Watershed Review
information on water and watersheds
Center for Water & Watershed Studies
Volume 1 Number 3 Summer 2003
http://depts.washington.edu/cwws

Directors' message

Derek Booth and Clare Ryan

Welcome to the summer edition of the Watershed Review. This issue highlights research underway by Ph.D. candidate Mindy Roberts in the department of Civil and Environmental Engineering, addressing the role of riparian zones in providing energy sources to small streams, particularly in urban and urbanizing environments. We are also starting to bring together a comprehensive overview of the projects currently in progress, with brief updates included here and more complete descriptions located on our web site. In addition, abstracts from recently completed theses and dissertations are provided, covering topics including watershed planning, evaluation of restoration projects, reproductive success of hatchery and wild steelhead, spatial and temporal distribution of humans in an Alaskan river corridor, and users of an Alaskan fishery. These studies reflect some of the remarkable range of water-related studies being undertaken at the University and the intent of the Center to help support and share the results of this body of research across the region.

During the spring, the Center awarded financial support to three graduate student projects. These included:

• *Food resource quality in small coastal streams of the Pacific Northwest* Carol Volk (Forestry) $960;

• *Accelerated anaerobic pollutant bioremediation using cellulose nitrate* Yinjie Tang (Chemical Engineering) $1000; and

• *Modeling instream wood recruitment and effects of riparian management* Steve Rentmeester (Fisheries) $500.

In addition, a gift of $2000 from the Washington Fly Fishing Club was awarded to:

• *Effect of marine-derived nutrients on aquatic macroinvertebrate production and community structure in salmon spawning streams* Jon Honea (Forestry); and

• *Food resource quality in headwater streams: Implications for instream biota* Carol Volk (Forestry).

Finally, the Andy Studebaker Graduate Support Fund provided travel funds to national and international scientific meetings during this past academic year to Center-affiliated graduate students Chris Brummer, Kris Jaeger,

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Snapshot of current research

The following project synopses give a snapshot of some of the current research affiliated with the Center for Water and Watershed Studies. More information about each project can be found on the Center web site (http://depts.washington.edu/cwws).

The impacts of road crossings on Puget Lowland creek hydrology and geomorphology

Christina Avolio, Civil and Environmental Engineering (MSCE)

This study uses field exploration, in combination with geospatial GIS analyses and hydrologic modeling, to 1) discern how best to measure the fluvial processes affected by the local land uses of road crossings, 2) use those results to determine if road crossings actually do impact Puget Lowland creek hydrology and geomorphology, and 3) estimate the relative significance of road crossing-disruption of the riparian zone, as compared to the cumulative influences of total basin urbanization. The field investigation has been used to compare geomorphic characteristics upstream and downstream of road crossings, and to calibrate theoretical erosive potential to observed sediment transport downstream of road crossings after storm events.

More snapshots of research projects continued on page 4.

In this issue

Energy regime: A missing link in the restoration of small urban streams?

Mindy Roberts, Center for Water and Watershed Studies, Dept. of Civil and Environmental Engineering, UW

Abstract

Urbanization may alter the amount of leaf and needle litter falling into streams due to removal or modification of riparian vegetation. Native aquatic species have evolved based on the timing and quality of allochthonous inputs endemic to a particular area. As non-native landscaping or invasive species replace native vegetation along the riparian corridor, the volume, timing, and nutritional content of the organic matter may change. Once leaves and other litter reach streams, the lack of large wood or other retention mechanisms in urban streams could enhance the transport of that material out of the systems. Finally, changes in physical, chemical, or biological processes may alter the decomposition of whatever organic matter remains.

Anthropogenic modifications to riparian vegetation contribute to urban stream degradation in a variety of ways, and thus rehabilitation efforts that do not consider this range may not restore key functions. Clearly, vegetation removal from riparian zones can increase water temperature by increasing the amount of solar radiation reaching the water surface, and it can reduce the supply of instream wood that would have protected stream banks and created pools and other retentive channel structures that trap sediments and organic matter. We are beginning to understand the additional roles that riparian forests play in watershed-scale nutrient cycling. The present research, being conducted by Ph.D. candidate Mindy Roberts, addresses the complementary function of riparian zones providing energy sources to small streams.

Background

Humans influence riverine systems by altering one or more of five groups of factors: flow, water quality, habitat, energy regime, and biotic interactions (Karr, 2001). Most research to date has focused on the first three, but relatively few studies have addressed energy regimes and biotic interactions, particularly in the urban and urbanizing environment.

Forested systems rely on terrestrial organic matter as the primary energy source (Triska et al., 1981). Allochthonous inputs, such as leaves from deciduous vegetation or needles from conifers, fall into streams where physical, chemical, and biological processes break down the organic matter. The energy is used at various trophic levels.

Studies have quantified anthropogenic impacts on leaf litter sources, fate, and transport as a result of forestry (Webster and Waide, 1982), agriculture (Oelbermann and Gordon, 2000), highway crossings (Stout, 1982), and eutrophication (Brown et al., 1983; Kaushik and Hynes, 1971). A recent study found the amount of non-forested land in the local riparian area influenced leaf breakdown (Sponseller and Benfield, 2001). However, even as urban development continues to expand in the Puget Lowland and elsewhere, no studies yet describe urbanization impacts on leaf litter dynamics. This study is designed to address the effects of urbanization on the sources, transport, and fate of organic matter in small urban streams.

Early results

This study is still in the early stages and will continue through 2004. Research sites are located in the Chico Creek and Clear Creek watersheds, located on the Kitsap Peninsula. Chico Creek supports the largest chum salmon run on the peninsula and offers a range of adjacent development from reference locations to medium-density residential and light commercial. Clear Creek runs through Silverdale and the watershed includes dense commercial and residential land uses.

Both field data and remote sensing information have been used to characterize sites. Riparian vegetation plots were established in the Chico watershed to quantify stem density, composition, and average diameter at breast height of adjacent trees. LiDAR data, provided by the Puget Sound LiDAR Consortium through Kitsap County GIS, provide highly detailed grids of vegetation height, which were spot-checked in the field using a laser range finder. These data, together with color orthophotos, have been used to develop a GIS data layer of riparian tree height, density, and composition to describe vegetation structure.

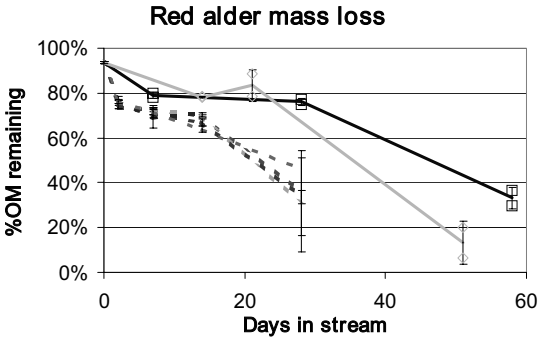
Litterfall baskets have collected organic matter since summer 2002 at five sites along Chico Creek. Two sites support mature riparian vegetation, dominated by 60-m red cedar, red alder, bigleaf maple, western hemlock, and Douglas fir. The remaining sites represent modifications typical of residential land use and an urban park, with narrow or negligible strips of disturbed vegetation adjacent to the stream channel. Additional sites may be added in summer 2003. Litter is separated into components (leaves, needles, red cedar, wood, moss and lichens, cones, and other materials), dried, and ashed to provide the mass of litter per unit area over time. Results will be used to compare the quantity of litter among sites and to evaluate patterns in litter components.

Litter samples from several native and non-native vegetation species

were collected in fall 2002 and will be analyzed for carbon and nitrogen content. The ratio of C:N is one indicator of the nutritional quality of the source material. Literature values for C, N, or C:N are available for some native species, but very little data quantify nutrient content of non-native species.

Previous studies have used surrogate leaf material placed in streams to determine organic matter retention (Bilby and Likens, 1980). Several materials have been evaluated to date, including colored acetate, flagging tape, polyethylene, coated nylon, and cotton cloth. The study will quantify surrogate material retention in study stream reaches and will attempt to correlate surrogate material retention with hydraulic retention.

To evaluate decomposition rates, pre-weighed packs of red alder (a common native species) and Himalayan blackberry (a common invasive species) were placed in streams at several locations in the channels of Chico and Clear creeks, with subsamples collected from 0 to 56 days to determine the change in organic matter content over time. Red alder decomposed more slowly in the urban Clear Creek sites than in the undeveloped and low-development Chico Creek sites, possibly due to enhanced physical abrasion from extensive salmon redd building at the Chico sites. In Clear Creek, red alder lost 15% of its organic matter in the first two days due to leaching, while leaching accounted for 25% of the mass loss in the Chico Creek sites in the same time period. Himalayan blackberry followed similar patterns but lost relatively little mass (5 to 10%) due to leaching. More extensive decomposition experiments are planned for fall 2003.



Rate of red alder decomposition in Chico Creek (solid lines) and Clear Creek (dashed lines).

Future directions and potential implications

A range of outcomes, contributing both to better scientific understanding of stream ecosystems and to practical management of these systems, is anticipated. This work should develop fundamental information on the relative impacts of disturbance on food quantity and quality, based on a moderate number of monitoring locations. The data will be used to quantify the range of variability of organic matter processing, which in turn could lead to a larger and more comprehensive future study.

In addition to quantifying surface organic matter fate and transport, the study will evaluate how organic matter is processed within the gravels. Better understanding of subsurface decomposition should be of great importance, given our emerging understanding of the role of hyporheic zones in natural (Brunke and Gonser, 1997; Triska et al., 1993) and urban (Reidy, 2002) environments. Results could spur future research into the biological and chemical function of hyporheic zones. Heavy metals and other toxics tend to adsorb to organic matter; temperature, dissolved oxygen, and redox gradients present in hyporheic zones may significantly affect the attenuation or storage of various compounds present in urban systems.

Understanding the full suite of riparian-stream links and the impacts of altering those links should improve our management of urban riparian zones in the future. We have few opportunities to study undeveloped riparian zones in urbanizing areas like the Puget Lowland, so the time is short for evaluating and quantifying the energy functions that these riparian zones perform. This should inform efforts to preserve irreplaceable functions, manage future development to maintain those functions, and enhance what has been impaired or lost.

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Differing conditions of the riparian corridor have pronounced consequences on the input, transport, and decomposition of organic material.

Snapshot of current research continued

Watershed disturbance analysis

Ian Lange, Economics (PhD)

This project uses a relatively new statistical technique called wavelet analysis to look at the variability of water temperature in streams of the Willamette River Basin that have multi-purpose control dams on them. Using time series data from the US Geological Survey, sites were paired above and below a dam and sites that span before and after the construction of a dam. With this data, we calculated the wavelet variance for each along with the confidence interval around each estimate. Regression results indicate that the mean wavelet variance is smaller after water has passed through a dam, suggesting that the construction of flood control dams have lowered the variability in the stream temperature. Because wavelet analysis gives the variance on a number of different time scales at once, wavelet variance is a superior metric for determining changes to water temperature regimes over time. With it, we can tell at what cycle a change in the water temperature is most pronounced.

Prioritizing freshwater habitat restoration for salmonid recovery

Jody Brauner, Quantitative Ecology Resources Management (PhD)

In the Pacific Northwest, timber harvest, agriculture and urban development have drastically altered freshwater systems and the species they support. To demonstrate the application of probabilistic tools coupled with a decision-making framework, this study is focused on steelhead trout habitat degradation. The research objectives of the study are threefold: 1) estimate the historic and current carrying capacity of juvenile steelhead trout, 2) simulate the effects of various restoration alternatives on channel morphology (pool formation), and 3) prioritize various restoration scenarios using Bayesian decision analysis.

Modeling instream wood recruitment

Steve Rentmeester, Fisheries (MS)

Pacific salmon benefit from many of the functions that large woody debris perform in stream ecosystems. As a result, salmon populations tend to be larger in streams with abundant large woody debris. Historic logging activities and the intentional removal of woody debris from streams have left many streams in the Pacific Northwest depauperate of instream wood. Recovery of instream wood loads to those found in unmanaged systems will require development of riparian forest, along with the gradual build up of stored wood.

Two approaches that may be used to speeding recovery processes are the manual addition of large woody debris pieces and the application of silvicultural techniques to riparian forests. While manual addition of woody debris is likely to support salmonid species in the near-term, if landscape or watershed-scale processes do not support the recruitment of large diameter woody debris then long-term recovery will require regular human intervention with associated costs. A modeling approach will be used to compare future large woody debris abundance under six restoration prescriptions. The expected outcomes of each restoration scenario will be modeled for a 100-year time frame and

then compared for both short-term and long-term response.

New strategies for stormwater management

Fife Highlands

Brent Zacharia, Civil and Environmental Engineering (MS)

To more effectively manage stormwater and respond to ESA listing of salmonid species in the region, a number of local jurisdictions are adopting new stormwater management guidelines that collectively are termed "Low Impact Development." The next, essential phase for incorporating these new practices into the regional development landscape is to construct pilot projects and monitor the hydrologic and market performance of Low Impact Development. Through installation of automated monitoring equipment at a site in Fife, we are collecting data on hydrological conditions for pre- and post-development. Once the site is developed, we will be able to assess how closely the hydrology mimics the pre-development hydrology, and which strategies hold the greatest promise for reducing the human and ecological consequences of stormwater runoff from developed areas.

High Point, City of Seattle

Amy Engstrom, Civil and Environmental Engineering (MS)

Seattle Housing Authority's plan to rebuild the High Point housing in West Seattle has opened an opportunity to install up-to-date stormwater management techniques in a large area contributing drainage to Longfellow Creek, a stream with existing and potential salmon habitat. Work here will assess the performance of the selected techniques through flow and water quality monitoring of High Point's stormwater runoff.

Seattle's Viewland swale, a recent effort to increase stormwater infiltration.

Future phases will continue the initial monitoring and will add additional discharges from selected stormwater management facilities installed to treat runoff from drainage subbasins.

Evaluating channel initiation in forested headwater streams

Kris Jaeger, Forestry (MS)

The ability to predict the extent of the channel network provides insight into landform evolution, in addition to short-term applications in harvest management. A predictive model can be developed that identifies the extent of the channel network, monitoring potential headward migration of channel heads as a result of timber practices, including road construction. The purpose of this project is to identify whether geomorphic variables determine the location of channel initiation within a basalt lithology.

Riparian stand and instream wood characteristics

Martin Fox, Forestry (PhD)

The goals of this project are to assess riparian characteristics in forests subject to a natural disturbance regime and to characterize the distribution, position, and other physical characteristics of instream wood to serve as a template for stream-habitat restoration and enhancement projects. This can be used to refine existing riparian management prescriptions in terms of basal area, stem density, and other stand components. The quality of these riparian areas will also be correlated to instream wood loads. This project will help link the effectiveness of riparian management to resource benefits.

Accelerated anaerobic pollutant bioremediation using cellulose nitrate

Yinjie Tang, Chemical Engineering (PhD)

Within freshwater streams and marine estuaries in Puget Sound are highly contaminated sediments such as those of the Duwamish River, Eagle Harbor, and parts of the Commencement Bay drainage. Residing in these contaminated sediments are polyaromatic hydrocarbons (PAHs), which are persistent because of their very low aqueous solubility, their tendency to adhere strongly to sediment particles, and their resistance to chemical- and bio-degradation. High sediment PAH concentrations pose a threat to fish directly through habitat and indirectly through the food chain. The large volume of contaminated sediment cannot be readily removed to be treated because the pollutant dispersal would be another threat to fish habitat and the bottom ecosystem of bacterial consortia and higher organisms dependent on them

would be radically disrupted. Therefore, for such large volume hazards, monitored natural attenuation or in-situ bioremediation is an effective contaminant reduction strategy. However, in undisturbed submerged sediments, anaerobic zones form as a result of bacterially-mediated reactions. Thus, other electron acceptors, such as nitrate, play an important role in biodegradation energy. This project is using a controlled-release method for long-term acceleration of PAH bioremediation by nitrate.

Anne Weekes, Virginia Travers, and Sandra Clinton pull hyporheic invertebrates from a well in Swamp Creek, King County.

Distribution of hyporheic invertebrates in urban streams

Anne Weekes, Forestry (PhD)

The presence of invertebrates deep in the substratum of streams has been well documented for many systems. However, there is a paucity of data for streams in the Pacific Northwest, and in particular for streams in urban and urbanizing areas. To improve our understanding of the distribution and composition of hyporheic invertebrates in this region, samples were collected from wells in seven Puget Sound Lowland streams.

To gain a better understanding of the relationship between hyporheic invertebrates and the physical environment supporting the biota, we also collected physical parameters. These included stream and hyporheic zone temperature at the well location, reach slope, suspended sediment concentrations within each hyporheic zone, channel and well sediment composition, average slope for the well reach, and low-flow surface and hyporheic-zone velocity.

Invertebrates were found in all streams; however, differences in composition were evident. Distribution between streams varied greatly, as did distribution of invertebrate groups within streams. Some groundwater-associated fauna, such as amphipods, were found in very small numbers, even though deeper wells were included in all the sampled streams.

Role of riparian red alder in the nutrient dynamics of streams

Carol Volk, Forestry (PhD)

One result of clearcut logging in the Pacific Northwest is that many watersheds are now dominated by riparian stands of red alder. This species colonizes disturbed areas quickly and can limit the establishment of coniferous forest species. In the Northwest, inputs of nutrients from decaying salmon carcasses have been reduced with declining salmon runs, and nitrogen-rich red alder litter may provide a critical source of nutrients to streams. We hypothesize that high nutrient inputs from red alder forests translate into more productive and nutrient-rich stream ecosystems, compared with streams bordered by coniferous species. Data suggest that red alder forests may provide important subsidies of limiting elements that fuel food webs in Pacific Northwest streams. This might be especially important in stressed systems, such as those that have experienced drastic resource removal through forest harvesting or reduced salmon runs.

The effect of salmon nutrients on aquatic insects

Jon Honea, Forestry (PhD)

Given that streams are highly variable habitats that are frequently disturbed by high flows, does the availability of marine nutrients really result in more insects overall? To answer this question we are measuring aquatic insect *production*, i.e., the amount of biomass (or energy) produced in a given area over a given amount of time. In this case we are comparing insect production in Kennedy Creek upstream and downstream of a series of waterfalls that prevents upstream salmon migration. (See Streamside Runoff V14 N2, available at http://depts.washington.edu/cwws/Outreach/Publications/StreamsideRunoff/SRV14N2.pdf)

Comparing rapid assessment techniques of stream channel conditions

Catalina Segura-Sossa, Civil and Environmental Engineering (MS)

Two rapid assessment methods, both designed to characterize instream geomorphic conditions, were applied by two independent field crews to 11 km of the main stream network of the Chico Watershed, located in the Kitsap Peninsula, western Washington State. The purpose of this study was to compare the overall results achieved by the

two methods and to evaluate the individual metrics used in each method.

In general, both methods gave similar results. The largest discrepancies appeared at channel gradients higher than 0.02, corresponding to the typical shift from predominantly pool-riffle to step-pool channel morphology. A channel cementation metric (common to both schemes) showed statistically different results between the two sets of observers. Bank stability and large woody debris used in the "rapid 2" gave comparable results to channel stability and complexity measured with the "rapid 1" method.

Nitrogen retention in riparian buffers of agricultural streams

Carrie Monohan, Forestry (PhD)

The purpose of this research is to determine biotic (e.g., subsurface microbial activity) and abiotic, factors influencing nitrogen retention within agricultural ecosystems of differing riparian buffer widths. Findings from this study will have direct implications for the management of lowland streams and will aid in recovery efforts of salmon stocks listed under the Endangered Species Act.

In an agricultural area (Lake Creek), Ashley Adams measures water table fluctuation.

Spatial and temporal characterizations of DO levels

Virginia Travers, Forestry (MS)

The Mill Creek basin is approximately fifteen square miles. It is located in southwest King County and runs west of and adjacent to the Green River. The Mill Creek basin has some of the most polluted streams draining into the Green-Duwamish river system, according to the Green-Duwamish Watershed Nonpoint Action Plan. As a result, King County's Department of Natural Resources and the Center are monitoring dissolved oxygen (DO) levels to determine the duration and timing of DO levels that are below rearing and incubation standards of salmonid species.

The ecotoxicology of mine waste contamination

Daniel Peplow, Forestry (PhD)

A study of mine-waste contamination effects on Methow River habitat on the eastern slopes of the north Cascade Mountains in Washington State, revealed impacts at ecosystem, community, population, individual, tissue, and cellular levels. Ore deposits in the area were mined for gold, silver, copper, and zinc until the early 1950s, but the mines are now inactive. An above-and-below-mine approach was used to compare potentially impacted sites to control sites. The concentrations of eleven trace elements in Methow River sediments downstream from the abandoned mine sites were higher than background levels. Exposed trout and caddisfly larvae in the Methow River showed reduced growth compared to controls. Contaminated sediments caused adverse biological effects at different levels of biological organization, from the cellular to ecosystem-level responses, even where dissolved metal concentrations in the corresponding surface water met water-quality criteria.

Seattle-Area Geologic Mapping Project

Derek Booth and Kathy Troost, Earth and Space Sciences

The Seattle-Area Geologic Mapping Project (SGMP) is a unique, ongoing collaboration of the University of Washington with local and federal governments. The project was initiated in 1998 through collaboration with the U.S. Geological Survey and the City of Seattle to improve the City's environmental protection and reduce the risk of geologic hazards (e.g., earthquakes and landslides) by providing state-of-the-art geologic information to citizens and departments within the City of Seattle. Since that time, the project has broadened to include mapping efforts for King County Department of Natural Resources and the City of Bothell. Our mission is to conduct geologic research and mapping, and to provide the best geologic data and expertise in support of hazard assessments, land-use decisions, and property information for citizens, agencies, planners, and other scientists. A wealth of recently acquired geologic data from the greater Seattle area is now on the web site at http://depts.washington.edu/sgmp.

Radio tags help track the movements and monitor internal body temperatures of adult spring chinook during upstream migration, Klamath River (photo by Josh Strange).

Thermal refugia use by adult salmonids

Josh Strange, Fisheries (MS)

Altered thermal regimes are a growing problem in rivers throughout the Pacific Northwest. The Klamath River of southern Oregon and northern California is no exception and has experienced increasing problems with high water temperatures, which has been spotlighted by recent fish kills of juvenile and adult salmonids. Thermal refugia clearly plays an important role in mitigating thermally related stress and mortality in the Klamath River, but the details are still not well understood, especially with regards to adult salmonids. This project will build upon previous studies and will investigate patterns and implications of thermal refugia use by adult salmonids.

Classifying riparian forest cover in the Cedar River Watershed

Lauren Mollot, Forestry (PhD)

This project will identify areas suitable for restoration within the riparian zones of the Cedar River Watershed by characterizing the riparian forest cover using GIS and ground-

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Thesis and dissertation abstracts

Below are abstracts from recently completed theses and dissertations of affiliated graduate students. The web site has a list of all affiliated students who have graduated, many of their abstracts, and some entire theses or dissertations (http://depts.washington.edu/cwws/Theses/abstracts.html).

Watershed councils and the Oregon Plan: An analysis of watershed planning processes

Ryan Bidwell, MS Forest Resources

The Oregon Plan for Salmon and Watersheds represents the State of Oregon's comprehensive policy effort to address salmon conservation and watershed health through locally based collaborative watershed councils. Although State legislation provides few explicit requirements of councils, it does call for them to conduct a watershed assessment to be used as the basis for the development of a prioritized action plan. Once completed, action plans should guide councils in the selection of restoration, education or other projects deemed necessary to recover local salmon populations and otherwise improve watershed conditions.

It is in many cases too early or otherwise too difficult to evaluate the success of watershed councils in restoring salmon populations or in improving watershed health. Given this fact, gaining a better understanding of the process employed in selecting council activities provides the best opportunity for preliminary assessment of the success of voluntary, collaborative groups in achieving ecological restoration goals. Accordingly, this research aims to better explain the process by which collaborative groups choose to or choose not to incorporate scientific information into their decisions and subsequent watershed restoration actions. Both the planning process and the final prioritized action plan itself (where completed) were evaluated for 29 watershed councils formed since passage of the Oregon Plan in 1997.

In practice, Oregon watershed councils continue to struggle in their efforts to move beyond their watershed assessments and begin the development and implementation of action plans. Specific findings include: 1) Many watershed councils are implementing restoration projects without a prioritized action plan; 2) Most watershed councils are not relying upon scientific information as the basis for selecting watershed restoration projects; 3) Watershed action plans that have been developed are often deficient in both process and content; and 4) Watershed planning processes do not appear to be improving over time. In general, these findings confirm expectations that collaborative decision-making processes may result in actions that successfully address shared social priorities but may not necessarily target ecological priorities.

As collaborative decision-making approaches seem to be an increasingly permanent fixture of natural resource management, it is important to consider how watershed councils and similar efforts might be assisted so as to more fully achieve both social and ecological policy goals. Findings from this study suggest that it is important to: 1) Provide clear policy expectations and guidance to assist collaborative groups in devising clear and concise watershed plans; 2) Make available affordable and user-friendly scientific tools to better inform collaborative decisions; 3) Revise funding strategies to reward councils who support proposed projects with a scientifically grounded watershed action plan; 4) Recognize that social priorities may be more politically and socio-economically feasible than purely ecological priorities. Further research should be conducted to explore how, or if, social priorities for restoration differ from ecological ones.

Evaluation of restoration projects and channel changes in the Little Naches basin, WA

Mark J. Muir, MS Forest Resources

The overall purpose of this study was to evaluate instream, riparian, and road restoration projects (1986-2002); habitat variability (1990-2001); and channel changes (1994-2001) in the Little Naches watershed in light of changing land-management practices and active restoration work in the basin over the same time frames. The Little Naches watershed has been a high priority for restoration because of the depressed state of salmonid populations and degraded habitat conditions. The American River, immediately to the south, was used as a reference of natural conditions and processes that existed historically in the area. Only active response or pool-riffle reaches were surveyed in both basins.

Between 1986 and 2002, the physical durability of instream structures varied with structure type, location in the channel, and channel type. Structures placed along the channel margins generally had greater longevity than channel-spanning structures. Instream manipulation was not effective at creating or maintaining habitat in the long term, particularly in active response reaches. Floodplain collector logs had high survival rates and were successful at encouraging micro-sites of sediment deposition and riparian plant establishment in a disturbed stream reach. Fine sediment levels measured from McNeil gravel samples showed a slight, statistically significant decrease in fine sediment (<0.85 mm) between 1991 and 2001, but the decrease cannot be directly linked to road restoration efforts.

Between 1990 and 2001, all four Little Naches response reaches showed an increase in primary pool habitat and decrease in riffle habitat. Total counts of large woody debris increased in three out of four reaches. Spawning sized gravels and the percent of reach area comprised of spawning habitat also increased in three reaches. The percent of stream length embedded with fine sediments decreased in three reaches. Cross-section surveys in the Little Naches basin (1994-2001) revealed localized channel migration in the most disturbed and confined reach, where several key pieces of large woody debris were recruited to the channel during a 1996 flood. These pieces of LWD were associated with complex pool habitat and further wood accumulations in 2001 and 2002. One reach exhibited characteristics indicative of a reach close to dynamic equilibrium while another reach was adjusting to a new main channel after an avulsion during the 1996 flood event. The channel and habitat changes observed in the Little Naches River appear strongly related to the flood events of 1990 and 1996 rather than to active management efforts.

Graphical and descriptive statistical analyses of 2001 stream survey data revealed key differences between the Little Naches and American River response reaches. The American River exhibited a more complex and diverse array of habitat for both juvenile and adult salmonids. Pool habitat, side-channel habitat, and LWD were all more abundant in the American River. Pools also had more total cover and deeper residual depths. The more dynamic and unconfined nature of the American River was illustrated by a high percentage of pool habitat associated with meander bends, floodplain connectivity, and gravel-bar dynamics.

The relative ranking of data sub-sets that explained the majority of variance between Little Naches and American River reaches was: 1) habitat percentages, 2) gravel-bar dynamics, 3) LWD quantity, 4) median grain size of the bed sediment, 5) pool cover, and 6) pool-forming agent. However, since no factor explained the majority of variance, all data sub-sets appeared important. Reach 8 of the Little Naches River most closely resembled conditions observed in the American River, while reach 4 was the most dissimilar.

In summary, results indicated that habitat conditions are improving in the Little Naches River (1990-2001), but they are not equivalent to those of the American River reference reaches. The information gained in this study can help prioritize the location and type of future restoration and preservation efforts within the Little Naches watershed.

Physical durability of instream and riparian restoration projects in the Little Naches basin. Durability or survival rate was considered to be the percent of structures functioning as intended during the 2002 survey. In general, mainstem Little Naches reaches were pool-riffle reaches.

Structure Type	N	Year installed	Location	% Functioning
Log v-weirs	3	1986-87	Little Naches	0%
Single log weirs	3	1986-87	Little Naches	100%
Rock u-weir	1	1987	Little Naches	100%
Passage rocks	27	1986-87	Little Naches	82%
Turning rocks	13	1986-87	Little Naches	0%
Floodplain collector logs	19	1986-87	Little Naches	100%
Off-channel habitats	2	1987, 1992	Little Naches	50%
Rock barbs	30	2000	Little Naches	100%

Regional salmon recovery planning in Washington State

Brian Petersen, MPA Public Affairs and MS Forest Resources

In response to declining salmon runs and subsequent federal listings under the Endangered Species Act, the State of Washington has put forth a regional recovery planning strategy as a means to recover salmon in the state. This approach on a regional scale attempts to write and ultimately recover all the anadramous fish species listed under the Endangered Species Act in a specific region.

Seven recovery regions exist in the state and this study looks at the two efforts furthest along in the recovery planning process: the Puget Sound Shared Strategy (SS), and the Lower Columbia Fish Recovery Board (LCFRB). The primary focus of this research analyzes these approaches using Elinor Ostrom's *Governing the Commons* as the theoretical basis to see if they meet the eight design principles of a common pool resource (CPR) institution.

The study utilized a snowball sampling methodology to identify and interview 18 participants for the study. All the participants received the same questions from an interview guide developed specifically for this project that focused primarily on the design principles.

Both the SS and the LCFRB emerged in response to listings of species in their regions and have successfully organized a planning process that has broad representation and participation from interested stakeholders. In terms of the design principles they are equivalent: they both fail to meet five of the design principles and thus do not represent CPR institutions.

The primary factor limiting their ability to meet all the principles is their lack of authority. The National Marine Fisheries Service has the ultimate authority over the planning process, and so these two efforts will not have the ability to organize and oversee the long-term implementation of the plans they write. Without having any authority they cannot meet the design principles. As a result, long-term species recovery remains questionable.

Devolving authority to these regional efforts would enable them to control and oversee the recovery process. Without authority these efforts will likely put together recovery plans that will not get implemented and which do not yield ultimate recovery of these species.

Reproductive success of hatchery and wild steelhead, *Oncorhynchus mykiss*

Jennifer E. McLean, PhD Aquatic and Fishery Sciences

Species and populations evolve through variation in reproductive success (RS) among individuals with different values of heritable traits. Estimates of RS can be obtained from observations of behavior or data on life history traits, but fitness is affected by many complex factors. Genetic parentage studies, however, can precisely determine the number of offspring attributable to individual parents with known traits. I coupled genetic, morphilogical, and behavioral data from hatchery and wild steelhead trout to assess their effects on fitness, i.e., reproductive success. Specifically, the effects of steelhead origin (hatchery versus wild), reproductive timing, and adult body size on reproductive success were tested.

Hatchery steelhead spawning in the wild had markedly lower RS than did native wild steelhead. Hatchery females greatly outnumbered wild females on the natural spawning grounds (N=90 and 73 vs. 11 and 10 wild females in the two consecutive years of the study), but produced only 4.4 – 7.0% the number of smolts produced per wild female. The wild steelhead population more than met replacement requirements at the adult stage (approximately 3.7 – 6.7 adult offspring-per-female), but the hatchery steelhead were far below replacement (<0.5 adults-per-female).

With respect to individual RS, the natural mating system was complex; monogamy, polygamy, polyandry, polygyny, and polygynandry were observed. Wild steelhead outperformed hatchery steelhead, and the timing of reproduction had a more significant role in production of smolt and adult offspring than did size, especially for females. Specifically, the return timing distribution of reproductively successful spawners formed a U-shaped pattern; adults breeding at intermediate times during high river flows produced fewer offspring than those earlier and later in the season. Body size did not affect offspring production. The overall production of adults-per-female in the hatchery was on the same order of magnitude as production by naturally spawning wild females. Parent body size and reproductive timing did not affect RS in the hatchery, despite a considerable range in fecundity (egg production), which was related to body size.

New publication

Center-affiliated faculty Robert Wissmar and Peter Bisson have edited a new book, *Strategies for restoring river ecosystems: Sources of variability and uncertainty in natural and managed systems*. The purpose of this book is to integrate perspectives on variability of physical and biological functions, and concepts of uncertainty in natural and managed systems, into strategies for renewing and conserving river ecosystems. The book is published by the American Fisheries Society and costs $92. It is available now in bookstores and in libraries soon.♦

Identifying the spatial and temporal distribution of human users in a river corridor

Brian Zwiebel, MPA Public Affairs and MS Forest Resources

An unobtrusive and non-invasive methodology for spatially and temporally analyzing visitor use and distribution was developed for the Alagnak Wild River in Katmai National Park. Spatial and temporal analyses of visitor use have been performed using GIS software, representing a unique innovation in the methods of social monitoring and visitor-use analysis. This methodology was developed in the spring of 2002 and implemented during the summer of 2002. It has been explicitly detailed to permit its application to other recreational settings, for example other rivers or lakes in Alaska. Typically, these locations present unique challenges where it is difficult or impossible to observe all users in a single day. This new methodology allows explicit spatial and temporal visitor use data to be collected in such areas.

The development and implementation of a documented, repeatable methodology that objectively defines user densities in the Alagnak Wild River corridor is a large step forward for the management of the river corridor. The busiest times and locations in 2002 were mid-day and mid-July, downstream of Katmai Lodge. This finding can be compared against observed trends in the future using the same methodology to understand long-term changes in river use. The resolution of this analysis, which quantifies user densities in 810-meter reaches of river, is a significant improvement over other counting methodologies documented in the angler-measurement literature. The methods used have been implemented for a full field season, and future user distribution surveys need only consult this report to implement the same program and collect comparable data. The program has been successful in objectively quantifying the spatial and temporal distribution of users in the Alagnak Wild River corridor.

Understanding diversity among participants in the Chitina Subdistrict Dipnet Fishery

Amber S. Kocsis, MS Forestry

This study examined motivations of participants in the Chitina Subdistrict Personal Use Dipnet Fishery in Chitina, Alaska. Participation in this salmon fishery had steadily increased from 1984 to 1998, hitting its record high of 10,006 participants in 1998. Since 1998, participation has declined and abruptly dropped to 6,851 in 2002. The classification for this fishery has changed three times since 1984. In addition, the fishery has been in significant conflict with other users of the salmon resources. Identifying sub-groups within this user population will aid in understanding the needs of the users, their motivations for using this fishery, and the psychological benefits that they derive by participating in this fishery. A mail questionnaire was administered to a sample of participants from the 2000 season. The response rate was 78.8%. Using the Recreation Experience Preference framework, four factors were deduced that have significance to the users of this fishery. Three subgroups, ranging in size from 19.2% to 42.5% of the sample, were identified through a cluster analysis. Segment A places highest priority on *Consumption Orientation and Traditional Lifestyle*. Segment B places highest value on *Outdoor Escape and Family Bonding*, as does Segment C. Segment B also places high value on *Social Bonding and Physical Exercise*. In fact, *Consumption Orientation and Traditional Lifestyle* was highly rated by all three segments. From these results, it is clear that Chitina dipnetters value the opportunity to catch salmon at Chitina but also have other varying motivations for using the fishery. ♦

Message from the directors continued

Mindy Roberts, and Catalina Segura-Sossa.

Many of you may know that as of September 16, 2003, Susan Bolton will be stepping down as Co-Director of the Center for Water and Watershed Studies, and Clare Ryan will return to her teaching and research responsibilities following her one year interim term as Co-Director. Derek Booth will continue as Director for the upcoming academic year, along with the rest of the continuing Center staff: Cara Berman (Research Scientist), Kathy Troost (affiliate Research Scientist), and Leslie Wall (Program Manager).♦

Classifying riparian forest cover continued

truthing techniques. Geomorphological characteristics of the channel and floodplain will be examined to discover potential natural disturbance hazards. The project will also include a suitability analysis by which areas of potential restoration could be located that are not prone to natural disturbance based on geomorphic conditions. These areas would then be considered most suitable for restoration.♦

Watershed Research Database

The Watershed Research Database is a tool for facilitating collaborative research among watershed scientists and water management professionals. The function of the Database is to enable specialists to view snapshots of completed and continuing research efforts by other scientists in the Pacific Northwest, and to post their own projects for others to view. Research on ecosystem dynamics and watershed management is housed in the Database. The site provides project summaries, contact information, and links to project reports, articles, and related websites. By increasing access to information on regional research efforts, we hope to facilitate information exchange and expand collaborative opportunities. This project was created by the Center in response to research needs expressed by researchers and managers at a February 2002 workshop. It is accessed from http://depts.washington.edu/cwws/wrd.html

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About *Watershed Review*

The *Watershed Review* is a free quarterly publication of the Center for Water and Watershed Studies. To subscribe to the longer 12-page newsletter, which expands on articles in this publication, please go to http://www.engr.washington.edu/epp/cwm.htm.

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