CENTER FOR STREAMSIDE STUDIES

Streamside Runoff

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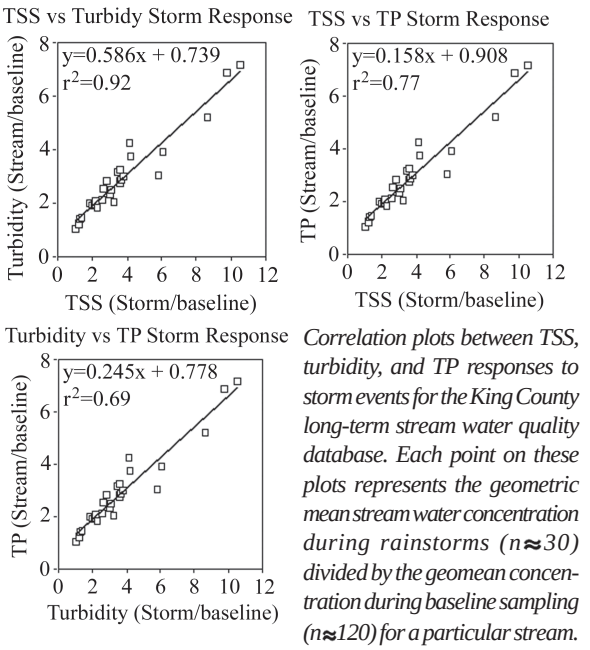
Land-use effects on water quality in Puget Lowland streams

The Puget Lowlands continue to experience growth and consequent changes in land use. Many of these changes in land use alter the hydrologic and sediment regimes of local streams and rivers. Sediment delivery to streams is increased when flow paths shift to more overland flow. Gravel roads and runoff from exposed soil are a common source of increased stream sediments. Several studies are nearing completion that investigate the relationship between land use and water quality including sediment, turbidity, and nutrients.

Total Suspended Solids (TSS) and turbidity are measures used to evaluate the amount of sediment in streams. TSS represents a direct measure of the weight of sediment in the water column, determined by measuring the residue in a sample of water that will not pass through a standard filter. Turbidity is an indirect measure of the presence of suspended solids in the water column based on the amount of light scattered in the water. Turbidity is often correlated with TSS, but the relationship may vary depending on the shape, size, and composition of sediment in a stream.



Correlation plots between TSS, turbidity, and TP responses to storm events for the King County long-term stream water quality database. Each point on these plots represents the geometric mean stream water concentration during rainstorms (n≈30) divided by the geomean concentration during baseline sampling (n≈120) for a particular stream.

Suspended sediments in streams

James Packman compared winter storm event suspended sediment concentrations and particle size distributions in eight streams that have a single primary land-use (forested, agricultural, or urbanized).

Sediment concentrations were highest in urban streams, while forest and agriculture streams had significantly lower median concentrations. During storm flows forest and agriculture streams had the highest (and similar) proportions of silts. Suspended sediment varied up to 3 orders of magnitude during storm events.

In agricultural basins, the land-use itself was not clearly responsible for the concentrations and particle sizes measured. The constant base flow that feeds the studied streams and the very low relief in these basins strongly limited sediment transport. Therefore, data from these basins are not comparable to the urban and forest basins.

Sediment and phosphorus

King County has been collecting stream samples from approximately 25 streams in the Lake Washington/Sammamish watershed for 10 years under both normal baseline flow and storm conditions. Variables analyzed include total phosphorus (TP), soluble reactive phosphorus (SRP), total nitrogen (TN), nitrate, ammonium, total suspended solids (TSS), and turbidity. Sara Stanley has analyzed these data and noted a strong correlation between both TP and TSS and TSS and turbidity under storm conditions. The analysis indicates that the dominant fraction of TP moved through stream systems in the particulate form. However, none of these relationships is apparent under normal flow conditions.

The percent of forest land cover in sub-watersheds was also examined to see whether land cover had an influence on instream concentrations under normal or stormflow conditions. (Percent urban cover could have been used because percent forest and per-

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Other Research

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cent urban are highly negatively correlated in this region.) Under normal flow conditions there was a slightly negative trend for turbidity as percent forest increased, but there appeared to be no correlation between TSS and percent forest cover. During storm conditions, TSS and turbidity increased substantially, regardless of the land cover of the stream watershed.

TP and land use

The objective of this study is to determine to what extent phosphorus export varies with sub-watershed land use. Four high resolution databases for three different stream types (highly urbanized—Thornton Creek, moderately urbanized—Swamp and North Creeks, and low-density residential—Issaquah Creek) are being developed. Daily observations of nutrient loading, sediment load, and stream flow are being collected at each site for approximately one year. Results thus far show that there are moderately strong positive correlations between TP and TSS for Issaquah, North, and Thornton Creeks. However, Swamp Creek has a poor correlation between these parameters.

Effects of turbidity and TSS on salmonids

CSS completed a white paper on the effects of turbidity and TSS on salmonids for the Washington State Department of Transportation (DOT). DOT's projects often include activities that may negatively affect water quality via disturbance of instream sediments for bridge and culvert construction or storm-water runoff laden with sediment from transportation construction sites. Sediment presence in salmonid bearing watersheds is a major concern because fine sediments can affect salmonid spawning, growth, and reproduction.

A pool forming behind large woody debris

Fine sediments can fill interstitial spaces in the substrate, preventing eggs from receiving oxygen flow and hindering the removal of waste products. Sediments blocking normal hyporheic upwelling can reduce or eliminate spawning habitat.

Overall salmon survival rates may be affected as well. Some manifestations of physiological stress to salmonids induced by sediment include increased blood and plasma glucose levels, decreased osmoregulatory capacity, and gill trauma. These physiological responses can decrease feeding and growth rates and increase susceptibility to disease.

Salmonid behavior, such as territoriality, can be altered by the presence of suspended sediment. Salmonids have been shown to avoid excessively turbid areas in laboratory tests. Movement to a less desirable habitat or to areas where competition for resources is greater may reduce survival. Suspended sediment in the water column has also been shown in some cases to reduce the feeding ability of juvenile salmonids because they are visible predators.

For more information on suspended sediment, see the US Geological Survey's Suspended Sediment Database for streams and rivers throughout the United States at http://webserver.cr.usgs.gov/sediment/.

James Packman is a graduate student in Forest Hydrology. Sara Stanley is a graduate student in Civil and Environmental Engineering. The salmon and turbidity report was written by Jeff Bash, Cara Berman, and Susan Bolton.

Instream wood: How much is enough?

Instream wood is recognized as an important feature linked to channel processes that benefit salmonids. Stream channel assessments and restoration/enhancement efforts often associate salmon habitat quality to the quantity and volume of woody debris. Existing wood targets used by resource managers do not adequately account for variations in wood quantity or volume due to differences in geomorphology, ecoregion, or disturbance regime.

To address this issue, field data on instream wood quantities and volumes from unmanaged basins within Washington State were used to develop references that consider the variability found in natural basins with different regional climates, geomorphologies, and hydrological influences. These reference values will help resource managers in the Pacific Northwest evaluate, manage, and initiate stream restoration/enhancement projects. Based on the assumption that streams draining unmanaged forest basins incorporate the range of conditions that salmonids and other species have adapted to, wood loads in these systems provide a reasonable reference for management. Surveys were conducted in 150 stream segments draining upstream basins without logging, roads, dams, or other human-induced conditions (except for fire suppression) that may influence natural wood loading and retention rates.

These data indicate that the most consistent predictors of wood volumes and quantities are basin size (as correlated with bankfull width) and ecoregion. Although trends in wood quantities and volumes were observed among various channel morphologies and disturbance types, these factors were not used as independent variables due to either the lack of statistical

significance or the correlation of these factors with bankfull width or ecoregion.

Based on these data, we suggest new values for wood quantity and volume to refine wood management targets. Percentile distributions describe the range of wood quantities and volumes in streams draining unmanaged basins by discrete bankfull width classes for three distinguishable ecoregion groups, as defined by our statistical methods. The data also support expanded definitions for minimum volumes of "Key Pieces" in channels between 20–100 m bankfull width, and for all channel widths in eastern Washington. "Key Pieces" are currently a regulatory definition for large pieces of instream wood as defined by the Washington Forest Practices Board (1997) for channels <20 m in western Washington. Based on the 75th percentile value, new values are suggested for wood quantity, volume, and key pieces for Washington. Examples of these values for western Washington are: >63 pieces of LWD per 100 m of channel length in channels between 6–30 m in bankfull width, and >99 m^3 of LWD volume per 100 m in channels between 0–30 m bankfull width. For the drier portions of the east-slope Cascades characterized by Douglas fir and Ponderosa pine forests, the 75th percentile of our data for the quantity of LWD per 100m is >29 pieces per 100 m in channels 0–6 m bankfull width, and >15 m^3 volume LWD in channels 0–30 m bankfull width. Because these references for in-stream wood incorporate sources of regional and geomorphic variability, they may more effectively serve as a management tool than existing targets for stream evaluation, restoration, and enhancement.

Martin Fox is a graduate student in Forest Resources.

Agriculture and salmonids: Future research

As salmonid listings under the Endangered Species Act (ESA) have become more common in the Puget Sound, new sectors of the economy are being affected by listings. Because agricultural lands tend to be concentrated in the lowland areas and fertile river valleys, this type of land use is in conflict with salmon use of lowland streams and side channels. Agriculture will be faced with regulations emerging from the Clean Water Act and the ESA. Best available science is the keystone to current regulatory policy in Washington and as such, information is needed on the condition of streams in agricultural lands, how those watersheds functioned historically, and ways to improve the ecological functions in streams and riparian zones in these areas.

Few studies have been done in western Washington on the effects of agriculture on the ecological condition of lowland streams and rivers. On April 18, 2001, CSS sponsored the meeting "Identification of Scientific Information Needs for Agriculture in Western Washington to meet ESA and Clean Water Act Requirements." Representatives from local, state, and federal agencies, WSU cooperative extension, and other interested parties participated and exchanged information about critical research needs for western Washington agriculture. This information was used in a literature search to locate studies with relevance to local agriculture practices.

The final report describes many factors that affect salmonid stream habitat and discusses the current gaps in knowledge on this topic, including nitrogen transformation processes, food webs, and sediment inputs. Materials from the meeting and the final report are available at http://depts.washington.edu/cssuw/Research/research.html.

Undergraduate research

Each summer NASA partially funds undergraduate students to work with faculty and graduate students on research projects. This summer there are 3 students assisting CSS-related projects. **Ashley Adams** is comparing eastern Washington stream temperatures with regulatory shade requirements and elevation. **Andrew Bryant** is looking at subsurface water level changes adjacent to urban streams. **Andrea Jones** is assisting with Center for Urban Water Resources Management and CSS Urban Stream Temperature project, specifically evaluating the consequences of last winter's drought on the extent of summertime perennial flow.

New research staff

Cara Berman and Sandra Clinton

CSS hired **Cara Berman** as a research scientist to assist with research projects and grant writing. Cara graduated with a Masters from the UW School of Fisheries in 1990. She then worked at the EPA for 10 years as a regional salmon ecologist creating strategies for salmon recovery. This year Cara will be developing a comparison of landscape, aquatic, and biological classification system to produce a framework that combines all three. She will also be investigating landscape scale thermal metrics on salmonid distribution patterns.

Sandra Clinton started as a Post Doc for CSS in July. She is moving her research on groundwater-surface water interactions from the Olympic National Park to the equally challenging, and in some cases (but not all) beautiful urban streams of King County. The research will focus on quantifying hyporheic storage, groundwater inputs, and hyporheic invertebrates in these systems.

White paper now on-line

Ecological Issues in Floodplains and Riparian Corridors (see Summer/Fall 2000 issue, vol. 12, No. 2) is now on-line at the Washington State Department of Fish and Wildlife (WDFW) website http://www.wa.gov/wdfw/hab/ahg/floodrip.htm. This white paper is part of a series commissioned by the WDFW and Washington Department of Transportation. The papers provide the scientific and technical basis for developing the Aquatic Habitat Guidelines.

Announcements

CONGRATULATIONS

Congratulations to the following students who completed their degrees: **Sandra Clinton** *Microbial metabolism, enzyme activity, and production in the hyporheic zone of a floodplain river* (Ph.D. Forestry); **Holly Coe** *Distribution patterns of hyporheic fauna in a floodplain riparian terrace* (M.S. Forestry); **Treva Coe** *Contrasting discharge patterns, juvenile salmonid use, and fish community structure in off-channel floodplain habitats, Queets River, Washington, during summer low-flow* (M.S. Fisheries); **Martin Fox** *A new look at the quantities and volumes of instream wood in forested basins within Washington State* (M.S. Forestry)*;* **Jennifer Ise** *Motivations of rural landowners to participate in conservation-oriented land management programs* (M.S. Marine Affairs)*;* **Jacque Klug** *Crafting collaboration: An implementation analysis of Washington's Watershed Planning Act* (M.S. Forestry); **Graham MacKenzie** *Trophic relations between Coho salmon carcasses, oomycetes and select caddisfly larvae* (M.S. Forestry); **Maeve McBride** *Spatial effects of urbanization on the physical conditions in Puget Sound Lowland streams* (M.S.C.E. Civil and Environmental Engineering)**; Kerri Mikkelsen** *Factors influencing the distribution of conifer and red alder in riparian zones in western Washington* (M.S. Forestry); **Jenna Scholz** *The variability in stream temperatures in the Wenatchee National Forest and their relationship to physical, geological, and land management factors* (M.S. Forestry)

CALENDAR OF EVENTS

October 2 – Dec 4, 2001 **Tuesday Morning Seminars**, 22 Anderson Hall, UW Campus. For a schedule, contact Leslie Wall (cssuw@u.washington.edu or 206-543-6920) or view http://depts.washington.edu/Events/events.html.

February 6, 2002 **CSS/CUWRM 2002 Annual Review**, HUB West Ballroom, University of Washington campus.

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

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