Annual Progress Report 2006

Interagency Regional Monitoring & Research Accomplishments

Northwest Forest Plan

Acknowledgements

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Annual Progress Report 2006

Summary

The 1994 Record of Decision (ROD) amended all Bureau of Land Management and Forest Service land and resource management plans in California, Oregon, and Washington within the range of the Northern Spotted Owl. In addition to establishing new management direction for federal forests, the ROD provided a framework for interagency monitoring. This document reports annual accomplishments of recent and ongoing monitoring and research efforts within the range of the Northern Spotted Owl.

Overview

In March 2006, the Regional Interagency Executive Committee (RIEC) identified sixteen Priority Questions to guide regional monitoring and collaborative research investments within the range of the Northern Spotted Owl. They also developed an overarching regional management objective and strategic fundamental objectives. Priority Questions are tiered to the fundamental objectives of the ROD. They are strategic because they will drive learning activities that address key agency decisions and are designed to focus monitoring and research investments over the next 10 years. These questions represent the issues deemed most pressing, both currently and in the future by the RIEC

At the RIEC's request, this annual report summarizes annual accomplishments from monitoring and research activities that tier to Priority Questions. The Priority Questions accomplishments are part of a revised Adaptive Management strategy, and will be reviewed annually by the RIEC to determine if changes in management policies, standards and guides, or priority questions may be warranted. The Monitoring Accomplishments and Research Accomplishment sections are organized by the sixteen Priority Questions.

Regional Management Objective:

Sustain northwest forest and rangelands for a broad spectrum of social, economic and ecological values for present and future generations.

1994 ROD Purpose and Need:

- Provide for healthy forest ecosystems with habitat that will support populations of native species (particularly those associated with late-successional and old-growth forests) and includes protection for riparian areas and waters.
- Produce a sustainable supply of timber and other forest products that will help maintain the stability of local and regional economies on a predictable and long-term basis.
- The agencies must take an ecosystem approach to forest management, with support from scientific evidence, and meet the requirements of existing laws and regulations.
- The agencies must cooperate with all federal agencies.

Strategic Fundamental Objectives

I. Healthy ecosystems
   - Restore watershed condition
   - Maintain and restore old growth habitat
   - Maintain and restore habitats for terrestrial and aquatic species
   - rovide for recovery of listed species
   - Reduce fire risk
   - Reduce risk of loss of habitat from other outside factors(insects, disease, etc)

II. Human dimension and quality of life
   - Produce a predictable & sustainable supply of timber
   - Provide non-consumptive goods and services

Priority Questions

Management questions best answered by monitoring:

- What is the status and trend of watershed condition?
- What is the status and trend of late-successional old-growth?
- What is the status and trend of Northern Spotted Owl habitat?
- What is the status and trend of Northern Spotted Owl populations?
- What is the status and trend of marbled murrelet habitat and populations?
- What is the status and trend of socioeconomic well being?
- What is the status and trend of government-to-government consultation?
- Did we accomplish planned activities and comply with standards and guides?

Management questions best answered by research:

- What is the status and trend of watershed function and how do management actions affect watershed processes and condition?
- How can landscapes be managed to provide for biodiversity and resiliency?
- How effective is federal land management, including the reserve system, in providing for conservation of listed and non-listed species?
- What are the relationships between NSOs, barred owls, and other stressors that will affect populations of NSO?
- What are the relationships between marbled murrelet status & stressors, how does this affect nesting distribution, and can habitat models effectively predict where murrelets nest?
- How is the distribution and abundance of forest habitat changing as a result of climate change and the interactions with fire, insects, disease, and other disturbances?
- What are the effects of fire on ecosystems, and how can restoration activities (pre-fire and post-fire) reduce the adverse risks of fire to ecosystems and communities, and achieve desired forest habitat conditions?
- How well has federal forest management provided for environmental qualities and values associated with late-successional, old-growth, and aquatic ecosystems?

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The federal agencies have developed an effectiveness monitoring program for the areas within the range of the Northern Spotted Owl, encompassing 24.5 million acres of federal land managed by the Forest Service, Bureau of Land Management, and National Park Service in western Washington, Oregon, and northwest California. This monitoring is focused on important regional-scale questions about older forests, listed species (northern spotted owls, marbled murrelets), watershed condition, relations between federal agencies and Tribes, changing socioeconomic conditions in communities closely tied to federal lands, and compliance with meeting Plan standards and guidelines. Monitoring accomplishments are reported below for the management questions best answered by monitoring. Monitoring activities do not directly contribute to the research related questions, and therefore accomplishments for the management questions best answered by research are not reported.

Management Questions Best Answered by Monitoring

What is the status and trend of watershed condition?

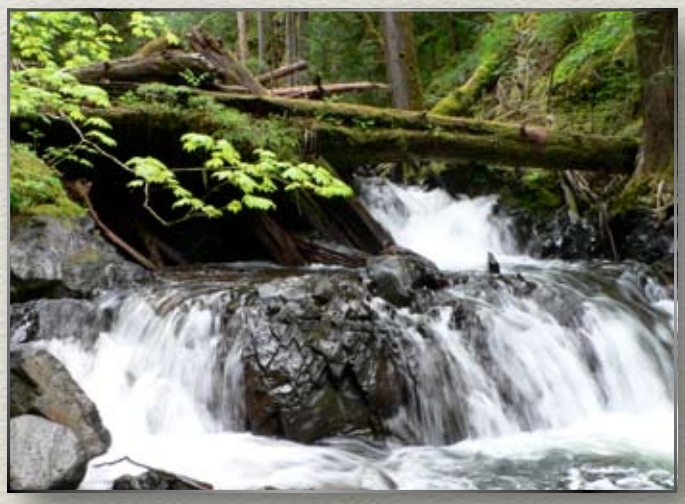
The watershed monitoring module (also known as the Aquatic and Riparian Effectiveness Monitoring Program or AREMP) was developed to determine whether the westside's aquatic conservation strategy is achieving the goals of maintaining and restoring the condition of watersheds.

2006 Accomplishments

Twenty watersheds spread were sampled during 2006 (Figure 1). These watersheds are a subset of the 250 watersheds selected for monitoring over a 5-year period. Data on the physical, biological, and chemical attributes were collected at 4-8 randomly selected sites in each watershed. Twenty trend sites were also surveyed to increase our ability to detect change.

AREMP crews also assisted the Roseburg Bureau of Land Management by providing monitoring for an extensive stream channel restoration project in the Wolf Creek watershed. Field crews sampled 41 reaches within Wolf Creek.

Photo by Steve Lanigan

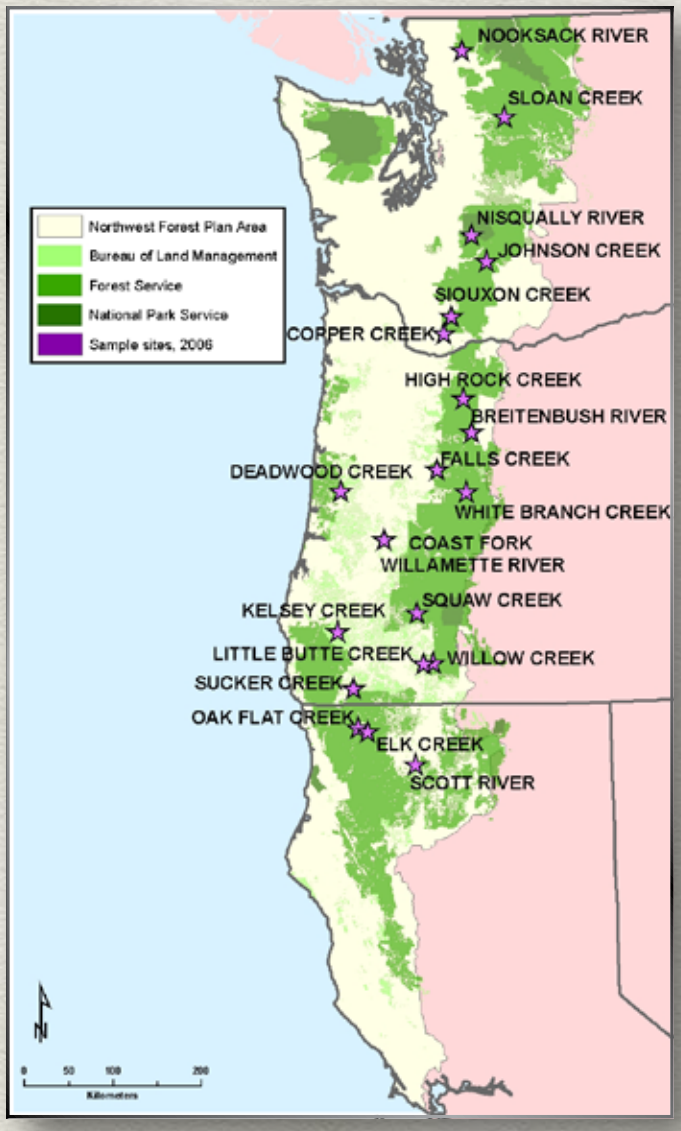


Monitoring Accomplishments

Regional watershed monitoring results for 2006 are available. Watershed condition status for the watersheds sampled in 2006 can be found at the website:

http://www.reo.gov/monitoring/reports/watersheds/aremp/aremp.htm. Reports at this site provide overviews of field (in-channel) data collection methods and calculations performed on the data, GIS data collection methods, the decision-support model used to evaluate watershed condition, and a guide on how to interpret the model results. The overall distribution of watershed condition scores are updated and provided for the Northwest Forest Plan, along with scores for each of the seven aquatic physiographic provinces in the Plan area. An evaluation of watershed condition trends will be done for the 2009 report.

Map of the watersheds surveyed during 2006 summer field season.



Looking Ahead

AREMP staff are continuing to modify the program in response to the RIEC direction to:

- Provide information on the status and trend of watershed condition at spatial scales that range from the 4th-field hydrologic unit to the entire region within a constrained budget.
- Standardize protocols and sample designs so that data can be shared with other state and federal agencies.
- Unify AREMP and PacFish InFish Biological Opinion (PIBO) in order to evaluate watershed condition in a consistent manner across Washington and Oregon.

Staff are addressing the scale issue by developing a "GIS/remote sensing-based monitoring program option" that will assess watershed condition for every watershed using GIS, remote sensing, and field data. A comprehensive review of the attributes collected and their associated protocols are being prepared to determine which attributes to continue to collect that will help meet AREMP program objectives. E Efforts to align AREMP with the PIBO monitoring program continue. These efforts include continuing development of a landslide model to determine the topographic features associated with landslides and the effects of land management on landslide frequency. A key component of this project is assessing how to extend the landslide models used by the Coastal Landscape Analysis and Modeling Study in NWFP monitoring.

The AREMP team leader continues to lead the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) watershed workgroup. The workgroup is continuing the analysis of data from a side-by-side protocol comparison test for in-channel physical attributes in the John Day Basin, Oregon conducted during summer 2005. Eleven different tribal, state, and federal agencies, including AREMP, participated in the test. The goal of the side-by-side protocol comparison test is to determine the best field protocols for assessing a common set of in-channel stream attributes. PNAMP also initiated discussions of developing a multi-agency integrated monitoring program for watershed/stream status and trend monitoring.

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Monitoring Accomplishments

What is the status and trend of late successional old-growth?

All monitoring modules underwent significant program review during 2005-2006. This followed publication of the first 10-yr assessment which yielded several key findings (Moeur and others 2005). Under the plan, late-successional and old-growth forest ecosystems (hereafter called "older forests") and the species dependent on them were to be maintained and restored. It was found through monitoring that older forests were being restored at a rate higher than expected. Amounts of older forest lost to wildfire were in line with expectations (about 1.5% per decade of the amount that existed when the plan was first implemented); but much less (about a tenth as much or .2%) was lost to harvest than was expected to be harvested (about 3% per decade) under Plan implementation.

Based on the knowledge gained from the first 10-yr assessment, the RIEC decided to continue assessing the status and trend of older forests. The use of remote sensing-based mapping of existing forest vegetation and vegetation change, combined with statistical analysis of FIA plot data are used to monitor status and trend of older forests.

2006 Accomplishments

Major progress was made during 2006 in the following areas:

Advances in existing vegetation mapping

An update of existing vegetation was initiated in partnership with a state-federal collaborative effort called the Interagency Mapping and Assessment project (IMAP). This program was highlighted in the 2005 annual monitoring progress report available at http://www.reo.gov/monitoring/report_show.php?show=general. IMAP is a program for building shared data, models, and analysis tools for broad to fine-scale landscape analysis and planning in Washington, Oregon and in the northern portion of California. The shared vegetation data and models create a framework for representing the implications of vegetative succession, management, and natural disturbances. The IMAP modeling process is being adapted for use in a State-wide forest assessment and for National Forest land management planning, as well as to support monitoring. Key issues in these efforts include integrating fire risks, fuel conditions, wildlife habitats, old forests, supply and demand for forest products, and others. The focus will be on using models that are sensitive to ecological setting and that can realistically represent forest succession, historical and current disturbance regimes, and management. The results are designed to be useful at various scales from regional monitoring to forest planning to watershed analysis.

IMAP modeling is supported by the production of a baseline map of existing vegetation using an approach developed by researchers at Pacific Northwest Research Station (PNW). The quantitative accuracy of the IMAP vegetation map has been shown to be as good as, and likely better than, the Interagency Vegetation Mapping Project/Classification and Assessment with Landsat of Visible Ecological Groupings (IVMP/CALVEG) map product (Ohmann and Gregory 2002) used in previous years. In 2006, vegetation maps for central Washington and all of Eastern Oregon, including the Eastern Cascades province, were completed and are under review.

Photo by Tom Spies

Tracking losses of older forest to wildfire will improve under a Remote Sensing Applications Center program to monitor burn severity on an annual basis. Biscuit fire aftermath.

Photo by Rocky Pankratz

Old growth forest

Monitoring Accomplishments

Advances in Change Detection Techniques

In the 10-yr report, acres of older forest and habitat lost to stand-replacing wildfire were reported. The monitoring program is now partnering with the Forest Service's Remote Sensing Application Center (RSAC) to use newly available data on annual fire severity effects. The program, called Monitoring Trends in Burn Severity (MTBS), monitors and maps fires 900 acres and larger in the western United States. The 900-ac threshold accounts for more than 98% of all area burned. Pre-burn and post-burn (one year after the fire) imagery are analyzed to map fire severity and delineate fire perimeters (Schwind and others in press). Three MTBS map products are released to users—a map depicting low, moderate, and high fire severity classes; a map depicting the Normalized Burn Ratio transformation used to detect vegetation change due to fire severity; and the fire perimeters. With annual fire spatial information, and more sensitivity to partial removal of vegetation to wildfire, it will be possible to report older forest and habitat losses yearly, and to more quickly alert managers to important habitat losses. In 2006, the MTBS program mapped fires that occurred in the 2004 fire season. In 2007, all retrospective fires between 1984 and 2003 will be analyzed, and work will begin on fires burning in fire seasons 2005-2006. More information is available at http://svinetfc4.fs.fed.us/mtbs/index.html.

In the 10-yr report (Moeur and others 2005), acres of older forest and habitat lost to stand-replacing harvest activities (due to clearcutting methods) were reported. The satellite-based approach used was not sensitive enough to account for vegetation changes resulting from partial harvest activities, such as thinning (Healey and others 2005). Recent technical advances make it possible to include partial harvest effects in our mapped estimates of vegetation change (Healey and others 2006). It is planned to update the estimates of older forest and habitat loss using imagery to be collected in 2007, providing a five year update of the last mapping cycle conducted in 2002. These results will be reported in the 15-yr assessment to be completed in 2009.

Photo by Tom Iraci

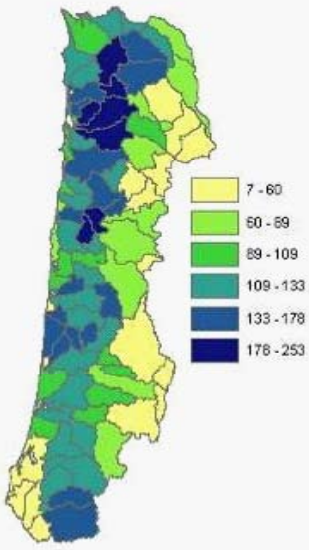
Old growth forest

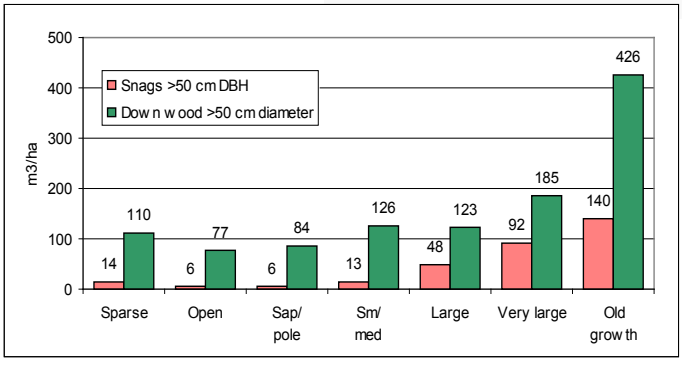
Looking Ahead

Updated existing vegetation maps under IMAP using 2007 imagery will be developed and analyzed for the next reporting cycle due out in 2009. A pilot test using the new methodologies will be conducted in FY2007 using data from the East Cascades and Coast provinces in Oregon. Another cycle of remote sensing change detection for mapping cumulative stand-replacing disturbances will take place using 2007 imagery (the previous cycle ended in 2002-2003).

Contact: Melinda Moeur, LSOG Module Leader, USDA Forest Service, mmoeur@fs.fed.us

Existing vegetation data produced by the IMAP program uses the Gradient Nearest Neighbor developed by researchers at PNW. The map data are derived from inventory plots and have a very rich set of attributes, as demonstrated in this example for Coastal Oregon. For more information, visit http://www.fsl.orst.edu/lemma





Monitoring Accomplishments

What is the status and trend of northern spotted owl habitat? What is the status and trend of northern spotted owl populations?

Photo by Janice Reid

Female spotted owl taking mouse offered by owl surveyor.

The northern spotted owl effectiveness monitoring program provides periodic estimates of the status and trend of the owl's population and habitat on federal lands. Population data are collected annually in each of eight, federal demographic study areas distributed across the range of the owl (figure 1). Biologists attempt to find and mark all spotted owls in these study areas while also gathering information on the age, sex and reproductive status of individual owls. Data from the demographic study areas are analyzed every five years to estimate annual survival, fecundity (number of female young fledged per territorial female) and annual rate of population change (lambda). The last analysis included data compiled through 2003. The next analysis will be completed in early 2009.

The status and trend of owl habitat on federal land is also updated every five years. The habitat analysis uses GIS-compatible data layers on owl locations, vegetation conditions, habitat capability of the federal land, and changes due to wildfire and timber harvest to model habitat suitability over time. A non-spatial assessment is also conducted using data from the current vegetation survey plots on lands administered by the Bureau of Land Management and the Forest Service. The next analysis to assess the habitat conditions as of 2007 is scheduled for completion in 2009.

2006 Accomplishments

No habitat monitoring activities or analyses were conducted in 2006 that would address this monitoring question beyond the information reported in GTR 648 in 2005. Habitat analyses (GTR-648) have produced maps depicting habitat suitability for each physiographic province in the range of the spotted owl. Habitat suitability was displayed for each 0.15-acre pixel where data were available and the lands were classified as being habitat-capable (forested lands below the elevation limits where most territorial spotted owls are know to nest). These habitat suitability and habitat-capable maps were used to assess the general abundance and distribution of owl habitat in the recent spotted owl recovery planning effort sponsored by the Fish and Wildlife Service. These maps are also being used in the development of a federal, interagency, regional assessment of fire risk relative to habitat in the dry forest areas of the owl's range.

During the 2006 field season, biologists surveyed 1161 sites (table 1). Occupancy by a pair of spotted owls was recorded at 41 percent of the sites. This is the lowest annual occupancy observed in the last six years. The average annual pair occupancy from 2001-2005 was about 49 percent. The count of young fledged during 2006 was 167, considerably less than the average of 380 young fledged per year over the previous five years. It is similar to the low of 166 fledglings noted in 2003. A year of observed low reproduction periodically is not unusual. No population status and trend analyses were conducted in 2006. The next population analyses will be done at the end of the 2008 field season.

Looking Ahead

Occupancy and reproduction data gathering will be continued in the demographic study areas during the 2007 field season. In addition, there will be a pilot test of a random plot methodology to assess the efficacy and cost of this protocol for monitoring owl populations. The test areas will be located on lands in the Wenatchee National Forest in Washington and Willamette National Forest in Oregon. The methodology, along with results from the pilot, will be peer reviewed and submitted to the federal managers for consideration as they chart the future of spotted owl monitoring on federal lands.

On the habitat side, another pilot test will assess model algorithms to be used to assess habitat conditions using the new vegetation base map being created for the range of the owl under the Interagency Mapping and Assessment Program (IMAP).

Contact: Joe Lint, NSO Monitoring Module Leader, Bureau of Land Management, joseph_lint@or.blm.gov

Monitoring Accomplishments

Table 1. Summary of northern spotted owl occupancy and reproduction by demography area for 2006. These are preliminary data; values may change in the final analysis.

Demographicarea	Sites surveyed (number)	Sites with a territorial pair (number)	(%)	Females Nesting (%)	Young Fledged (number)
Olympic Peninsula	98	30	30.6	85.0	29
Cle Elum	72	17	23.6	94.0	17
H.J. Andrews	166	81	48.8	21.0	20
North Coast	204	62	30.3	6.0	2
Tyee	198	71	35.8	22.0	13
South Cascades	169	75	44.4	39.0	30
Klamath	162	89	54.9	35.9	34
Northwestern California	92	48	52.2	34.0	22
TOTALS	**1161**	**473**	**40.7**	____	**167**

Figure 1. Northern spotted owl demographic study area.

Photo by Jared Hobbs

Barred owls continue to be detected during demography surveys.

Monitoring Accomplishments

What is the status and trend of marbled murrelet habitat and populations?

Photo credit: Josh London, Washington Dept. of Fish and Wildlife

Marbled murrelet in breeding plumage, in waters off Washington

The purpose of the effectiveness monitoring program for the marbled murrelet is to assess population trends and to determine characteristics and trends of suitable murrelet nesting habitat.

Information gathered for this assessment is used to help managers maintain and restore marbled murrelet habitat and populations on federal lands. Effectiveness monitoring for marbled murrelets has two facets: (1) assess population trends at sea using a unified sampling design and standardized survey methods and (2) establish a credible estimate of baseline nesting-habitat data by modeling habitat relations, and use the baseline to track habitat changes over time.

An effectiveness monitoring plan for the marbled murrelet was developed in 1999, which proposed long-term monitoring of at-sea populations and developing predictive models for estimating nesting habitat. The murrelet monitoring plan is available at: http://www.fs.fed.us/pnw/pubs/gtr_439.pdf. Population monitoring is based on estimates of the at-sea murrelet populations, for the coastal waters adjacent to the Plan area, in Washington, Oregon and northern California. A team of cooperating scientists conduct surveys for murrelets from boats along line transects in those coastal waters, during the murrelet breeding season. The transect data are used to generate population estimates, for each of five zones (based on Conservation Zones identified in the Marbled Murrelet Recovery Plan, Figure 2), and for the five -zones combined

To monitor the amount and distribution of murrelet nesting habitat, initial habitat analyses applied habitat suitability models to remotely-sensed and field-collected data. This effort established a baseline for murrelet nesting habitat 1994, and evaluated changes for the period ending in 2003. Future habitat analyses will occur at regular intervals to track habitat changes over time, with the next analysis planned for 2008-2009. Findings of the habitat and population monitoring program through 2003 were published in 2006 by the U.S. Forest Service Northwest Research Station, as General Technical Report number 650.

2006 Accomplishments

Field work focused on sampling to develop a population estimate for 2006, the seventh consecutive year of population sampling under the effectiveness monitoring program. In 2006, about 7,900 km^2 of coastal waters were sampled. Four teams collected the data, each focusing on one of four sampling zones (Zones 1 through 4, Figure 3).

A fifth zone which was surveyed in previous years, Zone 5, was not sampled in 2006 due to logistical constraints. Previous sampling showed Zone 5 to contain less than one percent of the murrelet population in the area, thus little information was lost by this one-year gap in sampling Zone 5. The average population estimate for Zone 5, based on 2000-2005 data, is about 145 murrelets (range 79-289).

The 2006 marbled murrelet at-sea population estimate was about 18,800 birds off the coast of the Plan area (Conservation Zones 1 through 5), with a 95% confidence interval for this estimate of about 15,900 to 21,700 birds (Table 2). The 2006 estimate was about 7 percent and 9 percent lower than the 2005 and 2004 estimates, respectively, and about 16 percent lower than the 2003 population estimate. The 18,800 estimated number includes an estimated 145 birds for Zone 5. While the 2006 estimate is lower than estimates for the previous 3 years, the 2006 population estimate falls within the 95% confidence intervals for population estimates for all other survey years, from 2000 to 2005. This, combined with the normal variations in murrelet population estimates, argues for caution in interpreting data from a few years, until a formal population trend analysis is conducted.

Over the 7 years of sampling, Conservation Zones 3 and 4 had the highest murrelet densities at the zone scale, and Zone 5 the lowest (figure 4). Population density varied among years and conservation zones, but showed only small annual changes at the scale of the Northwest Forest Plan area ("Zones 1-4 Combined" in figure 3).

Population demographic models have predicted population declines in the range of 3 to 7 percent per year, within the Plan area. The 2000-2006 population estimates are not consistent with a 7 percent annual decline over this period. The data, however, are not sufficient to detect lower rates of population decline, in the range of 2 to 5 percent per year, with confidence. Additional years of population monitoring will be needed to test for changes in murrelet populations of this magnitude, with a robust level of statistical confidence. For example, statistical power analyses indicate that sampling through 2008 would be needed to detect a 5 percent annual change at the spatial scale of the five-zone population estimate, with 95% confidence.

Table 2. Summary of marbled murrelet population estimates for the 2000-2006 breeding seasons, for the waters adjacent to the Northwest Forest Plan area.

Year	2006	2005	2004	2003	2002	2001	2000
Population Estimate	18,800	20,200	20,600	22,200	23,700	22,200	18,600
95% confidence interval for population estimate (+/-)	2,900	4,300	4,600	4,200	5,300	4,600	5,200

Looking Ahead

Monitoring of murrelet populations will continue in 2007. After 2007 population estimates are developed, the program plans to evaluate the 2000-2007 data for population trends. At the request of the RIEC, the population monitoring team is evaluating potential modifications to the sampling design that would reduce the effort and cost of population monitoring, while continuing to answer monitoring questions with statistical robustness. Results and recommendations will be presented to managers, who will decide on modifications, if any, to the current sampling design. The next analysis of nesting habitat status and trends will occur in 2008-2009, and will report on murrelet nesting habitat conditions after 15 years. Analytical methods may be refined based on results of the pilot program. The monitoring team met in 2006 to plan for this analysis, and will participate in a 2007 pilot test of the new vegetation data base (IMAP). The pilot will provide information on how to most effectively use the new vegetation data in habitat suitability models, to assess the amount and distribution of murrelet nesting habitat. Those models may be refined for the 2008 habitat analysis, based on results of the pilot program.

Contact: Gary Falxa, Marbled Murrelet Monitoring Module Lead, U.S. Fish and Wildlife Service, gary falxa@fws.gov

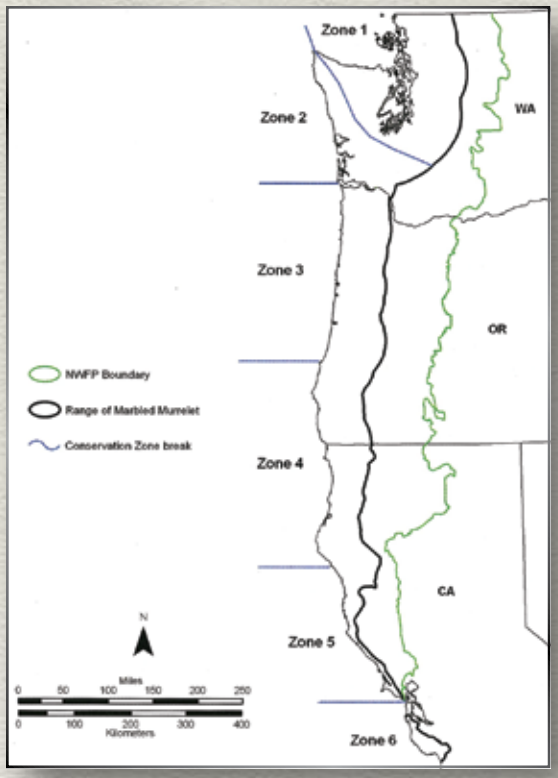
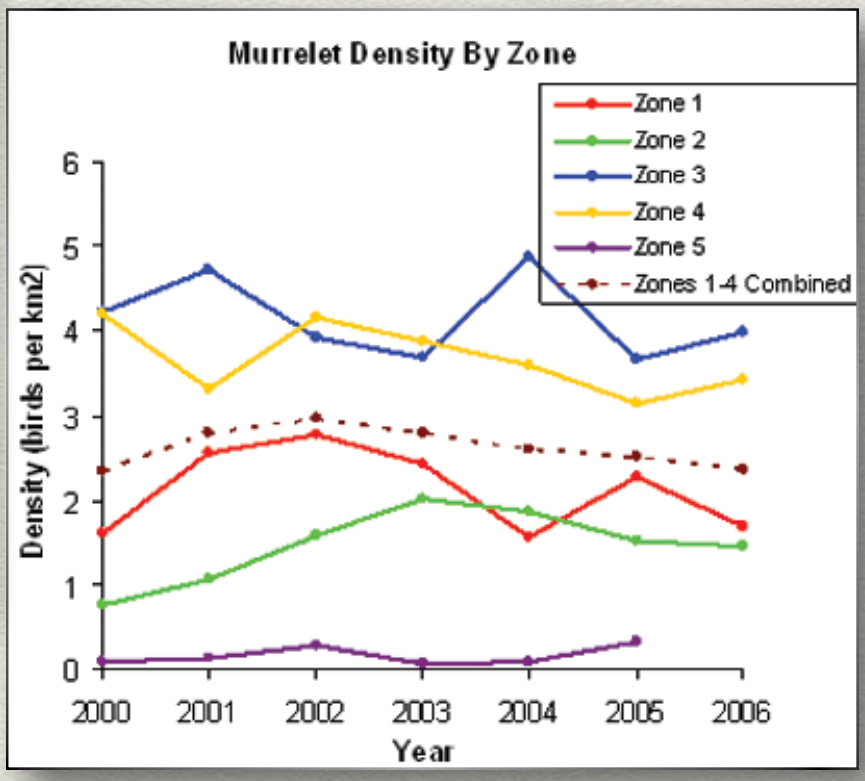


Figure 2. Marbled murrelet conservation zones, as in the recovery plan for this species (USDI Fish and Wildlife Service 1997). Zone 6 is not part of the Northwest Forest Plan.

Figure 3. Marbled murrelet population density (birds/km²) by conservation zone, for 2000-2006.



Monitoring Accomplishments

What is the status and trend of socioeconomic well being?

The purpose of the Socioeconomic Monitoring Module is to evaluate progress in meeting the Plan's socioeconomic goals. During the first decade of the Northwest Forest Plan, the Socioeconomic Monitoring Module focused on two questions posed in the Record of Decision (ROD). The questions are: 1) Are predictable levels of timber and non-timber resources available and being produced? 2) Are local communities and economies experiencing positive or negative changes that may be associated with federal forest management?

2006 Accomplishments

In 2006, the Northwest Forest Plan Socioeconomic Monitoring Team refined and published more than a dozen papers, reports, and peer-reviewed journal articles that explore and offer answers to the questions posed in the ROD. The publications include a six-volume set of General Technical Reports (GTRs) that provide detailed analyses of the data collected by the Team. They present a series of status and trend reports, a synthesis of all regional monitoring and research results, a report on interagency information management, and a summary report. The topics covered include timber and nontimber resources, rural communities and economies, public values and forest management, as well as program development and future directions. In addition to the above mentioned reports, the Team also produced peer-reviewed journal articles. One article discusses the Northwest Forest Plan as a model for broad-scale ecosystem management from a social perspective and the other describes socioeconomic change in the Region.

Looking Ahead

During 2007, the Socioeconomic Monitoring Team is documenting the protocol used for socioeconomic monitoring during the first decade of the Northwest Forest Plan. In addition, the Team's focus is shifting from the two questions posed in the ROD to a broad and more integrated single monitoring question: What is the status and trend of socioeconomic well being? To answer this question, the Team is developing a new socioeconomic monitoring protocol designed to monitor socioeconomic trends using existing data based on direction from the Regional Interagency Executive Committee. Among the existing data sources are: U.S. Census, Department of Labor Statistics, and Forest Service and Bureau of Land Management. Members of the Team are comparing the strengths and weaknesses of the two protocols.

Contact: Elisabeth Grinspoon, Socioeconomic Monitoring Module Leader, USDA Forest Service, egrinspoon@fs.fed.us

Photo by Susan Charnley

Photo by Susan Charnley

Scott Valley, CA (Area bordered by the Klamath National Forest)

Monitoring Accomplishments

What is the status and trend of government-to-government consultations?

The tribal monitoring program is designed to evaluate the unique government-to-government relationship between federal land managers and tribal governments in the Plan area. A total of 76 federally recognized tribes consult with land managers in the Plan area about resources, places of interest, and the quality of the federal-tribal relationship. Key issues addressed by tribal monitoring includes the conditions and trends of resources protected by treaty or of interest to American Indian tribes, access to those resources, condition of and access to sites of religious and cultural heritage, and the quality of the government-to-government relationship.

2006 Accomplishments

During 2006 the tribal monitoring team published the report entitled "The First 10-Years (1994-2003) - Effectiveness of the Federal-Tribal Relationship". Team members are working with the Tribal Monitoring Advisory Group to refine the Tribal monitoring protocol based upon lessons learned through the 2002–2005 monitoring efforts.

Looking Ahead

During 2006 and continuing into 2007 team members are working with the Tribal Monitoring Advisory Group (Chartered by the Intergovernmental Advisory Committee) to further refine the Tribal monitoring protocol. The protocol is being built upon lessons learned through the 2002–2005 monitoring efforts, and reflects the REIC direction to monitor: "What is the status and trend of government-to-government consultation?"

Contact: Gary Harris, Tribal Monitoring Module Leader, USDA Forest Service, grharris@fs.fed.us

Citations: Stuart, C. and Martine, K.., tech. eds. [2006]. Northwest Forest Plan—the first 10 years (1994-2003): Effectiveness of the Federal-Tribal Relationship. Tech. Paper R6-RPM-02-2006. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 53 p.

Photo by Ken Wilson

Tribal basket handicrafts.

Monitoring Accomplishments

Did we accomplish planned activities and comply with standards and guides?

Implementation monitoring is used to determine if planned activities and their associated standards and guides are being followed. In the past, a regional implementation monitoring program conducted from 1996-2005 documented high overall compliance in meeting Northwest Forest Plan and Record of Decision standards and guidelines. For example, overall compliance in the summer of 2005 was 97%.

2006 Accomplishments

A general review of all the monitoring modules for the Northwest Forest Plan, including the Implementation Monitoring Module, occurred in 2006. Due to the high overall levels of compliance, the Regional Interagency Executive Committee (RIEC) decided to discontinue regional-level implementation monitoring and invest limited monitoring resources on other priorities.

Looking Ahead

Annual monitoring continues to be an important activity at the local level and is reported in District and Forest monitoring reports.

Contact: Shawne Mohoric, US Forest Service, Region 6, smohoric@fs.fed.us

Photo by Steve Lanigan.

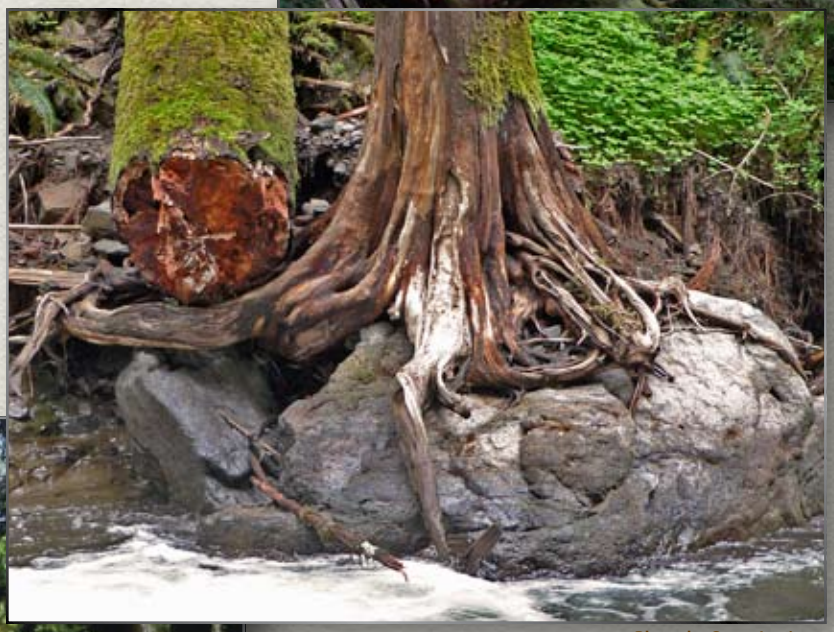
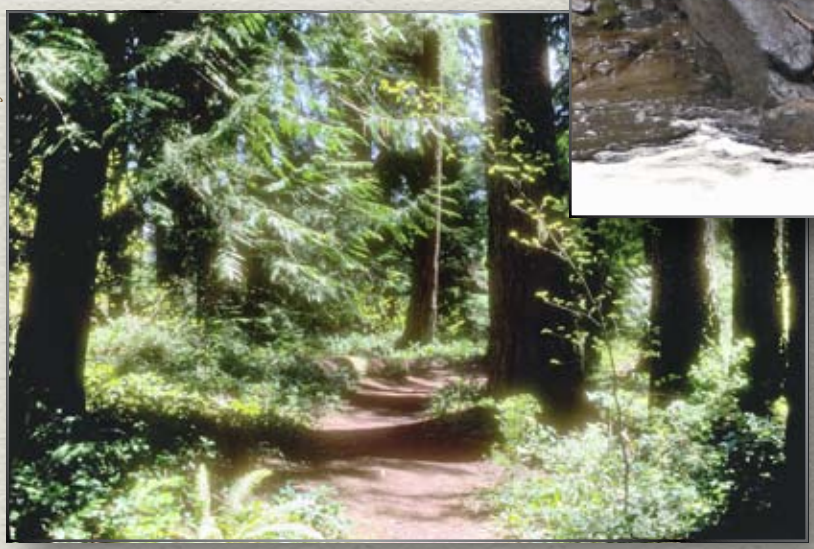


Photo by Steve Lanigan.

Photo by Tom Iraci.



Old growth forest.

Research Accomplishments

The major research organizations supporting implementation of the Northwest Forest Plan are: the Pacific Northwest and Pacific Southwest Research Stations of the USDA Forest Service, the Forest and Rangeland Ecosystem Science Center of the U.S. Geological Survey, the Pacific Northwest Ecosystem Management Research Program of the Environmental Protection Agency, and the Oceanic and Atmospheric Research Office of the National Oceanic and Atmospheric Administration. These research agencies provide valuable input to the RIEC including sharing key science findings, providing interpretations, and assisting with the development and implementation of regional monitoring activities.

The NWFP research agencies conduct individual research on a variety of biological, ecological, and socioeconomic topics of importance to the Pacific Northwest. The RIEC provides a forum for the research agencies to share their individual agency research results, and solicit input from the management and regulatory agencies on their future research needs. The development of the Priority Questions provides a direct mechanism for the research agencies to highlight research findings to the RIEC. The process also promotes opportunities for the research agencies to collaborate on future research to provide research products addressing the key issues facing the management agencies.

This report provides a brief snapshot of the research contributions to all of the Priority Questions and is not intended to summarize all research activities. Additional information on related topics can be obtained from the individual research agency offices and their websites. Research accomplishments generally contribute to answering Priority Questions as research has not been specifically designed to address the Priority Questions.

Management Questions Best Answered by Monitoring

What is the status and trend of watershed condition?

Improved model better identifies likely sources of landslides

The impact of landslides on fish has long been a source of debate. Some regard them as undesirable disturbances, whereas others point to recent studies that show deposition of wood and sediment from landslides may improve fish habitat. Scientists enhanced a model now referred to as the "western Oregon" model, that both identifies probable sites where landslides may begin and assesses their likelihood to reach fish-bearing streams. The model allows users to estimate the amount of wood a landslide may introduce into a stream based on vegetation conditions surrounding the stream channel. This model allows managers to determine which sites have the greatest potential for introducing materials into fish-bearing streams. With this knowledge, managers can tailor activities to reduce the negative effects of landslides and promote their potential positive effects for streams and fish.

Contact: Kelly Burnett, US Forest Service, Pacific Northwest Research Station, kmburnett@fs.fed.us

Partners: Earth Systems Institute; USDI Bureau of Land Management

Citations: Miller, D.J. and K.M. Burnett. in press. An empirical model to characterize debris-flow delivery to streams. Geomorphology.

Miller, D.J. and K.M. Burnett. in press. Effect of forest cover, topography, and sampling extent on the measured density of shallow, translational landslides. Water Resources Research.

Photo by Steve Lanigan.

Research Accomplishments

Evaluation of watershed conditions using reference sites has been developed

A new approach is used to evaluate conditions of watersheds at a range of scales using reference sites. Reference sites provide a wealth of data that describe interactions of watershed and ecological processes.

Contact: Tom Lisle, US Forest Service, Pacific Southwest Research Station, tlisle@fs.fed.us

Partners: US Geological Survey; Humboldt State University; Redwood Regional Watershed Center

For additional information: www.fs.fed.us/psw/topics/water/

Citations: Lisle, T. E., K. Cummins, and M. A. Madej. in press. An examination of references for ecosystems in a watershed context: results of a scientific pulse in Redwood National and State Parks, California. *in* M. Furniss and M. McCammon, editors. Advancing the Fundamental Sciences-A Conference for Forest Service Physical Scientists. USDA Forest Service.

Scientists identify landscape characteristics that influence salmon habitat features

To determine the influence landscape characteristics exert on the development of salmon habitat, scientists surveyed stream segments in the Elk River in southwest Oregon. They found that the depth and volume of pools in the stream segments, features important to juvenile salmon, were more strongly related to the amount of land area draining into the stream than to type of forest management. In contrast, the average density of large wood in the pools was at least partially an indicator of forest management. (Large wood is a key salmon habitat component.) The amount of large wood in the streams increased with the size of the trees in the surrounding forest. The identification of specific landscape characteristics that may affect salmon habitat is critical to forest planning and habitat restoration activities. The Aquatic and Riparian Effectiveness Monitoring Program is using approaches developed by the scientists to reduce monitoring costs. When landscape characteristics can be linked to habitat conditions, as this study has shown, fewer field studies are needed.

Photo by D. Baker.

In-stream structure (large wood) to enhance fish habitat, Willamette Province.

Contact: Kelly Burnett, US Forest Service, Pacific Northwest Research Station, kmburnett@fs.fed.us

Partners: Oregon State University; USDA Forest Service, Pacific Northwest Region; USDI Bureau of Land Management

Citations: Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17: 66-80.

Coho salmon benefit from intermittent streams

During the dry summer months, some streams in the region stop flowing and become isolated pools disconnected from their source. These streams flow again during fall, when precipitation increases. Scientists found that these intermittent streams are important habitat for coho salmon in the Oregon Coast Range. The standing pools left in these streams offer high-quality habitat and abundant food resources to fish, such as coho salmon. Juvenile coho salmon survived in these pools during summer and returned to the mainstem when fall rains increased waterflow. Juvenile fish that spent winter in these streams had higher survival rates and were larger than fish reared in the mainstem, owing to the habitat conditions and food intermittent streams provided. Adult coho salmon, too, benefit from intermittent streams. Ten to twenty percent of the adult fish that spawned in the study area did so in intermittent streams. Results from this study are providing management and regulatory agencies with a basis for developing practices and policies that promote intermittent

streams. Knowledge of the importance of these streams also may help establish criteria for prioritizing culvert replacements.

Contact: Bruce Hansen, US Forest Service, Pacific Northwest Research Station, bhansen@fs.fed.us

Partners: Oregon Department of Fish and Wildlife; Oregon State University; USDI Bureau of Land Management; U.S. Environmental Protection Agency

Citations: Ebersole, J.L., P.J. Wigington, Jr., J.P. Baker, M.A. Cairns, M. Robbin, B.P. Hansen, B.A. Miller, H.R. LaVigne, J.E. Compton, and S.G. Leibowitz. 2006. Juvenile coho salmon growth and survival across stream network seasonal habitats. Transactions of the American Fisheries Society 135: 1681-1697.

Survey design principles have been developed to facilitate integrating stream monitoring data

Multiple agencies in the Pacific Northwest monitor the condition of stream networks or their watersheds. Some agencies use a stream "network" perspective to report on the fraction or length of the network that either meets or violates particular criteria. Other agencies use a "watershed" perspective to report on the health or condition of watersheds. The agencies often use the same indicators and measurement protocols for data collection and often conduct monitoring in overlapping geographic regions. In these situations, agencies would like to combine data across different monitoring studies in a statistically sound manner to make regional estimates of condition. Three statistical survey design principles will facilitate combining such studies: (1) a clearly specified statistical target population of interest, including elements that comprise the population, (2) a consistent representation of that target population (such as a digital map of the stream network and watersheds), and (3) rules that incorporate randomization to guide the selection of the sample of sites on which measurements will be made. A case study illustrates the application of these design principles using two agency monitoring programs interested in combining stream channel data for different purposes: one for making network summaries and the other for evaluating watershed condition.

Contact: Anthony Olsen, Environmental Protection Agency, Olsen.tony@epa.gov

Partners: Environmental Protection Agency; US Forest Service; US Geological Survey; Oregon State University

For additional information: http://www.epa.gov/nheerl/arm/

Citations: Larsen, D.P., et al, 2007. Sound survey designs can facilitate integrating stream monitoring data across multiple programs. Journal of The American Water Resources Association, 43:2: 384- 397.

Photo credit Steve Lanigan.

Research Accomplishments

What is the status and trend of late-successional old-growth?

Database provides reference data on old-growth characteristics

Accelerating the development of old-growth, or late-successional, characteristics in young forests through management techniques often is complicated by the lack of clear structural targets. Clear and specific guidelines for stand structure have not been available for managers. Scientists created a database to provide managers with the structural targets they need. The database features information gathered from over 16,000 acres of old-growth forest in western Oregon, consisting of measurements of all conifers greater than 1 foot in diameter on nearly 600 forest sites. The database provides managers with an estimate of the total number of trees per acre in this vast and structurally varied area as well as the diameter classes of 13 species. Using the database, managers can find old-growth stands close to the young stands they are managing and use the complexity and structure of the old forest as a guide.

Contact: Paul D. Anderson, US Forest Service, Pacific Northwest Research Station, pdanderson@fs.fed.us

Partners: USDI Bureau of Land Management; US Geological Survey, Forest and Rangeland Ecosystem Science Center

Additional information: BLM Late-Successional and Old-Growth Conifer Data Series. http://fresc.usgs.gov/ArcIMS/Website/lsog/viewer.htm

Citations: Poage, N.J. 2005. Variability in older forest structure in western Oregon. U.S.Geological Survey, Scientific Investigations Report 2005-1385. 28 p.

Photo by Doug Huntington. Baker.

For young forests, thinning and underplanting may promote old-growth features

Throughout the Pacific Northwest, portions of federal land are being managed to promote the development of habitat for the threatened northern spotted owl and other species associated with old-growth forests. For hundreds of thousands of acres in the region's Coast Range, this involves converting young forests to more complex structures. In 1992, Station scientists began a study to evaluate whether the development of old-growth characteristics in young, Douglas-fir-dominated forests could be promoted through thinning and underplanting. Thinning, especially, is increasingly used by managers to increase diversity in forest structure. Scientists found that Douglas-fir and western hemlock seedlings underplanted in thinned stands grew, but the same species underplanted in unthinned stands frequently died. Seedlings in the thinned stands also grew taller and were more vigorous than surviving seedlings in unthinned stands. Shrubs initially decreased after thinning, but recovered to prethinning levels in 5 years. Managers on the Siuslaw National Forest have used these results to create a local version of the Forest Vegetation Simulator, a program that simulates forest growth and yield under a variety of conditions.

Contact: Paul D. Anderson, US Forest Service, Pacific Northwest Research Station, pdanderson@fs.fed.us

Photo by Rocky Pankratz.

Partners: Oregon State University; USDA Forest Service

Citations: Chan, S.S., D.J. Larson, W.H. Emmingham, K.G. Maas-Hebner, S. Johnston, and D. Mikowski. 2006. Thinning effects on overstory and understory development in young Douglas-fir stands in the Oregon Coast Range, USA. Canadian Journal of Forest Research 36: 2696-2711.

Maas-Hebner, K.G., W.H. Emmingham, D.J. Larson, and S.S. Chan. 2005. Establishment and growth of native hardwood and conifer seedlings underplanted in thinned Douglas-fir stands. Forest Ecology and Management 208: 331-345.

Stand structure attributes of east-side old-growth ponderosa pine forests in central Oregon and northern California can be used to guide and evaluate treatments

Low-elevation ponderosa pine forests east of the Cascade Range crest in Oregon and northern California have changed substantially in the last 100 years. To develop a set of old-growth reference conditions for managers, scientists studied the age, size structure, and spatial patterns of old-growth ponderosa pine forests at three protected study areas. The oldest trees were 618 years old and stands were multi-aged. Density of old-growth ponderosa pine in the upper canopy averaged 20 trees per acre with average diameter of 24 inches at breast height. Large dead ponderosa pines were common at all three study areas, averaging 4 per acre. The most common spatial pattern of upper canopy trees was a clumped distribution. Density of downed logs was 19 logs per acre, and most logs were decomposing, suggesting that they had been down for many years. Managers can use these reference conditions as a guide in projects to restore ecological integrity of ponderosa pine forests (including frequent surface fires) and projects to develop late-successional and old-growth characteristics. The reference conditions are used by Lassen National Forest and Klamath, Modoc, and Yahooskin Tribes (Klamath Tribes) in northern California and southern Oregon to guide development of a management plan for the nearly 700,000-acre Klamath Reservation Forest.

Contact: Andrew Youngblood, US Forest Service, Pacific Northwest Research Station, ayoungblood@fs.fed.us

Partners: US Forest Service, Deschutes National Forest; US Forest Service, PSW Research Station

Citations: Youngblood, A.; Max, T.; Coe, K. 2004. Stand structure in eastside old-growth ponderosa pine forests of Oregon and northern California. Forest Ecology and Management 199:191-217.

What is the status and trend of northern spotted owl habitat?

Research agencies have no completed contributions to this question during this reporting cycle. See Monitoring Accomplishments, section (page 8).

What is the status and trend of northern spotted owl populations?

Research agencies have no completed contributions to this question during this reporting cycle. See Monitoring Accomplishments, section (page 8).

Photo by D. Baker.

Density management, E. Washington Cascades Province.

Research Accomplishments

What is the status and trend of marbled murrelet habitat and populations?

Photo by Josh London, Washington Dept. of Fish and Wildlife.

Marbled murrelet in breeding plumage, in waters off Washington.

Monitoring marbled murrelet abundance with population surveys

One objective of the Marbled Murrelet Effectiveness Monitoring Plan for the Northwest Forest Plan (the Plan) is to monitor changes in marbled murrelet abundance throughout the Plan area, by using a unified and scientifically valid sampling design. Population monitoring surveys from 2000 to 2003 estimated a population of 22,200 murrelets with a 95 percent confidence interval of 18,100 to 26,400. We estimated the highest density of birds at the zone level over all 4 years to in zone 3. We observed the lowest densities of birds, 0.14 to 0.73 birds per square mile in zone 5. In 2006, we estimated 18,622 murrelets with a 95 percent confidence interval of 15,861 to 21,563. Our results did not detect a decrease in the size of the target population over the first 4 years of monitoring at the 5 percent significance level. Our measure for assessing this monitoring program is its power to detect changes in the mean density (and the resulting mean total population) of murrelets over time. When all of the zones are combined, we would have an 80- to 95-percent chance of detecting a 3- to 4-percent annual decrease with a 10-year sampling period.

Contact: Sherri L. Miller, US Forest Service, Pacific Southwest Research Station, smiller02@fs.fed.us

Partners: US Forest Service, Pacific Northwest Research Station; U.S. Fish and Wildlife Service; Crescent Coastal Research; Washington Department of Fish and Wildlife; Oregon Department of Fish and Wildlife.

Additional information: http://www.reo.gov/monitoring/reports/10yr-report/marbled-murrelet/index.html

Citations: Huff, Mark H., Martin G. Raphael, Sherri L. Miller, S. Kim Nelson, and Jim Baldwin, technical coordinators. 2006. Northwest Forest Plan – The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the Marbled Murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture; 149 p.

Miller, Sherri L., C. John Ralph, Martin G. Raphael, Craig Strong, Christopher W. Thompson, Jim Baldwin, Mark H. Huff, and Gary A. Falxa. 2006. Chapter 3: At-sea monitoring of Marbled Murrelet population status and trend in the Northwest Forest Plan Area. Pp. 31-60 in Mark H. Huff, Martin G. Raphael, Sherri L. Miller, S. Kim Nelson, and Jim Baldwin, technical coordinators. 2006. Northwest Forest Plan – The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the Marbled Murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture.

Models predict suitable nesting habitat for marbled murrelet

The nesting marbled murrelet habitat monitoring has two themes, presented as questions that apply to U.S. Forest Service and Bureau of Land Management lands in the Plan area: (1) What is marbled murrelet nesting habitat? (2) What is the amount of potential of nesting habitat at varying analysis scales? The inland murrelet survey location data was used to develop logistic regression equations to predict nesting sites that had habitat attributes similar to those of occupied sites. These equations were used to estimate odds ratios (transformed to a scale of -1 to 1) of inventory grid locations as nesting habitat based on vegetation and spatial data available for them, and estimated the amount of feder-

Photo by Monique Lance, Washington Dept. of Fish and Wildlife.

Marbled murrelet population survey crew, Washington.

Research Accomplishments

Photo by Aaron Barna, U.S. Forest Service, PNW Research Station.

Two marbled murrelets, one in foreground is in breeding plumage, in waters off Washington.

al land in habitat suitability classes at the Plan, state, and physiographic province scales; by reserved and nonreserved land allocations; and by marbled murrelet inland management Zones 1 and 2. The experimental models predicted that murrelet occupancy is more likely at sites that are closer to the sea, are on relatively flat terrain, are topographically cooler, have relatively fewer conifers above pole size, have greater basal area of trees above pole size, and that have greater basal area of larger-diameter trees. It was estimated that only 13 percent of U.S. Forest Service and Bureau of Land Management land had an even chance or better of being suitable nesting habitat. Washington had the highest proportion of federal land in the high suitability class for nesting, 7.4 percent; Oregon had 3.5 percent and California 4.8 percent. By physiographic province, the largest amount of high-suitability nesting habitat was in the Oregon Coast Range and Olympic Peninsula. Washington had the highest proportion of high suitability nesting habitat in federal reserves, 16.9 percent.

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Partners: US Forest Service, Pacific Northwest Research Station; U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife.

Additional information: http://www.reo.gov/reports/10yr-report/marbled-murrelet/index.html

Citations: Huff, Mark H., Martin G. Raphael, Sherri L. Miller, S. Kim Nelson, Jim Baldwin, Richard D. Young, Martin Brown, and Diane Evans-Mack. 2006. Chapter 4: Estimating the amount of Marbled Murrelet nesting habitat on federal lands by using a systematic grid sampling strategy. Pp. 61-96 in Mark H. Huff, Martin G. Raphael, Sherri L. Miller, S. Kim Nelson, and Jim Baldwin, technical coordinators. 2006. Northwest Forest Plan – The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the Marbled Murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture.

What is the status and trend of socioeconomic well being?

Research agencies have no completed contributions to this question during this reporting cycle. See Monitoring Accomplishments, section (page 13).

What is the status and trend of government-to-government consultation?

Research agencies have no completed contributions to this question during this reporting cycle. See Monitoring Accomplishments, section (page 13).

Did we accomplish planned activities and comply with standards and guides?

Research agencies have no contributions to this question during this reporting cycle. See Monitoring Accomplishments, section (page 14).

Photo by Jim Barry.

Photo by Tery Tuttle

Management Questions Best Answered by Research

What is the status and trend of watershed function and how do management actions affect watershed processes and condition?

Relatively narrow buffers can mitigate effects of upslope commercial thinning on near-stream microclimate in headwater riparian areas

The influence of riparian buffer width and thinning treatments on riparian microclimate was evaluated at sites across western Oregon. Through five–years following initial thinning of young Douglas-fir forests to various densities, riparian buffers prevented substantial change in near-stream air temperature and relative humidity. For thinned stands, summer mean daily air and soil temperature maxima increased, and mean daily humidity minima decreased with distance from stream. Microclimate gradients were strongest within 10 m of stream center, a distinct area of stream influence within broader riparian areas. Thinning resulted in subtle changes in microclimate as mean air temperature maxima were 1 to 4°C higher than in unthinned stands. With buffers 15 m or greater width, daily maximum air temperature above stream center was less than 1°C greater, and daily minimum relative humidity was less than 5% lower than for unthinned stands. In contrast, air temperatures were significantly warmer within patch openings and within buffers adjacent to patch openings than within unthinned stands. Buffers of widths defined by the transition from riparian to upland vegetation or topographic slope breaks appear sufficient to mitigate the impacts of upslope thinning on the microclimate above headwater streams.

Photo by A. Henning.

Upland habitat restoration, SW Oregon Province.

Contact: Paul Anderson, US Forest Service, Pacific Northwest Research Station, pdanderson@fs.fed.us

Partners: USDI Bureau of Land Management; Oregon State University

Citation: Anderson, P.D., D.J. Larson, and S.S. Chan. 2007. Riparian buffer and density management influences on microclimate of young headwater forests of western Oregon. Forest Science 53(2):254-269.

Small mammals and amphibians showed varied responses to headwater stream buffers after forest harvest

Forest-floor small mammals and stream/land amphibians showed varied responses to headwater stream buffers after timber harvest. Overall, small-mammal diversity increased in the patch-cut and no-buffer treatments, but particular species had differing population responses, with populations increasing for some species and declining for others. For amphibian responses, seven land species were found, but only western red-back salamanders were common. Neither red-backed salamanders nor total land amphibian numbers differed significantly by buffer type. Four aquatic and five streambank amphibian species were found. In the year after treatments, overall amphibian detections dropped in harvested sites, but the amount of change was not statistically different from amount of change in control sites. Populations declined for all stream amphibian species after timber harvest. These findings will be used by the Washington Department of Natural Resources in developing a long-term

Photo by Steve Lanigan.

Amphibian searches were done along the side of each sampled stream reach..

Photo by D. Baker.

Watershed assessment area, Willamette Province.

conservation strategy for headwater streams as part of a habitat conservation plan for state forest lands in Washington.

Contact: Randall Wilk, US Forest Service, Pacific Northwest Research Station, rwilk@fs.fed.us

Partners: Washington Department of Natural Resources

Citations: Wilk, R. J., and M. G. Raphael. 2006. Western Washington forest headwater stream management options experiment: responses of forest-floor small mammals and land and aquatic amphibians to stream buffer manipulation. USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington.63 pp.

In headwater streams, macroinvertebrate species richness is similar in young and old forests

In riparian and headwater-stream ecosystems, both macroinvertebrate diversity and density can be important components of the forest's overall health. Headwater streams play an important role in distributing nutrients and prey species, like macroinvertebrates, downstream. At sites in Oregon's H.J. Andrews Experimental Forest, scientists studied the long-term responses of macroinvertebrate communities to forest harvest and the natural variation and diversity of these macroinvertebrates in headwater streams. The scientists found that species richness was similar in streams through young- and old-growth stands throughout the year. The type of species, however, changed with season. Densities of stream-bed macroinvertebrates were highest in summer, and densities were slightly higher in streams through young stands. Streams through old-growth forests did not have consistent "indicator" macroinvertebrate species, as community composition differed among old-growth basins at different elevations. By documenting the long-term legacies of forest harvest, scientists provide managers the data for evaluating the ecological recovery of streams flowing through timber harvest areas. A better understanding of natural variability in headwater stream macroinvertebrates provides a context for evaluating streams across landscapes and using streams as indicators of ecological disturbance.

Contact: Sherri Johnson, US Forest Service, Pacific Northwest Research Station, sherrijohnson@fs.fed.us

Partners: Oregon State University

Citations: Frady, C, S.L. Johnson, and J.L. Li. 2007. Stream macroinvertebrate community responses as legacies of forest harvest at the H.J. Andrews Experimental Forest, Oregon. Forest Science. (In Press for April)

Hydrogeologic controls on summer stream temperatures in the McKenzie River basin, Oregon

Stream temperature is a complex function of energy inputs including solar radiation and latent and sensible heat transfer. In streams where groundwater inputs are significant, energy input through advection can also be an important control on stream temperature. For an individual stream reach, models of stream temperature can take advantage of direct measurement or estimation of these energy inputs for a given river channel environment. Understanding spatial patterns of stream temperature at a landscape scale requires predicting how this environment varies through space, and under different atmospheric conditions. At the landscape scale, air temperature is often used as a surrogate for the dominant controls on stream temperature. In this study we show that, in regions where groundwater inputs are key controls and the degree of groundwater input varies in space, air temperature alone is unlikely to explain within-landscape stream temperature patterns. We illustrate how a geologic template can offer insight into landscape-scale patterns of stream temperature and its predictability from air temperature relationships. We focus on variation in stream temperature within headwater streams within the McKenzie River basin in western Oregon. In this region, as in other areas of the Pacific Northwest, fish sensitivity to summer stream temperatures continues to be a pressing environmental issue. We show that, within the McKenzie, streams which are sourced from deeper groundwater reservoirs versus shallow subsurface flow systems have distinct summer temperature regimes. Groundwater streams are colder,

less variable and less sensitive to air temperature variation. We use these results from the western Oregon Cascade hydroclimatic regime to illustrate a conceptual framework for developing regional-scale indicators of stream temperature variation that considers the underlying geologic controls on spatial variation, and the relative roles played by energy and water inputs.

Contact: Gordon Grant, US Forest Service, Pacific Northwest Research Station, ggrant@fs.fed.us

Partners: University of California; San Diego State University; Oregon State University.

Citations: Tague, C., Farrell, M., Grant, G. Lewis, S. and Rey, S. in press. Hydrogeologic controls on summer stream temperatures in the McKenzie River basin, Oregon, Hydrologic Processes.

Jefferson, A., Grant, G., and Lewis, S., in press. A river runs underneath it: geological control of spring and channel systems and management implications, Cascade Range, Oregon, Advancing the Fundamental Sciences: A Conference for Forest Service Physical Scientists.

Jefferson, A., Grant, G., and Rose, T., 2006. Influence of volcanic history on groundwater patterns on the west slope of the Oregon High Cascades, Water Resources Research, Vol. 42, W12411, doi:10.1029/2005WR004812

Methods developed for evaluating downstream habitat response to upslope forest management

Photo by Steve Lanigan.

Methods for evaluating watershed-scale downstream habitat responses to upslope forest management activities have been developed through improving the understanding of sediment generation (effect of altered rainfall interception and transpiration on landslide generation; effect of altered hydrology on incision of low-order tributaries), sediment routing (developing predictive capability for routing of sediment slugs through channel systems), and hydrologic changes (developing approaches to predict peakflow and low-flow changes resulting from altered rainfall interception and transpiration after forest management activities). These findings assist with improving the understanding of the impacts of management-related physical changes on aquatic habitats through determining the influence of management-related hydrologic changes on low-order channel incision, the magnitude and duration of increased turbidity, and the location and duration of downstream aggradation.

Contact person: Tom Lisle, US Forest Service, Pacific Southwest Research Station, tlisle@fs.fed.us

Partners: California Division of Forestry; University of Washington

For additional information: www.fs.fed.us/psw/topics/water/

Citations: Gran, K., D. R. Montgomery, and D. G. Sutherland. 2006. Channel bed evolution and sediment transport under declining sand inputs. Water Resources Research 42:doi:10.1029/2005WR004306.

Lisle, T. E. in press. The evolution of sediment waves influenced by varying transport capacity in heterogeneous rivers. in T. B. Hoey, H. Piegay, and M. Rinaldi, editors. Gravel Bed Rivers VI. John Wiley & Sons.

Constructed side channels can be an effective technique to recreate off-channel habitats

Off-channel habitats, critical components in the life histories of Pacific salmonids (Oncorhynchus spp.), have become increasingly rare in human-modified floodplains. The construction of groundwater-fed side channels is one approach that has been used in the Pacific Northwest to recreate off-channel habitats. The effectiveness of this technique was evaluated by comparing 11 constructed side channels with paired reference sites (naturally occurring channels fed by mixed groundwater and surface water) in western Washington. While total salmonid densities were not significantly different between channel types, coho salmon (Oncorhynchus kisutch) densities were higher in constructed channels and trout densities were higher in reference channels during the winter. Constructed channels were deeper than reference channels and warmer in the winter and cooler in the summer but had lower physical habitat diversity, wood density, and canopy coverage. Significant differences were not detected in water chemistry or invertebrate

parameters between channel types. Summer coho density was inversely correlated with minimum daily temperature and with total nitrogen and total phosphorous concentrations. Relative to other stream habitats, both constructed and reference channels supported high densities of juvenile coho salmon during the summer and winter.

Contact person: Phil Roni, National Oceanic Atmospheric Administration Fisheries Service, phil.roni@noaa.gov

Partners: US Forest Service

Citations: Morley, S., P. Garcia, T. Bennett, and P. Roni. 2005. Juvenile salmonid use of constructed and natural side channels in Pacific Northwest Rivers. Canadian Journal of Fisheries and Aquatic Sciences. 62: 2811-2821.

Options for maintaining biologically significant, sustainable populations of wild salmon developed

The primary goal of the Salmon 2100 Project was to identify practical options that have a high probability of maintaining biologically significant, sustainable populations of wild salmon in California, Oregon, Washington, Idaho, and British Columbia. A peer reviewed book was produced as part of the Project to convey the results of the analyses to a wide audience. The Project assembled 33 salmon internationally recognized scientists, policy analysts, and salmon advocates to answer the question: "What is it really going to take policy-wise to have wild salmon populations in significant, sustainable numbers through 2100 in California, Oregon, Washington, Idaho, and southern British Columbia?."

The two key results from the Project are: 1) substantial and pervasive policy changes are necessary if wild salmon are to be recovered to sustainable levels over the long-term; such changes are now rarely part of the public dialog surrounding what the appropriate salmon recovery policy should be; and

2) there are policy options (23 were developed) that would have a high probability of successfully restoring salmon runs to significant, sustainable levels in CA, OR, WA, ID, and southern BC through 2100 and beyond. Most of the proposed policy options fell into one of four general categories: a) use extensive technological intervention often accompanied by a recalibration of the notion or definition of what is a "wild" salmon; b) implement some form of policy or ecological triage that would focus recovery efforts in areas of most likely success; c) change bureaucratic institutional structures and/or eliminate the currently pervasive "symbolic politics" that surrounds salmon policy; and d) alter behavior, both individual and societally in substantial ways.

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Partners: Environmental Protection Agency; Oregon State University

For additional information: http://oregonstate.edu/~lackeyr/Recent%20Publications.html

Citations: Lackey, Robert T., Denise H. Lach, and Sally L. Duncan. Editors. 2006. Salmon 2100: The Future of Wild Pacific Salmon. American Fisheries Society, Bethesda, Maryland, 629 pp.

Enhancing Wetlands for Wildlife Yields Benefits Fish

Photo by D. Baker.

Wetlands habitat restoration in key watershed, Deschutes Province.

During periods of high water, rivers may overflow their banks onto floodplains, rejuvenating freshwater wetlands and providing access to riverine fish. Periodic flooding of the shallow wetlands, accompanied by decomposition of organic matter and release of nutrients, accelerates the production of fish prey. A recent trend of enhancing freshwater wetlands by installing water-control structures benefits waterfowl and other wildlife, but has raised concerns about the effects on juvenile salmon. USGS scientists and colleagues compared juvenile coho salmon use of enhanced and unenhanced wetlands in the lower Chehalis River, WA floodplain. As oxygen levels declined and wetlands dried out throughout the spring, fish survival was greater in enhanced wetlands that allowed escape back to the main river channel. The results suggest that enhancing freshwater wetlands with water-control structures can benefit juvenile

salmon by providing conditions of greater growth, survival, and emigration.

Contact: Martin Fitzpatrick, US Geological Survey, Martin_Fitzpatrick@usgs.gov

Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

Citations: Henning, J.A., Gresswell, R.E., Fleming, I.A., 2006, Juvenile salmonid use of seasonal freshwater emergent wetlands in the floodplain and its implications for conservation management: North American Journal of Fisheries Management, v. 26, p. 367-376.

Restoration of Fish Passage Involves Tradeoffs

In many regions, suitable coldwater habitats for native fish are found mainly in protected natural areas, relegating the fish to more isolated pieces of their former native ranges. Managers sometimes install barriers to upstream movement to protect remaining native populations, but such actions may have unintended negative effects. USGS recently co-authored a report on strategies for considering potential tradeoffs. While restoration of fish passage through stream barriers may benefit native fish populations by increasing connectivity to other populations and habitats, isolated native fish may also be exposed to displacement or hybridization with non-native species. The report focuses on the case of native trout, providing a comprehensive overview of considerations and a framework for making decisions.

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Partners: USDA Forest Service

Photo by D. Baker.

Riparian area rehabilitation and abatement of a fish passage problem, SW Oregon Province.

For additional information: http://fresc.usgs.gov/products/papers/1552_Dunham.pdf

Citations: Fausch, K.D., Rieman, B.E., Young, M., Dunham, J.B., 2006, Strategies for Conserving Native Salmonid Populations at Risk from Nonnative Fish Invasions-Tradeoffs in using barriers to upstream movement: USDA Forest Service, Rocky Mountain Research Station RMRS-GTR-174, p. 44.

New Book Reveals Unique Perspectives on Fish Distribution in Rivers

Conventional studies of the distribution and abundance of fish in a river often are conducted at coarse scales, focusing on short sampling areas spaced at wide intervals. Such studies cannot address fundamental questions about the nature and variability of fish abundance between these zones. Investigations into the factors that influence this variability at both coarse and fine spatial scales could lead to more insight into predicting where fish gather. USGS scientist and colleagues mapped fish distribution in several rivers and streams in Oregon, and the findings are summarized in two chapters in a new book on the influences of landscapes on stream habitats and biological organisms. Unexpected patterns were revealed that provided a unique perspective on fish distribution and emphasized the importance of diverse habitat.

Contact: Christian Torgersen, US Geological Survey, ctorgersen@usgs.gov

Partners: USDI Bureau of Land Management; Oregon Department of Fish and Wildlife; Oregon State University; University of Idaho

Citations: Torgersen, C.E., Baxter, C.V., Li, H., McIntosh, B.A., 2006, Landscape influences on longitudinal patterns of river fishes- Spatially continuous analysis of fish-habitat relationships In Hughes, R., Wang, L., Wofford, J.E., eds., Influences of Landscapes on Stream Habitats and Biological Assemblages: Bethesda, MD, American Fisheries Society, p. 473-492.

Integrating Physical and Biological Systems Facilitates Aquatic Ecosystem Management

In aquatic ecosystems, the link between physical and biological systems has long been recognized, but the ability to translate that to effective management has been lim-

ited. USGS scientists and U.S Forest Service colleagues co-authored a new publication that proposes solutions for integrating physical and biological sciences, focusing on examples from the upper Columbia River basin (Oregon). The problems faced by resource managers require an understanding of natural processes, and the scales at which they emerge. These provide the context for understanding how human influences at small and large scales have affected native fishes and other aquatic resources. The review concludes with a series of key issues and questions that recommend integration among disciplines to more effectively manage aquatic ecosystems.

Contact: Jason Dunham, US Geological Survey, jdunham@usgs.gov

Partners: USDA Forest Service

Citations: Rieman, B.E., Dunham, J.B., Clayton, J., 2006, Emerging concepts for management of river ecosystems and challenges to applied integration of physical and biological sciences in the Pacific Northwest, USA: International Journal of River Basin Management, v. 4, no. 2, p. 85-97.

Aquatic and Terrestrial Systems Exchange Prey in Oregon Coast Range

We presented evidence of food web links between terrestrial invertebrates that fall into streams and feed fish, and adult aquatic insects that emerge from the stream and feed riparian birds. These exchanges were documented in an alder-dominated riparian area in the Oregon Coast Range. This across-habitat prey exchange could have direct and indirect influences on food web dynamics. For example, a predator that responds to a prey subsidy by switching its primary prey choice may have a positive, indirect effect on the original prey. This research was done as part of the Cooperative Forest Ecosystem Research program (CFER).

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Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

For additional information: http://ir.library.oregonstate.edu/dspace/bitstream/1957/2608/1/thesis712.pdf

Citations: Robillard, A.L., 2006, Seasonal Dynamics of a Riparian Food Web in the Oregon Coast Range Mountains: Corvallis, OR, M.S. Thesis, Oregon State University, 114 p.

When Streamside Litter is a Good Thing

Riparian forest overstories likely influence the delivery of nutrients to streams, and they affect the structure and composition of food webs in these ecosystems. Cooperative Forest Ecosystem Research program (CFER)-affiliated graduate student investigated annual litter inputs to 16 streams, and assessed how these inputs were influenced by overstory tree type, understory, and lateral slope. Results suggest that red alder-dominated riparian zones of the Oregon Coast Range have significantly different quantity, quality, and timing of leaf litter inputs to streams, and they are more impacted by topography adjacent to streams than conifer-dominated forests.

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For additional information: http://ir.library.oregonstate.edu/dspace/bitstream/1957/1017/1/Hart+Final+2.14.06.pdf

Citations: Hart, S., 2006, Riparian litter inputs to streams in the central Oregon coast range: Corvallis, OR, Oregon State University - MS thesis, 102 p.

Photo by Steve Lanigan.

How can landscapes be managed to provide for biodiversity and resiliency?

Fuel treatment effects on wildlife synthesized

Scientists at the Pacific Northwest and Rocky Mountain Research Stations synthesized available information on the effects of fuel treatments on terrestrial wildlife and invertebrates in dry coniferous forests in the West. A few general relationships emerged despite the difficulties in generalizing across a wide variety of studies and significant knowledge gaps. In general, fire-dependent species, species preferring open habitats, and those associated with early-successional vegetation or that consume seeds and fruit appear to benefit from fuel reduction activities. In contrast, species that prefer closed-canopy forests or dense understory, and those closely associated with habitat elements removed or consumed by fuel reductions, will likely be negatively affected. Some habitat loss may persist for only a few months or years, such as understory vegetation and litter that recover quickly. Loss of large-diameter snags and down wood—important habitat elements for many wildlife and invertebrate species—may take decades to recover and thus represent important habitat elements to conserve during fuel treatments. Treatments on a small percentage of the landscape will have less effect on wildlife and invertebrate populations than treatments covering a large percentage of the landscape. This synthesis should be helpful to fuel planners, fire managers, and National Environmental Policy Act specialists. Until some of the knowledge gaps are filled, an overall approach using prudence and conservation may be most appropriate. Management activities that retain habitat structures such as snags, down wood, and refugia of untreated stands may increase habitat diversity and benefit the greatest number of species in the long run.

Contact: Evelyn Bull, US Forest Service, Pacific Northwest Research Station, ebull@fs.fed.us

Partners: US Forest Service, Rocky Mountain Research Station

Citations: Pilliod, D.S.; Bull, E.L.; Hayes, J.L.; Wales, B.C. 2006. Wildlife and invertebrate response to fuel reduction treatments in dry coniferous forests of the western United States: a synthesis. USDA Forest Service, Rocky Mountain Research Station Gen. Tech. Rep. RMRS-GTR-173, Fort Collins, CO. 34 p.

Pacific golden chanterelle recovers 6 years after light stand thinning

The commercial harvest of wild edible mushrooms is a multimillion dollar industry in the Pacific Northwest. The Pacific golden chanterelle is one of the fungal species more highly valued, not only by commercial harvesters, but also by the general public. This chanterelle species is most productive in young Douglas-fir stands 20 to 60 years of age. A major concern by managers and the public has been the effects of forest thinning on this valuable resource. As part of an integrated, replicated young-stand thinning study in the central Cascade Range of Oregon, scientists monitored the productivity of the Pacific golden chanterelle after both light and heavy thinning. The mushroom's productivity significantly declined for the first 4 years in all thinning treatments. However, by year 6, the mushroom's productivity had nearly recovered to control levels in the light thinning treatment. Productivity remained far below control level in the heavy thinning treatment. This finding can provide guidelines for integrating edible mushroom management with other forest management goals.

Contact: Randy Molina, US Forest Service, Pacific Northwest Research Station, rmolina@fs.fed.us

Partners: US Forest Willamette National Forest; Oregon State University, Cascade Center for Ecosystem Management

Citations: Pilz, D., R. Molina, and J. Mayo. 2006. Effects of thinning young forests on chanterelle mushroom production. Journal of Forestry. 104(1):9-14

Symposium delivers new science on biodiversity conservation to wildlife biologists

Biodiversity conservation is a relatively new field and one that has been limited both by a lack of knowledge of ecological systems and the inherent complexity of land management. Station scientists presented the current science on biodiversity conservation to Pacific Northwest wildlife biologists at a symposium at Oregon State University. Eight review articles on the key biodiversity topics discussed at the symposium—such as forestry practices, invasive species, and habitat modeling techniques—were published as a special issue of Northwestern Naturalist. The special issue has been distributed locally to the more than 200 symposium attendees and internationally, such as to natural resource specialists in New Zealand, Southeast Asia, and Argentina.

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Partners: Defenders of Wildlife; Oregon State University, Institute for Natural Resources; U.S. Geological Survey, Biological Resources Division.

Citations: Olson, D.H., editor. 2006. Symposium Issue: Biodiversity. Northwestern Naturalist 87(1).

Biodiversity conference delivers tools to managers

A biodiversity initiative delivered existing tools and information to about 150 managers from the private sector and state and federal agencies at its June 2006 conference on "Managing for Biodiversity." Over 40 presentations gave a synthesis of current knowledge related to managing for biodiversity in Pacific Northwest forests. Topics included social and economic considerations of biodiversity management, the effects of invasive species on biodiversity, wildlife and plant responses to silvicultural practices and natural disturbances, sensitive species management, and management of special habitats such as wetlands, riparian areas, and oak savannas. Although some single-species conservation and monitoring programs are well developed, the monitoring of overall biodiversity remains challenging. What do single-species data tell us about overall biodiversity? What else do we measure? How does project-level measurement scale up to a regional picture? The biodiversity initiative helped Oregon and Washington state natural resource agencies, which have federal mandates and funds to develop monitoring strategies for their wildlife conservation programs, develop a regional vision and framework for monitoring biodiversity. The states are now taking the lead on development of regional programs to monitor biodiversity. The private sector, state agencies, and their federal counterparts are now sharing resources related to monitoring biodiversity. Finally, the initiative team is working with partners to meet another pressing need identified by managers, the development of a Web portal that is a central clearinghouse for biodiversity information and resources.

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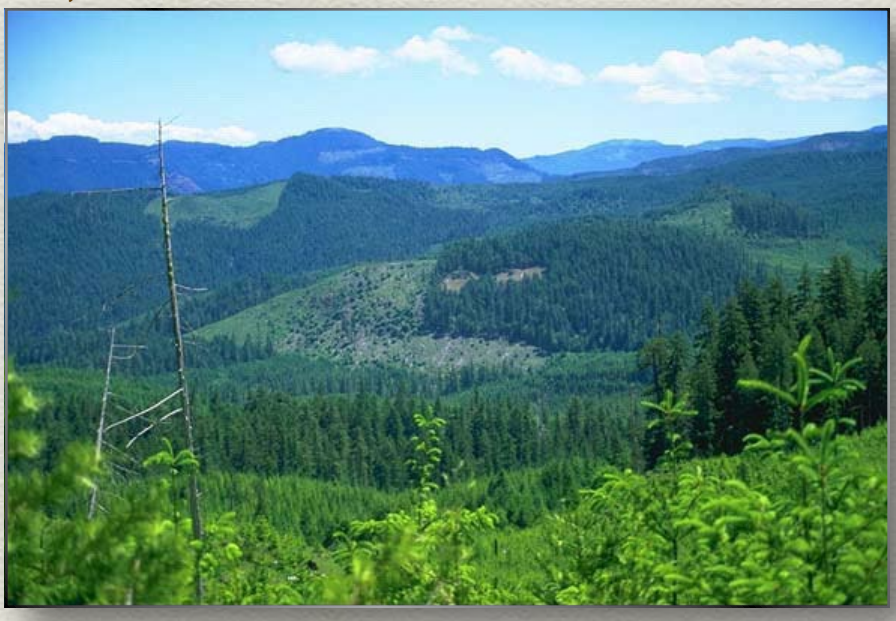
Partners: Defenders of Wildlife; Institute for Natural Resources, Oregon State University; National Council for Air and Stream Improvement; The Campbell Group; The Nature Conservancy; Oregon Department of Fish and Wildlife; USDI Bureau of Land Management, Oregon State Office and Regional Office, Fish and Wildlife Service, National Park Service; Washington Department of Fish and Wildlife; Washington Department of Natural Resources Natural Heritage Program

Citations: Nelson, Peter; White, Rachel; Molina, Randy. 2006. The Pacific Northwest Research Station's Biodiversity Initiative: collaborating for biodiversity management. Gen. Tech. Rep. PNW-GTR-670. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p.

Photo by C. Teleford.



In Oregon Coast Range, current policies may not produce the desired biodiversity

Since 1995, scientists involved with the Coastal Landscape Analysis and Modeling Study (CLAMS) have been conducting research on the ecological, economic, and social consequences of forest policies in Oregon's Coast Range. The collaborative study has yielded detailed models that simulate historical and current conditions of the area's nearly 5 million acres as well as projected conditions under different management scenarios. Recently, the CLAMS work was highlighted in the journal Ecological Applications. Findings were presented about potential cumulative effects of different land-

owner policies on biodiversity and timber. Some projected outcomes of current policies are consistent with management goals; for example, the area of diverse conifer forests is projected to increase. Other projected outcomes are not consistent with current policies, however. The models showed that hardwood and vegetation diversity are projected to sharply decline. These results can help construct alternative policies that better provide the desired mix of forest values. The CLAMS results have been used by managers and policymakers from the Oregon Department of Forestry and the Bureau of Land Management (BLM) to understand how their individual actions might affect biodiversity and economics. Some individual models from the study also have been used to analyze alternatives in the Interagency Modeling and Analysis Program (IMAP) assessment conducted by the State of Oregon and the USDA Forest Service, and in the BLM's Western Oregon Plan Revision analysis.

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Citations: Ecological Applications, 2007, Vol. 17, No. 1

Model allows for comparison of habitat conditions before and after forest management treatments

A model capable of predicting the suitability of habitat for a species of concern in the Pacific Northwest (the fisher) using standard forest vegetation inventory data was developed. This model is the first of others in development (for spotted owls and goshawks, in particular) and serves as an example of a tool that can assess the abundance and distribution of habitat for key species, at high resolution but over vast regional scales. The inventory data were derived from Forest Inventory and Analysis (FIA), a nationwide probability-based sample used to estimate forest characteristics. The model was developed by comparing vegetation and topographic data at 75 randomly selected fisher resting structures with 232 forest inventory plots. Vegetation data was collected at fisher resting locations using the FIA vegetation sampling protocol and centering the 1-ha FIA plot on the resting structure. To distinguish used and available inventory plots, we used nonparametric logistic regression to evaluate a set of a priori biological models. The top model represented a dominant portion of the Akaike weights (0.87), explained 31.5% of the deviance, and included the following variables: average canopy closure, basal area of trees ‹ 51 cm diameter breast height (dbh), average hardwood dbh, maximum tree dbh, percent slope, and the dbh of the largest conifer snag. Our use of routinely collected forest inventory data allows the assessment and monitoring of change in habitat suitability over large regions with no additional sampling effort. Although models were constrained to include only variables available from the list of those measured using the FIA protocol, this was not found to be a shortcoming. The model makes it possible to compare average habitat suitability values before and after forest management treatments, among administrative units, across regions and over time. Considering hundreds of plot estimates as a sample of habitat conditions over large spatial scales can bring a broad perspective, at high resolution, and efficiency to the assessment and monitoring of wildlife habitat.

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Partners: Department of Environmental and Natural Resource Sciences, Humboldt State University; East-West Forestry, Inc (Inverness, CA)

Citations: Zielinski, W. J., R. L. Truex, J. R. Dunk, and T. Gaman. 2006. Using forest inventory data to assess fisher resting habitat suitability in California. Ecological Applications 16:1010-1025.

Accelerating development of late-successional features in ponderosa pine stands

A study was implemented in the Goosenest Adaptive Management Area, to test different methods for accelerating development of late-successional features in ponderosa pine stands. In the immediate aftermath of treatment, quadratic mean diameter was increased substantially and initial growth measurements indicate an increase in diameter growth of 11-14% in thinned stands. Prescriptions designed to increase the proportion of ponderosa pine resulted in a 6 to 29 percent increase in pine basal area contribution with a mean of 16 percent. Prescribed fire applied in the fall

Photo by Bill Johnson.

Prescribed fire, Deschutes Province.

following thinning resulted in very little mortality among dominant trees (< 1 percent). A comparison was done of bird species between two ponderosa pine forests in northeast California: One forest with a canopy of large old growth trees, and another with large trees absent. 24 late seral units were surveyed and 20 second-growth units. Overall bird species diversity composition was similar at the two locations. Most of the species only found at one site were rare at that site. Plot diversity did not differ between the two locations. However when different foraging guilds were considered, differences between the two conditions were noted. Woodpeckers, bark gleaners and flycatchers were more abundant in the late-seral units. More foliage gleaners were found in the second growth stands. Woodpeckers and bark gleaners appear to be strongly associated with large trees and snags.

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Partners: Humboldt State University; Wildlife Conservation Society

For additional information: http://www.fs.fed.us/psw/programs/ecology_of_western_forests/projects/goosenest/

Citations: George, T.L., Zack, S., Laudenslayer, W.F. Jr. 2005. A comparison of bird species composition and abundance between late- and mid-seral ponderosa pine forests. In: Ritchie, M.W., Maguire, D., Youngblood, A., Proceedings of the symposium on ponderosa pine: issues, trends and management. USDA For. Serv. Gen. Tech. Rep. PSW-GTR-198.

Ritchie, M.W., Harcksen, K.A. 2005. Accelerating development of late-successional features in second-growth pine stands of the Goosenest Adaptive Management Area. In: Ritchie, M.W., Maguire, D., Youngblood, A., Proceedings of the symposium on ponderosa pine: issues, trends and management. USDA For. Serv. Gen. Tech. Rep. PSW-GTR-198.

Life history diversity is key factor in persistence of Pacific salmon

Life history diversity of imperiled Pacific salmon Oncorhynchus spp. substantially contributes to their persistence, and conservation of such diversity is a critical element of recovery efforts. Preserving and restoring diversity of life history traits depends in part on environmental factors affecting their expression. We analyzed relationships between annual hydrograph patterns and life history traits (spawn timing, age at spawning, age at outmigration, and body size) of Puget Sound Chinook salmon (Oncorhynchus tshawytscha) to identify environmental indicators of current and historic diversity. Based on mean monthly flow patterns, we identified three hydrologic regimes: snowmelt-dominated, rainfall-dominated, and transitional. Chinook populations in snowmelt-dominated areas contained higher proportions of the stream-type life history (juvenile residence >1 year in freshwater), had older spawners, and tended to spawn earlier in the year than populations in rainfall-dominated areas. There are few extant Puget Sound populations dominated by the stream-type life history, as several populations with high proportions of stream-type fish have been extirpated by construction of dams that prevent migration into snowmelt-dominated reaches. The few extant populations are thus a high priority for conservation. The low level of genetic distinction between stream-type and ocean-type (juvenile residence <1 year in freshwater) life histories suggests that allowing some portion of extant populations to recolonize habitats above dams might allow re-expression of suppressed life history characteristics, creating a broader spatial distribution of the stream-type life history. Climate change ultimately may limit the effectiveness of some conservation efforts, as stream-type Chinook may be dependent on a diminishing snowmelt-dominated habitat

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Partners: US Forest Service

Citations: Beechie, T.J., M. Ruckelshaus, E. Buhle, A. Fullerton, L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation. 130:560-572.

Two USGS Authors Contribute to New Conservation Book

Natural and human-caused disturbances, such as urbanization and development, can fragment or destroy natural habitats, threatening the survival of many plants and animal species. Maintaining or restoring connections between fragmented habitats is important for the conservation of species, but it can be challenging. A new book about conserving habitat connectivity synthesizes the current status of research and implementation, identifies application challenges, and highlights critical research areas. USGS

Photo by Steve Lanigan.

scientists co-authored a chapter about understanding how migratory birds interact with their environment through all life stages, and the latest techniques available to measure migratory connectivity are reviewed. A chapter about using genetic techniques to assess connectivity in salmonid fish, which is difficult to study using traditional methods was also included.

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Partners: USDA Forest Service

For additional information: http://www.cambridge.org/uk/catalogue/catalogue.asp?isbn=9780521857062

Citations: Neville, H., Dunham, J., Peacock, M. Assessing connectivity in salmonid fishes with DNA microsatellite markers, Chapter 13, p. 318-342. and Marra, P.P., Norris, D.R., Haig, S.M., Webster, M., Royle, A., 2006, Migratory connectivity In Crooks, K.R., Sanjayan, M., eds., Connectivity Conservation: Conservation Biology no. 14, Cambridge, UK, Cambridge University Press, p. 157-183.

Reproductive Ecology of Tailed Frogs

Tailed frogs live in cold, fast-flowing streams from western Montana to the Pacific coastal mountains. Initially considered one group, they were recently split into two species, inland and coastal, using molecular techniques. Both species are listed as federal species of concern and developing a better understanding of their natural history may identify critical habitats or other elements important for conservation. USGS scientists participated in a recently completed range-wide summary of existing and new information comparing the reproductive ecology of the two species. The ecological differences reported support the division of the two species and suggest that different management strategies may be necessary for each species.

Contact: Michael Adams, US Geological Survey, mjadams@usgs.gov

Partners: USDI Bureau of Land Management

Citations: Karraker, N.E., Pilliod, D.S., Adams, M.J., Bull, E.L., Corn, P.S., Diller, L.V., Dupuis, L.A., Hayes, J.P., Hossack, B.R., Hodgson, G.R., Hyde, E.J., Lohman, K., Norman, B.R., Ollivier, L.M., Pearl, C.A., Peterson, C.R., 2006, Taxonomic variation in the oviposition of tailed frogs (Ascaphus spp.): Northwestern Naturalist, v. 87, no. 2, p. 87-97.

Streambank Vegetation Affects Amphibian Diet

Reported high densities of amphibians in streams and along streambanks in the Pacific Northwest underscore their importance in riparian food webs. In the habitats sampled, larval Pacific giant salamanders consumed more food when western hemlock was overhanging the stream channel than when it was absent. Terrestrial western redback salamanders ingested more food as red alder cover in the riparian zone increased. These findings suggest that changes to riparian vegetation, such as the removal of shrubs or trees, might affect amphibians living there.

Contact: Martin Fitzpatrick, US Geological Survey, Martin_Fitzpatrick@usgs.gov

Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

Citations: Graff, P., 2006, Riparian Vegetation and Larval Pacific Giant (Dicamptodon tenebrosus) and Adult Western Redback (Plethodon vehiculum) Salamanders in the Oregon Coast Range: M.S. Thesis, Corvallis, OR, Oregon State University, 138 p.

Downed Wood important to Chipmunks

Forest practice regulations require that downed wood be left on the forest floor, primarily for ecological reasons. A recent study by CFER scientists is the first to document its use as travel paths by Townsend's chipmunks. In a forest with an average amount of downed wood available, chipmunks were three times more likely to select paths with downed wood than paths without, suggesting that downed wood may influence fitness or survival of individual chipmunks.

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For additional information: http://www.asmjournals.org/perlserv/?request=get-abstract&doi=10.1644%2F05-MAMM-A-136R1.1

Citations: Waldien, D.L., Hayes, J.P., Huso, M., 2006, Use of downed wood by Townsend's Chipmunks (Tamias Townsendii) in western Oregon: Journal of Mammalogy, v. 87, no. 3, p. 454-460.

Research Accomplishments

Genetic Analysis Proves Identity of Similar Salamanders

To the human eye, salamanders can be hard to tell apart. Without definite identification, errors may be made in determining the species conservation status, potentially influencing management options and economic impacts. Two different salamander species, the Cascade torrent and southern torrent, look alike and live in similar habitats. Both are protected by the Northwest Forest Plan and are known to live in non-overlapping areas separated by the Willamette River, OR. Torrent salamander populations were recently discovered both north and south of the river between two already known species sites. Since the new populations looked similar to both species, a more precise method of differentiation was applied. Genetic testing identified populations from each study site as either southern or Cascade torrents, and maintained the geographic separation originally determined for each species. The study extends the known ranges of the two salamander species.

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Partners: USDA Forest Service; USDI Bureau of Land Management

For additional information: http://www.bioone.org/perlserv/?request=get-abstract&issn=0018-0831-&volume=062&issue=01&page=0063

Citations: Wagner, R.S., Miller, M.P., Haig, S.M., 2006, Phylogeography and genetic identification of the newly-discovered populations of torrent salamanders (Rhyacotriton cascade and R. variegatus) in the central Cascades (USA): Herpetologica, v. 62, no. 1, p. 63-70.

Tagging Juvenile Salmonids

PIT tags, or passive integrated transponders, are microchips that are implanted in fish as a cost-effective method to remotely track fish movement and survival. Larger PIT tags generally can detect fish at a greater distance than small ones, but little information is available on the effects of implanting them in small juvenile salmonids. USGS scientists and colleagues implanted large PIT tags in steelhead after their first summer of growth, and the effects on survival and growth rates were reported in a new publication. Survival rates were lower for tagged fish, and growth rates were reduced when measured at both 10- and 20-day intervals. However, by 30 days post surgery, the implanted steelhead equaled or exceeded growth for control groups. These findings suggest that using large PIT tags in smaller fish may still be useful in situations where fish could be held prior to release

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For additional information: http://afs.allenpress.com/archive/1548-8675/26/3/pdf/i1548-8675-26-3-545.pdf

Citations: Bateman, D.S., Gresswell, R.E., 2006, Survival and growth of age-0 steelhead after surgical implantation of 23-mm passive integrated transponders: North American Journal of Fisheries Management, v. 26, p. 545-550.

Bats in Riparian Areas of the Oregon Coast

We measured bat use of 118 second- and third-order stream reaches throughout the Oregon Coast Range and measured vegetation characteristics at three spatial scales surrounding each of these locations. We used a model selection approach to determine which vegetation characteristics were most closely related to bat activity and a multilevel modeling approach to determine the amount of variation in bat activity occurring at different spatial scales. Vegetation characteristics measured at the smallest spatial scale explained more variation in bat activity than did vegetation characteristics at larger spatial scales. The influence of vegetation on bat activity was species-specific and operated more strongly through constraints imposed by vegetation architecture on bat flight abilities than through regulation of the distribution of insect prey abundance. Results indicate that small-scale forest management activities that alter cover of shrubs or canopy trees within riparian areas have the capacity to influence bat foraging habitat selection.

Contact: Martin Fitzpatrick, US Geological Survey, Martin_Fitzpatrick@usgs.gov

Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

Citations: Ober, H.K., 2006, Functional Relationships Among Vegetation, Nocturnal Insects, and Bats in Riparian Areas of the Oregon Coast Range: Corvallis, OR, M.S. Thesis, Oregon State University, p. 238.

Research Accomplishments

Genetic Study May Assist With Conservation Strategy for Salamanders

Southern torrent salamanders live primarily in small streams in the Coast Range mountains from northern Oregon to northern California. Concern that clear-cutting and thinning of forests might negatively impact the species led to their protection under the Northwest Forest Plan. The salamanders were recently found to be "not warranted for listing" under the U.S. Endangered Species Act due to lack of genetic information. In a new publication, USGS scientists and colleagues report on results of a genetic diversity study that may assist with the development of conservation strategies for the species. Genetic markers identified three main groups of salamanders living in non-overlapping areas separated by major rivers. Initial focus on preserving high-priority habitats for these groups may enhance their conservation.

Contact: Susan Haig, US Geological Survey, susan_haig@usgs.gov

Partners: USDI Bureau of Land Management; USDA Forest Service

Citations: Miller, M.P., Haig, S.M., Wagner, R.S., 2006, Phylogeography and spatial genetic structure of the southern torrent salamander- Implications for conservation and management: Journal of Heredity, v. 97, no. 6, p. 561-570.

Reducing Classification Ambiguity

The U.S. Endangered Species Act (ESA) allows listing of subspecies and other groupings below the rank of species. This provides the U.S. Fish and Wildlife Service and the National Marine Fisheries Service with a means to target the most critical unit in need of conservation. A new publication by USGS scientists and collaborators reviewed classification information and found no standardized criteria for determining subspecies. Minimum biological criteria are proposed that would provide a clear distinction between species and subspecies, thus reducing classification ambiguity.

Contact person: Susan Haig, US Geological Survey, susan_haig@usgs.gov

Partners: Oregon State University

Citations: Haig, S.M., Beever, E.A., Chambers, S.M., Draheim, H.M., Dugger, B.D., Dunham, S., Elliott-Smith, E., Fontaine, J., Kesler, D.C., Knaus, B., Lopes, I.F., Loschl, P., Mullins, T.D., Sheffield, L.M., 2006, Taxonomic considerations in listing subspecies under the U.S. Endangered Species Act: Conservation Biology, v. 20, no. 6, p. 1584-1594.

Woody riparian plant distributions in western Oregon

We studied riparian forests along mountain streams in four large watersheds of western Oregon and far northern California, USA, to better understand the multiscale controls on woody riparian vegetation in a geographically complex region. The woody riparian flora of western Oregon shows important biogeographic variation; species distributions showed strong associations with climatic variables, which were the primary correlates of compositional change between riparian sites at both scales analyzed. Additional local variation in composition was explained by measures of topography and disturbance.

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For additional information: http://www.springerlink.com/content/488048655n3x8123/

Citations: Sarr, D.A., Hibbs, D.E. 2006. Woody riparian plant distributions in western Oregon, USA: Comparing landscape and local scale factors. Plant Ecology DOI 10.1007/s11258-006-9208-2.

Photo by D. Baker.

Lack of coarse woody debris.

How effective is federal land management, including the reserve system, in providing for conservation of listed and non-listed species?

Models promote understanding of effects of altered habitat on salmonids

The development of Individual-Based Models for salmonids has improved the understanding of the effects of altered habitat on salmonids by allowing for the prediction of the combined effects of altered pool frequency, temperature, and turbidity.

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Additional information: www.fs.fed.us/psw/topics/water/

Citations: Harvey, B. C., Nakamoto, R. J., and White, J. L. 2006. Reduced discharge lowers summer growth of trout in headwater stream pools. Transactions of the American Fisheries Society 135:998-1005.

Models evaluate reserves for habitat suitability for area-limited species in northwestern CA

Protection of area-limited species is an important component of plans to conserve biodiversity, but the habitat needs of such species can be different and important habitats may not align with existing reserves. Empirically derived landscape suitability models were used for the spotted owl and the fisher to evaluate the overlap in habitat suitability for these two old forest-associated predators in an area of northern California The area includes designated wilderness areas and Late-Successional Reserves (LSRs). The site selection algorithm MARXAN was used to identify priority habitat areas for each species, and for both combined, and to compare these areas with reserves. Sites were selected under 2 constraints, to achieve a threshold proportion of total habitat value and to select new areas equal to the total current area in existing reserves. The rank correlation between predicted value for the two species was low (0.11), because areas of highest predicted habitat value were more widely distributed for the owl. This difference also meant that the sites selected to optimize habitat value were more aggregated for fishers than owls, resulting in greater overlap of owl habitat and current reserves. To capture 25, 50 and 75% of total habitat value for the owl required 14.0, 29.2, and 47.3% of the planning units, respectively; capturing the same for the fisher required only 5.3, 13.5, and 27.2%. A combined owl-fisher scenario resulted in areas that overlapped only ~50% of existing reserves. The current location of LSRs may not be the best solution to maintaining well-connected habitats for these area-limited species in northwestern California

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Partners: Klamath Center for Conservation; Department of Environmental and Natural Resource Sciences, Humboldt State University

Citations: Zielinski, W. J., C. Carroll, and J. R. Dunk. 2006. Using landscape suitability models to reconcile conservation planning for two key forest predators. Biological Conservation 133:409-430.

Evaluation of habitat quality of reserve system for the Del Norte Salamander

The primary purpose of this research was to illustrate the value of using FIA data for modeling wildlife habitat on Forest Service lands. However, the model was tested against the habitat quality of the reserve system in Northwestern California for the Del Norte Salamander (Plethodon elongatus). Although not dramatically different, on average, reserves had higher quality than did non-reserve lands. Nonetheless, the work indicated that non-reserve lands have habitat value for this species provided that they include the microenvironmental attributes identified in our best models.

Contact: Hartwell H. Welsh, Jr., US Forest Service, Pacific Southwest Research Station, hwelsh@fs.fed.us

Partners: Department of Environmental and Natural Resource Sciences, Humboldt State University

Citations: Welsh, H. H., Jr., J. R. Dunk, and W. J. Zielinski. 2006. Developing and applying habitat models using forest inventory data: an example using a terrestrial salamander. Journal of Wildlife Management 70:671-681.

Research Accomplishments

Forest canopy qualities found important for salamander

This research demonstrated the use of the forest canopy by a forest-dwelling salamander, the wandering salamander (Aneides vagrans), indicating a new habitat relationship and raising important questions about how to conserve these salamanders in the face of forest resource extraction methods that tend to reduce and eliminate the late seral canopy qualities required by these arboreal populations.

Contact: Hartwell H. Welsh, Jr., US Forest Service, Pacific Southwest Research Station, hwelsh@fs.fed.us

Partners: Biology Department, Humboldt State University

Citations: Spickler, J. C., S. C. Sillett, S. B. Marks, and H. H. Welsh, Jr. 2006. Evidence of a new niche for a North American salamander: Aneides vagrans residing in the canopy of old-growth redwood forest. Herpetological Conservation and Biology 1:16-27.

Reserves in northern CA assist with maintenance of genetic diversity among populations of soil-inhabiting beetles

The Klamath-Siskiyou ecoregion of northern California is one of the most diverse temperate coniferous forests. A network of late successional reserves (LSRs) has been established to maintain characteristics of late successional forest and to promote late successional characteristics in younger stands. Also, an important goal of conservation management is the maintenance of genetic diversity of ecologically important species. This study examined the level of genetic diversity among populations of a soil-inhabiting beetle, Acrotrichis xanthocera (Matthews) (Ptiliidae), within the LSR network. Using a partial DNA sequence of the mitochondrial cytochrome oxidase I gene, a total of 31 haplotypes were identified for 117 individuals. Genetic fixation indices and phylogenetic and nested clade analyses all suggest moderate gene flow among five LSR and five non-LSR populations. In addition, haplotype diversity was high and the occurrence of unique haplotypes was common for most populations, which suggests current or past isolation of some populations. These results suggest the LSR network maintains considerable genetic variation for this beetle. However, the genetic variation was not equally distributed among the LSRs. Thus, to facilitate gene flow throughout the ecoregion, it is suggested that future LSRs might be designed to reduce gaps among the current LSRs.

Contact: Nancy Gillette, US Forest Service, Pacific Southwest Research Station, ngillette@fs.fed.us

Partners: Ohio State University and Michigan State University

Citations: Caesar, R. M., N. Gillette and A. I. Cognato. 2005. Population genetic structure of an edaphic beetle (Ptiliidae) among late successional reserves within the Klamath-Siskiyou ecoregion, California. Annals of the Entomological Society of America (Conservation Biology and Biodiversity) 98 (6): 931-940.

Photo by Susan Charnley

Reserves in northern CA provide conservation value for terrestrial mollusks and salamanders

The Klamath-Siskiyou forests of northern California and southern Oregon are recognized as an area of globally outstanding biological distinctiveness. When evaluated at a national or global level this region is often, necessarily, considered to be uniformly diverse. Due to large variation in biotic and abiotic variables throughout this region, however, it is unlikely that biological diversity is uniformly distributed. Furthermore, land management decisions nearly always occur at spatial scales smaller than this entire region. Therefore, field data from a random sampling design was used to map the distribution of local and regional richness of terrestrial mollusks and salamanders within northern California's portion of the Klamath-Siskiyou region. The protection afforded by reserves established for varying reasons (e.g., for inspiration and recreation for people [e.g., wilderness areas] versus species conservation [e.g., late-successional reserves]) to hotspots of species richness and species representation of

these taxa were evaluated. No existing reserves were created with these taxa in mind, yet it was assumed that reserves established largely around considerations for the northern spotted owl (Strix occidentalis caurina) would afford adequate protection for many lesser known species. Species of terrestrial mollusks and salamanders share two general features: 1) they have extremely low vagility, and 2) they are often associated with moist, cool microclimates. Existing reserves disproportionately included areas of hotspots of species richness for both taxa, when hotspots included the richest ~25% of the area, whereas non-reserved lands contained greater than expected areas with lower species richness. However, when a more strict definition of hotspot was used (i.e., the richest ~10% of areas), local hotspots for both taxa were not disproportionately found in reserves. Reserves set aside largely for human aesthetics and recreation and those set aside for biodiversity both contributed to the protection of areas with high (greatest 25%) species richness. Existing biodiversity reserves represented 68% of mollusk species and 73% of salamander species, corresponding to the 99th and 93rd percentiles, respectively, of species representation achieved by simulating a random distribution of the same total area of reservation. Cumulatively, however, reserves set aside for inspiration and biodiversity represented 83% of mollusk species and 91% of salamander species. The existing reserves provide conservation value for terrestrial mollusks and salamanders. This reserve network, however, should not be considered optimal for either taxa.

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Partners: Humboldt State University

Citations: Dunk, J. R., W. J. Zielinski, and H. H. Welsh. 2006. Evaluating reserves for species richness and representation in northern California. Diversity and Distributions 12:434-442.

Density Management and Riparian Buffer Study Available

For over a decade, the Bureau of Land Management has collaborated with the USGS, the Cooperative Forest Ecosystem Research program, and the U.S. Forest Service on a Density Management and Riparian Buffer Study (DMS). The primary goal of the DMS is to demonstrate and test options for young forest management to meet Northwest Forest Plan objectives in western Oregon. A new USGS report describes the study objectives, design, results, and next steps. In addition, there are summaries of collaborative studies being conducted on DMS sites including vegetation response to density management treatments, headwater forest response to thinning, leave islands as refugia, and canopy gaps.

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Partners: USDI Bureau of Land Management; USDA Forest Service

For additional information: http://fresc.usgs.gov/products/papers/1538_Erickson.pdf

Citations: Cissel, J.H., Anderson, P., Berryman, S., Chan, S.S., Olson, D.H., Puettmann, K., Thompson, C., 2006, BLM Density Management and Riparian Buffer Study- Establishment Report and Study Plan: U.S. Geological Survey Scientific Investigations Report 2006-5087, p. 144.

Menu May be Most Important to Flying Squirrels

Food rather than forest structure may be the most important factor associated with northern flying squirrel abundance in some forests. USGS scientists and colleagues reported in a recent paper on the short-term effects of commercially thinned young forests on population parameters and diet of flying squirrels. Although flying squirrels commonly den in cavities in large snags or live trees found in older forests, flying squirrel densities in the young, structurally simple forests were comparable to those described in late-successional forests. These results indicate that components of old-growth forests such as large downed logs and large trees are influential, but they are not always the most important factors in determining flying squirrel abundance

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Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

For additional information: http://fresc.usgs.gov/products/papers/1659_Anthony.pdf

Citations: Gomez, D.M., R.G. Anthony and J.P. Hayes. 2006. Influence of thinning of Douglas-fir forests on population parameters and diet of Northern flying squirrels: Journal of Wildlife Management 69 (4):1670-1682.

Research Accomplishments

Red Tree Vole Genetic Structure and Diversity

Although red tree voles are endemic to forests in much of western Oregon, little is known about their population structure, population trends, or ecology. Concern that clear-cutting and thinning of forests might negatively impact red tree voles led to their listing as one of the "Survey and Manage" species in the Northwest Forest Plan. Understanding their genetic structure is an important part of developing appropriate management plans. USGS scientists and colleagues examined the genetic structure and diversity of the red tree vole across its range in the Pacific Northwest. They found the greatest genetic distances in an area that subdivided northern and southern regions. This north/south discontinuity likely corresponds to secondary contact following Pleistocene glacial retreat when separately evolved northern and southern lineages once again came into contact. A secondary delineation subdivided the northern sampling areas into eastern and western groups divided by the Willamette Valley. Additional fine-scaled spatial sampling is needed to provide a better understanding of the more recent evolutionary and phylogeographical determinants of red tree vole genetic structure.

Contact: Martin Fitzpatrick, US Geological Survey, Martin_Fitzpatrick@usgs.gov

Partners: USDI Bureau of Land Management; USDA Forest Service

Citations: Miller, M.P., Bellinger, R.M., Forsman, E.D., Haig, S.M., 2006, Effects of historical climate change, habitat connectivity, and vicariance on genetic structure and diversity across the range of the Red Tree Vole (Phenacomys longicaudus) in the Pacific Northwest United States: Molecular Ecology, v. 15, p. 145-159.

Photo by Jason Mowdy.

Downy, fledgling spotted owl ready for release after banding.

What are the relationships between northern spotted owls, barred owls, and other stressors that will affect populations of northern spotted owls?

Arboreal rodent demography informs ecosystem management of interior dry forests

A series of studies was completed on the ecological web supporting the threatened northern spotted owl in interior dry forests, with findings on northern flying squirrel demography and bushy-tailed woodrat abundance. Flying squirrels and woodrats make up about 60 percent of the owl's diet and potentially drive patterns of owl habitat selection and demography. Past research addressed the abundance and use of mycorrhizal fungi and arboreal lichens, both key biodiversity elements and food of many arboreal and terrestrial mammals. The study quantified the demography and habitat use of arboreal rodent prey in three forest types over 4 years in a portion of the Cle Elum long-term spotted owl demography study area. The dry forests studied are those targeted for large fuel-reduction programs. The flying squirrel data have already been used for several significant programs. The U.S. Fish and Wildlife Service (USFWS) used the data and findings in their 5-year status review of the northern spotted owl. The data and findings have also been used by government and private scientists analyzing 10-year demographic trends of the northern spotted owl. The principal investigator presented findings to the USFWS northern spotted owl recovery team, and serves on its science advisory committee. In addition, these findings will influence wildlife viability modeling for forest plan revisions on the Colville, Okanogan, and Wenatchee National Forests, and ultimately all forests in the Pacific Northwest Region.

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Partners: Central Washington University; Oregon State University; USDA Forest Service, Okanogan and Wenatchee National Forests

Citations: Lehmkuhl, J. F., K. D. Kistler, J. S. Begley, and J. Boulanger. 2006. Demography of northern flying squirrels informs ecosystem management of western interior forests. Ecological Applications 16: 584-600.

Lehmkuhl, J. F., K. D. Kistler, and J. S. Begley. 2006. Bushy-tailed woodrat abundance in dry forests of eastern Washington. Journal of Mammalogy 87(2): 371-379.

Lehmkuhl, J. F., M. Kennedy, E. D. Ford, P. H. Singleton, W. L. Gaines, and R. L. Lind. 2007. Seeing the forest for the fuel: integrating ecological values and fuels management. Forest Ecology and Management (in press).

What are the relationships between marbled murrelet status and stressors? How does this affect nesting distribution? Can habitat models effectively predict where murrelets nest?

When in search of food, marbled murrelets travel far and wide

Photo by Aaron Barna, U.S. Forest Service, PNW Research Station.

Marbled murrelets in breeding plumage, in waters off Washington.

The marbled murrelet relies on both oceans and forests to survive. During the breeding season, the female and male of each nesting pair alternate between foraging in coastal ocean waters and nesting inland on the branches of large, old trees. In previous studies, Station scientists documented the species' tendency to travel widely between their foraging and nesting sites—sometimes crossing the entire Strait of Juan de Fuca as they switch places with their mate. New research on the murrelet, a threatened species, used ground, boat, and aerial surveys to track 107 radiotagged murrelets throughout the breeding season and also collected blood samples for genetic analyses. Scientists confirmed and documented 14 murrelet nests within the older forests of Olympic National Park, Olympic National Forest, and Vancouver Island. They also found that murrelets' home range in 2005 was five times that of 2004, suggesting the birds had to travel greater distances to find food in 2005, when delayed upwelling of nutrient-rich waters likely resulted in less food. These findings will be critical to the U.S. Fish and Wildlife Service's upcoming rangewide status review of the marbled murrelet. Information on murrelets' at-sea movement also will help managers connect population monitoring results to inland nesting habitat.

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Citations: Raphael, Martin G., Beth Galleher, Mark H. Huff, Sherri L. Miller, S. Kim Nelson, and Richard D. Young. 2006. Chapter 5: Spatially-explicit estimates of potential nesting habitat for the Marbled Murrelet. Pp. 97-146 in Mark H. Huff, Martin G. Raphael, Sherri L. Miller, S. Kim Nelson, and Jim Baldwin, technical coordinators. 2006. Northwest Forest Plan – The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the Marbled Murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture.

Modeling shows that the majority of baseline marbled murrelet habitat occurs within reserves

The primary objectives of the Effectiveness Monitoring Plan for the marbled murrelet (Brachyramphus marmoratus) include mapping baseline nesting habitat and estimating changes in that habitat over time. Using vegetation data derived from satellite imagery, two approaches were developed to model habitat suitability. First, expert judgment was used to classify murrelet nesting habitat suitability. Second, the Ecological Niche Factor Analysis (ENFA) was used to compute habitat suitability scores based on attributes of 111 polygons that were occupied by marbled murrelets and average conditions over the physiographic provinces in which the murrelets occurred. Estimates of amounts of baseline habitat varied with the model used, but all models showed that over 80 percent of baseline habitat on federally administered lands occurred in reserved lands. A substantial amount of baseline habitat occurred on nonfederal lands; amounts of nonfederal habitat differed among provinces. Fire and harvest have led to losses of nesting habitat since the Plan was implemented, with higher rates of loss on nonfederal lands. Ingrowth of large-diameter stands has also occurred, and rates of ingrowth appear to exceed rates of loss of such stands but we are uncertain how much of this ingrowth can be considered nesting habitat. Given the pros and cons of the approaches used, scientists concluded that neither the Expert Judgment nor ENFA models are ideal. Given the anticipated difficulty in repeating the ENFA model in future monitoring updates, it is believed some version of the Expert Judgment model will have the greatest long-term utility. It should be possible to use ENFA to help build a stronger expert model that would take into account more information and that could be driven from underlying attributes (such as QMD and canopy cover) rather than

older forest classes. Model improvements would likely result from development of an improved Expert Judgment model and a more consistent approach to vegetation classification across California, Oregon, and Washington.

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Partners: U.S. Fish and Wildlife Service; Crescent Coastal Research; Washington Department of Fish and Wildlife; Oregon Department of Fish and Wildlife.

Additional information: http://www.reo.gov/monitoring/10yr-report/marbled-murrelet/index.html

Citations: Raphael, Martin G., Beth Galleher, Mark H. Huff, Sherri L. Miller, S. Kim Nelson, and Richard D. Young. 2006. Chapter 5: Spatially-explicit estimates of potential nesting habitat for the Marbled Murrelet. Pp. 97-146 in Mark H. Huff, Martin G. Raphael, Sherri L. Miller, S. Kim Nelson, and Jim Baldwin, technical coordinators. 2006. Northwest Forest Plan – The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the Marbled Murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture.

Photo by D. Baker.

How is the distribution and abundance of forest habitat changing as a result of climate change and the interactions with fire, insects, disease, and other disturbances?

Surprising relation found between tree thinning and bark beetle outbreaks

Using the Forest Vegetation Simulator (FVS) system, 60 years of fuel management treatments were modeled on a 16 000-hectare wildland-urban interface landscape in northeastern Oregon to predict how thinning treatments could affect wildfire behavior and the susceptibility of forests to a future bark beetle outbreak. As hypothesized, projected wildfire behavior was significantly moderated by thinning, although substantial acreages required repeated thinning to meet and maintain long-term forest restoration goals. Thinning treatments favored bark beetle host species resulting in more and larger diameter host trees. When an outbreak was simulated at year 30, substantially higher mortality from bark beetles was predicted for the thinning scenario. Wildland fire and bark beetle outbreaks are generally considered the most important disturbance factors in dry coniferous forests of the West. Federal land management agencies have adopted forest restoration strategies that call for thinning, reintroduction of natural and prescribed fire, and fuel reduction over wide areas in the Western United States. Although most agree that these activities have beneficial effects in terms of moderating wildfire, the effects on bark beetle dynamics and potential for widespread beetle-caused tree mortality are less clear, in part because the tools to analyze the problem are not well developed. This work resulted in a modeling frame-work that can be used to integrate the long-term potential impacts of bark beetles and other natural disturbance factors into landscape planning for wildfire risk and fuel treatments.

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Partners: US Forest Service, Forest Health Technology Enterprise Team (Fort Collins, CO); USDA Forest Service, Rocky Mountain Research Station

Citations: Ager, A.A., McMahan, E., Hayes, J.L., and E.L. Smith. 2007. Modeling the effects of thinning on bark beetle impacts and wildfire potential in the Blue Mountains of Eastern Oregon. Landscape and Urban Planning 80:301-311

Climate change may cause significant changes in California ecosystems

The potential effects of climate change on California ecosystems were analyzed with the dynamic vegetation model MC1, by using three updated climate change scenarios. Results showed that climate change may cause extensive changes in ecosystems, carbon cycles, and fire seasons throughout the state. Alpine ecosystems may be greatly reduced from their current area. Shrublands and woodlands may become forests under the wetter scenario, or grasslands under the two dry scenarios. The annual area burned in California increased under all three scenarios, ranging from 9 to 15 percent above the historical norm by the end of the 21st century. Under the wetter scenario, in which more vegetation would grow, annual biomass burned was projected to be about 18 percent greater than the historical norm. Even with more biomass burning, enough vegetation would grow under the wetter scenario that California would become a carbon sink (more carbon stored than released) of about 354 million tons total, by the end of the 21st century. Under the drier scenarios, in which less vegetation would grow, annual biomass burned was projected to be slightly less than the historical norm, and California would become a carbon source, losing carbon to the atmosphere. The MC1 study was part of the California Energy Commission's Public Interest Energy Research program, and it was part of the first biennial report on the potential effects of global warming on the California economy. The full report was a multi-institution collaboration. Currently, the Station's lead scientist on this research serves on a panel advising the governor of California on climate change.

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Partners: California Energy Commission; Scripps Oceanographic Institute

Additional information: Science Findings 75. Climate Change and California: Potential Implications for Vegetation, Carbon, and Fire. http://www.fs.fed.us/pnw/sciencef/scifi75.pdf.

Citations: Lenihan, J.M.; Bachelet, D.; Drapek, R.; Neilson, R.P. 2005. The response of vegetation distribution, ecosystem productivity and fire in California to future climate scenarios simulated by the MC1 dynamic vegetation model. In California Energy Commission Report CEC-500-2005-191-SF. 19 p.

Healthy Forests: Got Calcium?

Nitrogen and calcium are essential nutrients for healthy forests. A recent USGS study of Oregon forests shows that cycles of these nutrients are more tightly linked to one another than previously recognized. Across a range of sites, high levels of soil nitrogen strongly reduced calcium availability to trees. Detailed study of one site showed that rainfall was the primary source of soil calcium reserves tapped by trees. Intensive forest harvest can deplete this calcium reserve more rapidly than it is replenished, which is likely to impact long-term forest health and productivity. Continuing work is evaluating the potential to offset calcium deficiencies by planting different tree species and using calcium fertilizers.

Contact: Martin Fitzpatrick, US Geological Survey, Martin_Fitzpatrick@usgs.gov

Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

Citations: Perakis, S.S., Maguire, D.A., Bullen, T.D., Cromack, K., Waring, R.H., Boyle, J.R., 2006, Coupled nitrogen and calcium cycling in forests of the Oregon Coast Range: Ecosystems, v. 9, p. 63-74.

Tree Species Control of Soil Nutrients in Old-growth Forests

Tree species directly and indirectly affect soil nutrient cycles and fertility. Soils in old-growth forests containing Douglas-fir, western hemlock, western red cedar, and bigleaf maple were sampled for carbon and nitrogen (elements derived from the atmosphere) and other nutrients derived from rock weathering. For carbon and nitrogen, tree species effects on nutrient status emerged only at carbon- and nitrogen-rich sites. For rock-derived nutrients, species imprints on soils occurred across all levels of site fertility. Species effects on soils were individualistic; no single species increased the availability of all nutrients at all sites. Consequently, forest management that results in stands dominated by a single tree species is likely to reduce soil nutrient complexity, which may reduce soil fertility overall.

Contact: Martin Fitzpatrick, US Geological Survey, Martin_Fitzpatrick@usgs.gov

Partners: USDI Bureau of Land Management; Oregon Department of Forestry; Oregon State University

Citations: Cross, A., 2006, Tree species-soils relationships in old-growth forests of the Oregon Coast Range: Corvallis, Oregon, M.S. thesis, University, 110 p.

What are the effects of fire on ecosystems, and how can restoration activities (pre-fire and post-fire) reduce the adverse risks of fire to ecosystems and communities, and achieve desired forest habitat conditions?

Wildland-urban interface maps are available on the Internet

The wildland-urban interface (WUI), where homes and other structures are built among forests, grasslands, or shrubs, has received much attention owing to the growing number of structures destroyed in WUI wildfires and the increasing number of people and resources at risk in these areas. Forest fragmentation, habitat loss, and declining biodiversity in WUI areas are also concerns. A new assessment has produced maps and other data on the WUI for the coterminous United States, by using a standard, legislatively relevant definition and consistent mapping techniques. Most of the WUI is in the Eastern United States, especially in northern Florida, the southern Appalachians, and coastal areas of the Northeast. Other major WUI areas are located along the west coast, the Colorado Front Range, southeast Texas, and the northern Great Lakes States. The digital maps and other spatial data on the WUI are available on the Internet. The maps and databases are compatible with vegetation and fuel maps currently under development, which makes them useful for midscale analyses of fuel treatment needs, determining economic values at risk, and allocating federal cost-share, and as a partial basis for stationing wildland firefighting resources. The assessment is now publicly available on the Internet. The Website includes WUI maps, statistics, and a nationally standardized geographic information system data library for the WUI.

Photo by D. Baker.

Prescribed fire, Yakima Province

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Partners: University of Wisconsin; US Forest Service, Northern Research Station

Additional Information: See the Web site at http://www.silvis.forest.wisc.edu/projects/WUI_Main.asp

Citations: Radeloff, V.C., R.B. Hammer, S.I. Stewart, J.S. Fried, S.S. Holcomb and J.F. McKeefry. 2005. The Wildland-Urban Interface in the United States. Ecological Applications 15(3):799-805.

Hammer, R.B., V.C. Radeloff, J.S. Fried and S.I. Stewart. [In Press]. Wildland-urban interface growth during the 1990s in California, Oregon, and Washington. International J. of Wildland Fire.

Methodology helps predict how fuel treatments affect wildfire risk

In the Western United States, many models and a wealth of literature are available to help land managers classify a landscape's wildfire risk. Few frameworks and tools exist, however, for helping managers measure how fuel treatments actually affect wildfire risk. Scientists developed a methodology that applies quantitative and probabilistic risk assessments to wildfire risk management and fuels treatment planning. They tested this methodology on a large wildland-urban interface in eastern Oregon by using several hypothetical scenarios. Initial results suggest that the risk of probable loss from wildfire decreases as fuel treatment area increases. By simulating fuel treatment scenarios and evaluating their performance, this framework will help federal land managers identify the tradeoffs between different fuel treatment approaches.

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Partners: US Forest Service Pacific Southwest Region and Rocky Mountain Research Station

Citations: Ager, A., A. McMahan, J. Barrett, and C. McHugh. (In press). A simulation study of forest restoration and fuels treatments on a wildland-urban interface. Landscape and Urban Planning 80:292:300.

Ager, A.; Finney, M.; McMahon, A. 2006. A wildfire risk modeling system for evaluating landscape fuel treatment strategies. Pp. 149-162 in Fuels Management-How to Measure Success, Conference Proceedings (ed. P. Andrews and B. Butler), USDA Forest Service, Rocky Mountain Research Station, RMRS-P-41, Fort Collins, CO

Areas with southern aspect tend to burn with greater severity in southern Oregon and northern California

Pre-burn vegetation measures from the 2,500 ha Quartz fire in southern Oregon and the 50,600 ha Big Bar complex in northern California were used to evaluate the ability of vegetation and topographic characteristics to predict patterns of fire severity. Fire severity was characterized as high, moderate, or low based on crown scorch and consumption and changes in soil structure. In both fires vegetation plots with south aspects were more likely to burn with high severity than plots with east, north, or west aspects. This was the only consistent predictor across both fires. In the Quartz fire plots at higher elevations and with larger diameter trees were found more likely to burn with low or moderate severity. These correlations may have been influenced in part by the effects of unmeasured weather conditions. These results, in combination with previous studies of fire severity in the Klamath-Siskiyou region, suggest that areas with southern aspects tend to burn with greater severity than those of other aspects, areas with large trees burn less severely than those with smaller trees, and that correlates of fire severity vary extensively among fires.

Contact: C. John Ralph, US Forest Service, Pacific Southwest Research Station, cralph@fs.fed.us

Partners: The Klamath Bird Observatory

Citations: Alexander, John D., Nathaniel E. Seavy, C. John Ralph, and Bill Hogoboom. 2006. Vegetation and topographical correlates of fire severity from two fires in the Klamath-Siskiyou region of Oregon and California. International Journal of Wildland Fire 15: 237-245.

How well has federal forest management provided for environmental qualities and values associated with late-successional, old-growth, and aquatic ecosystems?

Channel pattern effectively stratifies the dynamics of rivers in forested systems

Channel pattern effectively stratifies the dynamics of rivers and their floodplains in forested mountain river systems of the Pacific Northwest, USA. Straight channels are least dynamic, with relatively slow floodplain turnover and floodplains dominated by old surfaces. Braided channels are most dynamic, with floodplain turnover as low as 25 years and predominantly young floodplain surfaces. Island-braided and meandering channels have intermediate dynamics, with moderately frequent disturbances (erosion of floodplain patches) maintaining a mix of old and young surfaces. Floodplain erosion return intervals increase in the order of braided, island-braided, meandering, and straight (8, 33, 60, and 89 years, respectively). A threshold channel size for lateral migration occurs at 15-20 m bankfull width. The most likely mechanism underlying this threshold is that larger channels are deep enough to erode below the rooting zone of bank vegetation. Above this threshold, channels not confined between valley walls exhibit channel patterns distinguishable by slope and discharge, and slope-discharge

Photo by Melinda Moeur.

Western hemlock seedlings regenerating on rotting logs.

domains can be used to predict channel patterns. Meandering and braided patterns are most consistently identified by the model, and prediction errors are largely associated with indistinct transitions among channel patterns that are adjacent in plots of slope against discharge. Locations of straight channels are difficult to identify accurately with our current model. The predicted spatial distribution of channel patterns reflects a downstream decline in channel slope, which is likely correlated with a declining ratio of bed load to suspended load. Ecological theory suggests that biological diversity should be highest where the intermediate disturbance regime of island-braided channels sustains high diversity of habitat types and successional states through time.

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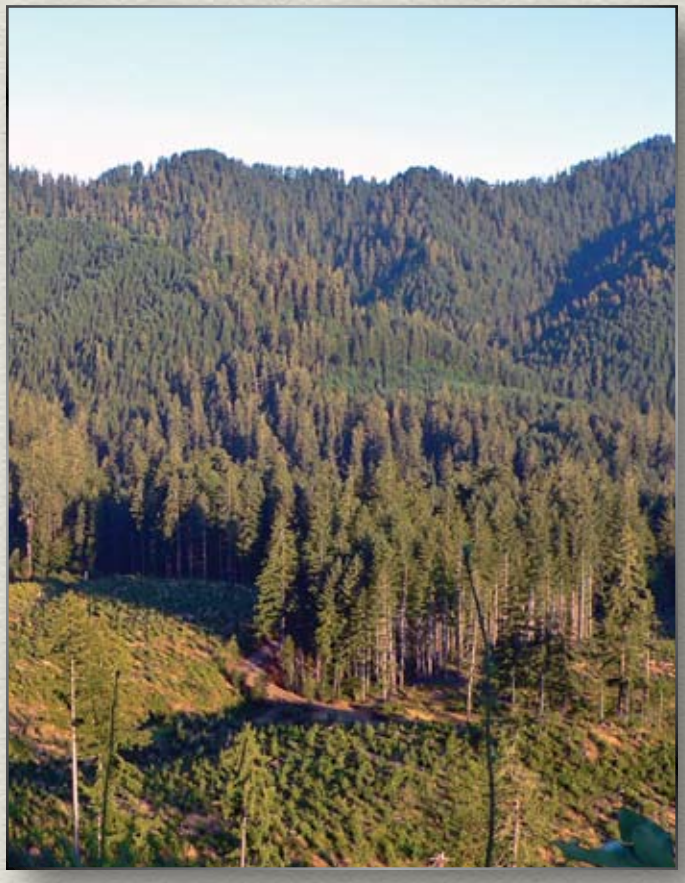
Citations: Beechie, T., M. Liermann, M. Pollock, S. Baker, and J. Davies. 2006. Channel pattern and river-floodplain dynamics in forested mountain river systems. Geomorphology 78(1-2):124-141.



Maintaining the integrity of connections among and between ecosystems is essential for promoting habitat complexity and community structure within river networks

Maintaining the flow of energy, materials and organisms between and among habitats is critical to ecosystem structure and function, because the movement of these elements affects resource abundance, habitat heterogeneity and biodiversity. Loss or disruption of these connections, therefore, may contribute to declines in species' abundance and distribution and ecosystem function. Surveys in three river basins and 13 reaches were conducted to examine interdependence between tributary streams and the larger rivers they enter. It was hypothesized that habitat complexity, environmental productivity, and abundance of primary consumers and predators would peak in mainstem rivers at or downstream of tributary junctions. To test this, a number of physical, chemical and biological attributes at points on mainstem rivers upstream and downstream of tributary junctions were measurerd. Wood abundance and volume, variability in median substrate size (i.e., substrate heterogeneity), concentrations of nitrogen and phosphorus in water, algal biomass and abundance of consumers and predators peaked with a higher frequency at or downstream of tributary junctions. Variables associated with habitat complexity (wood abundance and substrate heterogeneity) and productivity (algal biomass) were positively correlated with consumer abundance and fish abundance and diversity. Some of these variables were also correlated with the size of the tributary relative to the mainstem. These findings suggest that tributary streams have fundamental effects on the larger rivers they enter; maintaining the integrity of connections among and between ecosystems is essential for promoting habitat complexity and community structure within river networks.

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Citations: Kiffney, P. M., C. Greene, J. Hall and J. Davies. 2006. Gradients in aquatic habitat, productivity and diversity at tributary junctions. Canadian Journal of Fisheries and Aquatic Sciences 63:2518-2530.

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Photo by Steve Lanigan.

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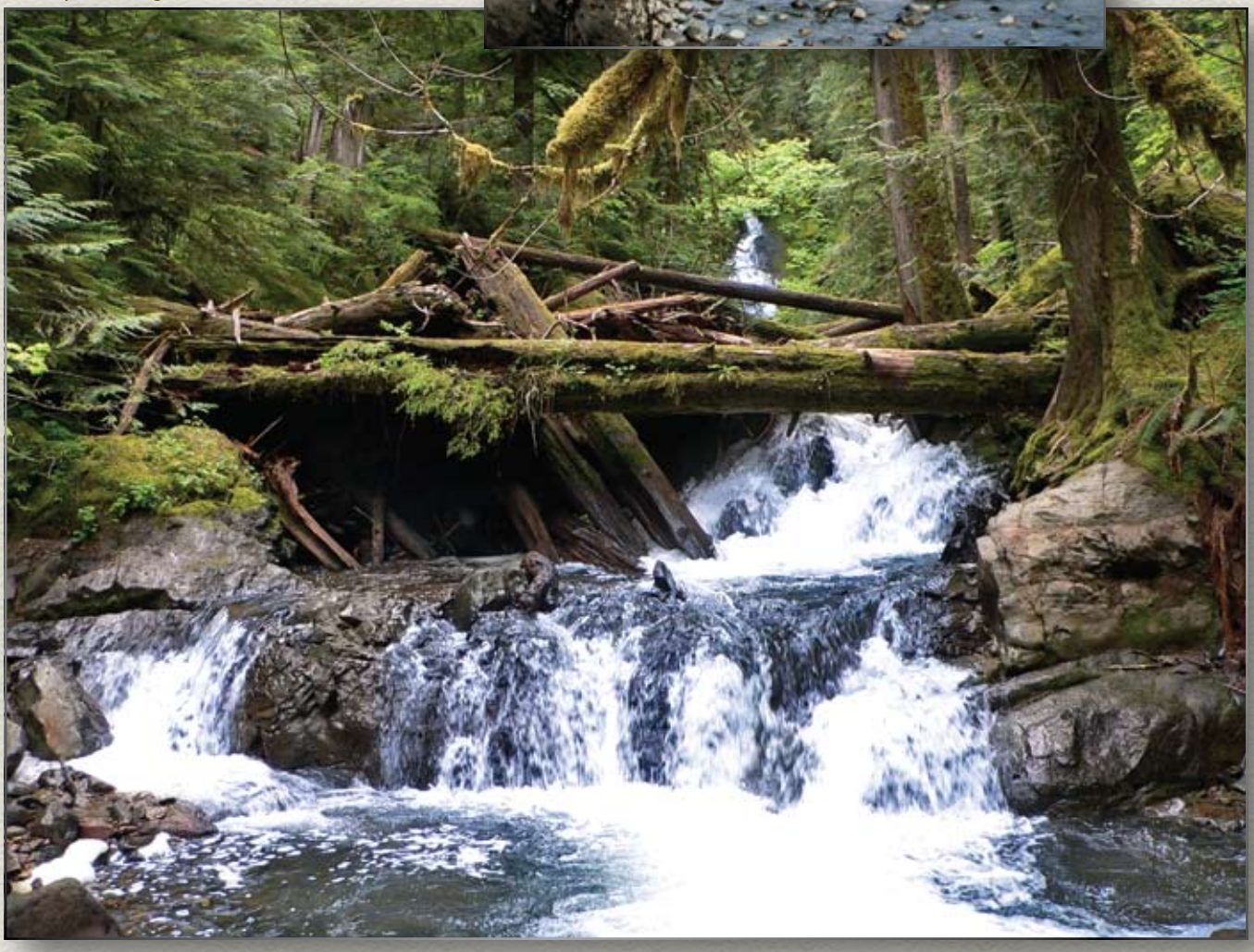

Additional References

Older Forests

Topic—Monitoring Results

Healey, Sean P., Warren B. Cohen, Yang Zhiqiang, Olga N. Krankina. 2005. Comparison of Tasseled Cap-based Landsat data structures for use in forest disturbance detection. Remote Sensing of Environment 97 (2005) 301 – 310.

Healey, Sean P., Zhiqiang Yang, Warren B. Cohen, D. John Pierce. 2006. Application of two regression-based methods to estimate the effects of partial harvest on forest structure using Landsat data. Remote Sensing of Environment 101 (2006) 115–126.

Moeur, Melinda; Spies, Thomas A.; Hemstrom, Miles; Martin, Jon R.; Alegria, James; Browning, Julie; Cissel, John; Cohen, Warren B.; Demeo, Thomas E.; Healey, Sean; Warbington, Ralph. 2005. Northwest Forest Plan–The first 10 years (1994-2003): status and trend of late-successional and old-growth forest. Gen. Tech. Rep. PNW-GTR-646. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 142 p. Available online at http://www.reo.gov/monitoring/reports/10yr-report/oldgrowth/index.shtml.

Ohmann, J.L.; Gregory, M.J. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest-neighbor imputation in coastal Oregon, USA. Canadian Journal of Forest Research. 32: 725-741.

Schwind, B., K. Brewer, B. Quayle, J. C. Eidenshink. In Press. Establishing a Nationwide Baseline of Historical Burn Severity Data to Support Monitoring of Trends in Wildfire Effects and National Fire Policies. Proceedings, Advances in Threat Assessment Conference, Boulder, CO July 18-20, 2006. USDA Forest Service Southern Research Station SRS-GTR.

Topic—Monitoring Trends in Burn Severity

Key, C.H. & Benson, N.C. (2005). Landscape assessment: remote sensing of severity, the Normalized Burn Ratio. In: D.C. Lutes et al. (Editors), *FIREMON: Fire Effects Monitoring and Inventory System*, Ogden, UT: USDA Forest Service, Rocky Mountain Research Station, General Technical Report, RMRS-GTR-164-CD:LA1-LA51.

Key, C.H. & Benson, N.C. (2005). Landscape Assessment: ground measure of severity, the Composite Burn Index. In: D.C. Lutes et al. (Editors), *FIREMON: Fire Effects Monitoring and Inventory System*, Ogden, UT: USDA Forest Service, Rocky Mountain Research Station, General Technical Report, RMRS-GTR-164-CD:LA1-LA51.

Brewer, K.C., Winne, J.C., Redmond, R.L., Opitz, D.W. & Mangrich, M.V. (2005). Classifying and mapping wildfire severity: A comparison of methods. *Photogrammetric Engineering and Remote Sensing*, 71(11), 1311-1320.

Cocke, A.E., Fulé, P.Z. & Crouse, J.E. (2005). Comparison of burn severity assessments using Differenced Normalized Burn Ratio and ground data. *International Journal of Wildland Fire*, 14, 189-198.

Roy, D.P., Boschetti, L. & Trigg, S.N. (2006). Remote sensing of fire severity: Assessing the performance of the Normalized Burn Ratio. *IEEE Geoscience and Remote Sensing Letters*, 3(1), 112-116.

Topic—Gradient Nearest Neighbor mapping

Ohmann, Janet L. and Matthew J. Gregory. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest neighbor imputation in coastal Oregon, U.S.A. Can. J. For. Res. 32: 725–741

K. B. Pierce Jr., C. K. Brewer, J. L. Ohmann. In press. Moderate Resolution Data and Gradient Nearest Neighbor Imputation for Regional-National Risk Assessment. Proceedings, Advances in Threat Assessment Conference, Boulder, CO July 18-20, 2006. USDA Forest Service Southern Research Station SRS-GTR.

Additional References

Topic—Satellite-based change detection

Healey, Sean P., Warren B. Cohen, Yang Zhiqiang, Olga N. Krankina. 2005. Comparison of Tasseled Cap-based Landsat data structures for use in forest disturbance detection. Remote Sensing of Environment 97 (2005) 301 – 310.

Healey, Sean P., Zhiqiang Yang, Warren B. Cohen, D. John Pierce. 2006. Application of two regression-based methods to estimate the effects of partial harvest on forest structure using Landsat data. Remote Sensing of Environment 101 (2006) 115–126.

Topic—Interagency Mapping and Assessment Project (IMAP)

Barbour, R. James, Miles A. Hemstrom and Jane L. Hayes. 2007. The Interior Northwest Landscape Analysis System: A step toward understanding integrated landscape analysis. Landscape and Urban Planning 80 (3): 333-334.

Hemstrom, Miles A., James Merzenich, Allison Reger and Barbara Wales. 2007. Integrated analysis of landscape management scenarios using state and transition models in the upper Grande Ronde River Subbasin, Oregon, USA. Landscape and Urban Planning 80 (3): 198-211.

Wales, Barbara C., Lowell H. Suring and Miles A. Hemstrom.2007. Modeling potential outcomes of fire and fuel management scenarios on the structure of forested habitats in northeast Oregon, USA. Landscape and Urban Planning 80 (3): 223-224.

Northern Spotted Owl

Anthony, R.G., Forsman, E.D.; Franklin, A.B.; Anderson, D.R.; Burnham, K.P.; White, G.C.; Schwarz, C.J.; Nichols, J.; Hines, J.; Olson, G.S.; Ackers, S.H.; Andrews, S.; Biswell, B.L.; Carlson, P.C.; DIller, L.V.; Dugger, K.M.; Fehring, K.E.; Fleming, T.L.; Gerhardt, R.P.; Gremel, S.A.; Gutierrez, R.J.; Happe, P.J.; Herter, D.R.; Higley, J.M.: Horn, R.B.; Irwin, L.L.; Loschl, P.J.; Reid, J.A.; Sovern S.G. 2006. Status and trends in demography of northern spotted owls, 1985-2003. Wildlife Monograph No. 163. Washington DC: The Wildlife Society. 48 p.

Anthony, R., S. Ackers, R. Claremont, D. McCoskey, N. Nielsen-Pincus, T. Plawman, and Alexis Smoluk. 2006. The demography of northern spotted owls (Strix occidentalis caurina) on the Willamette National Forest, Oregon. Annual Research Report. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, OR 12p.

Anthony, R., S. Andrews, F. Wagner, S. Adams, L. Friar, T. O'Brien, T. Phillips, and D. Strejc. 2006. Demographic characteristics of spotted owls (Strix occidentalis caurina) in the southern Oregon Cascades. Annual Research Report. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, OR 23p.

Forsman, E., J. Reid, M. Koranda, J. Mowdy, and A. Price. 2006. Demographic characteristics of northernspotted owls (Strix occidentalis) on the Tyee Density Study area, Roseburg, Oregon: 1985-2006. Annual Report.USDA Pacific Northwest Research Station, Corvallis, OR 15p.

Forsman, E., P. Loschl, C. McCafferty, B. Meiering, T. Snetsinger, S. Hamilton, R. Lee, J. Schilling and K. Skybak. 2006. Demographic characteristics of spotted owls in the Oregon Coast Ranges, 1990-2006. Annual Report. USDA Pacific Northwest Research Station, Corvallis, OR 15p.

Forsman, E., S. Sovern, and M. Taylor, S. Graham, D. Phipps, J. St.Hilaire, P. Singleton and S. Smith. 2006. Demography of spotted owls on the east slope of the Cascade Range, Washington, 1989-2006. Annual Progress Report. USDA Pacific Northwest Research Station, Corvallis, OR. 15p.

Additional References

Forsman, E., B. Biswell, D. Kelso, K. Laubenheimer. 2006. Demographic characteristics of northern spotted owls (Strix occidentalis) on the Olympic Peninsula study area, Washington, 1987-2006. Annual Report. USDA Pacific Northwest Research Station, Corvallis, OR 28p.

Franklin, A. B., P. C. Carlson, J. Rockweit, L. Quattrini, A. McKarley, A . N. Canter, A. Greenleaf, A. Roberts, A. VanLanen and J. Zeldt. 2007. Monitoring the population ecology of spotted owl (*Strix occidentalis caurina)* in northwestern California: Annual results, 2006. Final Report to USDA Forest Service, Region 5, Vallejo, California.

Gremel, S. 2006. Spotted owl monitoring in Olympic National Park: 2006 Annual Report. Olympic National Park. Port Angeles, WA 16 p.

Horn, R. C. Larson, S. Cross, R. Crutchley, K. Fukuda, M. Irwin, J. Lowden, M. Oleri, A. Rangeloff, and H. Wise. 2006. Demographic characteristics of northern spotted owls (Strix occidentalis caurina) in the Klamath Mountains Province of Oregon, 1983-2006. Annual Report, FY2006. Roseburg District, Bureau of Land Management, Roseburg, OR.

Lehmkuhl, J.F. 2004. Epiphytic lichen diversity and biomass in low-elevation forests of the eastern Washington Cascade Range, USA. Forest Ecology and Management 187: 381-392.

Lehmkuhl, J.F., L.E. Gould, E. Cázares, and D.R. Hosford. 2004. Truffle abundance and mycophagy by northern flying squirrels in eastern Washington. Forest Ecology and Management 200: 49-65.

Lehmkuhl, J.F. 2005. Wildlife adaptations and management in Eastside interior forests with mixed-severity fire regimes. Proceeding of the symposium on Mixed-Severity Fire Regimes: Ecology and Management, Spokane, Washington, November 17-19, 2004. The Association for Fire Ecology, Miscellaneous Publication 3. Davis, California, USA.

Marbled Murrelets

Bloxton, T.D.; and M.G. Raphael. 2006. At-sea movements of radio-tagged marbled murrelets in Washington. Presentation at 2006 annual meeting of the Pacific Seabird Group, in Girdwood, AK.

Huff, M.H.; M.G. Raphael; S.L. Miller; S.K. Nelson; J. Baldwin; R. Young; and M. Brown. 2006. Estimating "odds" of marbled murrelet nesting habitat. Presentation at 2006 annual meeting of the Pacific Seabird Group, in Girdwood, AK.

Huff , Mark H.; Raphael, Martin G.; Miller, Sherri L.; Nelson, S. Kim; Baldwin, Jim, tech. coords. 2006. Northwest Forest Plan--The first 10 years m(1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 149 p.

Huff, M.H. 2006. Introduction to effectiveness monitoring of the Northwest Forest Plan for marbled murrelets. In: Huff , Mark H.; Raphael, Martin G.; Miller, Sherri L.; Nelson, S. Kim; Baldwin, Jim, tech. coords. 2006. Northwest Forest Plan—the first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1-8. Chapter 1.

Huff, M.H.; M.G. Raphael; S.L. Miller; S.K. Nelson; J. Baldwin; R. Young; M. Brown; and D. Evans-Mack. 2006. Estimating the amount of marbled murrelet nesting habitat on federal lands by using a systematic grid sampling strategy. In: Huff , Mark H.; Raphael, Martin G.; Miller, Sherri L.; Nelson, S. Kim; Baldwin, Jim, tech. coords. 2006. Northwest Forest Plan—the first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 61-95. Chapter 4.

Additional References

Lance, M.M.; and S.F. Pearson. 2007. 2006 at-sea marbled murrelet population monitoring: research progress report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia, WA. 14 p.

Miller, S.L.; C.J. Ralph; M.G. Raphael; C. Strong; C.W. Thompson; J. Baldwin; M.H. Huff; and G.A. Falxa. 2006. At-sea monitoring of marbled murrelet population status and trend in the Northwest Forest Plan area. In: Huff , Mark H.; Raphael, Martin G.; Miller, Sherri L.; Nelson, S. Kim; Baldwin, Jim, tech. coords. 2006. Northwest Forest Plan—the first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 31-60. Chapter 3.

Nelson, S. Kim; Huff, Mark H.; Miller, Sherri L.; Raphael, Martin G. 2006. Marbled murrelet biology: Habitat relations and populations. In: Huff , Mark H.; Raphael, Martin G.; Miller, Sherri L.; Nelson, S. Kim; Baldwin, Jim, tech. coords. 2006. Northwest Forest Plan—the first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 9-30. Chapter 2.

Pacific Northwest Research Station. 2007. The secret life of marbled murrelets: monitoring populations and habitats. Science Findings 90: 1-5. U.S. Department of Agriculture, Pacific Northwest Research Station.

Raphael, M.G. 2006. Conservation of listed species: the northern spotted owl and marbled murrelet. Pages 117-144 in Haynes, R.W.; Bormann, B.T.; Lee, D.C.; Martin, J.R., tech. eds. Northwest Forest Plan—the first 10 years (1994-2003): synthesis of monitoring and research results. Gen. Tech. Rep. PNW-GTR-651. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 292 p.

Raphael, M.G. 2006. Unraveling the mysteries of the Marbled Murrelet. Friends of the San Juans. Summer 2006:10.

Raphael, M.G. 2006. Conservation of the marbled murrelet under the Northwest Forest Plan. Conservation Biology 20:297-305.

Raphael, Martin G.; Galleher, Beth M.; Huff, Mark H.; Miller, Sherri L.; Nelson, S. Kim; and Young, Richard D. 2006. Spatially-explicit estimates of potential nesting habitat for the marbled murrelet. In: Huff , Mark H.; Raphael, Martin G.; Miller, Sherri L.; Nelson, S. Kim; Baldwin, Jim, tech. coords. 2006. Northwest Forest Plan—the first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 97-146. Chapter 5.

Raphael, M.G.; J. Baldwin; G.A. Falxa; M.H. Huff; M. Lance; S.L. Miller; S.F. Pearson; C.J. Ralph; C. Strong; C. Thompson. 2007. Regional population monitoring of the marbled murrelet: field and analytical methods. Gen. Tech. Rep. PNW-GTR-716. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p.

Strong, C.S. 2007. Population and productivity monitoring of marbled murrelets in Oregon during 2006. Report to the U.S. Fish & Wildlife Service, Portland, Oregon. Crescent Coastal Research. P.O. Box 2108, Crescent City, CA. 19 p.

Watersheds and Aquatic Conditions

Burnett, K., G. Reeves, D. Miller, S. Clarke, K. Christiansen, and K. Vance-Borland. 2003. A first step toward broad-scale identification of freshwater protected areas for salmon and trout in Oregon, U.S.A. in: Beumer, J.P., A. Grant, And D.C. Smith, editors. Protected areas: what works best and how do we do it? Proceedings of the World Congress on aquatic protected areas. Cairns, Australia. Australian Society for Fish Biology: 144-154.

Keppeler, Elizabeth T. and Jack Lewis. In press. Understanding the hydrologic consequences of timber-harvest and roading: Four decades of streamflow and sediment results from the Caspar Creek Experimental Watersheds. In: Advancing the Fundamental

Additional References

Sciences: Proceedings of the Forest Service National Earth Sciences Conference, October 18-22, 2004, San Diego, CA. General Tech. Rep. PNW GTR-689, Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture, pp. 181-186.

Larsen, D.P; A.R. Olsen; S.H. Lanigan; C. Moyer; K.K. Jones; T.M. Kincaid.[In press]. A design-based approach for integrating stream monitoring data across multiple programs. Journal of the American Water Resources Association.

Lewis, Jack. 2006. Fixed and mixed-effects models for multi-watershed experiments. In: Proceedings, 3rd Federal Interagency Hydrologic Modeling Conference, Apr 2-6, 2006, Reno NV. 8 pp.

Lewis, Jack and Elizabeth T. Keppeler. In press. Trends in streamflow and suspended sediment after logging, North Fork Caspar Creek. In: Redwood Science Symposium: What does the future hold? March 15-17, 2004, Rohnert Park, CA. General Tech. Rep. PSW GTR-194. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 11 pp.

Moyer, C.; S. Lanigan; K. Gallo; J. Chambers; K. Fausti. 2007. Aquatic and Riparian Effectiveness Monitoring Program. 2006 annual technical report. Corvallis, OR. On file with http://www.reo.gov/monitoring/watershed-reports-publications.shtml.

Reeves, G.H, J.E. Williams, K.M. Burnett, K. Gallo. 2006. The Aquatic Conservation Strategy of the Northwest Forest Plan. Conservation Biology 20 (2), 319–329.

Reid, Leslie M. and Jack Lewis. In press. Rates and Implications of Rainfall Interception in a Coastal Redwood Forest In: Redwood Science Symposium: What does the future hold? March 15-17, 2004, Rohnert Park, CA. General Tech. Rep. PSW GTR-194. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 10 pp.

Socioeconomic

Charnley, S., tech. coord. [2006]. Northwest Forest Plan—the first 10 years (1994-2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 6 vol.

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Charnley, Susan. [2006]. Socioeconomic monitoring results. Volume II: Timber and nontimber resources. In: Charnley, S., tech. coord. Northwest Forest Plan—the first 10 years (1994-2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p.

Charnley, Susan; Donoghue, Ellen M.; Stuart, Claudia; Dillingham, Candace; Buttolph, Lita P.; Kay, William; McLain, Rebecca J.; Moseley, Cassandra; Phillips, Richard H.; Tobe, Lisa. [2006]. Socioeconomic monitoring results. Volume III: Rural communities and economies. In: Charnley, S., tech. coord. Northwest Forest Plan—the first 10 years (1994-2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 206 p.

Donoghue, Ellen M.; Stuart, Claudia; Charnley, Susan. [2006]. Socioeconomic monitoring results. Volume IV: Collaboration. In: Charnley, S., tech. coord. Northwest Forest Plan—the first 10 years (1994-2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p.

Additional References

Charnley, Susan; Donoghue, Ellen M. [2006]. Socioeconomic monitoring results. Volume V: Public values and forest management. In: Charnley, S., tech. coord. Northwest Forest Plan—the first 10 years (1994-2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p.

Charnley, Susan; Stuart, Claudia. [2006]. Socioeconomic monitoring results. Volume VI: Program development and future directions. In: Charnley, S., tech. coord. Northwest Forest Plan—the first 10 years (1994-2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

Buttolph, Lita P., W. Kay, S. Charnley, C. Moseley, and E.M. Donoghue. Socioeconomic Monitoring of the Olympic National Forest and Three Local Communities. Gen. Tech. Rep. PNW-GTR-679. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 144 p.

Charnley, Susan. 2006. The Northwest Forest Plan as a Model for Broad-Scale Ecosystem Management: a Social Perspective. Conservation Biology 20(2): 330-340

Donoghue, E.M.; Sutton, N.L. 2006. Socioeconomic Change in Planning Provinces of the Northwest Forest Plan Region. Northwest Science 80 (2): 73-85.

Donoghue, E.M.; Sutton, N.L.; Haynes, R.W. (2006) Considering Communities in Forest Management Planning in Western Oregon. Gen. Tech. Rep. PNW-GTR-693. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Donoghue, E.M.; Sutton, N.L. 2006. Community socioeconomic information system, [CD-ROM]. Gen. Tech. Rep. PNW-GTR-672. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

McLain, Rebecca J., L. Tobe, S. Charnley, E.M. Donoghue, and C. Moseley. 2006. Socioeconomic Monitoring of Coos Bay District and Three Local Communities. Gen. Tech. Rep. PNW-GTR-675. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 144 p.

Moseley, C. 2006. Northwest Forest Plan—the first 10 years (1994-2003): Procurement contracting in the affected counties. Gen. Tech. Rep. PNW-GTR-661. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 36 p.

Tribal

Stuart, C. and Martine, K.., tech. eds. [2006]. Northwest Forest Plan—the first 10 years (1994-2003): Effectiveness of the Federal-Tribal Relationship. Tech. Paper R6-RPM-02-2006. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 53 p.

Fire and Disturbances

Ager, A; Barbour, R.J.; Hayes, J.L. 2005. Simulating fuel reduction scenarios on a wildland-urban interface in northeastern Oregon. Pp. 215-227 in Systems Analysis in Forest Resources: Proceedings of the 2003 Symposium. USDA Forest Service Pacific Northwest Res. Sta., Gen. Tech. Rep. GTR-PNW-656. Portland, OR.

Lenihan, J.M.; Drapek, R.; Bachelet, D.; Neilson, R.P. 2003. Climate change effects on vegetation distribution, carbon and fire in California. Ecological Applications 13(6):1667-1681.