Interagency Regional Monitoring & Research Accomplishments

Annual Progress Report 2008

Northwest Forest Plan

Acknowledgments

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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

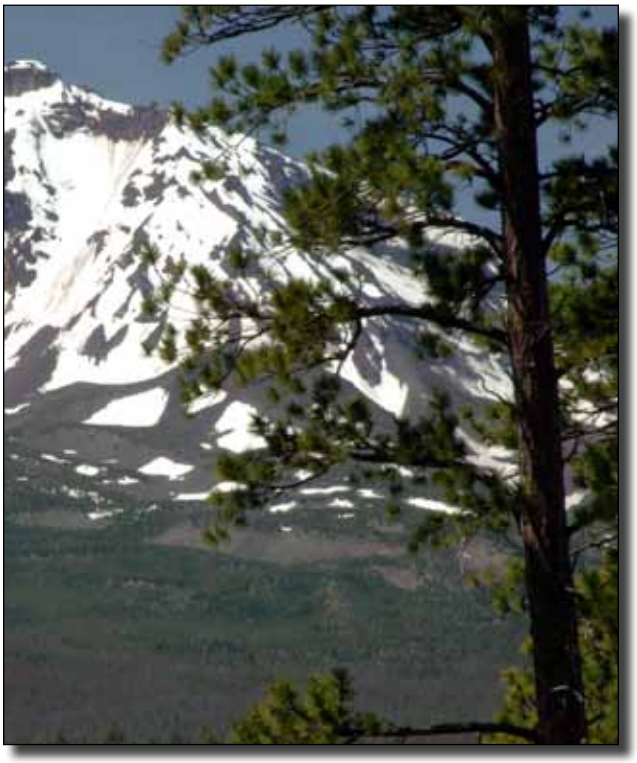
In March 2006, the Regional Interagency Executive Committee (RIEC) identified sixteen Priority Questions to guide regional monitoring and collaborative research investments within the range of the northern spotted owl. They also developed an overarching regional management objective and strategic fundamental objectives. The 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 periodically 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.



Tom Iraci

Strategic Fundamental Objectives

I. Healthy ecosystems

- Restore watershed condition
- Maintain and restore old growth habitat
- Maintain and restore habitats for terrestrial and aquatic species
- Provide 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 and sustainable supply of timber
- Provide nonconsumptive 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 and old growth forest?
- 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 among northern spotted owls, barred owls, and other stressors that will affect populations of northern spotted owls?
- What are the relationships between marbled murrelet status and stressors, how do these 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 (prefire and postfire) 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?

Tom Iraci

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Monitoring Accomplishments

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.

Miles Hemstrom

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 Northwest Forest Plan's aquatic conservation strategy is achieving the goals of maintaining and restoring the condition of watersheds.

2008 Accomplishments

Highlights of Aquatic and Riparian Effectiveness Monitoring Program (AREMP) accomplishments during the 2008 fiscal year include:

- **Continuing to refine the decision-support models used to assess watershed condition**
  - Held five workshops to refine aquatic province decision-support models used to assess watershed condition.
  - Added new metrics to each aquatic province watershed condition decision-support model, including a landslide risk assessment and macroinvertebrate metrics.
  - Assembled GIS layers used in the decision-support models.

Laser levels were used to measure stream channel morphology.

Steve Lanigan

- **Assisting local units in the use of decision-support models.**
  - Assisting Forest Service aquatic specialists in the use of our watershed condition decision-support models to:
    - Identify key watersheds for forest plan revisions
    - Evaluate the contribution of Forest Service lands to the sustainability of aquatic species.
- **Completing another successful field season**
  - Collected stream data from 21 watersheds to measure physical and biological attributes used to assess watershed condition as part of our normal field sampling program.
  - Continued our quality control program by resurveying 25 sites, as well as an additional 20 sites first surveyed in 2007 to detect watershed condition trends.
  - Participated in the second year of a pilot regional aquatic invasive species survey program.
  - Stayed within our allocated budget. The average cost to sample each watershed was $39,228.
  - Used Student Conservation Association interns as a successful component of the summer field staff.
- **Continuing our participation in the Pacific Northwest Aquatic Monitoring Partnership (PNAMP)**
  - Provided technical reviews for a manuscript describing a side-by-side protocol comparison test for in-channel physical attributes in the John Day Basin, Oregon, conducted during summer 2005. The manuscript will be submitted for publication in 2009.
  - Helped plan and participated in Lower Columbia River Endangered Species Act salmon recovery area workshops where state and federal agencies are proposing to use a master sample design to determine sampling sites, establish common protocols, and share data for habitat statues and trend monitoring.
  - Helped plan a November 2008 workshop for determining the "state of the art" regarding intrinsic habitat potential for fishes in the Pacific Northwest.

Aquatic invasives like New Zealand mudsnails, zebra mussels and quagga mussels are sometimes too small to be readily seen in the field. However, their presence would be detected when the macroinvertebrate samples we collect are processed.

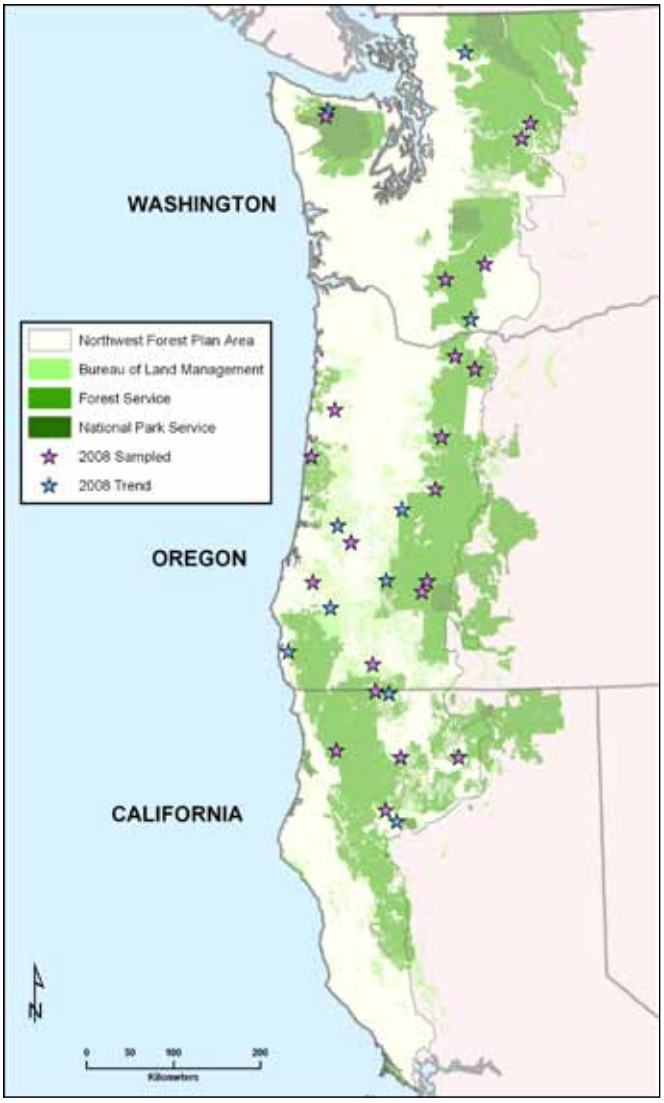
Steve Lanigan

Specialists from the Forest Service, Bureau of Land Management, and other federal and state agencies and nonprofit organizations joined researchers in refining decision-support models during a series of five workshops held in spring 2008.

Steve Lanigan

Steve Lanigan

Map of the watersheds surveyed during the 2008 summer field season. Watersheds coded in purple represent those in which initial surveys took place. Watersheds coded in blue indicate watersheds in which a site was surveyed in 2007 to assess our quality control efforts and then was resurveyed in 2008 for use in detecting watershed condition trends.



Looking Ahead

- Complete a 15-year assessment of watershed condition for all 6th-field watersheds with federal ownership within the Northwest Forest Plan area.
- Refine and update the decision-support models used for assessment watershed condition based on feedback from specialists who participated in five aquatic province workshops.
- Continue a pilot program for surveying invasive aquatic and riparian species.
- Collect shade measurements to help validate a shade prediction model being developed by Forest Service and Bureau of Land Management specialists.
- Develop a geospatial database to manage our field data.

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Web site: http://www.reo.gov/monitoring/watershed-overview.shtml

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

The late-successional and old growth (LSOG) monitoring program provides information to help determine the Plan's effectiveness in maintaining and restoring older forests in the area of the Northwest Forest Plan area. Its goal is to track LSOG status and trends. We use vegetation maps created from satellite imagery to estimate LSOG amount and distribution; maps of disturbance events to estimate losses from fires and harvesting; and field inventory data from regional and national inventory programs to estimate net trends (gains and losses). We also collaborate with other Regional programs and agencies to extend monitoring information and tools to other forest planning and project-level applications.

2008 Accomplishments

Highlights of the LSOG monitoring program during fiscal year 2008 include:

Mapping forest vegetation

- Worked closely with the Pacific Northwest Research Station (PNW) to extend gradient nearest neighbor (GNN) imputation methods to create forest vegetation maps populated with inventory plot data. On GNN maps, each pixel is attributed with all vegetation measures collected on the field plots. The information-rich pixel data can be summarized spatially and thematically to meet a variety of analysis needs, including estimates of LSOG and habitat for northern spotted owls and marbled murrelets. The GNN data and supporting information can be downloaded from PNW's Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) Web site (http://www.fsl.orst.edu/lemma).

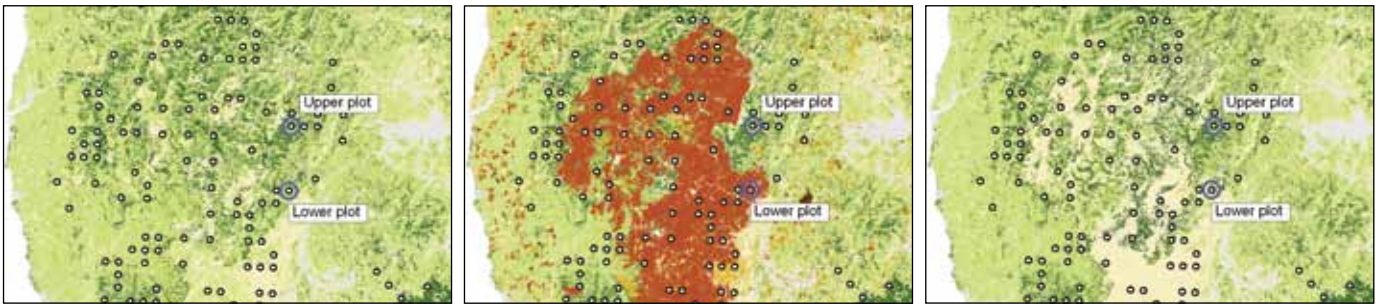
This old growth ponderosa pine in moist mixed conifer, east Cascade Range, Washington, is likely good northern spotted owl habitat.

Miles Hemstrom

- Implemented a 2-date "bookends" approach to develop temporally consistent maps at the beginning and end of the monitoring period. In the 10-yr analysis our map data were a baseline map and a change map. From these sources, we were unable to estimate ingrowth. Reporting was limited to the amount that was mapped as LSOG habitat in 1996, how much was lost, and whether it was removed by stand-replacing fire or harvest. Having consistent GNN bookend maps allows us to determine net change over the monitoring period, including growth or succession into LSOG habitat classes.
- Reached agreement with Pacific Southwest Region (Region 5) Remote Sensing Laboratory to extend GNN methodology to northwestern California. As a result the vegetation data will be spatially consistent across the entire Plan area.

Mapping forest disturbances

- Completed change detection and land use/land cover maps for the California portion of the NWFP area updated to 2007. Region 5 Remote Sensing Laboratory also completed mapping helpful ancillary information in the form of fire history, burn severity, and harvest activities.
- Worked closely with PNW to extended emerging technologies that use trajectory-based change detection to map disturbances annually in the Washington and Oregon portion of the Plan area. The PNW change data is easily grouped upwards into change classes compatible with the Region 5 change data.
- Having detailed change-detection information allows the reporting of loss of baseline LSOG or habitat to specific causes, intensities, and time periods.



Inventory plot

Forest class
- Nonforest
- Sparse forest
- Young forest
- Old forest

Disturbed 1996–2006
Intensity (percent cover removed)
- 70–100
- 40–70
- 15–40
- 0–15

Biscuit Fire aftermath

Tom Spies

An illustration in the Oregon Klamath province of the bookend vegetation maps overlaid with plot data and disturbance map data. The two plots circled in blue were considered old growth prior to the Biscuit fire. The upper plot escaped the fire, but the lower plot was completely consumed. Below is a summary of their pre- and postfire inventories:

	Upper plot		Lower plot	
	Prefire	Postfire	Prefire	Postfire
Diameter (inches)	39	41	32	0.1
Cover (percent)	76	77	74	4
Basal area (ft^2/ac)	477	479	186	1
Snags ≥20 in (number/ac)	5	5	2	64

Forest inventories

- Completed remeasurement of Current Vegetation Survey (CVS) field inventory plots in Pacific Northwest Region (Region 6) during the 2007 field season. In 2008, the data were cleaned and compiled into a master database. Remeasurement of CVS plots on BLM lands is at 75 percent and is scheduled for completion in 2011.
- Completion of remeasured Forest Inventory and Analysis (FIA) annual plots in Region 5 is at 80 percent (100 percent on the Klamath National Forest).
- Compiled the remeasured inventory information into a database for statistical analysis of LSOG amounts and distribution. This information will be used to validate the vegetation and change maps as well as produce independent LSOG trend estimates.

Collaboration with other regional programs

- During 2008, LSOG monitoring aligned closely with IMAP, the Interagency Mapping and Assessment Program. Under IMAP, wall-to-wall current vegetation maps are being created across Washington, Oregon, and northwest California using the GNN imputation approach. For the first time, Plan effectiveness monitoring vegetation maps will be consistent with the vegetation maps used for forest plan revisions in Region 6. More information about IMAP goals can be found at http://www.reo.gov/ecoshare; current vegetation maps for Oregon and Washington can be downloaded from http://www.fsl.orst.edu/lemma/.

Looking Ahead

During early 2009, the vegetation and disturbance mapping will be completed and made available for analysis by all of the effectiveness monitoring modules. Analysis and reporting is scheduled through calendar year 2009, with an early 2010 target date for publishing a 15-yr assessment.

Fuel build-up in late-successional moist mixed conifer, east Cascade Range, Washington.

Miles Hemstrom

Contact:

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

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

The northern spotted owl (NSO) 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. 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 5 years to estimate annual survival, fecundity (number of female young fledged per territorial female) and annual rate of population change (lambda). The latest analyses of demographic data occurred in January of 2009. Results from these analyses will be available in the summer of 2009 after they have been verified and interpreted.

The status and trend of owl habitat on federal land is also updated every 5 years. The habitat analysis uses GIS-compatible data layers on owl locations, vegetation conditions, habitat capability of the federal land, and changes owing to wildfire and timber harvest to model the habitat suitability over time. A nonspatial 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 to be completed in 2009.

Adult spotted owl.

Jason Mowdy

2008 Accomplishments

During the 2008 field season, biologists surveyed 1,148 sites associated with the eight demography study areas. Occupancy by a pair of spotted owls was recorded at just over 35 percent of the sites (table 1). The average annual pair occupancy from 2001 to 2007 was about 46 percent. The count of young fledged during 2008 was 234, which is below the average of 316 young fledged per year for the years 2001 through 2008. The number of young fledged has been above the average 3 of the last 8 years. Years where the average was exceeded had 492, 445, and 550 young fledged, and those years below the average recorded 166, 250, 167, 226, and 234 young fledged.

Dr. Eric Forsman received the "Wings Across the Americas" award for his research on northern spotted owls and work on long-term monitoring of population trends of the owl. This award is given annually by the Washington, DC, headquarters of the Forest Service to recognize scientists whose work emphasizes a strong partnership between research and management to improve the status of a bird species or a community of bird species. Forsman was honored for fostering a research/management partnership that has increased our understanding of the spotted owl and its ecology. The 2005 monitoring report, *Northwest Forest Plan—the First 10 Years (1994–2003): Status and Trends of Northern Spotted Owl Populations and Habitat*, was listed as a major publication in this award.

Table 1—Summary of northern spotted owl occupancy and reproduction by demography area for 2008. These are preliminary data; values may change in the final analysis.

Demographic area	Sites surveyed	Sites with a territorial pair		Females nesting	Young fledged
	Number	*Number*	*Percent*	*Percent*	*Number*
Olympic Peninsula	100	27	27.0	88.0	32
Cle Elum	75	10	13.3	83.0	9
H.J. Andrews	153	73	47.7	59.0	31
North Coast	203	59	29.1	72.0	42
Tyee	198	63	31.8	70.4	39
South Cascades	169	47	27.8	3.0	1
Klamath	156	79	50.6	56.8	53
Northwestern California	94	45	47.9	54.0	27
Total	1,148	403	35.1	__	234

Ray Davis

Janice Reid

Eric Forsman taking field notes.

Ray Davis

Juvenile spotted owl.

Steve Andrews

Amy Price banding juvenile barred owl.

Janice Reid

Monitoring Products

Data files on capture/resighting of owls, reproduction, owl geographic locations, and barred owl detections were compiled for each of the eight demographic study areas for all survey years (average of 22 years of survey) for use in the January 2009 status and trend analysis.

Looking Ahead

Occupancy and reproduction data gathering will be continued in the demographic study areas during the 2009 field season. A report on the results of the January 2009 analysis of the status and trend of the northern spotted owl will be completed. Habitat modeling software will be used to produce range-wide habitat suitability maps using vegetation data developed by Landscape, Ecology, Mapping, Modeling, and Analysis (LEMMA) team at Oregon State University, Forestry Science Lab. These owl habitat maps and the results from the population analysis will be the basis for the assessment of habitat and population status and trend for the 15-year monitoring report scheduled for completion in 2009–10.

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

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 conditions by modeling habitat relations, and use the baseline to track habitat changes over time.

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 conducts murrelet surveys 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 the five zones (based on Conservation Zones identified in Marbled Murrelet Recovery Plan, Figure 1), 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 for 1994, and evaluated changes for the period ending in 2003. Future habitat analyses are planned to occur at 5-year intervals to track habitat changes over time. 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. A new habitat analysis is in progress, which addresses the status and trends of nesting habitat during the Plan's first 15 years. Findings of the new analyses will be presented in the Monitoring Program's 15-year report.

Monique Lance

2008 Accomplishments

Field work focused on sampling to develop a population estimate for 2008, the ninth consecutive year of population sampling under the effectiveness monitoring program. Four teams collected the data for the five sampling zones (zones 1 through 5, figure 1), sampling about 8,800 km^2 of coastal waters.

The 2008 marbled murrelet at-sea population estimate was about 17,800 birds off the coast of the Plan area, with a 95% confidence interval for the estimate of between 14,600 and 21,000 birds (table 1). Although the 2008 estimate was slightly greater than in 2007, these two years represent the lowest population estimates since sampling began (table 1 and figure 2). Within the Plan area, zones 3 and 4 have consistently had the highest murrelet densities, and zone 5 the lowest. Densities are also higher on the coastal waters of the Olympic Peninsula, but this does not show in zone-scale densities, because these birds are spread between zones 1 and 2,

Martin Raphael

Table 1—Summary of marbled murrelet population estimates for the 2000–2008 breeding seasons, for the waters adjacent to the Northwest Forest Plan area, with 95% confidence intervals

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Population estimate	18,600	22,200	23,700	22,200	20,600	20,200	18,800	17,400	17,800
95% confidence interval	13,400–23,700	17,600–26,800	18,300–29,000	18,100–26,400	16,000–25,200	16,000–24,500	15,900–21,700	12,800–21,900	14,600–21,000

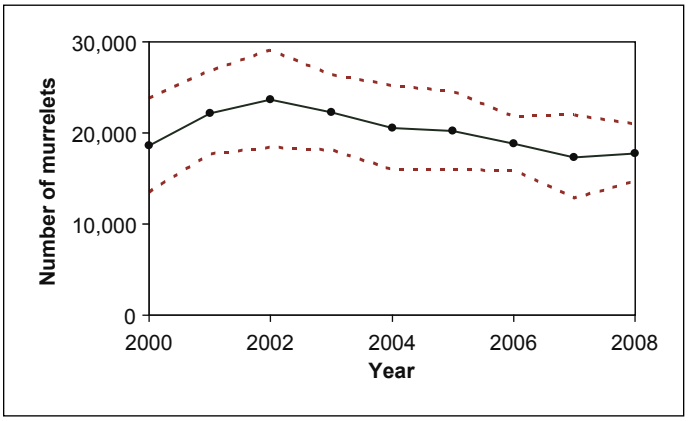
where average zone densities are affected by low murrelet densities in other portions of each zone.

The murrelet team conducted a trend analysis for the Plan area's murrelet population, using monitoring data from the 2000 to 2008 period. This analysis concluded that the murrelet population in the Plan area declined during that period, at an estimated annual rate of decline of about 2.4 percent, which is equivalent to an average decline of about 488 birds per year (standard error of 129 birds). Additional years of at-sea monitoring will be needed to test for trends at the scale of individual conservation zones, and to evaluate whether the decline observed to date continues into the future, and if so, at what rate.

Figure 1—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.

During 2008, the habitat team explored modifications to the habitat models used for the initial 1994–2003 analyses, taking advantage improved data sources and modeling approaches. A key new data source is IMAP, which maps vegetation structure and composition for the Plan area. IMAP provides more detail about forest characteristics important to nesting murrelets, than was available for the 10-year analyses. Another new source is location data for all known murrelet nest sites in the Plan area, which the team assembled in 2008.

Figure 2—Marbled murrelet at-sea population estimate for the Plan area, 2000–2008, with 95% confidence intervals



The Marbled Murrelet Effectiveness Monitoring Team was recognized by the Forest Service's Wings Across the Americas national award for 2009. The Forest Service presents the award to celebrate exceptional work by research and management partnerships that conserve birds, bats and butterflies and their habitats across the Americas.

Looking Ahead

In 2009, the habitat team will be busy conducting a new analysis of the amount and distribution of nesting habitat, during the Plan's first 15 years. This analysis will benefit from the new data sources described above. Together, the IMAP and nest location data should improve our ability to identify suitable nest habitat, by building habitat models based on the characteristics of sites where murrelets actually nest.

The population team will be preparing a summary of results to date for the 15-year report. Population surveys will also be conducted in 2009, as in previous years.

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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, and to address the socioeconomic monitoring question posed by the Regional Interagency Executive Committee: What is the status and trend of socioeconomic well-being?

2008 Accomplishments

During 2008, the new protocol for socioeconomic monitoring was revised and refined to monitor socio-economic trends using existing data. Specific indicators, measures, and data sources were identified. Among the existing data sources selected for the new monitoring protocol are: U.S. Census, Regional Economic Information System of the Bureau of Economic Analysis, Bureau of Labor Statistics, County Business Patterns, U.S. Department of Commerce, Forest Service, and Bureau of Land Management. Contacts were made with Bureau of Land Management counterparts to initiate the process of collecting data related to agency expenditures, timber supply, livestock grazing, recreation use, social contribution, agency jobs, and payments to county governments.

Looking Ahead

In 2009, data will be collected for the 15-year report. Writing of the report will be completed in 2010.

Contact:

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

The Tribal Monitoring Program is designed to evaluate the unique government-to-government relationship between federal land managers and tribal governments on federal lands within the range of the northern spotted owl. A total of 76 federally recognized tribes consult with land managers in this area about resources, places of interest, and the quality of the federal-tribal relationship. Key issues addressed by tribal monitoring include 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.

2008 Accomplishments

During this past year, the Tribal Monitoring Program conducted numerous interviews to evaluate the effectiveness of the federal-tribal relationship. In California, the Intertribal Timber Council conducted interviews for the monitoring program with California Tribes. In Oregon and Washington, Resource Innovations with the Institute for a Sustainable Environment at the University of Oregon conducted monitoring interviews. All work followed the protocol developed by the Tribal Monitoring Advisory Group in response to the Regional Interagency Executive Committee March 17, 2006, direction to monitor: "What is the status and trend of government-to-government consultation."

Looking Ahead

The remaining monitoring interviews will be completed in 2009. These interviews along with associated case studies will be compiled into a report that will be published in 2010.

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Terry C. Slider

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 to 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 percent. Owing to the high overall levels of compliance, the Regional Interagency Executive Committee (RIEC) decided to discontinue annual regional-level implementation monitoring and instead invest limited monitoring resources on other priorities. However, annual monitoring continues to be an important activity at the local level and is reported in district and forest monitoring reports.

2008 Accomplishments

The focus of efforts during this year was to initiate the preparation of a Plan implementation chapter for the 15-year regional monitoring report. The objective of this chapter will be to summarize accomplishments related to planned activities such as timber harvests, aquatic restoration, sensitive species, and partnerships. Key contacts were identified and data gathering was initiated.

Looking Ahead

Data gathering will be completed with the assistance of agency resource specialists. Based on this information, a plan implementation chapter will be prepared for the 15-year regional monitoring report.

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Keith Routman

Research Accomplishments

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?

Regional-scale indicators of condition of fish assemblages evaluated

Consistent assessments of biological condition are needed across multiple ecoregions to provide a greater understanding of the spatial extent of both desired and degraded condition. This study was a collaborative effort between scientists of the U.S. Geological Survey National Water Quality Assessment Program (NAWQA), and the U.S. Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program (EMAP). Regional-scale indicators of condition of fish assemblages were developed as part of the EMAP Western Pilot Study. These indicators were independently evaluated using data from the NAWQA program. Indicator values were significantly related to combined urban and agricultural land uses. The indicators were also corroborated well with independent, locally developed indicators. The regional-scale indicators are robust across large geographic scales, and can provide precise and accurate assessments of biological condition for western U.S. streams. They can also be used in areas where there is not an existing local indicator (e.g., a group of watersheds or national forests), or can provide a basis for putting local conditions into a regional context.

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U.S. Geological Survey, U.S. Environmental Protection Agency, Oregon State University

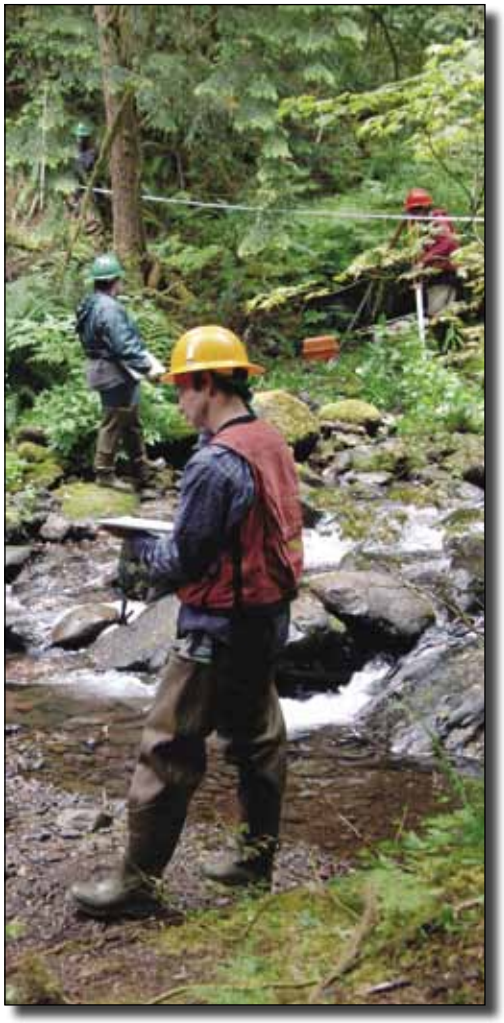
For additional information:

http://water.usgs.gov/nawqa

http://www.epa.gov/wed/pages/publications/authored/EPA620R-05005An_Ecological_Assessment_of_Western_%20Stoddard.pdf

Citation:

Meador, M.R., Whittier, T.R.; Gold-stein, R.M.; Hughes, R.M.; Peck, D.V. 2008. *Evaluation of an index of biotic integrity approach used to assess biological condition in Western U.S. streams and rivers at varying spatial scales.* Transactions of the American Fisheries Society. 137: 13–22.



Tom Iraci

Riparian forests regulate stream flow through evapotranspiration

Scientists found that riparian forests are the primary location of lost streamflow from evapotranspiration in late summer in small watersheds. A study in the H.J. Andrews Experimental Forest explains how daily fluctuations in discharge were generated and why. Observations of daily fluctuations showed that the time lag between maximum evapotranspiration demand and minimum discharge increased, and the amplitude in daily fluctuations decreased as streamflow decreased.

Recently there has been renewed interest in using land management to "harvest" water, especially to augment streamflow during seasonal droughts. This research indicates that vegetation management on upland portions of watersheds may increase total annual water yield, but efforts specifically designed to enhance low-flow discharge in summer would have to concentrate vegetation management efforts in riparian areas.

Also, water quality in many streams is often limited during the summer when low flows combined with high air temperatures raise water temperature, lower dissolved oxygen, and increase concentration of pollutants. This research highlights naturally occurring signals that could be used to improve understanding of watershed processes and help inform management designed to protect or improve water quality.

Contact:

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Partners:

Montana State University, Pennsylvania State University, U.S. Geological Survey

Citations:

Wondzell, S.M.; Gooseff, M.N.; McGlynn, B.L. 2007. *Flow velocity and the hydrologic behavior of streams during baseflow.* Geophysical Research Letters 34. L24404, DOI:10.1029/2007GL031256

Small streams are important sites for nitrogen uptake and processing

Nitrogen is an essential element for life, and historically the Pacific Northwest has had a limited supply. Humans have increased the supply through fossil-fuel combustion and fertilizers. Some of this excess is taken up by soils, but much enters aquatic ecosystems where it can be transported far downstream, potentially leading to noxious algal blooms and oxygen-starved estuaries.

Station scientists found that river networks, particularly small streams, can remove and retain some of this excess nitrogen, but their effectiveness is partly determined by surrounding land use. Across a range of land-use types (forest, agriculture, urban), the ability of small streams to process nitrate declined as ambient nitrate concentrations increased. The results from these short-term studies are being combined with results from 40-year studies of nutrient export in the H.J. Andrews Experimental Forest. These findings provide guidelines for restoring and maintaining ecosystem functions.

Contact:

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Partners:

Oregon State University, Lotic Intersite Nutrient Experiment

Citation:

Mulholland, P.J.; Helton, A.M.; Poole, G.C. [et al]. 2008, *Stream denitrification across biomes and its response to anthropogenic nitrate loading.* Nature. DOI:0.1038/nature06686.

Miles Hemstrom

Landslide model useful in managing fish habitat

The role of landslides in creating and maintaining fish habitat is a much-debated topic among scientists and land managers. Land managers traditionally worked to minimize the occurrence of all landslides. However, recent research suggests that landslides may be important sources of wood and spawning gravels, which are building blocks for fish habitat.

Scientists developed a model for western Oregon that identifies landslide initiation sites and assesses the likelihood that a landslide from that site will reach a fish-bearing stream. The model has been adapted to estimate relative volumes of wood that might be delivered to a stream. When using the model, managers will be able to identify and prioritize landslide sites with a high probability of affecting a fish-bearing stream either positively or negatively. The model facilitates analysis of alternative management scenarios, enabling the user to assess the potential for cumulative management effects.

This model was used extensively by the Oregon Bureau of Land Management to develop and evaluate options for a proposed new land management plan. It was also used by the Aquatic and Riparian Effectiveness Monitoring Program.

Contact:

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

Partners:

Earth Systems Institute, Bureau of Land Management, Oregon Headwaters Research Consortium, U.S. Geological Survey.

Miles Hemstrom

Citations:

Miller, D.J.; 2008. *A probabilistic model of debris-flow delivery to stream channels, demonstrated for the Coast Range of Oregon, USA*. Geomorphology. 94: 184–205.

Clarke, S.E., Burnett, K.M.; Miller, D.J. 2008. *Modeling streams and hydrogeomorphic attributes in Oregon from field and digital data*. Journal of the American Water Resources Association. 44: 459–477. DOI:10.1111/j.1752-1688.2008.00175.x

Miller, D., Burnett, K.M., Benda, L. 2008. *Factors controlling availability of spawning habitat for salmonids at the basin scale*. In: Sear, D.A.; DeVries, P., eds. Salmonid spawning habitat in rivers: physical controls, biological responses, and approaches to remediation. Symposium 65. Bethesda, MD: American Fisheries Society: 103–120.

Peak flow assessment completed for BLM Plan Revisions

Station scientists assessed the science relating to the effects of forest management on peak streamflows in the Pacific Northwest. The Bureau of Land Management used this assessment in their revised management plan for western Oregon. Scientists analyzed several decades of peak flow data from experimental watersheds across the Pacific Northwest and developed novel relationships to guide forest managers in assessing the risk of peak flow increases and channel responses in different geographic regions within the Pacific Northwest. The results of this effort were published in general technical report PNW-GTR-760.

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Partner:
Bureau of Land Management

Citation:
Grant, G.E.; Lewis, S.L.; Swanson, F.; Cissel, J.; McDonnell, J. 2008. *Effects of forest practices on peak flows and consequent channel response: a state-of-science report for western Oregon and Washington*. Gen. Tech. Rep. PNW-GTR-760. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 76 p.

Online tutorial leads to improved aquatic organism passage through culverts

Station scientists produced an online, multimedia guide for field procedures on assessing and designing culverts that provide optimal passage for fish and other aquatic organisms. The tutorial takes the place of a 1-week course, thus saving time, eliminating travel costs, and reducing participants' carbon footprint. The tutorial is highly interactive and includes video, audio, animation, live field forms, and links to other resources. It covers 50 topics relating to safe, effective culvert inventory and assessment. This tutorial complements a national guide written by a station scientist. The online tutorial is being used nationwide by land and road managers working for counties, states, timber companies, the Bureau of Land Management, Forest Service, and National Park Service.

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More information:
See "A tutorial for procedures for inventory and assessment of road-stream crossings for aquatic organism passage" at http://www.fs.fed.us/pnw/pep/PEP_inventory.html

Miles Hemstrom

Report details fish monitoring protocols for Northwest national parks

Rivers and streams that flow from Olympic, Mount Rainier, and North Cascades national parks represent some of the largest tracts of contiguous, undisturbed habitat for several key fish species of the Pacific Northwest. Native anadromous and resident fish populations are of high ecological and cultural importance, yet there is no fish monitoring program for these parks. A new report published by USGS in cooperation with the National Park Service describes procedures to monitor both fish communities and water temperature. The report covers sampling designs, methods, training procedures, safety considerations, data management, data analysis, and reporting. Use of

Keith Routman

the protocols will allow park managers to detect changes in abundance of and occurrence of native, nonnative, and hatchery fish.

Contact:

Andrea Woodward, U.S. Geological Survey, andrea_woodward@usgs.gov

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National Park Service

Citation:

Brenkman, S.J.; Connolly, P.J. 2008. *Protocol for monitoring fish assemblages in Pacific Northwest national parks*. Techniques and Methods 2-A7. Reston, VA: U.S. Geological Survey. 128 p.

Stream gauge data used to assess rate of recovery after logging and thinning

At the Caspar Creek Experimental Watershed, data from a network of stream gauges are being used to assess rates of recovery of hydrologic and sediment production processes after clearcut logging and subsequent precommercial thinning of the regrowing stands. Canopy removal from logging increased effective precipitation by an average of 21 percent owing to loss of foliar interception, contributing to an increase in peak flows from the logged tributaries. Increased flows, in turn, contributed to an increase in suspended sediment yield. Flow and sediment approached back-ground levels over the 10 years following clearcut logging, then increased again with precommercial thinning.

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More information:

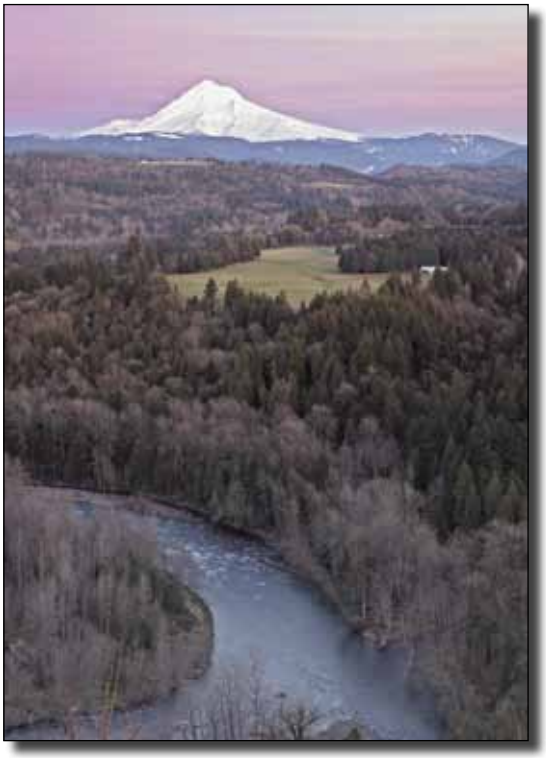
http://www.fs.fed.us/psw/topics/water/caspar/

Citation:

Keppeler, E.T.; Reid, L.M.; Lisle, T.E. [In press]. *Long-term patterns of hydrologic response after logging in a coastal redwood forest*. In: Planning for an uncertain future: monitoring, integration, and adaptation. Proceedings of the Third Interagency Conference on Research in the Watersheds, 8–11 September 2008, Estes Park, Colorado. U.S. Geological Survey.

Effectiveness of stream rehabilitation on Pacific salmon evaluated

Many watersheds in the Pacific Northwest have been adversely affected by human activities. As a result, watershed and stream restoration is needed in many areas to facilitate recovery of Pacific salmon populations to sustainable population levels. The primary objective of this research is to document effectiveness of stream rehabilitation techniques



Miles Hemstrom

currently in use in Pacific Northwest watersheds. The research represents a collaborative effort by the National Oceanic and Atmospheric Administration (NOAA), BLM, Oregon Department of Fish and Wildlife, and EPA to assess the effectiveness of boulder weirs for salmon spawning habitat restoration.

This study is one of the few published attempts to evaluate adult salmon response to restoration at both reach and watershed scales. Key findings include:

- Placement of boulder weirs in bedrock channels leads to localized increases in spawner abundance, although other factors (e.g., amount of spawning area or gravel) appear to influence coho salmon and steelhead spawner abundance and redd construction at a watershed scale.
- When placing boulders or boulder weirs to create spawning habitat in streams with a limited gravel supply, fisheries managers should consider locating the weirs near gravel sources or constructing the weirs in a manner that will maximize their ability to retain gravel.
- Finally, boulder weirs are artificial structures that can increase fish abundance but should not be seen as a substitute for restoring natural processes that create and maintain habitat.

Pete Bisson

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For additional information:

http://www.nwfsc.noaa.gov/research/divisions/ec/wpg/instreamrestoration.cfm

Citation:

Roni, P.; Van Slyke, D.; Miller, B.A.; Ebersole, J.L.; Pess, G. 2008. *Adult coho salmon and steelhead use of boulder weirs in southwest Oregon streams.* North American Journal of Fisheries Management. 28: 970–978.

Miles Hemstrom

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

Lichens indicate patterns of biodiversity, air quality, and climate

Scientists found that lichen communities indicate key patterns in air quality, climate, and biodiversity in forests of Washington, Oregon, and California. Increases in atmospheric nitrogen are causing a shift in lichen species composition in many parts of the Pacific Northwest. Lichen community composition in the region is also closely patterned on temperature and moisture conditions in the forest interior. The current arrangement of lichen communities suggests several species will be highly sensitive to climate change. Shifting lichen distributions will provide early warning of shifting climate in a region and help forecast how plant communities will respond. These baseline assessments help natural resource managers identify forests at high risk of degradation from poor air quality as well as areas of high biodiversity and conservation importance.

Sarah Jovan

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Partners:
Oregon State University

Citation:
Jovan, S., 2008. *Lichen bioindication of biodiversity, air quality, and climate: baseline results from monitoring in Washington, Oregon, and California*. Gen. Tech. Rep. PNW-GTR-737. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 115 p.

Restoration efforts with a broad goal of reducing sediment supply rates may benefit fish

Forest management activities may be accompanied by chronic increases in turbidity in affected streams, but the effects of such changes on salmonids and their strategies for coping with altered turbidities are not fully understood. Two experiments were conducted in a laboratory stream to quantify benthic feeding success of salmonids across turbidity treatments. Cutthroat trout and coho salmon were found to be capable of feeding from the benthos in flowing water at turbidity levels of 150 nephelometric turbidity units (NTU) or less, but both drift and benthic foraging success decreased over the examined turbidity range while activity levels increased, suggesting that successful foraging may come at a higher energetic cost. Results suggest that restoration efforts with a broad goal of reducing sediment supply rates may benefit fish both by reducing turbidity and by increasing channel complexity, thus providing a diversity of microhabitats that could provide sources of benthic prey during periods of high flow and elevated turbidity.

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

Citation:
Harvey, B.C.; White, J.L. 2008. *Use of benthic prey by salmonids under turbid conditions in a laboratory stream*. Transactions of the American Fisheries Society. 137: 1756–1763.

Keith Routman

Tom Iraci

Study results may result in minimizing impacts to beneficial arthropods for prescribed fire projects

Oribatid mites play a crucial role in forest soil nutrient cycling and decomposition processes. We studied responses of Acari, especially oribatid mites, to prescribed low-intensity fire in the southern Cascade Range in California. We compared oribatid population and assemblage responses to prescribed fire in stands that had been selectively logged to enhance old growth characteristics, in stands logged to minimize old growth characteristics, and in undisturbed forest reference stands. Low-intensity prescribed fire altered habitat characteristics within the organic layer of forest soil. Acarine populations declined following prescribed fire, and Oribatei losses accounted for two-thirds of that decline. Individual oribatid species responded differently to prescribed fire, with a few populations increasing after fire but most declining. The prescribed fire also altered oribatid assemblages, reducing species richness and species diversity and modifying assemblage dominance relationships. We also identified several oribatid taxa that were potential indicator species of fire effects upon forest soil fauna. Finally, our results suggested that oribatid responses to fire were intensified by stand alteration and especially by removal of old growth structural characteristics. Decline in oribatid abundance, species richness and diversity, and loss of equilibrium dominance relationships was greatest in the low structural diversity plots. These findings may be important for implementing prescribed fire to minimize impacts on this group of beneficial arthropods.

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Partners:

Humboldt State University, University of Georgia

Citations:

Camann, M.A.; Gillette, N.E.; Lamoncha, K.L; Mori, S.R. 2008. *Response of forest soil Acari to prescribed fire following stand structure manipulation in the Southern Cascade Range*. Canadian Journal of Forest Research. 38: 956–968.

Old growth characteristics intensified effects of fire on spider abundance

Spiders (Arachnida: Araneae) are frequently very effective indicators of old growth stand characteristics and past fires because of their acute sensitivity to differences in habitat architecture, but little is known of the spider fauna in the southern Cascade Range. We assessed spider responses to prescribed fire following stand structure treatments in ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) stands in the Cascade Range of California. Stands were logged or left untreated to create three levels of structural diversity. We logged one treatment to minimize old growth characteristics (low diversity), one to enhance old growth characteristics (high diversity), and we used unlogged research natural areas (RNAs) as old growth, highest diversity reference stands. We conducted low intensity prescribed fire on half of each plot following harvest. Spider assemblages in unburned, logged stands were similar to one

Joel Thompson

another but diverged from those in RNAs, with increased abundance, species richness and diversity in more structurally diverse stands. Prescribed fire, which altered habitat in the organic soil layer where many spiders forage, resulted in altered spider assemblages and population declines in most plots. Fire generally reduced spider species richness, evenness, and diversity. Several taxa were potential indicators of fire and old growth structure, and we discovered one species and one genus that were previously unknown. There was evidence that old growth characteristics intensified effects of fire on spider abundance. This outcome probably results from the deep litter layers in high-diversity stands and RNAs, which constituted greater fuel loads than low-diversity stands.

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Citation:

Gillette, N.E.; Vetter, R.S.; Mori, S.R.; Rudolph, C.R.; Welty, D.R. 2008. *Response of ground-dwelling spider assemblages to prescribed fire following stand structure manipulation in the southern Cascade Range*. Canadian Journal of Forest Research. 38: 969–980.

Two-observer method limits inaccuracies of forest animal surveys

Keith Aubry

Dense vegetation, rough terrain, and other variables may make it difficult to monitor forest-dwelling mammals. When direct counting is not practical, researchers in forested regions often rely on surveys of scat (animal waste) to study the abundance and distribution of large animals. Biases of observers may limit the usefulness of using scat as a substitute for direct counting. A USGS wildlife biologist, Kurt Jenkins, and co-author recently published results of a study to adjust for detection biases during surveys of Roosevelt elk (*Cervus canadensis roosevelti*) and Columbian black-tailed deer (*Odocoileus hemionus columbianus*) in Olympic National Park, Washington. Two observers sampling the same area provided a cost-effective way of reducing bias. It is important for future researchers to account for sampling inaccuracies, and the double-observer methods are readily adaptable to study large animals when direct counting is difficult.

Contact:

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Olympic National Park

Citation:

Jenkins, K.J.; Manly, B. 2008. *A double-observer method for reducing bias in faecal pellet surveys of forest ungulates*. Journal of Applied Ecology. 45: 1339–1348.

Forest gap creation affects nitrogen cycling

The creation of canopy gaps in young, managed forests is emerging as an alternative management tool to accelerate the development of old growth forest structure in the Pacific Northwest. The effect of gap creation on forest nitrogen cycling has received little attention, yet it has the potential to affect tree productivity, water quality, and other important ecosystem processes. We investigated nitrogen availability across canopy gaps in three managed forest sites. Findings revealed that 6 to 8 years after gap creation, available nitrogen was greater in gaps than in the

John Laurence

adjacent forest and did not vary with gap size. Elevated nitrogen cycling in gaps appears to be driven by litter inputs of young plants and by reduced nitrogen uptake within gaps.

Contact:

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Partners:

Bureau of Land Management, Oregon State University, Oregon Department of Forestry

Citation:

Thiel, A. 2008. *Nitrogen dynamics across silvicultural canopy gaps in young forests of western Oregon*. 111 p. Corvallis, OR: Oregon State University. M.S. Thesis.

Nitrogen dynamics influenced by streamside tree species

Riparian zones connect uplands to streams, and red alder (*Alnus rubra* Bong.) trees dominate these zones in western Oregon. Red alders are important contributors of nitrogen, which is critical for forest growth and food webs. Some land managers are converting riparian areas to Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) to increase the future sources of large wood for salmon habitat. To evaluate the nutritional role of different riparian tree species, we examined nitrogen-stable isotopes in riparian areas dominated either by red alder or Douglas-fir. As expected, red alders were sources for nitrogen. Surprisingly, red alder nitrogen was also detected in riparian areas dominated by Douglas-fir, even in areas where red alder had not been for over half a century. This legacy effect may benefit site nutrition long after red alder is no longer present.

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Partners:

Bureau of Land Management, Oregon State University, Oregon Department of Forestry

Citation:

Scott, E.E.; Perakis, S.S.; Hibbs, D.E. 2008. ^{15}N *patterns of Douglas-fir and red alder riparian forests in the Oregon Coast Range*: Forest Science. 54(2): 140–147.

Tom Iraci

Model to assess landscape scale ecosystem services

Land-use and land-management decisions affect a broad range of ecosystem processes that jointly determine the provision of ecosystem services valued by people. Although models that project the effects of land-use and land-management decisions on individual ecosystem service levels exist, there have been few landscape-scale assessments of multiple ecosystem services. Managing landscapes to deliver multiple ecosystem services requires integrating spatially explicit data and models from ecology, economics, and other disciplines. This work develops an integrated landscape-level model to predict landowner decisions as a function of existing market conditions and incentive-based conservation payments. The land-use model is then integrated with ecological models to predict the impact of land-use decisions on the provision of ecosystem services, specifically carbon sequestration and biodiversity. Results from the models show that policies aimed at increasing the provision of one ecosystem service can, but do not necessarily, increase the provision of other ecosystem services. We found some cases in which a policy directed toward one goal actually reduces the ability to attain another goal. For example, our results show that policies aimed at increasing the provision of

Miles Hemstrom

carbon sequestration do not necessarily increase species conservation and that highly targeted policies do not necessarily do as well as more general policies. In addition, none of the conservation payment policies produced increases in carbon sequestration and species conservation that approached the maximum potential gains on the landscape. Even without complete valuation of all ecosystem services, presenting decisionmakers with tradeoffs among ends provides information that allows clearer assessment and makes apparent what values must be to desire certain land-use patterns and certain outcomes over others.

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Citation:

Nelson, E.; Polasky, S.; Lewis, D.; Plantinga, A.; Lonsdorf, E.; White, D.; Bael, D.; Lawler, J. 2008. *Efficiency of incentives to jointly increase carbon sequestration and species conservation on a landscape*. Proceedings of the National Academy of Sciences. 105(28): 9471–9476.

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

Bat population status difficult to assess

Bats were one of the groups expected to benefit from a system of reserves for species associated with late-successional/old growth (LSOG) habitat designated under the Northwest Forest Plan (Plan). However, assessing the population status of bats, especially at large spatial scales, is challenging. We evaluated the use of occupancy estimation to assess population status and coarse-grained habitat associations for eight species of bats within the Plan area. Point estimates of occupancy for three species suggested association with LSOG that confirmed observations from radiotelemetry at finer spatial scales. However, estimate precision was low. We used model-averaged estimates of occupancy and detection to estimate survey effort required to meet precision targets relevant to Plan goals. Occupancy estimation was best suited to species with high detection probabilities. Species that are rare or

Sarah Beldin

difficult to detect will require enhancement of survey methods or more intensive survey effort to produce meaningful results at a regional scale.

Contact:

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Citations:

Weller, T.J. 2008. *Using occupancy estimation to assess the effectiveness of a regional multiple-species conservation plan: bats in the Pacific Northwest*. Biological Conservation. 141: 2279–2289.

Cool streams vital to two Pacific northwest salamanders

Of all the physical factors in the aquatic environment, temperature has the most dramatic effect on the physiology and behavior of amphibians. In the Pacific Northwest, timber harvest and other disturbances may cause stream temperatures to rise, which can affect amphibians that live in cold water. We evaluated critical temperatures for two species of salamanders that are native to the Pacific Northwest. Results indicated that southern torrent salamanders (*Rhyacotriton variegatus*) were among the most heat-sensitive species of amphibians, but neither species tested could survive stream temperatures in excess of 84 °F. Current forest practices retain riparian buffers along larger fish-bearing streams, but results indicate that these buffers are also important along headwaters and small streams to maintain favorable conditions for coldwater-associated species.

Contact:

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Partner:

Bureau of Land Management

Citation:

Bury, R., 2008, *Low thermal tolerances of stream amphibians in the Pacific Northwest—implications for riparian and forest management*. Applied Herpetology. 5(1): 63–74.

Determining the distribution of an amphibian disease agent

A recently discovered fungus has been associated with some amphibian declines and extinctions, but its distribution and prevalence are still being explored. In a recent paper, scientists described the incidence of this pathogen in amphibians along the northwest coast of North America. Of 242 amphibians tested, 52 were positive for the fungus. Their results add to the evidence that the chytrid fungus is geographically widespread. Results on the spatial extent of the fungus will help scientists understand the threat it poses to amphibians.

Miles Hemstrom

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Citation:
Adams, M.J.; Galvan, S.K.; Reinitz, D.; Cole, R.A.; Payre, S.; Hahr, M.; Govindarajulu, P. 2007, *Incidence of the fungus,* Batrachochytrium dendrobatidis*, in amphibian populations along the northwest coast of North America*. Herpetological Review. 38(4): 430–431.

Assessment prior to fish reintroductions may improve success

Translocations, or reintroducing a species to an area, can be an important conservation tool, but many translocations of fish species fail to establish new populations. These failures could be attributed to a lack of understanding of what factors might contribute to successful reintroductions. In a new report, the authors present a general framework for assessing the likelihood of successful translocations of the bull trout (*Salvelinus confluentus*), a threatened species that is declining in western North America. The authors use the framework to assess reintroducing bull trout into the Clackamas River, Oregon, and discuss the implications of this effort in the general context of fish translocations as a conservation tool.

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

Partners:
U.S. Fish and Wildlife Service

Tom Iraci

Citation:
Dunham, J.B.; Gallo, K. 2008, *Assessing the feasibility of native fish reintroductions—a framework and example applied to bull trout in the Clackamas River, Oregon*. Open-File Report 2008-1007. U.S. Geological Survey. 15 p.

Trade-offs between invasion and isolation for native cutthroat trout

In some areas, native salmonid fish face threats from both habitat loss and invasion by non-native trout. Unfortunately, management actions to protect native fish from one threat may cause or worsen the other. Authors developed a tool to analyze the benefits when either installing barriers to isolate populations of native fish or removing barriers to reconnect them. Barriers that affect fish passage include dams, irrigation diversions, and impassable road culverts. In several western Montana streams, applying the analysis helped to clarify management objectives and to prioritize conservation actions, providing a foundation for further work in management and research.

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Forest Service, Rocky Mountain Research Station

Citation:
Peterson, D.P.; Rieman, B.E.; Dunham, J.B.; Fausch, K.D.; Young, M.K. 2008, *Analysis of trade-offs between threats of invasion by nonnative brook trout* (Salvelinus fontinalis) *and intentional isolation for native westslope cutthroat trout* (Oncorhynchus clarkii lewisi)*:* Canadian Journal of Fisheries and Aquatic Sciences. 65: 557–573.

Diversity of streamside vegetation—diversity of bats in Oregon

Insect-eating bats often hunt along streams where vegetation provides food for their prey. Most previous studies to determine critical aspects of bat foraging habitat have only focused on local area features. Bats are highly mobile and rely on both small and large areas. Scientists investigated how

Tom Iraci

vegetation characteristics at three scales (along streams, in the nightly activity area, and within the watershed) influenced bat activity in the Oregon Coast Range. Generally, vegetation characteristics along streams had a greater influence than in the larger areas. Further, most bat species were more active in areas where vegetation did not interfere with flight. These results suggest that disturbances to vegetation along streams are likely to affect bats, and a diversity of vegetation types with open space above the stream channel promotes foraging for all species.

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Citation:

Ober, H.K.; Hayes, J.P. 2008. *Influence of vegetation on bat use of riparian areas at multiple spatial scales*. Journal of Wildlife Management. 72(2): 396–404.

Landscape features influence diversity in Oregon cutthroat trout

Researchers have long recognized the importance of disturbances for creating and maintaining the complex stream habitat necessary for conservation of species, but such disturbances can also cause mortality of native trout. Little is known about how the shape and size of stream networks and the ability of fish to move within them influence recolonization and redistribution following disturbance. Scientists examined genetic variability of isolated populations of coastal cutthroat trout (*Oncorhynchus clarki clarki*) in western Oregon to determine how

Tom Iraci

they were affected by large-scale disturbances. Genetic diversity was greater in Coast Range populations than in the Cascade Range, and the differences coincided with watershed complexity and the ability of trout to move among habitats. Overall, the findings suggest that interaction between the physical landscape and disturbance plays a major role in structuring genetic patterns in these isolated coastal cutthroat trout populations.

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Citation:

Guy, T., Gresswell, R.E., Banks, M.A., 2008. *Landscape-scale evaluation of genetic structure among barrier-isolated populations of coastal cutthroat trout*, Oncorhynchus clarkii clarkii. Canadian Journal of Fisheries and Aquatic Sciences. 65: 1749–1762.

Pete Bisson

Fish, forests, and instream cover

Oregon State University graduate student Heidi Vogel-Andersen recently completed her thesis about the importance of cover to cutthroat trout in three small streams in the Trask River watershed. Multiple researchers are collaborating in the Trask, where the effects of contemporary forest practices are being investigated. Results of the current study indicated that cover was limited for fish during low flows in summer and fall, and that fish consistently and strongly selected cover with predictable characteristics. These findings have important implications for understanding processes influencing fish population dynamics in small streams and provide useful measures of habitat conditions that can be incorporated into future research, management, and monitoring.

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Citation:

Andersen, H.V., 2008, *Transferability of models to predict selection of cover by coastal cutthroat trout in small streams in western Oregon, USA*. 131 p. Corvallis, OR: Oregon State University. M.S. Thesis.

John Laurence

Tom Iraci

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

Genetic study supports boundaries of spotted owl subspecies

Scientists reported the results of one of the largest genetic studies of any threatened bird species and the first to test subspecies boundaries in spotted owls. There is long-standing interest in determining the number and boundaries of these subspecies because the northern and Mexican spotted owls (*Strix occidentalis lucida*) are listed as threatened under the Endangered Species Act (ESA), but the California subspecies (*Strix occidentalis occidentalis*) is not. The results support the current sub-species boundaries and confirm previous suggestions that northern and California spotted owls hybridize in a narrow zone between southern Oregon and northern California. The study also detected some hybridization between northern and Mexican spotted owls in Washington state. These results have important implications for the conservation of spotted owls, particularly for ESA-listed northern and Mexican spotted owls.

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Citation:

Funk, W.; Forsman, E.D.; Mullins, T.D.; Haig, S.M. 2008, *Introgression and dispersal among spotted owl* (Strix occidentalis) *subspecies*. Evolutionary Applications. 1(1): 161–171.

John Laurence

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

Research agencies have not completed any projects contributing to this question during the reporting cycle.

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

Tom Iraci

Trout in Spirit Lake have unusual adaptations

As the closest and largest lake adjacent to Mount St. Helens, Spirit Lake underwent extensive changes during the 1980 eruption. It was transformed from a relatively pristine cold-water mountain lake to a larger, shallower lake containing a warm microbial broth in which no air-breathing organisms survived, including fish. The lake gradually returned to conditions that supported flora and fauna more typical of the Cascade Range over the next decade, but the first trout was not captured until 1993. The rainbow trout (*Oncorhynchus mykiss*) population has expanded rapidly, and the fish are exhibiting exceptional growth rates and unusual life histories. They grow fast, have unusual spawning characteristics, and die young, in marked contrast to trout in most mountain lakes.

The unusual adaptations of Spirit Lake trout to the volcanic environment have piqued international scientific interest. For example, scientists in Chile are seeking to extend lessons learned at Spirit Lake to lakes near the currently erupting Chaiten Volcano.

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Restoring spotted owl habitat may take landscape approach

The threatened northern spotted owl continues to decline despite 15 years of intense management effort. One significant threat continues to be the loss of habitat in dry forests from wildfire. Habitat gain and loss from uncharacteristic fire disturbance regimes has been extensively documented by station scientists. Their research has documented landscape dynamics, owl prey demography, and conflicts with competitive barred owls that are directly relevant to recovery plans for the northern spotted owl.

This information was central in shifting the recovery strategy for northern spotted owl habitat from a species-oriented reserve strategy to a whole-landscape strategy.

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Citation:

Lehmkuhl, J.F.; Peffer, R.D.; O'Connell, M.A. 2008. *Riparian and upland small mammals on the east slope of the Cascade Range, Washington*. Northwest Science. 82(2): 94–106(2008)

Interaction between climate change and invasive species may intensify threats

Exotic and native invasive species are among the most serious threats facing western wildlands. Land managers have traditionally relied on observations and lessons from the past to help plan for the future. However, environmental conditions are changing, and significant changes are predicted for the future. Working with partners and cooperators, scientists developed a set of rapid threat assessments, syntheses, and modeling projects that focused on the interaction of climate change and invasive exotic and native species on wildland resources in the Western United States. This work demonstrates that climate change has the potential to impact the geographic ranges of some species and alter existing climate-species relationships via a number of pathways. As a result, many species likely will be able to disperse into novel climate regions and expand their ranges or increase their populations within existing locations.

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Citation:

Bentz, B.J.; Fettig, C.J.; Hansen, E.M.[et al.]. 2008. *Climate change and Western U.S. bark beetles: rapid threat assessment*. Prepared for The Western Wildlands Threat Assessment Center, Prineville, Oregon. 79 p. http://www.fs.fed.us/wwetac/projects/PDFs/RTA_Bark_Beetle.pdf. (August 14, 2009).

Kerns, B.K.; Naylor, B.J.; Buonopane, M.; Parks, C.G.; Rogers, B. [In Press]. *Modeling tamarisk* (Tamarix *spp.) habitat and climate change effects in the Northwestern United States*. Invasive Plant Science and Management.

Tom Iraci

Scientists model potential impacts of climate change on California's ecosystem services

Station scientists were key contributors in a project examining the potential impact of climate change on services provided by California ecosystems. They simulated potential changes in vegetation distribution, associated carbon pools and fluxes, and wildfire occurrence in California under nine future climate and greenhouse gas emission scenarios.

This output was given to The Nature Conservancy, which is translating it into ecosystem services values for carbon, water availability, forage production, and carbon sequestration. Project results will be published in the 2008 Climate Change Impacts Assessment, the Second Biennial Report to the California Climate Action team, which submits these reports to the governor and the state legislature.

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Citation:

Lenihan, J M.; Bachelet, D.; Neilson, R.; Drapek, R. 2008. *Simulated response of conterminous United States ecosystems to climate change at different levels of fire suppression, CO_2 emission rate, and growth response to CO_2*. Global and Planetary Change. DOI: 10.1016?j.gloplacha.2008.01.006

Eini Lowell

Large-scale thinning may push bark beetles into other stands

Scientists used the Westwide Pine Beetle Model and Fire and Fuels Extensions of the Forest Vegetation Simulator (FVS) to simulate a bark beetle outbreak under different fuel treatment scenarios on a 173,000-acre landscape on the Deschutes National Forest. They also analyzed effects of a thinning strategy on subsequent dynamics of a simulated beetle outbreak.

The simulations suggested that thinning stands greatly reduced endemic bark-beetle-caused tree mortality. However, when a beetle epidemic was simulated by inducing drought stress, the beetle population migrated from outside the study area and attacked trees throughout the landscape, even when the majority of the area was thinned. A conclusion from these simulations is that large-scale thinning treatments do not reduce beetle-caused tree mortality under epidemic conditions. The results are supported by several published field studies. This work resulted in a modeling framework tool that can be used to integrate the long-term potential impacts of bark beetles and management activities into landscape planning for wildfire risk and fuels treatments.

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Citation:

McMahan, A.; Ager, A.A.; Maffei, H.; Hayes, J.L.; Smith, E.L. 2008. *Modeling bark beetles and fuels on landscapes: a demonstration of arcfuels and a discussion of possible model enhancements*. In: Havis, Robert N.; Crookston, Nicholas L., eds. 2008. Third Forest Vegetation Simulator Conference. Proceedings RMRS-P-54. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 1–14

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

Intense wildfire alters forest soil

For the first time, scientists were able to directly measure the effects of hot wildfire on forest soils. The 2002 Biscuit Fire burned about half of twenty-seven 15-acre study plots east of Gold Beach, Oregon, established before the fire.The fire burned at temperatures over 1,300 °F, as evidenced by the melted aluminum tags across the research plots—this is more than twice as hot as typical prescribed fires. Loss of topsoil and combustion of organic material were higher than most previous estimates. More than 10 tons per acre of carbon and 450 to 620 pounds per acre of nitrogen were lost, and nearly 60 percent of this came from the mineral topsoil below the organic layer. The loss of topsoil and soil carbon can negatively affect a range of processes including nutrient retention and water infiltration. To replace the documented amount of lost nitrogen would require nitrogen-fixing plants to

Alan Ager

Cecile Shohet

dominate the forest for decades. This study illustrates the dramatic effects of intense wildfire on soil nutrients and resulting site productivity. Understanding how fire can alter the available nutrients and thus change the productivity of a site is essential when undertaking reforestation efforts and projecting future stand development. Also, a forest that grows slower after an intense wildfire than it did before will have reduced rates of carbon sequestration.

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Citation:

Bormann, B.T.; Homann, P.S.; Darbyshire, R.L.; Morrissette, B.A. 2008. *Intense forest wildfire sharply reduces soil C and N: the first direct evidence.* Canadian Journal of Forest Research. 38: 2771–2783.

Scientists map seed zones for oceanspray based on climatic variables

Land managers generally try to use locally adapted and genetically diverse plant materials in restoration and revegetation efforts. Oceanspray (*Holodiscus discolor*) is an important restoration shrub in the Pacific Northwest; genetic variation exists within the species because local populations adapt to local conditions. In this study, station geneticists identified the patterns of genetic diversity of oceanspray related to climatic variables, such as average December minimum temperature, by characterizing the variability in growth and physical characteristics for individual shrubs from 39 locations in western Oregon and Washington.

As part of this study, scientists produced a seed zone map for land managers that illustrates adaptive patterns of genetic diversity of oceanspray within the Pacific Northwest. The map can be used to guide seed collection and deployment for native plant restoration and revegetation activities.

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Citation:

Horning, M.E.; McGovern, T.R.; Darris, D.C.; Mandel, N.L.; Johnson, R. 2008. *Genecology of* Holodiscus discolor *(Rosaceae) in the Pacific Northwest, USA*. Restoration Ecology. DOI: 10.1111/j.1526-100x.2008.00441.x

BioSum model optimizes fire hazard reduction and bioenergy capacity

The BioSum model is a tool for optimizing fire-hazard-reduction treatments and determining the economic feasibility of using material removed during treatment for traditional timber products or to produce bioenergy. Scientists applied BioSum to a 25-million-acre study area in western Oregon and northern California. They found the study area is capable of annually producing (1) $590 million in net revenue, (2) 6 to 12 million green tons of biomass, and (3) 0.8 to 1.2 billion cubic feet of merchantable wood over the course of a decade. This assumes a 10-year implementation and depreciation of the biomass plants constructed to support fuel treatment on all acres for which treatments would achieve fuel reduction benefits. Under this scenario, fuel hazard would be reduced on 2.8 to 8.1 million acres while providing bioenergy capacity of 496 to 1009

Mark Nechedom

megawatts—enough to power a city of 500,000 to 1,000,000 people.

Several clients have requested custom analyses using BioSum. Lakeview, Oregon, used the model as a basis for decisions on sizing a planned bioenergy facility; the California Department of Forestry and Fire used it to evaluate forest practices policy options; and it has been used in a regional analysis of opportunities to attract bioenergy investment capital in New Mexico, to assess bioenergy development feasibility in central Oregon, and in support of forest planning on the Shasta-Trinity National Forest.

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Partners:

Forest Service National Fire Plan, Western Forest Leadership Coalition

Citations:

Barbour, R.J., Fried, J.S.; Daugherty, P.J.; Fight, R. 2008. *Predicting the potential mix of wood products available from timbershed scale fire hazard reduction treatments.* Forest Policy and Economics. 10: 400–407.

Biomass studies lead to strategic thinking regarding fuel reduction treatments

Many forests in the Western United States are prone to larger, more severe wildfires than they were prior to settlement by Euro-Americans. Reducing fire hazard can be costly, but studies by station scientists indicate areas where the cost for fuel reduction treatments potentially may be offset by the sale of products removed during treatment.

Tree size, species, and proximity to a processing facility are some of the factors that determine the salability of wood removed during these fuel reduction treatments. A study focused on southwest Oregon and northern California found that large trees often need to be removed to accomplish fire-hazard-reduction goals, even when one objective is to minimize the amount of merchantable timber harvested. This is because the crowns on these trees are so large, they are often key factors in both torching (crown fire initiation) and crowning (crown fire spread). This information will help fire managers evaluate fuel conditions at a variety of spatial scales and consider various scenarios for reducing fire hazard. These studies are particularly useful for showing how treatment effectiveness and timber volumes might differ given different policy directions or budget constraints.

Tom Iraci

National forests are using the techniques developed for this study to evaluate potential stewardship contracts, and the Western Governors' Association used them to evaluate the potential to produce electricity and biofuels from all forests in the Western United States.

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Citation:

Barbour, R.J.; Fried, J.S.; Daughtery, P.J.; Christensen, G.; Fight, R. 2008. *Potential biomass and logs from fire-hazard-reduction treatments in Southwest Oregon and Northern California.* Forest Policy and Economics 10: 400–407.

Station scientists identify climate change adaptation options

Only recently have the Forest Service and other federal agencies begun thinking about ways to adapt to a changing climate. Station scientists contributed to the first effort to summarize adaptation options for national forests and provide the scientific basis for those options.

The report, *Synthesis and Assessment of Adaptation Options for Climate Change in National Forests*, was done as part of the U.S. Climate Change Science Program.

Tara Barrett

Also, station scientists and the University of Washington Climate Impacts Group, have established a long-term science-management partnership with the Olympic National Forest to develop locally focused adaptation options for addressing climate change. Through workshops, presentations, and consultations, they are providing the scientific basis for implementing climate adaptation management and planning on the Olympic National Forest. Further workshops explaining the Olympic National Forest pilot project have been conducted with other national forests in the region, and similarly focused planning processes to address climate change may be implemented on other regional forests.

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Citation:
Joyce, L.A.; Blate, G.M.; Littell, J.S.; McNulty, S.G.; Millar, C.I.; Moser, S.C.; Neilson, R.P.; O'Halloran, K.; Peterson, D.L. 2008. *National forests*. In: Julius, S.H.; West, J.M., eds. Preliminary review of adaptation options for climate-sensitive ecosystems and resources. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, DC: U.S. Environmental Protection Agency.

Station contributes to national primer on climate change and water

"**Climate Change and Water**: Perspectives From the Forest Service" is a brochure that succinctly explains the vital role healthy and resilient watersheds have in maintaining clean water supplies, and how these watershed services could be compromised if the climate changes as projected. It outlines steps resource professionals and landowners can take to prepare for climate change, manage for watershed resiliency, support entrepreneurial projects, advance knowledge, and connect with the public. It emphasizes that actions taken now can minimize future impacts.

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None

More information:
See "Climate Change and Water: Perspectives From the Forest Service" at http://www.fs.fed.us/emphasis/products/water-climate-brochure.pdf

Climate change task force begins evaluating genetic and silvicultural options

Station scientists and their colleagues at Oregon State University have formed a task force of forest managers, forest geneticists, tree breeders, silviculturists, and tree physiologists to explore management options for adapting to the effects of climate change on forests in the Western United States. As part of its outreach education efforts, the task force developed a Web site to inform the public about the potential effects of climate change and forest management options. The site has links to relevant publications, presentations, and upcoming workshops.

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For more information:
See http://tafcc.forestry.oregonstate.edu/index.html

Keith Routman

Wildfire scorches long-term soil carbon and nitrogen

Many short-term effects of wildfire on forest soils are known, but few studies have addressed the long-term legacies of wildfire on old-growth forest soils. USGS forest ecologist Steve Perakis and Oregon State University colleagues investigated Pacific Northwest Douglas-fir forests with known fire histories to evaluate long-term impacts of severe wildfire on soil nutrients. Old growth forests, with an average age of 550 years, had higher soil nitrogen availability than forests younger than 150 years, which can contribute to sustained tree growth as forests age. Forest soils also accumulated carbon and nitrogen between 150 and 450 years after wildfire, leveling off in forests older than 800 years. Results of this work suggest that carbon and nitrogen are sequestered in forest soils for several centuries after wildfire. More frequent fires may prevent such accumulation and ultimately decrease the role of forests as long-term sinks for atmospheric carbon dioxide.

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Citation:

Giesen, T.W.; Perakis, S.S.; Cromack, K.; 2008. *Four centuries of soil carbon and nitrogen change after stand-replacing fire in a forest landscape in the western Cascade Range of Oregon*. Canadian Journal of Forest Research. 38: 2455–2464.

Tom Iraci

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

Visitors differ in their preference for managing postfire recreation

The 2003 B&B Fire burned much of the Mount Jefferson, Mount Washington, and Three Sisters Wilderness areas in the Deschutes and Willamette National Forests. Forest managers wanted to know how best to manage for recreation after fire. Research focused on the Eight Lakes Basin within the Mount Jefferson Wilderness, where day hiking, backpacking, climbing, and horse camping are traditional uses. Visitors were asked about their past use, changes in use after the fire, and preferences for managing postfire recreation. Use declined slightly in burned areas 1 to 2 years later; however, these declines appeared less than those caused by the fee demonstration program implemented in 1998.

Visitors differed in their preferences for managing postfire recreation, with some visitors preferring little or no management, some preferring access and use restrictions coupled with site development, and some preferring either access and use restrictions or site development alone. The Willamette National Forest used these findings to develop a recreation monitoring plan for the B&B Fire area.

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Citation:

Brown, R.N.; Rosenberger, R.S.; Kline, J.D.; Hall, T.E.; Needham, M.D. 2008. *Visitor preferences for managing wilderness recreation after wildland fire*. Journal of Forestry. 106(1): 9–16.

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Additional References

Watersheds and Aquatic Conditions

Benda, L.; Miller, D.; Lanigan, S.; Reeves, G. 2009. *Future of applied watershed science at regional scales*. EOS, Transaction American Geophysical Union. 90: 156–157.

Lanigan, S.; Gallo, K.; Moyer, C. 2008. *Aquatic and Riparian Effectiveness Monitoring Program*. 2008 Annual Technical Report. On file with: http://www.reo.gov/monitoring/reports/watershed-reports-publications.shtml

Gruendike, P.; Lanigan, S. 2008. *Aquatic and Riparian Effectiveness Monitoring Program*. Aquatic Invasive Species Survey Report. 2008 Field Season. On file with: http://www.reo.gov/monitoring/reports/watershed-reports-publications.shtml

Roper, B.B.; Buffington, E.A.; Moyer, C.; Ward, M. 2008. *The role of observer variation in determining Rosgen stream types in northeastern Oregon mountain streams*. Journal of the American Water Resources Association (JAWRA). 44(2): 417–427. DOI: 10.111/j.1752–1688.2008.00171.x.

Vegetation Mapping and Monitoring

Cohen, W.B.; Fiorella, M.; Kennedy, R.E.; Yang, Z.; Powell, S.L.; Moeur, M. 2008. *Validation of near-annual resolution forest change maps derived from Landsat data*. Poster presented at the NASA Carbon Cycle and Ecosystems Joint Workshop, University of Maryland, College Park, 28 April–2 May.

Cohen, W.B., Z. Yang, R.E. Kennedy, M. Fiorella, M. Moeur, S. Healey. 2008. *A Landsat time-series visualization tool to support a new paradigm in forest change detection*. Presented at the FIA Science Symposium, Park City, UT, 21–21 October.

Cohen, W.B.; Yang, Z.; Kennedy, R.E.; Turner, D.P.; Law, B.E.; Goward, S.N.; Masek, J.G.; Moisen, G.G.; Huang, C.; GCollatz, G.J. 2009. *Validation of high temporal density Landsat time series disturbance maps to constrain carbon flux estimates from NACP ecosystem process models*. Poster presented at the 2nd NACP All-Investigators Meeting, San Diego, CA 17-20 February.

Cohen, W.B.; Kennedy, R.E.; Yang, Z. 2008. *Large-scale monitoring with Landsat time series: sampling, analyses, validation*. Presented at the Boreal & Temperate Forest Monitoring Workshop, 3rd GOFC-GOLD Land Cover Symposium, Jena University, Jena, Germany, 13–17 October.

Kennedy, R.E.; Cohen, W.B.; Yang, Z. 2009. LandTrendr and TimeSync: *Update on tools to tap the archive*. Presented at the Landsat Science Team Meeting, Ft. Collins, CO, 6–8 January 2009.

Kennedy, R.E.; Yang, Z.; Cohen, W.B.; Nelson, P.; Pfaff, E. *LandTrendr: Leveraging the Landsat archive to monitor landscape dynamics*. Oral presentation for national webinar for NSF-funded Integrated Geospatial Education and Technology Training (iGETT) project, December 2008.

Kennedy, R.E.; Yang, Z.; Cohen, W.B.; Fiorella, M.; Moeur, M.; Pfaff, E. *Capture of diverse forest dynamics with new approaches to tap the Landsat archive*. Oral presentation at Forest Inventory and Analysis (FIA) program biennial meeting, October 2008, Park City, UT.

Kennedy, R.E.; Yang., Cohen, W.B.; Nelson, P.; Pfaff, E. LandTrendr and TimeSync: *Leveraging the Landsat archive to monitor landscape dynamics*. Oral video presentation to Washington Geographic Information Council (WAGIC) meeting, October 2008.

Kennedy, R.E., Cohen, W.B.; Yang, Z. *The promise of an open Landsat archive: A new era for landscape monitoring and management?* Oral presentation at Landsat Science Team meeting, USGS Headquarters, Reston, VA, July 2008.

Kennedy, R.E. *A new approach for mapping subtle insect-related mortality and recovery dynamics in mesic and dry conifer forests*. Oral presentation at International Association of Landscape Ecology (IALE) annual meeting, Madison, WI, April 2008.

Kennedy, R.S.H.; Wimberly, M.C. [In press.] *Historical fire and vegetation dynamics in dry forests of the interior Pacific Northwest, USA, and relationships to northern spotted owl* (Strix occidentalis caurina) *habitat conservation*. Forest Ecology and Management.

Moeur, M.; Ohmann, J.; Hemstrom, M.; Burcsu, T.; Merzenich, J. [In press.] *Projecting watershed condition with interagency mapping and assessment project (IMAP) vegetation data and landscape models*. Proceedings, ASPRS 2008 Annual Conference, Bridging the Horizons, New Frontiers in Geospatial Collaboration. April 28–May 2, 2008, Portland, Oregon.

Pierce, K.; Ohmann, J.L.; Wimberly, M.C.; Fried, J.S.; Gregory, M.J. [In press.] *Mapping wildland fuels and forest structure for land management: a comparison of nearest-neighbor imputation and other methods*. Canadian Journal of Forest Research.

Northern Spotted Owl

Anthony, R.; Ackers, S.; Claremont, R.; Domschke, C.; Schwartz, M.; Smoluk, A.; Wyss, L. 2008. *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. 40 p.

Anthony, R.; Andrews, S.; Friar, L.; Phillips, T.; Strejc, D.; Wagner, F. 2008. *Demographic characteristics and ecology 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. 27 p.

Forsman, E.; Snetsinger, T.; McCafferty, C.; Swingle, J.; Hamilton, S.; Plawman, T.; Cederstrom, J.; Koski, I. 2008. *Demographic characteristics of spotted owls in the Oregon Coast Ranges, 1990–2008*. Annual Report. USDA Pacific Northwest Research Station, Corvallis, OR. 14 p.

Forsman, E., Sovern, S.; Taylor, M.; Graham, S.; Phipps, D.; St.Hilaire, J.; Singleton, P.; Smith, S. 2008. *Demography of spotted owls on the east slope of the Cascade Range, Washington, 1989–2008*. Annual Progress Report. USDA Pacific Northwest Research Station, Corvallis, OR. 19 p.

Forsman, E.; Reid, J.; Mowdy, J.; Oleri, M.; Price, A. 2008. *Demographic characteristics of northern spotted owls* (Strix occidentalis caurina*) on the Tyee Density Study Area, Roseburg, Oregon: 1985–2008*. Annual Report. USDA Pacific Northwest Research Station, Corvallis, OR. 18 p.

Franklin, A.B.; Carlson, P.C.; Rockweit, J.T.; Canter, A.N.; Roberts, A.; Hanks, T.; Schielke, B.; Lewicki, K. 2009. *Monitoring the population ecology of spotted owl* (Strix occidentalis caurina*) in northwestern California: Annual results, 2008*. Final Report to USDA Forest Service, Region 5, Vallejo, CA.

Gremel, S. 2008. *Spotted owl monitoring in Olympic National Park: 2008 annual report*. Olympic National Park. Port Angeles, WA. 17 p.

Horn, R.S.; Cross, Crutchley, R.; Fukuda, K.; Larson, C.; Lowden, J.; Rosier, J.; Stegmeier, J.; Wise, H.; Irwin, M. 2008. *Demographic characteristics of northern spotted owls* (Strix occidentalis caurina*) in the Klamath Mountains Province of Oregon, 1985–2008*. Annual Report, FY2008. Roseburg District, Bureau of Land Management, Roseburg, OR. 14 p.

Marbled Murrelet

Falxa, G.; Baldwin, J.; Lynch, D.; Nelson, S.K; Miller, S.L; Pearson, S.F; Ralph, C.J.; Raphael, M.G.; Strong, C.; Bloxton, T.; Galleher, B.; Hogoboom, B.; Lance, M.; Young, R.; Huff, M.H. 2008. *Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2004–2007 summary report*. 25 p. Available at: http://www.reo.gov/monitoring/mm-overview.shtml

Falxa, G.A.; Baldwin, J.; Lance, M.; Miller, S.L.; Pearson, S.F.; Raphael, M.G.; Strong, C. 2009. *Marbled murrelet population size and trend in the Northwest Forest Plan area*. Presentation at 2009 annual meeting of the Western Section of The Wildlife Society. Sacramento, CA. Abstract at: http://joomla.wildlife.org/Western/.

Falxa, G.; Baldwin; J.; Lance, M.; Miller, S.L.; Pearson, S.F.; Raphael, M.G.; Strong, C. 2008. *Marbled murrelet population size and trend in the Northwest Forest Plan area*. Presentation at 2008 annual meeting of the Pacific Seabird Group. Blaine, WA. Abstract at: http://www.pacificseabirdgroup.org/.

Hall, L.; Peery; M.; Harvey; J.; Golightly, R,; Newman, S.; Raphael, M.; McFarlane-Tranquilla, L.; Nelson, S. 2008. *Characterizing dispersal patterns in marbled murrelets using microsatellites*. Annual Meeting, Pacific Seabird Group. Blaine, WA. Abstract at: http://www.pacificseabirdgroup.org/.

Additional References

Lance, M.M.; Pearson, S.F.; Raphael, M.G.; Bloxton, T.D. 2009. *2008 at-sea marbled murrelet population monitoring: Research Progress Report*. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia, WA. 17 p.

Long, L.L; Miller, S.L; Ralph, C.J.; Elias, E.A. 2008. *Marbled murrelet abundance, distribution, and productivity along the coasts of northern California and southern Oregon, 2005–2007.* Report to U.S. Fish and Wildlife Service and Bureau of Land Management, Arcata, CA. U.S. Department of Agriculture, Forest Service, Redwood Sciences Laboratory, Arcata, CA. 44 p.

Raphael, M.G.; Bloxton, T.D. 2008. *Abundance and productivity of the marbled murrelet in the San Juan Archipelago, Washington, USA*. Presentation at 2008 annual meeting of the Pacific Seabird Group, in Blaine, WA. Abstract at: http://www.pacificseabirdgroup.org/.

Raphael, M.G. Molina, R., editors. 2007. *Conservation of rare or little-known species: biological, social, and economic considerations*. Island Press, CA. 392 p.

Raphael, M.G.; Baldwin, J.; Falxa, G.A.; Huff, M.H.; Miller, S.L.; Pearson, S.F.; Ralph, C.J.; Strong, C.; Thompson, C. 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. 2008. *What is going on with the California Current? Changes in the coastal avifauna of central Oregon over 13 years*. Presentation at 2008 annual meeting of the Pacific Seabird Group, in Blaine, WA. Abstract at: http://www.pacificseabirdgroup.org/.

Strong, C.S. 2008. *Population and productivity monitoring of marbled murrelets in Oregon during 2008*. Report to the U.S. Fish and Wildlife Service, Portland, Oregon. Crescent Coastal Research, Crescent City, CA. 13 p.

Strong, C.S. 2009. *Seabird abundance and distribution during summer off the Oregon and southern Washington coast*. Unpublished report to National Fish & Wildlife Foundation and USFWS Columbia River Estuarine Fund. Crescent Coastal Research, Crescent City, CA. 46 p.

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