Center for Streamside Studies

Streamside Runoff

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The mission of the Center for Streamside Studies is to provide the scientific information necessary for the resolution of management issues related to the production and protection of forest, fish, wildlife, and water resources associated with the streams and rivers in the Pacific Northwest.

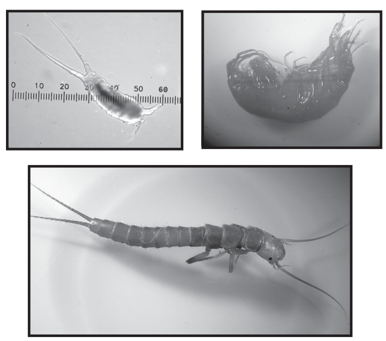
Down under: Hyporheic research in the Queets River floodplain

The hyporheic zone is the area of subsurface water beneath and adjacent to streams and rivers where surface and ground waters mix. This important subsystem connects river and riparian areas, retains nutrients and organic matter, and harbors a diverse and unique community of invertebrates. In western Washington, hyporheic zones exist in floodplain rivers with coarse sediments where water exchange occurs. Given the extensive floodplains that exist on unmanaged rivers, hyporheic zones historically have played a very important role in the structure and function of rivers in this region.

Clinton and Coe studied microbial production and invertebrate distribution in the hyporheic zone of a floodplain terrace on the Queets River, Olympic National Park, Washington. This research revealed the presence of highly active and diverse biological communities, the importance of maintaining hyporheic linkages in floodplain rivers, and expanding connections between riparian zones and subsurface systems.

Microbial respiration and production

Microorganisms, such as bacteria and fungi, integrate biogeochemical cycling and energy flow in ecosystems. Although many factors (e.g., temperature and species composition) control the rates of microbial processes, available dissolved organic matter (DOM) is often a limiting factor. Algal production is a major source of DOM for microorganisms in the stream surface, but does not occur in the hyporheic zone. Consequently, microorganisms are dependent on the input of DOM (comprised of phosphorus, nitrogen, and carbon) from the stream surface for respiration and production. In large floodplain rivers, hyporheic flowpaths also occur beneath productive riparian terraces where overlying riparian soils may provide an alternative source of high quality (nutritious) DOM.



Invertebrates commonly found in the hyporheic zone. Clockwise from upper left, harpacticoid copepod (resides for most of its life in the hyporheic zone), amphipod (a groundwater invertebrate), and stonefly (spends part of its life cyle in the surface water).

Clinton investigated two patterns of microbial activity in terrace wells: (1) among different patch types and (2) along hyporheic flowpaths. Riparian patch types included gravel bars, young alder (<20 years), old alder (20-70 years), and mixed old-growth conifer (>70 years). She found that subsurface water in the terrace was derived from surface water, which had insufficient carbon for supporting hyporheic respiration. This factor, combined with inconsistent rates of microbial production along flowpaths, suggested that riparian soils were a potential DOM source for microbial metabolism. Laboratory experiments confirmed that hyporheic microorganisms could use riparian soil leachates as efficiently as surface water DOM.

Understanding limitations on microbial production is important since microbes are responsible for the retention and transformation of nutrients as water moves through the hyporheic zone. These nutrients are re-delivered to the surface stream where hyporheic water upwells into surface water. In the nutrient limited rivers of the Pacific Northwest (PNW), this nutrient subsidy stimulates algal growth that is the base of the food web for invertebrates and fish. Thus, managing riparian soils as a source of DOM for hyporheic microbial productivity maintains overall river ecosystem function and adds to the understanding of other riparian-river interactions (e.g., shade, large woody debris, bank stability).

Invertebrates

Recently, researchers have focused attention on the importance of invertebrates in the hyporheic zone. Although there is no known direct relationship between hyporheic bacteria and invertebrates, invertebrates probably use bacteria as a food source.

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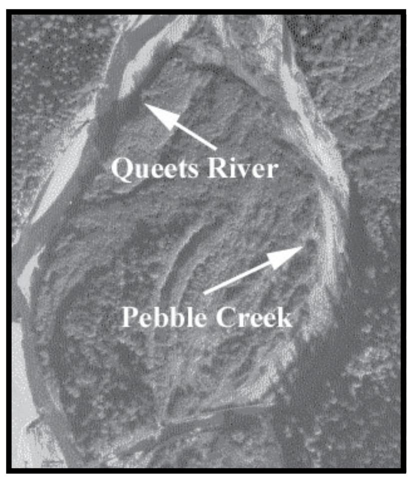
Studies investigating hyporheic invertebrates have focused on communities within the wetted channel or in small channel gravel bars. In contrast, Coe described hyporheic invertebrate community structure in a large, forested floodplain terrace. In all wells sampled, cyclopoid copepods, copepod nauplii, and rotifers were the dominant invertebrate groups found. Archiannelids (considered to be associated with groundwater fauna rather than hyporheic), water mites (hydrachnidia), and harpacticoid copepods were common, but did not contribute substantially to overall invertebrate abundance. In contrast to other floodplain studies, surface water aquatic insects such as midges (chironomids), no see-ums (ceratopo-gonids), and stoneflies (ple-coptera) were collected from the wells, but were rare across sample dates.

Overall invertebrate distribution varied across the terrace, but did not significantly change seasonally. High invertebrate abundances were found in wells containing large amounts of wood fragments, suggesting that wood may be an important indirect and/or direct food source for hyporheic invertebrate communities. The importance of wood for invertebrates in the surface environment is already well established. The source of wood within this hyporheic zone is unknown but is likely large woody debris, supplied by riparian areas and buried by sediment through channel migration. Deforestation of riparian areas would reduce the supply of wood into surface and subsurface environments. Similarly, management practices preventing channel migration would reduce the ability of rivers to bury wood. Hyporheic invertebrate communities can provide unique insights into the linkage between rivers and their adjacent floodplains, and may ultimately play an important role as indicators of water quality and ecosystem health.



An aerial view of the floodplain terrace, bounded by the Queets river (left) and Pebble Creek (right). Approximately 50 wells were sampled in the terrace.

Summary

Researchers have demonstrated that rivers and streams with hyporheic zones have higher rates of metabolism, greater invertebrate diversity, recover faster from disturbance, and retain more nutrients than those without hyporheic zones. Few of these studies have occurred in the PNW ecoregion, and scientists are only beginning to incorporate this important subsystem into current understanding of river structure and function. Studies investigating linkages between riparian vegetation, subsurface flows, and aquatic systems are necessary in understanding land-use impacts from forestry, agriculture, and urbanization on the health of river ecosystems. Although many conservation and restoration efforts focus on rehabilitating and maintaining surface processes, few projects incorporate the hyporheic zone. This research project has demonstrated that the hyporheic zone of floodplain rivers have a high amount of biological activity (both microbial and invertebrate) and that these components should be considered in management plans that address overall river nutrient retention and biodiversity.

(Sandra Clinton received her Ph.D. and Holly Coe graduated with an M.S. degree from Forestry. Two fact sheets on hyporheic zones will be available on the CSS website at http://depts.washing-ton.edu/cssuw/publications/publications.html)

The effects of trace element contamination from mines on trout in the Methow River

Like many other areas in Washington, communities in the Methow Valley in Okanogan County, Washington, originated during the mining booms of the 1800s. Although mining ceased to be a dominant economic force after the 1930s, it continues to be of interest because it has the potential to inject hundreds of millions of dollars into local economies and provide stable jobs in rural areas that are often economically depressed.

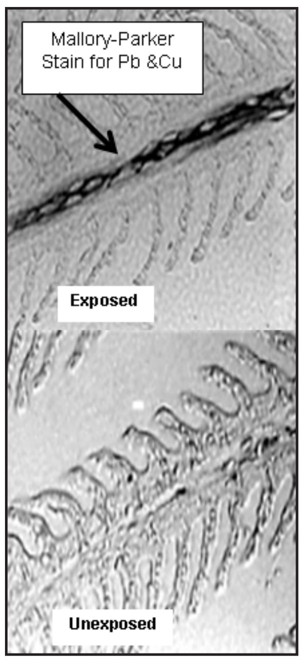
Washington currently ranks 24th in the nation in nonfuel mineral production, which is valued at over one-half billion dollars per year. Metallic commodities include gold, silver, copper, iron, zinc, lead, cadmium, and magnesium. Mining, however, is also accompanied by serious social and ecological consequences because it is unsustainable as sources are depleted and can lead to irreversible ecological consequences.

One reason for the ecological problems caused by mines is that the metals of interest are often associated with sulfide minerals. When exposed to air and water, sulfide minerals release sulfuric acid and trace elements at levels that are often toxic in the environment. Trace elements such as copper, iron, selenium, and zinc are nutrients that are essential and required by organisms at concentrations measured in parts per billion, whereas elements such as arsenic, cadmium, mercury, and lead are not known to be essential dietary requirements. All trace elements, however, have the potential to be toxic when present at elevated concentrations. The occurrence of toxicity and the release of trace elements are undoubtedly accelerated by the development of underground mines and the influx of oxygenated air into the mineralized bedrock.

In order to better understand the environmental impact of mines that expose sulfide minerals, the University of Washington, College of Forest Resources, and the Center for Streamside Studies have been funded by the Bonneville Power Administration to measure the effects of abandoned mine waste on endangered steelhead and spring chinook salmon habitat in the Methow River. Although management activities are aimed at protecting organisms at the population level, toxic effects can be expressed at the cell, tissue, and individual level as well. This is because toxicity is a chemical phenomenon that begins with a reaction between the trace element and the organism at the molecular level. Initial reactions generate secondary responses that affect the behavior, reproduction, and survival of individuals and ultimately populations, communities, and ecosystems. This study looked at the effects of trace element contamination at the cellular, tissue, and population level in caddisfly larva (*Ecclisiomyia spp.)* and rainbow trout (*Oncorhyncus mykiss)*.

Trout intestine cells exposed to trace element contaminants were examined using transmission electron microscopy to reveal the accumulation of electron-dense granules in their mitochondria. The accumulation of metals in gut cell mitochondria indicates that the intestine is one source of metal uptake and toxicity. Another source of metal uptake is the gills. Tissue sections from gill filaments of exposed trout were examined using metal-specific stains and a light microscope. Results showed that there is an accumulation of copper or lead inside the gills of exposed trout. Liver and kidney necrosis (cell death) was also observed at the tissue level. At the population level, exposed trout in the Methow River showed reduced growth and increased mortality compared to unexposed populations upstream from mine contamination. This study indicates that trace elements at elevated concentrations react with the energy-producing mitochondria in cells, which leads to secondary responses that ultimately affect the growth and survival of organisms exposed to contaminants from abandoned mines.

(Dan Peplow is working on his PhD)



Metal specific stains showing the accumulation of either lead or copper in gills of trout from the Methow River below three abandoned mine sites located south of Twisp in Okanogan County, Washington.

Regional Riparian Stand Cooperative

Present land management regulatory frameworks place a great emphasis on riparian protection. Current forest practices in the Pacific Northwest are based on resource objectives or performance targets determined by the presumed successional or growth trajectory (pathways) of riparian stands. Because detailed information characterizing riparian stands is currently very limited, riparian stand growth is projected using empirical forest growth and yield models based on data collected from upland stands. However, incremental growth and mortality data collected in these areas may not accurately reflect stand dynamics in riparian zones. Factors such as soil moisture, frequency and intensity of disturbance, or site productivity may contribute to riparian stand conditions that differ greatly from upland areas. Reliance upon data collected in upland stands to predict how riparian stands function may lead to inaccuracies in predicted or presumed riparian conditions. In order to ensure that resource objectives accurately reflect natural processes, riparian growth data are needed to validate and refine growth models and increase the understanding of how riparian forests establish, grow, and die.

Recognizing the critical need for coordinated research and a database to manage the information, the Center for Streamside Studies and NCASI (National Council for Air and Stream Improvement, Inc.) have provided the initial funding for developing a prospectus for a Regional Riparian Stand Cooperative (RRSC). A RRSC would provide a long-term source of high-quality information on successional dynamics (establishment, growth, and mortality) of riparian forests and the effects on the riparian ecosystem and associated aquatic environments. The RRSC would provide a structure through which data can be collected, analyzed, and shared across the region, including northern California, Oregon, Washington, and southern British Columbia. The effort would specify standardized protocols for data collection and provide a single location where these data would be stored and maintained.

The formation of a riparian research cooperative enables stakeholders to leverage research dollars, de-

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CSS Merging

This year, the Center for Streamside Studies will be merging with the Center for Urban Water Resources Management, based in the College of Engineering at the UW. Merging these two centers brings multiple benefits to students, researchers, and the region at large, drawing from the interdisciplinary expertise at the University of Washington that spans the ever-expanding boundary between "forested" and "urban" landscapes. The value of such a merger is already being enjoyed, in part, by students and faculty affiliated with either centers who jointly participate in seminars, research, and information transfer.

Announcements

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velop standardized methods, and sample across the landscape of the Pacific Northwest. The product would be high quality, comparable data collected with standards suitable for use in trend monitoring, adaptive management, and research purposes and long-term research sites suitable for current and future ecological studies and adaptive management trials. Such an undertaking is probably beyond the means of any one organization, but could be accomplished through a collaborative effort. For more information, contact the Center for Streamside Studies at 206-543-6920.

CALENDAR OF EVENTS

January 8 – March 12, 2002 and April 2 – June 4, 2002 **Tuesday Morning Seminars**, 22 Anderson Hall, UW Campus. For a schedule, contact Leslie Wall (206-543-6920 or cssuw@u.washington.edu) or view http://depts.washington.edu/Events/events.html.

February 6, 2002 **CSS/CUWRM 2002 Annual Review of Research**, HUB West Ballroom, University of Washington campus. For an agenda and directions, see http://depts.washington.edu/Events/events.html.

CONGRATULATIONS

Congratulations to the following students who completed their degrees: **Estelle Balian** *Stem Production Dynamics of Dominant Riparian Trees in the Queets River Valley, Washington* (MS, Fisheries); **Michelle Connor** *Ecological Correlates to Monotypic Stands of Spiraea Douglasii in Palustrine Wetlands of the Lowland Puget Sound Region* (MS, Forestry); **Nancy Gove** *Detecting Relationships Between Land Use and Water Quality Trends: Questions of Association, Scale, and Independence* (PhD, Quantitative Ecology and Resources Management); **Johnny Grady** *Effects of Buffer Width on Organic Matter Input to Headwater Streams in the Western Cascade Mountains of Washington State* (MS, Fisheries); **Jim Helfield** *Interactions of Salmon, Bear, and Riparian Vegetation in Alaska* (PhD, Forestry); and **Joshua Latterell** *Distribution Constraints and Population Genetics of Trout in Unlogged and Clear-Cut Headwater Streams* (MS, Fisheries). **Tom O'Keefe**, a research scientist in Fisheries, finished his dissertation at the University of Wisconsin.

S T R E A M S I D E   R U N O F F

The Center for Streamside Studies is a joint effort of the College of Forest Resources and the College of Ocean and Fishery Sciences

Center for Streamside Studies
University of Washington
Box 352100
Seattle, WA 98195-2100

In this issue:

Editor: Leslie Wall

For information about the Center call 206-543-6920 cssuw@u.washington.edu