Workshop Summary

Wood Dynamics
Sediment Routing
Hydrologic Function
Temperature and Dissolved Oxygen
Organic Matter and Nutrient Cycling

Headwaters Research Cooperative

Riparian Function and Microclimate
Geomorphology and Classification
Invertebrates and Periphyton
Fish and Amphibians
Basin Level Effects

HRC Workshop
Corvallis, Oregon
October 29-30th, 2001

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Headwaters Research Cooperative:
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Headwaters Research Cooperative
Workshop Summary
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Headwaters Research Cooperative Workshop Summary

Introduction

The ecology of headwater systems and their importance to downstream habitats and functions is not well understood. This is in part because headwater streams have not received as much attention as other portions of the watershed. Research and management policies have mainly focused on either larger fish–bearing streams or the headwalls above these small streams.

Currently, natural resource agencies and forest landowners in the Pacific Northwest are debating how to best manage headwater streams. Since there is limited research on headwater streams it is difficult to arrive at science–based policy and management decisions. Specifically, managers need fundamental information on the biodiversity, riparian structure, sediment and nutrient transport rates, water quality, and hydrologic processes of small streams. Furthermore, forestland managers and policy makers need research that specifically addresses the implications of management around headwater streams across a range of conditions.

The Oregon Headwaters Research Cooperative (OHRC) has formed in Oregon to help address these headwater research needs. The purpose of the cooperative is to investigate local and downstream effects of forest management on the biota and habitat characteristics of headwaters stream systems. The goals of the OHRC are:

1. To gain scientific understanding of the physical and biological processes of headwaters stream systems.
2. To examine the local and downstream responses of headwater streams to a range of forest management prescriptions.

As a step in forming the cooperative, the provisional steering committee held a workshop on October 29-30 2001 in Corvallis, Oregon. The overall purpose of the workshop was to solicit input on the direction and priorities for the Headwaters Research Cooperative. Specifically, the goals of the workshop were to:

- Frame the state of the science on headwaters streams through technical presentations by speakers with recognized expertise in specific areas.
- Identify gaps in the science through follow-up facilitated discussions by workshop participants.
- Articulate hypotheses and research priorities through small group sessions by workshop participants for the prospective research cooperative to pursue.

What follows is a summary of the workshop presentations and discussions as well as a summary of the next steps being taken by the Headwaters Research Cooperative towards meeting those goals.

What is a Headwater Stream?

The formation of the OHRC, in and of itself, is an acknowledgement of the limited number of studies currently focused on very small streams. Therefore, clearly defining what the OHRC means by 'headwater streams' will assure that the OHRC funds projects that will fill that particular void. While the variability of these very small streams defy a precise definition the following has been selected for the purposes of this cooperative:

> *A headwater stream has an average annual stream flow less than 2 cubic feet per second. Stream width can vary greatly, particularly between sites west and east of the Cascade Mountains. In western Oregon the bankfull width ranges from less than 1 meter to 3 meters. In eastern Oregon the bankfull width can be much wider and the streams are typically dry in the summer. Headwater streams function differently at a basin scale depending on their position in the basin. They typically do not support fish populations.*

The OHRC considers this a working definition that will be adjusted and tuned as research advances our knowledge on the characteristics of these small streams.

Technical Session Summaries

The first day and half of the workshop was dedicated to presentations and discussions on the state of the science and research gaps. Ten, two-hour, technical sessions were organized by topic to address physical and biological headwater issues. For the first hour of each technical session, two speakers presented the state of the science for the given topic followed by a second hour of facilitated group discussions on research gaps. What follows are summaries of those ten technical sessions.

Hydrologic Function

This session covered the current understanding of hydrologic processes in headwater streams. Dr. Bob Beschta presented surface water hydrology while Dr. Jeff McDonnell presented subsurface flow dynamics.

<u>Surface Hydrology</u>

Forest hydrology is concerned with the occurrence, movement and distribution of water across forested watersheds and also how forest practices influence these phenomena. The parameters most commonly studied in forest hydrology include water yield, timing of peak flows, and changes in low flows or alterations in water quality. The spatial and temporal scales at which these parameters are studied influence their outcomes. For example, a change in small to moderate peak flows as a result of forest practices was measured on small watersheds, but was not detected in larger basins (Beschta et al. 2000). Thus, simply scaling down from studies on larger streams may not capture the dynamics of small headwater streams.

While headwater streams make up a high percent of the drainage network, the processes controlling their hydrologic response as well as their influence on downstream resources are not well understood. Studies are needed to understand the role of headwater streams in routing of energy and material in the broader stream network. Most of the small stream research was done

30 years ago under a vastly different set of forest practices. Thus, new studies are needed to address the effect of contemporary forest practices on these streams.

Subsurface Hydrology

One of the traditional assumptions in subsurface hydrology is that flow follows topography. However, recent work by Grayson (1997) showed that under dry conditions there was weak topographic control on subsurface flow while under wet conditions flow followed topography more closely. Another assumption is that subsurface models are steady state, however, that may not necessarily be true as well. For example, recent work by Seibert et al. (in review) shows that the relationship between depth to groundwater and runoff changes with hillslope position. Thus, some of our assumptions about subsurface flow dynamics may need to be re–examined.

The study of subsurface hydrology depends heavily on modeling responses. Many of these models work well, however, they may work well for the wrong reasons. We need to understand models on a process level so that they are not just calibrated to produce expected responses while arriving at those responses from perhaps inappropriate pathways. Additional gaps identified by the speaker include:

Research Gaps: Identified by Speakers

? What is the hydrologic effect of roads in headwater streams?
? How do modern forest management practices such as mechanical harvesting and site preparation impact soil and water resources?
? How does current use of fire (e.g., low severity burns, pile and burn) effect soil and water resources?
? How subsurface volume controls explicit solution of water and tracer mass balance: look at fundamental controls on mixing.
? What defines a headwater stream: mean residence time and catchment averaging length. How do management practices influence watershed response trajectories?

Research Gaps: Identified through group discussions

? *Channel Response*: understand how flow resistance changes both naturally and as a result of land use practices. Also look at channel morphology as an indicator of flow variation and understand loss of water to channel substrate.

? *Classification of Streams*: devise classification schemes for small streams that reflect the relevant resource (fish, etc.). This could involve using biology as an indicator. In general, a common theme was how do we define these streams.

? *Groundwater/surface water*: develop a better understanding of hillslope /groundwater interactions as well as reservoir effects and how to identify controls on depth of reservoirs (remote sensing). This would help in understanding application of surface materials (e.g., pesticides) to movement to surface water.

? *Hydrology General*: Interception rates during large storms and snow pack processes.

- *Landscape control on stream generation*: Is it possible to define and predict when a stream becomes perennial? What are the factors that control perennial flow (e.g., basin area, geomorphology or depth to H_2O table)? Also look at factors that can help predict low flow volume change, i.e., describe the relationships between stream flow and basin area (or other metrics).

- *Models:* Are rain on snow models working for small and large watersheds? However, models can t be used in isolation, must take a multi-pronged approach which incorporates modeling, watershed, physiology, etc. process

- *Resource (biology, etc) implications*: hydrology must also be understood in context of the resource of interest and be balanced with specific function/process relationships in mind. For example, instead of just examining whether the effects of increases in smaller peak flows is statistically significant, examine whether there is an effect on the biology or morphology. Another example is whether potential increases in summer flow from timber is beneficial to fish. In addition, the downstream impact of practices must also be considered.

- *Scale: spatial and temporal*. Understand variability at a spatial and temporal scale for small headwater streams. For example, how to storms effect headwater streams, one might receive the full impact of a storm event while a neighboring watershed may miss the storm cell. To understand effects of time and geographic location on observed effects, studies need to be spatially explicit as well as continue for long periods of time (e.g., hydrologic recovery).

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Sediment Routing

The purpose of this session was to discuss and summarize mechanisms and rates of sediment storage and routing within headwaters streams and throughout a basin. Dr. Christine May discussed the issue from a field research perspective and Dr. Dan Miller provided an empiric modeling perspective. The discussion ranged from small-scale physical controls on sediment routing to how these controls might be quantified over larger scales to infer basin-wide attributes that are affected by headwaters streams.

Field Research

Multiple processes drive sediment production, transport, and storage in headwater streams. The dominant transport mechanism in small headwater streams of the Oregon Coast Range is debris flows (Dietrich and Dunne, 1978; Swanson et al., 1982; Benda and Cundy, 1990). In general headwater streams in the Oregon Coast Range, accumulate sediment and wood over long time periods and episodically transport these materials downstream via debris flows. The average frequency of debris flow occurrence is estimated to be roughly 360 years, based on dendrochronology. In a field study in the Oregon Coast range, the volume of wood and sediment stored in the channel was strongly correlated with the time since the previous debris flow (May 2001). Wood stored the majority of the sediment in these steep channels. With an adequate supply of wood, low-order channels have the potential to store large volumes of sediment in the intervals between debris flows, representing a dominant storage reservoir for sediment in mountainous terrain. In the absence of wood these small streams may become a chronic source of sediment to downstream areas.

Empirical Modeling

Predictive models can be used to estimate the flux of sediment and wood throughout a basin, and in turn the probable volume of wood and sediment stored in channel beds and valley floors. Such models can be used in two ways: 1) to estimate average values, and 2) to estimate fluctuations over time. Results from both types of modeling were presented, with a focus on sediment transfer by debris flow. The models described were primarily empirical models, with parameter values derived by field observations. Topography and vegetation control rates of sediment production by landsliding, (landslide density). Channel gradient, channel network structure, riparian vegetation, and upstream scour length all control rates of sediment transport by landslides, (probability of runout). It is possible to empirically constrain landslide density in terms of topography and vegetation cover, but care must be taken to ensure that variations in the spatial density of landslide source areas are accounted for in comparing densities from site to site. Using these empirically constrained topographic and vegetation controls on sediment production and transport by debris flows, the CLAMS topographic and vegetation-cover data sets were used (see e.g., www.fsl.orst.edu/clams/) to predict the probability of debris flow scour and deposition for all channels within coastal Oregon basins.

Large spatial variability in the potential for debris flow impacts was found. Overprinted on this spatial pattern of landslide and debris flow probability, storms and changes in vegetation drive variability in rates of sediment production and delivery over time. Lacking long time series of observed landslide rates, we use computer simulations to estimate temporal variability. A time-sequence simulation, with wildfire as the only driver of changes in vegetation, illustrated variation within a watershed of sediment storage and transport over time. Such models highlight the potential importance of watershed history, since past rates of sediment flux determine the volume available for transport during subsequent storm events. We find that predicted rates of landsliding, even when averaged over four decades (the typical extent of our aerial photograph record) vary dramatically over time.

Research Gaps: Identified by Speakers

? How do we use such models to inform management decision making and future research?
? How do we test and verify such models?

- Can we characterize (quantify) the effects of other controlling factors (geology, climate, history)?
- Can we characterize rates of other sediment producing processes (for which empirical data is sparse): earth flows, bedrock landslides, seismically driven mass wasting?
- What are the consequences of changes in process rates? For geomorphic attributes, for biological community?

Research Gaps: Identified through Group Discussion

- *What is the influence of transport mechanisms on sediment production?* What is the relative importance of deep-seated flows, debris flows and fluvial sediment transport on small streams in terms of sediment production and incision rates?

- *What factors influence landslide and sediment routing?* Quantify the importance of wood volume, wood location (e.g. channel, floodplain) and wood size in modifying sediment routing in these small streams. How does wood get entrained in debris flows (source areas) and how does it affect runout distances? Develop a better description of climate to be used in modeling efforts. Continue to examine "reloading" time frame and landslide initiation sites – do we know enough? For example we many need to consider planer side slopes as initiation sites. What is the role of site preparation activities such as slash burning on sediment routing?

- *What is the role of Surface Erosion?* This session focussed on debris flows. We need to examine the potential for fires to create hydrophobic soils and increase surface erosion and peak flows.

- *Issues of Scale?* We need improved resolution at the microscale to better represent these processes across the landscape and enable remote evaluations.

- *What is the role of headwater streams in sediment routing and what are the linkages to biota?* Better classify headwater streams relative to sediment, wood, flow, and biota. What are the linkage between in-channel sediment, subsurface flows, and low flows and how do these relate to summer time temperature regimes? Are there differences in the headwater reloading rate, sediment and composition, etc. among different forests management regimes? What is the influence of roads on landslides frequency, size, transportation, and quality?

- *Management Implications:* What are the linkages between upland forest management and sediment routing within and downstream of headwaters streams? Gather empiric information related to management effects on sediment and wood loading and routing (also flow and temp). Model various management regimes and their effects on wood and sediment loading and routing. Quantify the direct relations between biological responses (fish habitat) and diversity to sediment routing and disturbance frequency. Evaluate pool loss in eastern Oregon. Produce integrated procedures to diagnose specific situations – what kind of place is this? What do I need to operate?

- *Historical context*: Understand the historic sediment routing trends.

? *Modeling*: We need a comprehensive roads data base – for large spatial scale public/private land to better inform the modeling and management processes. Use models to support the adaptive management process. Integrate models – multiple phenomena. Road, harvest, residential histories to enrich model. How do current models that are based on wildfire handle today's managed landscape? How do use historic disturbance regimes to inform management decisions?

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Stephen Lancaster's web site: www.fsl.orst.edu/wpg/people/stephen.htm) for an example of a process-based modeling approach.

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Wood Dynamics

The purpose of this session was to discuss and summarize mechanisms and rates of large wood delivery, storage, and movement within headwaters streams and throughout a basin. Dr. Bob Bilby reviewed the ecological function of large wood in streams and summarized regional differences in the volume of wood stored in small streams, and management related effects. Dr. Gordon Reeves discussed sources of wood in debris torrent-prone systems and the implications for restoration and management goals at the reach and watershed scale. Both speakers confirmed that research has revealed a great deal about the site-specific role of large wood in small streams but far less about the interactions between large wood and sediment delivery, disturbance, and other basin-level processes. The discussion ranged from small-scale physical controls on sediment routing to how these controls might be quantified over larger scales to infer basin-wide attributes that are affected by headwaters streams.

Small streams tend to have a higher abundance of wood than larger streams, although the average piece size tends to be smaller. In larger streams aggregation of multiple pieces of wood is more common than on smaller streams. This is attributed to infrequent wood transporting events such as debris torrents. Wood abundance varies regionally and is related to forest species. The largest volumes of wood have been observed in Redwood forested streams (1765 m^3/ha) and the lowest was observed in Engleman spruce (69 m^3/ha) and Pine (22 m^3/ha) dominated forested streams. This is a function of fire disturbance particularly recurrence interval), site index, and tree size.

Wood influences sediment retention and transport, organic matter retention, hyporheic flow, nutrient cycling, and invertebrate community composition and abundance. Removal of the overstory around small streams is likely to result in smaller changes in wood abundance than is observed on larger streams. This is because smaller pieces of wood are functional on smaller streams so these streams recover their wood sources more quickly than larger streams. There will be fewer big pieces and changes in pool types and total pool area are expected. Harvest around small streams may initially increase sediment and organic matter storage as a result of logging slash. As slash decomposes sediment and organic matter are routed downstream. As riparian wood delivery increases, sediment and organic matter storage will increase. The ecological significance of the changes is dependent on the spatial distribution of conditions and rate of recovery.

Headwater streams are important sources of wood to larger order streams, particularly in debris-torrent prone systems. A study in the Oregon Coast Range found that 48% of the total volume came from upslope sources. The mean volume per piece was smaller from upslope sources than near-stream sources. Predictive models demonstrate the stochastic nature of wood loading throughout time and space. These models can also predict likely headwater sources of wood. Understanding historic landscape variability in wood distributions and likely sources of large wood can improve our ability to manage these small headwaters streams and set restoration and management goals.

<u>Research Gaps Identified by Speakers</u>

? Wood Delivery
  - Importance of torrent delivered wood to higher order channels
  - Management options to provide a source of wood for transport when torrents occur

? Sediment and Organic Matter Transport
  - Rate and timing of sediment delivery to higher order channels
  - Rate, timing and characteristics of organic matter delivery
  - Drifting macroinvertebrates in relation to headwater condition

? Spatial and temporal considerations
  - Response of higher order streams to different combinations of tributary condition
  - Disturbance of tributary conditions change through time as a result of forestry and natural disturbance processes.

<u>Research Gaps: Identified by group discussion</u>

Many questions from other sessions (riparian, geomorphology, classification, nutrients, temperature) relate to wood dynamics.

? *Research ability and cost*: Can research identify management options that might mimic wood delivery? Can research help maximize benefit for fish, and reduce cost for landowners and managers?

? *Wood delivery and stream impact*: What is the effect of windthrow on wood volume and sediment and morphology? Does harvesting near small headwater streams have less impact on wood abundance than harvesting near larger streams?

- *Wood interception devices*: Road fills, culverts, and interception of wood and sediment. Highway and bridge requirements to remove large wood. How does peak flow play into this?

- *Wood dynamics and function:* How does smaller diameter wood (<10cm) function in headwater streams? Quantify the importance of wood volume, wood location (e.g. channel, floodplain) and wood size in modifying sediment routing in these small streams. How does wood get entrained in debris flows (source areas) and how does it affect runout distances? Continue to examine "reloading" time frame and landslide initiation sites – do we know enough? For example we many need to consider planer side slopes as initiation sites. What is the role of site preparation activities such as slash burning on sediment routing? Are debris jams in small streams thermal barriers? What is the relative importance of deep-seated flows, debris flows and fluvial on wood transport on small headwaters streams? How does wood from different tree species function in small streams? Evaluate the importance of wood in the context of other geomorphologic controls (e.g. wood is not always the dominant geomorphic control). How does stream gradient and particle size effect wood abundance and function? Evaluate wood dynamics in low gradient and/or non-forested areas.

- *Fire*: Effects of low intensity, high frequency fire events on accumulations of wood on the east side and visa versa on the west side?

Riparian Dynamics and Microclimate

This session covered the current state of knowledge with regard to riparian dynamics and microclimate associated with small headwaters streams. Dr. David Hibbs discussed riparian dynamics and Dr. Sam Shan discussed microclimate factors. Both highlighted the variability of riparian structure and processes.

<u>Riparian Dynamics</u>

Dr. Hibbs focused on the ecological dynamics of these systems and brought to the forefront the process of succession in riparian systems. These dynamic systems have spatial differences not only at the watershed scale, but also at scales finer than the reach scale. Two concepts he stressed were common threads in other sessions, disturbance and recovery from disturbance. These occur throughout the landscape, but at a temporal scale that may be too long for it to be very apparent. The relationship between flood and bed load transport and the eventual colonization of alder may be repeated in a rather short cycle within some geomorphologies, while less frequent disturbances or different ones (i.e. fire) could initiate longer vegetation cycles. So at a watershed scale the diversity of riparian vegetation can be large.

Another factor he discussed relates to this diversity of riparian vegetation in its influence on food chains for riparian animal communities. He speculated that if biodiversity were a goal, than homogeneous riparian plant communities and structure would be counter to that goal.

Riparian Microclimate

Microclimate gradients vary based on macroclimate, topographic features and regional location (westside-eastside). However, it's not simply whether small differences in local riparian conditions occur, but why and how those changes are important to organisms. In headwaters systems these organisms are very diverse, including moisture obligates as mosses and amphibians. While most of the available data (which is limited) has found gradients of microclimate factors like relative humidity, air, and soil temperature to be measured in tens of feet rather than hundreds of feet, there is little supporting information on effects to biota.

Sam also presented some results from the density management work on canopy responses to different stem densities. Even at low stream densities, canopies closed within a few years. This short term change in factors such a shading needs to considered in the context of what is the larger gain in increased growth in the remaining stems, particularly if a management goal to create conditions approaching "old-growth".

Research gaps: Identified by Speakers

? Increase our understanding of spatial and temporal variability. How do disturbance régimes impact regeneration and future development of the vegetation community?
? Conduct basic research on general vegetation composition and dynamics, regional diversity, and local diversity (reach to reach).
? Are there predictable changes in response to altered disturbance regimes (e.g. cattle impact, harvest practices, landslides)?
? Increase our understanding of riparian food dynamics.
? How does change in microclimate affect organisms? What are the physical or biological components affecting microclimate and how do we determine this? Role of microclimates in headwaters is not only focused on shade and temperature but also on other organisms such as mosses and amphibians. We know little about them and what kind of climate they need. There is naturally a sharp decrease in relative humidity in a system from the stream to 25 ft in an unharvested system. What does this mean to an organism and what impact does that have when there is a harvest unit? Will they still be able to find a microclimate in that buffer to maintain their needs?
? How fast does vegetation respond? What is the interim impact? Do you see the same changes between hardwoods and conifers in a system? Vegetation responds quickly when the canopy opens up (a few years). Canopy development is fairly rapid in roughly 40-year-old stands for example. Density removed will affect growth over the next several years and the vegetation that grows.

Research Gaps: Identified through group discussion

? *Riparian Dynamics*: Lack of understanding of cyclic patterns and how and if they have been changed. What is historic range in natural variability in relation to the local range of variability? Has there been a shift in disturbance processes? Long-term monitoring projects need to be developed and maintained. How do riparian and microclimate processes and characteristics of headwater streams differ from larger streams? How does management affect riparian characteristics and functions in both the long-term and short-term? What is the interaction between vegetation and upslope stability?

- ? *Riparian habitats*: What are the limiting factors of various types of riparian inhabitants? Microclimates in intermittent streams may be critical to survival of various organisms (eg. salamanders, mollusks). What is the best design to study animal refuges that do not harm the animals in the process in order to study them in their habitat? Habitat surrogate choices are important. Some organisms may be very difficult to monitor.

- ? *Management of riparian areas:* Need a standard classification system. What level of riparian area protection is needed? Through an understanding of process, can we identify appropriate measures to provide sustainable habitat for headwater riparian obligates? What can land management agencies do on their land to go about business and follow regulations at the same time?

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Organic Matter and Nutrient Cycling

This session examined the current state of knowledge concerning processing and transport of organic material and nutrients within and from headwater systems. Dr. Peter Kiffney described nutrient dynamics in headwater streams and how these systems differ from larger steams. Dr. Stan Gregory expanded on that presentation by discussing the importance of small and large wood on nutrient dynamics.

While headwater streams are numerous (95% of total stream channels and 75% of stream length) and provide essential ecological services, little is known about their ecology. Headwater streams have the shortest of uptake length for nitrogen and phosphorous, important regulators of water chemistry and aquatic production. This role in water quality goes beyond the headwaters, as these systems are critical to nutrient dynamics downstream. Linkages are one way to understand the importance of headwater streams to downstream channels and entire watersheds.

Nutrient processing within headwater riparian ecosystems can create highly productive areas on the landscape and these areas are important sources of biodiversity. Invertebrate diversity in intermittent headwater streams may be higher than in permanent streams. These systems deserve more effort in understanding because they provide essential ecological functions, are the links for many material transported between adjacent and downstream reaches. Yet headwaters riparian zones receive the least protection on forested landscapes.

Wood mediates ecological process such as nutrient dynamics. Retention of leaves and other smaller organic material during transport is higher in streams with more roughness in the channel (wood, boulders), meaning shorter travel distances for leaves (which are potential food resources). The invertebrate communities in small streams are important in processing organic material and eventual transport downstream. Nutrient spiral through the riparian ecosystem, nutrients moving in tighter spirals in systems with large and small in-channel wood the system.

The factors leading to the recruitment of organic material in headwater stream channels are only recently been investigated. Wood delivered to stream; how it gets into stream, how many pieces, and how large is important in understanding these systems. Modeling may be the best approach to compare and contrast different management scenarios.

<u>Research Gaps: Identified by speakers</u>

? What is the role of headwater streams in organic matter and nutrient dynamics, and the contributions these channels make to downstream ecosystems? How do these differ between stream, regions and season?

? Can manipulation of riparian buffer widths be used to determine effects on community and ecosystem dynamics?

? What are the role and distribution of hot spots within a watershed? Examine tributary junctions to determine influences on main stem habitat, including water chemistry and nutrient loading, and biological productivity and diversity. Sites on larger rivers that are downstream of tributary junctions may have higher levels of biological productivity and diversity compared to sites upstream of these junctions because of subsidies of materials from headwater streams.

? Wood dynamics; including how wood is delivered to streams, how many pieces. Are present, piece size, and wood movement through time (e.g., episodic transport during debris flows, importance of tributary junctions, etc? Wood sources including riparian areas, tributary streams, and upslope areas, and directionality of wood sources into streams. Wood breakage and decomposition in streams.

Research Gaps: Identified through Group Discussion

? *Nutrient dynamics*: Determine the contribution of microbial food webs, especially where dissolved organic carbon and dissolved organic nitrogen is a main component. Nutrient work related to ungulates or mammals impact on nutrient cycling and nitrates. What are nutrient relationships between aquatic and upland systems (both directions)? How do they change seasonally? Can we identify nutrient or productivity hotspots and what linkages exist between those areas and rest of the landscape? How is the nutrient transfer affected by particle size and substrate type? Cumulative change in shift from conifer to alder? What are the consequences of the patterns we see between the two types?

? *Management implications:* Is there a diminishing point of return for in-stream wood and its impact on fish? What are the effects on headwater streams at their own level? How far and to what intensity do effects translate downstream, if at all? How does buffer width effect instream primary production and nutrient levels. Determine ways to differentiate and establish priorities for stream restoration opportunities, including associated cost-benefit analysis and environmental benefit.

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Dissolved Oxygen and Temperature Dynamics

The purpose of this session was to summarize our understanding of the functions and dynamics of dissolved oxygen (DO) and water temperature in headwater forest streams. Dr. Arne Skaugset of Oregon State University and Dr. Sherri Johnson of the USDA Forest Service led the discussions. Dr. Skaugset described work on DO as part of the Alsea Watershed Study. Dr. Johnson described small watershed studies in the HJ Andrews Experimental Forest and stream temperature dynamics within a large basin. Dr. Skaugset concluded with some findings from recent water-temperature monitoring efforts in small headwater streams.

<u>Dissolved Oxygen</u>

Aquatic organisms require dissolved oxygen for aerobic respiration. Most research has been conducted for fish-bearing streams. Much of our understanding in the Pacific Northwest comes from the Alsea Watershed Study, where one watershed was completely clearcut and slash was introduced into the stream. Severely depressed DO levels were found due to a combination of elevated stream temperature (resulting from increased insolation; DO saturation concentration inversely related to temperature) and increased biochemical oxygen demand (BOD). Work at Oregon State University has characterized key components required to model DO/BOD dynamics in forest streams, including the amount and rate of oxygen demand created by forest slash and the rate of reaeration in small headwater streams. Forest practices that keep fresh slash out of streams and maintain stream temperatures near normal should minimize DO problems. One example was an unpublished Flathead Lake Biological Center report that has traced depressed DO in a lake to harvest units in the watershed upstream.

Temperature

A variety of factors influence stream temperature, including incoming and outgoing radiation, convective and conductive heat exchanges, and various groundwater and hyporheic zone water transfers within the stream. For small forest streams, a change in solar radiation input is the dominant factor in increased stream temperature. Clearcutting has been shown to shift maximum temperatures to periods of highest solar angle rather than minimum flows. In the Cascades, recovery times of stream temperatures following clearcutting were observed to be approximately 15 years. Stream temperatures show great variations both temporally and spatially. Relative relationships can change seasonally. One example presented was a cool tributary that increased in importance as summer flows in the main channel decreased. Controlled experiments at the H.J. Andrews Experimental Forest in a bedrock reach (scoured by debris flows) showed how shade affects stream temperatures at a reach level. With 100% shading, stream temperature maxima decreased, but not mean or minimum temperatures. Field observations downstream of clearcuts also supported these findings. However, other research at Oregon State University has not found these reductions when streams enter reaches with forested canopy. The HJ Andrews work also demonstrated how important subsurface water exchange is in regulating stream temperature. Where a large proportion of the stream travels through hyporheic pathways, travel times are much slower and diurnal stream temperatures fluctuations are dampened, with lower maxima. The importances of harvesting to groundwater temperature and the significance of increased groundwater temperatures to stream temperatures have not been well studied.

Research Gaps: Identified by Speakers

? Can oxidizable leachates from slash, introduced by harvesting adjacent to small headwater streams be transported in sufficient quantities to influence fish-bearing streams?
? Can oxidizable leachates from slash, introduced by harvesting adjacent to small headwater streams be transported downstream in sufficient quantities to influence sensitive reaches or waterbodies like lakes and reservoirs?
? In the fall, are DO concentrations in headwater streams with riparian alder significantly depressed compared to those dominated by conifers?
? Do increases in headwater stream temperatures significantly increase temperature downstream in reaches with fish?
? Does the architecture of riparian canopies significantly influences shading?
? How do clearcuts influence stream temperatures downstream? Do reaches with closed canopy influence mean and minimum temperatures, or just maximum?
? What are the effects of thinning of riparian areas on stream temperatures?
? How do changes in microclimatic gradients in harvested areas influence stream heat budgets, especially for factors like conduction?

Research Gaps: Identified through Group Discussion

- ? Do increases in groundwater temperatures following harvesting can influence stream temperature?
- ? Do debris torrents significantly increase stream temperatures?
- ? Do phreatophytes remove significant amounts of water from streams and does this influence stream temperatures?
- ? Do changes in viscosity due to increases in water temperature result in important changes in stream functions?
- ? For both temperature and DO a question was raised about what organisms we are trying to protect. Some members of the audience suggested that there is a need to determine the physiological limits required by organisms in headwater streams, including but not limited to amphibians and fish.

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Geomorphology and Channel Classification

The purpose of this session was to discuss and summarize mechanisms that drive the development of stream channel morphology and potential methods/systems for classifying these streams. Michael Furniss provided a background on the various classification systems for streams and offered a method to unite the science. Dr. Rhett Jackson discussed his research on dominant factors affecting channel morphology and habitat. The discussion ranged from specific nomenclature to the impacts of small wood in streams.

Classification

Headwater streams are the most abundant channels in any landscape, and often are the most geomorphically diverse and active places. Discriminating between different streams at scales larger than the site can be difficult. Discerning the geomorphic processes and sensitivities to management among small streams at watershed and site scales is crucial to designing appropriate practices on streamside slopes. Existing stream classification systems are inadequate for any logical grouping of appropriate practices based on research findings. A system of multi-scale, interdisciplinary stream/riparian description, based on a consensus ontology was suggested. This ontology could have many benefits including the comparison of research findings, communication, avoidance of misapplication of findings, promote the systematic multi-scale application of research findings, and provide a framework to more effectively discover the gaps in our knowledge.

Channel Morphology and Habitat (field research)

Channel morphologies were surveyed of 42, 1st and 2nd –order streams to provide descriptive data on headwater streams on Washington's Coast Ranges. Statistical models were utilized to determine the dominant factors affecting channel morphology and habitat. Findings suggest that geomorphological relationships documented in larger streams do not apply to headwater streams. Relatively small pieces of wood, inorganic materials, and organic debris were major step forming agents. Stream power and unit power were dominant channel shaping factors. Reach-scale morphology depends on both flow and gradient.

Surveys of streams with various forested buffers documented some immediate channel changes (increase of in-stream slash and retention of fines) due to harvest activities to the stream edge. Channel condition is expected to change over time as the slash decays and new vegetation develops on the channel margins. No temperature changes could be detected apparently due to the shade and thermal buffering provided by the slash. Thin riparian buffers prevented slash burial of channels and maintained habitat structure, but large amounts of buffer blowdown were observed one year after harvest. Channel responses to harvest are documented in Jackson et al. (2001).

Research Gaps: Identified by Speakers

? What is the role of root permeation in providing for channel and streamside slope stability? What kinds of channels and streamside slopes are sensitive to changes in root abundance and strength?

? There is a strong need for training and guidance for managers through better integration of research. Managers need a system by which to make operational decisions regarding management practices around headwater streams. Research should be integrated into a operational designs that are based on ecological classification or descriptions of small headwater streams.

? Roads can have major effects on small streams, but vary greatly in actual and potential effects. A system of tracking road performance is needed, so we accumulate data sets that help define problem areas and how impacts can be avoided and minimized.

? In order for research to be applied and ultimately improve management practices it needs to be accessible. Accessibility can be improved through improved cataloguing and use of key words.

? Need to develop and use two important small stream descriptors:

Flow duration (expressed as months per year) and,

Channel base level control (e.g. wood, rock, roots)

Research Gaps: Identified through Group Discussion

? *Development of ontology:* What is a headwaters stream?

? *What are the appropriate protection measures to preserve function?*: Where will buffers be effective? What is the intent of buffers? Have we gained or lost function if the buffers blow down? How important are hillslope processes relative to buffers?

- *What is the role of Surface Erosion?* This session focussed on debris torrents but we need to examine the potential for fires to create hydrophobic soils and increase surface erosion and peak flows. How does stand type effect blowdown?

- *What is good habitat?* What is the correct definition of a pool in a headwaters stream? What is the value and extent of subsurface habitat? What are the processes that bring in LWD? Different landforms/geomorphology respond differently to change. What is the relationship of channel size to functional and total wood frequency? How do the ranges of functional wood size vary with channel size?

- *What is the role of GIS*? Consistent and high quality GIS layers w/metadata.

- *Physical and Biological Process Linkages:* In some small streams roots clearly play a much larger role than wood pieces in controlling physical processes. Identify the primary physical processes controlling the function of the headwater stream and what is the interface with the biotic processes and feedback loops.

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Basin Level Effects

The purpose of this session was to frame the state of knowledge and critical research needs regarding the importance of headwater streams to basin-level effects. Dr. Lee MacDonald from Colorado State University, and Dr. Kelly Burnett from PNW Research Station, Corvallis, Oregon gave summary presentations.

State of the Knowledge

There are many challenges in our current ability to predict change in hydrologic regimes, sediment yield, and channel morphology, in part due the high variability of basin and channel processes. The watershed system exhibits a low signal-to-noise ratio that confounds precision of stochastic models and predictability of deterministic models. The high uncertainty associated with predicting basin level effects suggest that success will be most high with more qualitative risk-based approaches.

It is desirable to first identify key resources supplied by headwater streams then understand and manage to support on-site and downstream aquatic function relative to these resources. Although management approaches for headwater streams may be coarse filter (i.e., based on broad-scale disturbance regimes) or fine filter (i.e., directed at individual resources), the latter is likely the more feasible approach for private lands at present. A fine filter approach does, however, require accurate delineation of the headwater stream network, which is a hurdle not necessarily encountered with a coarse filter approach. An example from the Oregon coast range demonstrated how either a statistical model or a process-based model could be used to distinguish which headwater streams were, and were not, important source areas of large wood or sediment for downstream salmonid habitat. Such information is essential when designing a fine filter approach aimed at efficiently protecting basin-level functions of headwater streams.

Research Gaps: Identified by Speakers

- Rainfall interception during large storms.
- Peak flow synchronization issue.
- Forest harvest effects on rain-on-snow events.
- Metapopulation studies for headwater species.
- Relative role of headwater streams in providing for downstream resources, interaction between resources, and management effects on delivery of resources.
- Bio/physical studies to support coarse filter management such as those aimed at determining range of natural variability and characterizing the natural disturbance regime.
- Socio/economic studies to determine methods for increasing the social acceptability of coarse-filter management when applied to multi-owner landscapes.

Research Gaps: Identified through Group Discussion

- *Temporal and spatial variability across time scales.* What is range and distribution of conditions (i.e. what is pristine?), consider also arid eastern side of state.
- *Recovery rates for different processes and management impacts*. At what point do natural disturbances overwhelm management effects. To what extent will past management influence processes today and in the future?
- *Integration of GIS layers*; physical and historical layers for nested basin analyses and regional/interregional comparisons.
- *Comparative hydrologic and sediment budgets*. Quantitative, multivariate assessment of controls on headwater channel morphology, and explicit budgets of source areas.
- *Need to identify key resources relevant to headwater systems*. Developing downstream indicators that are tied to upstream effects as way to reduce noise.
- *Alternate conceptual methods* (approaches) may be found in other fields, e.g. decision analysis.
- *Lack of easily accessible data to look at basin-level effects*. To what extent are we using outdated or needlessly incomplete data?
- *Low flow hydrology in headwater streams*.

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Fish and Amphibians

The purpose of this session was to summarize and discuss our current understanding of the distribution, ecology, and status of fish and amphibians within headwater streams. Dr. Bob Gresswell discussed the importance of headwater systems for fish and Dr. Marc Hayes provided an overview of headwater amphibians, with an emphasis on sampling issues. The discussion ranged from diversity and abundance of headwater stream fish and amphibian taxa to sampling and methodological issues. Difficulties associated with measuring responses of headwater fauna to management practices also were discussed.

<u>Fish</u>

Headwater stream systems are harsh environments for fish, which must adapt to often unfavorable habitat conditions (e.g., steep gradients, patchily distributed habitat). As watershed elevation increases, species richness decreases. Relatively little is known concerning headwater stream fish biodiversity, but resident cutthroat trout appear to dominate the fish fauna, and it has been suggested that these cutthroat populations may function as metapopulations. Headwater streams also influence fish in lower watershed positions by functioning as delivery sources of habitat (e.g., wood, sediment) and nutrients (Vannote et al. 1980). Disturbances in headwater systems interact in a complex manner with vegetation, landform, and climate to trigger these downstream deliveries. Disturbance events in headwater streams will benefit some species but may harm others, and impacts will occur at multiple scales (e.g., stream, segment, reach, habitat, microhabitat).

A field study examined 60 randomly selected third-order basins (total population of third-order watersheds in western Oregon ? 2800 basins), stratified by ecoregion and geology, with isolated populations of cutthroat trout. Fish were patchily distributed, with significant spatial and temporal variation above waterfalls. In winter, most fish were found in pools, but encountered more often in cascades and riffles during summer. Fin clipping showed that 80% of fish didn't move more than 5 habitat units, although the percentage was much lower (43%) when radio tagging methods were employed.

Amphibians

Three species (tailed frogs, torrent salamanders, Pacific giant salamanders) dominate the amphibian assemblage of PNW headwater streams, although several terrestrial species often are associated with adjacent riparian habitats. These three species share several life history traits (e.g., lengthy larval aquatic stage, presumed small home ranges, and limited dispersal abilities) and habitat requirements (cold streams with clean gravel and cobble). Early studies established the pervading paradigm that PNW headwater stream amphibians are associated with late-seral forests and that disturbance to vegetation may result in local population extinctions (e.g., timber harvesting may increase sediment deposition and increase water temperatures via canopy removal). More recent studies (Diller and Wallace 1996, Wilkins and Peterson 2000) indicate persistence of headwater amphibians in managed forests and demonstrate the need to focus on importance of abiotic features (e.g., parent geology, topography, channel characteristics) to predict distribution of headwater amphibian species and responses to disturbance. Discrepancies among studies regarding distribution, abundance, and management sensitivity of headwater amphibians may be related to the lack of standardized and validated sampling methods (Hayes et al. 2001). Sampling methods and intensities need to be properly scaled to questions (e.g., occurrence vs. density, macrohabitat vs. microhabitat associations) and evaluated for both precision and accuracy.

Research Gaps: Identified by Speakers

Fish

? Still lacking basic data on distribution, life history characteristics, and habitat requirements of headwater fish, and factors influencing their persistence.
? How are fish numbers and size impacting types (size) of streams they can migrate to?
? What are genetic patterns of fish populations in headwater streams?
? Do they function as metapopulations?
? What is contribution of headwater stream fish populations and habitat to downstream populations? Can we develop standardized sampling methodologies for characterizing headwater fish distribution and habitat?

Amphibians

? What suite of biotic indicators is sufficient to measure significant ecological change (on site and downstream) in response to forest management activities?
? What sampling methods and intensities are most appropriate for a) detecting occurrence/density, b) monitoring persistence trends and responses to management?
? Can we generate estimates of variance, precision, and accuracy of different sampling methods?
? Do amphibians persist in managed or disturbed headwater systems? What are the appropriate temporal and spatial scales to measure persistence?

Research Gaps: Identified through Group Discussion

- ? *Need for basic information on headwater species*: Lack of basic life history/habitat requirements for headwater species. What is the importance of intermittent channel habitats? Of particular need are data on movements of headwater stream species. Includes vertical and horizontal in-stream movements (e.g., do headwater amphibians persist in streambeds during low-flow events), daily and seasonal variation, as well as potential colonization of adjacent basins. How much do we know about non-salmonid fish species in headwater streams?

- ? *Integrated approaches?* Integrated, multidisciplinary studies are badly needed. Single-element studies often cannot be used for evaluating impacts. Examine fish and amphibians collectively.

- ? *Historical context?* Understand the historic and current role of natural disturbance in shaping headwater fish and amphibian life histories. Inter-relationships of species ecologies with natural disturbance histories at multiple scales. How do current disturbance regimes approximate or deviate from historic regimes.

- ? *Issues of sampling and scale?* Determine what scales are appropriate for sampling techniques and research question(s). Serious sampling and methodology limitations exist that limit our ability to answer questions. Many methods untested (variance, precision, power). Long-term studies needed with adequate spatial replication.

- ? *Management Implications?* What are the linkages between forest management (upland and riparian) and persistence of headwater fish and amphibians. Both direct and downstream effects must be considered. How do we measure changes in headwater stream habitats and effects on amphibians/fish? Use manipulative research approaches (e.g., measures responses of metrics before and after implementation of various management prescriptions; BACI designs) rather than retrospective observational studies. Need sufficient pre-treatment calibration period for this approach. Ultimately useful for formulating/refining management rules. If a change is identified, is it biologically significant, favorable vs. unfavorable? How do we maintain persistence across scales in managed settings? Studies needed to identify real problems that are relevant to current management practices.

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Invertebrates and Periphyton

In this session Dr. John Richardson (Dept. of Forest Sciences, Univ. of British Columbia) and Dr. Chuck Hawkins (Utah State University) provided an overview of the current knowledge on aquatic invertebrates in headwater streams and outlined some key research questions or gaps. Dr. Richardson also discussed some issues related to periphyton in headwater systems.

State of the Knowledge

Headwater stream systems are biologically diverse and productive. Invertebrates, for example, often show as high or higher diversity in headwater streams (intermittent or perennial) as that found in larger streams. Productivity, though less often measured, can also be high, and comparable to larger streams and rivers. The high biological diversity in headwater streams results from the heterogeneous nature of them (widely variable physical, chemical and landscape characteristics). Factors that affect assemblage abundance, diversity and composition include temperature, substrate, hydrology, oxygen concentration, ionic composition, and food sources. Invertebrates depend not only on in-stream conditions (necessary for the survival of the aquatic immature stages), but also on riparian and bank conditions (necessary for adult survival and reproduction).

Changes in invertebrate/periphyton abundance, diversity, and/or composition have been observed in conjunction with forest management. Altering one or more of the environmental factors listed above may make local stream conditions less suitable for some species and more suitable for others. Reducing or eliminating riparian vegetation has produced increases in periphyton biomass and shifts to more filamentous forms, and shifted invertebrate communities to more generalist species.

The importance of invertebrate and periphyton assemblages in headwaters to biological functions downstream is poorly understood. However, the diverse and sometimes unique fauna of headwater streams are by themselves important, and contribute to overall biodiversity.

The current level of knowledge about the biota in headwater stream systems was debated. It was agreed that the heterogeneous conditions in headwater systems complicates cause and effect studies and understanding. However, it was also noted that most studies on aquatic organisms have been conducted on small streams and the information base is extensive. Still the amount of information on truly headwater streams (1st or 2nd order) is less extensive than for mid order (3rd or 4th order) streams.

Research Gaps: Identified by Speakers

- ? What effect has wide-scale transformation of forested landscapes had on the regional biodiversity (across various scales – watershed, basin, ecoregion, etc.) of headwater stream invertebrates?
- ? What effects has the alteration of headwater assemblages had on local ecosystem functioning and downstream movement of energy and nutrients?
- ? What is the relative importance of in-stream alterations, which influence immature life stages, and stream-side alterations, which directly affect adults?
- ? What are the main causal mechanisms in headwater systems that alter invertebrate assemblages?

Research Gaps: Identified through Group Discussion

- ? *How can alterations to aquatic assemblages be identified without knowing what the assemblage should be?* There is a need to identify and sample reference type (minimal to no disturbance) headwater streams to characterize undisturbed invertebrate assemblages. RIVPACs type models use these data to predict expected taxa at study sites.
- ? *What key attributes of headwater streams determine species composition, diversity and abundance?* There is a need to include cause and effect testing of environmental attributes. Most studies use physical habitat as the predictor for assemblages, even though some organisms might be present because of indirect factors such as foodweb effects.
- ? *What are the cumulative downstream effects on biota resulting from modifications along headwater streams?*
- ? *How long does recovery take for a degraded state of stream? How variable are recovery rates given different management practices and types of streams (high gradient vs. low gradient; different geology, etc.)*
- ? *What is the appropriate spatial and temporal scale for studying aquatic assemblages in headwater systems?*
- ? *How many trophic levels need to be assessed – is assessing macroinvertebrates alone sufficient?* Will depend on questions being asked. Need to know if invertebrates vary in parallel with other components of the ecosystem if we want to index overall system health.
- ? *Microhabitats that do not get sampled: are they overlooked or are they purposefully skipped over?* Some microhabitats may not be capable of being sampled. Also, assessment of system condition does not necessarily require that all habitats are sampled, just that the habitat(s) sampled be representative of what is happening system wide.

Small Group Sessions

The first day and half of the workshop was dedicated to presentations and discussions on the state of the science and research gaps. During the second day, workshop participants broke up into smaller groups to discuss research hypotheses and priorities. What follows are summaries from those small group discussions.

Hydrological Function, Stream Temperature and Dissolved Oxygen

Since the quality and quantity of streamflow in small headwater streams are connected, these two topics were grouped for the small group discussion on the second day. Only a fraction of workshop participants (approximately 7 researchers, landowner and agency representatives) discussed the top priorities for hydrologic function and water quality research. Some of the group's priorities were different from the previous day's discussion while some of the priorities perhaps more properly belonged in other sessions. Research priorities were grouped under major headings.

Low Flow (includes some basic streamflow questions)

? Where does streamflow initiate – what is the seasonal variation?
? What is the relationship of low flow to watershed area?
? How does low flow relate to low frequency (e.g. interdecadal) climate variability?
? What is the variation of low flow with vegetation change (based on long term data?)
? How does low flow vary geographically (e.g. with geology, climate, or vegetation)
? Does low flow affect presence or absence of fish? Is this a foundation for classification?

Residence Time of Water and Chemical Constituents

? Fate and transport of chemicals and nutrients (nutrient spiraling) by water.
? Relationship to low flows and evapotranspiration (longer residence=greater opportunity to be evaporated). Potential to use isotopic tracers to determine residence time.

Temperature

? Downstream recovery rate and vegetation influences on recovery rate.
? Improved spatial modeling of temperature.
? Factors influencing regional temperature patterns.

Snow

? Peak flows from rain-on-snow (still basic questions).
? Low flow variations through season (i.e. winter low flows).
? Vegetation influence through interception of snow and rain.

Sediment Routing, Wood Dynamics, and Channel Geomorphology

The routing of sediment and wood are inseparable from the geomorphology of small headwater streams. Therefore these topics were grouped together for a discussion identifying the top sediment, wood and geomorphology research priorities. A sub-group of workshop participants (approximately 20 researchers, landowner and agency representatives) discussed the role of headwater streams in routing sediment and wood. These processes influence the channel geomorphology at both the local and basin scales. The group posed an overarching process level question with related research goals:

- ? *What role do headwater streams play in routing wood and sediment to downstream reaches?*
  - Better characterize/classify headwater streams relative to sediment, wood, flow, and biota.
  - Gather empiric information related to management effects on sediment and wood loading and routing (also flow and temp.).
  - Model various management regimes and their effects on wood and sediment loading and routing.

The group also discussed some key research questions that need to address specifically on headwater streams.

- ? *What are the effects of fire on surface erosion and runoff?*
- ? *How does wood get entrained in debris flows (source areas) and how does it affect runout distances?*
- ? *Does a change in geomorphic input result in a change in watershed process and ultimately a change resource condition?*

Riparian Dynamics and Microclimate

This sub-group of about fifteen individuals reviewed and built on the earlier presentations and group discussions. While there was largely full agreement on the research needs, two issues were discussed at length.

- ? Regional differences in Oregon and Northwest.
- ? Need for integration of research needs brought out in this session's discussions as well as the other sessions.

In Oregon here are considerable differences in riparian communities and the factors that drive their present condition and potential future pathways of development. So at large scales, research needs to determine what is how processes differ in these ecosystems. These process differences include the obvious distinction of east versus west systems, to the more subtle changes in north-south gradients with both the Cascade and Coast Ranges to within watershed differences due to elevational, aspect or other factors. Past management, as well as disturbance histories further complicates this. Therefore as we develop projects to investigate riparian ecology, we need to be cognizant that research results may have limited applicability. Although, replicating research across areas should provide results that would be both area specific and help understand the relative importance of various factors.

Participants in his sub-group were interested in avoiding projects that lacked integration of other disciplines. It was brought out, that locating sites that meet logistical requirements might limit the number of potential sites, particularly if adaptive management was part of the design. Therefore careful planning of projects was important to get the most out of possible sites and avoid duplication of efforts. For example, studies of headwater hydrology and animal communities would be types of research that may complement any projects targeting microclimate gradients.

Research Priorities for Aquatic Biota

This group was too large so two subgroups were formed.

Sub-group I:
Key question: What suite of biotic and abiotic indicators is sufficient to measure significant ecological change (on site and downstream) in response to forest management activities?

1. Basic species life history/ecology/habitat data needed for headwater fish and amphibians. Key focal areas: movements (in-stream, among stream, dispersal, migration, metapopulation dynamics)
2. Inter-relationship of species ecology with habitat history at multiple scales.
3. How do we maintain 1&2 (e.g. species persistence) across scales in managed systems?

Sub-group II:
In general the issues discussed by a subgroup focusing on aquatic biota are grouped into three main categories:

- Ecosystem function and scale issues
- Sampling method and assessment issues
- Cause and effect questions/issues.

Ecosystem Function & Scale Issues

- If a change is identified, when is it significant and what is the biological meaning?
  - The observed changes should be related to natural variability and disturbance responses.

- How do invertebrate or algae responses in small streams relate to downstream biota? (e.g. food delivery rates and responses).

- Long term, integrated multidisciplinary, studies on broad spatial scales are needed.
  - Single element studies often cannot be used for evaluating problems.

- Need to refine definition and/or a classification scheme of small streams
  - Geomorphic constraints (e.g. upslope, downslope, intermittent channels).
  - Should try to separate functionality and biota differences (if any), and identify probable differences in spatial patterns of disturbances and disturbance differences.

Sampling Method & Assessment Issues

- Adequate sample design and size to get an assessment of stream status (e.g. healthy, ok, degraded) relative to management perturbations.
  - Variability needs to be overcome: scale problems, method problems, etc.

- Are the results, relative to the methods, defensible?
  - Convince peers, test and validate methods, demonstrate that methods work relative to objectives.

? Select appropriate bio-indicators.
  - What suite of bio-indicators are robust enough to allow for the evaluation of significant change? What does significant mean? Persistence downstream and in time?

Cause & Effect Issues

? Vary riparian management prescriptions and observe biological responses.
  - Mechanistic manipulative studies are needed for formulating/refining management/rules.
  - Stress systems study for a measurable response. Identify stressor(s). Identify threshold levels of stress. Identify persistence. Evaluate how to avoid the stress.

? Invertebrates, fish and algae are important biota potentially affected by riparian management and these three classes need response evaluations.
  - Invertebrates and fish respond to hydrology, hydraulics, temperature, sediment, food (instream and terrestrial sources), predators, physical diversity of habitats. Algae respond to light, nutrients, temperature, and grazers.

? If studies identify a measurable problem, they also need to quantify the degree of problem (relate to natural disturbances as a comparison, is it persistent downstream, or persistent in time), the cause of the problem.

? Historical practices versus modern practices. Studies should be represent current forest practices, otherwise not relevant to formulating/refining appropriate management rules.

Small Stream Classification & GIS Issues

Ontology and Classification

For headwater streams there is a lack of controlled vocabulary that is necessary for comparing results and defining causal mechanisms. Existing stream classification systems are too coarse and mono-disciplinary to adequately represent headwater streams. The new headwater stream classification system should build on the current classification systems because they do reduce uncertainty, provide improved inferential strength, knowledge accessibility, a common stratification, and a standard set of descriptors. A new headwater small stream classification system should establish a reporting mechanism for communication among disciplines and a basis for stratification for research at an adequate resolution that represents variability of small streams. This group proposed the following approach:

? Stratify the headwater landscape in a manner that characterizes the important processes and functions of headwater streams useful for research and management. This classification eliminates the need for one definition. Develop a classification system that incorporates or integrates the following elements by evaluating and adapting existing classification systems.

- Design useful criteria
- System for describing things
- Hierarchical
- Geoclimatic
- Vegetation
- Climate

- Elevation
- Geology/soils
- Slope (stream, sidescapes)
- Adaptive
- Biotic/abiotic
- Physically based

<u>GIS Issues</u>
Utilities of current GIS data for headwater areas are limited due to the scale and resolution of the data. Often, stream networks as mapped by the GIS do not extend into the headwater areas. The resolution of data is often at the 1:24,000 scale which is insufficient to adequately address or model headwater processes at the site or sub-basin scale and is too generic for the scale of site-specific headwater questions.

1. Develop the data layers or techniques to quantify the spatial variability of headwater streams.
2. Develop data layers that track landuse and transportation systems through time
3. Key to modeling and data needs discussed in 1 and 2, is the foundational need for an ontology and classification system for headwater streams.

Workshop Synopsis

The scientific community has long recognized the need for research on very small headwater streams as evident in the words of Luna Leopold (1956):

> *"The flow of water in natural channels may be described as perennial, intermittent, or ephemeral. A perennial stream carries some flow at all times. An intermittent stream is one in which, at low flow, dry reaches alternate with flowing ones along the stream length. Those which carry water only during storms, and are therefore called ephemeral, are generally smaller but much more numerous than the perennial ones. ...Despite the fact that the channels of ephemeral streams are generally recognized to have an important part in the erosion of land and resultant production of fluvial landforms, they have not received careful or concentrated investigation."* L. Leopold and J. Miller, 1956.

It has been estimated that small streams comprise approximately 95% of total stream channels and 75% of stream length. These streams are fundamentally different than larger streams, minimizing the applicability of research findings from larger streams. While the effects of forest management on small streams have not received much research attention, there is currently a stipulation that forest managers should increase protection of these small streams. Future research focused on small headwater streams is a priority given the extent of the landscape potentially affected by increased protection of these streams. Given this situation, the Headwaters Research Cooperative convened leading forestry, biologic, aquatic, riparian, and physical scientists at a workshop in October 2001 to articulate the state of the science, identify research gaps and prioritize research for small headwater streams.

Headwater streams vary greatly in terms of how they function both locally and at a basin scale. This variability manifests itself in a range of channel morphology, hydrologic regime, riparian, and biologic characteristics. There were some general reoccurring themes and priorities that came out of workshop presentations and discussions as follows:

- The variability of small streams challenges our ability to predict process and management effects at a large scale.
- Implications of process and management are married to the scale of analyses both in time and space. One of the challenges faced with small stream research is the limitation of current topographic maps and digital elevation models to represent them.
- Current stream classification systems do not adequately address the uniqueness and variability of headwater streams. There is a need to develop ontology for these streams.
- Retrospective studies on the effects of management are of limited utility given the evolution of forest practices over the past 20 years. Future research should focus on current practices.
- There is a need for both modeling and empirical studies. Such efforts should be collaborated to improve utility. It is not good enough for models to work the mechanics have to be right.
- Integrated research involving disciplines from both the physical and biological sciences is preferred.
- Define the variation in headwater stream characteristics with linkages to physical and biological processes. Use this understanding to develop a classification system that can be applied operationally and can help predict the location and extent of headwater stream miles.

Clearly, there are a multitude of issues surrounding headwater streams. Forestland managers and researchers alike are just coming to grips with the range of issues spanning economic, social, and environmental concerns. A limited number of studies representing a small portion of the variability form the basis of current management strategies and policies. In addition, researchers and managers are limited by the utility of current classification, evaluation, and analytical tools within the context of headwater streams. Ideally, today's research will provide the necessary information to address the range of issues and guide future management and policy decisions. The fact that entire workshops are dedicated to small stream issues, is itself an indication of both a shifting and perhaps more holistic focus on the part of researchers and land managers as well as an indication of the uniqueness of headwater streams. Ideally this document has accurately and completely captured and summarized the breadth and depth of discussions that took place over a two-day period. Overall the workshop was instrumental in the formation of the OHRC and will significantly guide the direction and priorities of the cooperative.

Reference

Leopold and Miller. 1956. Ephemeral stream-hydraulic factors and their relation to the drainage network. *USGS Professional Paper 282-A*. USGS Gov. Printing office. Wash.DC.

Headwaters Research Cooperative

There was overwhelming support and interest for the October 2001 workshop and a consensus that a headwaters research cooperative could help promote applied research. Parallel efforts in Washington, British Columbia, and California are indications that headwater stream issues represent a common focus area for forest managers throughout the Pacific Northwest. Given the broad support for and attendance at the workshop, the organizers met and approved a charter to form and direct the actions of the OHRC (See appendix A). In summary the OHRC steering committee will have a maximum membership of 20 participants with a mandatory annual fee or in-kind contribution. The committee will appoint two chairpersons to serve on an annual basis and meet 1-2 times a year. Current steering committee members are shown in Appendix A. The committee will work to leverage additional funds, send out RFP's, and fund applied research on headwater streams. The goal for 2002 is to fund 1-2 projects.

The workshop participants emphasized the need to keep research applied. The research should address management considerations such as roads, "buffers", skid trails, and site preparation (e.g. chemicals, slash treatment). Many topics were posed as important gaps in the science. The OHRC has reviewed the workshop materials and selected the following three areas as the top priorities for the upcoming year.

- **Temperature:** How do forested headwater stream temperature patterns vary across Oregon? How does timber harvest effect this variability in stream temperature patterns? Where do observed increases in stream temperature influence downstream reaches with fish?
- **Sediment**: How do fluvial processes in headwater channels affect the retention and transport of gravels, sands and fine sediment and how do various channel structures and morphologies influence these processes?
- **Biota:** Develop an experimental design that allows comparisons of headwater fauna during the course of forest management. Examine the factors that influence the distribution and abundance of selected headwater riparian and/or aquatic organisms.

The OHRC will favor proposals that address a combination of two or more research issues described above, demonstrating an integration of disciplines within one project. Currently available funding is $125,000. Proposals that include contributing funds from other sources are desirable. Other cooperators and funding are being sought, so additional projects may be approved in the future. The OHRC is ultimately interested in being able to extrapolate study results throughout the state (both eastern and western Oregon). Proposals are due by **May 1, 2002**. More details are provided in appendix B regarding research proposals.

Appendix A: Oregon Headwaters Research Cooperative: Organizational Charter

The Oregon Headwaters Research Cooperative (OHRC) is a broad coalition of agencies, associations, and corporations that share an interest in research regarding small, generally non fish-bearing streams commonly referred to as "headwater" streams. The OHRC does not attempt to duplicate existing programs. The following charter solely addresses the make up and function of the OHRC.

Steering Committee

The main task the SC will undertake is to evaluate research proposals and make a recommendation for funding. In the likely event that funding requests exceed available funds, the SC will be asked to prioritize requests. As such, SC members should come from a scientific background to provide the expertise needed to adequately evaluate the merit and soundness of proposed research projects. SC members may submit proposals but cannot vote on RFP decisions when their proposal is a candidate.

The OHRC seeks participation from state and federal agencies, private industry, and non-governmental organizations in Oregon. All interested parties are invited to attend OHRC meetings and sponsored events. The OHRC will be managed by the Steering Committee (SC).

In general, membership on the SC is open to all interested parties. The SC will operate by consensus when possible. It is the goal of the OHRC to have continuous, reliable participation by members. Membership is open to agencies/organizations that are not able to provide funding to OHRC in any given year but wish to be members. If at any time in the future the size of the group becomes unmanageable (regular participation by more than 20 individuals), the SC will at that time seek to limit the membership. Furthermore, any corporation, agency, or group (an entity) can request permission from the larger group to allow more than one representative such that representation covers geographical or programmatic scope within a company, group, or agency.

When the SC is unable to reach consensus, decisions will be made based on a simple majority of voting members present. Voting members are those people who represent an entity that has made a minimum annual contribution of $2500 or $5000 in-kind support. In-kind contributions and involvement will be described in a letter approved by the SC. Both majority and minority positions will be documented.

Chairpersons

The SC will elect 2 Chairpersons that will serve for two years. The Chairpersons position may rotate among participating agencies and organizations of the OHRC. The OHRC Chairpersons will be responsible for facilitating meetings, disseminating information to the group, facilitating correspondence with applicants and grantees, and coordinate fund administration with the responsible organization. Chairpersons will maintain a list of committee members. The Chairpersons may delegate any or all of the above tasks to other Steering Committee members, as needed.

Steering Committee Responsibilities

The SC will meet at a minimum of once a year. It is likely that the SC will meet two or three times per year. The Chairpersons will determine the specific purpose and timing of meetings. In general, annual meetings will be held to discuss project progress reports and evaluate new proposals for funding. SC representatives are encouraged to seek input from their respective agency/organization's employees, researchers, and others prior to OHRC meetings where funding decisions will be made. The SC will actively seek and consider input from outside agencies/organizations when identifying priorities and reviewing proposals.

Project Prioritization

The SC should use the following criteria to identify its final priority projects:

1. The projects will increase our scientific understanding of physical and biological resources and processes of headwater streams.
2. Strive for consistency with the recommendations from the October 2001 Workshop consistent with addressing critical gaps in knowledge of headwater streams.
3. Consider feasibility within the constraints of OHRC budget and timelines.
4. Focus on applied forest management in Oregon with the context of the greater Pacific Northwest region. Strive for an appropriate balance of east and west Oregon research.

OHRC Communication Plan

The OHRC seeks to provide a transparent process under which funding decisions are made and findings are reported. The OHRC priorities and ultimately scientific findings from OHRC-funded projects will be communicated to state and federal agencies, private industry, and non-governmental organizations in Oregon. The OHRC SC will utilize the most efficient mechanisms for communication, including peer-reviewed journal articles, and presentations at professional scientific meetings.

2002 Oregon Headwaters Research Cooperative Steering Committee

Co-chairs: Bob Danehy: Boise Cascade
Liz Dent: Oregon Department of Forestry

? Bob Alverts: Bureau of Land Management
? David Anderson: Boise Cascade
? Bob Bilby: Weyerhaeuser
? Jeff Dambacher: Oregon Department of Fish and Wildlife
? Bob Gresswell: United States Geologic Service
? Rick Hafele: Oregon Department of Environmental Quality
? Marcia Humes: Oregon Department of Forestry
? George Ice: National Council for Air and Stream Improvement
? Chris Jarmer: Oregon Forest Industries Council
? Vic Kaczynski: Private Consultant
? Maryanne Reiter: Weyerhaeuser Co.
? Kevin Roberts: Plumb Creek
? Kevin Russell: Willamette Industries

Appendix B: Request for Research Proposals

Oregon Headwaters Research Cooperative

To: Natural Resource Researchers
From: Bob Danehy and Liz Dent: Co-chairs of the Oregon Headwaters Research Cooperative
Subject: **Request for Research Proposals on the Management and Ecology of Headwater Streams**
Date: March 28, 2002

The Oregon Headwaters Research Cooperative (OHRC) is soliciting research proposals that address the management and ecology of headwater streams. The purpose of the Oregon Headwaters Research Cooperative 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 interested in initiating new science on headwater streams. 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. The priority of the OHRC is to support research that speaks to current forest management issues. With input from researchers, agency scientists, and land managers the OHRC has identified three priority areas of interest with regard to headwater streams:

? **Temperature:** How do forested headwater stream temperature patterns vary across Oregon? How does timber harvest effect this variability in stream temperature patterns? Where do observed increases in stream temperature influence downstream reaches with fish?
? **Sediment**: How do fluvial processes in headwater channels affect the retention and transport of gravels, sands and fine sediment and how do various channel structures and morphologies influence these processes?
? **Biota:** Develop an experimental design that allows comparisons of headwater fauna during the course of forest management. Examine the factors that influence the distribution and abundance of selected headwater riparian and/or aquatic organisms.

The OHRC will favor proposals that address a combination of two or more research issues described above, demonstrating an integration of disciplines within one project. Currently available funding is $125,000; therefore, proposals that include contributing funds from other sources are desirable. Additional cooperators and funding are being sought, so additional projects may be approved in the future. Proposals are due by **May 1, 2002**. More details are provided in the attached documentation.

The OHRC is ultimately interested in being able to extrapolate study results throughout the state (both eastern and western Oregon). Proposals should justify whether to focus the study in one region or to provide regional contrasts. Forestlands in Oregon span a wide range of climatic regions with large differences in annual precipitation and temperature regimes, and variability in forest canopy, and factors such as elevation, aspect, soils, and geology. Even within an ecoregion high variability in some hydrological and ecological processes is expected and should be incorporated in the proposed study design.

A paired stream approach, replicated within identified strata can be a powerful research tool to determine differences between a treatment and controls. The OHRC is also interested in establishing a network of study sites (perhaps using a paired stream approach) that multiple studies could utilize. Our expectation is that such a network might provide synergies for project integration that might yield considerable benefits toward addressing interdisciplinary issues. Proposals should consider how the study design might adapt to fit within this network concept, and how the researchers might integrate resources to help establish such a network. Additional ideas that further the implementation of this concept are encouraged. We do recognize that forcing a study design into such a concept may compromise the quality of the study with regard to the questions posed. Therefore, study designs that do not fit well into this network concept will receive equal consideration.

Oregon Headwaters Research Cooperative[1]
REQUEST FOR PROPOSALS #1

How Does Forest Management in Headwater Streams Change Temperature Patterns in Oregon?

BACKGROUND

There is concern that harvesting small, non-fish-bearing streams will increase stream temperatures and adversely impact downstream fish communities. Stream temperature monitoring in non-fish-bearing streams in both Washington (Caldwell et al.1991; Johnson et al. 2000) and Oregon (ODF 1995) indicated that small stream temperature response to timber harvest is highly variable. This RFP is an attempt to first understand the variability of stream temperature patterns in small headwater streams and then to further understand how timber harvest influences these patterns.

Forest practice rules are designed to maintain shade and stream temperatures along fish-bearing streams. These forest practice rules have been and are currently being tested by the Oregon Department of Forestry to ensure that they are achieving shade and temperature protection objectives (http://www.odf.state.or.us/FP/fpmp/TechReport.htm, ODF Technical Reports 2, 3, 12, and 13). One concern that has been raised is that small, non-fish-bearing headwater streams that do not receive the same level of shade protection as larger fish-bearing streams may be exposed to increased insolation as a result of timber harvesting of adjacent slopes. This could result in elevated stream temperatures for these headwater streams. These temperature changes might then be transported downstream to fish-bearing streams, significantly elevating temperatures in streams that are otherwise well protected.

While these concerns are frequently expressed, others argue that there are important processes, such as exchange between surface and subsurface streamflow and rapid recovery of adjacent brush, that limit the potential for headwater streams to significantly influence downstream temperatures. Temperature is not a purely conservative pollutant. Work to resolve this debate on these small streams is scant. In 2001 Dr. Arne Skaugset of Oregon State University conducted a pilot project measuring temperature changes in headwater streams in Oregon and the transport of heat downstream. Work in Washington by Jackson (2000) shows that small headwater stream temperature responses to timber harvesting is highly variable. Johnson and Jones (2000) found that changes in temperatures for headwater streams are muted, depending on rates of transport and exchange with hyporheic water. Because small headwater streams can make up the majority of the length of stream miles in a stream network, increased retention of shade near these streams can have a disproportionate impact on land available for management. To allow policy managers to weigh the various forest practice rule options that might be used to protect stream temperatures, we need to understand how harvesting affects temperatures of headwater streams and how headwater streams influence downstream temperatures. This was one of the key questions identified at the OHRC workshop held in Corvallis, Oregon, in October 2001.

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[1] Information about the Oregon Headwaters Research Cooperative is provided in the cover letter and at the end of this package.

OBJECTIVES

The objective of this RFP is to solicit proposals to evaluate:

1. How do forested headwater stream temperature patterns vary across Oregon?
2. How does timber harvest effect this variability in stream temperature patterns?
3. Do observed increases in stream temperature influence temperatures downstream in reaches with fish?

Some proposal considerations include: what conditions (hydrologic, vegetative, etc.) influence transport of elevated headwater stream temperatures downstream; and when is this significant? Patterns that might lead to adverse temperature changes in fish-bearing streams otherwise protected by shade retention requirements should be identified. It is anticipated that funding will be provided for research during the summer of 2002. If appropriate, results should be published in a referred journal.

REFERENCE LIST

Caldwell, J. E., Doughty, K., and Sullivan, K. 1991. *Evaluation of downstream temperature effects on type 4/5 waters*. TFW Report WQ4-91-004. Washington State Department of Natural Resources: Olympia, WA.

Oregon Department of Forestry (ODF). 1995. *Cooperative stream temperature monitoring: Project completion report for 1994-1995*. Oregon Department of Forestry: Salem, OR.

Jackson, C. R. 2000. *Integrated headwater stream riparian management study progress report #4*. Prepared for the National Council for Air and Stream Improvement, Inc.: Corvallis, OR.

Johnson, S. L., and Jones, J. A. 2000. Stream temperature responses to forest harvesting and debris flows in western Cascades, Oregon. *Canadian Journal of Fisheries and Aquatic Science* 57:1-10.

See pages 48-49 for details on proposal format, selection process, funding, and the OHRC.

Oregon Headwaters Research Cooperative
REQUEST FOR PROPOSALS #2

Influences of Fluvial Processes on Sediment Retention and Transport Through Headwater Streams

I. BACKGROUND

Research has revealed a great deal about sediment routing processes in headwater channel systems where debris flows and landslides are the dominant transport mechanism (Dietrich and Dunne 1978; Benda and Dunne 1987; Robison et al. 1999). However, even in the Pacific Northwest most forest streams are not subject to debris torrents. Instead, fluvial processes may be more immediately relevant to forest management practices. Fluvial processes, combined with riparian inputs, generally control the channel structures and local morphology of headwater channels. Fluvial processes have significant influence on local habitat, hydrology, delivery of sediment and heat to alluvial channels, and may influence the recovery of debris flow tracks.

Few studies have addressed the fluvial sediment regimes of headwater channels. Recent work by Jackson et al. (2001) demonstrates significant differences in the amount of sediment associated with forested, buffered, and unbuffered headwater channels, due in part to differences in wood loading (slash) and blowdown (from buffers). Work by Liquori (2002) suggests that shear stress trends in headwater channels are inverse to those observed in alluvial channels (i.e., upstream decreases in headwater channels) and are somewhat correlated to channel morphology. MacFarlane (2001) studied flow resistance in headwater streams resulting from wood. Other work by O'Connor and Harr (1994) and Curran (1999) studied slightly larger channels, but may provide insight that may be useful in describing sediment transport processes in headwaters.

Interactions between mass wasting, fluvial, and riparian processes influence the form and function of aquatic habitats both in the headwater ecotone and in downstream portions of the channel network. We need to better understand the complex dynamics of sediment in headwater channels if forest managers are to be successful in developing effective strategies that maintain aquatic ecosystem functions. This study should anticipate future efforts that will seek to integrate the various process domains into a comprehensive conceptual framework around which forest management polices may be built.

II. OBJECTIVES

The objectives of this research are to evaluate:

1. How fluvial processes in headwater channels affect the retention and transport of gravels, sands and fine sediment.
2. How various channel structures and morphologies influence, and are influenced by these processes.

The focus of the work should aim to address these questions specifically within a managed forest context. This work should lay the framework for sediment regimes in headwater channels upon which additional work may be built. Future efforts may seek to link this work to patterns associated with wood recruitment and functions in headwater channels. This work should seek to explain some of the variability and complexity associated with headwater channels. Some possible considerations include: the proportional influence of wood as compared to other roughness elements (roots, bedrock, boulders); response to different morphological and/or management situations; and/or the effects of harvest-related slash accumulations.

REFERENCE LIST

Benda, L., and Dunne, T. 1987. *Sediment routing by debris flow: Erosion and sedimentation in the Pacific Rim*. IAHS Publication # 165. Corvallis, OR.

Curran, J. H. 1999. *Hydraulics of large woody debris in step-pool channels, Cascade Range, Washington*. Master's thesis, Colorado State University, Fort Collins, CO.

Dietrich, W. E., and Dunne, T. 1978. Sediment budget for a small catchment in mountainous terrain. *Zeitschrift Für Geomorphologie* 29:191-206.

Jackson, C. R., Sturm, C. A., et al. 2001. Timber harvest impacts on small headwater stream channels in the coast ranges of Washington. *Journal of American Water Resources Association (JAWRA)* 37(6):1533-49.

Liquori, M. K. 2002. Observations on the morphology of headwater channels. *Symposium on Small Stream Channels and Their Riparian Zone: Their Form, Function and Ecological Importance in a Watershed Context*. February 19-20, 2002, Vancouver, British Columbia.

MacFarlane, W. A. 2001. *Flow resistance in step-pool streams of the Washington Cascades*. Master's thesis. Colorado State University, Fort Collins, CO.

O'Connor, M., and Harr, R. D. 1994. *Bedload transport and large organic debris in steep mountain streams in forested watersheds on the Olympic Peninsula, Washington*. Timber Fish & Wildlife Report. Washington State Department of Natural Resources.

Robison, E. G., Mills, K., et al. 1999. *Storm impacts and landslides of 1996*. Oregon Department of Forestry: Salem, OR.

See pages 48-49 for details on proposal format, selection process, funding, and the OHRC.

Oregon Headwaters Research Cooperative
REQUEST FOR PROPOSALS #3

Factors Influencing the Distribution and Abundance of Selected Organisms of Headwater Streams in Managed-Forested Landscapes

I. BACKGROUND

There has been an increased interest in understanding the ecology of small, non-fish-bearing streams. This emphasis on identifying non-fish-bearing waters comes from concern about aquatic dependent species besides salmonid fishes (Biggs et al. 1999; Olson et al. 2000; Angradi et al. 2001) and the recognition that these streams deliver material and energy to downstream resources (Bilby and Bisson 1992; Dieterich and Anderson 1998). Headwater streams account for most of stream channel length in a watershed. While these streams typically do not support fish, small streams and the associated riparian zone can support rich flora and fauna. The habitats provided by these areas differ from upland forests. Riparian habitats are moister and cooler, supporting plants and animals not found in adjacent uplands (Olson et al. 2000). The role of likely important interrelated factors such as channel features, hydrologic patterns (Del Rosario and Resh 2000), microclimate (Danehy and Kirpes 2000), nutrient dynamics (Peterson et al. 2001), riparian structure (Maridet et al. 1998) and wood loads (Robison and Beschta 1990) for headwater organisms have not been well studied. Added to the challenge is the high degree of variability in these systems both between and within ecoregions (Minshall and Robinson 1998).

These headwater systems contribute to landscape biodiversity (Olson et al. 2000) as well as provide food to downstream populations of fish (Schlosser 1995). These characteristics and contributions of headwater streams require more study, particularly on managed-forested landscapes. Within managed landscapes the systematic reopening of canopies (and the attendant increases in insolation) lead to increases in primary production and often changes in community composition (Wallace et al. 1988; Sabater et al. 2000). While changes can be expected, different assemblages (periphyton, marcroinvertebrates, or amphibians, for example) may respond differently, and the extent of change and knowledge of which factors stimulated the changes are critical to developing effective forest management prescriptions. Also, the time necessary to return to pre-harvest conditions and the successional pathways are poorly understood in headwater systems (Wallace 1990). The OHRC workshop in Corvallis, Oregon, in October 2001, identified several key questions needing further study that contractors may want to consider.

II. OBJECTIVES

The objectives of this RFP is to solicit proposals to:

1. Develop an experimental/monitoring design that allows comparisons and contrasts of headwater fauna during the course of forest management[1].

2. Examine the factors that influence the distribution and abundance of selected headwater riparian dependent and/or aquatic organisms.

The OHRC steering committee will offer to assist the successful candidate in identification of suitable research sites.

III. REFERENCE LIST

Angradi, T., Hood, R., and Tarter, D. 2001. Vertical, longitudinal and temporal variation in the macrobenthos of an Appalachian headwater stream system. *American Midland Naturalist* 146(2):223-42.

Biggs, B. J. F., Smith, R. A., and Duncan, M. J. 1999. Velocity and sediment disturbance of periphyton in headwater streams: Biomass and metabolism. *Journal of the North American Benthological Society* 18(2):222-41.

Bilby, R. E., and Bisson, P. A. 1992. Allochthonous versus autochthonous organic matter contributions to the trophic support of fish populations in clear-cut and old-growth forested streams. *Canadian Journal of Fisheries and Aquatic Sciences* 49(3):540-51.

Danehy, R. J., and Kirpes, B. J. 2000. Relative humidity gradients across riparian areas in Eastern Oregon and Washington forests. *Northwest Science* 74(3):224-33.

Del Rosario, R. B., and Resh, V. H. 2000. Invertebrates in intermittent and perennial streams: Is the hyporheic zone a refuge from drying? *Journal of the North American Benthological Society* 19(4):680-96.

Dieterich, M., and Anderson, N. H. 1998. Dynamics of abiotic parameters, solute removal and sediment retention in summer-dry headwater streams of western Oregon. *Hydrobiologia* 379:1-15.

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See pages 48-49 for details on proposal format, selection process, funding, and the OHRC.

Proposal Process

I. PROPOSAL FORMAT

Proposals should not exceed five single-sided pages (not counting a one page vitae for each investigator) and **must** include the following topics and headings:

1. Project title
2. Principal investigator (name, title, address, phone, fax, and e-mail)
3. Collaborators (name, title, and address)
4. Introduction or background
5. Objectives (hypotheses to be tested or questions to be addressed)
6. Draft outline of the study design, analyses, and approach
7. Schedule and milestones
8. Investigator, collaborator (one page vitae per investigator that includes the investigator's educational background, citations of key publications most directly related to proposed work, URL of personal or project website, etc.) and institutional qualifications, equipment, facilities, etc.
9. Budget showing resources required by year and amount requested from OHRC (and all other sources individually if the proposal has multiple sources of funding); indirect costs should not exceed 10% of total budget

Proposals can be expanded to seven or nine pages if two or three of the priority areas of interest (temperature, sediment, biota) are covered in one proposal.

II. THE PROPOSAL SELECTION PROCESS

The OHRC Steering Committee will review the proposals and select one or more contractors. Successful applicants will be asked to consider OHRC comments when preparing a final proposal. In making its selection, OHRC will use the following criteria:

1. Relevance of the proposal to the research interests identified in the RFP
2. Clarity of the objectives and draft outline
3. General scientific and technical quality of the proposed outline
4. Qualifications of the research team
5. Probability of achieving the objectives within the proposed schedule and budget (based on resources identified in the proposal)
6. Reasonableness/adequacy of the cost relative to the objectives
7. Potential for the approach to succeed and provide early results
8. Proposals that collaborate with OHRC cooperators may be given preference

III. FUNDING

Proposals should cover a one year period and may request up $125,000 from the OHRC. OHRC will pay no more than 20% in indirect costs. Funding for carrying out the study plan must be approved based on development of a satisfactory proposal and on funds being available to OHRC. **<u>Proposals (3 copies) must be received by May 1, 2002, and should be sent to:</u>**

Regular Mail Address:

Dr. George Ice
NCASI
PO Box 458
Corvallis, Oregon 97339-0458
(541) 752-8801, ext. 230
(541) 752-8806 FAX
GIce@wcrc-ncasi.org

Overnight Mail Address:

Dr. George Ice
NCASI
720 SW Fourth Street
Corvallis, Oregon 97333
(541) 752-8801

Proposals submitted by e-mail in MS Word format are acceptable.

IV. ABOUT OHRC

The purpose of the Oregon Headwaters Research Cooperative 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 interested in the science of headwater streams. 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.

Dr. George Ice
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