The Science and Management of Headwater Streams in the Pacific Northwest
November 2005
Corvallis, Oregon

Welcome to the Symposium on the Science and Management of Headwaters Streams. It is with great pleasure that we present two full days of new and synthesized research on the topic of headwater streams. The scientific community has long recognized the need for research on very small headwater streams. These streams are fundamentally different than larger streams, minimizing the applicability of research findings from larger streams. There is a need for research focused on small headwater streams, given the extent of the stream network they comprise. The ecological and economic implication of managing around these streams and setting policies for these streams needs to be enumerated.

Goals of the Oregon Headwater Research Cooperative
The Oregon Headwaters Research Cooperative (OHRC) was formed in 2000 to support this research need. The purpose of the OHRC is to investigate local and downstream effects of forest management on biota and habitat characteristics of headwater stream systems. The OHRC is supported by a small group of agencies, organizations and companies. The goals of the research cooperative are: (1) to gain scientific understanding of the physical and biological processes of headwater stream systems; and (2) to test the local and downstream response of headwater streams to a range of forest management prescriptions.

Clearly, there are a multitude of issues surrounding headwater streams. Forestland managers and researchers alike are just beginning to articulate the range of issues spanning economic, social and environmental concerns. When the OHRC formed in 2000, a limited number of studies representing a small portion of the variability formed the basis of current management strategies and policies. Over the past five years additional research has taken place that can begin to provide information to address the range of issues and guide management and policy decisions.

From the outset the OHRC planned to sunset after five years and as such this marks the final year for our cooperative. We will maintain our web site for the next few years as a vehicle for continued communication on the topic of headwater streams. Look for follow-up documents from this meeting, final reports, as well as information on a final set of request for proposals. Our intent is to help fund 2-3 more research projects on unresolved headwater stream topics. http://www.headwatersresearch.org/

Proceedings in the Journal of Forest Science
One of our goals was to facilitate the exchange of scientific findings among scientists, forest managers, and policy makers. This is the third in a series of workshops, forums, and symposiums we sponsored to support this goal. Information from these previous meetings is available on our website. The Journal of Forest Science has agreed to publish suitable papers from this meeting together as a special issue. This peer reviewed collection of research papers will serve as the proceedings from this meeting.

Acknowledgements
Many individuals have made important contributions to the Oregon Headwaters Research Cooperative over the years. In the interest of space, we won't thank individual people, but offer our sincere appreciation to the following organizations that have supported OHRC over the past five years. The following members of the OHRC provided staff to form the cooperative, set goals, guide decisions, and financial support to fund research and sponsor meetings.

Boise Cascade
National Council for Air and Stream Improvement
Oregon Department of Environmental Quality
Oregon Department of Fish and Wildlife
Oregon Department of Forestry
Oregon Forest Industries Council
Plum Creek Timber Company
Weyerhaeuser Company

In addition we thank the Oregon Forest Resources Institute, Watershed Research Cooperative at Oregon State University, the Oregon Chapter of American Fisheries Society, and the Bureau of Land Management who have helped support meetings and the cooperative over the years.

Agenda November 17-18 2005

Thursday, November 17, 2005

Introduction
8:00 – 8:15 *Oregon Headwaters Research Cooperative Opening and Welcome* – **Liz Dent**

8:15 – 8:35 *Headwater Streams in Southeast Alaska: Why Do We Care?* **Mason Bryant**, PNW Research Station, USDA Forest Service, Juneau, AK; **T. Gomi**, Kyoto Univ., Kyoto JAPAN; and **Jack Piccolo**, Juneau Fisheries Center, Univ.of Alaska Fairbanks, Juneau, AK

Session I: Hydrology and Water Quality of Headwater Streams
Moderated by **Liz Dent**, Oregon Department of Forestry, Salem, OR

8:35 – 8:55 *Processes That Influence the Downstream Propagation of Stream Temperature* **Arne Skaugset**, Oregon State University, Corvallis, OR

8:55 – 9:15 *Influence of Timber Harvesting on Water Temperatures in a Northern Idaho Watershed* – **John Gravelle** and **Timothy Link,** University of Idaho, Moscow, ID

9:15 – 9:35 *Biogeochemistry of Managed Forest Headwater Streams at Low Elevations in Western Washington* **– Garrett Liles**, University California Davis, Davis, CA; **Robert Edmonds**, **Daniel Vogt**, Univ. of Washington, Seattle, WA; **Richard Bigley**, Washington State Dept. of Natural Resources, Olympia, WA; **Peter Bisson**, PNW Research Station, USDA Forest Service, Olympia, WA; and **Jeff Richey**, Univ. of Washington, Seattle, WA

9:35 – 9:55 *Forest Harvest Impacts on the Hydrologic Yield of a Mountainous Watershed in the Continental/Maritime Hydroclimatic Region* – Jason Hubbart**,** Timothy Link**, and** John Gravelle**, University of Idaho, Moscow, ID; and** William Elliot**, Rocky Mountain Research Station, USDA Forest Service, Moscow, ID**

9:55 – 10:15 *Hydrological Connectivity between Headwater Systems and Downstream Waters* – **Jeff McDonnell,** Oregon State University, Corvallis, OR

10:15 – 10:35 BREAK

Session II: Sediment and Wood Dynamics of Headwater Streams
Moderated by **Maryanne Reiter**, Weyerhaeuser Company, Springfield OR

10:35 – 10:55 *Effects of Current Timber Harvest Practices on Suspended Sediment Loads in Mica Creek, Idaho* – **Diana Karwan**, Yale University, New Haven, CT; and **John Gravelle**

10:55 – 11:15 *Effects of Debris Flow Fans on Channel Morphology of Fish-bearing Streams in the Oregon Coast Range* – **Paul Bigelow**, **Lee Benda**, Earth Systems Institute, Mt. Shasta, CA.; **Dan Miller**, Earth Systems Institute, Seattle, WA; and **Kevin Andras**, Earth Systems Institute, Mt. Shasta, CA.; and **Kelly Burnett**, PNW Research Station, USDA Forest Service, Corvallis, OR

11:15 – 11:35 *Coalescing Debris-Fill Complexes in Headwater Valleys of the Oregon Coast Range* – **Stephen Lancaster**, Oregon State University, Corvallis, OR; and **Gordon Grant**

11:35 – 11:55 *Effects of Different Riparian Management Treatments on Small Headwater Streams at the Upstream Extent of Fish Use for Streams in Western Oregon* – **E. George Robison**, Humboldt State University, Arcata CA; and **John Runyon**, Adolfson Associates, Inc., Portland, OR

11:55 – 12:15 *Assessing Sediment Inputs to Headwater Streams From Timber Harvest: An Above and Below Monitoring Approach* – **Kate Sullivan,** PALCO, Scotia, CA; and **Robert Darby**

12:15 – 1:00 LUNCH (Included in registration)

Session III: Riparian and Biological Characteristics of Headwater Streams-Part 1
Moderated by **Jeff Light**, Plum Creek Timber Company, Toledo, OR

1:00 – 1:20 *Abiotic and Biotic Responses of Headwater Streams To Adjacent Timber Harvest: Results of a Four-Year Manipulative Study* – **C. Rhett Jackson**, **Darold Batzer**, University of Georgia, Athens, GA; **Sarah Cross**, North Carolina Wildlife Resources Commission, Raleigh, NC; **Stephanie Haggerty**, Kirkpatrick and Lockhart, Newark NJ; and **Christopher Sturm**, City of Thornton, Thornton, CO

1:20 – 1:40 *Reach-Scale Patterns Of Riverine Biodiversity And Productivity: Role Of Tributary Junctions* – **Peter Kiffney,** NOAA Fisheries, Mukilteo, WA; **Correig Greene** and **Tom Good**, NOAA Fisheries, Seattle, WA

1:40 – 2:00 *Riparian Buffer and Upslope Density Management Influences on Microclimate of Young Headwater Forests of Western Oregon* – **Paul Anderson**, and **David Larson**, PNW Research Station, USDA Forest Service, Corvallis, OR; and **Samuel Chan**, Sea Grant Extension, Oregon City, OR

2:00 – 2:20 *Riparian Microclimate, Overstory Canopy and Understory Vegetation and Soil Moisture Relationships to a Range of Timber Harvest Prescriptions in Headwaters Forests of the Central Oregon Coast Range* – **Samuel Chan**; **Paul Anderson**; **Robert Danehy** and **Maryanne Reiter**, Weyerhaeuser Company, Springfield, OR

2:20 – 2:40 *Relationships Between Forest-floor Invertebrate Distribution, Movement, and Microclimate Under Alternative Riparian Management Practices* – **Jessica Rykken**, Harvard University, Cambridge, MA; and **Andrew Moldenke**, Oregon State University, Corvallis, OR

2:40 – 3:00 BREAK

Session III: Riparian and Biological Characteristics (Part I continued)
Moderated by **Rick Hafele**, Oregon Department of Environmental Quality, Portland, OR

3:00 – 3:20 *Invertebrates and Organic Matter Respond to Forestry and Summer Low Flows in Small Streams of Coastal British Columbia* – **John Richardson**, University of British Columbia, Vancouver, BC; and **Peter Kiffney**

3:20 – 3:40 *Responses of Headwater Diatom Communities to Natural Determinants and a Range of Timber Harvest Prescriptions in the Central Oregon Coast Range* – **Robert Danehy**; **Samuel Chan**; **Gary Lester**, Ecoanalysts. Inc., Moscow, ID; **Russell Langshaw;** and **Ted Turner** Weyerhaeuser Company, Springfield OR

3:40 – 4:00 *Influence of Forest Harvest on Aquatic Insect Emergence From Perennial and Intermittent Headwater Streams in the Central Oregon Coast Range.* – **Janel Banks, Alan Herlihy**, and **Judith Li**, Oregon State University, Corvallis, OR

4:00 – 4:20 *Impacts of Forest Harvest on Aquatic Macroinvertebrate Community Composition in a Northern Idaho Watershed* – Justin Broglio**,** Timothy Link**,** Jeff Braatne**, and** John Gravelle**, University of Idaho, Moscow, ID**

4:20 – 4:40 *Effect of Riparian Buffers on Emergence of Aquatic Insects From Headwater Streams in Western Oregon* – **Andrew R. Moldenke**, Oregon State Univ., Corvallis, OR

4:40 – 5:00 *Invertebrate Drift Origin and Composition in Calapooia River Headwater Tributaries* – **Russell Langshaw** and **Robert Danehy**

5:00 – 7:00 PM Poster Session and Reception (included in registration)

Friday, November 18, 2005

Session IV: Science Synthesis and Management Implications of Headwaters Research

8:00 – 8:10 Moderated by **George Ice**, National Council for Air and Stream Improvement, Corvallis, OR

8:10 – 8:30 *Economic Implications of Forest Management Around Headwater Streams* **– Bruce Lippke, Kevin Ceder**, **Kevin Zobrist**, University of Washington, Seattle WA. **Kernen Lien**, Community Development, Lewis County, WA

8:30 – 9:10 *Hydrology and Water Quality of Headwater Streams in the Pacific Northwest* – **Stephen Schoenholtz**, Oregon State University, Corvallis OR

9:10 – 9:50 *Integrating Current Research on Sediment and Wood Dynamics of Headwater Streams* – **Christine May**, University of California, Berkley, CA

9:50 – 10:10 BREAK

10:10 – 10:50 *The Biology of Headwater Streams and Their Riparian Areas in Forested Landscapes* – **John Richardson,** University of British Columbia, Vancouver, BC, Canada

10:50 – 11:30 *Influence of Headwater Streams to Downstream Reaches* **– Lee MacDonald**, Colorado State University, Ft. Collins, CO

11:30 – 12:10 *Management and Policy Options for Headwater Streams: A Synthesis and Reflection* **– Paul Adams**, Oregon State University, Corvallis OR

12:10 – 1:00 LUNCH (included in registration)

Session V: Biological Characteristics of Headwater Streams – **Part 2**
Moderated by **Kim Jones**, Oregon Department of Fish and Wildlife, Corvallis, OR

1:00 – 1:20 *Use of Headwater Amphibians as Indicators of Watershed Health* – **Lowell Diller** and **Laura Burkholder**, Green Diamond Resource Company, Korbel, CA

1:20 – 1:40 *Effects of Headwater Riparian Reserves of Four Widths with Upslope Thinning on Instream and Bank Vertebrates* – **Deanna Olson**, PNW Research Station, USDA Forest Service, Corvallis, OR; and **Cynthia Rugger**, College of Forest Resources, Oregon State University Corvallis, OR, and **George Weaver**, Hewlett Packer Company, Corvallis OR

1:40 – 2:00 *Habitat Associations of the Southern Torrent Salamander* (Rhyacotriton variegatus) *on Industrial Forestlands in North Coastal California and Implications for Management* – **Sal Chinnici**, **David Bigger**, **Daniel Dill** and **Michael Dunkelberger**, SCOPAC, Scotia, CA; and **Robert Darby**

2:00 – 2:20 *Landscape Pattern and Coastal Cutthroat Trout Distribution in Forested Montane Catchments* – **Christian Torgersen,** USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR; **Robert Gresswell**, USGS Northern Rocky Mt. Science Center, Bozeman, MT; *__Douglas Bateman__, Oregon State University, Corvallis, OR; **David Hockman-Wert**, USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR

2:20 – 2:40 BREAK

Session VI: Management and Policy of Headwater Streams
Moderated by **Jim Cathcart** Oregon Department of Forestry, Salem, OR

2:40 -3:00 *The Effect of Digital Elevation Model Resolution on Stream Network Prediction and Computational Requirements* – **Adam Mouton** and **Peter Schiess,** University of Washington State, Seattle, WA

3:00 – 3:20 *Spatially Explicit Terrain Databases: A Planning Tool for Natural Resource Management, Restoration, Monitoring, and Conservation* – **Lee Benda, Daniel Miller, Kevin Andras, Paul Bigelow,** Earth Systems Institute; **Gordon Reeves,** PNW Research Station, USDA Forest Service, Corvallis, OR; and **David Michael,** Oregon Department of Forestry, Forest Grove, OR

3:20 – 3:40 *Evaluating Riparian Policies for Headwater Streams in the Oregon Coast Range* – **Kelly Burnett**, PNW Research Station, Corvallis, OR; **K. Norman Johnson**, Oregon State University, Corvallis, OR; ***Daniel Miller**; **Gordon Reeves,** and **Tom Spies**, PNW Research Station, Corvallis, OR; **T. Larsen**, Oregon State University, Corvallis, OR

3:40 – 4:00 *Small Headwater Stream Protections in Oregon: A Case Study on the Integration of Science Into the Policy-Making Process*– **Jim Paul** and **Brad Knotts**, Oregon Department of Forestry, Salem, OR

4:00 – 4:10 Closing Remarks – **George Ice**

Presentation Abstracts

Policy and Management Options for Headwater Streams: Synthesis and Reflection

Paul W. Adams

Forest Engineering Department, Oregon State University, Corvallis, OR

Abstract

The primary policy and management concern and focus for headwater streams in the Pacific Northwest has been their potential influence on downstream fish habitat. The channels and riparian areas of these streams also have some links to wildlife habitat, drinking water and other values, but to date these have represented relatively minor policy issues. Although a broad array of policy approaches are available, regulations have been the primary tool used by state and federal agencies in the region to promote desired management for these areas. On both public and private lands such measures are based largely on a passive management philosophy (e.g., tree retention) that assumes significant ecological functions and benefits will follow over extended spatial and temporal intervals. Some notable exceptions exist, including formal state programs with "voluntary" measures to actively improve fish habitat (e.g., The Oregon Plan) or retain riparian trees (e.g., Idaho) in order to avoid further regulations or legal liability.

As a policy approach itself, small stream research and analysis has a notable history in the region, and its evolution helped spur wide interest in policy and management that integrate stream and riparian ecology with forest practices. However, this work may now be significantly repeating itself or examining minutiae, while also continuing to largely ignore key questions whose answers may substantially improve the effectiveness of our resource policies and management. Some of the greatest issues and questions arise in the socioeconomic sphere, which suggests that it may be time to pointedly study and integrate the life cycle and behaviors of *Homo sapiens* into the ecosystems for which we are developing policies and management strategies. Otherwise, we may continue to confound or alienate large numbers of forest owners and managers, while also adding to an array of unintended local and global environmental consequences.

Riparian Buffer and Upslope Density Management Influences on Microclimate of Young Headwater Forests of Western Oregon

Paul D. Anderson[1], David Larson[1], Samuel S. Chan[2]

1. USDA Forest Service, PNW Research Station, Corvallis, OR 97331
2. Oregon State University, Sea Grant Extension, 200 Warner-Milne Road, Oregon City, OR 97405

Abstract

Commercial thinning is a predominant silvicultural activity on federal forest lands being managed to enhance ecosystem function and biodiversity in the Pacific Northwest. Vegetative buffers are retained adjacent to streams to mitigate impacts of thinning on riparian features and processes. However, the width and configuration of buffers needed to mitigate potential impacts of forest thinning on stream and riparian ecosystems, particularly for smaller streams of headwaters forests remains undetermined.

We investigated the influences of buffer width and upslope density management treatments on riparian and adjacent upslope microclimates associated with headwaters streams of Cascade and Coast Range forests of western Oregon. Spatial and temporal variation in canopy cover, microclimate, understory vegetation, and forest floor conditions were monitored along transects extending from stream center upslope into thinned or unthinned stands, and with riparian buffers ranging in width from approximately 7 to 65 m.

Through five years after thinning, summer air and soil temperatures increased and relative humidity decreased with upslope distance from the stream. Gradients were strongest within 10 to 15 m of stream center. In thinned stands, late-afternoon air temperature was 1 to 4 °C greater and relative humidity as much as 18 % less, relative to unthinned stands. When buffers of 15 m width or greater were retained, air temperatures at stream center differed by less than 0.5 °C and relative humidity differed by less than 4 % from that for unthinned stands. Thus, regardless of thinning intensity, all but the narrowest buffers were effective in maintaining microclimate at stream center similar to that in unthinned stands.

Influence of Forest Harvest on Aquatic Insect Emergence From Perennial and Intermittent Headwater Streams in the Central Oregon Coast Range

Janel Banks, Alan Herlihy, Judith Li

Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331

Abstract

This study compared the community assemblages of emergent aquatic insects from 20 headwater streams in the central Oregon Coast Range. Study streams varied in flow duration and timber harvest condition. Ten streams were located in recently logged catchments (<1 year); three streams were intermittent and seven were perennial. The remaining ten streams (four intermittent and six perennial) were located in forested catchments that have not been logged for at least 34 years. For each of three sampling periods (August-September 2003, October-November 2003, and April-May 2004), emergence traps were set for four weeks. Regardless of flow duration or season, more aquatic insects emerged from streams in logged than forested catchments. More Trichoptera and aquatic Diptera emerged from clearcut sites than unlogged sites. More Plecoptera emerged from intermittent than perennial streams. More Ephemeroptera emerged from intermittent, unlogged sites than perennial, unlogged sites. NMS ordination analyses indicated that emergent aquatic insect communities differed by season and by riparian condition. Channel dimensions (active channel and bankfull width) and catchment area were correlated with ordination-axes, but were not different between logged and forested sites. The amount of riparian cover (canopy, understory, and groundcover), stand age, slash, and stream cover were all considerably different between logged and forested sites and were highly influential on emergent assemblages. Stream substrate composition was also influential on adult assemblages. Mean water temperature in summer, fall, and spring was highly correlated with seasonal variation in assemblages. Stream flow-duration does not appear to strongly influence adult community assemblages.

Spatially Explicit Terrain Databases: A Planning Tool for Natural Resource Management, Restoration, Monitoring, and Conservation

Lee Benda1, Daniel Miller2, Kevin Andras1, Paul Bigelow3, Gordon Reeves4, and Dave Michaels5

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[4] Pacific Northwest Research Station, USFS, 3200 Jefferson Way, Corvallis, OR 97331
[5] Oregon Department of Forestry, 801 Gales Creek Road, Forest Grove, OR 97116

Abstract

Watershed scientists and managers are in need of terrain databases that describe watershed controls on aquatic habitats and that can be applied rapidly and consistently over large areas at low costs. Recent ecological advances highlight the hierarchical relationships between watersheds and their aquatic habitats, including the roles of basin scale, topography, physical heterogeneity, river networks, and disturbance. Within this context, new techniques for topographic analysis of digital data can resolve many watershed to reach scale controls on aquatic habitats, including attributes pertaining to basin topography and erosion processes, channel network configuration and valley morphology, channel and habitat morphology and sensitivity, and aspects of natural disturbance regimes and sensitivity to land use impacts. Data can be mapped at the scale of valley segments to individual watersheds and queried to search, sort, rank, and classify across populations of watersheds over millions of acres. We illustrate terrain analysis in four landscapes in western Oregon using a subset of available parameters included in *Earth Systems Institute's Terrain Resource Inventory and Analysis Database* (*TRIAD*) to examine differences in: 1) erosion potential by debris flow, 2) effects of mass wasting on channels, 3) types and abundance of different habitat types, and 4) sources and distribution of physical heterogeneity. Similar to how stream classification can enhance the ability of watershed scientists and managers to interpret reach scale channel characteristics, terrain analysis helps users interpret watershed and network scale controls on river habitats and facilitates comparative analyses of environments across dozens to hundreds of watersheds for forest and fish habitat management, restoration planning, monitoring, and conservation. Terrain databases, in conjunction with software tools, can provide new types of information for landscape management and can support existing watershed programs including habitat inventories, watershed analyses, habitat conservation plans, land acquisitions, cumulative effect studies, restoration plans, and TMDL assessments.

TRIAD is presently being applied to approximately 25 million acres across the Pacific Northwest for federal and state agencies, and private landowners.

Effects of Debris Flow Fans on Channel Morphology of Fish-bearing Streams in the Oregon Coast Range

Paul Bigelow[1], Lee Benda[2], Dan Miller[3], Kevin Andras[2], and Kelly Burnett[4]

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3. Earth Systems Institute 3040 NW 57th St., Seattle, WA 98107
4. U.S. Forest Service Pacific Northwest Research Station, 3200 Jefferson Way Corvallis, OR 97331

Abstract

We evaluated the direct and indirect effects of debris-flow deposits on the morphology of fish-bearing streams in the Umpqua watershed, Oregon Coast Range. Field work consisted of continuous (6.4 km) surveys in third- through fifth-order streams (drainage area < 10 km^2 and slope < 7%) where the effects of debris flows are most evident and such basin sizes encompass approximately 70% of coho salmon habitat. In the relatively unmanaged watersheds, debris flows originating from first- and second-order streams deposited sediment and large wood and created fans at tributary confluences. Overall, boulder deposits, channel gradients, sediment depth, large wood, and deep pools increased in proximity to young (< 60 years) and old debris-flow fans at confluences. In many cases the variation in channel morphology was significantly higher in reaches near fans and therefore the associated diversity of aquatic habitats in fish-bearing streams increased with proximity to debris-flow deposits at tributary confluences. In addition, the spatial scale of physical diversity driven by debris-flow deposits at confluences is on the order of one- to two-hundred meters set by the average spacing of low-order headwater tributaries in river networks. While the immediate effects of debris flows in fish-bearing streams can be destructive, it appears that debris-flow deposits contribute to the formation and diversity of aquatic habitats over longer time frames. Our field analysis helps understand the origin of patchy aquatic habitats influenced by debris-flow deposits and how habitat diversity is organized at the scale of river networks by natural disturbances.

Impacts of Forest Harvest on Aquatic Macroinvertebrate Community Composition in a Northern Idaho Watershed

Justin Broglio, Timothy Link, Jeff Braatne, and John Gravelle

University of Idaho, College of Natural Resources, Moscow, ID 83844

Abstract

Timber harvest and road construction in mountainous watersheds have the potential to increase the quality and amount of fine sediment entering stream systems. These sediment alterations can impact all biotic components of the stream ecosystem. The direct effect of contemporary timber harvest and road construction practices on aquatic macroinvertebrate populations are analyzed in a northern Idaho watershed. Macroinvertebrates are valuable bioindicators to assess the effects of timber harvest due to their sensitivity to changes in sediment, organic material, temperature, and light. In this study, macroinvertebrate community structure and diversity were used as measures of stream habitat quality in relation to two timber harvest techniques in the experimental catchments. Three aquatic macroinvertebrate taxa were used as indicators of stream quality: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies), "EPT". In relation to initial timber harvest, there were no major changes in functional feeding groups or EPT richness. However, changes were observed in overall macroinvertebrate abundance, downstream EPT abundance values, and Shannon-Wiener Diversity Index values. Long-term and detailed food web studies are needed to fully assess stream responses to clear-cut and partial-cut harvesting practices.

Headwater Streams in Southeast Alaska: Why do we Care?

M. D. Bryant[1], T. Gomi[2], and J. Piccolo[3]

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[2] T. Gomi, Kyoto University, Gokasho, Uji, Kyoto 611-0011, JAPAN
[3] J. Piccolo, Juneau Fisheries Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, Alaska 99801, ftjjp1@uaf.edu

Abstract

Headwater streams may comprise more than 70% of the area of a watershed and until recently, they have been largely over-looked by managers and ecologists in Southeast Alaska and elsewhere. However, their importance in shaping downstream processes is becoming more widely recognized. Recently, a series of studies were completed in Southeast Alaska that examined the physical and biological features of headwater streams. We review and synthesize these studies to define headwater stream characteristics in Southeast Alaska, describe some processes that occur in these streams, and discuss their importance to watersheds. Alterations in large wood abundance and distribution have predictable effects on sediment storage and transport in headwater streams. Legacy wood remaining in streams more than 25 yrs after logging was an important structural component. Invertebrate populations captured in drift samples are diverse, and more than 60 % of the taxa were aquatic. Downstream transport of invertebrate drift from reaches without fish may be an important to juvenile fish residing in the lower reaches. Drift density is inversely related to stream discharge, so small streams may provide better foraging and growth potential. Resident and anadromous fish live and spawn in headwater reaches with gradients > 10 % and occupied small step pools formed by large woody debris. Dolly Varden were the dominant species in higher gradient reaches, but juvenile coho were also present. Steelhead were seasonal residents. Headwater streams link hill slope processes to watersheds and can have important consequences for salmonid populations throughout a watershed.

Evaluating Riparian Policies for Headwater Streams in the Oregon Coast Range

K. M. Burnett[1], K. N. Johnson[2], D. J. Miller[3], G. H. Reeves[1], and T. A. Spies[1]

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[3.] Earth Systems Institute, 3040 NW 57th St., Seattle, Washington 98107

Abstract

Debris flows are key disturbances and create habitat complexity in many streams throughout the Pacific Northwest. Forest clearing near headwater streams can affect local susceptibility to debris-flow initiation, distances debris flows travel, and types and volumes of materials delivered to fish-bearing streams. Thus, logging along headwater streams is prohibited on federal lands and intensely debated for other ownerships. Because headwater streams are numerous and differ in susceptibility to debris-flow effects, the ability to target riparian protection at headwater streams that are debris-flow sources for fish-bearing streams is of great interest. As part of the Coastal Landscape Analysis and Modeling Study (CLAMS), we compared three riparian management alternatives for headwater streams: 1) current policies; 2) buffers on all headwater streams, 3) buffers on only headwater streams with a moderate to high probability of delivering debris flows to fish-bearing channels. We identified this group of headwater streams based on topographic characteristics using a debris-flow initiation and runout model developed in CLAMS. We used another CLAMS model, the landscape policy simulation model (LAMPS), to simulate spatial effects of the riparian policies over time on forest composition and structure. Riparian policies were compared for landscape-level outcomes, including area in buffers, timber-harvest volumes, riparian forest conditions, and probabilities of debris-flow effects in fish-bearing channels. Debris-flow effects were estimated by re-running the debris-flow model as empirically calibrated for different forest cover classes. Through this research we hope to demonstrate incremental efficiencies in maintaining ecosystem function while minimizing negative economic impacts to forest owners.

Riparian Microclimate, Overstory Canopy and Understory Vegetation and Soil Moisture Relationships to a Range of Timber Harvest Prescriptions in Headwaters Forests of the Central Oregon Coast Range

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Abstract

In the Oregon Coast range, small, frequently ephemeral headwater streams and associated riparian areas have been managed without distinction from adjacent upland forest. Our study was undertaken to 1) identify and characterize those features that delineate headwaters riparian areas from upland forest, and to 2) evaluate the effects of various timber harvest activities on those features. We examined overstory structure, radiation, understory vegetation and spring and summer microclimate within 35 m from stream center for 19 reaches distributed among 45-60 year-old Douglas-fir stands having been thinned, clear cut, or left unharvested within the past decade.

Upland relative density (RD) averaged 32, and 21 in unharvested and thinned stands, respectively. Streamside density of thinned stands (RD 31) was similar to that of unharvested stands. The percentage of radiation penetrating the forest canopy at stream center averaged 57%, 10 % and 3 % for clearcut, thinned and unharvested stands, respectively. Summer maximum air temperatures and minimum relative humidities at stream center differed between the clear-cut (32 ^{o}C; 38%), thinned (27 ^{o}C; 46%), and mature (20 ^{o}C; 61%) stands. Maximum streambed temperatures were similar in thinned and unharvested stands and about 2 °C less than those for clearcuts. A narrow vegetative buffer of trees or dense shrubs along headwater streams in clear-cuts lowered insolation at the stream and resulted in microclimates more similar to thinned stands. Soil moisture did not differ among harvest type, but was substantially greater at 15 m than 5 m from stream center.

Unique characteristics distinguished riparian and upland zones. Irrespective of harvest type, strong microclimate gradients occurred within 5 m of stream center and upland conditions were observed within 15 m of the stream. The relatively cooler temperatures, higher humidities and availability of soil moisture within 5 meters of the stream channel can contribute to spatial definitions of riparian zones within headwater forests of the Oregon Coast Range.

Habitat Associations of the Southern Torrent Salamander (*Rhyacotriton variegatus*) on Industrial Forestlands in North Coastal California and Implications for Management

Sal J. Chinnici, David Bigger, Daniel R. Dill, Michael W. Dunkelberger, and Robert Darby

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Abstract

We investigated the distribution and habitat of the Southern Torrent Salamander (*Rhyacotriton variegatus*) in streams on industrial managed forests in Humboldt County, North Coastal California. Our study area on PALCO land is managed under a Habitat Conservation Plan (HCP). Among the HCP's many conservation strategies are extensive measures designed to reduce sediment inputs to streams from roads to protect both amphibian and salmonid habitat. We surveyed 40 headwater seeps, springs, or watercourses between 1999 and 2005 for salamanders and related habitat characteristics to the presence or absence of salamanders. To investigate the potential impacts of road construction and maintenance on salamanders, we selected watercourses that were bisected by a road and then compared the presence or absence of salamanders to upstream and downstream sites. We also explored for potential effects of the type of road surface (native or rock) and other road characteristics on salamanders. We discuss how our results compare to other studies describing the distribution, habitat, and the impacts of timber management on this species.

Responses of Headwater Diatom Communities to Natural Determinants and a Range of Timber Harvest Prescriptions in the Central Oregon Coast Range

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Abstract

We examined 18 coast range headwater watersheds within clear-cut, thinned and mature stands. Estimates of insolation at the summer solstice ranged from 45 megajoules/m^2/day at a mature site to 884 at a recent clear-cut. Summer base flow discharge was from 0.02 to 1.98 l/s (mean - 0.5 l/s) with rate of travel ranging from 0.39 to 3.45 m/sec (mean - 1.14). All sites had a well defined source at low flow. Hydrologic sources included wet areas, obvious seeps, and flowing springs. Mean drainage area and distance to hydrologic sources were 9.9 ha and 251 m respectively. Nutrient availability was low, dissolved phosphorus ranged from 0.002 to .01 (mean - 0 .006) and nitrate 0.003 to .077 (mean - 0 .0230) mg/l.

We found 72 diatom species. One species, *Achnanthes lanceolata* a small horizontal from, comprised over 50% of the diatom assemblage at most sites and over 80% at six sites. Diatom communities were strongly influenced by water quality factors. *A. lanceolata* was positively correlated with dissolved phosphorus and negatively correlated with percent fine sediment. Assemblages at thinned sites were more similar to mature sites than recent clear-cuts. Biomass ranged from 0.5 to 2.5 gm^2 with the highest values seen at sites with moderate light. Diatom assemblages were more diverse at sites with higher groundwater inputs. This suggests that headwater streams with more consistent flows can sustain diatom communities during periodic drought disturbance.

Use of Headwater Amphibians as Indicators of Watershed Health

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Abstract

It has been suggested by numerous authors that amphibians are sensitive to environmental perturbations and have the potential to be good bio-indicators. To investigate the efficacy of using these species as indicators of watershed health, we studied the habitat associations, and since 1997, monitored populations of torrent salamanders and tailed frogs. Both species were found associated with consolidated geologic formations, but torrent salamanders were generally found in seeps and the uppermost headwater reaches of streams, while tailed frogs occurred somewhat lower in the watershed. Although numerous (649 located to date), torrent salamanders sites were relatively small (<100 m^2) mostly isolated patches of habitat with relatively few individuals (probably <100). Tailed frog sites were less numerous (252 located to date), but were much larger areas of contiguous habitat (many >10,000 m^2). Mark recapture estimates of adult female frogs indicated populations as high as 1.5-2.0 individuals per m of stream indicating populations of 1000's of frogs. Both species showed a positive association with stream gradient, but the association was much stronger for torrent salamanders compared to tailed frogs (mean gradient 31.8 and 9.1%, respectively). Our data further supported the conclusion that both species were less likely to be found in areas with higher levels of fine sediments and embeddedness. We predicted that torrent salamanders were more sensitive to direct impacts of land management activities while tailed frogs were more likely to be influenced by indirect cumulative effects. However, the current monitoring data do not indicate an association between populations of these headwater amphibians and levels of land management activities.

Hydrologic and Temperature Response of Cascade Headwater Streams to Projected Climate Change

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Abstract

A growing number of empirical and modeling studies predict that projected climate change will lead to significant reductions in winter snowpacks hence summer streamflow in mountainous regions of the Western US. Under such scenarios, headwater catchments are likely to be disproportionately affected, by virtue of both their abundance and landscape position. Our previous work in this region demonstrates strong differences in summer streamflow and temperature regimes between the younger High and older Western Cascade geologic provinces. These differences are related to the prevalence of deeper groundwater spring systems in the High Cascades that maintain higher and more consistent summer streamflow volumes relative to those of the shallow subsurface-dominated Western Cascades. Here we use a spatially distributed, process-based hydro-ecological model, (RHESSys) to explore the response of these distinct summer streamflow signatures to climate forcing. Results indicate that the groundwater system of the High Cascade site is likely to buffer the impact of increasing temperature and associated changes in snow accumulation and melt. Simulation results for the Western Cascade site, on the other hand, show responses similar to those predicted by previous larger scale hydrologic modeling efforts. At the same time, low flow in High Cascade headwater streams is more sensitive to changes in annual precipitation than Western Cascade streams. We also explore the potential impacts of climate change on stream temperature regimes. These results illustrate the importance of groundwater flow mechanisms as a key control on climate change sensitivity of headwater streams in Oregon.

Influence of Timber Harvesting on Water Temperatures in a Northern Idaho Watershed

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Abstract

Concerns regarding the impacts of contemporary timber harvest practices on stream water temperature emphasize the need for an increased understanding of temperature patterns related to disturbances in headwater areas. A network of water temperature recorders was installed in the Mica Creek Experimental Study Area in northern Idaho to investigate the relationships between forest treatments and stream temperatures. Sensors were placed in first-order, non-fish bearing unimpacted reaches, non-fish bearing harvested reaches, and downstream into second and third-order fish bearing reaches of the stream network. Treated watersheds consisted of 50 percent canopy removal by contemporary clearcut methods and selective cut practices. Harvesting followed the current Idaho Forest Practices Act regulations. The Stream Protection Zone (SPZ) for non-fish bearing reaches required an equipment exclusion zone within 30 feet (9.1 m) of the ordinary high water mark or definable bank. Any fish bearing stream which bordered the harvesting was protected with an SPZ of at least 75 feet (22.9m), with a requirement to leave at least 75% of existing shade. Water temperature at the downstream fish-bearing sites was collected continuously since 1991. Timber harvesting occurred in the summer and fall of 2001. Temperature data were collected in the non-fish bearing sites for the summers of 2001 through 2004. Water temperature maxima in the non-fish bearing reaches increased by 1.4° to 3.6°C in the clearcut first-order watersheds, probably due to increased solar radiation from decreased canopy cover. There was also an apparent, yet slight, 0.2° to 0.6°C upward trend in the year immediately following harvest at the selective cut sites when compared to the control tributaries. Despite the temperature increases in the non-fish bearing reaches, there was no apparent increase in water temperature maxima at the fish bearing sites downstream. Continued monitoring at these sites is planned to evaluate stream temperature trends over subsequent years.

Forest Harvest Impacts on the Hydrologic Yield of a Mountainous Watershed in the Continental/Maritime Hydroclimatic Region

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Abstract

The continental/maritime region of the inland Northwest is a transitional climate influenced by both maritime and continental weather patterns. To date there are no published studies of hydrologic impacts resulting from timber harvest in this region of the U. S. Streamflow data were collected since 1991 at the Mica Creek Experimental Watershed (MCEW) located in northern Idaho. Following the six-year calibration period, treatments consisted of road construction followed by four years of monitoring. This was followed by 50% clearcut, and 50% partial cut (50% canopy removal over 50% of the catchment) timber harvests followed by three years of monitoring. Analysis to assess change in hydrologic yield was completed using linear regression and analysis of covariance (ANCOVA). Results indicate significantly ($p = 0.01$) increased water yield following road construction on north to northeast facing slopes of almost 80 mm, while change was insignificant on predominantly southeast facing slopes. Water yield also increased significantly ($p < 0.00$) following clearcut harvest practices in excess of 300 mm/yr, and approximately 55 mm/yr ($p = 0.05$) following partial cut harvesting. Paired catchment analysis showed that cumulative effects of experimental treatments were minimal 2.5 km downstream from the harvest treatments with an increase of approximately 30 mm ($p < 0.00$). Monthly and seasonal analyses revealed that the largest effects of harvest practices were seen during the snow deposition and melt season from December through June. During the period of July-October, road construction was observed to increase water yield significantly ($p = 0.04$) by as much as 8.5 mm. During the same time period, clearcut harvest did not significantly increase water yield while partial cut harvest did ($p < 0.00$) by almost 7 mm. Evapotranspiration (as approximated by the residual of the water balance equation) was reduced by 43 % and 8.5 % following clearcut and partial cut harvest respectively. This is among the first quantitative analysis examining the relationships between contemporary timber harvest practices and catchment hydrology in the Continental/Maritime region of the United States. Results

from this work will establish a basis upon which to develop tools for effective watershed management in the Continental/Maritime hydroclimatic region.

Abiotic and Biotic Responses of Headwater Streams To Adjacent Timber Harvest: Results of a Four-Year Manipulative Study

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Abstract

Abiotic and biotic responses of headwater streams to adjacent timber harvest were monitored in the first (1999) and third (2001) summers following harvest in 15 streams draining four logging sites in Washington State's Coast Ranges. Six watersheds were clearcut to streambanks, four were provided buffers, and four served as references. In 1999, clearcut channels were covered or buried by 0.5 to 2 meters of logging slash, increasing channel roughness and trapping fine sediments, while particle size distributions were almost unchanged in most buffered and all reference streams. In 2001, slash in clearcut channels had partially degraded, but channel conditions still reflected slash burial. Fine sediment fractions were still elevated but dropping. Buffered streams experienced 33% to 64% blowdown, and increased light stimulated growth of streamside herbaceous and shrubby vegetation. In 1999, clearcut streams supported higher collector and shredder macroinvertebrate densities, likely due to increased woody debris and sediment inputs, and organic and inorganic matter accretion was higher in buffered and clearcut streams. By 2001, watershed specific macroinvertebrate responses emerged, with EPT (mayfly, stonefly, and caddis fly) taxa increasing in certain study streams and amphipod crustaceans increasing in others. Many of these macroinvertebrates feed on algae, so increases may have resulted from increased primary productivity as slash cover declined and insolation increased. In one watershed, harvested streams became dominated by sediment-dwelling worms. No macroinvertebrate groups declined after harvest, perhaps because streams were naturally oligotrophic. Results suggested that clearcutting to stream channels had negative effects on local *Dicamptodon* and *Ascaphus truei* populations while *Rhyacotriton* numbers appeared unaffected.

Comment:

Effects of Current Timber Harvest Practices on Suspended Sediment Loads in Mica Creek, Idaho

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Abstract

The concern regarding sedimentation effects from current timber harvest practices emphasizes the necessity for a greater understanding of how both road construction and timber harvest relate to stream sediment levels. In order to investigate this, a network of seven automated stream monitoring flumes was installed in the Mica Creek Experimental Watershed, North Idaho. Beginning in 1991, water samples collected at each flume under both flow-based and stream-stage storm rise conditions and have been analyzed for total suspended solids (TSS). This period of record encompasses a pre-treatment time interval from 1991 to 1997, and two treatment time intervals: post-road from 1998 to 2001 and post-road/post-harvest from 2001 to present. Treated and control catchments were statistically compared using a paired watershed approach for each time interval. The impacts corresponding to road construction remain difficult to discern from the larger variation in the entire suspended sediment record as only one of the two roaded watersheds experienced a significant increase in sediment load. The impacts corresponding to timber harvest differ based on harvest regime and time period of analysis. Results suggest a correlation between increased sediment loads and clear cutting for a brief period following the harvest. No such correlation was found in the partial cut watershed. Continued monitoring at these sites is planned to evaluate trends over subsequent years.

Reach-Scale Patterns of Riverine Biodiversity and Productivity: Role of Tributary Junctions

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Abstract

Although headwater streams comprise 75-90% of total length in most watersheds, how they effect the mainstem rivers they flow into is not understood. Recent research has shown that the physical and biological diversity of mainstem rivers at tributary junctions are higher compared to points upstream of these junctions. However, researchers have yet to link these observations with individual, population, and community level processes. In 2002-2004, we examined whether tributary junctions created productivity and structural gradients, and if so, whether these gradients affected abundance and growth of invertebrates, fish and birds (2004). A large flood event in 2004 also allowed us to examine how disturbance affected these patterns. Our initial findings suggest that tributary junctions create gradients in velocity, nutrients, periphyton, insects and fish abundance. Moreover, tributary junctions were loci for large-scale distributions of sediment and wood, enabling even the smallest tributary to have large affects of physical habitat.

Coalescing Debris-fill Complexes in Headwater Valleys of the Oregon Coast Range

Stephen T. Lancaster and Gordon Grant

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Abstract

Headwater streams are important links in the sediment transport chain connecting production from steep uplands to supply in downstream, fish-bearing channels. In headwater basins that are forested and where debris flows are common, debris-flow deposition forms valley-spanning dams of wood, boulders, or both, and significant volumes of sediment are stored behind these dams. In three headwater streams (basin areas of approximately 2 sq. km) in the Oregon Coast Range, the following data were collected: (a) longitudinal channel profiles; (b) locations and heights of debris dams; (c) sediment storage volumes; and (d) exposed bank stratigraphy. In all three basins, these data indicate a zone of concentrated mainstem debris-flow deposition where stream gradients first decrease to approximately 10%. Deposits in this zone do not form fans per se but, rather, comprise coalescing debris-fill complexes. These complexes have large unit storage volumes (defined as valley-floor sediment storage volume per upstream contributing area), and because coalescing debris-fill complexes are formed in headwater valleys with relatively low bankfull discharge, these complexes represent a buffer between episodic sediment input from the hill slopes and continual sediment output to fish-bearing streams. An empirical model of susceptibility to debris-flow inundation is based on hypothesized landslide susceptibility, an observed relationship between debris-flow runout length and elevation change between source and deposit, and tributary junction angles and corroborates the occurrence of coalescing debris-fill complexes where greater debris-flow susceptibility arises and is attributable to multiple sources, e.g., tributaries and main stem. Prior field data and simulation results indicate that debris-flow deposition in these complexes is sensitive to wood volume and depositional history: Entraining wood from valley floors and spreading over prior deposits decrease debris-flow velocities and favor deposition. Depletion of large, entrainable wood upstream of these complexes might lead to debris flows bypassing this zone and traveling through reaches where deposition on prior deposits is less likely. Conversely, present debris-flow deposition in reaches downstream of this zone may be less sensitive to changes in entrainable wood volume and depositional history because of overriding controls associated with tributary junctions, e.g., abrupt changes in stream gradient, flow direction, and valley width.

Invertebrate Drift Origin and Composition in Calapooia River Headwater Tributaries

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Abstract

Recent studies suggest that invertebrates drifting from non-fish bearing streams provide a food subsidy to fish bearing streams that they flow into. However, the origin of these drifting invertebrates is unknown. To determine if these drifting invertebrates are produced locally or are a cumulative result of invertebrates drifting from upstream, we examined the composition of drift in six headwater tributaries of the Calapooia River during late summer. Characteristics of these streams were similar and representative of small headwater streams within the basin and had drainage areas of 22 - 156 hectares, bank full widths of 0.9 - 1.7 meters, baseflow discharge of 1.0 - 2.6 liters per second, stream gradients of 9 – 21 percent, and streamflow rate of travel was approximately 1.5 – 2.4 meters per minute. Substrates were generally dominated by cobbles and/or large wood retaining sediment wedges of fine materials. At each sample stream, all flow was directed through driftnets placed directly upstream of a fish barrier. Drift samples were collected in 250-micron nets for 24 hours during four consecutive days at two-week intervals. After the first four sampling days a treatment was applied to half of the sampled streams. During the next 51 days all invertebrate drift in three treatment streams was intercepted by 250-micron blocking nets 100 meters upstream of the drift collection nets. Repeated Measures ANOVA indicates there was not a significant difference between treatment and control streams for mean count per m^3 ($p=0.76$) or mean dry mass per m^3 ($p=0.33$). There was a significant difference between the pretreatment and final sampling periods for both counts per m^3 ($p=0.01$) and dry mass per m^3 ($p=0.02$). RMANOVA analyses of individual taxa indicate significant differences ($p<0.05$) between treatments (3 taxa) and periods (18 taxa). These results are supported by Non-metric Multidimensional Scaling (NMS) ordinations that clearly demonstrate temporal invertebrate assemblages differences. However, the treatment did not appear to influence assemblage composition. These results suggest that invertebrate assemblages in these headwater streams change rapidly. Furthermore, invertebrates appear to be produced locally or may travel slowly downstream (e.g. less than 2 meters per day).

Biogeochemistry of Managed Forest Headwater Streams at Low Elevations in Western Washington

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Abstract

Interest in ecological and biogeochemical conditions of forested headwater streams has recently increased nation wide. Biogeochemical knowledge of small stream systems at low elevation sites across western Washington state is limited and no studies exist that address forest harvesting, stand development and headwater stream chemistry. This study was conducted in the Capitol State Forest near Olympia, WA. and utilized both the small watershed and chronosequence approaches to investigate the effect of different stand age classes on stream chemical parameters and system recovery after forest harvest. Three-forest stand age classes each with three stream basins were monitored; two early stages of stand development (young open canopy (5-7 year) and young closed canopy (15-18 year)) and maturing reference stands (second growth ~50-70 year). Stream water samples were analyzed for total Nitrogen (TN), ammonium (NH_4-N), nitrate (NO_3-N), total organic Carbon (TOC) and base cations from June 2004 through June 2005. There was a strong positive relationship ($R^2 = 0.89$) between stream TN and dissolved inorganic Nitrogen (DIN) ($NO_3^- + NH_4^+$) and constituted > 90% of TN. Mean stream TN concentrations were low (< 0.34 mg/L) and fall within values reported for forested streams in the Pacific Northwest. A general trend of increased N concentration with stand development was evident, with lowest N concentration found in streams associated with 5-7 year stands and highest in the maturing reference stands. A positive relationship was also found between TOC and sum of base cations (SUM), but the trends related to stand age were different from stream N. Mean TOC and SUM values were similar for the 5-7 year and reference stands where15-18 year stands had concentrations and equivalents of charge that were almost double. These differences were attributed to high fine root density and turnover at canopy closure that promoted production of soluble organic C and cation leaching from the soil. Soil solution N captured on ion exchange resin capsules was related to stream N concentrations showing a linkage between soil and stream processes. These findings increase our knowledge of headwater stream chemistry

and linkage with adjacent forest stands and general stream system recovery with stand development.

Economic Implications of Forest Management Around Headwater Streams

Bruce Lippke, Kevin Ceder, Kevin Zobrist, and Kernen Lien

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Abstract

The economic impact of headwater streams is dominated by no-harvest buffer rules. The practical definition of headwaters has evolved with recent changes in stream typing methodology. While headwaters may result in a smaller relative impact to harvest revenues than the buffers on downstream riparian areas, the redefinition of headwaters to fish-bearing streams under the Washington Forest and Fish Regulations appears to expand harvest limitations with subsequent worsening of forest management economics. We use Lewis County as a case study and evaluate the impact of redefined stream types and headwater buffers on landowner harvest potentials. Both small and large landowners experienced more than 130% increased losses from headwater streams under the revised stream typing. The total impact of new stream typing methodologies has doubled the cost of buffer protection yet we anticipate that impacts are underestimated. As new technologies such as LIDAR refine ability to identify and map headwater streams, estimates of buffer areas required by regulation will likely increase further. As economic returns from forest management are increasingly marginalized, forest owner losses can be expected to motivate accelerated land conversions away from forest use, suggesting implications for more serious ecological problems. Even ignoring the risk of land conversions, comparisons between the costs of buffers with the magnitude of fish produced from an equal investment in hatcheries raises fundamental questions about the effectiveness of the protection relative to other alternatives. Thinning treatments and narrow buffers cost much less, reduce the motivation for land-conversions and accelerate development of desired old forest conditions. Alternative strategies that anticipate cumulative effects and examine alternative cost allocations merit more attention.

Influence of Headwater Streams on Downstream Reaches

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Abstract

The combined source areas of headwater streams typically account for 60-80% of the total catchment area. This, plus the typical increase in precipitation with elevation, means that headwater streams are directly responsible for much of the streamflow in downstream areas. Headwater streams also are a primary source of other constituents of interest, including coarse and fine sediment, large woody debris, coarse and fine particulate matter, and nutrients. However, the relative importance of headwater streams as a source for these other constituents is highly variable because the magnitude and quality of each constituent can be affected by inchannel storage, dilution, biological uptake, diminution, and chemical transformations. Hence the relative importance of headwater streams as source areas diminishes with distance downstream, and with increasing natural and anthropogenic inputs from higher-order channels and their adjacent hillslopes. The linkage between headwater conditions and downstream resources is further complicated by the temporal variability in connectedness, the potential time lag between a given input and a downstream response, the need to quantify in-channel processes, and the spatial and temporal variation in downstream inputs. The complex nature of the in-channel processes and channel-hillslope interactions makes it difficult to quantitatively link upstream inputs to downstream conditions in higher-order channels. A spatially-explicit, process-based approach is necessary to evaluate how changes in a given set of headwater conditions and management activities will affect downstream resources. The temporal variability in headwater inputs and downstream conditions hinders our ability to detect significant changes over time, and to relate a given downstream change to a specific change in headwaters management. These issues have direct implications for adaptive management, which implicitly presumes that one can rapidly detect change, adjust management in response to that change, and that management changes will rapidly generate a corresponding response in the resource of concern. These conditions may rarely be satisfied at anything larger than the headwater scale.

Integrating Current Research on Sediment and Wood Dynamics in Headwater Streams

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Abstract

Headwater streams in steep mountainous terrain pose a significant challenge for riverine research and forest management. Processes that govern the input, storage, and transport of sediment and wood are poorly understood and differ geographically. At the upstream extent of the channel network, headwater streams represent a transition from hillslope to channel processes. At the downstream extent, these channels transition from mass wasting to fluvial process dominance. Mass transport processes typically consist of debris flows, earth flows, and episodic gulley incision. In the interval between episodic transport events, headwater streams can store large volumes of sediment and wood, and form important habitat for amphibian and invertebrate communities. During this time period, the export of fine sediment is influenced by the proximity of timber harvest to the stream, the detachment and routing of material through the road network, and the accumulation of small wood in the channel. The export of coarse sediment is affected by the presence of large wood and landslide deposits that overwhelm the transport capacity of the channel. Forest management guidelines typically designate headwater streams as occurring upstream of the distribution of fish; however, a topographically-based classification of headwater streams could prove useful for identifying which transport and storage processes are dominant in a particular area.

Effect of Riparian Buffers on Emergence of Aquatic Insects From Headwater Streams in Western Oregon

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Abstract

Emergence of stoneflies, caddisflies and mayflies was analyzed in 5 sets of headwater streams in the central Cascades of Oregon. Emergence traps were set along the same stream in adjacent stands that were a) clearcut, b) clearcut with riparian buffer and c) undisturbed control. Sampling took place from spring to late fall at 2-week intervals. Species richness of "EPT's" in these headwater streams is low, and most of the species occur in all 5 localities and all 3 treatments, permitting quantitative analysis. Emergence of Chironomids and other Diptera shows far greater treatment effect than EPT's; in late fall there are enormous emergences of Chironomidae from clearcut streams that are completely absent in the forested and buffered sites.

The Effect of Digital Elevation Model Resolution on Stream Network Prediction and Computational Requirements

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Abstract

The effects of digital elevation model (DEM) grid size for stream network predictions in the northwestern United States were examined to test the accuracy of high-resolution LiDAR (Light Detection And Ranging) digital elevation data. LiDAR elevation data were gridded at 2-, 6-, and 10-m scales and flow paths were predicted by four common routing algorithms known as D8, D-Infinity, Multiple Flow, and DEMON, D8 being the least sophisticated. These routing algorithms were also applied to a 10-m USGS DEM to compare LiDAR with the previously used data for hydrologic modeling. The analyses indicated that as topographic detail increased, all LiDAR-derived models delineated more streams and located streams in their topographically correct position when compared to a 10-m USGS DEM.

Stream maps generated by either D8 or DEMON converged as the DEM resolution was increased. The data suggests that increased DEM resolution decreases the need for sophisticated models, reducing processing times required to create accurate stream locations and attributes.

LiDAR digital elevation data also improved the modeling of perennial stream heads in a direct comparison to a 10-m USGS DEM. Distances between stream heads predicted using a LiDAR dataset and field verified stream heads were significantly less than those predicted using a USGS dataset. This illustrates the potential use of LiDAR to accurately predict perennial flow in a given landscape. As LiDAR datasets become more available, automated creation of stream networks and their hydrologic features will become more feasible and the accuracy of the results will be much improved.

Hydrological Connectivity Between Headwater Systems and Downstream Waters

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Abstract

This presentation reviews the state of our scientific understanding of how runoff is produced in headwater catchments, specifically from the hillslope to the catchment scale. The linkage to the larger watersheds of which these headwater systems are a part is discussed in terms of physical and chemical behavior during and between events. Examples from the Pacific Northwest are used as case study demonstrations of widely observed threshold behavior where connectivity between hillslopes and riparian zones and stream channels is defined by spatial patterns of connected subsurface saturated zones. A common feature with many of these examples is the dominance of pre-event water in the stream channel, even in headwater systems with high rainfall-runoff response. New evidence of topographic control on streamwater residence times from the HJ Andrews Experimental Forest suggests that the larger watershed is the sum of its component headwater catchments. These observations are summarized in terms of what they might mean for landscape sensitivity to landuse change and the integrity of navigable waters downstream of the headwaters.

Effects of Headwater Riparian Reserves of Four Widths With Upslope Thinning on Instream and Bank Vertebrates

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Abstract

Headwater streams and riparian areas are emerging as significant biodiversity hotspots in managed forests. We initiated our studies of managed headwater forests of western Oregon, to characterize the resident biota and to assess management approaches to retain biodiversity during timber harvest. We detected three fish species and 13 amphibians in surveys across >140 headwater stream reaches at 13 study sites. Amphibians were most abundant and diverse in streams and immediately along stream banks, with the amphibian assemblage becoming considerably simpler in the upland forest. Different assemblages were associated with instream perennial and intermittent reaches. Using a before-after-control design, we investigated the response of these animals to four widths (approximately 6, 15, 70, 145 m) of no-entry riparian reserves along headwater streams in young managed Douglas-fir stands, 40-70 years old, with upslope forest thinning. Stands of about 20 hectares were reduced from 600 trees per hectare (tph) to 200 tph. Analyses (ANOVA) with data from year-1 and year-2 post-treatment surveys at 11 sites have revealed few significant negative effects on species abundances with any buffer width. However, in a couple of cases, bank salamander species (*Plethodon* spp.) abundances showed treatment effects, and fish disappeared from reaches. These findings appear to be context-specific to selected sites and site conditions. Overall, a combined riparian buffer and upslope moderate thinning approach seems to have retained the aquatic vertebrate community along channels among sites. To hedge uncertainties, however, a mix of riparian reserve widths might be applied in headwaters where biotic values are of concern.

Small Headwater Stream Protections in Oregon: A Case Study on the Integration of Science Into the Policy-making Process

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Abstract

The goal of current stream protections in Oregon along small non fish-bearing streams is to "support the functions and processes that are important to downstream fish use waters and domestic water use." The primary focus of these protections is the "maintenance of cool water temperatures," however sediment production and bank stability are also "functions and processes" that the rules are intended to provide for.

There are at least two reasons for the emphasis on water temperature and sediment protection. First, of all the functions and processes along small non fish-bearing streams, relatively more was known about temperature and sediment in 1994 when the rules were adopted than any other. And second, these two functions and processes were believed to have the greatest potential to impact downstream fish use waters.

In 1999, Governor Kitzhaber directed the Board of Forestry through Executive Order #01-99 to convene an advisory committee to determine "to what extent changes to forest practices are needed to meet state water quality standards and protect and restore salmonids". The Forest Practices Advisory Committee (FPAC) summarized the general science as well as specific research and monitoring findings relative to the effectiveness of the Forest Practices Act. This review included an evaluation of current small non fish-bearing stream protections, and was presented to the Board of Forestry in September 2000. Based in-part on the work of the FPAC, the Board is currently in the process of reviewing a number of proposed rule changes related to riparian protection in Oregon, including small non fish-bearing stream protections. This review is incorporating a number of recent scientific reviews and rule review processes, and evaluating that information in light of the relevant social, economic, and environmental context of the Forest Practices Act.

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The Biology of Headwater Streams and Their Riparian Areas in Forested Landscapes

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Abstract

Headwater streams and their riparian areas, i.e., headwater systems, differ from larger streams in a number of fundamental ways that shape the biological communities characteristic of headwaters. Here we focus on three of these differences for headwater systems in temperate, forested landscapes. One such difference is the small channel size relative to the forest canopy, creating a physical template based on reduced light inputs, greater microclimatic effects from the channel, higher per area rates of organic matter inputs, and reduced primary production. A second difference from the interaction of hydrology and sediment transport is the somewhat lower hydraulic power acting during peak flows than in larger channels. Another distinction is that headwaters are either fishless (due to barriers) or have smaller (numerically and/or size-wise) fish populations, leading to reduced effects of predation by fish and fewer, if any, piscivores in headwaters. These characteristics of headwater environments lead to a number of traits of the biological communities. One characteristic is the predominance of organic matter inputs as the primary source of biologically available energy, and a community in the stream and riparian areas based on consumption of decomposing vegetation, especially leaf litter. The biological response to the microclimate of riparian areas is contingent upon the contrast with adjacent upslope forests. In some instances, such as mesic coastal forests, the riparian area may not be appreciably different from upslope forest, whereas in xeric landscapes the distinction may be quite profound. Bank stability in these largely colluvial reaches tends to be high and may be one reason for characteristic use of these areas by certain species, such as some amphibian species and bryophytes, amongst others. The disturbance regimes of headwater systems may be catastrophic, as infrequent and large, mass failures, and which can lead to channelized debris flows, or chronic, such as extreme low flows. One of the species dependent on mass wasting disturbances in Pacific Northwest headwater systems is red alder, which can have large influences on headwater systems. Periodic extreme low flows favor resistant taxa and pioneer species that can quickly recolonize habitat. Headwater systems appear to have characteristic distinctions from larger systems, but there have been relatively few designed comparisons of headwater systems to larger channels, which will be required to confirm our conjectures. Still, there is sufficient evidence that headwaters form distinct systems such that management should not treat them simply as big streams writ small.

Invertebrates and Organic Matter Respond to Forestry and Summer Low Flows in Small Streams of Coastal British Columbia

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Abstract

At the upper end of streams in the Pacific coastal ecoregion lives a fauna, largely of invertebrates, that is able to endure large winter flows and low summer flows. This fauna includes animals thought mostly to be associated with more continuously-flowing streams. Some of these species even spend multiple years as larvae and still persist through these low flow periods, e.g. Cordulegaster, Despaxia, and some corydalids. However, the degree of low flows in some summers can eliminate species with persistent effects that lag for a year or more following the period of low flow. The community associated with these small streams are sensitive to variation in climate (including climate change) and land use. Despite such low flows in summer, densities of some organisms were as high, or higher, than more perennial streams. Organic matter stored in stream channels may be one explanation for these patterns. During summer low flows the advection and entrainment of organic materials are negligible, resulting in negligible export of particulate organic matter, although dissolved material continued to be transported. This storage of organic matter during low flows may be responsible for sustaining relatively high densities of some consumers in streams with little or no surface flow in summer. As long as there are groundwater inputs, these will be cooler than advective water in the stream and help maintain the animals, which are considered to require cool water. Some effects may be related to shallow soil depth, a legacy of glaciation in BC and northern WA. Small streams also have more limited hydraulic power even at peak flows, so these communities may not be as adversely affected by winter storms as communities further downstream.

Effects of Different Riparian Management Treatments on Small Headwater Streams at the Upstream Extent of Fish Use for Streams in Western Oregon

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Abstract

Stream channel morphology, large wood, shade cover and other characteristics were measured for 42 stream reaches in Western Oregon. These stream reaches were purposely chosen to straddle the upstream extent of fish use which represents a key demarcation point in terms of ecology and forest practice regulation. Fifteen of these reaches were associated with timber harvest activity in the adjacent forest within the three previous years. The other 27 reaches were not associated with recent harvest activity but most had some forest management activity in the past. These streams had small but variable watershed areas from seven to 837 acres and had narrow channel widths averaging approximately three feet for wetted and eight feet for bankfull width. The 15 treated stream reaches had a small fish stream buffer downstream from the upstream extent of fish use with no such buffer upstream. While treated and untreated reaches had similar sizes and slopes, treated reaches had lower levels of shade cover and increased slash in the stream in the upstream portions of the reaches. The small fish stream buffer (20-50 feet in effective width on each stream side) resulted in a drop in cover levels over the stream from 88% to 80% while the upstream areas with out buffering were reduced from 87% to 52% cover. Differences in channel morphology, wood loadings and slash were not detected in the downstream portion of the reach with small fish stream buffers but increases in slash loading were detected for the upstream portion that did not have buffers.

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Relationships Between Forest-floor Invertebrate Distribution, Movement, and Microclimate Under Alternative Riparian Management Practices

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Abstract

Headwater streams and their riparian zones are a common, yet poorly understood, component of Pacific Northwest landscapes. We sought to describe the ecological significance of headwater stream riparian zones as habitat for forest-floor invertebrate communities, and to assess how alternative management strategies for riparian zones may impact these communities. We compared community composition of forest-floor invertebrates at five distances along 70 m trans-riparian (stream edge to upslope) gradients in mature forests, clearcuts, and across riparian buffers of ~30 m width. In the buffer treatments, we looked for evidence of microclimatic edge effects, and also biological edge effects, as characterized by species distribution and movement patterns across the forest-clearcut boundary. Invertebrates were collected in pitfall traps, in five replicate blocks of three treatments each, in the Willamette National Forest, OR. Air and soil temperature, and relative humidity were measured at a subset of pitfall locations at the same sites. A pitfall grid was installed at one riparian buffer site for a mark-release-recapture study to record carabid beetle and lycosid spider movements across the buffer edge. Ordination revealed a distinct "riparian" invertebrate community within 1 m of the stream edge in mature forest treatments, which was strongly related to a cool, humid microclimate. The stream appeared to influence microclimate at least 20 m upslope in the mature forest treatments. Invertebrate community composition in buffer treatments was far more similar to that of mature forests than to the community composition of clearcuts, a pattern mirrored by microclimate. Microclimatic edge effects were not evident beyond 10 m into the buffer, suggesting that the stream's cool, humid influence on microclimate may be modifying any warm, drying effects coming in from the forest-clearcut edge. While biological edge effects were not clear for invertebrate communities, individual species showed various responses to the buffer edge, depending on their habitat affinities and mobility. These results suggest that invertebrate distributions are strongly associated with microclimate, and that riparian buffers of ~30 m width provide suitable habitat for many forest species. However, buffer edges may serve as barriers to dispersal for some forest interior species, or be permeable to invasion by open-habitat

species, with possible consequences for long-term population and community dynamics within the buffer.

Hydrology and Water Quality of Headwater Streams in the Pacific Northwest

Stephen H. Schoenholtz and Maryanne Reiter

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Abstract

Hydrologic regimes and water quality of headwater streams in the Pacific Northwest are of growing interest as society grapples with the need to develop sensitive, reliable, and feasible indicators of sustainable forest management. Responses of headwater streams to forest management are of particular interest because these small, non-fish-bearing streams often comprise 60-90% of the stream network within larger catchments and are inextricably linked to downstream reaches. Varying requirements of forest-practice regulations for the protection of headwater streams reflect the uncertainty concerning effects of forest management at this scale and in the broader landscape.

Considerable research has been conducted on larger streams and rivers in the Pacific Northwest that support fish populations. However the assumption that smaller headwater streams have hydrologic and water quality dynamics that are similar to larger fish-bearing streams is not well supported. For example, a distinguishing characteristic of headwater streams is greater variability in their flow-duration patterns as compared to downstream reaches. Simple flow-duration categories in these streams include continuous (perennial), spatially discontinuous (intermittent) or temporally discontinuous (ephemeral). This variability in spatial and temporal flow creates distinct biophysical patterns in headwater streams. Predicting flow regimes of headwater streams is difficult because a multitude of factors control the origin of channels as well as the flow within those channels. This difficulty is challenging researchers and regulators as they attempt to model the upper extent of continuous flow for stream-protection purposes.

Although determination of stream perenniality is important, understanding of the full range of hydrologic processes and subsequent responses to forest management is essential in order to put them in the context of broader landscape functions. Studies to date have reported a wide range of responses in stream flow and water quality, including annual water yield, peak flow, low flow, sediment transport, streamwater temperature, and streamwater chemistry to forest management. This variability includes both the magnitude and longevity of these hydrologic responses. Complex interactions between a variety of possible flow paths, flow responses, and the biogeochemical and biophysical processes controlling water quality within headwater streams of the Pacific Northwest create many challenges for understanding hydrologic and water quality characteristics of these streams and their responses to forest management. This paper reviews recent research findings from studies of headwater streams in the Pacific Northwest and

summarizes our current understanding of the effects of forest management on their complex hydrologic processes and water-quality dynamics.

Processes That Influence the Downstream Propagation of Stream Temperature

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Abstract

The cumulative effects of harvesting adjacent to perennial, non-fish-bearing, headwater streams on the temperature in main stem, fish-bearing streams continues to be a focus of concern regarding the management of headwater watersheds. During the summers of 2001 the processes that influence the downstream propagation of temperature were monitored in 10 stream reaches that extended 300 m downstream of fish/no-fish barriers located downstream of a clearcut harvest unit. Steady-state tracer dilution methods were used to quantify the influx of groundwater seepage and longitudinal velocity of the stream. Temperature profiles with high spatial resolution were used to quantify longitudinal variability in stream temperature. The influx of groundwater into the stream did not explain the variability in stream temperature along the study reaches. Longitudinal stream velocity, as quantified by the mean velocity of tracers in the stream, correlated better with the longitudinal variability in stream temperature. The forced exchange of surface flow with the subsurface environment provided an observable mechanism that cooled surface flow. These data indicate that, while not impossible, it is highly unlikely that harvesting adjacent to perennial, non-fish-bearing streams will result in increased stream temperatures downstream in fish-bearing reaches of the stream. Further, those headwater streams that are likely to be able to contribute to cumulative temperature effects could be readily identified and any thermal impacts associated with harvest activities could be easily mitigated.

Assessing Sediment Inputs to Headwater Streams From Timber Harvest: An Above and Below Monitoring Approach

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Abstract

Concern over timber harvest related sediment delivery to headwater streams in the Freshwater Creek drainage of coastal northern California led to the development of this study. A number of sediment prevention measures are applied to roads and during harvest as determined by California forest practice rules, augmented by PALCO's multispecies Habitat Conservation Plan. This paper reports on results of water quality sampling above and below harvest units and road crossings to detect changes in turbidity and or suspended sediment concentration in potentially impacted streams located at or near operating areas. Management activities within timber harvest plan areas included new road construction, road upgrading, and timber harvest. Six pairs of ISCO sediment samplers were established in small headwater streams above and below proposed timber harvest units to detect any change in turbidity and suspended sediment and evaluate the overall effectiveness of all of the operation precautions over time. Timber Harvest Plan Units were evaluated using a BACI design (before, after and control) by placing automatic pumping samplers above and below units. Harvest sites are in the second year of a five year study with harvest having occurred on a few of them to date. Extensive grab sampling during storms in streams within harvest units and at road crossings have provided a picture of the spatial distribution of water quality in operating areas. Road grab sampling has showed that the improved road construction and use practices are generally effective in preventing turbidity from increasing more than 20% above the ambient turbidity level.

Landscape Pattern and Coastal Cutthroat Trout Distribution in Forested Montane Catchments

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Abstract

Headwater streams are dynamic environments in which landscape characteristics exert strong influences on stream fish distribution. Although geology, topographic factors, and land use have been shown to affect trout population density at a site-specific level, few studies have investigated landscape features associated with the distribution, or total linear distance occupied, of trout in an entire watershed. To evaluate landscape influences on the distribution and abundance of coastal cutthroat trout (*Oncorhynchus clarki clarki*), we conducted spatially continuous surveys of stream habitat and trout abundance in forty randomly selected watersheds and nine independently selected catchments used for model validation (500-1000 ha) in the Cascades, Coast Range, and Klamath Mountains ecoregions of western Oregon. We evaluated the relationship between trout distribution and landscape explanatory variables derived from geographic information system (GIS) data layers and satellite imagery available from state and federal natural resource agencies. We used multiple linear regression and Akaike's Information Criterion (AIC) to identify the best approximating explanatory models from a set of 34 a priori candidate models determined from the literature on trout distribution in forested montane landscapes. Our investigation of cutthroat trout populations across a broad range of headwater environments revealed that stream channel gradient, mean annual precipitation, and the proportion of young forest in the watershed were primary factors associated with the distribution of cutthroat trout. Understanding effects of basin-scale factors on trout distribution is critical in forested regions such as the Pacific Northwest where resource managers must consider impacts of logging on aquatic ecosystems.

Poster Abstracts

Overview of the Western Washington Forest Headwater Stream Riparian Ecosystem Management Studies (REMS) Project: Testing Alternative Headwater Stream Management Options

Richard E. Bigley, Peter A. Bisson, Martin G. Raphael, Jeff Ricklefs, Alex Foster, and Randall Wilk

Abstract

In 2001, the Washington State Department of Natural Resources and the USFS Pacific Northwest Research Station initiated a project to determine the possible influence of different management approaches on 1st order streams in western Washington. The study design imposed a range of riparian buffer configurations on headwater streams. Three buffer configurations are being compared: variable width buffers, fixed width buffers, and no buffers. An unmanaged basin is used as a control. The design and implementation of treatments in an operational setting will be discussed. Treatments were replicated in 8 locations and encompass 31 streams. Pre-treatment data describing stream channel characteristics, understory vegetation, and air and stream temperature will be used to illustrate the inherent variability in replicate streams.

A highly collaborative approach to this research was taken to provide a broad context for resource managers to weigh the management alternatives. Concurrent research studies are examining the effects of the different buffer configurations on litter fall input, aquatic invertebrates, instream fine particulate organic matter, riparian associated mollusks, stream-associated and terrestrial amphibians, small mammals, air and stream temperature, down woody debris, fish occurrence, understory vegetation, stand composition, stream hydrology, water chemistry, nutrient export, and soil processes. Current cooperators include the Washington State Department of Natural Resources, USDA Forest Service, the University of Washington, and the Washington State Department of Ecology.

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Spatial Subsidies from Headwater Streams to Fish Bearing Habitats Across Climatic and Disturbance Gradients in the Wenatchee National Forest

Christopher A. Binckley*[1,2], Joshua Y. Kill[3], Karinne L. Knutsen[3], and Mark S. Wipfli[1,2]

Abstract

An increasingly important theme in ecology concerns the magnitude to which different habitat types are linked by energy and nutrient subsidies. This concept can be exemplified by salmonid populations that receive such subsidies from numerous headwater streams. Since these species continue to be the focus of intense management programs, information regarding how these spatial subsidies vary across larger scale climatic and disturbance regimes is needed to improve conservation efforts.

We are quantifying how headwater stream spatial subsidies are influenced by different climatic ecoregions and land use histories and how these further affect downstream salmonid populations. Drift samples of invertebrates, organic, and inorganic material are being collected from 60 streams located in the Cascade Mountains of Washington state. Of these, 30 located are located within each of two ecoregions (e.g. wet/dry) of which 15 have been recently logged while 15 remain relatively undisturbed. The abundance of fish downstream will be measured to determine relationships between headwater subsides and salmonid population parameters. We hypothesize that headwater streams will cluster into four groups based on ecoregion and land use and that salmonid abundance will correlate with the amount of subsidy.

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Effectiveness of the Current TFW Shade Methodology for Measuring Attenuation of Solar Radiation to the Stream

Michael B. Bonoff and Dale McGreer

Abstract

In 2003, the Washington Department of Natural Resources CMER (Cooperative Monitoring, Evaluation, and Research) Committee implemented a study designed to determine the effectiveness of the eastern Washington riparian shade prescriptions on solar radiation reaching streams within the Bull Trout Habitat Overlay management zone. This presentation summarizes the methodology, pre-harvest data collection, and the first field season of post-harvest data collection for this study. The primary working hypothesis for this study is that there is no significant difference in solar energy reaching the stream pre- and post-harvest when the "all available shade" rule is applied. Seventeen stream sites (nine in 2003, eight in 2004) were surveyed prior to harvest. Adjoining reference and treatment reaches (300 meters each) were established on each stream, and solar radiation data were collected at 50 meter intervals by a 2-man crew working simultaneously within each reach. To ensure symmetry around solar noon, the timing of data collection was pre-programmed based on known solar elevations at a particular site. Solar radiation data were also collected at a nearby, unobstructed hilltop site to assess attenuation due to riparian cover, and to ensure that established "clear sky" conditions were maintained throughout the day.

Average pre-harvest ratios of percent available radiation (PAR) for these 17 sites ranged from 3 to 18 percent, suggesting that attenuation of solar energy is high and relatively constant at these streams, regardless of cloud conditions. Post-harvest data will be collected during the summer of 2006.

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Amphibians Rule in Headwater Streams: Abundance, Tolerance Limits, and Sensitivity to Timber Harvest and Wildfire

R. Bruce Bury

Abstract

In Pacific Northwest headwaters, stream amphibians are the dominant vertebrate in both numbers and biomass. We have 12 species in three endemic families: Tailed frogs, and Torrent and Giant salamanders. They prefer cold, rocky, perennial streams. Past logging reduced stream amphibians in many watersheds, and increased habitat fragmentation. My research over the last 4 decades on these unique species indicates several trends or surprises: (1) We found little or no recovery of Tailed frogs and Torrent salamanders 3-5 decades after large clear-cuts of 1950-60s. (2) Larvae of all species die at ca. 30^{o}C and appear intolerant (and some die) at 23-26 C if kept for long periods; eggs of the Tailed frog perish >19 C. (3) In the Siskiyou Mountains, larval Tailed frogs in streams in the Quartz Fire were half the number found in unburned forest whereas in the Biscuit Fire there were no differences between burned and unburned sites; giant salamanders were unfazed by wildfire. (4) Harvested stands appear to burn more severely (up to 85% burned) than adjacent old-growth stands (ca. 33%). Accelerated erosion and sedimentation can follows fire and timber harvest, leading to loss of amphibian eggs. (5) Tailed frogs and giant salamanders move into uplands in the rainy season so we must consider these animals in a watershed context (aquatic-riparian-upland). Buffer zones are needed along headwaters to maintain low stream temperatures and substrate integrity. We now need to ensure corridors between populations, encourage recovery of populations, and develop a long-term monitoring program.

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What Monitoring, not Modeling, Reveals About Channel Wood Production Rates in Small, Steep Stream Channels or Real Channel Wood Production Rates, Revealed!

Charles Chesney

Abstract

Long term ecological monitoring was conducted to describe the functional roles of wood in small, steep stream channels, and to document the relationship between riparian vegetation, tree fall, channel wood, and sediment storage. Results from monitoring over 5800 trees are presented for three ecological processes: rates of tree fall, and production rates of fallen trees making fluvial (channel) wood or terrestrial (down) wood. Over a period of four years of monitoring (2000-2004) at eighteen sites, 33% of fallen trees became fluvial (channel) wood, and 67% of fallen trees became terrestrial (down) wood. However, most channel wood was above and near the channel, and not hydraulically active channel wood. Three of fifteen sites with tree fall had no new channel wood production. In ten of twelve sites with new channel wood production, over two-thirds of new channel wood was zone 3 and 4 wood (located above and near the channel, not within the wetted perimeter of the channel). Implications for creating channel wood budgets are discussed, including requirements for year 2005 measurements of fluvial import, terrestrial input, and fluvial export for this Milan Project (300-year duration).

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Influence of Riparian Management on Headwater Invertebrate and Organic Matter Subsidies to Downstream Food Webs

Shannon M. Claeson[1], Karen Wilk[1], Alex D. Foster[1], and Peter A. Bisson[1]

Abstract

We examined the fluvial transport of invertebrates and detritus from forested headwater to downstream fish habitats in SW Washington State as part of the Riparian Ecosystem Management Studies (REMS) project. Export was sampled seasonally in 22 streams distributed among six 3rd-order watersheds for approximately one year prior to logging. We are in the process of determining the effect of alternative buffer configurations on invertebrate and detrital export after logging by comparing unmanaged control streams to streams with continuous, fixed width buffers (total width averaging 30 m), variable width buffers (patchy), and no buffer (clearcut). Prior to logging, invertebrates exported from headwaters were primarily aquatic in origin (97% aquatic, 3% terrestrial). Dipterans were the most abundant invertebrate captured in drift nets (32.8%, mean 71 individuals/day), followed by plecopterans (13.1%, mean 28 individuals/day), and ephemeropterans (8.2%, mean 19 individuals/day). Mean organic detrital export was greatest during the winter (20.0 g/day), when stream discharge was high, and lowest during the summer (4.2 g/day). Mean invertebrate export was also greatest during winter (477 individuals/day) and lowest during summer (136 individuals/day). Mean invertebrate abundance varied by watershed (range: 146-342 individuals/day).

These results show that forested headwaters provide potential food items to downstream fishes and invertebrates, although their influence may vary seasonally and by watershed. We expect invertebrate abundance, community composition, and detrital export to change after riparian management treatments.

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Effects of Wildfire on Fish Populations: Contemporary Changes and Long-term Consequences

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Abstract

Wildfire is a major force shaping freshwater aquatic ecosystems in many parts of North America. We studied the effects of wildfire on aquatic vertebrates (bull trout, rainbow trout, and tailed frogs) in headwater streams in the Boise River basin, located in central Idaho. The prevalence of wildfire in this basin has increased dramatically in the past 20 years. By looking at several spatial scales and different types of biological responses, we were able to identify species at risk to wildfire and the potential roles that wildfire may play in regulating natural ecosystem processes. Results from this work also point to the importance of critically evaluating commonly assumed biological indicators of population health for aquatic vertebrates in relation to dramatic environmental changes. Environmental changes we observed in streams following wildfire ranged from minor and short-term to major changes lasting several decades. An understanding of these influences may provide important insights into predicting how aquatic vertebrates will respond to changing climate and wildfire regimes.

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Temperature, Geometry, Surface Flow, and Wetlands of Selected Headwaters Streams: Capitol Forest and the Willapa Hills, WA

William J. Ehinger, and Jack Janisch

Abstract

As part of the Riparian Ecosystem Management Studies (REMS) project in SW Washington, we are examining the effects of three different riparian buffers on stream temperature. *In situ* temperature loggers were placed at the uppermost point of perennial flow and within and below the harvested reach for one or two years prior to harvest. In addition, hemispherical canopy photos were taken at intervals along the stream, riparian wetlands have been delineated and mapped, instream woody debris recorded, and the spatial extent of surface flow has been measured several times over the June-September period. Post harvest measurements began in 2005, with analysis of the immediate post harvest period expected in early 2007.

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Evaluating Terrestrial Gastropods as Indicators for Monitoring the Effects of Alternative Buffer Configurations Along Headwater Streams

Alex D. Foster Joan Ziegltrum, Karen Wilk, Kim Gridley, Shannon Claeson and Peter Bisson

Abstract

We are evaluating different buffer configurations and their effects on terrestrial gastropod populations along small headwater streams in SW Washington State as part of the Riparian Ecosystems Management Studies (REMS) project. Two buffer configurations, applied to whole small watersheds are being tested; these include a continuous, fixed width buffer and a variable width, patch buffer type. The two buffer types are compared to clearcut watersheds with no buffers and to unlogged controls. Study streams were located in two geologically distinct areas: Capitol Forest, located immediately west of the city of Olympia, and the Willapa Hills located along the Washington Coast. Data were collected twice each season for fall of 2002, spring 2003, and fall 2003 before timber harvest began.

The results reported here refer to the pre-logging phase of the study. A total of 2190 gastropods were collected in Capitol Forest and 1548 were collected at the Willapa sites. The ratio of snails to slugs was 22:1 at the Capitol sites and 15:1 at the Willapa sites. At both the Capitol and Willapa sites, snail abundance was lowest during the early fall and late spring, yet slugs did not follow this general trend. Diversity was highest at the Capitol sites with 14 snail species present; with the small snails *Columella sp*. and *Vertigo sp*. dominating the mollusk community at 44% and 20% respectively. Out of the 10 slug species detected at Capitol Forest, the warty jumping slug (*Hemphillia glandulosa*) made up 43% of the slug community, with the Malone's jumping slug (*H. malonei*) comprising 23% and the Pacific banana slug (*Ariolimax columbianus*) comprising 12%. At the Willapa sites, tightcoil snails (*Pristiloma sp*.) made up 64% of the community with the Northwest Heperian snail (*Vespericola columbianus*) comprising 23%. The Pacific banana slug dominated the slug community at 56%. The Malone's jumping slug was absent from the Willapa sites, in contrast to Capitol Forest where it existed sympatrically with the warty jumping slug. Microhabitats within riparian areas may have influenced abundance and diversity; however continued data collection will be required to evaluate seasonal variability and possible treatment effects.

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Macroinvertebrate Dynamics of Small-stream Communities in the H.J. Andrews Experimental Forest: A Seasonal Comparison of Streams Through Young and Old Growth Riparian Zones

C. H. Frady[1], S. L. Johnson[2], and J. L. Li[1]

Abstract

The H. J. Andrews Experimental Forest has long been a theater for research directed at quantifying biotic and abiotic responses to habitat alteration and disturbance. The effects of forest harvest are of great concern, and several small basins (< 100ha) in HJA were clear-cut to compare and contrast disturbed ecosystems with analogous undisturbed areas. Because riparian vegetation often composes the food base for invertebrates in small streams, we expect changes in structure and abundance of riparian vegetation to affect stream invertebrates using those resources. From June 2003 to June 2004, we collected benthic and emergent invertebrates seasonally in 3 streams through young growth forests and 3 streams through old growth forests in the H.J. Andrews Experimental Forest. Each reach was a first to second order perennial tributary to Lookout Creek. Streams through young and old growth forests were paired at three elevations to account for variability in local landscape characteristics including aspect, overlying geology, and local vegetation. The primary objectives of our study were to compare stream invertebrate densities, taxa richness, and community structure between young and old growth riparian zones 20-40 years post-harvest; by examining samples collected throughout the year, we also determined how invertebrate community patterns vary seasonally. We found no differences in benthic or emergent taxa richness and densities between streams through young and old growth forests. However, benthic and emergent densities, as well as emergent richness were greater in summer than in other seasons. Using ordination techniques, we found differences in benthic community structure between streams through young and old growth forests when red alder was present in young growth riparian zones. Additionally, both benthic and emergent communities displayed unique structure and composition among seasons.

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Riparian Litter Inputs to Streams in the Central Oregon Coast Range

Stephanie Hart, David Hibbs, and Steven Perakis

Abstract

Riparian zone vegetation can influence terrestrial and aquatic food webs through variations in the amounts, timing, and nutritional content of leaf litter inputs. Differences in riparian topography and vegetation composition and density may modulate the quantity and quality of these inputs. In coastal Oregon riparian forests, we are investigating lateral and vertical litter inputs to sixteen headwater streams throughout the year and assessing how these inputs are influenced by composition or density of red alder (*Alnus rubra*) or Douglas-fir (*Pseudotsuga menziesii*) overstory, associated understory species, and lateral slope. Preliminary results suggest that understory shrubs do not obstruct lateral movement of litter on slopes of 0 to 60% during most months. Less lateral movement, however, was associated with shrubs in autumn months at coniferous sites. Initial results suggest that lateral movement distance is less than 5m except at deciduous sites in spring and summer. Regardless of the distance litter moved, these analyses indicate that slope has a marked positive effect on lateral litter movement, but this effect appears to differ by season and overstory composition. Annual lateral ($F_{1,14}$=4.4; p=0.055) and vertical ($F_{1,14}$=8.4; p=0.011) litter inputs to streams from deciduous sites exceed inputs from coniferous sites. Our initial results suggest that forest management promoting conifer dominance in riparian zones of the central Oregon Coast Range will decrease leaf litter quantity and quality, and dampen the seasonal pattern of leaf litter inputs to streams, potentially affecting the structure and composition of food webs in these ecosystems.

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Macroinvertebrate Community Response to Natural and Forest Harvest Gradients in Western Oregon Headwater Streams

Alan Herlihy, William Gerth, Judith Li, and Janel Banks

Abstract

To examine the effects of forest harvest practices on headwater stream macroinvertebrates, we compiled a 167 site database with macroinvertebrate, fish, physical habitat and catchment land cover data from the three forested ecoregions in Western Oregon. Macroinvertebrate taxonomic and functional feeding group composition were very similar among the three ecoregions (Coast Range, Cascades and Klamath Mountains). On average, 55% of the individuals at each site were in the orders Ephemeroptera, Plecoptera or Trichoptera. Dipteran taxa (mostly chironomids) accounted for another 34%. At almost all sites, non-insects made up less than 10% of the macroinvertebrate assemblage. There were 189 different macroinvertebrate taxa at the 167 sites with richness at individual sites ranging from seven to 71 taxa. Ordination by non-metric multidimensional scaling revealed a strong association between %Ephemeroptera, especially *Baetis*, and site scores along the first axis. This axis was also strongly related to %coarse substrate and fast water habitat. The second axis was strongly related to %intolerant individuals, site slope and elevation. No strong relationships were evident between any ordination axis and either logging activity, presence/absence of fish, catchment size or ecoregion. Based on macroinvertebrate index of biotic integrity (IBI) scores, 62% of the sites had no impairment, 31% of the sites had slight impairment and only 6% of the sites had moderate or severe impairment. IBI scores were not strongly related to forest harvest history. Percent sand+fine substratum was the environmental variable most strongly related to macroinvertebrate IBI.

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The Mica Creek Experimental Watershed: An Outdoor Laboratory for the Investigation of Coupled Hydrological and Ecological Processes

Timothy Link, Kathleen Kavanagh, John Marshall, Han-Sup Han, Woodam Chung, Karen Humes, Russ Qualls, Jan Boll, Erin Brooks, Andrew Hudak, Jeffrey Evans, John Gravelle, Jason Hubbart, Andrew Warnsing, Enhao Du, William Elliot, and Terry Cundy

Abstract

Experimental catchments have proven to be extremely useful for investigations focused on fundamental hydrologic processes and on the impacts of disturbances on hydrologic regimes, water quality, and terrestrial and aquatic ecology. Recent studies have illustrated how watershed responses to experimental treatments vary greatly between watersheds with differing physical, ecological and hydroclimatic characteristics. Concurrent collection of meteorological, hydrological, biogeochemical, geological and ecological data within catchments is needed to develop a mechanistic understanding of how disturbances impact watershed systems. The Mica Creek Experimental Watershed (MCEW) in northern Idaho is a fourth-order catchment that is being intensively instrumented to understand how current forest harvest practices are affecting hydrologic and biogeochemical fluxes and watershed health. The experimental catchments encompass a 28 km^2 area spanning elevations from 975 to 1725 m msl, and are influenced by a combination of Continental and Maritime climate regimes. Data collection includes standard hydrometeorological variables stratified by elevation and canopy cover, canopy throughfall, distributed snowcover, and soil water content. Net ecosystem CO_2 and water fluxes are measured using eddy-covariance and augmented with sap flow measurements. Nine sub-catchments are monitored for flow, temperature, sediment, and nutrients. Stream health is assessed through macroinvertebrate and fish surveys, and through detailed quantitative analyses of food resources. Remotely-sensed data collection includes LiDAR and hyperspectral imagery for determination of canopy and topographic structure. The project will assess how forest harvest impacts a wide range environmentally relevant variables and will serve as a model for how integrated research at the watershed scale can effectively address complex, interdisciplinary problems.

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Type N Experimental (Prescription-Level) Buffer Treatment Study

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Abstract

The Type N Experimental Buffer Treatment Study will assess the effectiveness of the Forest and Fish Report (FFR) patch buffer prescriptions along non-fishbearing (Type N) streams in western Washington. The purpose of this study is to evaluate the relative effectiveness of alternative prescriptions in meeting FFR resource goals, which include the response of stream-associated amphibians (SAAs) to differing buffer strategies. We will compare one application of the FFR buffer to 2 alternative treatments (0% and 100% stream length buffered) and an unharvested reference. Blocks of four treatments will be replicated 5 times for a total of 20 sites. Differences in treatments will be measured in changes of amphibian occupancy and density (target SAAs are *Ascaphus*, *Rhyacotriton*, and *Dicamptodon* species), water quality, primary productivity, and elements exported to fishbearing streams (e.g., invertebrates). The proposed study timeline includes 2 years of pre- and 2 years of post-treatment data collection. The study design will enable at least one post-treatment sampling to occur 10 years after the application of treatments. Currently, the project is at the tail of the site selection phase, involving interactive cooperation among 2 state and 2 federal agencies, 8 private landowners, and 2 Indian Nations. Site selection involves a 4-part process, and includes: GIS screening of available non-fishbearing basins meeting size, elevation, gradient, and geology criteria; acquisition of landowner information including stand age and projected harvest; field verification of GIS information and target amphibian presence; and the grouping of sites into blocks. Data in the core design will be analyzed using a repeated measures analysis of variance (ANOVA). Analyses will distinguish potential differences among treatments, and assess the ability of each alternative buffer prescription to maintain headwater habitat and system functions.

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

Joselin J. Matkins[1], Steven S. Perakis[1,2], David E. Hibbs[1]

Abstract

Many riparian forests of the Oregon Coast Range are currently dominated by red alder overstories. However, interest in increasing future sources of shade and large wood for streams is leading to conversion of red alder riparian forests to Douglas-fir. A large interdisciplinary research project (http://www.fsl.orst.edu/cfer/research/resproj/riplink/riplink.html) is examining how these conversions may impact food webs in order to better inform riparian management decisions. We examined decomposition of red alder and Douglas-fir leaf litter, and evaluated the effects of litter source, riparian habitat, and nitrogen fertilization on decay rates. Our results suggest that 1) red alder litter decays more rapidly than Douglas-fir in all habitats, even across a wide range of Douglas-fir litter quality, 2) this is especially true in red alder habitats, indicating an interaction between litter type and habitat, and 3) habitat exerts a minor influence on decay rate of Douglas-fir. Paradoxically, rates of Douglas-fir litter decay were negatively related to initial litter nitrogen concentrations across the range 0.7 – 1.4%N, contrary to patterns observed in other ecosystems. Overall, our results indicate a strong species-specific effect of overstory composition on riparian ecosystem processes. These effects can influence energy and nutrient budgets of riparian food webs, and suggest a need for broader consideration of potential impacts resulting from conversion of red alder to Douglas-fir dominated riparian zones.

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Linkages Between Bat Diets, Insect Abundance, and Riparian Vegetation

Holly Ober and John Hayes

Abstract

Riparian areas provide important foraging habitat for insectivorous bats in the Pacific Northwest. Efforts to assess the impacts of potential riparian vegetation management plans on bats have been hampered by limited knowledge of (1) which insects bats consume, and (2) the distribution of potential insect prey items in relation to riparian vegetation composition. We examined these two factors in the Coast Range of western Oregon during the summers of 2002, 2003, and 2004 in an effort to better understand the linkages between riparian vegetation, insects, and bats.

We captured free-flying bats, held them in cloth bags for ~1 hour to allow time for defecation, then removed guano from bags and placed it in the freezer until time of analysis. In the laboratory we teased apart each guano sample (n = 368) in a Petri dish containing 95% ethyl alcohol. Using a dissecting microscope we identified food items to Order by comparing insect fragments in guano to whole insects collected the same night. Lepidoptera was the most important prey item, followed by Diptera, when assessed via either frequency of occurrence or percent volume.

We collected insects in 36 randomly selected 2nd and 3rd order stream reaches from sunset until sunrise using black light traps. Each night we sampled one conifer-dominated stream reach and one deciduous-dominated stream reach. Abundance and biomass of the 3 most common Orders (Diptera, Lepidoptera, and Trichoptera) were either slightly or significantly higher in deciduous-dominated stream reaches than in conifer-dominated stream reaches.

In summary, Lepidoptera and Diptera were the most important prey items in the diets of bats. Abundance of Lepidoptera, and biomass of Lepidoptera, Diptera, and Trichoptera were significantly higher in deciduous-dominated stream reaches than conifer-dominated stream reaches. Therefore, vegetation management strategies that alter the composition of riparian vegetation could have deleterious effects on the nutritional ecology of bats if the aim of such strategies is to decrease the presence of deciduous trees in favor of conifers.

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Are Headwater Streams Important to Forest Ecosystems? Adult Aquatic Insect Communities in Temporary and Perennial Headwater Streams in Western Oregon

R. A. Progar and A. R. Moldenke

Abstract

The riparian areas encompassing headwater streams comprise over fifty percent of federally managed land in the Pacific Northwest. Forest management practices and their consequences are likely to have direct effects on the abundance and diversity of arthropods in these sensitive habitats, and indirect effects through the foodweb on vertebrates of concern. We examined the effect of stream flow (perennial vs. dry-season temporary), and canopy presence on adult insect fauna collected from emergence traps in headwater streams at three sites in the conifer forests of western Oregon. In comparing temporary and perennial streams, Trichoptera and Ephemeroptera emerged in greater numbers in perennial streams, taxon richness was higher overall, and density and biomass of aquatic insects were higher during the summer in perennial streams than in temporary streams, which by then were either dry or drying up. In contrast, Diptera and Plecoptera emerged in greater numbers from temporary streams, and density and biomass of all aquatic insects were higher in these streams during the spring. These results are consistent with our hypothesis that the absence of vertebrate predators (fish and giant salamanders) allows insects in temporary streams to flourish, and supports our conclusion that temporary streams are as important as perennial streams in serving as: (1) a potential source of colonization for perennial streams and (2) an important factor in the terrestrial food web as an abundant food source for insectivorous vertebrates. Both temporary and perennial headwater streams flowing through clearcut uplands support higher densities, biomass and richness than forested streams. The proliferation of insects in headwater streams flowing through clearcuts may be attributed to higher insolation which increases primary production.

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Hydrologic Losses of Nitrate from Coast Range Soils

Emily Sinkhorn and Steven Perakis

Abstract

Terrestrial export of nitrogen from upland soils influences the quantity and speciation of nitrogen delivered to riparian zones of headwater streams. The long history and patchy occurrence of red alder, a nitrogen-fixing species, has left a mosaic of high nitrogen inputs into soils throughout the Oregon Coast Range. We sampled soil water from ten Douglas-fir stands in the Oregon Coast Range to examine patterns of nitrogen export across a gradient of N-poor to N-rich soils. These sites span a gradient of percent surface soil nitrogen from 0.21%-0.69% but have similar tree age (~25 years) and sandstone parent material within the coastal Oregon climate zone. At each site, 3 pairs of lysimeters were placed at 20cm and 1m depths and monitored monthly for soil water nitrogen concentrations. Preliminary data suggest that hydrologic losses of nitrate from deep soils at these sites ranged from 0.00670 to 2.787 mg N / L and followed the gradient in percent soil nitrogen. In addition, N-rich sites have consistently yielded low ammonium to nitrate ratios in relation to N-poor sites, suggesting upland soil nitrogen status may govern the speciation of nitrogen delivered to riparian areas and streams. Further analyses will determine if nitrogen export has a continuous relationship with percent soil nitrogen, or if there is a threshold soil N availability that influences hydrologic nitrogen loss. Not only does soil nitrogen availability influence nitrogen loss from upland forests, with implications for terrestrial base cation depletion, but also delivery of nitrate for processing in riparian zones and streams.

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Wood and its Contribution to Step Formation, Sediment Storage and Other Functions in Headwater Streams of the Northwest Cascades, Washington

Curt Veldhuisen[1], Drew Coe[2], Dave Luzi[3], and Mike Olis[1]

Abstract

We have been collaborating on a descriptive field study to evaluate the role of wood in headwater streams of the northwestern Cascades. The objectives are to: 1. Identify differences in wood volume, size, and function between streams in unlogged and previously logged forest stands 2. Examine the role of wood and other roughness elements (boulders, roots, bedrock) in keying alluvial storage wedges, and 3. Examine the role of wood and other roughness elements on pool formation, particle sizes, energy dissipation and other fluvial processes. Results may be useful for evaluating riparian management strategies along headwater streams.

Field surveys focused on segments (20-40 times channel width) chosen from 43 non-fish-bearing channels 1 to 4 m wide across a range of gradients (9-67%). Data collection included a longitudinal thalweg profile to identify steps, pools and sediment storage wedges. Additionally, all wood pieces larger than 2 cm x 0.5 m were tallied by diameter and function class; piece lengths and decay were extrapolated from a sub-sample.

Preliminary analysis indicates that streams in unlogged forests have somewhat higher total wood volume than logged, due to greater large-diameter (>40 cm) pieces. Streams in previously logged forests had greater volumes of smaller material (<40 cm), presumably contributed from the second-growth stands. Valley form appears to exert a major control on wood loading, in that steep valleys have the largest wood volumes. Most (~70%) wood pieces (regardless of size) contributed to one or more fluvial functions (e.g. step composition, bank armoring, roughness). Non-functional pieces consisted mainly of: 1. Loose pieces shorter than the channel width and 2. Large, valley-spanning pieces likely to enter the channel in the future. Wood is the dominant step-forming element, though clasts, bedrock and roots are also significant. Sediment storage at the segment scale is strongly associated with the in-channel wood volume. Ongoing analysis is likely to refine and expand on these results and their implications.

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Western Washington Forest Headwater Stream Management Options Experiment: Responses of Small Mammals to Buffer Manipulation

Randall Wilk, and Martin G. Raphael

Abstract

Understanding the responses of forest-floor vertebrates to streamside habitat manipulation is a key component of aquatic conservation strategies, especially along headwater streams. We present results for small mammals sampled from 4 experimental treatments: (1) fixed-width buffer (n = 7), usually $\leq$ 9 m per side; (2) patch buffer (n = 3), usually buffering the headwall or stream source - especially around fragile or unstable soils; (3) no buffers (n = 7) - clearcuts; and (4) unharvested controls (n = 6). We sampled in or along 23 streams in 6 study sites, 3 in the Black Hills and 3 in the Willapa Hills. All sites are in state - managed industrial coniferous forests in western Washington. (We concurrently sampled aquatic and land amphibians, but are not presenting those results in this poster.)

The timing of experimental treatments was driven by forest market conditions and the treatments did not occur as originally scheduled. We planned 2 years of pretreatment surveys at each site (2003-2004), but the planned 2nd year of pretreatment study was completed in only 1 site. Because treatments took place during the 2004 sampling, crews could not enter sites that year. We plan to compare post-treatment capture rates among all sites over the next few years.

To sample small mammals, we installed transects of 36 live traps, spaced 5 m apart and located within 2 m of the stream. We placed transects at approximately the center of the reach proposed for treatment. We trapped 5 4-day periods distributed from May through September.

Treatments occurred over an 18-month period, September 2003 to April 2005. We compare capture rates on 2003, the pre-treatment year, with 2005, the first post-treatment year in which all streams could be sampled (except for the 2 common shrews that have not been identified to species for 2005 at this writing). We show mean (+ SE) captures rates for streams within treatment groups (range = 3 - 7 per group) for the pooled 2 regional blocks

Diversity (controlled for the number of captures) increased following treatment in most treatments but declined in the control at the Willapas. After cutting, there was less similarity within treatments in the Willapa than in the Black hills.

To date, we have captured 16 mammalian species. Capture rates of 11 species were large enough for analysis. Capture rates were greatest for 2 common species of shrews, the shrew mole, northwestern and forest deer mice, red-backed and creeping voles, 2 semi-aquatic shrews, Pacific jumping mouse, and Townsend's chipmunk.

Coefficients of variation in mean capture rates for most species were large, averaging over 50% among streams in at least 1 block for every species. Given these

large coefficients, we anticipate that it will be difficult to detect statistical differences in abundance among treatments following disturbance unless effect sizes are very large in this before-and-after control-impact study. These results, and experiences in conducting this large-scale experiment, illustrate the difficulty inherent in experimental field studies. However, despite this wide variation, we can see patterns of magnitude of the biological effects of some of the buffer treatments upon different species.

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Cumulative Watershed Effects of Forestry Practices on Stream Habitats

Yixin Zhang and John S. Richardson

Abstract

Watershed effects of past forestry practices accumulate in forested landscapes where operations and management have occurred for long periods of time, and impact on stream biodiversity and ecosystem processes. Theory predicts that cumulative watershed effects of timber harvest relating to forest cover change alter stream habitat structures and influence forest fluvial species richness and abundance. By comparing watersheds with different forest practice histories through old growth forests to recently disturbed forests, this study investigated impacts of past forest practices associating with cumulative watershed effects on stream habitats in Chilliwack River basin area. We found characteristic difference of stream habitats that were related to past forestry operation. Stream reaches in well-matures forests had coarser substrates than did stream reaches in young-growth forests impacted by recent forest practices. A diagram of two principal components separated six reference sites in well-matures forests from five test sites in young-growth forests. Using a modelling technique - partial least squares projection to latent structures (PLS), we investigated the relationship between multiple environmental variables and ecological responses of benthic communities. Predictive PLS models were developed based on environmental variables at reference stream reaches. Results indicated that reference reaches with high species richness and high relative abundance of benthic invertebrates were characterized by low volume of LWD and low amounts of LWD in fresh or heavily decayed conditions, low accumulation level of FPOM and CPOM on stream substrate. These PLS models were modified by excluding the variable of mean forest age, and were used to predict species richness and relative abundance of benthic communities. A significant impact of past forestry practices was detected on both species richness and relative abundance of benthic invertebrates at the test sites. Species richness and the relative abundance at the test sites were significantly lower than expected. Thus, the finding of this study provides evidence for the importance of past forest management practices associating with cumulative watershed effects in influencing habitat alteration and determining present-day stream biodiversity

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Requests for Proposal

The Headwaters Research Cooperative (HRC) completes its original mission with the completion of the Conference on the *Science and Management of Headwater Streams in the Pacific Northwest* and the publication of the meeting proceedings. However our understanding of headwater ecosystems is far from complete. HRC has adequate funding to facilitate additional research and will be releasing the following RFPs. These projects will be administered by the National Council Air and Stream Improvement, Inc. (NCASI) forest watershed program.

Request For Proposal 1

Research objective: During the development of research projects, HRC learned that the identification of streams that met the criteria of headwaters was difficult. In the past five years we estimate that as many as 100 headwater sites have been identified in western Oregon as project funded by HRC, Agenda 2020, EPA's EMAP program, and other efforts.

The HRC request proposals to identify these sites, map them within a GIS system, develop contact information about the landowner, and monument the sites on the ground. This Headwaters Research Network (HRN) will be made available to any and all potential researchers who agree not to reveal landowner information. Access to these sites will be strictly at the discretion of the landowner, but this will provide a research base for future headwater studies.

Request For Proposal 2

Research objective: The prospective researchers will identify a research gap that has not been adequately addressed. The gap will be identified based on the research presented at this meeting as well as an understanding of other contributions to our understanding of headwater ecosystems. The researchers will develop a proposal to address that gap and they will conduct the research at sites in the Headwaters Research Network and other suitable sites.

Criteria for awarding of the grant will include the importance of the identified research gap, how the HRN will be employed in the study, and the amount of matching funds.

The HRC expects to be able to fund both projects. It is possible that funding could allow more than one project from RFP #2. Look for the RFPs in January 2006 on our website (http://www.headwatersresearch.org/)