrained searches and to measure vegetation and microhabitat characteristics of the riparian zone in fall of 2002 and spring of 2003.

Aquatic surveys were conducted at all 10 sites three times, and three sites were additionally sampled. Amphibian searches and microhabitat measurements were taken each sample period in 10 permanent 2-m long transects at each site. Amphibians spotted outside of transects and quadrats were captured when possible. A light-touch survey method was used at all times to ensure the least amount of disturbance to areas that were repeatedly sampled and to facilitate future recapture of animals.

All captured amphibians were measured and weighed, and their gender was determined when possible. Animals were anesthetized in a solution of MS-222 (3-aminobenzoic acid ethyl ester) buffered with sodium bicarbonate so that stomach contents could be collected and individuals marked with a Visible Implant Fluorescent Elastomer tag. Each animal was released near a cover object at the point of capture after it had recovered.

We sampled terrestrial invertebrates by randomly locating 10 invertebrate pitfall traps within the study site and opening them for the duration of the amphibian trapping period at that site. In addition, soil samples were collected at random locations throughout the study site and epigeic soil-dwelling invertebrates were extracted by a Berlese funnel trap. Aquatic benthic invertebrates were sampled with a 0.09-m^2 Surber sampler with a 500 *u*m sieve at six random locations within each reach during each aquatic sample period.

Invertebrate identification is ongoing. All stomach samples are photographed in a petri dish, and the amount of surface area covered by stomach contents is measured (mm^2) by computer. This approach accounts for the miscellaneous and often unidentifiable matter that is usually present in stomach samples. Prey items are identified to the taxonomic level of order. Prey from larval *Dicamptodon tenebrosus* from Ernest Creek, which makes up 56% of all *D. tenebrosus* captures, are identified to the family level when possible. Benthic and terrestrial invertebrate samples will also be identified to the order level.

Preliminary Research Results and Management Implications

We captured a total of 527 amphibians over all survey periods, including 359 individuals captured during aquatic surveys and 168 during terrestrial sampling. The most common species was the aquatic larval stage of *D. tenebrosus*, occurring in all but one of the sites and accounting for 51.8% of all amphibians captured (76% of all aquatic survey captures). Stomach sample identification has been completed for two aquatic seasons (July and October) for this species. In July, we captured 77 larval *D. tenebrosus* and successfully extracted 76 stomach samples. Two individuals had essentially empty stomachs, and one individual was too small for the gastric lavage tube. We found 19 different taxa in all the stomach samples. Ephemeroptera, Plecoptera, Diptera, and Trichoptera were the four most abundant food items (Table 1), together comprising over 63% of all invertebrate prey items. In October, we captured and sampled 52 *D. tenebrosus* larva. Diptera were the most abundant prey item, followed by Ephemeroptera, Plecoptera, and Trichoptera, accounting for 70% of the total invertebrate prey. Ephemeroptera, Plecoptera, and Trichoptera occurred in stomach samples in a higher proportion than they occurred in the benthic samples for these two seasons (Figure 1). This suggests prey selectivity for these taxa. When all invertebrate identification is completed, a formal seasonal diet and prey selectivity analysis will be conducted.

Overall, aquatic invertebrates accounted for ≥85% of the *D. tenebrosus* prey; <10% were of terrestrial origin in both seasons (the remaining items were too

decomposed to identify to order). These results are not unexpected, as *Dicamptodon tenebrosus* is a sit-and-wait predator that feeds primarily on benthic invertebrates. Presence of terrestrial prey items indicates that invertebrates are eaten when they fall into the stream or that larval *D. tenebrosus* can successfully feed at the stream margin or surface. Noninvertebrate items frequently observed in the stomach samples included conifer needles, small rocks, balls of silt, pieces of vegetation, and in one case an *Acer circinatum* leaf, and in another an invertebrate egg sac.

The influence of riparian vegeta-

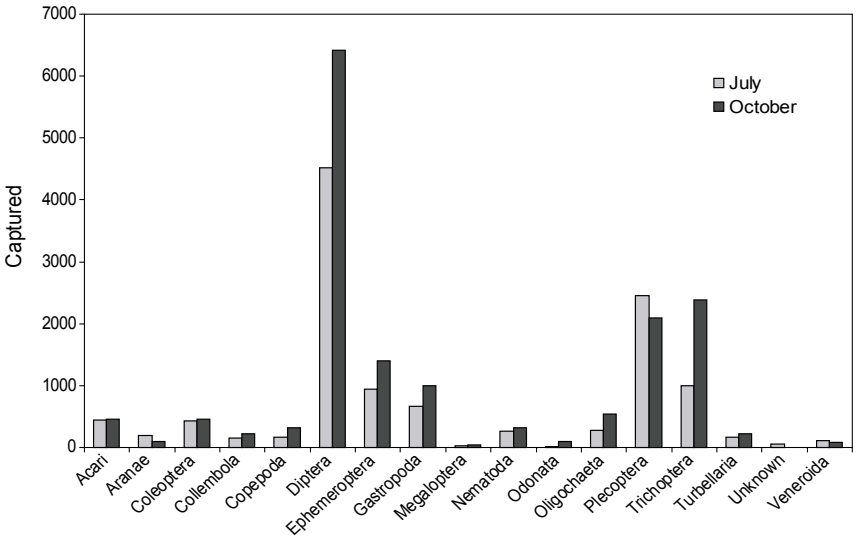


Figure 1. Benthic taxa across all sites, July and October, 2002 (only taxa with >50 individuals shown).

Table 1. Frequency of occurrence of prey items for larval *Dicamptodon tenebrosus* captures, July and October, 2002.

	July			October	
Prey Items	n[a]	% Occurrence[b]	Prey Items	n	% Occurrence
Acari	4	5.3%	Acari	5	7.7%
Aranae	6	7.9%	Aranae	1	1.9%
Chilopoda	2	0.0%	Chilopoda	0	0.0%
Coleoptera	16	10.5%	Coleoptera	8	5.8%
Collembola	4	0.0%	Collembola	10	0.0%
Copepoda	10	6.6%	Copepoda	0	0.0%
Decapoda	1	1.3%	Decapoda	1	0.0%
Diplopoda	0	0.0%	Diplopoda	4	7.7%
Diptera	66	40.8%	Diptera	96	51.9%
Ephemeroptera	109	57.9%	Ephemeroptera	41	46.2%
Gastropoda	13	11.8%	Gastropoda	33	32.7%
Hemiptera	1	0.0%	Hemiptera	0	0.0%
Homoptera	9	2.6%	Homoptera	1	1.9%
Hymenoptera	46	6.6%	Hymenoptera	2	1.9%
Isopoda	3	3.9%	Isopoda	3	5.8%
Lepidoptera	13	2.6%	Lepidoptera	0	0.0%
Megaloptera	1	1.3%	Megaloptera	0	0.0%
Nematoda	3	2.6%	Nematoda	0	0.0%
Neuroptera	1	0.0%	Neuroptera	0	0.0%
Opiliones	1	0.0%	Opiliones	1	1.9%
Orthoptera	2	1.3%	Orthoptera	0	0.0%
Ostracoda	11	13.2%	Ostracoda	10	11.5%
Plecoptera	77	44.7%	Plecoptera	42	44.2%
Trichoptera	37	30.3%	Trichoptera	27	28.8%
Turbellaria	1	1.3%	Turbellaria	0	0.0%
Unknown Invertebrates	19	15.8%	Unknown Invertebrates	9	17.3%
Veneroida	0	0.0%	Veneroida	1	1.9%

[a] Total number in each taxon (n)
[b] % of stomachs in which each taxon occurs (% Occurrence)

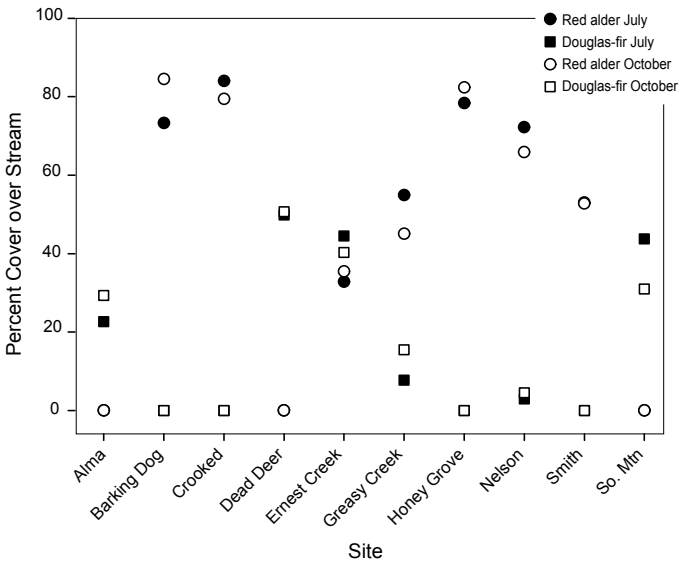


Figure 2. Stream cover of red alder and Douglas-fir, July and October 2002.

tion composition on amphibian diet and occurrence will be examined in future analyses. Vegetation characteristics were measured at five transects per stream during each aquatic sampling period, July and October 2002, and June 2003. A range of stream conditions exists among red alder (*Alnus rubra*) and Douglas-fir sites. An exploratory two-way Analysis of Variance with Tukey Multiple Comparisons suggests that percent cover of red alder and Douglas-fir over streams differs among sites but not among seasons (Figure 2). Analyses of variables, i.e., vegetation, stream microhabitat, and invertebrate information, will be used to build habitat models for stream and riparian amphibians once all invertebrate identification is complete.

Study Timeline

All field data collection has been completed. Invertebrate sample identification is ongoing. Data processing and analysis have begun and are expected to continue through 2004. Completion of a Master's thesis is expected in spring 2005.

Relationships Among Vegetation, Insects, and Bats in Riparian Areas

Holly Ober and John P. Hayes

The composition of plant communities bordering streams plays an important role in determining the suitability of individual stream reaches as habitat for various wildlife taxa by influencing both nutritional resources and habitat structure. Nutritionally, live foliage on riparian trees provides resources to terrestrial herbivorous insects, while leaf litter fallen from these trees provides energy and nutrients for aquatic invertebrates. Structurally, vegetation influences volant organisms by determining flight paths and influences aquatic organisms within streams by regulating channel formation, sediment transport, and water currents. Nutritionally and structurally, therefore, riparian vegetation plays a role in determining the community composition of both invertebrates and the vertebrates that rely on them for food.

Research has shown that conifer logs are superior to deciduous logs in providing stream conditions appropriate for some of the habitat needs of spawning salmon, so vegetation management regimes that encourage riparian conifer establishment have been implemented in some areas of the Oregon Coast Range. Little is known, however, regarding the relative importance of coniferous versus deciduous vegetation with regard to other wildlife taxa associated with riparian areas. This study is one of several CFER studies investigating the importance of plant community composition in structuring food webs in riparian areas of the Coast Range.

Riparian areas provide crucial foraging habitat for bats in Douglas-fir (*Pseudotsuga menziesii*) forests of the Pacific Northwest. All 10 species of bats that occur in these forests in the Oregon Coast Range forage solely on insects. Previous research has demonstrated that nocturnal flying insect abundance is higher in riparian areas than in forest interiors, and thus bat activity follows a similar pattern. Terrestrial plants support the insects that form the prey base that the bats rely on. For example, moths (Lepidoptera) feed directly on terrestrial foliage, and caddisflies (Trichoptera) feed on stream leaf litter that had terrestrial origins. We are investigating the linkages among riparian vegetation, nocturnal insects, and bats, with the following specific objectives:

- to determine 1) the relationship between bat use of stream reaches and vegetation compo sition bordering these reaches and 2)whether vegetation composition of the surrounding watershed influences these relationships
- to compare the community composition and biomass of nocturnal flying insects in stream reaches dominated by deciduous vegetation with that of stream reaches dominated by coniferous vegetation
- to characterize prey selection patterns of bats
- to develop models for appraising implications of potential riparian vegetation management prescriptions on bats

Methods

Bat use of riparian areas

In 2002, we monitored bat activity in 41 stream reaches in six randomly selected fifth-field watersheds, ranging from 141 to 514 km^2, in the central Oregon Coast Range. In 2003, we repeated this effort in 37 new stream reaches in six additional watersheds in the southern Coast Range, as well as in eight stream reaches

from a watershed used the previous year. In 2004, we repeated this effort once again in 40 new stream reaches in six additional watersheds in the northern Coast Range, as well as in the eight stream reaches that have been monitored each year (Figure 1).

We monitored echolocation calls at each stream reach once during each 2-week period between mid-June and early September, for a total of four visits per stream reach in 2002 and five visits per stream reach in 2003 and 2004. Echolocation calls of bats were recorded from sunset until sunrise by calibrated, automated Anabat II detectors with Anabat zero crossings analysis interface modules. We used a blocked sampling design, simultaneously monitoring along 5–8 stream reaches within a given watershed. The use of a blocked sampling design improves precision in comparisons of activity levels among the different habitat types within a watershed by removing overall variability in bat activity among nights.

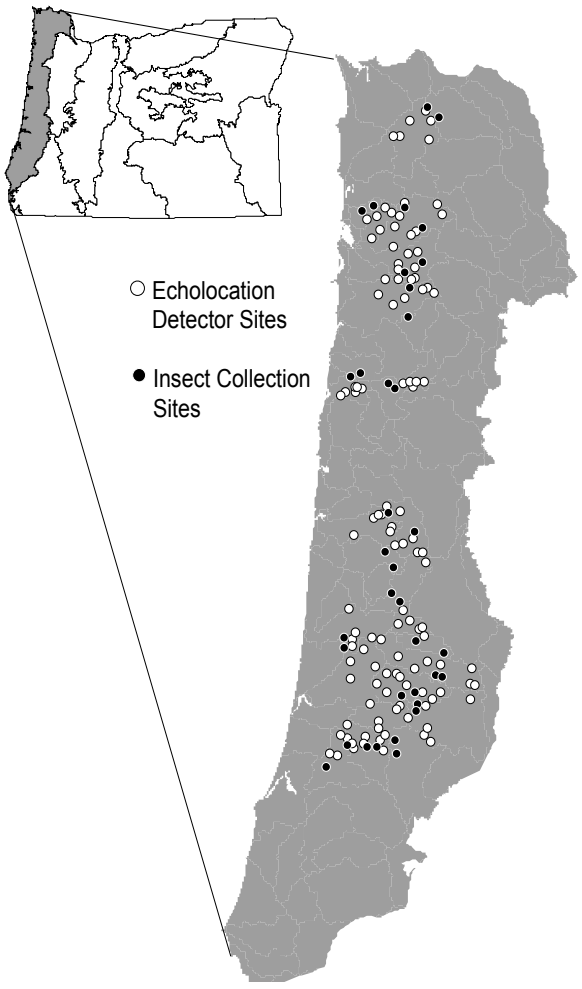


Figure 1. Location of echolocation monitoring and insect collection sites in the Oregon Coast Range.

Insect use of riparian areas

We collected insects in six fifth-field watersheds in the central Oregon Coast Range in 2002 and in six new plus one previously monitored watershed in both 2003 and 2004 (Figure 1). Insects were collected once during each 2-week period between mid-June and early September, for a total of five visits to each stream reach each summer. We sampled insects from sunset until sunrise, using black-light and aquatic emergence traps. We used a paired sampling design, simultaneously sampling in two stream reaches within the same watershed, one dominated by coniferous and the other by deciduous vegetation.

Bat prey selection

In 2002, we used mist nets to capture bats in each of the stream reaches where insects were collected (described above). Because of low capture rates when using this method, in 2003 and 2004 we used H-nets and hoop nets to capture bats under bridges within each of the watersheds in which insects were collected.

Preliminary Research Results and Management Implications

Bat echolocation calls

In 2002 and 2003, overall bat activity (all species combined) was variable among watersheds and was not strongly related to vegetation composition at this spatial scale (Figure 2). Overall bat activity was also variable among stream reaches, but appeared to increase as the proportion of deciduous vegetation increased at the stream reach scale (Figure 3).

We will analyze echolocation data files statistically during the spring of 2005, taking into account bat species groupings and examining the relationship between

bat activity and 1) vegetative composition and clutter at the stream reach scale and 2) vegetation composition at the watershed scale. We will use an information-theoretic approach to develop habitat relationship models for determining which habitat characteristics are the best predictors of bat activity levels.

Insect samples

A preliminary analysis of 2002 and 2003 data suggests that abundances of the two most abundant orders, Diptera and Trichoptera, were similar between coniferous and deciduous stream reaches ($F_{1,10}$ = 2.65, P = 0.107 for Diptera) ($F_{1,2}$=0.40, P = 0.591 for Trichoptera). There was suggestive evidence, however, that abundance of Lepidoptera in deciduous reaches was greater than in coniferous reaches ($F_{1,10}$ = 4.58, P = 0.058) (Figure 4). Moreover, lepidopteran species richness was greater in deciduous stream reaches than in coniferous stream reaches ($F_{1,10}$=7.74, P =0.019). There was also suggestive evidence that lepidopteran species diversity (calculated with Shannon-Weaver's index) was greater in deciduous stream reaches than in coniferous stream reaches ($F_{1,10}$ = 4.51, P = 0.060) (Figure 5).

We will continue sorting insects during the fall of 2004. During winter 2005, we will analyze insect data to further elucidate relationships between riparian vegetation composition and insect abundance, biomass, species richness, and species diversity.

Bat prey selection

We obtained guano samples from seven bat species. We captured 50, 306, and 177 bats in 2002, 2003, and 2004, respectively. We will analyze samples from the three species caught most frequently: *Myotis yumanensis*, *Myotis volans*, and *Eptesicus fuscus*. We will begin identifying insect remains within guano pellets to determine the proportion of the diet represented by each insect order during summer 2005.

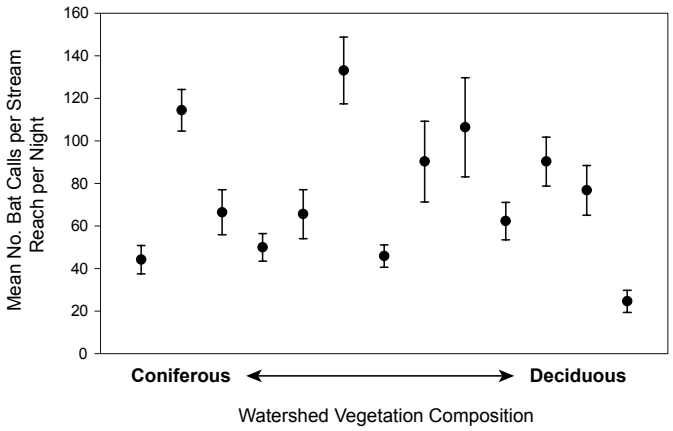


Figure 2. Mean number of bat echolocation calls per stream reach per night within each watershed in 2002 and 2003 as a function of watershed plant community composition. Error bars represent 95% confidence intervals.

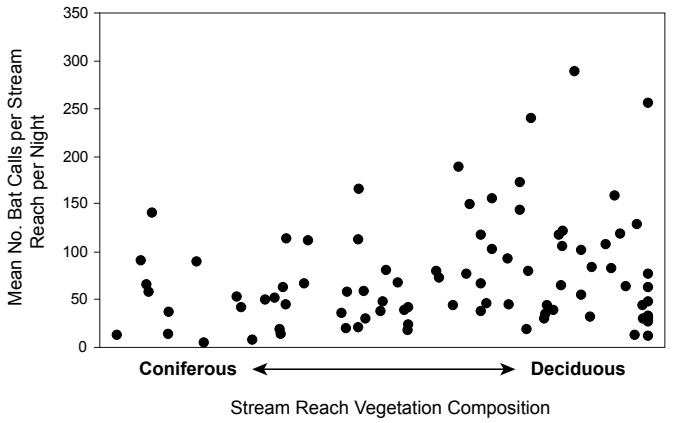


Figure 3. Mean number of bat echolocation calls per stream reach per night in 2002 and 2003 as a function of stream reach plant community composition.

Study Timeline

Data collection has been completed, and data processing has begun. A final report and manuscripts should be completed by 2006.

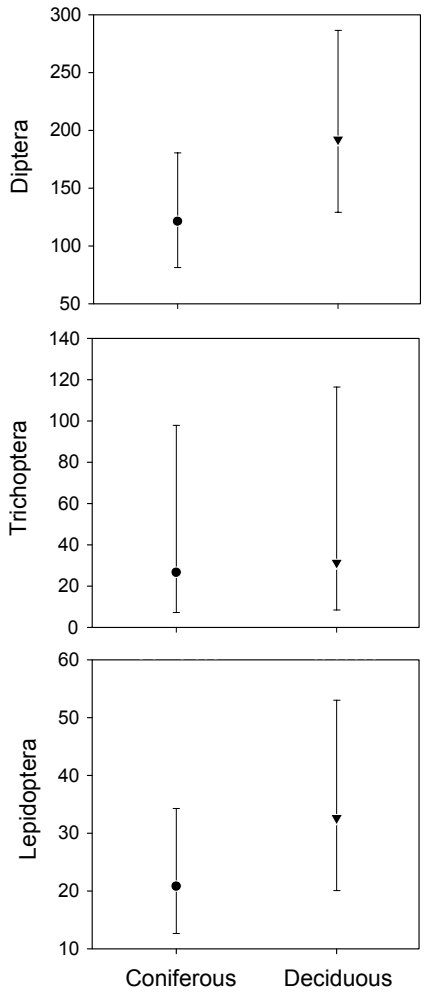


Figure 4. Abundance of Diptera, Trichoptera, and Lepidoptera captured in conifer-dominated and deciduous-dominated stream reaches in 2002 and 2003 combined. Error bars represent 95% confidence intervals.

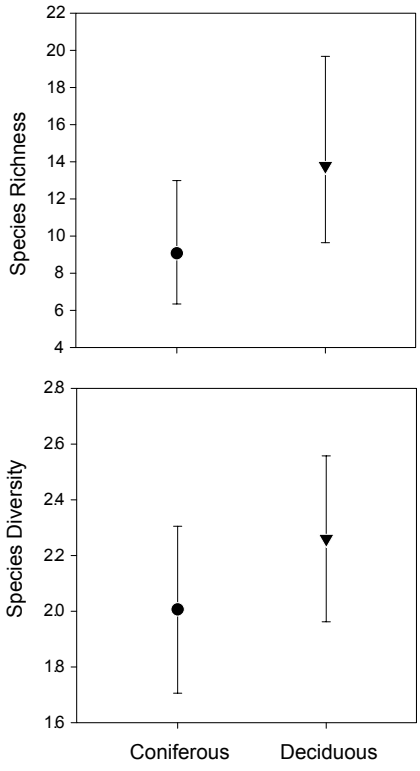


Figure 5. Species richness and Shannon-Weaver species diversity of Lepidoptera captured in conifer-dominated and deciduous-dominated stream reaches in 2002 and 2003 combined. Error bars represent 95% confidence intervals.

Influence of Aquatic and Terrestrial Invertebrates on Riparian Vertebrate Predators

Amanda Robillard and Judith L. Li

In riparian areas, terrestrial and aquatic habitats overlap, creating a zone where they interact, the aquatic-terrestrial interface. Coupling of the two systems allows for movement of energy between them and generates intertwining food webs. As a result, riparian consumers, such as fish or birds, have alternative prey items external to their respective habitats. Energy flows between aquatic and terrestrial habitats, creating what some have called an ecological subsidy (Polis et al. 1996, Time, space, and life history: Influences on food webs. Pages 435–460 in *Food Webs*; Nakano and Murakami 2001, *Proceedings of the National Academy of Sciences* 98:166–170).

Subsidies can occur in many situations; in this study we are examining reciprocal subsidies to terrestrial and aquatic predators in a riparian area. Emerging aquatic insects are available to riparian avian consumers, and terrestrial invertebrates may be consumed by fish. But to what extent are the consumers utilizing these alternative prey sources?

Several studies show the reliance of salmonids on terrestrial insect input to streams. For example, Wipfli (1997, *Canadian Journal of Fisheries and Aquatic Sciences* 54:1259–1269) determined that terrestrial invertebrates may comprise over 50% of juvenile salmonid diet in Alaskan streams. Nakano et al. (1999, *Ecological Research* 14:351–360) found rainbow trout consumed more terrestrial insects than aquatic insects. Salmonid biomass was reduced when terrestrial invertebrates were excluded from a stream in Japan (Kawaguchi et al. 2003, *Ecology* 84:701–708).

Conversely, emerging aquatic insects contribute directly to the flow of energy from aquatic to terrestrial habitats. After macroinvertebrates metamorphose into their final life-history stage, the adult insects leave the water to reproduce. High densities of emerging aquatic insects are found along streams, subsequently increasing predator densities (Lynch et al. 2002, *Austral Ecology* 27: 515–526; Murakami and Nakano 2002, *Ecology Letters 5: 333–337*). In a grassland system, densities of insectivorous riparian birds were correlated with peak emergence of aquatic adult insects (Gray 1993, *American Midland Naturalist* 129:288–300). An observational study in a riparian area determined that 25.6% of the annual energy budget for several riparian bird species came from aquatically derived nutrients (Nakano and Murakami 2001, *Proceedings of the National Academy of Sciences* 98:166–170).

It is clear that fish are consuming terrestrial insects; gut analyses have shown the importance of this prey type (Wipfli 1997, *Canadian Journal of Fisheries and Aquatic Sciences* 54:1259–1269; Nakano et al. 1999, *Ecology* 80:2435–2441). Though fecal samples of birds have been used to determine prey selection directly, avian consumption of aquatic adult insects in riparian zones has only been observed. We are examining riparian food webs in three Oregon Coast Range watersheds by sampling aquatic and terrestrial insects, riparian birds, and fish. Through the use of mist netting, avian fecal and feather samples have been collected. Fecal analysis will potentially provide direct evidence of how aquatic secondary production is subsidizing riparian insectivorous birds. Analysis of feather samples will be used to determine avian diet and to compare the isotopic signatures found in the tissue to food items found in the fecal samples.

Fish diet will be analyzed directly through stomach content samples. Both will be compared to the composition and availability of aquatic and terrestrial invertebrates collected from four sampling methods.

By using these techniques in different seasons, we will estimate interdependence among these groups. We hope to address the following questions: Are fish able to utilize terrestrial insects in times when benthic invertebrates are naturally low? Is the emergence of aquatic insects essential to birds in times when energy demands are high? Using diet analysis and information on invertebrate composition and abundance from data collected in summer and fall 2003 and spring 2004, we will address these questions.

Methods

A pilot study was conducted in summer and fall of 2003 in the Coast Range of Oregon on Honey Grove Creek approximately 1 mile east of Alsea; this drainage empties into the North Fork of the Alsea River. The area has a checkered ownership pattern that consists of lands under Bureau of Land Management (BLM), private forest industry, and private residential ownership. The vegetation is characteristic of the Western Hemlock Vegetation Zone and the riparian area is dominated by red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) as a result of timber harvest in the mid-1950s. For this study, two tributary reaches of Honey Grove Creek and a reach of the mainstem (MS) were examined. The two tributary reaches were used in earlier studies conducted by the Cooperative Forest Ecosystem Research (CFER) program: the "Bird Reach" was the site of a study to examine avian response to different harvest treatments, and the "Amphib Reach" was used to collect amphibians for a diet analysis. The methodology of the pilot study is described in detail in the 2003 CFER Annual Report.

In spring of 2004, two additional Coast Range watersheds were sampled—Rock Creek and Nelson Creek. Rock Creek is a tributary of the South Fork of the Alsea River and is located approximately 15 miles southeast of Alsea. This watershed is managed by the BLM. It is dominated by late-successional/old-growth forest and is considered to be in nearly pristine condition. Three tributary reaches were sampled. Nelson Creek is a tributary to Lake Creek in the larger Siuslaw River watershed and is located approximately 20 miles southwest of Triangle Lake. The BLM owns 30% of the land; the remainder is private forest industry and nonindustrial land. The vegetation in Nelson Creek is 76.6% hardwood and was subject to timber harvest in the early 20th century. Two tributary reaches and the mainstem were sampled.

Invertebrate sampling

To sample emerging aquatic adult insects, four emergence traps were set on all three reaches in each watershed (n = 36); the traps (1 m^2, pyramid-shaped, covered in fine-mesh screen) were placed in the middle of the stream. Benthic samples were taken with a Surber sampler (500-mm mesh size, 0.093 m^2) in six locations per reach in each watershed (n = 54) immediately before electrofishing was conducted. Pan traps sampling 0.75 m^2 were set with an inch of water and fragrance-free detergent that broke the surface film; there were six pan traps per reach in each watershed (n = 54). Two Malaise traps were placed on one reach in each watershed during sampling, one streamside and one upslope (n = 6). These traps operate as flight interception traps; they were used to assess the aerial invertebrate composition, movement, and potential availability to birds as prey.

In spring 2004, insect traps were randomly placed on all three reaches in a watershed for 2–3 days before and during vertebrate sampling. To describe trap locations within each study reach, we can look at the emergence traps as an example. Four emergence traps were placed on each 300-m reach—one in each of four 75-m segments. Placement within each segment was determined using a random number generator. A similar process was used for pan-trap locations and Surber-sample collection sites.

Diet sampling

To assess fish diet, fish were collected with a Smith-Root variable wave backpack shocker on all three reaches

in each watershed. After fish were anesthetized, stomach samples were obtained by gently flushing the stomach with water from a fine-tipped squirt bottle; stomach contents were collected on paper coffee filters and preserved in 95% alcohol. Fish weight and length were recorded at the same time. Nelson and Honey Grove creeks were sampled in May; Rock Creek was sampled in July. For every sampling effort, our goal was to capture 20 individuals of each fish species present.

Bird fecal and feather samples were collected in each watershed during May and June 2004. In early morning on 12 capture days (four per watershed), bird fecal samples were obtained from individual birds after capture in mist nets (Figure 1). To collect these samples, birds were held in paper sacks for a short period; the fecal sample was taken from the bag and preserved with 95% alcohol. Feather samples for isotopic analysis were taken only from year-round residents; the primary feather was collected from the wing.

Figure 1. Fecal sample taken from a Pacific-slope flycatcher.

Preliminary Results and Management Implications

We have recently completed preliminary analysis of the summer insect data from pan, emergence, and benthic samples from the Bird Reach in the Honey Grove watershed. We report initial results here; however, these results are based on a small, incomplete sample. There appeared to be more aquatic than terrestrial insects collected in pan and emergence traps during the summer of 2003 (Figure 2). But the differences were not significant (two-sided t-test, $P = 0.12$).

There were also seasonal differences in insect captures on the Bird Reach (Figure 3). In particular, the seasonal difference was significant between the number of aquatic insects found on Bird Reach in summer and fall (two-sided t-test, $P = 0.05$). In the summer, there were 243 more aquatic insects captured than in the fall. The seasonal difference in terrestrial insect captures was not significant, though there was a trend toward significance (two-sided t-test, $P = 0.09$). Ninety-five more terrestrial insects were captured in the summer than in the fall.

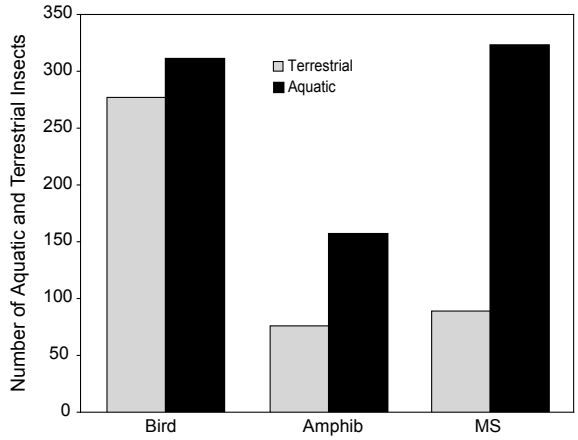


Figure 2. Number of aquatic and terrestrial insects collected in pan and emergence traps during summer 2003.

Another notable difference was found in seasonal benthic insect abundance on Bird Reach and MS (Figure 4). On both reaches, more insects were found in June than in September. In addition, there was a change in composition. On MS in June, Plecoptera made up the greatest proportion (42%) of captures, whereas in September Plecoptera contributed far less to the total

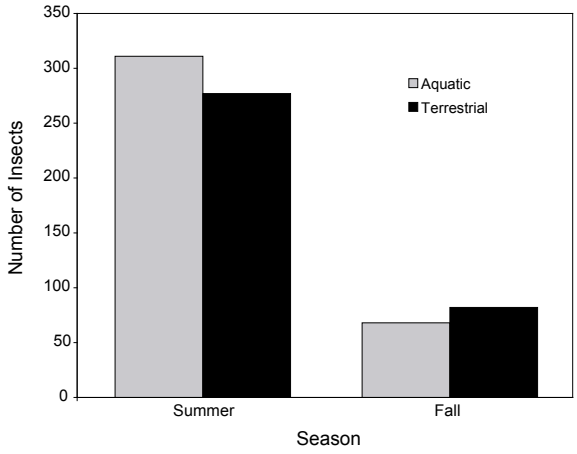


Figure 3. Number of insects collected in pan and emergence traps in Bird Reach during summer and fall 2003.

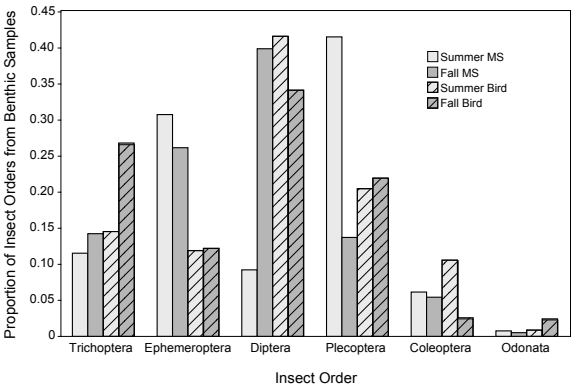


Figure 4. Proportion of insect orders from benthic samples by season in Bird Reach and MS.

insect abundance (14%). In contrast, the proportion of Ephemeroptera and Trichoptera remained relatively unchanged. On the Bird Reach, the proportion of benthic Trichoptera varied considerably over the two seasons. This order represented 14% of the sample in June and 26% of the sample in the fall. There was a 7% decrease in the proportion of Diptera between seasons; all other orders remained relatively the same.

On two days in June 2003, 16 birds were captured and fecal samples collected (Table 1). The species captured included the Song Sparrow (*Melospiza melodia*), Swainson's Thrush (*Catharus ustulatus*), Pacific-slope Flycatcher (*Empidonax difficilis*), Winter Wren (*Troglodytes troglodytes*), and Wilson's Warbler (*Wilsonia pusilla*). During two days in September, 11 fecal samples were collected; however, no Wilson's Warblers or Pacific-slope flycatchers were captured. The fecal samples are currently being analyzed.

Over 12 days in May and June of 2004, 47 birds were captured, resulting in 46 fecal and seven feather samples (Table 2). Two additional species, the Black-headed Grosbeak (*Pheucticus melanocephalus*) and American Robin (*Turdus migratorius*), were captured.

Study timeline

During fall 2004, there was an additional sampling effort on Honey Grove Creek to collect fish diet and insect samples. Insect identification and diet analysis should be completed by spring 2005. Data analysis will be complete by June 2005.

Table 1. Number of bird fecal samples by species collected during 2003 in Honey Grove watershed.

Species	Wilson's Warbler	Winter Wren	Swainson's Thrush	Song Sparrow	Pacific-slope Flycatcher
17 and 23 June	2	3	6	3	2
12 and 19 September	0	3	5	3	0

Table 2. Number of bird fecal samples by species collected in spring 2004.

	Swainson's Thrush	Winter Wren*	Wilson's Warbler	Song Sparrow*	Black-headed Grosbeak	Pacific-slope Flycatcher	American Robin
Honey Grove	9	2	0	0	1	0	0
Nelson	10	0	3	3	1	1	1
Rock	11	1	1	1	0	2	0

Dates: *Honey Grove- 5/10, 5/17, 6/16, 6/17; Nelson - 5/15, 6/11, 6/12, 6/14; Rock - 5/24, 6/2, 6/3, 6/4*

** = resident species* and feather sample collected

Vertical and Lateral Litter Inputs to Streams from Riparian Forests of the Central Oregon Coast Range

Stephanie Hart, Steven Perakis, and David E. Hibbs

Greater attention to riparian forest management has increased the demand for scientific information about riparian areas. This need has pointed out what we know—and do not know—about riparian ecological structure and function. Riparian forests provide shade, woody debris, and terrestrial litter that help maintain stream functions and processes. The interaction of aquatic and terrestrial systems may be especially pronounced in small streams, where litter inputs from riparian vegetation are likely to provide a majority of the energy and nutritional base for aquatic food chains. Little is known, however, about the quantity or source locations of litter input that are important in aquatic and terrestrial food chains.

Current management regulations in Oregon promote conversion of riparian forests dominated by red alder (*Alnus rubra*) to evergreen-dominated overstories, with the goal of increasing the long-term supply of structural large woody debris (LWD) to channels (Emmingham et al. 2000, *OSU Forest Research Laboratory Research Contribution* 24:1–34). Less is known, however, about the changes in non-LWD processes resulting from this management choice. In particular, aquatic and terrestrial riparian food chains often depend strongly on the quantity and quality of detrital inputs from riparian vegetation (Gregory et al. 1991, *BioScience* 41:540–551), and favoring evergreen over deciduous overstories will alter nutritional subsidies to these ecosystems.

There is a lack of knowledge about how riparian area characteristics, including lateral slope and vegetation composition and density, may lead to differences in input of both vertical litter (which falls directly from overhead) and lateral litter (which moves down the slope). Management decisions favoring evergreen overstories in riparian forests make it important to understand how the timing, quantity, and quality of these kinds of litter differ between forest types and topographic settings.

Studies that have measured vertical and lateral litter inputs suggest that, although lateral litter movement is greater on steeper slopes (Fisher 1977, *Internationale Revue der Gesamtem Hydrobiologie* 62:701–727; France 1995, *Freshwater Biology* 34:495–499), lateral movement may decrease with increases in the roughness, or spatial density, of understory riparian vegetation, large logs, and boulders. In addition, previous studies have indicated that the contribution from understory vegetation could be as great as 28% of total litter quantity (Bray and Gorham 1964, *Advances in Ecological Research* 2:101–157).

This project addresses the potential impacts of overstory vegetation on vertical and lateral inputs of litter to streams with varied slopes and understory compositions. Information about timing, quantity, and quality of litter inputs to streams can be used to better understand the effects of riparian forest management on food chains. More specifically, this report addresses the following objectives:

- to measure amounts and identify sources of vertical and lateral litter inputs
- to characterize the seasonal pattern of vertical and lateral litter movement

Methods

Study sites

Eight riparian sites with an overstory dominated by Douglas-fir (*Pseudotsuga menziesii*) and eight sites with

an overstory dominated by red alder (*Alnus rubra*) were selected in and adjacent to the Alsea River watershed in the central Oregon Coast Range. Sites were selected on the basis of vegetation composition, proximity to small streams, and steepness of adjacent hillslope. Each dominant overstory type has lateral slopes ranging from 0–65%. Several research sites are common to other CFER studies.

At each site, we randomly assigned four 8-m x 30-m plots within selected uniform areas along a ≤300-m stream reach for a total of 960 m^2 study area per site (Figure 1). Vertical and lateral litter was sampled in the following control and experimental treatment plots:

- Cut: In a 5-m x 8-m section adjacent to the stream, understory was cut every 2 months for the duration of the study. All understory plants >5 cm in height and <10 cm diameter at breast height (DBH) were removed (data not presented here).
- 5-m fence: An 8-m-long fence was constructed parallel to the stream, 5 m from the stream edge. The fence served to block laterally moving litter originating from upslope of the fence (data not presented here).

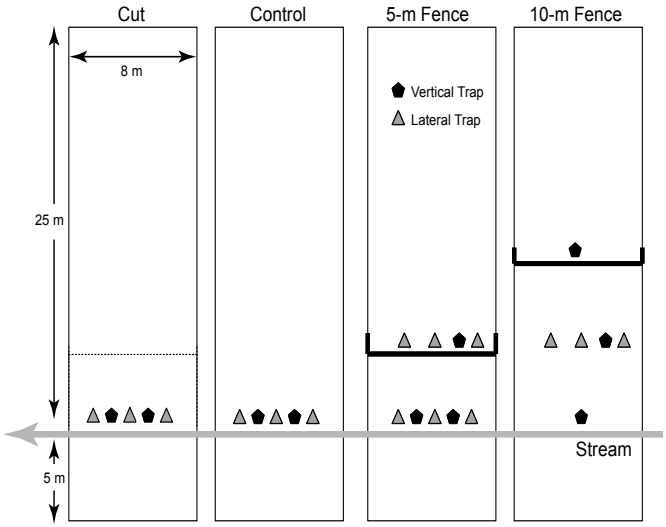


Figure 1: Schematic of treatments and placement of vertical and lateral traps on a hypothetical stream reach. Treatments are each 30 m × 8 m and were randomly assigned to nonrandomly selected uniform areas.

- 10-m fence: An 8-m-long fence was constructed parallel to the stream 10 m from the stream edge. This fence blocked laterally moving litter originating upslope of the fence (data not presented here).
- Control: No cutting or fencing occurred in the control.

Vertical and lateral litter traps were deployed at each site to capture litter inputs to streams from above and from the side. Vertical traps constructed from laundry baskets and suspended mesh were set to capture overstory and understory litter falling vertically from a height of >0.33 m above the forest floor. Lateral traps were set to collect litter moving down the slope rather than falling directly from vegetation. Lateral traps were constructed of PVC rectangles with a mesh backing (Hart et al., 2003 CFER Annual Report).

The cut, control, and 5-m fence treatments have two vertical and three lateral traps deployed at the stream edge. The 10-m fence treatment has no lateral traps at the stream edge, but, along with the 5-m fence treatment, each has one vertical and three lateral traps located 5 m from the stream. These fifteen lateral traps and eight vertical traps, plus two additional vertical traps in the 10-m fence treatment (at 0 m and 10 m from the stream), make a total of 25 traps at each site (Figure 1). In addition, four of the sites have vertical traps set directly over the stream for comparing vertical litter caught at the stream edge and over the stream.

Vegetation and Plot Sampling

Measurements of vegetation and plot characteristics were conducted between June and September 2003 for each site (Hart et al., 2003 CFER Annual Report).

Litter Collection and Sample Preparation

Vertical and lateral litter was collected monthly between August 2003 and August 2004. After collection, litter was dried and sorted into five types. Sorted samples of evergreen overstory, deciduous overstory, understory, twigs, and 'other' were weighed and analyzed

for carbon and nitrogen content between August 2003 and December 2004.

We collected 400 samples of leaf litter each month and have included results from the first seven months (September 2003–March 2004) in this report unless otherwise specified. Total litter inputs was calculated on the basis of stream surface area and reach length so that a 20-m length of stream 4-m wide would have 80 m^2 of surface area and 40 m (20 m on each side) of lateral length.

Research Results and Management Implications

Red alder and Douglas-fir sites provided different amounts of total litter inputs to streams, and the material provided was composed of different leaf litter types. Red alder sites provided 32% more litter inputs than Douglas-fir sites. For each 20-m reach of an average stream, Douglas-fir sites provided 26.3 kg and red alder sites provided 34.9 kg of litter inputs. Lateral litter inputs comprised 7% of the total Douglas-fir litter inputs and 10% of the total red alder litter inputs for the equivalent of a 4-m-wide stream (Figure 2). These lateral litter input calculations are for all sites regardless of slope. Future analyses will examine potential effects of slope and seasonality on patterns of litter input at our sites and the dependence of these effects on overstory type.

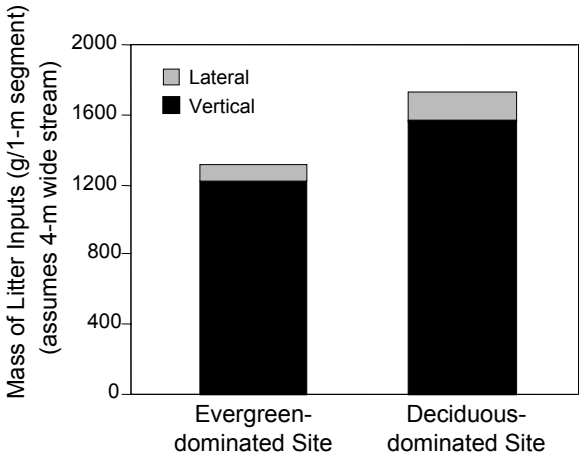


Figure 2: Total litter input amounts (g/1-m segment) to a 4-m-wide stream for September through March. The average stream width for this study, 4 m, was selected for calculating total litter inputs from vertical and lateral movement.

Deciduous tree litter was the dominant litter type in vertical and lateral traps at all sites in autumn months (September, October, and November). The abundance of deciduous litter on sites classified as evergreen-dominated may be explained by the presence of bigleaf maple (*Acer macrophyllum*) and red alder near the stream's edge at those sites, although we expect inputs from these species will be reduced in other seasons. Evergreen tree litter was of secondary importance at Douglas-fir sites in autumn months (vertical litter collected = 34%, lateral litter collected = 34%) and was of minimal importance at red alder sites (vertical litter collected = 0%, lateral litter collected = 2%) in autumn months. This likely is because there was little Douglas-fir or western hemlock (*Tsuga heterophylla*) at deciduous-dominated sites, particularly near the stream's edge. Understory vegetation contributed

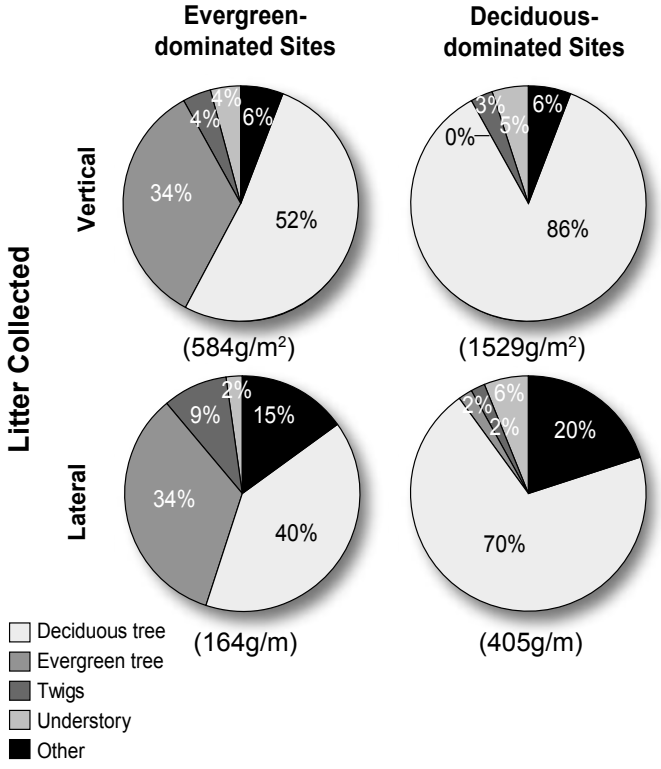


Figure 3: Litter type composition of vertical and lateral litter collected in autumn. Cumulative total litter mass collected from vertical and lateral traps in September, October, and November is in parentheses.

between 2 and 6% of the litter collected under both red alder and Douglas-fir overstories in autumn (Figure 3).

Seasonal patterns of vertical litter fall were as expected for red alder (peak in autumn) and Douglas-fir sites. Litter inputs from deciduous vs. evergreen sites were similar for all months except November, however, which highlights the important role of seasonality as a factor distinguishing these two vegetation types. We observed more total litter inputs from all sites in the winter months than we expected (Figure 4). Laterally moving litter made up a higher percentage of total litter inputs at red alder sites in winter months than in other seasons, largely because of decreased vertical inputs during that period. We expected lateral litter movement of red alder would decrease in the winter because most leaf litter at red alder sites would be wet and matted down (Figure 5), but it does not appear to be that simple. Fall lateral movement is dominated by litter, specifically leaves, from deciduous overstory, but lateral movement in other seasons may be dominated by other litter types, such as twigs or deciduous tree catkins.

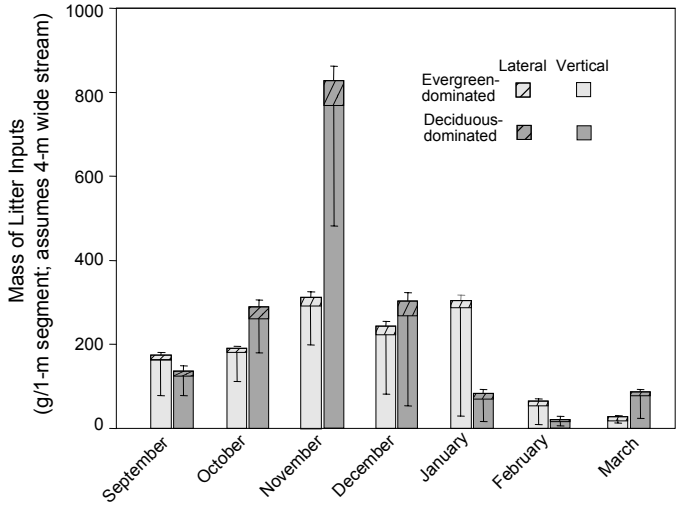


Figure 4: Seasonal pattern of vertical and lateral litter movement for September–March.

Collectively, these results indicate that deciduous-dominated riparian forests provide more vertical and lateral litter than evergreen-dominated forests. The additional litter provided by red alder sites can be attributed directly to the peak in leaf senescence of deciduous trees. Lateral litter inputs were at least 7–10% of total litter inputs in streams 4 m wide or less. Slope measurements and information from the cut treatment in this study will be used to further examine the relationship of slope and understory plants to the amount of laterally moving litter. The results from the nutrient analysis will allow us to quantify the nutritional quality of the litter inputs for each season and overstory type. Our initial results suggest that forest management activities promoting the dominance of evergreen overstories in riparian zones of the central Oregon Coast Range will change the quantity, timing, and quality of leaf litter inputs to streams, potentially affecting the development of food webs that depend on litter subsidies in these ecosystems.

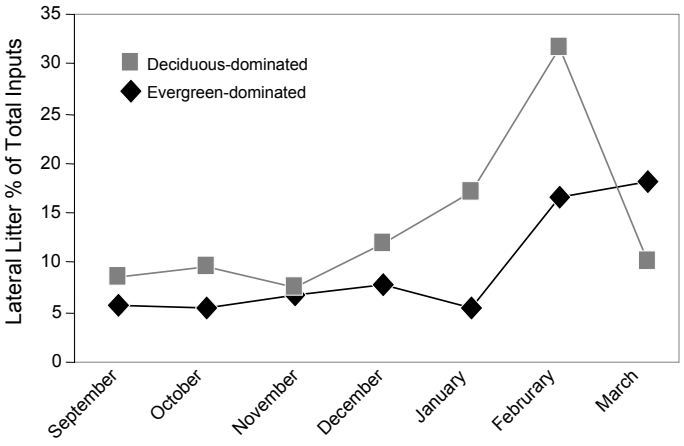


Figure 5: Relative contributions of vertical and lateral litter inputs from September–March.

Study Timeline

Vegetation data collection was completed in September 2003, and litter data collection was completed in August 2004. Processing of litter was completed in December 2004. Analysis and interpretation of data will continue through winter 2005. A final report will be completed in summer 2005.

Litter Decay in Coast Range Riparian Zones: Biogeochemical Controls and Implications for Terrestrial and Aquatic Food Chains

Joselin Matkins, David E. Hibbs, and Steven Perakis

Decomposition of leaf litter plays a vital role in riparian zone function. Both aquatic and terrestrial food chains rely on energy and nutrients derived from the riparian forest. Current management regimes in the Coast Range of western Oregon recommend conversion of riparian forests dominated by red alder (*Alnus rubra*) to Douglas-fir (*Pseudotsuga menziesii*) forests, in part to increase long-term supplies of structural large woody debris (LWD) to streams. Yet we have little information on the rate and timing of energy and nutrient release associated with litter decay in these two riparian forest types. Changes to the energetic and nutrient cycles associated with red alder and other deciduous species might impact aquatic and riparian food chains. Encouraging the growth of conifers over hardwoods may alter long standing nutritional subsidies and nutrient cycles within these riparian systems.

Vegetation, such as leaves and needles, plays many critical roles in the productivity of riparian terrestrial and aquatic habitats. However, only a few organisms, primarily insects, feed directly on riparian vegetation. Instead, most organisms derive their nutrition from food chains, which are supported at their base by the breakdown and incorporation of decaying leaf litter. Leaf litter breakdown in both terrestrial and aquatic systems is a complex interaction among chemical, physical, and microbial processes that plays a vital role in the trophic dynamics of riparian forests. The rate of leaf litter decay is affected by both internal factors of the litter—the chemical and physical characteristics of the leaves themselves—and external environmental factors.

In the terrestrial environment, research has shown that leaf litter quality plays an important role in determining decomposition rates and nutrient dynamics. High quality litter, such as that from red alder, decomposes rapidly and quickly releases energy and nutrients. This results in faster nutrient cycling and greater soil productivity. In contrast, litter of low initial quality, such as that from Douglas-fir, decays more slowly, leading to low nutrient uptake and lower soil fertility.

Controls of litter decomposition are fundamentally similar in aquatic habitats; however, important differences exist. The nutritional budget of stream ecosystems is complex and relies on energy created within the stream, from the riparian communities bordering the stream, and from nutrients carried by the groundwater. Water flow also causes mechanical fragmentation of leaf litter, potentially speeding up the rate of decomposition. This may result in less nutrient retention in streams than on land because water carries away the nutrients and residues released by decomposition, whereas these are recycled in soils.

In this study, we are experimentally examining the influences of litter type and stand type on leaf litter decay in both the terrestrial and aquatic environment. Questions addressed in this study include the following: Does litter type (Douglas-fir vs. red alder) influence the rate of litter breakdown? Does decompositional environment (Douglas-fir vs. red alder-dominated stands) influence breakdown rates for common litters? Is there an interaction between environment and litter type? How does a wide range of initial litter quality (lignin:nitrogen ratio) affect the breakdown rate of litter from a single species (Douglas-fir)? Does externally added nitrogen (N) affect the breakdown rate of Douglas-fir litter? Is there an inter-

action between initial litter quality and externally added N? These questions will be examined in the context of the terrestrial and aquatic environments.

Justification for this research is twofold. Though it has been shown extensively that the lignin:N ratio plays an important role in the rate of decay across species, the relationship has not been tested within a single tree species. Second, understanding how and when energy and nutrients are taken into food webs is integral to understanding the structure and function of riparian zones of the Oregon Coast Range, particularly in relation to N cycling. This research will further our understanding of both the patterns and the controls underlying mechanisms of leaf litter decay. It thus will provide new information on the consequences of conversion of riparian forests from forests dominated by red alder to forests dominated by Douglas-fir.

Methods

For both the terrestrial and aquatic experimental components of this study, we used a litterbag method in which preweighed material was confined within mesh bags. Changes in mass, nutrient content, and carbon chemistry will be measured over the duration of the study. Initial litter samples were collected from nine sites in the Oregon Coast Range. Douglas-fir dominated eight of these sites, which were chosen to represent the broadest spectrum of foliar N available. Red alder litter was collected at a ninth collection site. Litter samples were collected during September and October 2003 by shaking branches of 20- to 35-year-old trees and collecting the resulting litter on tarps placed beneath the trees. The resulting litter ranged in N from 0.74% to 1.40% for locations dominated by Douglas-fir (Figure 1) and 2.33% for locations dominated by red alder.

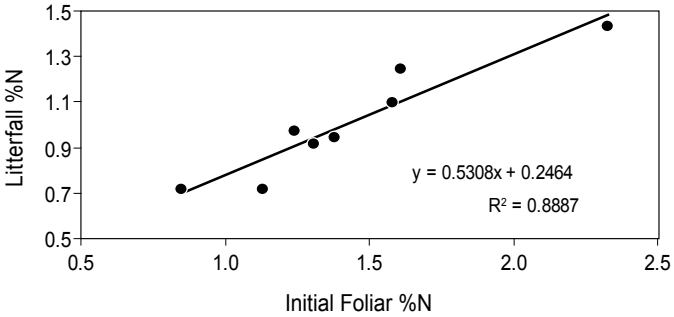


Figure 1. The relationship between [N] of green foliage and litter collected under Douglas-fir sample trees and used in the litter decay study. S1 through S8 indicate the [N] of the litter source from low to high.

For the terrestrial experiment, approximately 5 g of dry litter was placed in each of 3,500 litterbags made of 1-mm nylon mesh. On 20 November 2003, the litterbags were placed on the soil surface in one of three stand/soil types: 1) dominated by red alder, 2) dominated by Douglas-fir, or 3) fertilized, dominated by Douglas-fir. There were four replications of each stand type and three plots in each replicate. Site selection for the terrestrial experiment was accomplished by using plots established and examined by Emily Scott (2003 CFER Annual Report) in the central and southern Coast Range.

The aquatic experiment was initiated on 4 September 2004. The aquatic experiment used the same litter sources and litterbag methods described above. Because correlations have been observed between N levels in the stream and the amount of red alder found in the watershed, we selected study sites to span a range of aquatic N levels as indexed by the percent of watershed area dominated by red alder. Water samples were subsequently taken and tested for ammonium, nitrate, and total N levels. We established eight aquatic sites; four with high N levels and four with low N levels.

Preliminary Results

The N concentration of green litter on a tree is a very good predictor of the N content of litter falling from that tree (Figure 1). For every unit change in percent N of green litter, approximately half of that change was realized in the percent N of litterfall (slope, Figure 1).

Based on repeated litterbag measurements at one Douglas-fir and one red alder site, preliminary results indicate that red alder consistently decays more rapidly than Douglas-fir, and that the rate of decay for both alder and Douglas-fir litter seems to vary only slightly with forest type (Figure 2). Variation observed in the

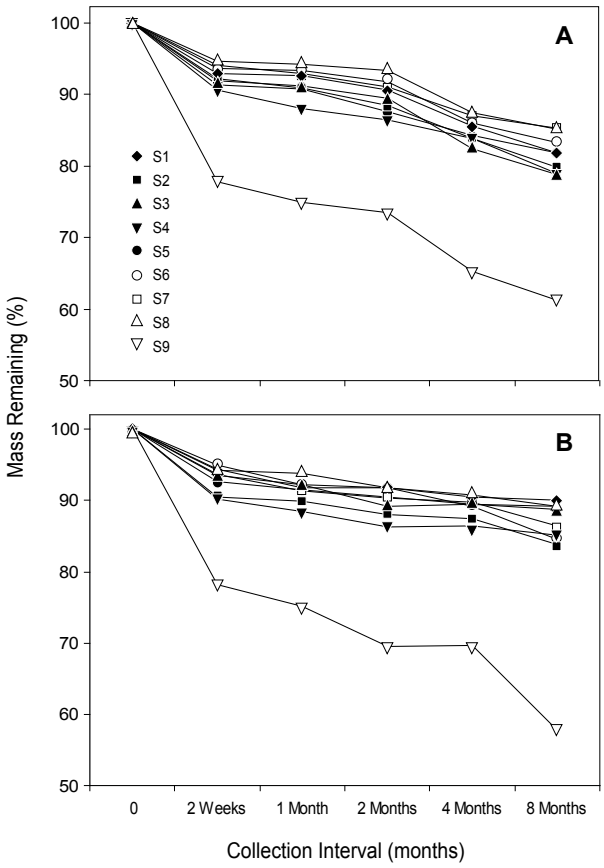


Figure 2. Percent mass remaining of Douglas-fir (S1-S8) and red alder (S9) litter samples placed under (A) a Douglas-fir stand and (B) a red alder stand. S1 through S8 indicate the Douglas-fir litter sources, from low to high [N]. S9 indicates the red alder litter source.

decay rate of the various Douglas-fir litter samples may relate to the initial percent N. Planned chemical analyses of two critical litter components, N and lignin content, will shed more light on the patterns seen among sites.

Study Timeline

The terrestrial experiment was initiated November 2003. Data collection will continue through November 2005. The aquatic experiment was initiated September 2004. Data collection will continue through November 2005. Lab work began during spring 2004 and data analysis will be conducted during the fall and winter of 2004/2005. Thesis writing will occur during the spring and summer of 2005.

Information Exchange

Finding effective ways of delivering and sharing information is a priority for the CFER program. A strong expression of that priority was the formal establishment of an information exchange program in 1998 to assess information needs and facilitate information flow to CFER cooperators and the broader scientific and management communities in the Pacific Northwest.

Goals

The information exchange program maintains a set of goals that guide the development of activities and products by personnel exclusively assigned to these duties. The goals of the information exchange program are to:

- identify and prioritize research topics by assessing needs of managers and researchers within the cooperating organizations;
- develop appropriate mechanisms to convey information;
- ensure effective and timely transfer of research information to the scientific and management community; and
- facilitate continual two-way communication between managers and researchers

2004 Highlights

- CFER researchers gave 42 presentations at professional meetings and conferences, delivered 8 seminars and lectures, and participated in 10 workshops and field tours as presenters or organizers.
- A fact sheet was developed that summarized research examining the processes and rates of sediment and wood replenishment to headwater streams in the Oregon Coast Range.
- The BLM's Density Management Workshop and Field Tour were cosponsored and hosted by the CFER program. A supporting fact sheet and poster were also developed.
- A fact sheet was developed that summarized research on the influence of forest management on headwater stream amphibians at multiple spatial scales.

2004 Activities and Products

The CFER information exchange program has carried out numerous activities since the program's inception. Many of these were developed to create an awareness of the CFER program and its research. With the completion of many of CFER's initial projects, the emphasis for information exchange is shifting to the dissemination of research results. Communication efforts during this phase of the program will promote the development of materials and planning of events that present research outcomes and management considerations to help with the implementation of effective forest practices.

The following are descriptions of activities and products from year 2004.

CFER Web Site

The CFER web site continues to be an important means of disseminating information about CFER's research and information exchange activities. The initial version of the web site was made available in June 2000. Because of growth-related changes, we are currently redesigning the existing interface to increase site usability. The redesign includes reformatting of the navigation menu to include "CFER Products" as a primary heading. This will increase accessibility to the growing number of programmatic publications and products available for download. Among the publications available are copies of our newsletter, fact sheets, student abstracts, and this report.

In addition, database-driven pages are being developed, which will allow for quicker updating as the web site continues to grow. Periodic updates on the latest additions to the web site can be received by joining the CFER listserve (http://www.fsl.orst.edu/cfer/news/join/join.html).

CFER Newsletter

The program's newsletter, *CFER News*, continued to inform cooperators and the general public about CFER's research and activities. Each issue of *CFER News* was circulated to approximately 800 people and organizations during 2004. The newsletter was established to highlight research and activities of interest to people making decisions about land management. Recurring features include summaries of completed research, updates on current research and field activities, and personnel information. Examples of recent topics addressed in the newsletter include a summary of the Landscape Scenario Analysis Project; an overview of trophic relations among birds, arthropods and shrubs; and summaries of scientific publications of interest to forest managers. To receive future issues of *CFER News*, contact the CFER program office (541-737-7612; CFER@fsl.orst.edu). Current and past issues may also be viewed or downloaded from our web site as a PDF file.

Stream Amphibian Fact Sheet

Pacific giant salamanders, tailed frogs, and torrent salamanders are important inhabitants of headwater streams in forests of the Pacific Northwest. Because riparian management activities can greatly influence the availability and quality of amphibian habitat, identifying the effects of management activities on amphibians at multiple spatial scales is important in developing appropriate management practices. CFER researchers Margo Stoddard and Dr. John Hayes investigated the relationships between headwater stream amphibians and habitat characteristics measured at four spatial scales (2-m sample unit, patch, sub-drainage, and drainage). Results from their study were summarized in a USGS/CFER fact sheet titled "Influence of Forest Management on Headwater Stream Amphibians at Multiple Spatial Scales."

Some key results highlighted in the fact sheet include the following:

- The presence of large substrate (e.g., pebbles, cobbles) in the streambed was found to be a key habitat component for stream amphibians at fine spatial scales.
- Occurrence of stream amphibians was high in streams with northeasterly facing aspects.
- The presence of forested habitat next to streams and the amount of forested stream length in drainages were important in predicting the occurrence of stream amphibians.

- Landscape-scale variables can be used to assess management approaches and habitat suitability for stream amphibians.

This fact sheet is available as a PDF from the CFER web site (http://www.fsl.orst.edu/cfer/pdfs/CFERFS03.pdf) or may be requested as a hardcopy from the CFER program office (541-737-7612).

Wood in Headwater Streams Fact Sheet

Debris flows in steep, headwater streams often transport sediment and wood to downstream reaches, leaving behind a channel that has been scoured to bedrock. The erosion of a channel to bedrock provides a unique opportunity to measure the rate at which wood and sediment refill a channel. As part of the CFER program, former Oregon State University graduate student Christine May and Dr. Robert Gresswell examined the processes and rates of sediment and wood replenishment to headwater streams in the Oregon Coast Range. Their research was summarized in the fact sheet titled, "The Importance of Wood in Headwater Streams of the Oregon Coast Range." Some key results from their research include the following:

- Wood and sediment accumulation rates in the channel were strongly correlated with the time since the previous debris flow.
- Large wood was the focal point for sediment accumulation because it provided a physical obstruction to sediment transport.
- Sediment that was stored behind wood in the channel increased the streambed roughness, decreased the local slope of the channel, and further reduced the capacity for sediment transport.
- With an adequate supply of wood, small streams have potential to store large volumes of sediment in the interval between debris flows and can function as one of the dominant storage reservoirs for sediment in mountainous terrain.

This fact sheet is available as a PDF from the CFER web site (http://www.fsl.orst.edu/cfer/pdfs/CFERFS04.pdf) or may be requested as a hardcopy from the CFER program office (541-737-7612).

CFER Roving Seminar Series

To further enhance linkages between research and management, the CFER program established the 'CFER Roving Seminar Series' in 2002. This is a program of CFER scientists traveling to Oregon Department of Forestry (ODF) and Bureau of Land Management (BLM) offices to present seminars and discuss issues of interest to managers. The seminar series is aimed at increasing face-to-face communication between researchers and research-users. We invite you to contact the CFER program office to arrange a presentation for your agency or organization.

CFER Poster Program

In the scientific context, posters are frequently produced to present research results at conferences and scientific meetings. However, a similar but less technical poster can be created to introduce projects to a broader audience. In 2003, we initiated a poster program intended to highlight studies being conducted as part of CFER research as well as to increase visibility of the CFER program at ODF and BLM offices. We appreciate the willingness of our cooperators to display the posters in areas of high traffic, and we will continue sending "replacement" posters throughout the upcoming year. If you are interested in having posters mailed to your organization, please contact the CFER program office.

Students and Natural Resource Communication

Because natural resource issues are confusing and complex, natural resource professionals must possess more than the traditional set of technical skills to effectively address these issues. Solid communication skills are among the most beneficial tools of today's land manager. This academic year, Drs. Janet Erickson and Judy Li are offering a course through the Department of Fisheries and Wildlife at Oregon State University designed to provide students (and future natural resource professionals) with the concepts and techniques necessary for successful communication in natural resource organizations. In the course, undergraduate students are developing a communication product related to studies within the "Riparian Linkages" research theme of the CFER program.

The students, working as a group, are reviewing studies about riparian influences on fish and wildlife food webs (e.g., cutthroat trout, bats, spiders, birds, amphibians), choosing and analyzing their audience, designing clear messages related to this research, and managing a communication project through to completion. The final product developed by the students will be distributed to resource managers during the summer of 2005.

BLM's Density Management Workshop and Field Tour

The Density Management Study (DMS) was initiated by a partnership between the BLM and the U.S. Geological Survey, which quickly grew to include Oregon State University (OSU), the U.S. Forest Service Pacific Northwest Research Station (PNW), and Region Six of the U.S. Forest Service. The CFER program provides administrative and outreach support for the DMS and promotes new research opportunities on DMS sites.

A two-day workshop and field tour, co-sponsored by the CFER program, was organized to bring forest managers together with researchers to share information and early results from the Density Management and Riparian Buffer Studies. The June 1 symposium attracted over 150 participants and featured 14 presenters. Topics addressed during the presentations included vegetation response to density management treatments, headwater forest response to thinning, leave islands as refugia for low-mobility species, and many other topics. An overview of the program as well as the PowerPoint presentations can be found on the workshop's web site (http://www.fsl.orst.edu/cfer/DMS/DM.html).

A fact sheet and poster were also developed to provide information about the mission, goals, objectives, research, and information exchange activities of the DMS. The fact sheet is available as a PDF from the CFER web site (http://www.fsl.orst.edu/cfer/pdfs/DMS.pdf) or may be requested as a hardcopy from the CFER program office (541-737-7612).

Snag Bibliography Web Page Update

A comprehensive bibliography of publications on snag-associated wildlife species was made available by CFER researchers during May of 2001. The bibliography compiled by Jennifer Weikel (currently with the Forest Health and Monitoring program, ODF) and Dr. John Hayes and published by the Forest Research Laboratory at OSU featured 1,400 citations on the ecology, habitat use, and management of habitat for 43 birds and 13 mammals. Currently, the bibliography and web page are being updated to make available the most recent research on this relevant topic. Literature on snag-associated species that has been published since the bibliography was originally created is being researched and pertinent citations are being added to the bibliography. The updated searchable bibliography should be available from the CFER web site by early 2005.

CFER Communications

Conference Presentations

January 31, 2004. Paper presentation: "Vertical and lateral litter inputs to streams in managed forests of the Oregon Coast Range." Science and Math Investigative Learning Experiences (SMILE) Teachers' Workshop. Oregon State University, Corvallis, Oregon. (Hart)

February 9–11, 2004. Paper presentation: "Integrating science, management, and policy: Welcome and opening remarks." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Arnett)

February 9–11, 2004. Paper presentation: "Influence of stand development, structure, and management on habitat relationships of bats in forests." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Arnett)

February 9–11, 2004. Paper presentation: "Forest-wildlife relationships with snags created by topping." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Arnett, Schmitz, Maguire, Walter)

February 9–11, 2004. Paper presentation: "Active management in riparian zones for wildlife habitat." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Hibbs)

February 9–11, 2004. Session moderator: "Sustainable forest management and wildlife." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Stoddard)

February 9–11, 2004. Paper presentation: "Influence of forest management on amphibian populations in the Pacific Northwest." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Stoddard)

February 9–11, 2004. Session moderator: "Wildlife relationships with forest management - II." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Waldien)

February 9–11, 2004. Paper presentation: "Influence of forest management on small mammal populations in the Pacific Northwest." Symposium on Integrating Silviculture and Wildlife Habitat Management co-sponsored by the Oregon Chapter of The Wildlife Society and the Society of American Foresters. Bend, Oregon. (Waldien, Maguire)

February 11–13, 2004. Paper presentation: "A landscape perspective on roosting ecology of bats in western Oregon. "Oregon Chapter of The Wildlife Society Annual Meeting. Bend, Oregon. (Arnett)

February 11–13, 2004. Session moderator: "Ecology and management of bats." Oregon Chapter of The Wildlife Society Annual Meeting. Bend, Oregon. (Hayes)

February 11–13, 2004. Paper presentation: "Associations of bats with conifers and deciduous trees in riparian areas." Oregon Chapter of The Wildlife Society Annual Meeting. Bend, Oregon. (Ober)

February 11–13, 2004. Poster presentation: "Incidental capture of birds in small mammal traps: A cautionary note for interdisciplinary studies." Oregon Chapter of The Wildlife Society Annual Meeting. Bend, Oregon. (Cooley, Waldien)

February 29–March 4, 2004. Paper presentation: "Allocation of monitoring sites for regional surveys." Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. (Gresswell)

March 2, 2004. Paper presentation: "Landscape factors and genetic structure among barrier isolated populations of coastal cutthroat trout." Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. (Guy)

March 2, 2004. Paper presentation: "Factors influencing within-watershed genetic variation of coastal cutthroat trout." Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. (Wofford)

March 2, 2004. Paper presentation: "Model food webs: Integrating empirical studies of riparian predation in the Oregon Coast Range." Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. (Li)

March 2, 2004. Paper presentation: "Food availability of coastal cutthroat trout in relation to riparian vegetation." Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. (Romero)

March 2, 2004. Paper presentation: "Seasonal and diel variation in diet of coastal cutthroat trout in the Oregon." Annual Meeting of the Western Division of the American Fisheries Society. Salt Lake City, Utah. (Romero)

March 2, 2004. Paper presentation: "Factors influencing within-watershed genetic variation of coastal cutthroat trout." Annual meeting of the Western Division of the American Fisheries Society Annual Meeting. Salt Lake City, Utah. (Wofford, Gresswell, Banks)

March 3, 2004. Paper presentation: "Visualization techniques for studying landscape pattern and fish distribution." USGS GIS Workshop. Denver Federal Center, Denver, Colorado. (Hockman-Wert, Gresswell, Torgersen, Bateman, Wofford)

March 10, 2004. Paper presentation: "Science in support of management: Contributions of the Cooperative Forest Ecosystem Research Program." 2004 State Forest Program Conference sponsored by the Oregon Department of Forestry. Corvallis, Oregon. (Perakis)

March 10, 2004. Poster presentation on various CFER-related research activities. 2004 State Forest Program Conference sponsored by the Oregon Department of Forestry. Corvallis, Oregon. (Erickson)

March 10, 2004. Poster presentation. "Relationships between riparian vegetation, insects, and bats in the Oregon Coast Range." 2nd Bats and Forests Symposium and Workshop. Hot Springs, Arkansas. (Ober, Hayes)

March 11, 2004. Paper presentation: "Relationships between forest management and bats." 2nd Bats and Forests Symposium and Workshop. Hot Springs, Arkansas. (Hayes)

March 11, 2004. Paper presentation: "Selection of day roosts by three species of bats at multiple spatial scales in managed forests in western Oregon." 2nd Bats and Forests Symposium and Workshop. Hot Springs, Arkansas. (Arnett)

April 24, 2004. Paper presentation summarizing research concerning the effects of fire on aquatic systems. Wildfire, Watersheds, and Communities Conference sponsored by the Middle Fork Willamette Watershed Council. University of Oregon, Eugene, Oregon. (Gresswell)

May 17–19, 2004. Paper presentation: "Describing spatial pattern in stream networks: A practical geostatistical approach." American Water Resources Association's 2004 Spring Specialty Conference on Geographical Information Systems (GIS) and Water Resources III. Nashville, Tennessee. (Torgersen, Gresswell)

May 17–21, 2004. Paper presentation: "Coupled nitrogen and calcium cycling in forests across a gradient of soil nitrogen availability." 2004 Joint Assembly of the American and Canadian Geophysical Unions. Palais des Congrès de Montreal, Montreal, Québec, Canada. (Perakis)

June 6–10, 2004. Paper presentation: "Statistical considerations for variogram estimation in stream networks." 2004 North American Benthological Society Annual Meeting. Vancouver, British Columbia. (Torgersen, Gresswell)

June 6–10, 2004. Paper presentation: "Multiscale dynamics of coastal cutthroat trout in headwater stream networks." 2004 North American Benthological Society Annual Meeting. Vancouver, British Columbia. (Gresswell, Bateman, Torgersen, Guy, Hendricks, Romero, Wofford)

June 6–10, 2004. Poster presentation: "Emerging aquatic insects in western Oregon headwater streams." 2004 North American Benthological Society Annual Meeting. Vancouver, British Columbia. (Li)

June 6–10, 2004. Paper presentation: "Emergence of adult aquatic insects in coniferous and hardwood-dominated reaches, Coast Range, Oregon." 2004 North American Benthological Society Annual Meeting. Vancouver, British Columbia. (Premdas, Li)

August 1–6, 2004. Paper presentation: "Influence of alternative silvicultural practices on songbirds in western Oregon." 89th Annual Meeting of the Ecological Society of America. Portland, Oregon. (Hayes, Stoddard)

August 1–6, 2004. Poster presentation: "Vertical and lateral litter inputs to streams from riparian forests of the central Oregon Coast Range." 89th Annual Meeting of the Ecological Society of America. Portland, Oregon. (Hart, Hibbs, Perakis)

August 1–6, 2004. Paper presentation: "Losses of dissolved organic nitrogen from terrestrial ecosystems: Patterns and significance." 89th Annual Meeting of the Ecological Society of America. Portland, Oregon. (Perakis)

August 1–6, 2004. Poster presentation: "Predicting input of riparian trees in western Oregon." 89th Annual

Meeting of the Ecological Society of America. Portland, Oregon. (Hibbs, Shatford)

August 2, 2004. Invited panel member: "How to succeed in ecology." Evening symposium of the 89th Annual Meeting of the Ecological Society of America. Portland, Oregon. (Perakis)

August 22–26, 2004. Paper presentation: "Spatial distribution of coastal cutthroat trout within and among headwater stream networks." Annual Meeting of the American Fisheries Society. Madison, Wisconsin. (Gresswell, Bateman, Torgersen, Guy)

August 22–26, 2004. Invited paper presentation: "Landscape influences on the spatial extent of coastal cutthroat trout distribution in low-order forested watersheds of western Oregon." Annual Meeting of the American Fisheries Society. Madison, Wisconsin. (Torgersen, Gresswell, Bateman, Hockman-Wert)

September 18–22, 2004. Invited paper presentation: "Multiscale concepts for understanding stream fish habitat relationships in riverine landscapes." The Wildlife Society Annual Conference. Calgary, Alberta. (Torgersen, Gresswell)

September 22, 2004. Poster presentation: "Vertical and lateral litter inputs to streams from riparian forests of the central Oregon Coast Range." Oregon State University Graduate School Orientation. Oregon State University, Corvallis, Oregon. (Hart, Hibbs, Perakis)

October 11–13, 2004. Invited presentation: "Using half-duplex passive integrated transponder tags to evaluate fish distribution patterns in small watersheds." Annual USGS Conference on Science in Oregon and Washington. H.J. Andrews Experimental Forest, Blue River, Oregon. (Bateman)

October 31–November 4, 2004. Paper presentation: "Coupled nitrogen and calcium cycling in forests of the Oregon Coast Range", Annual Meeting of the Soil Science Society of America. Seattle, Washington. (Perakis)

November 3, 2004. Poster presentation: "Vertical and lateral litter inputs to streams from riparian forests of the central Oregon Coast Range." Research Advances in Fisheries, Wildlife, and Ecology Symposium: Integrating Functional and Evolutionary Ecology. Oregon State University, Corvallis, Oregon. (Hart, Hibbs, Perakis)

November 3, 2004. Poster presentation: "Relationships between bats, insects, and riparian vegetation in the Oregon Coast Range." Research Advances in Fisheries, Wildlife, and Ecology Symposium: Integrating Functional and Evolutionary Ecology. Oregon State University, Corvallis, Oregon. (Ober, Hayes)

Other Presentations and Events

February 17, 2004. CFER Roving Seminar presentation at the BLM Eugene District Office. Eugene, Oregon. (Hibbs, Waldien)

March 1, 2004. Meeting with BLM Brummit ID team to discuss CFER's Landscape Scenario Analysis Project. North Bend, Oregon. (Torgersen)

March 17, 2004. Master's thesis seminar titled "The use of $\delta^{15}N$ and $\delta^{13}C$ to analyze food webs and identify source-sink relationships in riparian canopy vegetation of the Oregon Coast Range." Oregon State University, Corvallis, Oregon. (Scott)

March 17, 2004. Meeting with specialists from the BLM to discuss management implications of ongoing research on coastal cutthroat trout. Coos Bay, Oregon. (Gresswell, Wofford, Bateman)

March 18, 2004. Meeting with the Southern Oregon Flyfishers to discuss results of studies being conducted within the CFER Program. Grants Pass, Oregon. (Gresswell)

March 24–27, 2004. Distribution of CFER-related information products at the Annual Meeting of the Society of Northwestern Vertebrate Biology. Ellensburg, Washington. (Erickson)

April 13, 2004. Landscape Analysis Project Workshop and Field Trip with Coos Bay BLM district personnel. East Fork Coquille Watershed, Oregon. (CFER researchers)

April 24, 2004. Participation in the one-day conference titled "Wildfire, Watersheds, and Communities"

sponsored by the Middle Fork Willamette Watershed Council. (Gresswell)

May 5, 2004. BLM/USGS-Forest and Rangeland Ecosystem Science Center (USGS-FRESC) Research Needs and Capability Workshop. Portland, Oregon. (Erickson, Hayes, Perakis, Torgersen)

June 1–2, 2004. Co-sponsorship of the Density Management Study Workshop and Field Tour, CH_2M Hill Alumni Center, Oregon State University, Corvallis, Oregon. (CFER program)

June 24, 2004. Master's thesis seminar titled "Canopy type and seasonal influences on adult aquatic insect emergence and riparian spiders." Oregon State University, Corvallis, Oregon. (Premdas)

July 9, 2004. Science strategy meeting with Rosy Mazaika (Policy and Budget Lead – Water Program). BLM State Office, Portland, Oregon. (Torgersen)

July 12, 2004. Co-sponsorship of the BLM Landscape Objectives in RMP Revisions Workshop. Oregon State University, Corvallis, Oregon. (Torgersen, Hayes, Erickson)

July 16, 2004. Workshop on BLM hydrology and cumulative effects information needs with BLM, CFER, OSU, and USDA Forest Service. H.J. Andrews Experimental Forest, Blue River, Oregon. (Torgersen)

July 27, 2004. Site visit and progress report (oral presentation) on the Landscape Scenario Analysis Project. BLM Coos Bay District, Coos Bay, Oregon. (Torgersen, Hockman-Wert)

August 12, 2004. Master's thesis seminar titled "Landscape scale evaluation of genetic structure among barrier-isolated populations of coastal cutthroat trout, *Oncorhynchus clarki clarki*." Oregon State University, Corvallis, Oregon. (Guy)

August 25–26, 2004. Presentations to participants of the Bat Conservation and Forest Management Workshop sponsored by Bat Conservation International and others. Spokane, Washington. (Ober, Hayes)

Fall 2004. Organized seminar series: "Managing forests and watersheds in the Pacific Northwest." Department of Forest Science, Oregon State University, Corvallis. (Torgersen)

September 8, 2004. Workshop on spatially explicit landscape modeling (BLM, CFER, USDA Forest Service). BLM Eugene District, Eugene, Oregon. (Torgersen, Hockman-Wert)

September 29, 2004. Invited seminar presentation titled "Nitrogen cycling in terrestrial ecosystems: Implications of leaky plumbing." Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. (Perakis)

October 11-13, 2004. Organized workshop: "Science in small headwater basins." Annual USGS Conference on Science in Oregon and Washington. H.J. Andrews Experimental Forest, Blue River, Oregon. (Torgersen)

November 8, 2004. Invited seminar presentation titled "Nitrogen cycling in terrestrial ecosystems: Implications of leaky plumbing." Department of Biology, Duke University, Durham, North Carolina. (Perakis)

November 15, 2004. Invited seminar presentation titled "Nitrogen cycling in terrestrial ecosystems: Implications of leaky plumbing." Department of Zoology, Oregon State University, Corvallis, Oregon. (Perakis)

November 17, 2004. Invited seminar presentation: "Landscape pattern, network structure, and the distribution of cutthroat trout in headwater streams." Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. (Torgersen)

Publications

CFER Program Publications

The following publications are available from the Cooperative Forest Ecosystem Research (CFER) program office (CFER@FSL.orst.edu or 541-737-7612).

CFER News. A newsletter providing programmatic information. Recurring features include summaries of completed research, updates on current research, and personnel information.

Cooperative Forest Ecosystem Research program. 1998. CFER Long-Range Strategic Plan. Corvallis, Oregon. 10 p.

Hayes, J.P., J. Weikel, M. Huso, and J.L. Erickson. 2003. Response of Birds to Thinning Young Douglas-fir Forests. U.S. Geological Survey: Fact Sheet FS-033-03, 4 p.

May, C.L., R.E. Gresswell, and J.L. Erickson. 2004. The Importance of Wood in Headwater Streams of the Oregon Coast Range. U.S. Geological Survey: Fact Sheet FS 2004-3055, 4 p.

Miller, J.C., and P.C. Hammond. 2000. Macromoths of Northwest Forests and Woodlands. Forest Health Technology Enterprise Team. Morgantown, West Virginia. 130 p.

Muir, P.S., R.L. Mattingly, J.C. Tappeiner II, J.D. Bailey, W.E. Elliott, J.C. Hagar, J.C. Miller, E.B. Peterson, and E.E. Starkey. 2002. Managing for Biodiversity in Young Douglas-fir Forests of Western Oregon. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0006. 76 p.

Smith, J.P., R.E. Gresswell, and J.P. Hayes. 1997. A Research Problem Analysis in Support of the Cooperative Forest Ecosystem Research (CFER) Program. U.S. Geological Survey, Biological Resources Division, Forest and Rangeland Ecosystem Science Center. Corvallis, Oregon. 92 p.

Stoddard, M., J.P. Hayes, and J.L. Erickson. 2004. Influence of Forest Management on Headwater Stream Amphibians at Multiple Spatial Scales. U.S. Geological Survey: Fact Sheet FS 2004-3018, 6 p.

Tappeiner, J., N. Poage, and J.L. Erickson. 2003. Managed Forest Reserves: Preserving Diversity. U.S. Geological Survey: Fact Sheet FS-034-03, 4 p.

CFER Products

McCune, B. 2002. Web Page: Epiphytes and Forest Management. http://www.onid.orst.edu/~mccuneb/epiphytes.htm

This web site summarizes a decade of research results concerning the management of Pacific Northwest lichens. The home page includes a list of questions from which the supporting pages branch. Information is organized in a hierarchical manner providing a greater level of detail as the site is explored.

Weikel, J.M. and J.P. Hayes. 2001. Web Page: Habitat Use by Snag-Associated Species: A Bibliography for Species Occurring in Oregon and Washington. http://www.fsl.orst.edu/cfer/snags/bibliography.html

A comprehensive, easily searched bibliography of publications on snag-associated wildlife species. Compiled by Jennifer Weikel and John Hayes, the bibliography contains over 1,400 citations on the ecology, habitat use, and management of habitat for 43 birds and 13 mammals. Citations can be searched on the web or imported directly into various reference management programs.

Gresswell, R.E., D.S. Bateman, G. Lienkaemper, and T. Guy. 2000. Web Page: Headwater Stream Barriers in Western Oregon. http://fresc.usgs.gov/Corvallis/research/barriers/index.html

This web page provides a brief description of procedures used to develop a spatial database of physical barriers to anadromous fish in streams of western Oregon and a hot link for retrieving the metadata and database from the USGS Forest and Rangeland Ecosystem Science Center.

Managing for Biodiversity in Young Forests. Producer Mark Reed. Videocassette or DVD. Forestry Media Center, Oregon State University, 2000.

In this 28-minute video, researchers who studied birds, moths, lichens, bryophytes, and understory vegetation discuss their findings and possible implications for future management of young forests in western Oregon.

Publications by CFER Scientists (2004)

Beschta, R.L., J.J. Rhodes, J.B. Kauffman, R.E. Gresswell, G.W. Minshall, J.R. Karr, D.A. Perry, F.R. Hauer, and C.A. Frissell. 2004. Postfire management on forested public lands of the western United States. Conservation Biology 18:957–967.

Gresswell, R. E. 2004. Effects of the wildfire on growth of cutthroat trout in Yellowstone Lake. Pages 143–164. *In* L. Wallace, editor. After the Fires: The Ecology of Change in Yellowstone National Park. Yale University Press.

Gresswell, R. E., D. S. Bateman, and G. W. Lienkaemper. *In press*. Geospatial techniques for developing a sampling frame of watersheds across a region. *In* T. Nishida, P. J. Kailola, and C. E. Hollingworth, Editors. Proceedings of the Second International Symposium on GIS in Fishery Science. Fishery GIS Research Group, Saitama, Japan.

Hagar, J., S. Howlin, L. Ganio. 2004. Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades. Forest Ecology and Management 199: 333–347.

Keim, R.F., A.B. Price, T.S. Hardin, A.E. Skaugset, D.S. Bateman, R.E. Gresswell, and S.D. Tesch. 2004. An Annotated Bibliography of Selected Guides for Stream Habitat Improvement in the Pacific Northwest. Research Contribution 44. Forest Research Laboratory, Oregon State University, Corvallis.

May, C.L. and R.E. Gresswell. 2004. Spatial and temporal patterns of debris-flow deposition in the Oregon Coast Range, USA. Geomorphology 57:135–149.

Manning, J.A. and W.D. Edge. 2004. Small mammal survival and downed wood at multiple scales in managed forests. Journal of Mammalogy, 85(1):87–96.

Perkins, T. and M. Wilson. *In press.* The impacts of *Phalaris arundinacea* (reed canarygrass) invasion on wetland plant richness in the Oregon Coast Range, USA depend on beavers. Biological Conservation.

Sarr, D.A. and D.E. Hibbs. 2004. Woody plant distributions in western Oregon riparian forests: Insights for restoration and management. Pages 119–127. *In* K. Mergenthaler, J. Williams, and E. Jules, editors. Proceedings of the Second Conference on Klamath-Siskiyou Ecology. Cave Junction, Oregon.

Sarr, D.A., K. Puettmann, R. Pabst, M. Cornett, L. Arguello. 2004. Restoration ecology: New perspectives and opportunities for forestry. Journal of Forestry 102:20–24.

Stoddard, M.A., and J.P. Hayes. *In press*. Influence of forest management on headwater stream amphibians at multiple spatial scales. Ecological Applications.

Torgersen, C.E., and D.A. Close. 2004. Influence of habitat heterogeneity on the distribution of larval Pacific lamprey (*Lampetra tridentata*) at two spatial scales. Freshwater Biology 49:614–630.

Torgersen, C.E., R.E. Gresswell, and D. S. Bateman. *In press*. Pattern detection and longitudinal analysis of linear networks: quantifying spatial variability in stream fishes. *In* T. Nishida, P. J. Kailola, and C. E. Hollingworth, Editors. Proceedings of the Second International Symposium on GIS in Fishery Science. Fishery GIS Research Group, Saitama, Japan.

Wender, B.W., C.A. Harrington, J.C. Tappeiner. 2004. Flower and fruit production of understory shrubs in western Washington and Oregon. Northwest Science 78:124–140.

Wofford, J.E.B., R.E. Gresswell, and M.A. Banks. *In press.* Factors influencing within-watershed genetic variation of coastal cutthroat trout. Ecological Applications.

CFER Student Theses and Dissertations (2004)

Troy Guy (M.S., Department of Fisheries and Wildlife): *Landscape Scale Evaluation of Genetic Structure among Barrier-isolated Populations of Coastal Cutthroat Trout, Oncorhynchus Clarki Clarki.*

Genetic structure of a species is ultimately the result of the capacity of individuals to disperse and persist in a heterogeneous and changing environment. The effects of extrinsic barriers to dispersal have increasingly been shown to play a large role in the structuring of contemporary genetic diversity, but describing a relationship between landscape structure, stochastic disturbance, and genetic diversity is a major challenge. In this study, 27 barrier-isolated populations (2,232 individuals) of coastal cutthroat trout from western Oregon were

characterized at seven microsatellite loci to examine the extent of genetic differentiation. Watershed-scale environmental factors that are associated with the shaping of genetic diversity were assessed. Isolated headwater populations of coastal cutthroat trout are strongly differentiated (mean Fst = 0.33), but intrapopulation microsatellite genetic diversity (mean number of alleles per locus = 5, mean He = 0.60) was only moderate. Differences in genetic diversity in the Coast Range (mean alleles = 47) and in the Cascade Mountains (mean alleles = 30) were statistically significant (P = 0.02). It appears that this pattern is related to the relative forces of drift and gene flow acting in these different physical environments. Comparisons between landscape structure and genetic diversity suggest that an interaction between disturbance frequency and physical landscape features may play a substantial role in the structuring of genetic diversity among isolated cutthroat trout populations.

Sharmila Premdas (M.S., Department of Fisheries and Wildlife): *The Influence of Canopy Type and Seasons on Adult Aquatic Insect Emergence and Riparian Spiders in the Oregon Coast Range.*

The objective of my study was to examine differences in riparian tree and shrub composition associated with adult aquatic emergence and implications for terrestrial spiders in these sites. Seasonal abundance and biomass of adult emergent aquatic insects, riparian arthropod abundances, and spider densities were compared between conifer- and hardwood-dominated sites in headwater streams of the Oregon Coast Range. Collections of insects were taken from emergence and sticky traps along with hand-collected spiders from May 25 to July 10 and from Aug 1 to Sept 15. Comparisons of emergent insect orders responding to riparian composition and seasons were made using two-way ANOVA. Plecoptera and Diptera emerged more abundantly from hardwood-dominated sites. Ephemeroptera and Plecoptera biomass was higher in hardwood-dominated streams. Seasonal estimates indicated that emergent Ephemeroptera, Plecoptera, and Diptera were more abundant and had higher biomass in spring compared to summer. Riparian distributions of Ephemeroptera, Plecoptera, and Trichoptera were more concentrated at stream edge, while riparian Diptera were more evenly distributed. Riparian orb-web spiders also were more numerous at stream edge. Diptera, Ephemeroptera, Plecoptera, Trichoptera, and terrestrial prey collected on riparian sticky traps were more abundant in hardwood-dominated sites. Spider collections were dominated by the families of Araneidae, Linyphiidae, and Uloboridae. Orb-web weaving spiders were more abundant in conifer-dominated sites, and higher abundances were associated with vine maple, rather than salmonberry. Whereas spider densities were higher during summer, aquatic and terrestrial prey were more abundant in spring.

Nicolas Romero (M.S., Department of Fisheries and Wildlife): *Seasonal Influences on Food Availability and Diet of Coastal Cutthroat Trout in Relation to Riparian Vegetation*.

Current riparian management objectives in the Pacific Northwest promote both retention of existing conifers and conversion of hardwood-dominated areas to conifers. Although understanding of relationships between riparian vegetation and salmonid prey availability is growing, temporal variation in these relationships is poorly understood. Seasonal fluxes in availability of aquatic and terrestrial invertebrate prey for coastal cutthroat trout were investigated by estimating invertebrate biomass from aquatic (benthos and drift) and allochthonous (terrestrial) sources in three watersheds in the Oregon Coast Range. To investigate the influence of vegetation type on food sources, samples were collected in each watershed from stream sections dominated by deciduous, conifer, and mixed vegetation. During each sample period, diet was assessed by examining gut contents of captured trout. Stream discharge appeared to be most influential factor regulating seasonal fluxes of aquatic invertebrate biomass in the benthos and drift. Total allochthonous invertebrate biomass at deciduous and mixed vegetation sites was almost 30% higher than at coniferous sites. Although aquatic insects dominated the total gut

contents during this study, prey from terrestrial origin was more common during summer and fall. These results suggest that systematic removal of deciduous vegetation in riparian zones to promote conifers may have unintended consequences on the food resources of coastal cutthroat trout and the productivity of aquatic food webs in the Pacific Northwest.

Daniel Sarr (Ph.D., Department of Forest Science): *Multiscale Controls on Woody Riparian Vegetation: Distribution, Diversity, and Tree Regeneration in Four Western Oregon Watersheds.*

I studied riparian forests of four western Oregon watersheds (dry south to wet north) to determine the multiscale controls on woody riparian vegetation. I conducted separate analyses of controls on plant distribution, diversity, and tree regeneration using vegetation and environmental data collected in two related field studies: 1) a multiscale riparian forest inventory; 2) a comparative study of natural forest gaps and interiors.

Climatic moisture (vapor pressure deficit in summer) was the primary correlate of compositional change between riparian sites at all scales analyzed, demonstrating that the majority of riparian species responded directly or indirectly to the landscape scale climate gradient. Additional variation in composition was explained by measures of local topography and disturbance.

Climate, as indexed by modeled gross primary productivity (GPP), explained the majority of the variation in multiple regression models of plant diversity that included local and landscape scale variables. As GPP increased from dry to wet climates, understory light and moisture heterogeneity decreased, coincident with declines in alpha-, beta-, and hectare-scale diversity, suggesting that climate controls diversity indirectly through its effects on local conditions.

Tree regeneration varied sharply across the climate gradient; seedling frequency and diversity declined and nurse log use increased from the driest to wettest climates. Life-history attributes of riparian tree species provided important clues to their regeneration success in different environments. These relationships were explored in a model that linked species shade and drought tolerance with expected variation in the environment caused by climate and disturbance. The model accurately predicted regeneration patterns for four of five functional groups of tree species.

The studies in this dissertation provided compelling evidence of regional variation in riparian vegetation composition, diversity, and dynamics, illustrating that these communities are strongly shaped by landscape scale as well as local scale factors. Moreover, climate-related differences among riparian sites were at least as important as the local variation within them in explaining spatial vegetation patterns. These findings argue for a more inclusive, multiscale perspective of riparian forest ecology that more closely integrates larger scale controls, such as climate, with local hydrologic processes.

Emily Scott (M.S., Department of Forest Science): *The Use of δ15N and δ13C to Analyze Food Webs and Identify Source-Sink Relationships in Riparian Canopy Vegetation of the Oregon Coast Range.*

In the Coast Range of western Oregon, some natural resource managers are converting red alder-dominated riparian areas to conifers to increase the future source of in-stream large wood for salmonid habitat. However, studies in Alaska have shown red alder-dominated riparian areas support greater invertebrate biomass compared to conifer-dominated areas. In addition, red alder can influence the nutrient dynamics of a site with N-rich litter inputs. Thus, these forest conversions have the potential to change riparian food webs and nutrient dynamics. The objectives of this thesis were to determine the utility of natural abundance stable isotopes of nitrogen and carbon in food web analyses and to describe nutrient dynamics and source-sink relationships in red alder- and Douglas-fir-dominated riparian areas of the central Oregon Coast Range. We address three questions in this study: 1) What is the degree and source of δ15N and δ13C variation in foliage of Douglas-fir and red alder? 2) Are

Douglas-fir and red alder isotope signatures sufficiently distinct to be used in food web analysis? and 3) Are there differences in nutrient dynamics and source-sink relationships between Douglas-fir- and red alder-dominated riparian areas? To address these questions, we sampled foliage, litterfall, forest floor material, and soil from ten Douglas-fir- and red alder-dominated riparian sites as well as foliage from plantation Douglas-fir and red alder for δ15N, δ13C, and nutrient concentrations.

Douglas-fir had greater variation in foliage δ15N within a tree crown, within a site, and among sites than red alder. Red alder had consistent foliage δ15N at all scales, near –1.5‰, a value that is characteristic of nitrogen fixing species. Both species had similar levels of variation in foliage δ13C at all scales. Douglas-fir was slightly enriched in 13C compared to red alder suggesting greater water-use efficiency in Douglas-fir. Overall, the difference between δ15N and δ13C of red alder and Douglas-fir at our study sites were, on average, less than 2.0‰. It is unlikely stable isotopes could be used over broad geographic areas as a tool for determining the contributions of Douglas-fir versus red alder to food webs, although site-specific research may be possible where Douglas-fir and red alder demonstrate greater isotopic differences. Douglas-fir and red alder exhibited opposite source-sink relationships with soil for N exchange: Douglas-fir was a sink for soil N whereas red alder served as a N source. Douglas-fir sites had a higher N status and lower soil δ15N along the stream compared to upslope, trends not found at red alder sites. Soil δ15N near streams on Douglas-fir sites was similar to the soil δ15N on red alder sites suggesting that a legacy of past red alder along the stream may have contributed to the N status and soil δ15N gradients on Douglas-fir sites. Soil δ15N and soil %N did not indicate a presence of marine N on our sites. δ15N and δ13C of foliage and soil suggested decomposition processes of leaf litter differed between Douglas-fir and red alder, likely due to different litter chemistries and possible influences on decomposition enzymes. A shift in species composition from red alder-dominated to Douglas-fir-dominated riparian areas would alter source-sink relationships with soil N and litter decomposition processes, although some legacies of soil enrichment in N by red alder would persist.

Budget Summary

	2004 Budget			2005 Proposed Budget		
	OSU	USGS	Total	OSU	USGS	Total
Stand Structure Project	103,390	81,000	184,390	121,032	135,000	256,032
Riparian Wood Project	38,136	0	38,136	0	0	0
Landscape Project	87,471	110,000	197,471	5,833	150,000	155,833
Riparian Linkages Project	165,953	35,000	200,953	152,183	0	152,183
Information Exchange	84,746	0	84,746	99,872	0	99,872
Administration and PI Salaries	169,068	0	169,068	190,835	0	190,835
Indirect Costs[1]	117,836	0	117,836	120,245	0	120,245
Total[2]	**766,600**	**226,000**	**992,600**	**690,000**	**285,000**	**975,000**

[1] Indirect costs for OSU in 2004 are based on an indirect rate of 18% on $538,559 requested from USGS, 26% on $39,682 provided by ODF, and 15% on $70,522 provided by BLM for development of a new landscape modeling project (LSAP). Indirect costs for OSU in 2005 are based on an indirect rate of 20% on $408,333 requested from USGS, 18% on $42,373 requested from BLM, and 26% on $119,048 requested from ODF.

[2] Total annual budget in 2004 is based on $861,500 provided by USGS, $50,000 provided by ODF, and $81,100 provided by BLM. The proposed budget for 2005 is based on $775,000 provided by USGS, $150,000 provided by ODF, and $50,000 provided by BLM.

CFER Staff

Principal Investigators

W. Daniel Edge is the Department Head in the Department of Fisheries and Wildlife at Oregon State University and one of the wildlife ecologists on the CFER science team. Dan received a B.S. in Wildlife Biology, a B.S. in Forestry, an M.S. in Wildlife Biology, and a Ph.D. in Forestry, all from the University of Montana. Dan's primary research interests are the impacts of forestry and agricultural practices on wildlife communities.

Robert E. Gresswell received degrees from the University of New Mexico (B.S.), Utah State University (M.S.), and Oregon State University (Ph.D.). Since 1997, Bob has been working as an aquatic ecologist for the USGS Forest and Rangeland Ecosystem Science Center and the CFER Program. He recently accepted a position with the USGS Northern Rocky Mountain Science Center in Bozeman, Montana, but will continue to play an important leadership role with CFER, especially in the areas of aquatic ecology and fish biology.

John P. Hayes is program coordinator and a wildlife ecologist for the CFER program. He also serves as a professor in the Department of Forest Science at Oregon State University where he teaches coursework in forestry-wildlife interactions. John received his B.S. in Wildlife Science at Oregon State University, his M.S. in Biology at Southern Oregon State College, and his Ph.D. in Ecology and Evolutionary Biology at Cornell University. His research interests include the influence of forest management on wildlife populations, the influence of spatial scale on habitat selection, and the ecology and management of bats.

David E. Hibbs is a forest ecologist and silviculturist for the CFER program. He is a professor in the Department of Forest Science at Oregon State University where he teaches forest community ecology and directs the Hardwood Silviculture Cooperative. He has his B.S. in Plant Ecology from Carleton College, his M.S. in Forestry from the University of Massachusetts, and his Ph.D. in Forest Ecology from the University of Massachusetts. His research interests include stand development and succession in temperate and tropical forests.

Judith L. Li is an assistant professor in the Department of Fisheries and Wildlife at Oregon State University where she has been a member of the faculty for 11 years. She is a stream ecologist with particular interest in freshwater invertebrates and food webs. Her studies have ranged from forested systems of the Oregon coast and the Cascades to arid eastern Oregon. Her research is most often multidisciplinary in which she, her students, and colleagues examine the interactions among stream vertebrates and invertebrates in mesic, arid, and urban settings. Judy has degrees from the University of California, Berkeley (B.S.); the University of California, Davis (M.S.); and Oregon State University (Ph.D.).

Steven Perakis joined the CFER research team as a research ecologist with the USGS Forest and Rangeland Ecosystem Science Center. Steve's research centers on understanding biogeochemical cycles in terrestrial ecosystems, and he has particular interest in discerning how processes and activities within forests shape nutrient losses, whole-system nutrient balances, and linkages between terrestrial and aquatic ecosystems. Steve has degrees in Ecology and Ecosystem Science from the University of Pennsylvania (B.S.), the University of Washington (M.S.), and Cornell University (Ph.D.), with a year of post-doctoral experience from Stanford University. He also holds a courtesy appointment in the Department of Forest Science at Oregon State University.

Christian Torgersen is a postdoctoral researcher with the USGS Forest and Rangeland Ecosystem Science Center and a fish ecologist for the CFER program. A recent graduate of Oregon State University (Ph.D., 2002), Christian has an interdisciplinary background in fisheries science and geography and is interested in the influences of landscape pattern and habitat fragmentation on the distribution of stream fishes. His research involves the use of geospatial applications, such as remote sensing and GIS, and statistical modeling to predict the occurrence and abundance of coastal cutthroat trout in western Oregon.

Collaborating Scientists

John Cissel is the BLM science liaison for western Oregon and for CFER. He is a BLM state office employee and has offices in Corvallis and Eugene. John has extensive experience working at the science and management interface, and has particular interests in landscape ecology and landscape management planning. He has a B.S. in Forestry from Michigan State University, an M.S. in Forest Management and Operations Research from Pennsylvania State University, and has completed additional graduate coursework in forest ecology at Oregon State University.

Klaus Puettmann is an associate professor in the Department of Forest Science at Oregon State University. Klaus received his diploma from Albert-Ludwig University, Freiburg, Germany, and his Ph.D. from Oregon State University. His research interests include silviculture of temperate forests, regeneration dynamics in diverse structured forests, plant interaction, and density management. He recently joined the CFER research team as an investigator with the BLM's Density Management Study.

Research Assistants and Biological Technicians

Doug Bateman is a research assistant for the CFER program. He has worked for the College of Forestry at Oregon State University since 1989. Doug received his M.S. in Fisheries Science from Oregon State University in 1998. His interest in disturbance ecology and the natural history of aquatic organisms has led to research on the effects of landscape patterns on fish distributions in watersheds in western Oregon.

David Hockman-Wert is a research technician for the CFER program studying landscape pattern and fish distribution using geospatial techniques. He received his B.A. in Biology from Eastern Mennonite University and his M.A. in Environmental Studies from the University of Oregon. His multidisciplinary interests include GIS, landscape ecology, cultural geography, and the human dimensions of natural resources.

Tom Manning is a research assistant currently working with CFER on the Timbered Rock project, investigating the effects of salvage logging on wildlife populations. He received his M.S. in Environmental Biology from the University of Minnesota, Duluth in 1989 and has worked in OSU's Department of Forest Science since 1995. His work since then has centered on effects of forest management practices on small mammal populations.

Jeff Shatford is a research assistant in plant ecology for the CFER program studying understory vegetation in young forests and the production and input of coarse woody debris into streams. He received his B.S. in Biology from Queen's University and M.S. in Forestry from the University of British Columbia. His research interests include the regeneration of forbs and shrubs in forests and grasslands and the maintenance of plant diversity in managed landscapes.

Information Exchange

Janet Erickson is the information exchange specialist for the CFER program. She is responsible for conveying information about the CFER program and its research projects to land managers and other audiences. She develops and manages the production of a variety of information products, such as the CFER web site, written publications, videos, displays, field tours, and symposia. Janet received her B.S. in Biology from Pacific Lutheran University and her M.S. and Ph.D. in Wildlife Science from the University of Washington.

Nancy Creel is the administrative assistant for the CFER program. She provides financial, administrative, and clerical support for researchers and outreach specialists participating in the CFER program. Nancy manages mailing lists, prepares CFER research proposals, and provides monthly financial statements. She works closely with all members of the program's staff in support of the research and information exchange goals of the CFER program.

Graduate Students

Ed Arnett is a Ph.D. student in the Department of Forest Science. He is investigating the influence of landscape structure on bats.

Alison Cross is a Master's student in the Department of Forest Science. She is investigating tree species controls on soil nutrient dynamics in mixed old-growth stands in the Oregon Coast Range.

Michelle Donaghy Cannon is a Ph.D. student in the Department of Forest Science and the Department of Fisheries and Wildlife. She is studying how birds are distributed in large severely burned patches relative to remnant unburned forest.

Paula Graff is a Master's student in the Department of Fisheries and Wildlife. She is investigating food web relationships of amphibians in riparian areas dominated by conifer and hardwood plant communities.

Jessica Halofsky is a Ph.D. student in the Department of Forest Science. She is investigating factors that affect fire severity and post-fire vegetation recovery in riparian areas in the Biscuit Fire of southwest Oregon.

Stephanie Hart is a Master's student in the Department of Forest Science. She is investigating the movement of allochthonous inputs of headwater stream riparian areas.

Mike Heck is a Master's student in the Department of Fisheries and Wildlife. He is investigating the effects of fire on growth and demographics of coastal cutthroat trout.

Joselin Matkins is a Master's student in the Department of Forest Science. She is investigating how nitrogen and other factors influence the decay of Douglas-

fir and red alder leaf litter in both terrestrial and aquatic habitats of riparian zones.

Holly Ober is a Ph.D. student in the Department of Forest Science and the Department of Fisheries and Wildlife. She is studying the influence of bats in riparian areas.

Bill Rehe is a Master's student in the Department of Fisheries and Wildlife. He is examining the influences of landscape variables on age and growth of coastal cutthroat trout.

Amanda Robillard is a Master's student in the Department of Fisheries and Wildlife. She is conducting a study to assess a riparian food web with emphasis on ecological subsidies.

Dave Waldien is a Ph.D. student in the Department of Fisheries and Wildlife. He is investigating the influence of coarse wood on small mammal populations.

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