FISH AND WILDLIFE HABITAT IN MANAGED FORESTS RESEARCH PROGRAM

PROGRESS REPORTS

FY 2004
(July 1, 2003 - June 30, 2004)

College Of Forestry
Forest Research Laboratory
OREGON STATE UNIVERSITY
Corvallis, Oregon

February 20, 2004

Foreword

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, with 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 Forest Engineering, Forest Resources, and the Forest Science Departments, with collaboration from scientists residing in other OSU units and federal agencies not uncommon.

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 this new 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 this new 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.

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.

The budget for FY2004 is $349,000, a result of the projected harvest of 3.49 billion board feet. The FY2004 program of work reflects several changes from FY2003. Two research projects were completed, 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 five research projects.

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.

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, 2003

FISH AND WILDLIFE HABITAT IN MANAGED FORESTS RESEARCH PROGRAM

PROGRESS REPORTS
February 20, 2004

This is a compilation of the progress reports from the projects and activities that are part of the FRL research program on fish and wildlife habitat in managed forests, which is funded by the 1993 legislative increase in the Oregon Forest Products Harvest Tax rate. The program is described in detail in the November 1, 1994 document "MEETING FISH AND WILDLIFE NEEDS IN MANAGED FOREST, A PROGRAM OF RESEARCH of the FOREST RESEARCH LABORATORY."

This is the ninth full progress report for this Program.

This document highlights the following:

a. Eight research projects were active in FY 2004, including five continuing from the previous year and three new ones. Of these, two are completed or not scheduled for further funding in FY2005.

b. For projects or functions that are ending, progress is reported as a termination report that is intended to provide a final overview of the accomplishments and implications of the efforts to date.

Steven D. Tesch
Program Manager

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NEW PROJECTS

Following guidance by the Technical Advisory Committee and final approval by the FRL Director, three new activities were initiated in FY 2004. New projects are intended to meet high priority needs identified during the annual advisory committee meeting.

Research Projects

Study 1: Contributions of Riparian Vegetation to Terrestrial and Aquatic Food Chains: Contrasting Alder and Douglas-fir Riparian Forests

Principal Investigator: Steven Perakis, USGS Forest and Rangeland Ecosystem Science Center, OSU, & CFER Program

Co-Principal Investigator: Dave Hibbs, OSU Department of Forest Science Department & CFER Program

Relevance to program mission: This research addresses the contribution of riparian vegetation to the nutritional needs of organisms in riparian terrestrial and aquatic food chains. It builds on ongoing CFER studies of riparian food chains by assessing the biological availability of different leaf litter types in both terrestrial and aquatic riparian environments in the Oregon Coast Range.

Objectives: In both alder- and conifer-dominated riparian reaches, characterize

1) the biological availability of plant litter in both riparian forest and stream ecosystems
2) how stream and soil chemical characteristics further regulate biological availability of litter.

Project Overview: Vegetation plays many critical roles in the productivity of riparian terrestrial and aquatic habitats. Two roles have received much attention in previous studies: large wood and shade. While both of these issues are far from completely understood, enough understanding has been generated that they are being used as the basis for current and new riparian management regulations.

An ignored yet critical role of riparian vegetation is as a source of nutrition for riparian consumer organisms including insects, birds, bats, rodents, amphibians and fish. With the main exception of insects, however, only a few organisms feed directly on riparian vegetation. Instead, most organisms derive their nutrition from food chains, which are supported at their base by the breakdown and incorporation of leaf litter into fungi, insects, etc. In headwater streams, riparian leaf litter inputs provide essential subsidies that fuel in-stream productivity, in addition to subsidizing food chains of terrestrial riparian habitats.

Plant species vary greatly in the nutritional quality of their leaf litter, and these variations translate directly to differences in the timing and rates of leaf litter breakdown. Given the critical role that riparian vegetation plays in subsidizing the productivity of riparian food chains, there is a risk that riparian management strategies based solely on large wood and shade needs may be creating a new set of problems, a new set of limiting conditions. Intuitively it makes sense to balance large wood and shade needs with the nutritional values provided by riparian vegetation, yet information on the nutritional role is sorely lacking.

The CFER program has initiated a large, multi-year program to address this nutritional issue. It has ongoing studies to examine how vegetation composition and physical characteristics of riparian zones influences the delivery of leaf litter to riparian soils and streams in both alder- and conifer-dominated riparian systems. This information is being related to the diets and fitness of birds, bats, insect, amphibians and fish. This ongoing work indicates that spiders, birds, salamanders, and other organisms are often most abundant in red alder dominated habitats, presumably due to the greater nutritional quality of red alder and associated plant species (CFER Annual Report 2003). A critical connection that we addressing in this study is a direct measure of the biological availability of red alder and Douglas-fir as nutritional food sources in both riparian forest and aquatic environments.

Study Approach: The CFER riparian food chain study has for two years examined a series of sites within the Coast Range located in the Nestucca, Alsea, and Siuslaw drainages. For the FRL research described here, we recruited Joselin Matkins as a Masters student into the Department of Forest Science in Fall 2003. Field work began immediately in Fall 2003 at sites already in use for CFER studies of aquatic insect and riparian amphibians.

The overall research approach is to examine the rate of leaf litter decay (measured as the loss of mass and specific biochemical compounds) as an integrative measure of the nutritional quality of different leaf litters in terrestrial and aquatic riparian environments. We are actively pursuing a suite of interrelated questions in this study:

Q1: Does litter type (Douglas-fir *vs*. red alder) influence the rate and/or temporal pattern of litter decay?

Q2: Does habitat type (Douglas-fir *vs*. red alder) influence decay characteristics of common litters?

Q3: Is there an interaction between habitat type and litter type?

Q4: How does a wide range of initial litter quality (lignin:nitrogen ratio) affect the decay rate of litter from a single species (Douglas-fir) over time?

Q5: Does externally added nitrogen (N) affect the decay rate of Douglas-fir litter?

Q6: Is there an interaction between initial litter quality and externally added N?

Q7: For all of the above, how does the stable isotope composition of leaf litter ($\delta^{13}C$ and $\delta^{15}N$) that is used to trace food webs change throughout the process of litter decay?

Q8: For all of the above, how do rates compare in terrestrial *vs.* aquatic riparian habitats?

Study Progress: Terrestrial components of the riparian field studies into Questions 1-7 began in earnest in Fall 2003. We selected 1 red alder and 8 Douglas-fir stands to provide sources of leaf litter for field experiments. The 8 Douglas-fir stands were known to exhibit a wide range of initial litter qualities ranging from nitrogen-poor to exceptionally nitrogen-rich (range: 0.85 to 2.33 %N) (see Table 1). Based on our previous work, we expect that red alder foliage will be very nitrogen rich (~ 2.6 %N). From each site, we collected 10 kg of fresh leaf/needle litter by shaking trees above exposed tarps. Litter was dried at 65 C to prepare for litter bag construction.

We constructed 3,240 individual 5 g litter bags for the terrestrial potion of this project. Litterbags were placed in the field in November 2003 at 4 red alder sites, 4 unfertilized Douglas-fir sites, and 4 fertilized Douglas-fir sites (Table 2). We are fertilizing the Douglas-fir sites with nitrogen at a rate equivalent to nitrogen fixation by red alder (150 kg N ha^{-1} yr^{-1}). Litterbag collections began in December 2003, and will continue for a total of 10 collection intervals over 3 years. Laboratory measurements of litter mass loss, biochemical characteristics (lignin, C, N), and stable isotope composition ($\delta^{13}C$, $\delta^{15}N$) are being initiated. Overall, this information will allow us to determine how the source quality of the litter and the habitat conditions interact to contribute to rates of litter decay. Changes in the stable isotope composition of the litter over time will also be used to constrain the potential for tracing vegetation contributions through food webs at these sites.

The aquatic component of this research (Q8) is in development, and will use an approach similar to the studies described above. Enough litter was collected in Fall 2003 to construct litterbags for both the aquatic and terrestrial components of this work. This will allow us to directly compare results from aquatic *vs.* terrestrial riparian habitats. Streamwater nitrogen concentrations will be varied using GIS to select watersheds with differing coverage of red alder, which is known to result in 10-fold differences in nitrogen of Coast Range streams (Compton et al. 2003). Streamwater concentrations will be verified in the laboratory. Based on studies elsewhere, we expect much faster rates of litter breakdown in streams. Litterbags will be placed in Douglas-fir and red alder dominated stream reaches starting in Fall 2004, and collected over 2 years, to compare the effects of habitat type, external nitrogen supply, and internal leaf nitrogen concentrations on decay rates. Stable isotope changes will also be measured as a basis for food web studies.

Table 1 - Source sites and initial foliage nitrogen concentration (mean of n=5 per site) for Douglas-fir and Red-alder litter

Source of Litter	Plot ID / Owner	Litter type	Foliage %N
1	Steinberg Mountain (ODF)	Douglas-fir	0.85
2	Jensen (Starker)	Douglas-fir	1.13
3	7 (Hampton)	Douglas-fir	1.24
4	77 (Simpson)	Douglas-fir	1.31
5	58 (Georgia Pacific)	Douglas-fir	1.38
6	East Beaver # 4 (ODF)	Douglas-fir	1.58
7	Chopping Block (ODF)	Douglas-fir	1.61
8	Toledo fertilized (Plum Creek)	Douglas-fir	2.33
9	Alder 1 (Plum Creek)	Red alder	Unknown (~2.5)

Table 2 - Sites, habitat type, foliage stable isotope composition (n=5 per site), and nitrogen fertilization regime for terrestrial riparian studies					
Study Site	**CFER Site ID**	**Habitat type**	**Foliar $\delta^{15}N$ (‰)**	**Foliar $\delta^{13}C$ (‰)**	**N fertilization (kg / ha-yr)**
1	Record Creek	Red alder	-1.04	-29.01	n/a
2	Honey Grove	Red alder	-1.10	-27.29	n/a
3	Williams Creek	Red alder	--	--	n/a
4	Nelsen Creek	Red alder	-1.13	-27.93	n/a
5	S. Fork	Douglas-fir	-1.32	-27.25	150
6	S. Fork	Douglas-fir	-1.32	-27.25	control
7	Wolf Creek	Douglas-fir	-2.52	-26.64	150
8	Wolf Creek	Douglas-fir	-2.52	-26.64	control
9	Yew Creek	Douglas-fir	-2.88	-26.73	150
10	Yew Creek	Douglas-fir	-2.88	-26.73	control
11	Alsea	Douglas-fir	-1.73	-25.74	150
12	Alsea	Douglas-fir	-1.73	-25.74	control

Expected Completion: The project is progressing on schedule and we anticipate a highly conclusive and productive study. Overall, 3 years of field study are planned for the terrestrial components of this research, and 2 years of field study for the aquatic components. A detailed timeline for this study is provided below (Table 3).

Expected Reporting: We expect that Master's thesis preparation will begin in Fall 2006 after 2 years of field study, with a final project report to FRL-TAC scheduled for Spring 2006. However, the PI's plan to extend this study an additional year to address a significant gap in current knowledge concerning discrepancies in short- *versus* long-term rates of litter decay. This extension will require very modest sample collection and analysis effort on the part of the PI's, and will not affect our original commitment to the FRL reporting deadline. In addition to a final report presented to the FRL TAC committee, we expect that several peer-review publications will result from this project, aligned around Questions 1-8 presented under *Study Approach*.

Table 3 - Timeline	Year 1 – 2003/04				Year 2 - 2004/05				Year 3 - 2005/06			
	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp
Terrestrial Riparian Studies	■	■	■	■	■	■	■	■	■	■	■	■
Collect litter & prepare bags	■	■										
Initiate field experiment		■										
Fertilize plots and collect samples	■	■	■	■	■	■	■	■	■	■	■	■
Aquatic Riparian Studies	■	■	■	■	■	■	■	■	■	■	■	■
Collect litter & prepare bags	■	■		■	■							
GIS site selection			■	■								
Initiate field experiment						■						
Collect samples						■	■	■	■	■	■	■
Chemical and Isotopic analyses			■	■	■	■	■	■	■	■	■	■
Report and Thesis Preparation										■	■	■

Budget: FY04: $30,000 **FY05**: $35,000 **FY06**: $25,000

References Cited:

CFER. 2003. Cooperative Forest Ecosystem Research Annual Report, *in press*.

Compton, J.E., M.R. Church, S.T. Larned and W.E. Hogsett. *in press*. Nitrogen export from forested watersheds in the Oregon Coast Range: The role of N_2-fixing red alder. Ecosystems

Study 2: Managed Forests and Their Role in Maintaining Water Quality in a Multi-land Use River Basin

Principal Investigator: Stephen H. Schoenholtz, Associate Professor, Department of Forest Engineering, OSU

Collaborators: USDA ARS National Seed Forage Production Research Center (NSFPRC), USDA NRCS, US EPA, OSU Department of Fisheries and Wildlife, Oregon DEQ, Calapooia Watershed Council, Weyerhaeuser Company, and Willamette National Forest.

Relevance to program mission: The Calapooia River is a tributary of the Willamette River that flows 100 km from headwaters in the west-central Cascade Range to its confluence with the Willamette River near Albany. The headwaters of the Calapooia are forested and occur within the Willamette National Forest. The river then flows through land predominately occupied by industrial forestry landowners, which is subjected to intensive, contemporary forest management designed to provide a long-term source of wood while sustaining soil and water resources and long-term productivity. As the river flows into the Willamette Valley, land use changes from forest management to agriculture, with a primary emphasis on grass seed farming.

Winter steelhead (*Salmo gairdneri*) and cutthroat trout (*Salmo clarki*) occur in the Calapooia River. However, the river is 303(d)-listed for impaired water quality because of dissolved oxygen, temperature, and fecal coliform levels that do not comply with federal and state water quality standards. Furthermore, the Oregon Department of Environmental Quality has identified high concentrations of nitrate-N and ammonium-N as concerns in the Calapooia Basin. The success of eliminating impairment of water quality for rivers such as the Calapooia depends on availability of scientific information specific for the river, including data on water quality in relation to land use within the watershed, and the role of the riparian zone which functions as the interface between terrestrial processes and aquatic properties and processes. The multiple land use types within the Calapooia Watershed offer an outstanding opportunity to evaluate the role of contemporary forest management regarding water quality in relation to other types of land management within the river basin.

Although investigations of riparian function in relation to nitrogen and phosphorus dynamics have occurred and are ongoing within the Willamette Valley, research to date in the Calapooia watershed has focused exclusively within an agricultural setting. Thus, there is a lack of information that integrates the relative role of different land uses within this multi-landuse basin, where contemporary forest management plays a significant role. This project is assessing water quality in both agricultural and forestry settings in order to help promote basin-wide natural resource management aimed to improve water quality and aquatic habitat in the Calapooia River.

Objectives:

- Evaluate the relative contribution of current forest management practices to water quality, with an emphasis on dissolved nitrogen (DN) and temperature, in the Calapooia River.
- Investigate relationships between land use and river water quality throughout the watershed.
- Contribute to development of integrated river basin management that will improve habitat for aquatic species, particularly winter steelhead and cutthroat trout.
- Collaborate with ongoing investigations within the watershed.

Approach:

Dissolved Nitrogen

The above objectives will be achieved by assessing dissolved nitrogen and water temperature along the length of the river in relation to adjacent land use and riparian conditions. River water and stream water samples collected at monthly intervals will be analyzed for dissolved total N, dissolved organic N (DON), nitrate-N, and ammonium-N in the USDA-ARS NSFPRC laboratory on the Oregon State University campus. The USDA-ARS has agreed to provide laboratory analyses as in-kind support for this project.

A total of 90 sites have been selected for synoptic water quality sampling. These sites are visited at a minimum of once per month beginning in Oct 2003. During the months of December to March, sites will be visited once every two weeks. These sites are distributed throughout the entire watershed, encompassing all of the major land uses. The watershed has been divided into three major portions (Figure 1): (1) the upper which is predominantly forested, (2) the middle which is forested on the hillslopes and has substantial components of mixed agriculture on the valley bottoms, and (3) the lower portion which is predominantly grass seed farming. Each of these portions has an equal number of sample sites. Forty four of the sample locations are in small sub-basins, between 3 and 20 km^2. These will provide a population for statistical evaluation of relationships between landuse and DN in the surface water of the overall Calapooia Watershed. Remaining sampling locations are located along the major tributaries of the Calapooia River, and are considered large sub-basins, generally >40 km^2. Samples from medium-sized sub-basins, between 20 and 40 km^2, and along the entire longitudinal profile of the Calapooia River will also be collected. Water sampling locations along the Calapooia River and in the medium and large sub-basins will provide a greater understanding of the impact that DN is having on water quality within the entire watershed.

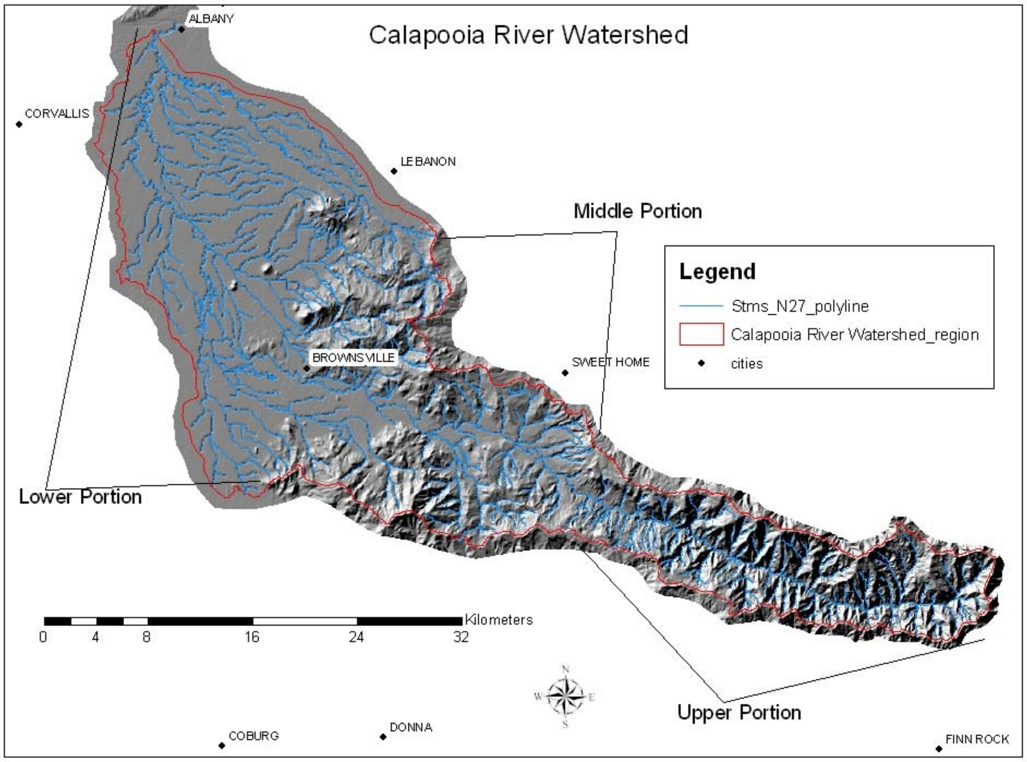


Figure 1. The Calapooia River watershed has three distinct portions, each containing different proportions of landuse and landcover. Managed forests are found predominantly in the upper portion, mixed agriculture and forestry are found in the middle portion, and the lower portion is predominantly grass seed farms.

Relationships between landuse and water quality will be developed using results from the field samples and a Landuse/Landcover (LULC) GIS database developed from satellite imagery of the Willamette Valley. An updated version of this database will be available in February of 2004. These data will be based on 2000 satellite imagery, thus field verification will be required. Field verification will be completed in the summer of 2004 to ensure that the LULC satellite imagery data reflects current land management.

Multiple scales of analysis will be an important component of the analysis in this project. When developing relationships between LULC and DN in surface waters of the Calapooia Watershed, multiple scales of analysis will be completed in the 44 small sub-basins. A GIS program will be used to create buffers at multiple lateral and longitudinal scales around the stream networks in the 44 small sub-basins. LULC data will then be clipped based on the scale of analysis, and proportion of each LULC class will be regressed against DN concentrations. This process will identify particular scales that provide the strongest relationships between a particular landuse and DN, thereby providing resource managers with water quality data relevant to land management strategies. For example, if it is found that agriculture has the strongest relationship with nitrate-N concentrations within 300 m of streams, then application rate of nitrogen fertilizers within this area could be adjusted accordingly.

These data will also provide a context of how managed forests impact DN concentrations in the Calapooia Watershed. This will be accomplished by utilizing the data from all of the 90 sampling locations.

<u>Stream Temperature</u>

The objective relating to stream water temperature will be met by installing a series of stream temperature probes at various locations throughout the Calapooia Watershed. A subset of the 90 sampling locations will be selected for installation of temperature probes. Placement of probes will occur along the longitudinal profile of the Calapooia River, as well as in the small, medium and large sub-basin sample sites used for synoptic sampling of DN. Installation of probes will commence in early April 2004 and they will be removed in November 2004. Probes will be reinstalled for the following year as well.

Project Results to Date: Detailed planning for this project began in June of 2003, upon the arrival of Bill Floyd, a new graduate student in the Department of Forest Engineering. Much of the summer 2003 was dedicated to a literature review and collection of multiple sources of GIS data for the Calapooia River. A rough draft of the subsequent study plan based on GIS data was completed by the end of August 2003. Upon completion of field visits in September 2003, 90 sampling locations were selected from a potential of 110. Initial sample collection occurred in October 2003.

As of January 31, 2004, four full synoptic sampling runs have occurred and laboratory analyses are available for the first three months. Concentration of DN in surface waters was low throughout the Calapooia Watershed in October and November (Figure 2). Furthermore, most of the streams in the lower portion of the watershed flowing through the grass seed fields were dry during the fall months. Results from the sample run in December show a sharp increase in DN concentration in the Calapooia watershed, especially in the lower portion (Figure 3). At this time of year all streams are flowing and discharge rates tend to be high.

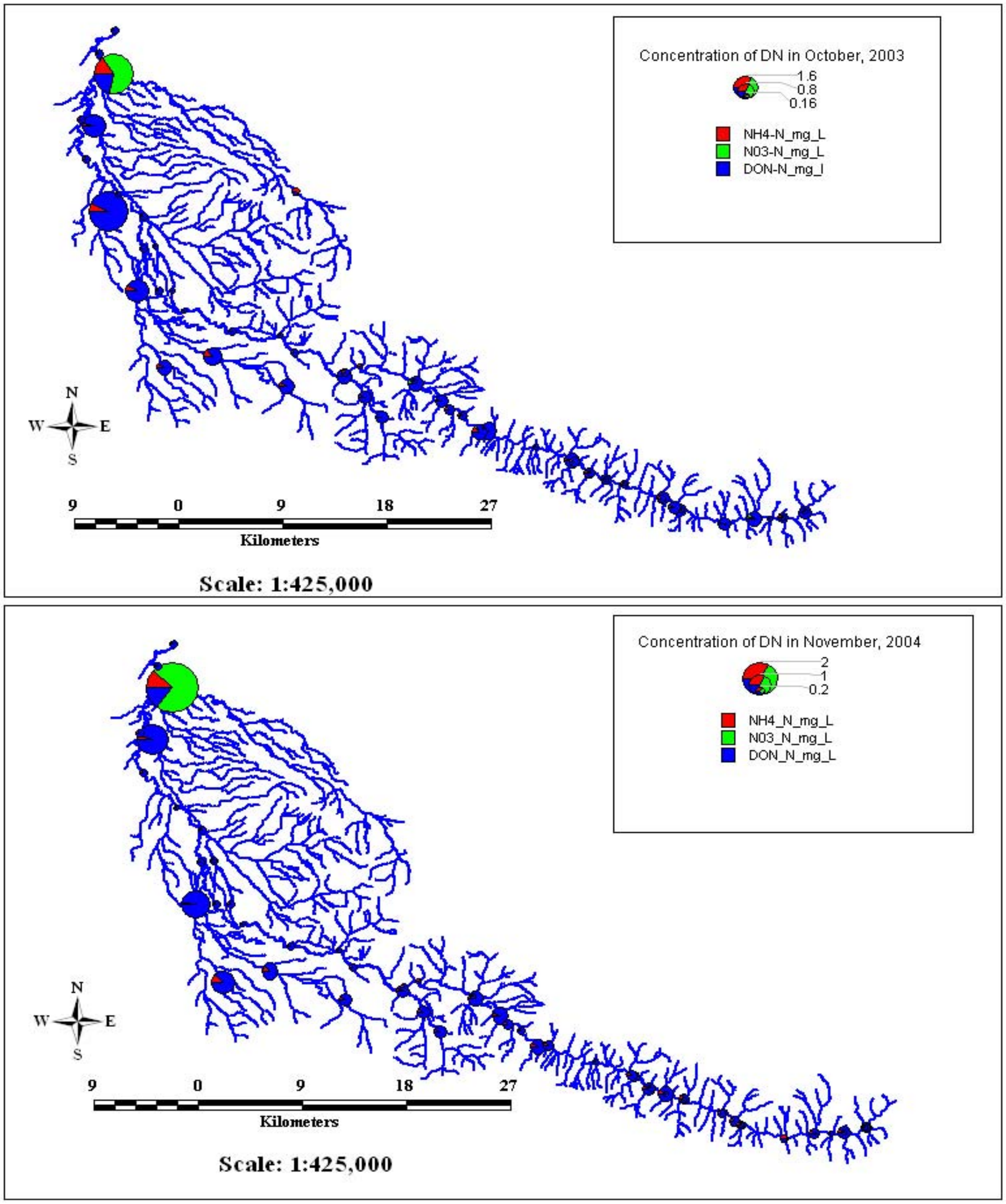


Figure 2. Dissolved nitrogen concentrations from October and November 2003 synoptic sampling of the Calapooia River Watershed. Pie graphs are missing in the lower portion of the watershed because many tributaries were dry during this sampling period.

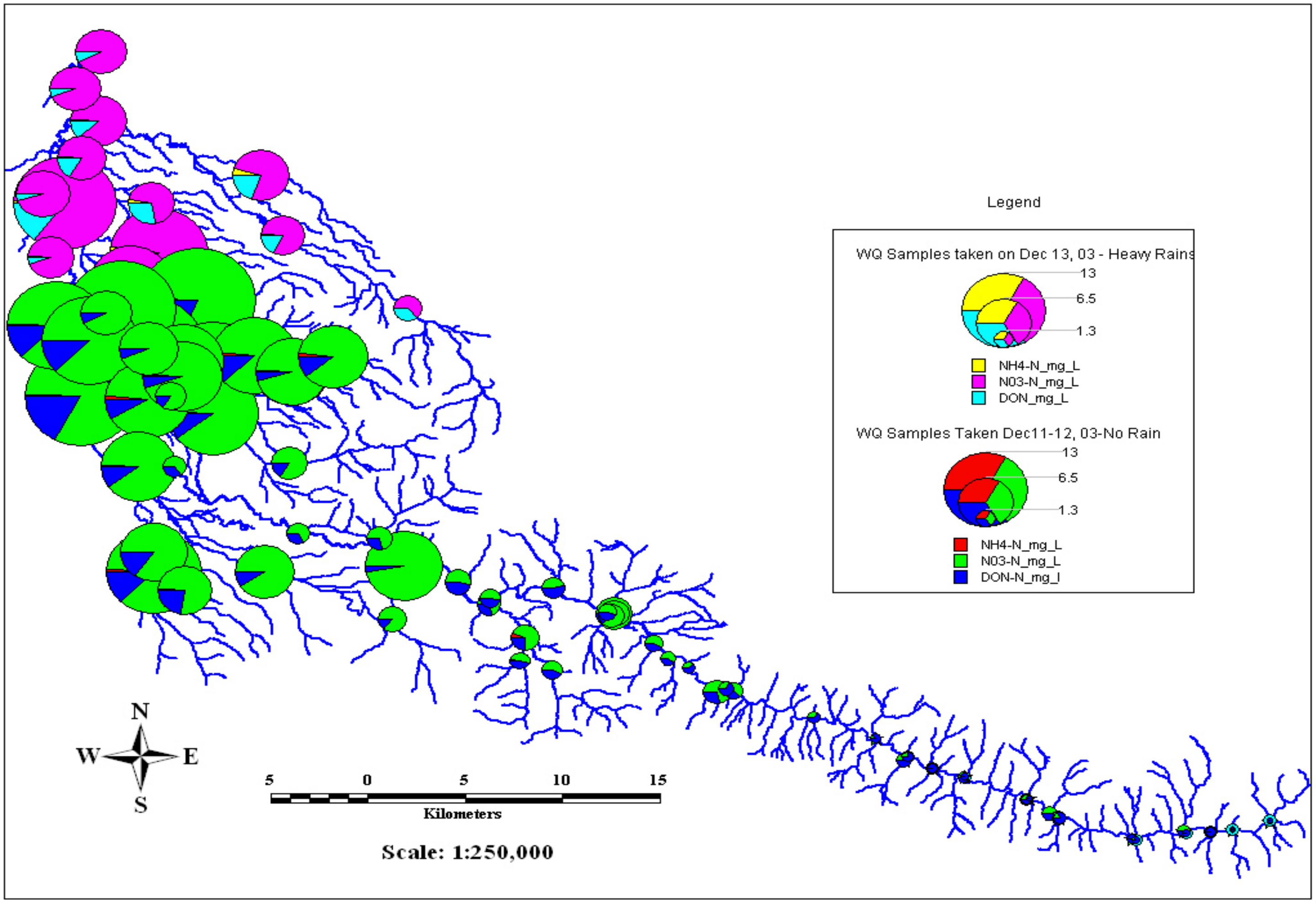


Figure 3. Dissolved nitrogen concentrations from synoptic sampling in the Calapooia Watershed in December 2003. December 11 and 12 samples were taken during a period of very little rainfall. December 13 samples were taken during a very intense rainstorm. High dissolved nitrogen concentrations are almost entirely found in streams located in sub-basins dominated by agriculture.

Future Plans: Synoptic sampling is planned for the remainder of the water year, twice per month until March, and then once per month until September 2004.
An issue has been identified in relation to the quality of the stream GIS dataset we are using. It is unclear as to the source of the data and it appears as though many of the streams are not geographically accurate. This has the potential to create difficulty when developing relationships between LULC at multiple scales, especially at the scale closest to the stream network. If the stream network is incorrect by 15 to 30 m, LULC classes may be misrepresented at a particular scale. In order to create a reliable stream dataset, streams will need to be digitized by hand from airphotos. This will be accomplished this spring and summer. Field verification of LULC data will also occur over the summer of 2004. Upon completion of this, the process of dividing each sub-basin into multiple scales will commence.

Timeline: Winter/Spring/Summer/Fall 2004 – continue water sampling, conduct laboratory analyses, initiate data analysis; Winter/Spring/Summer/Fall 2005 – complete sampling, lab and data analyses; Winter/Spring/Summer/Fall 2006 – finish thesis/dissertation, submit final report, write manuscripts based on thesis/dissertation results.

Budget:	FY 2003-04	FY2004-05	FY2005-06
	$40,000	$43,000	$46,000

Study 3: Habitat Conservation for Stream Amphibians in a Managed Forest Landscape

Principal Investigators: Michael J. Adams, USGS FRESC and John P. Hayes, Department of Forest Science, OSU

Relevance of topic to program mission: Although numerous studies have suggested negative effects of timber harvest on headwater stream amphibians in the Pacific Northwest, other studies show that stream amphibians remain common in many second- and third-growth forests. This apparent discrepancy may be a matter of scale and regional differences in timber harvest effects. We propose to investigate how forest management interacts with landform, surface geology, and other regional characteristics to influence distribution and abundance of stream amphibians in a multi-age forest landscape. This study will include participation in the Hinkle Creek paired watershed study where amphibians will be monitored before and after timber harvest on control and treatment plots. The proposed work will be an important step toward understanding the physical, biological, and management factors influencing distribution and abundance of stream amphibians in western Oregon. The work will build on previous work on amphibians in the Oregon Coast Range funded by the FRL Fish & Wildlife Habitat in Managed Forests Research Program.

Objectives:

1. To assess influences of forest management practices in the Hinkle Creek drainage on abundance and distribution of stream amphibians.
2. To test the efficacy of existing habitat association models for stream amphibians in the Oregon Cascades.
3. To develop forest management recommendations for stream amphibians.

Overview of approach and methods: The Hinkle Creek study will assess the effects of riparian tree retention on headwater streams. It will provide an unprecedented opportunity to examine within basin variability of stream conditions and stream organisms. Amphibians are not currently being examined in the Hinkle Creek study, but it would be highly desirable to add them to the study because of the important role they play in stream ecosystems and their indicator status. We will use data from Hinkle Creek to assess spatial and temporal variation in the distribution and abundance of stream amphibians, and the influences of forest management activities on stream amphibians. We will expand these results by also surveying stream amphibians throughout the Oregon Cascades to determine the ability of existing models to predict amphibian density.

The following methodological approach will be used:

1. Monitor stream amphibians in North and South Forks of Hinkle Creek from 2004-2006. Six stands will be harvested in the South Fork in 2005 and we will analyze how stream amphibians respond spatially and numerically to the change in the forest mosaic.
2. Sample managed forests in Oregon Cascades (non-wilderness FS lands, state lands, timber company lands). We will randomly chose stream reaches and relate stream amphibian density to landform, surface geology, substrate, and forest characteristics. Habitat associations of stream amphibians in the Oregon Cascades have not been previously studied.
3. Compare and synthesize models that predict stream amphibian density; produce region-specific recommendations for habitat conservation in managed forests. Increasing

evidence suggests that the sensitivity of stream amphibians to timber harvest varies greatly among and even within regions. We will use a GIS to produce adaptive management recommendations.

Progress: An initial survey of the Hinkle Creek drainage was conduct in August of 2003 with support from USGS FRESC. The survey helped to determine the stream amphibian species present and the structure and layout of the Hinkle Creek basin. The Hinkle Creek drainage falls between of the ranges of the Cascade and the southern torrent salamanders (*Rhyacotriton cascadae* and *Rhyacotriton variegatus*), and no torrent salamanders were detected during the amphibian surveys. The Pacific giant salamander (*Dicamptodon tenebrosus*) was abundant in many of the stream segments surveyed and appears to be relatively widespread in the Hinkle Creek drainage. Tailed frog (*Ascaphus truei*) adults and tadpoles were not found in any of the stream surveys. In 2002, the fish survey crews have a record of a tailed frog observed in a 50 ft section of stream, but our hand survey in the same area failed to detect any tailed frogs. Additionally one Dunn's salamander (*Plethodon dunni*), one rough-skinned newt (*Taricha granulosa*), and a few red-legged frogs (*Rana aurora*) were observed outside of transects. In the Hinkle Creek drainage, the stream amphibian research will likely focus on the Pacific giant salamander, due to the absence or rarity of other stream amphibians species.

In the fall of 2003, Niels Leuthold was brought on as a PhD student at Oregon State University. Niels is now nearing completion of a literature review of the effects of timber management on stream amphibians in the Pacific Northwest and, in January, began work on a detailed study plan to meet the goals of the research proposal. The stream amphibian research is in the early stages and we expect to conduct extensive fieldwork from 2004-06.

We have attended several meetings relating to the Hinkle Creek research project. At meetings on July 24th and December 4th, Mike Adams presented overviews of the stream amphibian project.

Timeline: Field work would begin in Fall 2003, and continue during spring and fall 2004, 2005, and spring 2006. Data analysis and reporting will take place in 2006 and 2007, with final publications published in 2008.

Budget:
FY04: $39600 FY05: $41600 FY06: $43700 FY07: $45800 FY08: $6000

CONTINUING RESEARCH PROJECTS

Study 4: Influence of Silvicultural Treatments and Manipulation of Downed Wood on Abundance and Demographics of Small Mammals (1999 - 12/2002) (Extension requested to 12/2003)

Principal Investigator: John P. Hayes, Department of Forest Science

Relevance of topic to program mission: Understanding the influences of a diversity of silvicultural approaches on wildlife and use of habitat components by wildlife in forests is central to the program's mission. This research will fill some of the gaps in our understanding of the influences of alternative silvicultural practices, green tree retention, and addition of dead wood to forest stands on wildlife.

Background: Interactions between components of stand structure and the abundance, survival, and reproductive success of wildlife can be complex. Although we have developed a more clear understanding of relationships between some aspects of stand structure and abundance of some species of wildlife, our understanding of the relationships between many structural elements and wildlife abundance is poorly developed, and information concerning the influence of stand structure on survival and reproductive success is almost totally lacking for most species of wildlife. Ecological theory regarding demographic responses of wildlife to silvicultural manipulations suggests a paradox: population abundance is not always an adequate index to habitat quality. Areas may function as "population sinks" or "ecological traps" that provide adequate habitat to attract animals to colonize a site, but do not provide adequate resources to promote self-sustaining populations. Understanding the influences of silvicultural activities on demographic parameters such as survival and reproduction is critical to fully understanding the ramifications of various management strategies on wildlife.

Wildlife ecologists generally agree that fallen dead wood is a key habitat component for many species of wildlife. However, our understanding of the quantitative relationships between fallen dead wood and wildlife is extremely poor. Moreover, most of the existing information is based on observational, correlative studies that lack predictive power. As a result, it is not possible to fully evaluate the ecological costs and benefits of different management strategies.

Objectives: This project has 3 specific objectives: 1) To determine the influence of selected silvicultural activities on the abundance and demographics of small mammals, 2) To determine the response of small mammals to the addition of downed wood in different stand conditions, and 3) To examine the importance of downed wood in path selection by Townsend’s chipmunks.

Overview of approach and methods: This study is taking place on the McDonald-Dunn Research Forest in uncut stands and stands harvested between 1989 and 1991. The study is being conducted in three geographic blocks in the Research Forest. In each block, we selected two control stands, two clearcut stands, two patch-cut stands, and two two-story stands for study, for a total of eight stands per block and twenty-four stands in total. Twenty-one of the stands were randomly selected from blocks in the College of Forestry Integrated Research Project (CFIRP) stands, and three additional stands were selected in the nearby area. The three silvicultural treatments were applied to the CFIRP stands between 1989 and 1991. Clearcuts retained 0.5 green trees/acre; patch-cuts removed one-third of the volume in the stand by creating a series of 1/2-acre circular patches; two-story stands uniformly removed three-quarters of the volume throughout the stand; and control stands did not receive any treatment. Prior to treatment, stands were 90 to 130 years old. One stand of each silvicultural treatment within each block was randomly selected to receive additions of downed wood.

We established an 8 x 10 trapping grid (0.63 ha) with 10-m spacing between grid points in each stand. A buffer of at least 35 m (generally >50 m) was maintained between the outer set of traps and the edge of the stand. One large, collapsible Sherman live-trap is placed within 1 m of each grid point; starting April 2000, one tomahawk trap will be placed at every other station (20 tomahawk traps per grid). Small mammal populations will be sampled for 5 nights during the spring (April and May), summer (July and August), and fall (October and November) during the study. During each trap session, traps are baited with peanut butter and a commercial mixture of rolled barley, rolled corn, rolled oats, and cane molasses. Traps are covered with milk containers for insulation and protection from the rain. Traps are checked once a day for 5 days. Each small mammal captured will be identified to species, sex, and reproductive condition, weighed, tagged with a uniquely numbered metal ear tag, and released at the site of capture.

To evaluate the importance of downed wood to path selection by Townsend's chipmunks, we attached spools of lightweight thread to the tails of chipmunks in 6 patch cut stands in summer and fall 2001. Trails were identified and data collected on the use of downed wood every 2 m along the trail.

Progress: This research was initiated in 1999. As of January 2004, we have completed 11 trap sessions (summer and fall 1999, spring, summer, and fall 2000, 2001, 2002). During March and April, 2001, we added a total of 1,474 cf of logs to three clearcuts (11 logs were helicoptered into each stand). A similar volume of wood in the form of whole trees was added to three patch cuts (5 trees were felled in each stand).

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

For the silvicultural treatment objective, we completed 5 seasons of trapping (1999 and 2000). In 55,200 trap nights, 6,690 individuals of 18 species of mammals were captured 20,169 times. There are species-specific responses to silviculture treatments with some species being more abundant in control and patch cuts (e.g., northern flying squirrels [Figure 1]) and others generally being more abundant in two-story and clearcut stands (e.g., deer mice [Figure 2]). Townsend's chipmunks had high abundances in clearcut, two-story, and patch cut stands (Figure 3). Patch cut stands offer diverse habitat conditions in a relatively small area and serve as habitat for species that need an overstory canopy and or species that respond to open habitat conditions.

For the downed wood objective, we have completed 11 seasons of trapping (1999, 2000, 2001, and 2002, trapping completed). In 63,600 trap nights, we captured 22 species of small mammals a total of 25,361 times. At this point in the analysis, no differences in the abundance of any small mammals are apparent as a result of the wood treatment (Figures 4 and 5).

We attached spools of thread to 41 Townsend's chipmunks in summer and fall 2001. 5,093 m (mean = 124 m per chipmunk). On average, 17% of a trail was arboreal (in shrubs and trees). Of the remaining trail, 49% was associated with dead wood. All but one chipmunk used wood more than it was available (Figure 6) and use decreased with increasing wood availability. At average wood densities (26%), the relative odds of a wood point being on a path were 2.5 to 3.5 times higher than on random points. A decrease of 10% of wood in the environment results in an increase in the relative odds of use between 6 and 36%. No differences were observed between the sexes and the seasons.

We caution that the summaries of the capture data presented above are preliminary and that large seasonal and annual cycles in populations of small mammals must be accounted for when interpreting capture data (Figures 1 to 5).

Timeline: Data management and analysis will continue for all 3 objectives in 2004. We anticipate completion of the analysis and a doctoral dissertation on this study by May 2004.

Budget: No additional funds are requested for this study.

This research is partially funded by the Cooperative Forest Ecosystem Research program.

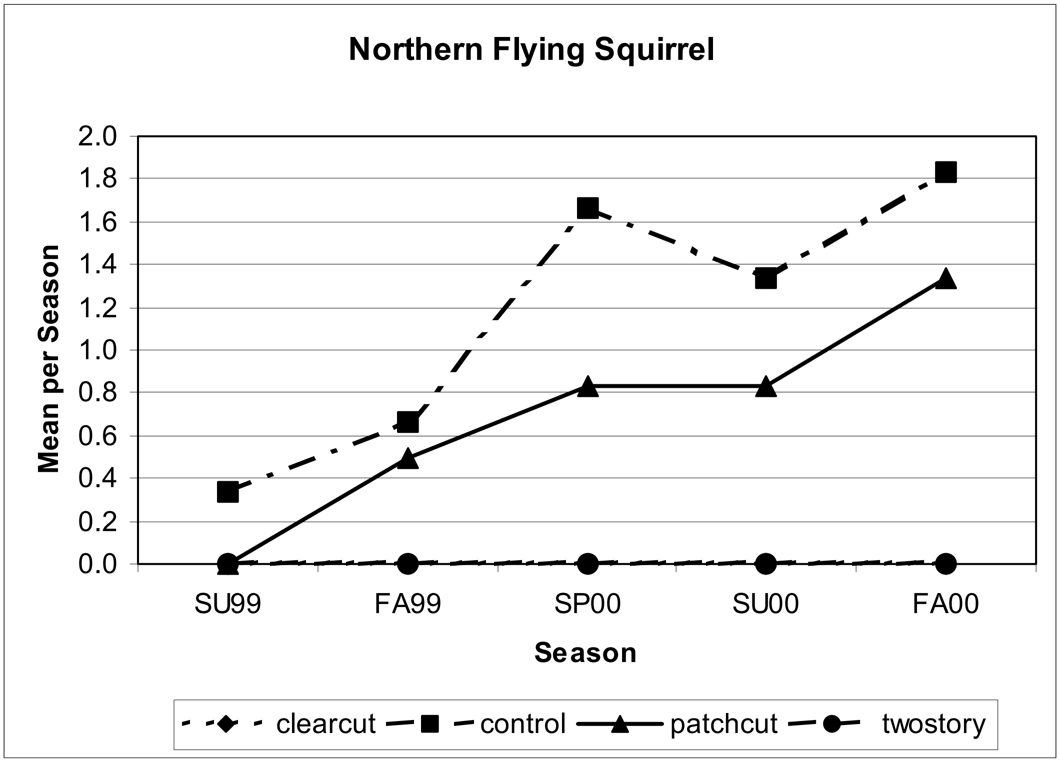


Figure 1. Mean captures of northern flying squirrels by season in stands differing in silvicultural treatments.

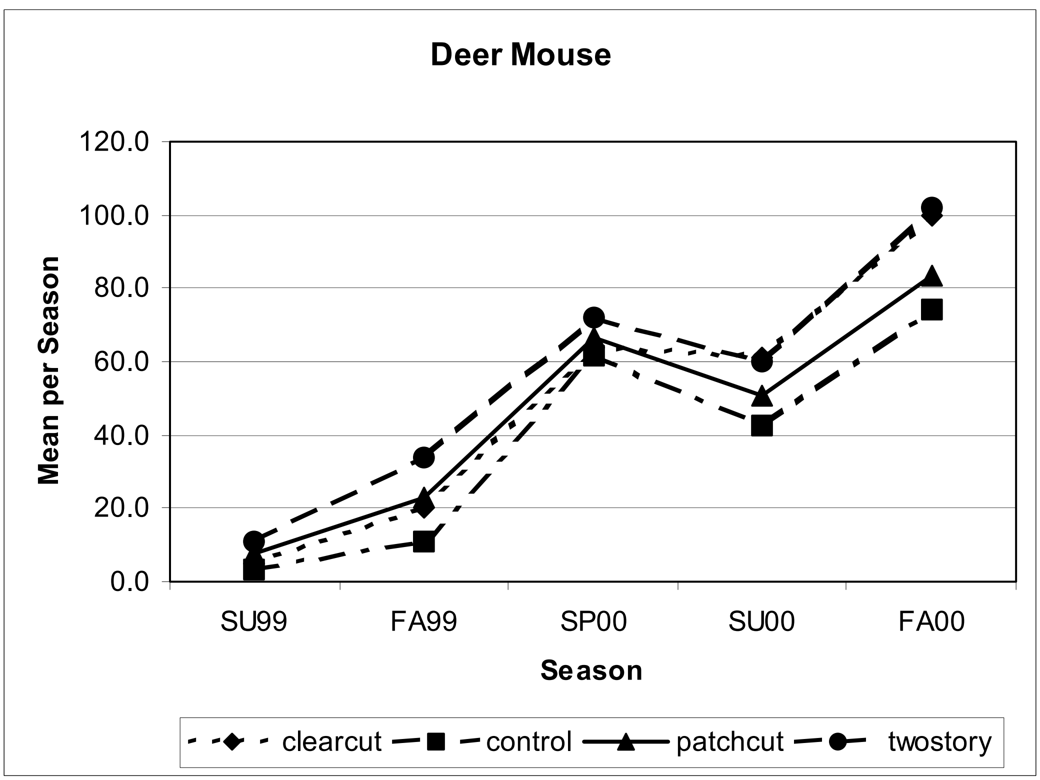


Figure 2. Mean captures of deer mice by season in stands differing in silvicultural treatments.

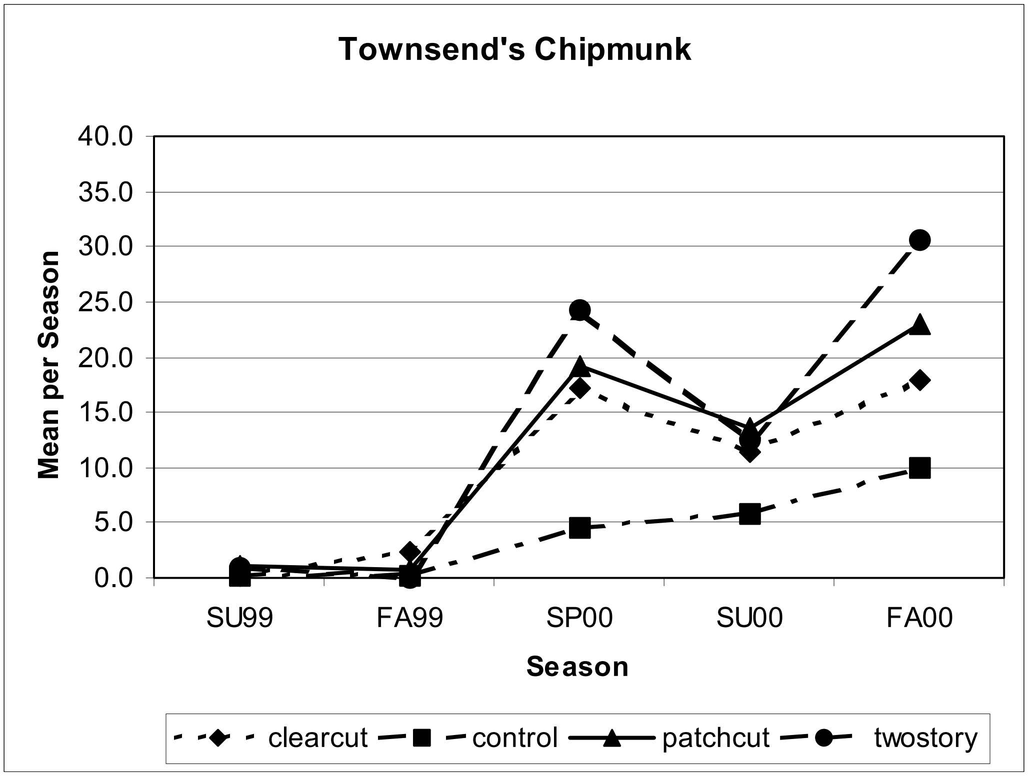


Figure 3. Mean captures of Townsend's chipmunk by in stands differing in silvicultural treatments.

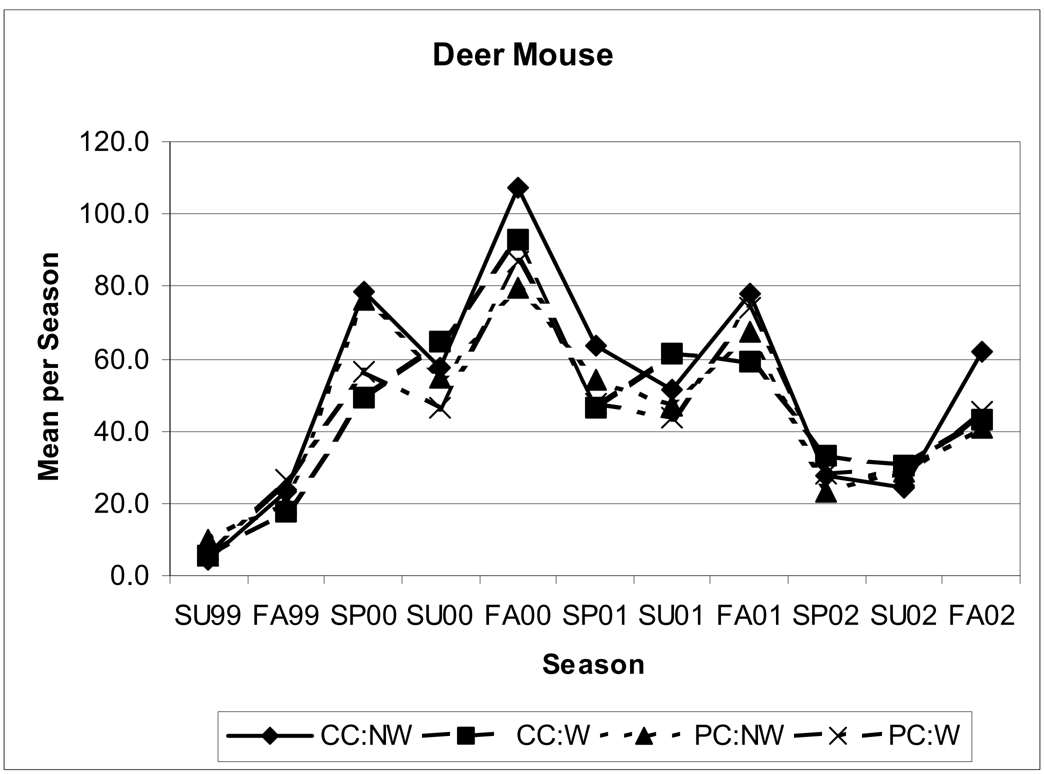


Figure 4. Mean captures of deer mice by season for the wood objective. CC:NW = clearcut with no wood added, CC:W = clearcut with wood added, PC:NW = patch cut with no wood added, PC:W = patch cut with wood added.

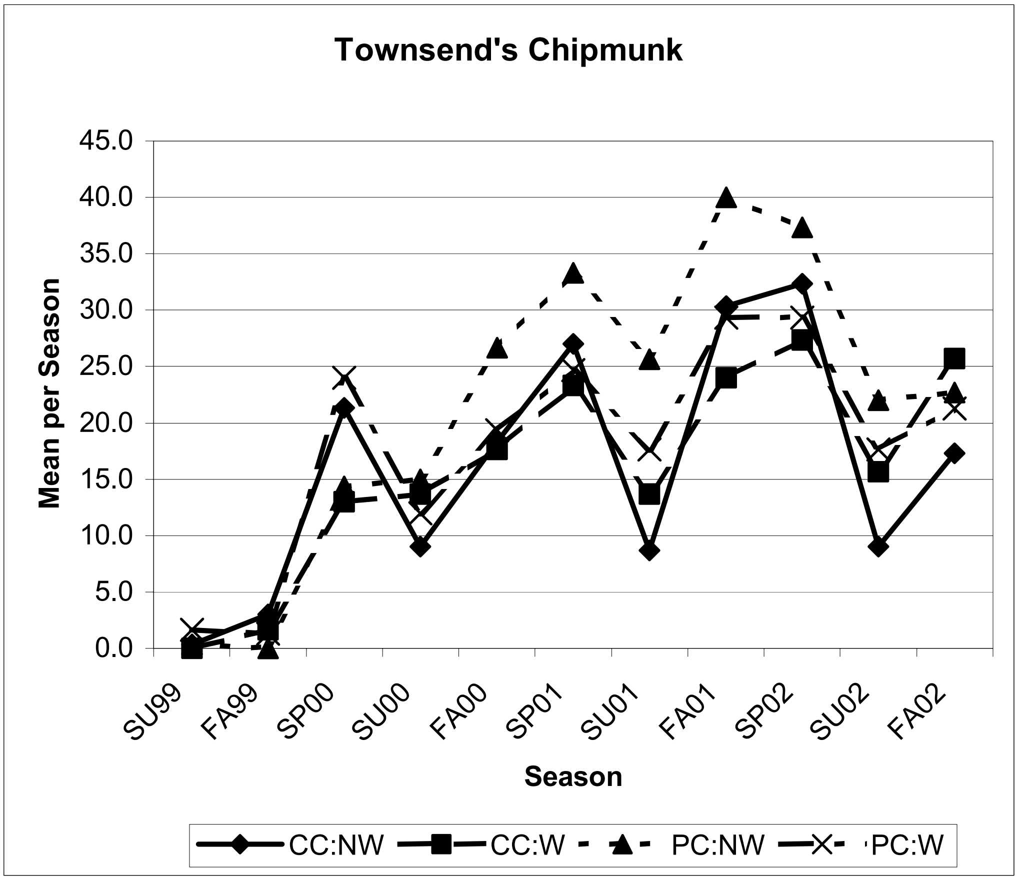


Figure 5. Mean captures of Townsend's chipmunks by season for the wood objective. CC:NW = clearcut with no wood added, CC:W = clearcut with wood added, PC:NW = patch cut with no wood added, PC:W = patch cut with wood added.

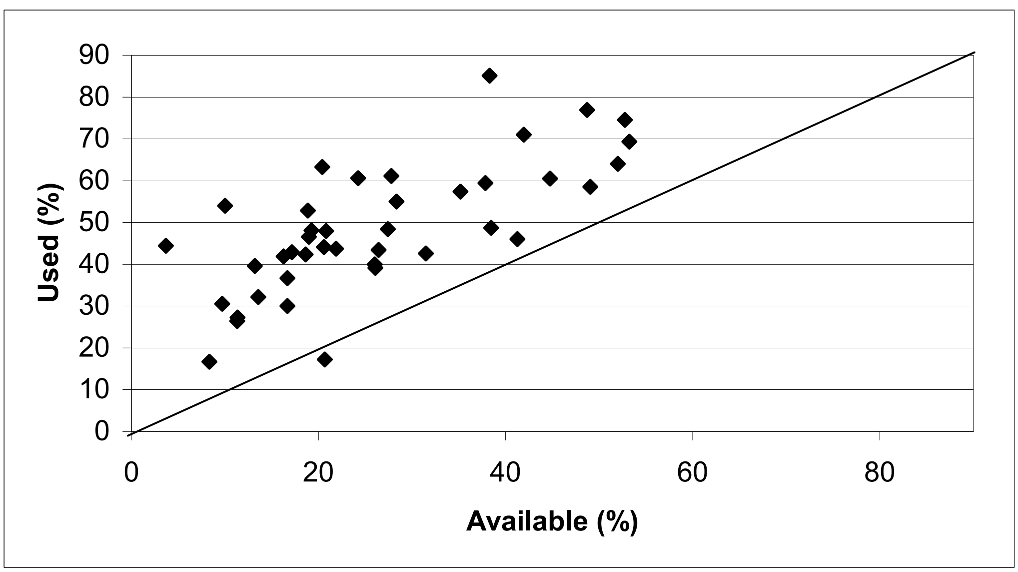


Figure 6. Figure 1. Plot of use versus available downed wood by 41 Townsend's chipmunks in western Oregon, 2001. The solid line represents use of downed wood in proportion to its availability.

Study 5: The Role of Perennial, Non-Fish-Bearing Streams in the Temperature and Flow Regimes of Small, Fish-Bearing Headwater Streams During Summer in Western Oregon (2001 - 2004)

Principal Investigators: Arne Skaugset, Associate Professor and Hans Gauger, Graduate Research Assistant, Department of Forest Engineering, OSU

Problem Statement: Traditional research on timber harvesting and stream temperature has focused on how the removal of stream-adjacent, shade-bearing trees affects the temperature of perennial, fish-bearing streams during summer low flows. Contemporary forest practice rules that prescribe the width and composition of buffer strips adjacent to streams that will, among other objectives, mitigate the effect of the removal of streamside vegetation are a result of this research. In contrast to this traditional research on stream temperature, this project proposes to investigate how timber harvesting on hillslopes adjacent to small, fish-bearing streams, as opposed to within riparian areas, may affect stream temperature. As a part of the Forest Practice Advisory Committee (FPAC) process, a subset of the small, perennial, non-fish-bearing streams (type N streams) have been identified as potentially temperature sensitive. These streams are called type NT streams and they are identified as small, perennial, non-fish-bearing streams whose discharge makes up more than 30 percent of the discharge in the receiving small, fish-bearing stream (small type F).

It is hypothesized that timber harvesting adjacent to unbuffered, type NT streams can result in temperatures that are unacceptable in small, type F streams even though the small, fish bearing stream itself is adequately buffered. In this case, the process governing temperature increases in the buffered small, type F stream is increased temperatures in the unbuffered, type NT streams that, when mixed with water in the small, type F stream, cause stream temperatures that are unacceptable.

The data on this subject in the literature is virtually non-existent. The purpose of this project is two fold. First of all, the temperature regimes of small, type F streams, harvested type NT streams, and fully shaded type N or NT streams will be determined. Secondly, the low flow hydrology of these headwater streams and the shade present for the small, type F streams will be quantified to allow insight into processes.

Objectives:

1. To characterize the thermal regimes and low flow hydrology of small, non-fish bearing perennial streams draining both recently harvested and shaded headwater streams.
2. To investigate the processes that influence the temperature of small, perennial fish bearing streams during summer low flows, namely the effects of shade and low flow hydrology.

Research Approach: The research approach is to investigate the temperature, streamflow, and shade for 10 small, type F streams throughout western Oregon. Each study stream has a recently harvested type NT stream draining into it and that recently harvested type NT stream is paired with a fully shaded type N stream. Four kinds of data were collected. First of all, synoptic studies were undertaken to get high-resolution stream temperature and discharge profiles for each of the small, type F streams during the summer. During these synoptic studies, stream temperature was determined using Vemco temperature loggers and discharge was determined using a steady state tracer injection method. A tracer was injected at the head of the small, type F stream and the concentration of the tracer in the stream was determined simultaneously with stream temperature. The dilution of the tracer downstream is a function of increasing discharge. Secondly, pulse injection tracer tests were used to estimate stream hydraulic properties such as velocity. Thirdly, meteorological parameters were measured using two portable weather stations. One of these stations was set up in the harvest unit. The other station was set up 500 feet downstream from the boundary of the harvest unit. Finally, stream shade and wetted width was determined to account for incoming solar radiation.

Research Accomplishments: During the summer of 2003, six study sites were intensively sampled. These study sites consisted of five new study sites, and one of the study sites from the summers of 2001 and 2002. Jeremy Appt, a faculty research assistant in the Forest Engineering Department and Hans Gauger carried out the summer fieldwork for the third year of this project. This project nom makes up Hans' master project. Tim Royer, a graduate research assistant assisted in field work at the end of the summer.

In addition to the new study sites, some changes were made in the methods. During the summer of 2003, pulse tracer injection tests were used to estimate the variability in water velocity. We had hypothesized pulse injection could supplant steady state injection for discharge estimation. This method proved to lack the accuracy of the steady state method. We chose one site to revisit, in order to perform a steady state injection test to obtain the discharge profile.

During the summer of 2003, we collected temperature and meteorological data for approximately one week at each site. Pulse injection tests often required several days of field work for each study reach. Two sites that had been scouted during the spring proved to have access incompatible with the methods and hardware employed by this project.

Case Study Site: Tribulation

Analysis of data collected during the summer of 2003 has begun on one of the sites, dubbed "Tribulation." The following highlights the temperature regime of this site.

Using steady state tracer dilution, we obtained a discharge profile of the stream. Discharge of the stream increased downstream from 2.7 at the boundary of the clearcut to 4.8 L/s 1000 feet downstream.

Daily stream temperatures at the downstream boundary of the clearcut ranged from a maximum of 19˚ C to a minimum of 14.5˚ C. At a distance 1,000 feet downstream from the boundary of the clearcut, daily stream temperatures varied only slightly between a maximum of 16.5˚ C and minimum of 15.5˚ C.

The water velocity estimates from both pulse and steady state tracer dilution tests indicated that water could travel the length of the study reach in approximately 2.5 hours.

An interesting feature of this site is the cooling that takes place within the first 500 feet of the clearcut boundary. The discharge profile does not show significant groundwater influx through this section of the reach, so the cooling most likely will not be explained entirely by advection.

Figure 1. Instantaneous Temperature Profiles for Tribulation Site

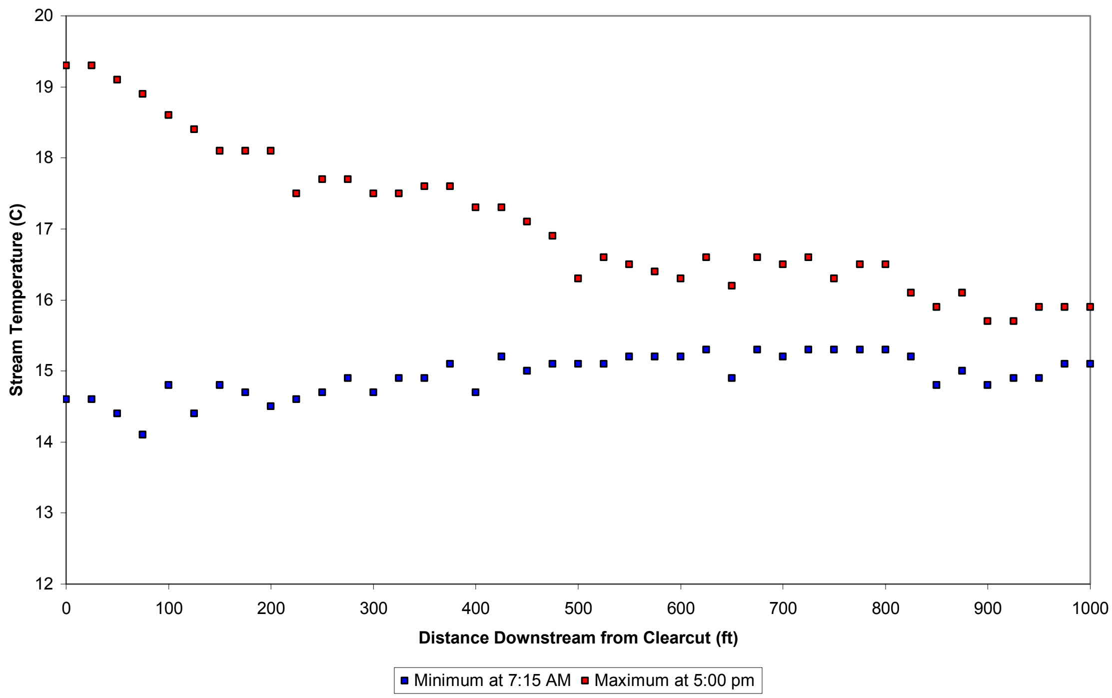


Figure 2. Discharge Profile for Tribulation Site

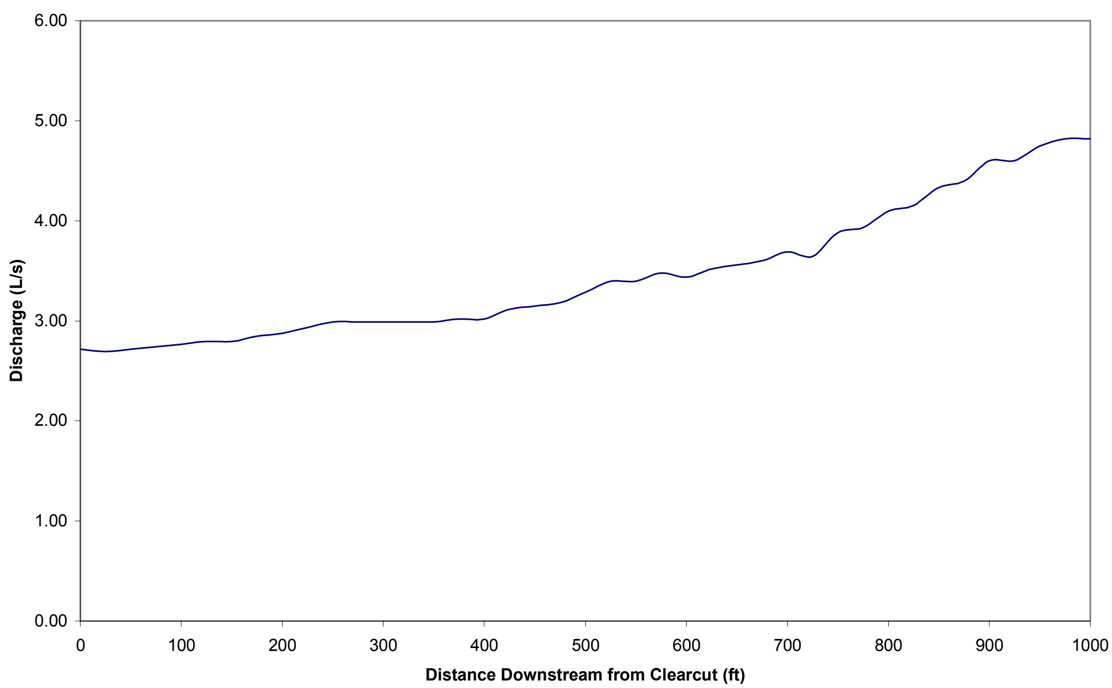
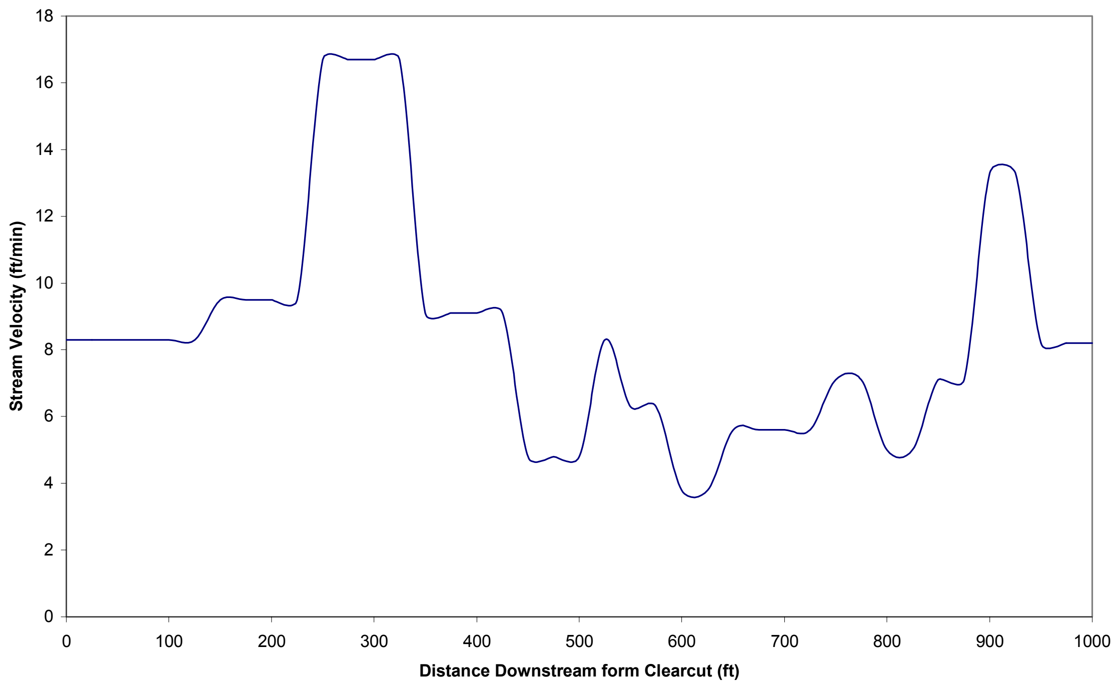


Figure 3. Velocity Profile for Tribulation



Conceptual Model

The data that has been collected to date allows for the development of a conceptual model regarding how we think temperature is propagated downstream. Again, a review of our data and the literature indicate that maximum daily stream temperature may increase, decrease, or stay about the same in any given stream. Here are partial explanations and the development of the conceptual model to help explain these behaviors.

Decrease in Temperature

Streams that are described as cooling or that have a demonstrably lower maximum daily stream temperature 1,000 feet below the harvest unit compared to the temperature at the base of the harvest unit are often also associated with very slow longitudinal stream velocities. The very slow longitudinal stream velocities are also associated with landslide-prone terrain and the presence of remnant debris flow deposits. In this case there are two mechanisms that could explain the cooling in these stream reaches. First of all, the velocities are sufficiently slow that the heated water from the clearcut will spend at least one night in a cooling cycle before it makes it to downstream sensors. Thus, all of the energy associated with heating in the harvest unit is lost and on subsequent days that water will not heat up as much because it is in a shaded environment. Thus one reason for cooling is not so much that the water cools down, but rather on subsequent days it doesn't heat up as much.

A second reason may directly have to do with a cooling mechanism. When the stream water goes through a debris flow deposit, it physically cools down. Our data and data from the literature show that stream water at the base of a debris flow deposit is 3 to 5°C cooler than the water flowing into the deposit. This forced hyporheic exchange is a direct cooling mechanism for the stream. Warmer water flows through and around much cooler substrate and heat is shed in that manner. This is an extreme example of hyporheic exchange. For streams where hyporheic exchange is not as forced or extreme but is along the lines of what is more normally expected, a simple exchange of water between the surface water and water in the substrate, this exchange might very well be a direct cooling mechanism. It would just have a smaller effect.

Thus, the conceptual model allows for stream cooling by two mechanisms. One is by hyporheic exchange where there is direct cooling of water by contact with substrate. The second mechanism is by a reduction in heating the stream water in subsequent days because of shade.

Constant Temperature

There are a subset of the streams that stay about constant in daily maximum stream temperature from the top to the bottom of the study stream reach. These streams also have the higher stream velocities. The longitudinal stream velocity is directly proportional to discharge, thus high discharge streams have high velocities and low discharge streams have low velocities. Again two factors are at play here. First of all, the high velocities mean that the water can go from the top to the bottom sensor in a short time, usually in the span of a few hours. The maximum daily temperature at the base of the harvest units usually occurs in mid-afternoon while the maximum temperatures at the downstream end of the reach are in early evening. The water showing up at each sensor has been exposed to virtually the same amount of solar radiation, there is no great differential in the amount of energy received by the water and thus no great differential in heating so they have roughly the same temperature. Also, these streams have the highest discharges and this represents a lot of thermal inertia. So these are the streams that are going to be hardest to heat up. So they should stay at roughly the same temperature.

Increasing Temperature

The streams that have increasing temperatures have moderate to high velocities and none of them are associated with remnant debris flow deposits. They are also in harvest units and a buffer strip for a small, fish-bearing stream provides the shade. The most logical explanation at this time is that the increase in temperature results from increased heating due to addition solar radiation that reaches the stream from gaps in the buffer strip. With the increased equipment we will have it will be possible to explore this mechanism a little more fully.

Research Plan: The research plan this spring will focus on analysis of data collected for the Tribulation site. The magnitude of the cooling mechanisms will be evaluated using an above ground energy budget combined with time-of-travel calculations and groundwater influx.

Timeline: There is one year left on the project.
Project initiated 2001
Project terminated 2004

Budget: The Oregon Forestry Industries Council (OFIC) remains a partner on this project and has pledged support as needed.

Study 6: Examining Linkages Between Multi-Scaled Riparian Data, Fish Habitat Characteristics and Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) Populations

Co-Principal Investigators: Barbara Schrader, Forest Resources Department and Lisa M. Ganio, Forest Science Department
Collaborating Scientist: Robert Gresswell, USGS Forest and Ecosystem Science Center

Overview: In this study we examined the association between riparian vegetation patterns and fluvial processes, and examined linkages between riparian data from fine, medium and large scales in order to answer questions relating to habitat distribution of Oregon coastal cutthroat trout (*Oncorhynchus clarki clarki).*

Objectives:

1. Devise a sampling scheme to characterize riparian vegetation to analytically link existing instream fish habitat data to landscape characteristics.
2. Develop a hierarchical analysis examining the relationships between riparian characteristics at small to large scales.
3. Link and aggregate the riparian information developed in this project to the CFER Landscape Study of coastal cutthroat trout distribution and abundance above barriers to fish passage.

Background: Riparian vegetation is an important component of stream networks influencing fisheries and wildlife habitat. To analyze the effect of forest management on riparian habitats, researchers and managers need reliable data from the multiple spatial scales of riparian habitat. However, it is difficult to obtain this information because of the complexity of riparian systems.

Riparian vegetation influences fish habitat in a variety of ways - providing shade, litter inputs, increasing stream habitat complexity with inputs of wood, and channel stabilization by streamside roots of trees. It is unclear what level of detail of riparian vegetation is most important in explaining variability of fish habitat and fish abundance. For example, is the composition and variation in vegetation characteristics at the fine scale (fish habitat unit) more important than the vegetation characteristics at a medium (reach, segment) or large (landscape) scale? Does large-scale vegetation data in a Geographic Information System (GIS) layer help explain fish abundance? How well does large-scale vegetation information in GIS layers match the vegetation characteristics on the ground?

Methods: Research was focused in upper Camp Creek, a tributary to the Umpqua River in the Oregon Coast Range. Cooperative Forest Ecosystem Research (CFER) scientists studying cutthroat trout above barriers to fish passage collected spatially explicit, fine-scale fish habitat data and cutthroat abundance estimates in this watershed in the summer of 2000. The mainstem of upper Camp Creek was divided into twenty-three reaches and assigned geomorphic reach types. Either a major tributary junction, geologic barrier to fish migration, major change in channel and valley form, or a fish-bearing tributary formed a reach. The study area contained six Bedrock (BR), three Cascade (CA), five Pool-Riffle (PLRI), and five Step-Pool (STPL) reaches.

Riparian vegetation sampling was conducted in 19 of the 23 reaches in the mainstem. In each reach a 30m by 30m site was randomly selected on each side of the stream. Three 10m (width) by 30m (length) belt transects were established parallel to the stream. Belt 1 was adjacent to the stream, with Belts 2 and 3 located immediately upslope from Belt 1.Overstory trees were sampled in each belt, while understory vegetation was characterized by 3 subplots per belt.

Work completed spring 2001-winter 2003: Data for the Camp Creek Basin was compiled from multiple sources. This data includes spatial information for multiple GIS layers (sub-basin, stream layer, stream reach and segment layers, vegetation, ownership, elevation, slope, and aspect) as well as fine scale fisheries inventory data (habitat availability and fish abundance by habitat unit, reach and segment; geomorphic classification and riparian vegetation). Initial analysis has been completed comparing vegetation composition of 30m and 100m buffers around the stream for the length of the stream and by individual reach and segment. Fish occurrence by habitat type, and reach and segment has also been analyzed.

Field sampling to characterize vegetation at the reach level was completed summer 2002. We sampled all accessible reaches and segments. Riparian characteristics sampled included surface height above low flow, vegetation composition, and riparian area width.

Work completed winter 2003 through summer 2003

Objective 1: Completion of M.S. thesis by Mayumi Takahashi, Summer 2003. This work examined patterns in riparian herb, shrub and conifer vegetation as a function of distance from stream, channel reach morphology, and height above the streamflow.

Overstory Vegetation

Upper Camp Creek was dominated by a mix of hardwood and conifer species including red alder, big leaf maple, Douglas-fir, western redcedar, and western hemlock. As expected, red alder was most abundant in areas adjacent to the stream, while Douglas-fir and western hemlock abundance increased on the hillslopes. Western redcedar was evenly distributed across sampled belts, however, there was a noticeable difference in the size class distribution of redcedar, with large, old trees occurring on the hillslopes and smaller diameter trees occurring close to the stream, likely inferring a response to disturbance from flooding, slope failure, or other causes.

Understory Vegetation

Understory plant diversity and abundance patterns also changed predictably with increasing distance from the stream. Twenty-two species of shrubs and 62 species of herbs were observed in the study area. Overall species diversity and richness was highest within 10 meters of the stream. Shrub species richness and cover did not vary with distance from stream. Although species diversity varied with distance from stream, overall cover was consistent across the sampled belt transects – shrubs 29%, herbs 44%. Understory vegetation was dominated by four species, two shrubs and two herbs with 80 species occurring with cover values less than 5%.

Three gradients describing variation of riparian plant community were observed using non-metric multidimensional scaling (NMS) analysis: a strong moisture gradient from streamside to hill slope, a closed canopy forest gradient from conifers to hardwoods, and a gradient of vine maple abundance. Riparian vegetation varied with increasing distance from the stream and height above the streamflow. Distance from stream and height above streamflow were highly correlated Species correlated to NMS axes values implied that moisture tolerance was an important factor to describe distribution of riparian vegetation in upper Camp Creek.

Channel-Reach Morphology and Riparian Vegetation

We expected vegetation composition in upper Camp Creek to respond to changes in moisture and disturbance related to stream geomorphic characteristics. The study area was classified on a reach-level based on stream configuration, gradient and the constrained character of the stream. Four types of reaches, Pool-Riffle, Step-Pool, Bedrock, and Cascade. Pool-Riffle reaches in general were the least constrained reaches encountered in the study area, while Cascade reaches had the highest gradient, and theoretically were the most constrained. Step-Pool and Bedrock reaches were intermediate in stream flow constraint to Pool-Riffle and Cascade reaches.

A few general patterns of vegetation associated with reach types were observed and warrant further investigation. Because ours was an observational study we cannot infer cause and effect. Red alder and salmonberry were expected to dominate in unconstrained reaches, primarily the Pool-Riffle type since they would most likely be affected by fluvial disturbance. Red alder dominated all reach types, but was significantly more abundant in Step-Pool reaches compared with Cascade and Pool-Riffle reaches. Stink currant was most associated with Pool-Riffle reaches, while salmonberry dominated Step-Pool reaches (more intermediate in channel constraint). Western hemlock was most abundant in Bedrock reaches. Western redcedar was more abundant in Cascade reaches which were highly constrained and located closer to the headwaters than other reaches.. Though western redcedar occurs along a wide moisture gradient, it is worth considering if geomorphic conditions contribute to patterns of western redcedar abundance.

Objectives 2 and 3: Hierarchical Modeling of the Camp Creek mainstem.

A Bayesian hierarchical modeling approach was employed as an analysis tool to establish linkages between the data from multiple scales to indices of fish abundance for the Camp Creek drainage in southwestern Oregon. We initially sought to use data from 3 scales but ultimately used only two scales. Originally we attempted to use large scale riparian vegetation data obtained from GIS coverages but subsequent analysis indicated that the orientation of the 30 m pixels relative to the orientation of the stream made it difficult to clearly associate this information with the established channel units. In addition we found that the large-scale vegetation category called ‘mixed’ spanned such a large range of conifer/hardwood mixture proportions that it did not correlate with data from other scales. Therefore we did not use this scale. At the channel-reach scale, we used reach-level geomorphic classifications developed by CFER scientists; interpool distance, a measure of the connectivity among pools in a reach and channel-reach estimates of overstory structure within 10 and within 30 m of the stream edge from Mayumi Takahashi’s thesis. At the finer, channel unit scale we used channel unit measurements of unit length, width and pool depth as well as relative abundance of coastal cutthroat.

Relative abundance of trout was associated with both fine-scale and reach-scale variables. At the fine scale, relative abundance was not associated with pool length, width or volume but was associated with maximum pool depth. The association of relative abundance with max depth changed depending on the geomorphic classification of the reach. Cascade-type reaches had had overall lower relative abundance of trout than the other geomorphic categories. But the remaining geomorphic categories did not differ in overall relative abundance. Interpool distance and reach level measures of overstory structure were not associated with relative abundance of trout.

Outputs:

1. Thesis: Takahashi, Mayumi. 2003. "The Land-Water Interface: Patterns of Riparian Vegetation in an Oregon Coast Range System"

2. Invited Presentation: Ganio, L.M, R. E. Gresswell, A. I. Gitelman. 2003 Hierarchical Modeling of the Camp Creek System. For: Understanding wild riverine fish populations at watershed to regional scales: new concepts, tools and applications. American Fisheries Society annual meeting, Quebec City, Quebec. August

3. Volunteered presentation: M. Takahashi, B. Schrader and L.M. Ganio. 2003. The land-water interface: Characteristics of Riparian buffers in an Oregon Coast Range System, The 4th North American Forest Ecology Workshop, Corvallis, OR. June 16-20. (Presentation by Takahashi, recipient of best poster award)

Study 7: Influence of Alternative Silvicultural Practices on Songbirds

Principal Investigator: John P. Hayes, Forest Science Department

Relevance of topic to program mission: Understanding the influences of a diversity of silvicultural approaches on wildlife is central to the program's mission. This research will fill some of the gaps in our understanding of the influences of alternative silvicultural practices and green tree retention practices on wildlife.

Objectives: To determine the relative influences of clearcutting and two uneven-age management approaches (group selection and two-story stands) on abundance and diversity of songbird populations in western Oregon.

Overview of approach and methods: This study is being conducted on the CFIRP research sites in Oregon State University's MacDonald-Dunn Forest. The CFIRP sites consist of sets of control stands and three silvicultural treatments (clearcut, two-story stands, and patch cuts) replicated in three blocks; patch cuts are a form of group selection where 1/3 of the stand's basal area was removed in 0.2-ha openings, two-story stands are similar to a form of green tree retention. Treatments for this study were implemented between 1989 and 1991. Response of bird populations to treatment during the first 2 years following treatment was studied by Chambers et al. (1999; Ecological Applications 9:171-185). Chambers et al.'s work is extremely valuable and provides the only available information on the influences of uneven-age forest management on songbirds in western Oregon, and some of the only information available on the implications of uneven-age management on birds in conifer systems anywhere. However, the management implications of their work are limited by the temporal limitations of their study. As structural development of these sites progresses, habitat conditions at the sites differ considerably from those at the time of treatment. For example, the patch cuts have developed considerable structural complexity in the ten years since the stands were harvested; this increased structural diversity may have important implications to songbirds that were not evident during the initial years following harvest. Our study is examining longer-term implications of these management approaches to songbirds, examining songbird response 11 to 14 years post-treatment. The combination of the work completed by Chambers et al., work in progress on the sites on small mammals by Waldien and Hayes, and results from this study will provide a solid base of understanding of the influences of these silvicultural approaches on wildlife.

Abundance of birds was assessed during the breeding season using variable radius point counts. Point count stations were established in each stand, and each point is being visited a minimum of six times each year during the breeding season. Habitat assessments were conducted during field seasons to assess the vegetative and structural characteristics of the stands, and these will be related to observed distributions and abundances of songbirds. Approaches to statistical analysis were developed with assistance from the Department of Forest Science's Quantitative Sciences Group.

Progress: Two modifications to the design of the study described by Chambers et al. (1999) were made in 2002. Only a subset of previously established point count stations were used and new point count stations were established in some stands to ensure independence of variable circular plots. Also, only two randomly selected patch cut areas in each of three blocks (Peavy, Lewisburg Saddle, Dunn) were surveyed instead of conducting point counts in several contiguous small patch cut stands (defined by harvest boundaries) in each block. In the current study, two patch cut stands, two two-story stands, two modified clearcut stands, and one control stand were surveyed in each of the three blocks. All old and new point count stations locations were determined with a GPS and were recorded. Point counts were conducted from mid-May to early July 2002 and 2003. Habitat assessments were conducted during June-August 2003.

We conducted 6-8 point counts at each station between mid-May and early July 2002-2003. A total of 11041 bird detections representing 72 species were noted within all variable circular plots in all treatments. Among treatments, percentages of detections were comparable in the modified clearcut (32%), two-story (32%), and patch cuts (28%). Detections in the control stands represented 9% of total detections. Fewer species were found in the control (49) than in the patch cut (58), two-story (65), or modified clearcut (64) stands. Species composition across treatments apparently differed (Figure 1). Similar to results from only data collected in 2002, some species, such as winter wrens, hermit warblers, and Pacific slope flycatchers were found more frequently in stands with mature forest (control and patch cut stands) whereas species such as house wrens and willow flycatchers were detected most frequently in stands with open habitat (modified clearcut and two-story stands). These trends are consistent with findings of Chambers, et al (1999) who found the bird communities in modified clearcut and two-story stands were similar, and bird communities in the control and patch cut stands were similar. Preliminary results from this study also showed high levels of detections of several species in patch cuts (e.g., red-breasted sapsucker, red-breasted nuthatch, and western tanager), suggesting development of understory in these stands since harvest may provide habitat for a broader suite of species than that which can be provided in unharvested control stands (Figure 1).

Using data from 6-point counts during each year (early June-early July, 2002-2003), mean numbers of detections per visit were compared among treatments. Forty-two species were detected >30 times over the course of the study. Among these species, 25 showed patterns suggesting differences in detection could be attributed to differences in open (modified clearcut and two-story) vs. closed (control and patch cut) habitat (Table 1). The majority of species that differed across habitat types are normally associated with open habitat (68%) whereas only five species (32%) were associated with closed habitat. Further analysis will focus on examining changes in relative measures of species abundance over time, comparing results of Chambers et al. (1999) with data collected in 2002 and 2003.

Timeline:

Spring 2004: Final data analysis and manuscript preparation.
Fall 2004: Publication of results.

Budget:

FY2003 $44,000 **FY2004** $33,000 **FY2005** $3,000.

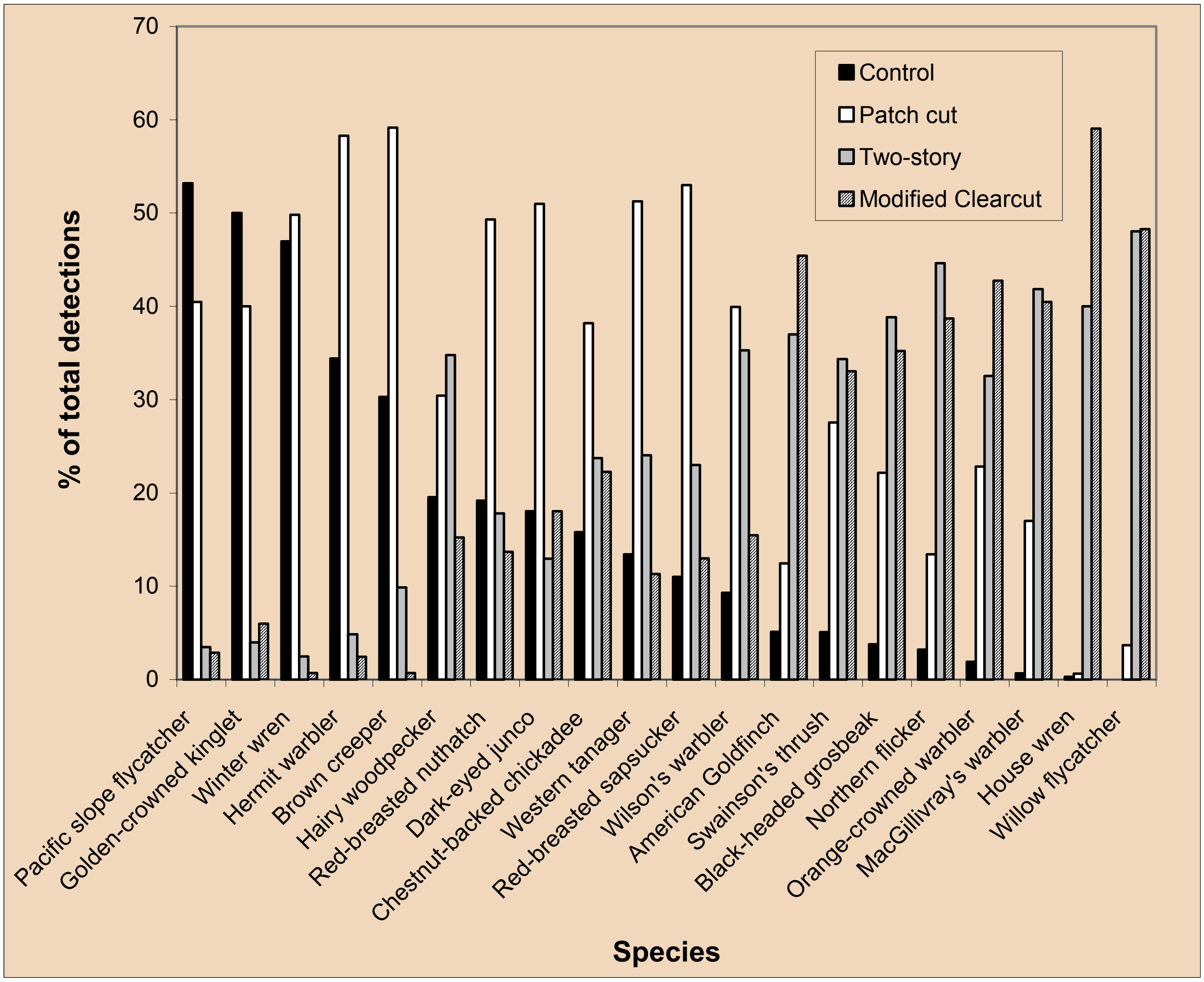


Figure. Percent of detections of each of 20 bird species in four silvicultural treatments in the MacDonald-Dunn forest, May-July 2002 and 2003. Species are representative of 72 total species surveyed. Species on the left side of the chart were detected most frequently in stands with mature forest (control and patch cut) and species on the right were detected most frequently in stands with open habitat (two-story and modified clearcut).

Table 1. Preliminary results from Analysis of Variance contrasts of mean detections per visit for species detected >30 times. Species that differed in response between open (modified clearcut and two-story stands) and closed (control and patch cut stands) habitat types are shown.

Habitat type	
Open	**Closed**
American Goldfinch	Brown creeper
Bewick's wren	Dark-eyed junco
Black-headed grosbeak	Golden-crowned kinglet
Common yellowthroat	Hermit warbler
Cedar waxwing	Pacific slope flycatcher
House wren	Red-breasted nuthatch
MacGillivray's warbler	Western tanager
Mourning dove	Winter wren
Northern flicker	
Orange-crowned warbler	
Olive-sided flycatcher	
Purple finch	
Rufous hummingbird	
Spotted towhee	
Swainson's thrush	
Willow flycatcher	
Wrentit	

Study 8: Forest Management Strategies in Hinkle Creek Watersheds: Evaluation of Baseline Seasonal Stream Water Nutrient Concentrations and Soil Resources

Investigators: Kermit Cromack, Jr., PI, and Dave Hibbs, Co-PI, Forest Science Dept., OSU; Arne Skaugset and Stephen Schoenholtz, Co-PIs, Forest Engineering Dept., OSU

Relevance to program mission: This research addresses the need to obtain baseline data for both stream chemistry and soil resources for two forest watersheds, the North and South Forks of Hinkle Creek 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. A solid representative database for both stream and soil nutrients in these watersheds would provide a model upon which to help gauge the effects of current and expected intensive forest management practices on industrial forest land. It would be particularly worthwhile to obtain such data from the Hinkle Creek watersheds prior to initiation of an anticipated 10-year study of intensive forest management.

Objectives: There are two main objectives: 1) to obtain monthly water nutrient concentration data for two consecutive years in six headwater streams, and in the North and South Forks of Hinkle Creek. Stream nutrients to be measured include: total N, P, and base cations (Ca, K, Mg, Na), dissolved inorganic carbon (DIC), dissolved organic N (DON), and inorganic N (DIN), plus stream pH, collected monthly; 2) to obtain data for soil resources and geomorphology on these watersheds, including soil physical properties (porosity and bulk density), pH, soil texture, and soil C, N, P, S, base cations (Ca, Mg, K, Na), cation exchange capacity, and soil N and P availability. This research is designed to integrate with the proposed Hinkle Creek Research and Demonstration Area Project on Hydrology and Water Quality being led by Arne Skaugset, OSU Forest Engineering Department.

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 that 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 would provide a valuable initial database of stream nutrient concentrations and soil resources for the proposed new Hinkle Creek Research and Demonstration Area Project.

Approach: To accomplish the first objective for obtaining seasonal nutrient concentration data, we will collect samples directly from streams monthly, while minimizing disturbance to stream sediment. Samples will be transported in coolers on ice and taken within 24 hrs. to the Co-operative Chemical Analytical Laboratory at OSU for water analysis. The second objective, to collect soil samples in riparian zones and upslope forest areas, is being accomplished using recently published soil survey maps as a guide to select representative locations within the overall watershed. In addition, representative soil pits are being dug to obtain soil descriptions and underlying parent materials, and to check on soil map accuracy.

Project Results to Date: In September, 2002, we selected two control and four treatment watersheds for stream sampling, in addition to stream sampling sites just above the confluence of the North and South Forks of Hinkle Creek, for collection of stream samples for chemical analyses. We also recruited Lance George as an M.S. graduate student working jointly in the Forest Science and Forest Engineering Departments at OSU for our Hinkle Creek Study. Since the original 8 sampling points were described, we also have been taking samples from 3-4 other locations directly below clearcuts completed in 2001 and with subsequent intensive vegetation control measures in place. We are trying to determine where the higher nitrate totals found in BB Creek originate and what water quality effects occur below a fresh clearcut. The tributaries sampled above BB Creek proper are ephemeral, but subsurface flow from these aquifers provides much of the summer low flow. Clay Creek also is being sampled directly above a clear-cut, then sampled again after passing through it, to ascertain any stream water chemistry changes that might be attributed to the clear-cut.

Our first stream samples were collected on October 24, 2002, with subsequent samples collected each month continuing through the present month of January, 2004. Complete stream chemistry results are available for October, 2002 through December, 2003, and the averages are presented in Table 1. Results are given for the following analyses: dissolved organic total N (DON), dissolved total N, unfiltered total P, dissolved total P, dissolved PO_4-P, alkaline HCO_3-C, conductance, NO_3-N + NO_2-N, NH_4-N, dissolved Si, dissolved Na, dissolved K, dissolved Ca, dissolved Mg, dissolved SO_4-S, dissolved Cl, suspended sediment, and pH. All stream water N concentrations are low, except for some higher NO_3-N concentrations for two partially treated watersheds, Clay and BB Creeks. These small watersheds were partially cut over about 20% of their areas in 2001, prior to initiation of the integrated Hinkle Creek Project in 2002. Results for NH_4-N show that this inorganic form of N is present in low concentrations in all of these watersheds. Organic N, as both particulate, unfiltered total N, and as dissolved total N, also occurs in low concentrations. Phosphorus are lower than those observed for Watershed #10 on the H.J. Andrews LTER for an old-growth Douglas-fir forest that was growing on volcanic derived soils (Sollins et al., 1980). However, P concentrations are higher at Hinkle Creek than those sighted for several Environmental Protection Agency (EPA) ecoregions in the USA (NCASI, 2001; Ice and Binkley, 2003). Among base cations, Ca is present in higher concentrations than K or Mg. Suspended sediment was low during the dry season and higher during winter flows, as would be expected.

When comparing stream chemistry data between Hinkle Creek and the H. J. Andrews LTER small watersheds, (Tables 2 and 3), we found that results for many of the analyses are broadly similar, especially for N and P. Cation concentrations were higher for Ca and Mg in the Hinkle Creek watersheds than for the H. J. Andrews watershed #10 (Sollins et al., 1980). More recent H. J. Andrews LTER stream chemistry data from Vanderbilt et al. (2002) show that both inorganic N and organic N concentrations are low (Table 3), and are comparable to the Hinkle Creek watersheds. Work done on the Alsea River basin watersheds (Brown et al., 1973) shows generally higher concentrations for NO_3-N (Table 4) than for Hinkle Creek, except for the BB Creek watershed and the South Fork of Hinkle Creek in November - December, 2002 and December, 2003, (Figures 4 and 5) which are similar to Alsea Basin NO_3-N concentrations. Forest soils in the Oregon Coast Range generally have higher concentrations of soil N and C (Rothe et al., 2002), and thus, may have higher stream NO_3-N concentrations even on undisturbed control sites (Table 5) (Brown et al., 1973; Compton et al., 2003).

Newly published soil surveys from the NRCS and Douglas County SCS were used to set up a methodology for sampling the representative Hinkle Creek soil resources. Fifteen main soil types were mapped, representative soil pits were dug in accordance with the location of the mapped soils, and standard soil survey descriptions were created. Joel Norgren, an experienced soil scientist with many years of mapping expertise, was hired to help select locations for the soil sampling. Twenty-seven soil pits were dug during summer, 2003, their descriptions recorded, and locations noted. These soil pits will be revisited during late winter and spring 2004, and soil samples will be taken from the different horizons. This information will be used to create an estimate of total soil C and N resources, and other soil physical and chemical properties noted above will be examined. To date, soil cores from 4 different depths in 9 pits have been collected and dried for storage. The summer of 2004 will be spent filling in any perceived gaps in the soil resources data, by digging a few more pits, and sampling soils of interest. Figures 1 and 2 show the location of the grab sampling points for stream nutrients and soil pits already in place. Figures 3, 4, and 5 show seasonal trends in NO_3-N fluxes.

Timeline: Winter /Spring/Summer/Fall 2003 - continue collection of stream and soil samples; Winter/Spring/Summer/Fall 2004 - continue stream nutrient sample collection and soil sample collection and analysis; Winter/Spring/Summer 2005 - finish stream and soil collections and data analysis; Fall/Winter/Spring 2005/2006 - finish theses/dissertation, submit final report and write manuscripts based upon theses results.

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Figure 1. Hinkle Creek Experimental Forest

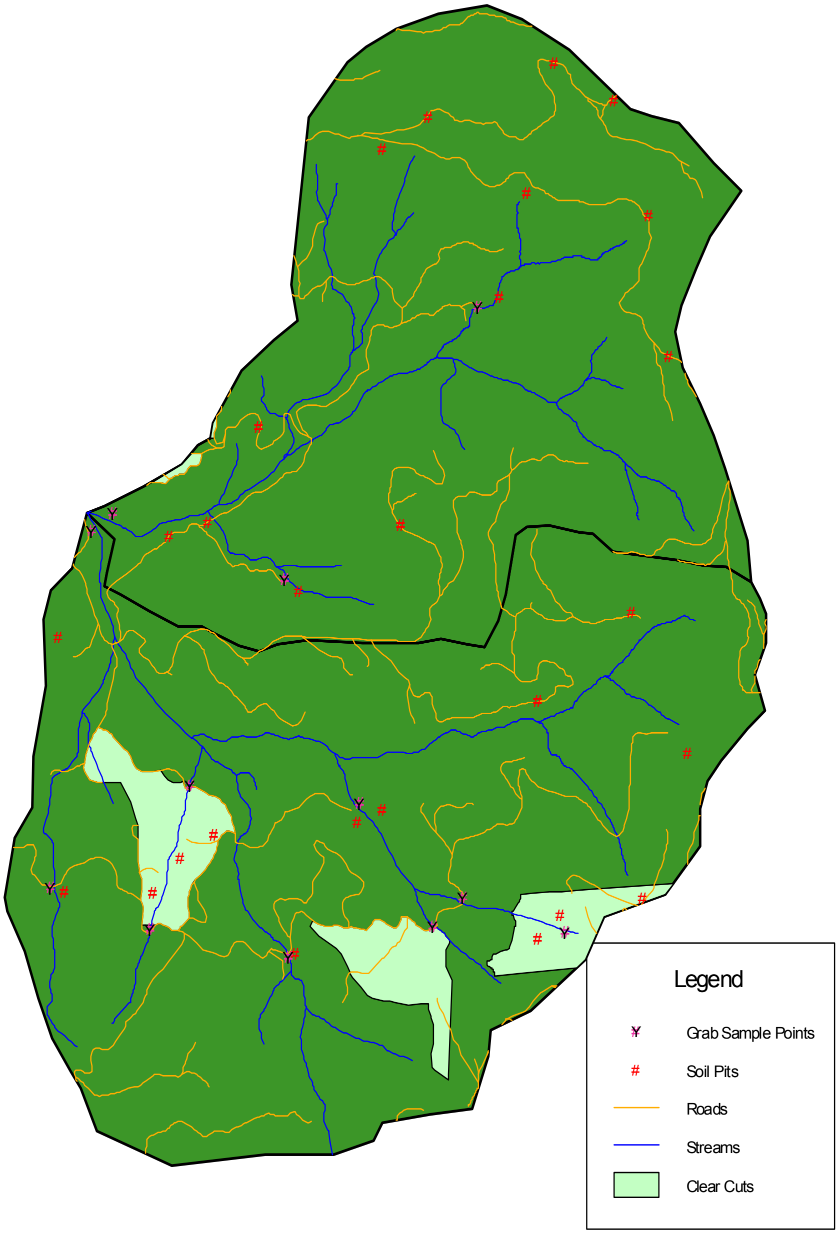
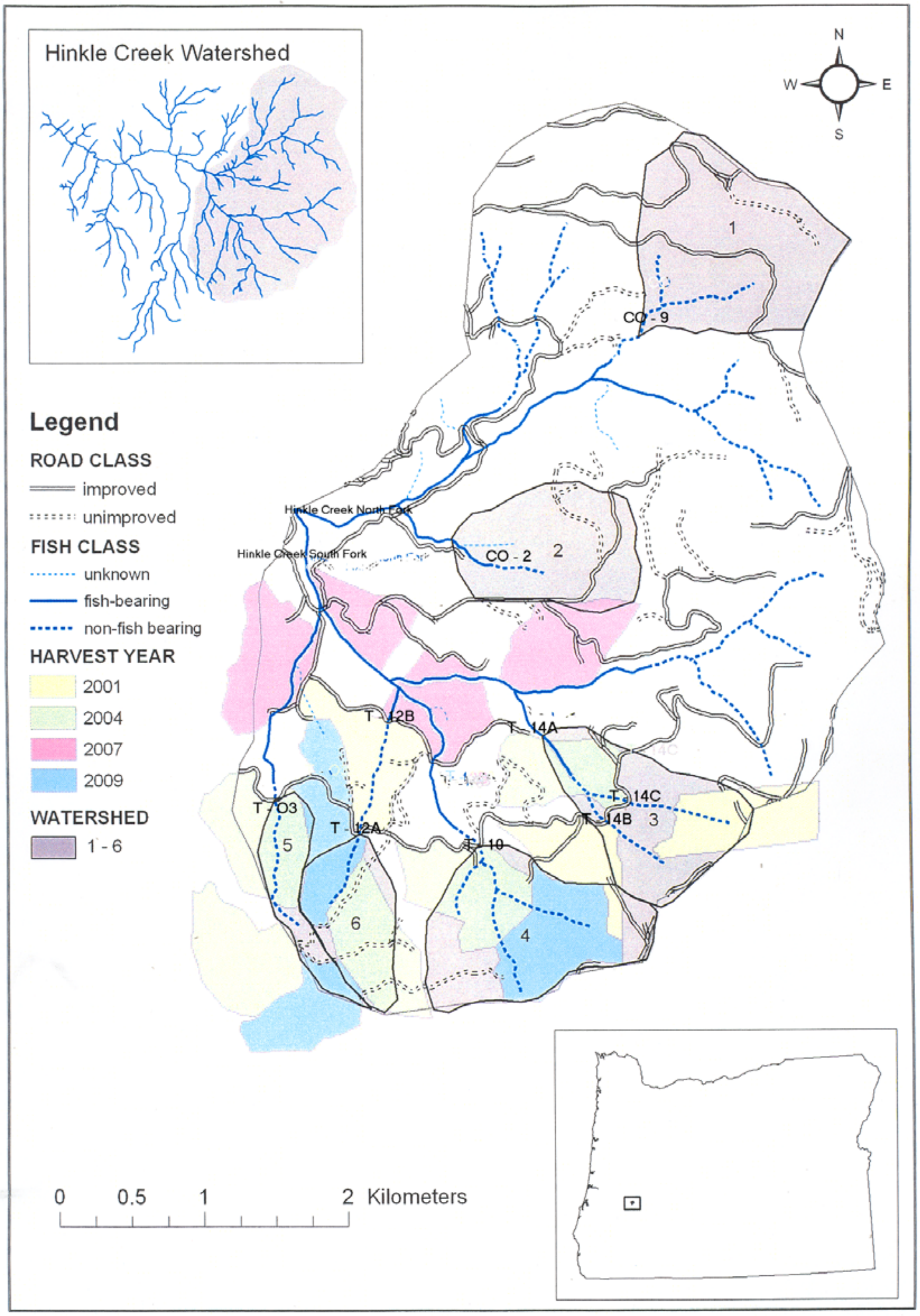


Figure 2.



Stream Legend and Sampling Locations
C-O2 = DeMearsman Creek
C-O9 = Myers Creek
T-03 = Fenton Creek
T-12 = Clay Creek
T-10 = Russell Creek
T-14 = BB Creek

Table 1. October 2002 – December 2003 Hinkle Creek Watershed Stream Chemistry Data. Average Concentrations.

October 2002 – December 2003	**Control CO2**	**Control CO9**	**Hinkle Creek North Fork Confl.**	**Hinkle Creek South Fork Confl.**	**Treat. Fenton Creek**	**Treat. Russell Creek**	**Treat. Clay Creek**	**Treat. BB Creek**
Total DON-N mg/L	0.032	0.025	0.040	0.039	0.025	0.019	0.028	0.031
Dissolved Total- N mg/L	0.055	0.039	0.062	0.139	0.051	0.043	0.070	0.510
Unfiltered Total - P mg/L	0.028	0.024	0.019	0.020	0.047	0.024	0.030	0.021
Dissolved Total - P mg/L	0.024	0.017	0.017	0.018	0.032	0.019	0.021	0.019
Dissolved PO_4 -P mg/L	0.015	0.010	0.009	0.009	0.032	0.013	0.014	0.012
Alkaline HCO_3 - C mg/L	6.036	8.771	6.885	5.642	5.857	6.463	5.644	6.678
Conductance µs/cm	52.50	75.60	59.37	49.47	51.43	55.45	49.68	61.32
NO_3 -N + NO_2 - N mg/L	0.013	0.009	0.017	0.105	0.017	0.023	0.028	0.501
NH_4 - N mg/L	0.009	0.005	0.004	0.006	0.010	0.004	0.012	0.010
Dissolved Si mg/L	8.772	8.940	8.077	8.160	9.641	8.541	7.640	8.019
Dissolved Na mg/L	4.164	4.306	4.228	3.283	4.816	3.253	3.285	3.245
Dissolved K mg/L	0.517	0.309	0.497	0.368	0.593	0.271	0.417	0.263
Dissolved Ca mg/L	4.914	8.788	6.030	5.196	4.367	6.302	5.335	7.083
Dissolved Mg mg/L	1.394	2.702	1.730	1.401	1.230	1.517	1.251	1.896
Dissolved SO_4 – S mg/L	0.182	0.110	0.150	0.126	0.194	0.130	0.136	0.156
Dissolved Cl mg/L	1.558	1.583	1.854	1.396	1.512	1.652	1.448	1.556
Suspended sediment mg/L	3.202	2.790	2.372	2.008	8.241	3.376	6.624	1.806
pH	7.47	7.68	7.58	7.51	7.48	7.52	7.52	7.59

* Dissolved SO_4 – S and Dissolved Cl are from Oct. 2002 – Feb. 2003 only

Figure 3. Inorganic N concentrations in Clay Creek A above clear-cut and Clay Creek B below clear-cut (Oct. 2002 – Dec. 2003).

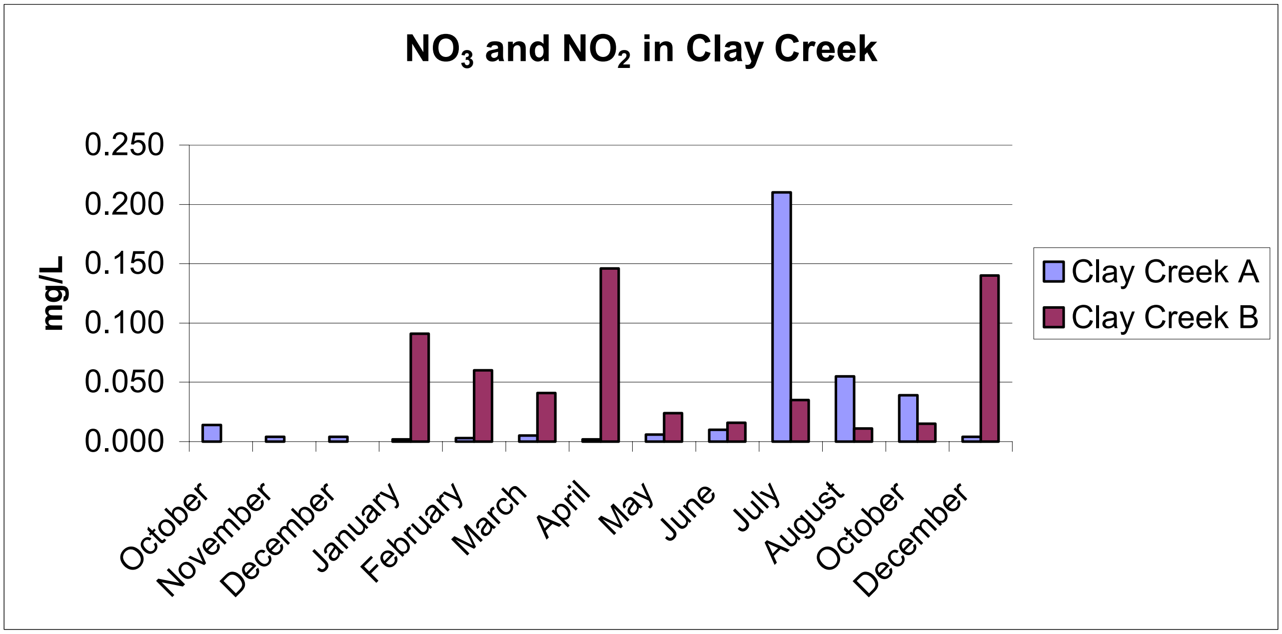


Figure 4. Inorganic N concentrations in Hinkle North and South Forks, and in BB Creek (Oct. 2002 – Dec. 2003). BB Creek A is the main branch below tributaries.

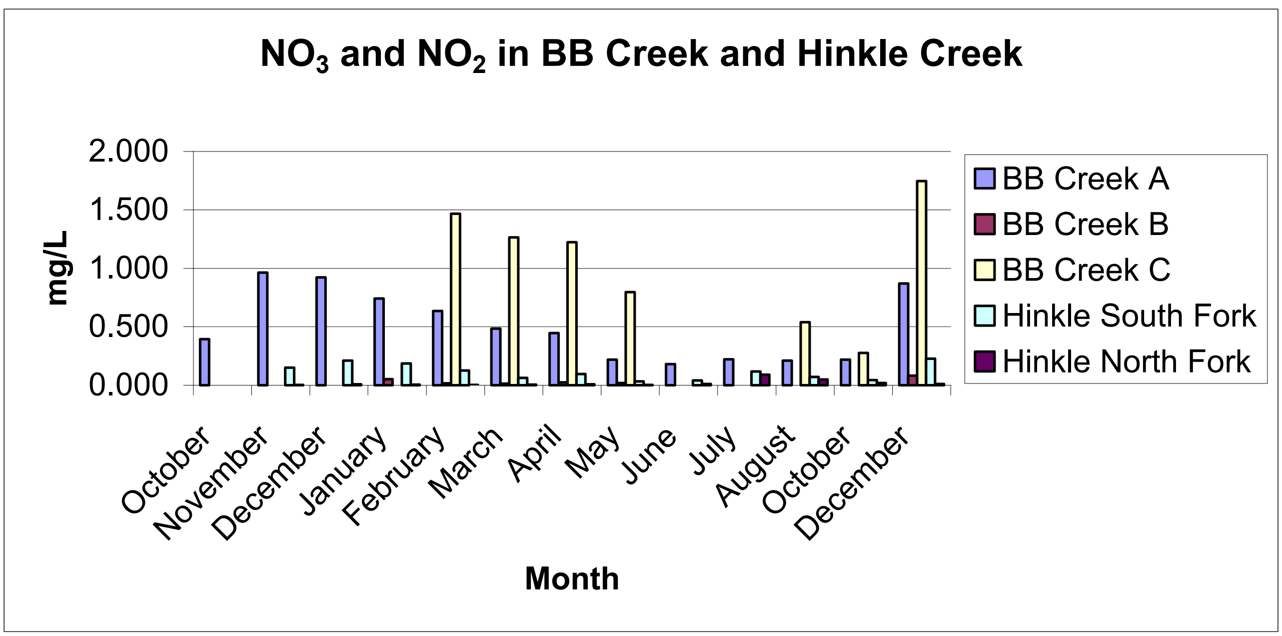


Figure 5. Inorganic N concentrations in Hinkle North and South Forks and in the main branch of BB Creek (Oct. 2002 – Dec. 2003).

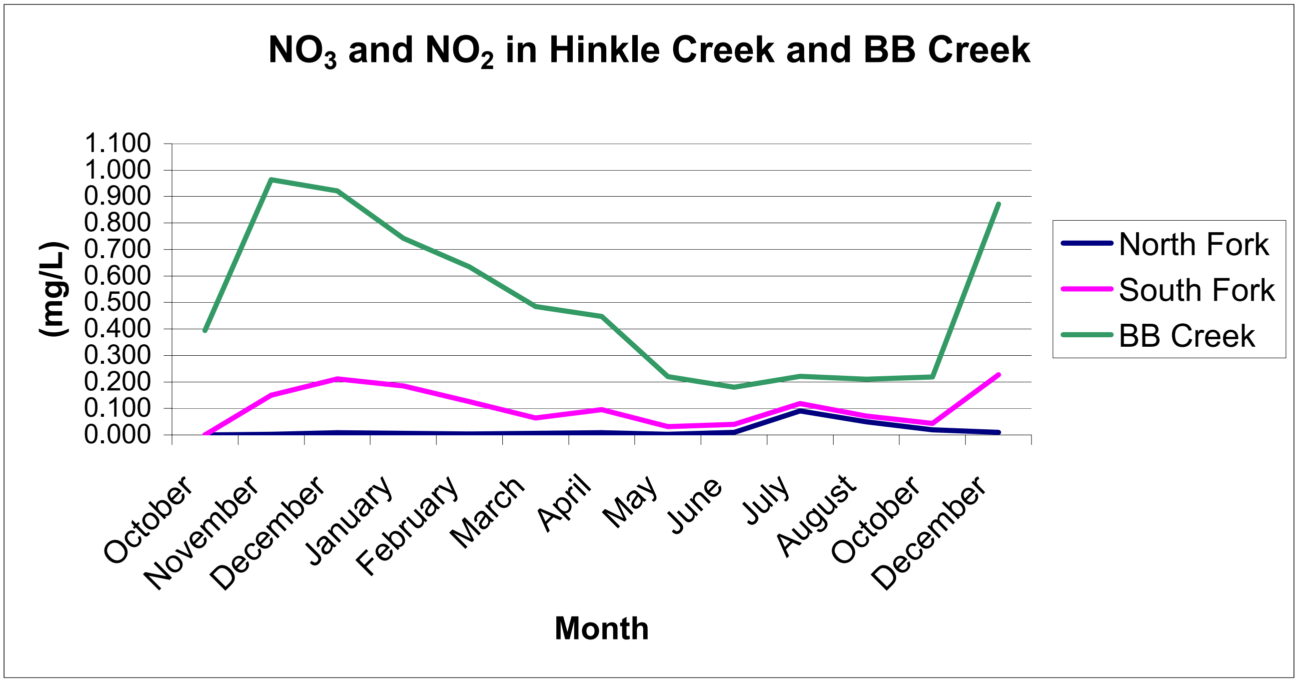


Table 2. Stream chemistry data from HJ Andrews WS#10 weir from 1973-75 (Sollins et al., 1980).

NO_3-N + NO_2-N mg/L	0.19
Kjeldahl N mg/L	0.035
Na mg/L	1.96
K mg/L	0.339
Ca mg/L	3.20
Alkalinity HCO_3–C mg/L	4.17
Total P mg/L	0.054
SO_4–S mg/L	N/A
Cl mg/L	N/A
Mg mg/L	0.834

N/A denotes not analyzed.

Table 3. Average inorganic and organic N concentrations for three old-growth-dominated streams at HJ Andrews (Vanderbilt et al., 2002).

Concentration	WS #2 (1982-2001)	WS #9 (1969-2001)	WS #8 (1972-2001)
NO_3-N mg/L	0.001	0.003	0.004
NH_4-N mg/L	0.007	0.008	0.009
DON mg/L	0.02	0.04	0.02
PON mg/L	0.02	0.02	0.01

DON denotes dissolved organic N.
PON denotes particulate organic N.

Table 4. Annual mean NO_3-N (mg/L) concentrations for three streams in the Alsea River basin both before (1965-1966) and after (1967-1968) treatments (Brown et al., 1973).

Year	Flynn Creek (uncut control)	Needle Branch (clear-cut)	Deer Creek (patch-cut)
1965	1.21	0.12	1.12
1966	1.16	0.19	0.98
1967	1.18	0.44	1.21
1968	1.18	0.43	1.12

Table 5. Yearly flow rated average concentrations of several streams in the Oregon Coast Range in 2000 (mg/L) (Compton et al., 2003)

Concentration	Teal Creek	Baxter Creek	Curl Creek	Bear Creek	Slick Rock	Salmon River
NO_3-N (mg/L)	1.352	1.203	0.875	0.652	0.074	0.167
DON (mg/L)	0.052	0.063	0.048	0.047	0.020	0.033
Ca (ueq/L)	363	71	356	274	133	151
Mg (ueq/L)	207	85	200	192	65	92
Na (ueq/L)	638	162	291	243	110	140
K (ueq/L)	18	12	6	11	4	4

ueq/L = microequivalents per liter

TERMINATION REPORT

Title: Snags and Reserved Green Trees: Mortality Rates and Primary Cavity Nester Use

Principal Investigators: Chris C. Maguire and Scott T. Walter

Objectives: In managed forests, considerable emphasis is placed on retaining and creating snags for cavity nester use and in placing green trees in reserve for future snag replacement. We currently have a poor understanding of snag longevity and the permanence of reserved green trees in westside forests subject to different silvicultural practices. Quantification of the fall rates of snags and green trees, and of the temporal use of decaying snags by avian species, will provide data to effectively manage snags as wildlife habitat.

This study was designed to:
(1) quantify the 10-year fall rates of isolated and clustered snags in clearcut, two-story, and patch-cut stands;
(2) quantify the 10-year mortality rates of green trees under the same silvicultural treatments;
(3) compare avian cavity nester use of snags after 10-years with results from the first 5-years.

Progress and Accomplishments:

Between 1989 and 1991, 30 stands in McDonald-Dunn Forest under the College of Forestry Integrated Research Program (CFIRP) were subjected to three harvest treatments: clearcut, two-story, and patch-cut. In addition, green trees were topped (in excess of 1,000 trees) to create snags (3.8/ha) in either isolated or clumped distributions. Avian use of snags was assessed in 1995 providing information on use during the first 5-years following snag creation. One objective of the current study is to follow-up the 5-year study with a re-assessment of avian snag use 10-years following snag creation. The long-term intent of the project is to build a temporal database focused on avian snag use and snag longevity at 5-year intervals.

During the spring breeding and rearing season, birds make frequent trips between the cavity and the environment for the purpose of feeding young. During spring 2000, each snag was observed three times to assess current and past nesting and feeding use. All species of birds using snags were recorded along with cavity location information. These data are being used to quantify the temporal pattern of snag use and to determine whether clumped snags are utilized more often than scattered snags.

In conjunction with cavity nester and snag use surveys, snag longevity was assessed. Because snags that have fallen in the decade since their creation have not been salvaged, snag mortality was accurately quantified from a total count. These data are being used to evaluate differences in fall rates between silvicultural treatments, and snag spatial arrangements.

It is not uncommon under current forest management practices to leave green trees in harvest units to provide a temporal source of snags. The proximity of leave green trees to other trees is likely to have a significant influence on their standing duration. Thus fall rates of green trees in all three silvicultural treatments were quantified in summer/fall 2001 using a complete count. These data will provide for comparison of the survival potential of green trees under silvicultural regimes reflecting different densities and retention patterns of trees.

Scott Walter, a former masters student from the Department of Forest Science, undertook this project in partial fulfillment of his degree requirements. Fieldwork was completed between April 2000 and February 2002, and Scott defended his thesis in November 2003. Project funds terminated in June 2003.

Results of the study include the following:

- Eight species of birds nested in created snags and a mean of 5.1 total cavities per snag were found one decade after creation; no active nests were observed in topped trees that remained alive.
- Compared with six years prior, the mean number of cavities per created snag increased 3.3- to 6-fold across treatments, and 4 additional avian species were observed nesting.
- Higher cavity-nesting bird levels, species richness, and species diversity occurred in open-canopy stands (two-story and clearcut treatments) compared to closed-canopy stands (group-selection treatment).
- No difference was found in nesting or foraging levels between clustered and scattered snags.
- Active nests in created snags were most commonly located in the top 25% of the bole, cavities on average faced northeast, and created snags with and without dead branches received equal nesting use.
- Only one topped conifer fell in the decade since creation.
- Across silvicultural treatments, residual green tree basal area, DBH, and height growth, and crown width and crown fullness did not differ among silvicultural treatments 10-12 years following harvest; 45% of trees experienced greater basal area growth in the decade following harvest than in the decade prior to harvest.
- Mean live crown ratio (live crown length/total tree height) of residual trees was greatest in clearcuts (0.74), and the percentage of trees with epicormic branching was highest in two-story stands (35%).
- Over the decade since harvest, residual tree mortality resulted in 134 standing dead trees (snags) and 185 blowdowns; two-story stands experienced the highest recruitment of snags (0.76 per ha) and blowdowns (1.12 per ha).

Publications

Walter, S.T. 2004. Snag longevity, bird use of cavities, and conifer response across three silvicultural treatments in the Oregon Coast Range. M.S. Thesis, Oregon State University, Corvallis, Oregon. 124 pp.

Walter, S.T. and C.C. Maguire. Conifer response to three silvicultural treatments in the Oregon Coast Range. Canadian Journal of Forest Research (*in review*).

Walter, S.T. and C.C. Maguire. Snags, cavity-nesting birds, and silvicultural treatments in western Oregon. Journal of Wildlife Management (*in review*).

This is a final report (1-21-04).

TERMINATION REPORT - PROJECT NOT FUNDED IN FY2004

Title: The Magnitude and Timing of Surface Runoff from Forest Roads Relative to Stream Flow in Live Stream-crossing Culverts in the Oak Creek Watershed

Principal Investigators: Arne Skaugset, Assistant Professor, Department of Forest Engineering, OSU and Elizabeth Toman, Graduate Research Assistant, Department of Forest Engineering, OSU

Problem Statement: Since the listings of the coastal Coho salmon and other species and stocks of salmon as threatened or endangered, the environmental effects of forest management activities on aquatic habitat have come under increased scrutiny. Forest roads are a management activity that can have a deleterious effect on water quality and aquatic habitat for salmon and trout and thus has recently received increased scrutiny. Forest roads may change watershed hydrology by intercepting subsurface flow from hillslopes (Jones and Grant 1996) and they are chronic sources of fine sediment (Bilby et al 1989). While all roads interact with hillslopes and generate fine sediment at some level, the road segments that are directly connected to streams are the segments that are most likely to affect changes in watershed hydrology and have a deleterious effect on aquatic habitat (Wemple et al 1996).

Objective: To determine the magnitude and timing of surface runoff from forest roads connected to live streams and compare it to the magnitude and timing of streamflow in the receiving stream at the crossing.

Research Approach: For this project, the effect of the most common type of road/stream connectivity on the magnitude and timing of stream flow in the receiving stream at the stream crossing will be investigated. This type of connectivity is when a road crosses a stream at a midslope location and at approximately right angles to the stream. Depending on the grade of the road at the stream crossing, there will be either one or two road ditches that will contribute surface runoff and thus, sediment, directly to the stream at the culvert. The purpose of this project is to instrument and monitor several of these stream crossing culverts in the Oak Creek watershed in the College of Forestry's school forest: the McDonald-Dunn Research Forest.

The primary equipment used will be capacitance rods and trapezoidal flumes. Capacitance rods will be installed at the inlet of the stream crossing culverts to measure and record water level. Trapezoidal flumes will be placed in the road ditches that flow into the stream crossing culverts and water level will be measured and recorded with capacitance rods in these structures also. Raingages will be installed throughout the watershed to monitor rainfall. With this instrumentation, the timing and magnitude of the flows in the road ditches can be compared with the timing and magnitude of the flows in the stream at the live stream crossing culvert installation. Instrumentation for this project is being supported by a grant from the National Council for Air and Stream Improvement (NCASI).

Research Accomplishments: With this project, the research infrastructure within the Oak Creek watershed as well at the database infrastructure continues to grow. Discharge continues to be collected at the stream gauging structure on Oak Creek, which consists of a concrete-hardened cross-section and a stilling well, through the 2002-2003 winter. During the spring 2003 a shed was built to house the stilling well and other equipment. An outrigger (adjustable crane) was also built to house a turbidimeter and automatic water sampler. This new equipment will collect data during the winter 2003-2004. Tipping bucket rain gauges at four locations and a micrometeorology tower continued to collect data pertaining to precipitation intensity, temperature, relative humidity, wind speed, and solar radiation.

A digital elevation map made from LIDAR imagery is being used as a base map for this project. The topographic details of the Oak Creek watershed, including the watershed boundary, have been delineated down to the Oak Creek gauging station the Forest boundary. This area is now referred to as the headwaters of Oak Creek. The watershed that is the headwaters of Oak Creek has an area of 824 hectares. There are 4,877 meters of stream and 4,572 meters of road in the watershed that results in a stream density of 5.92 m/ha and a road density of 5.55 m/ha. There are 99 road drainage structures on the roads within the watersheds. Of these, 24 are stream crossing culverts and the remaining 75 are drainage relief or cross drain culverts.

During the winter 2002-2003, capacitance rods were installed on all the stream crossing culverts. These instruments collected water height data at the culvert inlet every 10 minutes. Sixteen of the 22 stream crossing culverts were instrumented with flumes in the adjoining ditches measuring surface road runoff into the stream at that crossing. Water level in the trapezoidal flumes was also measured using capacitance rods. Water level and temperature data from the capacitance rods at the culverts and in the flumes were downloaded and stored monthly.

The five largest storms during the 2002-2003 winter were analyzed. All were sub-annual events with a 100 percent chance of occurring annually. Flow in the ditches was compared in time to flow in the stream at the stream crossing culvert. Discharge measurements were calculated from water heights at the culverts using a hydraulic flow equation. Water heights in the flumes were converted to discharge using an equation provided from the flume manufacturer. Flow measured at the culvert was termed “culvert flow” and flow measured by the flumes was termed “ditch flow.” Ditch flow subtracted from culvert flow gave an estimate of “stream flow” without the influence of the road. Hydrographs of ditch flow, stream flow, and culvert flow through time were created and compared at each stream crossing culvert.

The effect of runoff from the road on flow in the stream depended on the interaction of the road with the hillslope. Where the road intercepted subsurface flow from the hillslope, the peak flows and flow volumes were affected more greatly than for those road segments where the ditch flow was primarily road surface runoff. These effects were highly variable and could not be predicted using traditional topographic indicators. Figure 1 shows storm hydrographs for a road segment that intercepts subsurface flow and a road segment that only receives runoff form the road surface. There are significant differences in shape of the hydrograph and in the magnitude of discharge between the two sites.

Increases in stream peak flow due to ditch flow ranged from 0.0 to 11.3 l/s, and increases in total stream runoff volume ranged from 0.0 to 2200 m^3. Increases in peak flow and storm runoff volume had the greatest impact at the smallest streams where peak flow increased up to 610 percent and total stream runoff increased nearly 5000 percent due to the influence of the road. Distributions of stream peak and stream runoff increases are right-skewed with greater increases from the road segments that intercept subsurface flow (Figures 2 and 3).

The hydrographs of ditch flow had a peak flow that generally occurred before the peak flow of the adjoining stream. This increased stream flow on the rising limb of the stream hydrograph. An example of this is shown in Figure 4.

Research Plans: Data collection for this project is completed, however, this project is only one of several that are ongoing in the Oak Creek watershed and share a common dataset. Data collection at all culverts within the watershed and at the Oak Creek weir continues under the direction of a research assistant.

Data from this project and the analysis will constitute the M.S. thesis for Elizabeth Toman. A thesis defense and completion is scheduled for Spring 2004.

Additional funding opportunities are being sought to continue to develop Oak Creek into a place where cutting edge research on the hydrology of forest roads and roaded watersheds can take place.

Publications and Technology Transfer Activites:

Toman, E.M. and A.E. Skaugset. 2003. The magnitude and timing of runoff from forest roads relative to stream flow at live stream crossing culverts in western Oregon. Council on Forest Engineering Conference, Bar Harbor, Maine.

Skaugset, A.E., J.J. McDonnell, R.F. Keim, and E.M. Toman. 2003. Use of stable isotope as a diagnostic tool for determining connectedness of road runoff to stream peak flows in disturbed forest environments. Poster Presentation. American Geophysical Union Fall Meeting, San Francisco, California.

Project Duration:

Project Initiated: 2001
Project Terminated: 2003

References:

Bilby, R. E., K. Sullivan, and S. H. Duncan. 1989. The generation and fate of road-surface sediment in forested watershed in southwestern Washington. Forest Science Vol. 35, No. 2, pp. 453-468.

Jones, J. A. and G. E. Grant. 1996. Peak flow responses to clear-cutting and roads in small and large basins, western Cascades, Oregon. WRR 32(4):959-974.

Wemple, B. C., J. A. Jones, and G. E. Grant. 1996. Channel network extension by logging roads in two basins, western Cascades, Oregon. Journal of the American Water Resources Assoc. 32(6):1195.

Figure 1. Hydrographs for a road segment that intercepts subsurface flow (bottom panel) and a road segment that only receives runoff from the road surface area. The top panel shows precipitation through the storm period. Total precipitation for the event was 49.0 mm.

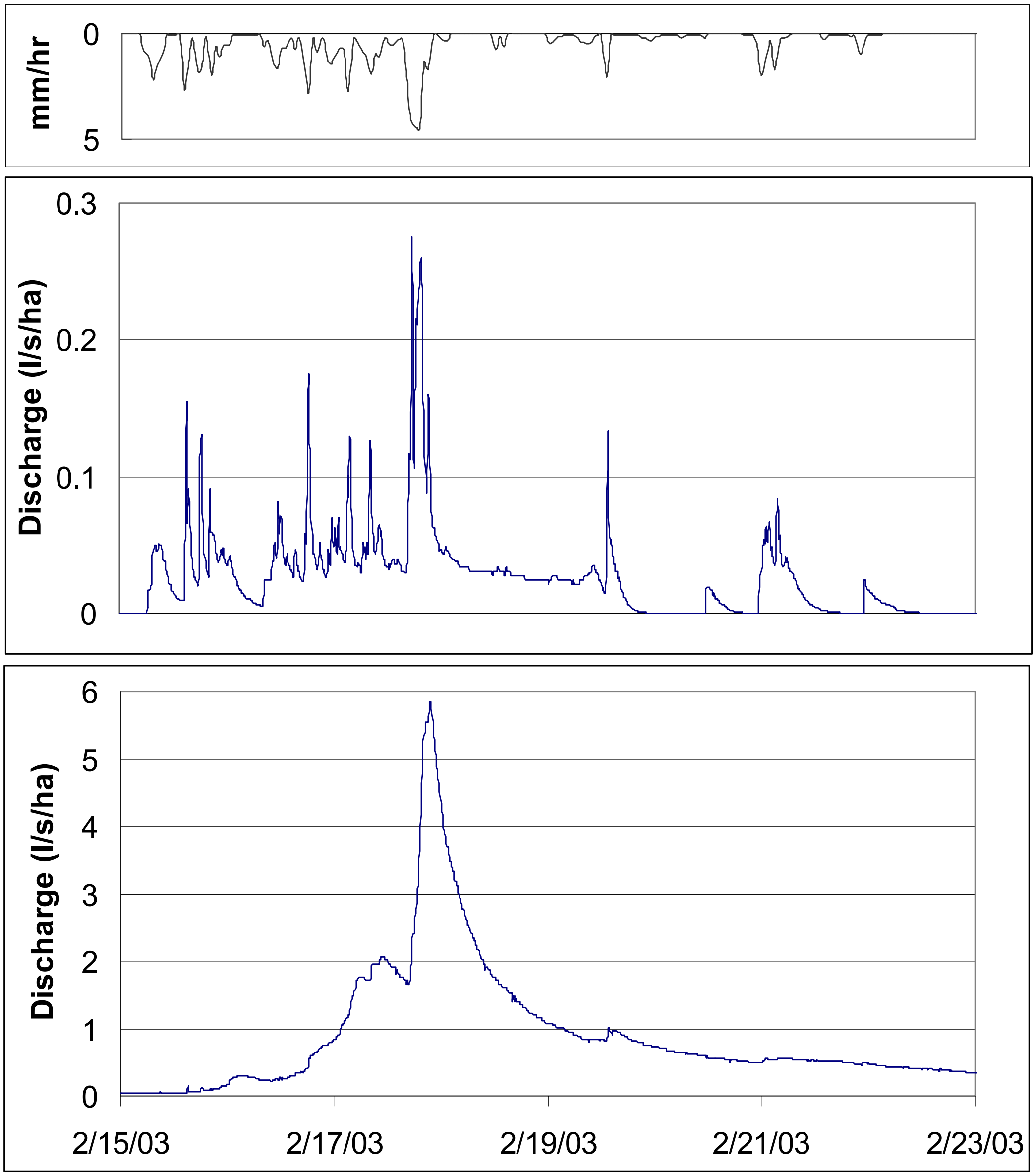


Figure 2. Frequency distribution for stream peak increases due to road runoff. Road segments that intercepted subsurface flow are shown in solid and the road segments that only received runoff from the road surface area are shown in grid pattern.

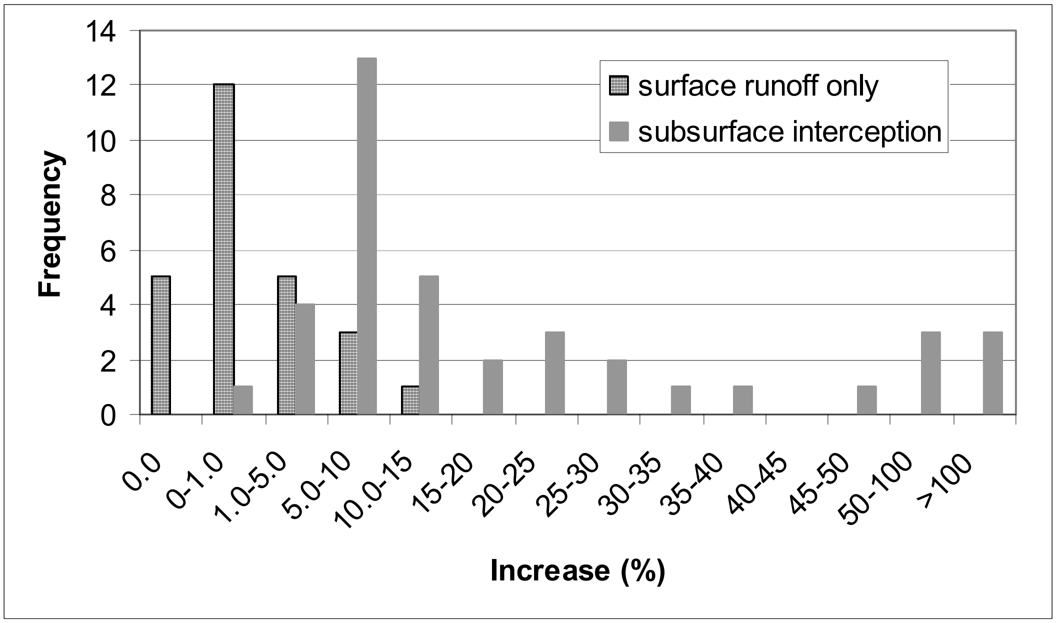


Figure 3. Frequency distribution for stream runoff volume increases due to road runoff. Road segments that intercepted subsurface flow are shown in solid and the road segments that only received runoff from the road surface area are shown in grid pattern.

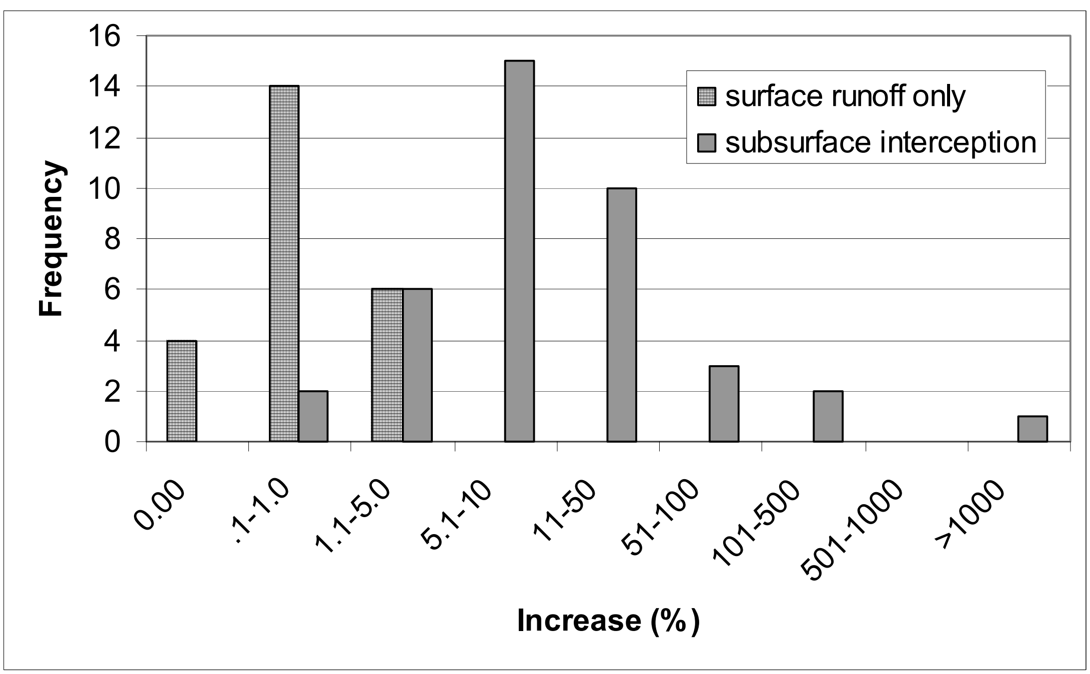


Figure 4. Hydrograph of stream flow and ditch flow during a March 2003 storm. The ditch peak occurred almost two hours before the peak of the stream.