FISH AND WILDLIFE HABITAT
IN MANAGED FORESTS
RESEARCH PROGRAM

PROGRAM OF RESEARCH

FY 2009
(July 1, 2008 - June 30, 2009)

College of Forestry
Forest Research Laboratory
OREGON STATE UNIVERSITY
Corvallis, Oregon
The 1993 Oregon Legislature added $0.10 per thousand board feet to the Oregon Forest Products Harvest Tax rate for research through the Forest Research Laboratory (FRL) to provide new information about meeting the needs of fish and wildlife in managed forests of Oregon. The FISH AND WILDLIFE HABITAT IN MANAGED FORESTS RESEARCH PROGRAM (F&W Program) was established on November 1, 1994, guided by recommendations from a Technical Advisory Committee comprised of fish and wildlife specialists and forest managers from government, industry, and non-industrial land owners to the FRL Director. The F&W Program is primarily conducted within the College of Forestry’s Forest Engineering, Forest Resources, and the Forest Science Departments, with strategic collaboration from scientists residing in other OSU units and federal agencies.

Based on the harvest level at the time, the F&W Program was initially funded with $457,485 in increased Harvest Tax revenues annually. Research, technology transfer, and service activities were selected by College program leaders based on advice received from the Technical Advisory Committee and in consultation with key faculty. When the F&W program was initiated in 1994, the overall FRL research program already included numerous research projects on fish and wildlife in managed forests. These efforts were funded with revenues from the State and grants obtained from various sources. The establishment of the F&W program unfortunately coincided with reduced State appropriations to the FRL as a result of the passing of Measure 5 and decreased timber harvest on federal lands. Thus, in the first few years of the F&W Program, the revenues from the increased Harvest Tax rate were critical in ensuring the timely completion of those existing fish and wildlife studies and maintaining an adequate core of faculty expertise.

In recent years, all activities funded through the F&W Program are new efforts that address timely issues identified collaboratively by the Technical Advisory Committee, College program leaders, and the faculty. Since 2002, new projects have been selected with a priority towards those that contribute to the scientific information base that supports the Oregon Forest Practices Act.

Many of the F&W Program’s activities have been conducted with additional funds from several sources, making their “value” far greater than the funds from the Harvest Tax. This is not duplication of funding, but illustrates how Harvest Tax funds are leveraging other resources, making “the dollars go farther.” Without the FRL funds AND the other funds, many of these projects would not be possible. Other FRL programs continue to contribute to or complement the goals of the F&W Program. Funded from a variety of sources, these activities are not included in documents describing this F&W Program because they are not explicitly part of the effort funded by the increase in Harvest Tax rate.

The base budget for FY2009 is $350,000, based on a projected harvest of 3.5 billion board feet. This initial budget allocation is supplemented by an additional $55,450 resulting from reconciliation of program funds against actual harvest tax receipts for FY2007, and carryover of unallocated funds from FY2008. Four research projects were completed in FY2008 providing resources for reallocation to new activities. Based on the advice of the F&W Program’s Technical Advisory Committee, these resources are sufficient to initiate three new projects and continue seven research projects.

I am confident this program will help with both policy and management - to the benefit of the people of Oregon.

Hal Salwasser, Dean and Director
College of Forestry and Forest Research Laboratory
July 1, 2008
Historically, fish, wildlife and timber have been managed largely independently. With increasing demands for more of all of these resources from a common land base, it has become essential to find ways in which their individual productivities can be optimized in aggregate. Current forest resource management, policy, and regulation attempt to do this, but they are hampered by serious gaps in knowledge. In some cases these are very specific gaps, requiring testing of a specific strategy. In other cases it is a larger and more fundamental gap, requiring the development and testing of new concepts. This enhanced program of research, service and technology transfer was developed to fill at least a portion of these gaps. The goal is to provide the information needed by forest managers and policy makers in the establishment and evaluation of forest policy, and the active management of Oregon forests, with a specific focus on the science needed to support the Oregon Forest Practices Act.

The purpose of this document is to describe the Fiscal Year 2009 activities of the FRL that comprise the program funded by the 1993 legislative increase in the Oregon Forest Products Harvest Tax rate. This document is organized by new and continuing projects and activities, which can be sorted into three areas: a) Research, b) Service and c) Technology Transfer. Oregon Forest Products Harvest Tax revenues fund projects and activities wholly or in part. A description of each active project follows this introduction.

Research: Three new research projects were initiated in FY2009:

1) The importance of sculpins in headwater streams: implications for understanding forestry influences on salmon and trout
2) Characterization of stream warming trends based on stream features and management of riparian cover
3) Temperature profile recovery fifteen years after clearcutting along medium and large fish-bearing streams: effect of buffer design

Seven continuing research projects are funded by this program in FY2009, including:

1) Forest management strategies in the Hinkle Creek Watershed demonstration area project: Evaluation of post harvest treatment seasonal stream water nutrient concentrations
2) Analysis of cumulative impacts on biotic and abiotic responses in stream networks due to contemporary forest practices
3) Macroinvertebrate response to harvest in the Hinkle Creek Watershed
4) Assessing the effects of contemporary forest practices on watershed function at the Alsea Watershed
5) Quantifying use and selection of hiding cover by salmon and trout across paired watershed studies in western Oregon

6) Influence of Intensive Forest Management on Biodiversity in Pacific Northwest Commercial Forests

7) On-site and Cumulative Off-Site Effects of Timber harvest on Stream Temperature

Service: The service area includes activities that are not research, but which support current forest management and policy development activities. No active projects are underway this year.

Technology Transfer: Technology transfer is a function that is an integral part of the research process. No active projects are underway this year.
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OSU Forest Research Laboratory  
Fish and Wildlife Habitat in Managed Forests Research Program  
Budget for FY 2009  
July 1, 2008 - June 30, 2009

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<td>Temperature profile recovery fifteen years after clearcutting along medium and large fish-bearing streams effect of buffer design (2009-2010)</td>
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| Continuing Projects and Activities | |
|-----------------------------------|--------|--------|--------|
| Forest management strategies in the Hinkle Creek Watershed demonstration area project: Evaluation of post harvest treatment seasonal stream water nutrient concentrations (2007-2010) | 43,272 | 31,146 | |
| Kermit Cromack, Lisa Ganio, Arne Skaugset, Judith Li | | | |
| Analysis of Cumulative Impacts on Biotic and Abiotic Responses in Stream Networks Due to Contemporary Forest Practices (2006-2009) | 30,000 | | |
| Lisa Ganio, Robert Gresswell, Judith Li, Arne Skaugset | | | |
| Macroinvertebrate response to harvest in the Hinkle Creek Watershed (2008-2010) | 56,262 | 60,592 | |
| Judith Li, Lisa Ganio | | | |
| Assessing the effects of contemporary forest practices on watershed function at the Alsea Watershed (2008-2011) | 34,225 | 35,764 | 37,380 |
| Jeff McDonnell, George Ice, Jeff Light | | | |
| Quantifying use and selection of hiding cover by salmon and trout across paired watershed studies in western Oregon (2008-2009) | 30,189| | |
| Jason Dunham, Arne Skaugset | | | |
| Influence of Intensive Forest Management on Biodiversity in Pacific Northwest Commercial Forests (2008-2010) | 36,000 | 36,000 | |
| Gary Roloff, Matthew Betts, Larry Irwin | | | |
| On-Site and Cumulative Off-Site Effects of Timber Harvest on Stream Temperature (2008-2010) | 35,000 | 35,000 | |
| Arne Skaugset | | | |

**Totals** $304,860 $253,450 $37,380

Guidance for FY 2009 harvest level is estimated at 3.5 billion board feet. Based on that assumption the initial gross FY2009 budget is $350,000, of which $263,157 is spendable after the 33% administrative support charge is deducted. Additional resources available for allocation, in net spendable form, include $35,526 of harvest tax receipts in excess of FY2007 budget and $6,177 of unallocated budget carry forward from FY 2008, for a total spendable resource pool of $304,860. Commitments for continuing projects in FY 2009 total $234,759. The net spendable amount available for allocation to new projects in FY 2009 is $70,101.

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1 Encumbered in FY2008 budget allocation - not included in commitments for continuing projects in FY2009
New Projects

Following guidance by the Technical Advisory Committee and final approval by the FRL Director, three new activities were initiated in FY2009. New projects are intended to meet high priority needs identified during the annual advisory committee meeting.

New Research Project Study 1:

Title: The importance of sculpins in headwater streams: implications for understanding forestry influences on salmon and trout (2009-2010)

Investigators: Drs Arne Skaugset and Jason Dunham

Relevance to Mission: The Trask River Watershed Study seeks to quantify influences of contemporary forest practices on habitats supporting native fishes and amphibians by comparing environments and populations before and after harvest in streams with and without harvest. The approach in this study is similar to ongoing and past work in the Oregon Coast Range in that it assumes a “bottom up” view of fish habitat. A “bottom up” view emphasizes the importance of stream and riparian habitats in controlling the flow of energy “up” through food webs in streams. Accordingly, measures of instream cover and food availability are commonly made to link stream and riparian habitats to trout and salmon.

In the Trask Watershed, characteristic of many streams in the Oregon Coast Range, there are other fishes present, particularly sculpin (cottids) at all sites. Two species of sculpin (reticulate and prickly) are present in large numbers in the Trask, and can outnumber salmon and trout (salmonids) by a considerable measure. Given that both cottids and salmonids rely primarily on the same kinds of prey, it is quite possible that cottids could play a major role in determining food availability for salmonids. Furthermore, it is not difficult to envision that the role cottids play may equal or exceed influences from other instream and riparian influences on food availability to salmonids.

Whereas species interactions involving salmonids (e.g., competition between coho, steelhead, and coastal cutthroat trout) have often been a research focus in the past, we are unaware of any studies in the field that explicitly consider the relevance of cottids in the Pacific Northwest. This is an essential question to consider if we are attempting to understand the influences of forestry on salmonids. It is very possible that the influence of cottids on the food supply for salmonids could be substantial and perhaps even an overriding factor that obscures the influences of the typical “bottom up” influences we consider.

Objectives and Methods. We propose the following work in the Trask River Watershed to address prey consumption and compare diet overlap between cottids and salmonids:

1. Quantify the similarity diets and growth of individually tagged cottids and salmonids during early summer through fall, representing a major transition in prey availability from relatively abundant aquatic macroinvertebrates (early season) to terrestrial invertebrates (later season). Comparisons of prey consumption between different aged fish within a species and among species will be made. If possible we will attempt to include Pacific giant salamanders in our samples, although this species is not as common as cottids and salmonids in Trask (although a top consumer in other systems).
2. Quantify late-season patterns of growth, abundance, movement, and survival of both cottids and salmonids at four focal sites within the Trask River (a part of annual monitoring in Trask).

3. Use continuous temperature data collected at each site and individual growth rates to estimate consumption following standard bioenergetics approaches, including a new model developed specifically for prickly sculpin (D. Beauchamp, University of Washington, pers. comm.). In simple terms, a bioenergetic approach assumes that growth = consumption - metabolic costs. By rearranging this equation, and with information on growth and temperature (the major control on metabolism), rates of consumption are estimated.

4. Compare consumption rates measured directly for individual fish in the field to those modeled using a bioenergetics approach. This will be a useful complement to the labor intensive method of directly interrogating fish with stomach samples to estimate consumption rates. If successful it can also be applied to existing data on individual fish growth and temperature collected in other watershed studies.

Expected outcomes. If, as we expect, we find that cottids collectively represent a major consumer of macroinvertebrate prey in streams, our view of a salmonid-dominated fish community controlled by “habitat” will be fundamentally changed and expanded to consider the key role that cottids also play in headwater streams. This will represent a major shift in how we study salmonid-habitat relationships in these ecosystems. Future monitoring and modeling of fish population dynamics in Trask will be updated to incorporate these influences.

Budget FY 2009-2010 (please see footnote)

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\(^1\) Note: This budget includes the total cost for stipend, OPE, and assumes a full tuition waiver. If as anticipated, Heidi Vogel (Quantifying use and selection of hiding cover by salmon and trout across paired watershed studies in western Oregon) completes her thesis on schedule (summer 2008), there may be an opportunity to use funds from that project to augment this effort. Also, Mark Raggon is currently funded by a USGS internship that may cover up to $5000-$8000 of his salary during part of the year. If this proposal is funded, please contact the PIs to figure a final cost for this. It may be considerably less than requested above.
New Research Project Study 2:

Title: Characterization of stream warming trends based on stream features and management of riparian cover. (2009-2010)

Investigators: Michael Newton, Professor Emeritus; Elizabeth C. Cole, Sr. Research Assistant, Department of Forest Science.

Relevance of topic to program mission: This project deals directly with evaluation of management criteria and ODF stream rules. It will be based on detailed interpretation of data collected over the past six years in which streamside vegetation has been quantified and measured in terms of basal area, light reaching the stream, and quantity and location of vegetative cover. Streamside cover ranges from uncut conifers, uncut hardwoods, ODF standard rules in clearcuts, residual cover organized to shade the stream, and shrub-only buffers in four fish-bearing streams. One is in the foothills of the Cascades and three are widely different stream systems in the Coast Range. Each stream has a full suite of buffer descriptions. The Cascades buffers are all dominated by conifers, and Coast Range streams are dominated by hardwoods. Streams range from large to medium/small. Each stream was surveyed for pools and woody debris before and after harvest. All streams have four to six years of temperature monitoring every 100 meters in study reaches of 2000-2700 m long. On each stream, clearcuts spanning the stream for 250-400 m were installed after two years of baseline measurements of stream temperature and one measurement of baseline cover with basal areas next to the stream and 15m away. Two to four years of post-harvest temperature data have been recorded, reflecting changes introduced both by harvest and by recovery of cover combined with innate features of streams. Cover has been measured by ocular estimation, spherical densiometer by cardinal direction, and by fisheye photos spaced 30 m apart through the length of the stream study reach. Fisheye data has been converted to gross incoming and net radiation with net radiometer calibrations. Each year of water temperature measurement has been accompanied by air temperature thermistors near the stream surface with each type of streamside cover. Stream discharge, velocity and volume have been recorded 3-4 times each summer for 2-3 years. Stream productivity has been measured in three streams, and fish production measured in three streams bracketing time of harvest. Data gathered will provide comprehensive information about how buffer design influences rates of temperature change, up and down in fish-bearing streams. This will help develop BMPs for these kinds of streams.

Objectives:
1. Develop energy exchange equations that allow interpretations of partial contributions of actual shade on water, air in the immediate vicinity of water, stream velocity and volume, and azimuth/slope of the streambed.
2. Provide descriptions of cover most effective in managing water temperature.

Overview of Methods: Water temperature fluctuates diurnally in shade in all our data. We ask the question of how much more heat is exchanged when radiation load is increased in various degrees, other things being equal. Equations will be needed that deal with confounding influence of sun on air temperature, and that allow influence of stream features. Organization of our data to accomplish this will be the most time-consuming activity. These equations can then be compared with existing models for determination of partial contributions of cover changes with timber harvest and how residual stands are designed. They will also be able to determine rate of cooling when water warmed by an extraneous source of heat is allowed to equilibrate with air temperature. Existing data will be used for most of this exercise. Preliminary analyses will
determine where data gaps exist, and those will be filled in with data gathered in the second-year of the study.

**Timeline:** Year 1. Existing data will be proofed and formatted for analysis. Equations will be developed that provide interpretations of partial effects of each factor measured, based on observed temperature change rates when an array of conditions are present. Year 2. Additional water temperature data will be collected in locations where temperature fluctuations are outside expected ranges, and environmental features noted.

**Budget:**

**7/1/08-6/30/09**

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Total cost 7/08-6/09 $17,518

**7/1/09-12/31/09**

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Total cost 7/09-12/09 $11,575

**Total cost of project:** $29,093
New Research Project Study 3:

Title: Temperature profile recovery fifteen years after clearcutting along medium and large fish-bearing streams: effect of buffer design (2009-2010)

Investigators: Michael Newton and Elizabeth C. Cole, Department of Forest Science

Relevance: The investigators established studies of seven fish-bearing streams with objectives of linking buffer cover and design to rise of stream temperature following logging. Four of those streams were harvested with 300 and 600-foot clearcuts across the streams and three were given one-sided clearcuts along a half-mile of stream length. Streams with zero basal area of trees for buffers were replanted with equal mixtures of four types of conifer seedlings in marked clusters at 440 trees per acre, extending to 100 ft from the bank with and without weed control in each clearcut, and with plantations extending 60 feet into buffers at each end. Units logged with one-sided buffers were planted operationally. The experimental plantations were followed four years and the results published, with tree growth and cause of damage for each tree summarized. Longer-term follow-up has not occurred in either set of streams. These studies were done at a cost of $133,000 from four land-owners for the first set, and a similar amount from three industries and ODF for the set with one-sided buffers. To date, there have been no longer-term reports of similar experiments to determine the outcomes of either one-side planting and one-side natural cover or both-side planting with mixed species with and without weeding. A predecessor report of fourth-year outcomes was published as: Newton, M. and E. C. Cole, 2004. Linkage between riparian buffer features and regeneration, benthic communities and water temperature in headwaters streams, western Oregon. In: C. Harrington and S. Schoenholtz, Tech. Eds. USDA Forest Service General Technical Report PNW-GTR-642. pp 81-101 . . .

Objectives: 1. Provide fifteenth year summary of survival of experimental trees
2. Observe whether one-sided buffer has maintained integrity since establishment
3. Observe whether significant changes have occurred in warming trends in the last 12+ years.

Methods: In summer, 2009, install thermistors in the same locations as located when studies were conducted originally to measure rate of warming with downstream movement in ways that identify change. Within individual cutting and planting units, we will make a live tree count according to distance from the stream and whether covered by residual trees at the time of planting. The one-sided buffers were intended to provide shade on the south sides of streams with a 40-foot leave strip of residual trees and brush. We will evaluate their present cover with densiometer, and record existing evidence of down trees, their approximate sizes and whether they fell across the streams, then determine if rate of warming has changed.

Timeline: Thermistors will be set out summer 2009 and collected in September. Tree and cover evaluations will be done fall-winter, 2008-9. Data summaries will be completed winter 09-10 and prepared for publication by spring 2010.
Budget:

7/1/08-6/30/09

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Total for project $33,789
Continuing Projects

These projects continue from last year’s program. They contribute directly to the goals of this research program and are funded at least partially by Oregon Forest Products Harvest Tax and reflect the FRL’s commitment to learning more about how to enhance the compatibility between timber, fish and wildlife values in managed forests. These studies include the following:

Continuing Research Project Study 4:

**Title:** Forest Management Strategies in the Hinkle Creek Watershed Demonstration Area

**Project:** Evaluation of Post-Harvest Treatment Seasonal Stream Water Nutrient Concentrations

**Principal Investigators:** Kermit Cromack, Jr. and Lisa Ganio, Forest Science Department; Arne Skaugset, (PI) Forest Engineering Department; Judith Li, Fisheries and Wildlife Department, Oregon State University

**Relevance to program mission:** This research is obtaining post-harvest treatment data for stream chemistry for two paired forest watersheds, the North and South Forks of Hinkle Creek Watershed Research and Demonstration Area Project. Current forest management practices are designed to promote sustainable silvicultural systems on these two paired watersheds, which are productive for timber, water, fish, and wildlife resources. An extensive three-year pre-harvest treatment database has been obtained for both stream and soil nutrients in these watersheds (George, 2006) during 2002-2005, together with effects of basin wide N fertilization during 2004-2005. Clearcutting harvest treatment of four small headwater catchments in the South Fork was began in late 2005 and was completed during spring of 2006. It is important to continue the stream chemistry research in order to provide a model upon which to help gauge effects of current and expected intensive forest management practices on industrial forest land. It will be particularly worthwhile to obtain such data from the Hinkle Creek paired watersheds in order to assess 4 years of post-treatment effects from intensive forest management practices during 2006-2010.

**Objectives:** There are two main objectives: 1) to obtain seasonal stream water nutrient concentration data for four additional years in six headwater streams, and also in the North and South Forks of the Hinkle Creek Watershed Demonstration Area. Stream nutrients to be measured include: total N, P, and base cations (Ca, K, Mg, Na), inorganic carbon (DIC), dissolved organic N (DON), inorganic N (DIN), SO₄, Cl, and Si, plus stream pH and conductivity, collected seasonally; 2) to obtain organic and inorganic N data for steam water chemistry for at least two series of storm based sampling during fall and winter of each year, to be integrated with the hydrology research. This research is designed to integrate with the watershed research being conducted by the Hinkle Creek Research and Demonstration Area Project on Hydrology and Water Quality being led by Arne Skaugset from the Forest Engineering Department at OSU.

**Overview:** Oregon has highly productive forests growing on soils that can be effectively managed for timber resources while maintaining stream water quality suitable for fish and wildlife resources. In addition to maintaining productive forests, one goal of current forest management is to maintain stream water of high quality for fish and wildlife. The same nutrients which are essential in adequate quantities for tree growth (N, P, and base cations, plus micronutrients) also are required by both fish and wildlife species. This project will provide a valuable database for stream nutrient concentrations after clear cutting treatments for four
headwater catchments and two uncut control headwater catchments, and also for the North and South Forks of the Hinkle Creek Watershed Research Project.

**Timeline:** Fall/Winter/Spring 2006/2007 – collect initial stream samples, recruit a new graduate student, and develop study plan; Summer/Fall 2007 – continue stream nutrient sample collection and analysis; Winter/Spring/Summer/Fall 2008 – continue stream sample collections and data analysis; Winter/Spring/Summer/Fall 2009 – continue stream sample collections and data analysis; Winter/Spring 2010 – finish thesis, submit final report, and write papers based upon these results.

**Progress to date:** Sampling for stream nutrient concentration at Hinkle Creek was completed for the pre-treatment period in October, 2005. Partial clearcutting treatments on the four experimental treatment watersheds were completed during the winter and spring of 2006. Stream nutrient sampling was resumed in late June, 2006 on the two control and four treatment watersheds, and on the North and South Forks of Hinkle Creek, and have continued through November, 2007. The two control watersheds (DeMearsman and Meyers) were fertilized with 220 kg ha⁻¹ of urea N in the late fall of 2004, and showed higher NO₂ + NO₃ concentrations during 2005 (Figure 1). The North and South Forks show a general difference in N concentrations post-harvest for 2006-2007 Table 1). Stream N concentration data for 2006-2007 show that the control watersheds are returning to pre-treatment N concentrations, while the partial clearcutting treatment watersheds have shown significantly increased N concentrations starting about eight months after harvest treatments were completed (Table 2). These N concentrations are well within the range of values reported by Binkley et al. (2004). Control and post-harvest watershed stream N concentrations for Hinkle Creek are very similar to those observed by Vanderbilt et al. (2003) for the HJ Andrews Experimental Forest, but are generally lower than those for forested watersheds within the Oregon coast Range (Compton et al. 2003).

**References**
George, L.R. 2006. Baseline stream chemistry and soil resources for the Hinkle Creek Research and Demonstration Area Project. M.S. Thesis – Forest Science Department and Forest Engineering Department, Oregon State University, Corvallis, Oregon. 113 p.
Figure 1. Hinkle Creek watershed creek NO$_3$-N + NO$_2$-N concentrations. Fenton and Russell Creeks are treatment basins and Myers and DeMearsman Creeks are controls. All basins are completely forested. Basin-wide fertilization occurred after the October 2004 sampling.
Table 1. Hinkle Creek North & South Fork average N concentrations: June 2006 – November 2007

<table>
<thead>
<tr>
<th>Hinkle Creek Treatments</th>
<th>NO$_2$ + NO$_3$</th>
<th>Total dissolved N</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Fork control watershed</td>
<td>0.027*</td>
<td>0.083*</td>
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<tr>
<td>South Fork post-harvest treatment watershed</td>
<td>0.069</td>
<td>0.108</td>
</tr>
</tbody>
</table>

*p<0.05

Table 2. Hinkle Creek post-harvest treatment experimental watershed stream N concentrations: June 2006 – November 2007

<table>
<thead>
<tr>
<th>Stream Nitrogen Post-Harvesting</th>
<th>Total Dissolved N$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>June, 2006 – November, 2007</strong></td>
<td>&lt;----------------------mg L$^{-1}$------------------------&gt;</td>
</tr>
<tr>
<td><strong>NO$_3$$^a$</strong></td>
<td></td>
</tr>
<tr>
<td>Control Streams</td>
<td></td>
</tr>
<tr>
<td>DeMearsman</td>
<td>0.030</td>
</tr>
<tr>
<td>Myers</td>
<td>0.044</td>
</tr>
<tr>
<td>Post-harvest Streams</td>
<td></td>
</tr>
<tr>
<td>Beeby</td>
<td>0.239</td>
</tr>
<tr>
<td>Clay</td>
<td>0.143</td>
</tr>
<tr>
<td>Fenton</td>
<td>0.180</td>
</tr>
</tbody>
</table>

$^a$F-test (d.f. 4, 30) = 4.12 $P < 0.01$

$^b$F-test (d.f. 4, 25) = 3.42 $P < 0.04$
Continuing Research Project Study 5:

**Title:** Analysis of cumulative impacts on biotic and abiotic responses in stream networks due to contemporary forest practices (2006-2009)

**Principal Investigators:** Lisa M. Ganio, Robert Gresswell, Judith Li, and Arne Skaugset

**Relevance to program mission:** The impacts of contemporary intensive forest management activities on stream ecosystems are being studied at the “Hinkle Creek Paired Watershed Study.” As a part of this study, the cumulative effects of contemporary forest management activities on the physical, biological, chemical characteristics of the terrestrial, riparian and aquatic ecosystems is being studied at the scale of a complete 5,000 acre watershed. A study plan authored by the principle investigators of the Hinkle Creek Paired Watershed Study identified the complex interactions among these systems and the need to integrate multiple response variables over multiple spatial and temporal scales. The analysis of the interactions between the response and explanatory variables over multiple spatial and temporal scales is further complicated by their association along a stream network. The data obtained from a stream network includes characteristics that increase the complexity of any resultant analysis.

1. **Spatial autocorrelation in a stream network** is a concern when data are collected in close physical proximity. Spatial analysis methods for stream networks need to account for distance between points along the network, not as-the-crow-flies distance. But such analysis methods for networks are not used routinely or available in existing software.

2. **Connectivity or neighbor relationships** (in spatial analysis) between points must account for flow patterns through the network. In some cases the connectivity relationships are clear (e.g. sediment flows downstream) and other cases may be more difficult to elucidate (e.g. how far up and downstream will/do amphibians move?).

An important objective in the Hinkle Creek Study is the integration of responses from multiple spatial and temporal scales to examine the downstream cumulative impacts of management on the subject area responses. Comments by reviewers of the original study plan pointed out the need for a better description of the data analysis that would consider cumulative impacts and better describe the integration that would occur between the original disciplinary projects. Such an analysis and integration must appropriately account for flow through the system and for spatial autocorrelation at the relevant scale. This project would develop the appropriate analysis methods for data from stream networks and describe how data from the individual disciplinary research projects would be integrated. These methods would be applicable to any ecological network and specifically apply to the multiple response variables in paired-watershed studies designed to address cumulative impacts of forest management on biotic and abiotic components of stream systems.
Objectives
1. Summarize existing statistical models used in natural resources and quantitative ecology to account for flow and autocorrelation for data from stream networks.
2. Evaluate the adequacy of these methods for the analysis of cumulative effects in paired-watershed studies.
3. Develop data analysis strategies to account for spatial autocorrelation and directional flows in data from paired watershed studies.

Approach
1. A summary of statistical modeling, methodology and strategies used in ecological network settings and described in the peer-reviewed literatures of hydrology, wildlife management, fisheries, stream ecology, statistics and quantitative ecology will be produced. Methodologies and models that incorporate spatial and temporal autocorrelation, cumulative effects and directional flow will be targeted. We will also specifically search for any methods used in ecological network settings.
2. Several methods best suited to the research hypotheses of the Hinkle Creek Study will be identified and applied to data from this study. Strengths and weakness of these approaches will be identified and recommendations for future stream and watershed studies will be produced.
3. A statistical analysis strategy (e.g., models, methods) for integrating autocorrelation and flow information into data analysis will be developed for ecological questions from branched stream settings. We anticipate integrating methods from multiple fields and potentially developing new methods.

Timeline: PhD student would begin in Fall 05. Objective 1 would be accomplished by Fall 06; objective 2 would begin during Summer 06 and continue through at least Fall 07; objective 3 would begin Summer 07. (FY2006-2009)

Budget:
Year 1 (FY 06): $25,000
Year 2 (FY 07): $30,000
Year 3 (FY 08): $30,000
Year 4 (FY 09): $30,000
Continuing Research Project Study 6:

Title: Macroinvertebrate response to harvest in the Hinkle Creek Watershed (2008-2010)

Investigators: Judith Li, Associate Professor, Department of Fisheries & Wildlife, OSU
Lisa Ganio, Associate Professor, Department of Forest Science, OSU

Relevance to program mission: As useful indicators of riparian conditions and essential components of stream foodwebs, aquatic macroinvertebrates will be used to examine instream response to harvest in non-fishbearing and downstream, fish-bearing streams at Hinkle Creek. We continue to work with Roseburg Lumber Co. who owns the land, and research colleagues at OSU; the data and techniques developed at Hinkle will also inform new research on the Trask River. In the context of pre-harvest patterns we have already established, this project will document successional changes in a time frame that will include several generations of invertebrates adapting to harvest in the headwaters.

Objectives:

- Compare post-harvest benthic invertebrate abundance, biomass and diversity to pre-harvest levels.
- Assess changes in rates of invertebrate drift and emergence from streams following harvest.
- Determine cumulative effects of invertebrate availability on fish diet, particularly cutthroat trout.
- Estimate network effects of changes in headwater sites propagated downstream and across the watershed.

Post harvest effects will be assessed by comparing invertebrate responses to 2 1/2 years preharvest data at South Fork Hinkle and with North Fork Hinkle sites retained for reference conditions. The same techniques used to collect benthic invertebrates, drift, emergent adults, and fish diet in preharvest sampling (2004-2006) will be deployed in this subsequent study. We will examine local and downstream effects at 24 sites distributed in headwater sites that were cut, downstream tributaries and mainstem reaches of Hinkle Creek. Care has been taken to locate sites within and below harvest sites of 2006 and in the next harvest cycle planned for 2008. Benthic samples will be collected in spring, summer and fall, whereas drift and emergence sampling will be optimized by accounting for physical conditions (such as presence of flow in spring), life history patterns and invertebrate activity levels (e.g. maximal rates of emergence in summer). Collections of fish diet using non-lethal lavage techniques, that are coordinated with fish sampling crews, will compare fish consumption to prey availability in post-harvest stream conditions. By project completion we will be able to describe 4 years following harvest in the South Fork Hinkle Creek basin.

Timeline for post harvest assessment:

2007: Enumerate & analyze 2006 samples; Collect benthic, drift & emergence (24 sites)
2008: Enumerate & analyze 2007 samples; Collect invertebrates as in 2007, initial post harvest samples on mainstem Hinkle
2009: Enumerate & analyze 2008 samples; Collect entire year of post 2008 harvest.
2010: Enumerate & analyze 2009 samples

Budget: FY2008 FY2009 FY2010
$56,021 $56,262 $60,592
Continuing Research Project Study 7:

Title: Assessing the effects of contemporary forest practices on watershed function at the Alsea Watershed (2008-2011)

Investigators: Jeff McDonnell, Department of Forest Engineering; George Ice, NCASI; Jeff Light, Plum Creek Timber Company

Relevance to program mission: The re-activation of the Alsea Watershed Study represents one of the most important opportunities in decades to assess the effects of contemporary forest practices on aquatic habitat in the Oregon Coast Range. Because of its rich history (described in detail at http://www.ncasi.org/programs/areas/forestry/alsea/default.aspx), the Alsea Watersheds provide an opportunity to compare water resource responses to current forest practices with those resulting from an extreme manipulation in the 1960s. This study will assess the effectiveness of current Best Management Practices (BMPs) for timber harvesting on the physical, chemical, and biological characteristics and habitat quality in small streams with resident trout and anadromous salmon. This project will also focus on riparian management areas adjacent to both non-fish-bearing and fish-bearing headwater streams.

Objectives: Oregon has extremely diverse hydrologic systems, resulting from significant differences in climate, topography, soils, geology, and vegetation. In a recent USGS hydrologic classification study, Dave Wolock showed that Oregon possessed 16 of the 20 different hydrologic-landscape regions identified for the United States—many more than any other state. This tremendous hydrological diversity in how watersheds function affects the dominant modes of runoff delivery to streams. As a result the hydrological (water quantity and quality) consequences of contemporary forest practices will be different in different watersheds of the state (e.g., Western Cascades vs Coast Range). Preliminary research by the McDonnell Hillslope & Watershed Hydrology group (see http://www.cof.orst.edu/cof/fe/watershd/ for papers and reports) suggests that watershed function in the Coast Range is greatly influenced by the highly permeable sandstone bedrock. This considerable storage potential means that Coast Range catchments store water for considerable periods of time (months to years) but then rapidly (minutes to hours) release it during storm events. Because overland flow is so rare, even during large rainstorms in the Oregon Coast range, we hypothesize that most of the change in water flow as a result of modern forest practices will be due to the changes in age, origin, and pathway of subsurface flow through permeable soils and sedimentary bedrock. These changes interact with changes in shade, sediment sources, and nutrient availability to result in water quality and aquatic habitat responses.

The proposed work goes beyond the traditional, black-box, paired-watershed approach already planned for the Alsea in order to illuminate the internal water cycling processes to explain why and how changes in runoff and water quality may occur in response to forest practices and how riparian zones function in the context of water storage and delivery to the stream. Again, the paired-watershed approach is not able to provide answers to these types of questions. We argue that understanding how the watersheds store and transmit water, in addition to simple change detection, is an important next step in watershed management in Oregon and in forming the right kinds of models to forecast such changes in similar hydrologic regimes of the state (for the right kinds of process reasons).

The objectives of the research in year 1 are to: (1) Quantify the mean residence time of water draining the Alsea Watersheds before harvest, (2) Quantify the time-source components of storm runoff (i.e., event water vs pre-event water) before harvesting, and (3) Calculate how such
measures scale within and beyond the three monitored Alsea Watersheds. Research in subsequent years will focus on hydrologic model development and testing using the information gained via the experimental, tracer-based work. This will involve the development of new, simple representations of the dominant processes operating in the Alsea Watersheds. Once a model is working for the right process reasons, the model will be used as a scenario generation tool for examining a wider range of virtual forest practices under different land management scenarios and climate conditions.

**Basic overview of approach/methods:** The original Alsea Watershed Study assessed the effect of timber harvesting on water, aquatic habitat, and salmonid resources using a paired-watershed approach. Flynn Creek was an undisturbed control watershed in the original study and remains an undisturbed Natural Research Area under management by the USDA Forest Service. Deer Creek was partially cut and demonstrated the effectiveness of streamside management zones. Needle Branch was impacted by nearly complete clearcut timber harvesting and subsequent slash burning, with no streamside vegetative buffer. It experienced dramatic water quality responses for temperature and dissolved oxygen. Changes in discharge, sediment, and nutrients were also noted, although these were somewhat more subtle, if more prolonged. The regenerated forest on Needle Branch is again ready for commercial harvest. The proposed timber harvesting plan involves two harvest units and will provide an opportunity to examine cumulative effects on water resources.

We will initiate water sampling at the Flynn, Deer, and Needle Branch Creeks’ gauging structures in the Alsea basin to complement the ongoing data collection. **We will quantify the mean residence time of water draining the Alsea Watersheds** before harvest by taking weekly samples from each gauging location for year 1. These samples will be analyzed for stable isotope composition (18-O and 2-H) in the new McDonnell stable isotope lab in 006 Peavy Hall. These isotope tracers are naturally occurring parts of the water molecule. As such, they can be used to trace the movement of water through the Alsea Watersheds (and sub-catchments thereof) for quantification of water age and origin using now-standard techniques developed by McDonnell and his team. The time series of bulk storm rainfall samples will be related to the degree of damping and lagging expressed in the stream water—mean residence time will be computed using the convolution integral approach. This technique was described in a review paper by McGuire and McDonnell in Journal of Hydrology in 2006. Quantify the mean residence time of water draining the Alsea Watersheds before harvest. **We will quantify the time-source components of storm runoff (i.e., event water vs pre-event water)** by conducting storm-based sampling for hydrograph separations using existing ISCO water samplers in the field. We will begin storm-based sampling in Fall 2007 and follow the wetting-up cycle of the catchment in order to chronicle the changing source components of flow as the watersheds activate progressively shallower and younger stores of water. Now-standard 2- and 3-component hydrograph separation techniques will be used, as described in the Elsevier text Isotope Tracer in Catchment Hydrology, edited by Kendall and McDonnell in 1998. In addition to the fixed gauging stations at Flynn, Deer and Needle Branch, we will position additional ISCO samplers (from the McDonnell hydrology lab) at sites nested within the catchments and at larger watershed scales that the catchment are a part of. **Scaling relations in hydrograph components and residence time will be examined** in order to increase the transfer value of this work to other Coast Range watersheds. Such scaling measures have been developed for Western Cascades systems (see the terrain-based predictive model for the Western Cascades in McGuire et al 2006 Water Resources Research). We expect fundamentally different scaling relations for the Coast Range system due to the permeable bedrock. This scaling component will complement the existing investment at the Alsea by increasing our understanding of specific hydrologic processes and assisting our interpretation of the hydrologic and water quality (and ultimately the
biological) response to contemporary forest practices and allow for improved management and staffing of this watershed study.

**Timeline and Budget**

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<tr>
<th></th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
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<tr>
<td>$32,714</td>
<td>$34,225</td>
<td>$35,764</td>
<td>$37,380</td>
<td></td>
</tr>
</tbody>
</table>

* It is important to note that commercial rates for 18-O and 2-H samples are ~$40/sample. We anticipate running 2000 samples in year 1. Therefore, the leveraging of in-house mass spec time alone exceeds (greatly) the requested year 1 project funds. The outside investment from NCASI, Plum Creek Timber Company, and other co-operators, as well as the existing database and monitoring infrastructure are conservatively estimated to represent $5,000,000 over 10 years.
Continuing Research Project Study 8:

Title: Quantifying use and selection of hiding cover by salmon and trout across paired watershed studies in western Oregon (2008-2009)

Investigators: Drs Arne Skaugset and Jason Dunham

Relevance to program mission: Three paired watershed studies are now underway in western Oregon, and include Hinkle Creek (Umpqua River basin) and two watersheds in the headwaters of the Alsea and Trask Rivers in the central and northern coast range, respectively. These studies seek to quantify influences of forest practices on habitats supporting native fishes and amphibians by comparing environments and populations before and after harvest in streams with and without harvest. Much work has focused on fish growth, movement, population abundance and size structure. Less has focused on specific mechanisms influencing survival. It is well-established that survival may vary seasonally for many species, but why survival is lower or greater is not well understood. In other words, is survival tied to starvation, predators, disease, or other factors? We suspect predators play a major and unstudied role.

Predators like birds and mammals in particular have strong impacts on salmon and trout in larger lakes and rivers, but studies in small streams such as those studied in the three paired watersheds are lacking. One reason is that observing these predators directly is a daunting logistical challenge. Predators may only visit an area once in a year or even less frequently and have an important influence on fish populations. Thus, it is necessary to devise indirect approaches for understanding how fish may interact with predators in small streams, and how the ability of fish to avoid predators is tied to local habitat conditions. This is a key linkage between the response of fishes to forestry and natural processes that influence availability of habitat that fish may need to avoid predators (hiding cover).

In this study we propose to measure characteristics of hiding cover and quantify use and selection of hiding cover by salmon and trout in the three paired watersheds. We will take advantage of existing marked fish to study their patterns of habitat use in relation to unused habitats to measure the strength of selection of habitats by individuals. By understanding what hiding cover is, and obtaining a measure of the quality of hiding cover (i.e., selectivity), we will have a much better sense of how fish use habitat to avoid predation. Work will occur during seasonal low flows in summer and fall, where fish may be more confined and vulnerable to predators (D. Bateman, personal communication). To determine if fish are using hiding cover, we will approach the stream with mobile antennas submerged to detect locations of marked individual fish. Fish that do not move after detection are assumed to be using hiding cover, whereas fish that leave the vicinity are assumed to be using a different tactic (evasion) for avoiding what they perceive to be predators (humans entering their habitat). When possible, underwater observation will be used for verification. Measures of hiding cover will include size of pools (e.g., area, depth) and availability of instream cover (e.g., wood, un-embedded substrate, undercut banks, boulders, turbulence). Other factors (e.g., velocity, light) may also be important. At the level of individuals, natural selection should drive individuals to select habitats that provide greater opportunities for feeding and for surviving the threat of predators. The relative benefits of different habitats should also be conditioned on characteristics of the individual (e.g., size) and external factors such as temperature and the density of con-specific and hetero-specific competitors, as well as availability of different habitat types (e.g., if cover is abundant and available, then selectivity should be lower).
Objectives:
1) measure habitat use and availability for coastal cutthroat trout, steelhead trout, and coho salmon to model patterns of habitat selection within individual locations (stream reaches)
2) compare results among locations to understand conditions that may modify habitat selection (e.g., among paired watersheds, sites)
3) identify habitat characteristics within each location that are most important to different species in terms of the strength of selection observed by individual fish.

Budget: FY2008 FY2009
$29,483 $30,189
Continuing Research Project Study 9:

Title: Influence of intensive forest management on biodiversity in Pacific Northwest commercial forests (initially funded for 2008-2010)

Investigators: Dr. Gary Roloff, Dr. Matthew Betts, Dr. Larry Irwin

Relevance to program mission: A recent consensus of National Council for Air and Stream Improvement (NCASI) wildlife biologists responsible for management activities on forestlands in the Pacific Northwest indicated a need for ecological evaluations concerning the affects of intensive conifer plantation forestry (conducted according to state forest practices rules) on elements of biodiversity. This information need is consistent with the Fish and Wildlife Habitat in Managed Forests (F&W in Managed Forests) Research Program’s mission of providing new information about wildlife habitat within Oregon’s managed forests. The proposed project fulfills F&W in Managed Forests’ high priority theme “2) Assessing effects of contemporary forest practices on terrestrial habitat and biodiversity”.

Objective: Derive strong inference on the response of biodiversity elements to varying intensity silviculture regimes.

Overview of Approach: The focus of the proposed work is on stand response to intensive forest management practices and not on the specific in how the response was achieved (i.e., the study design will control for amount of vegetation kill or soil disturbance and not for the specific tank mixes or mechanisms used to disturb soil). Fixing a design to a specific mechanism of intensive forest management is risky because these mechanisms are dynamic and constantly evolving. First we will identify study areas in the coastal and western Cascades zones of Oregon and Washington (n=4 study areas). Within study areas conduct a manipulative experiment based on a randomized complete block design with each block consisting of 5 treatments: 3 intensities of stand establishment practices (i.e., based on percent vegetation kill, soil disturbance, vegetation kill regime), a control, and a fenced control. One block will consist of 5 stands >300 m apart but in the same general geophysical environment. We will seek funding to implement the study on a minimum of 8 blocks (40 stands total) per landscape. We will evaluate within stand and broader-scale (e.g., adjacent stand structure and configuration) influences on observed community responses. Community responses will include measures of population performance for small-scale species (i.e., those species that can be reliably linked to the scale of our treatment including plants, insects, small mammals, herpetofauna, and birds).

Timeline:
- Spring-Summer-Fall 2007 – Recruit PhD student to work at OSU under the guidance of Dr. Matthew Betts. Begin study site and stand selection process. Recruit landowners and begin meeting with silviculturists to discuss study design implementation.
- Winter 2008 – PhD student begins program.
- Spring-Summer-Fall 2008 – Work with cooperating landowners to ensure implementation of experimental design. Study proposal with detailed methodology. Identify additional funding sources (e.g., NCASI).
- Spring-Summer 2009 – Work with landowners on deploying experimental design.
- Spring 2012 – PhD student graduates

Budget: Initially funded at $36,000/year for 3 years. Further funding is contingent on study refinement and cooperative funding.
Continuing Research Project Study 10:

Title: On-site and cumulative off-site effects of timber harvest on stream temperature (2008-2010)

Principal Investigator: Dr. Arne Skaugset, Assoc. Prof., FE, COF, OSU

Relevance to program mission: The effect of timber harvest on stream temperature in perennial, non-fish-bearing streams is the focus of continuing debate regarding the management of headwater streams. Of particular concern are the cumulative effect of multiple harvest units along headwater and fish-bearing streams and their effect on stream temperature at a watershed scale. Of concern is the idea that while the on-site effect of timber harvest on stream temperature from a single harvest unit may be acceptable, these effects may accumulate over space and time with multiple harvest units and may result in unacceptable stream temperatures off-site in main stem, fish bearing streams. The Hinkle Creek Paired Watershed Study (HCPWS) was installed to investigate just this problem, specifically to investigate the effect of multiple harvest units in space and time on the stream temperature in a main stem, fish-bearing stream.

Objectives:
- To determine the on-site effect of timber harvest adjacent to main stem, fish-bearing streams on stream temperature.
- To determine the cumulative off-site effect of multiple harvest units adjacent to headwater and main stem streams harvested during two entries on stream temperature.
- To investigate the processes that influence on-site and cumulative off-site harvesting effects on stream temperature.

Research Approach: The HCPWS was initiated in 2001. A network of thermistors was installed in the study watersheds that summer and for every summer since. The calibration period for data collection lasted until the end of summer 2005. During the winter 2005-2006, the first harvest entry was installed with the harvest of roughly 12 million board feet of timber from 380 acres of forest land. The harvest units were installed on perennial, non-fish-bearing streams and were placed to optimize the impact of timber removal on stream temperature. During the summer 2006, the first post-treatment stream temperature data was collected and these data will continue to be collected until the end of the project. In 2008, the second harvest entry is planned for Hinkle Creek. In this entry, four units, which will also total about 400 acres, will be harvested adjacent to the main stem and tributary fish-bearing streams and there will be two years remaining to evaluate the post-treatment data from the two harvest entries.

During this coming summer, in addition to the regular network of thermistors in the watersheds, thermistors will be placed directly upstream and downstream of each planned harvest unit on the S. Fork Hinkle Creek and a similar number of thermistors will be placed in complementary locations in the N. Fork. The cover provided by the canopy for both streams will be measured using hemispherical photos and correlated with net radiation measured with a radiometer. An inventory of the large wood in the main stem and tributaries will be undertaken.

The effect of the harvest on stream temperature, on-site and cumulative off-site will be evaluated using time series analysis correcting for serial autocorrelation. The effects on stream temperature will be correlated with observed changes in incoming solar radiation, groundwater flux, and hyporheic exchange. Methods will be developed to obtain a distance integrated measurement of stream temperature. After the first winter, blow down in the buffer strips will be quantified and correlated with additions of large wood to the streams.

Budget: FY2008 FY2009 FY2010
$35,000 $35,000 $35,000
TECHNICAL ADVISORY COMMITTEE

FRL FISH AND WILDLIFE HABITAT IN MANAGED FORESTS RESEARCH PROGRAM

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