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RESEARCH ON STREAMSIDE ISSUES THROUGH THE WOOD COMPATIBILITY INITIATIVE

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ABSTRACT:

Through the Wood Compatibility Initiative (WCI), the Center for Streamside Studies (now the Center for Water and Watershed Studies) at the University of Washington has undertaken a series of research efforts addressing production and protection of forest, fish, wildlife, and other aquatic and riparian resources. These efforts consist of micro-habitat and habitat-unit-scale mechanistic studies, trans-scale studies exploring hierarchical linkages of structure and function, as well as the development of a landscape classification model linking physical and biological processes across scales and integrating terrestrial and aquatic ecosystem components. Wood Compatibility Initiative funded projects have involved collaboration with scientists at the Pacific Northwest Research Station, National Marine Fisheries Service, U.S. Fish and Wildlife Service, Weyerhaeuser Company, the City of Seattle, the Lummi Nation, and others. The Center for Streamside Studies has addressed the role of large woody debris in streams, including stream input processes and hydraulic and biologic functions. Other studies have investigated freshwater habitat condition and its relation to salmonid productivity and the role of hyporheic flux in redd selection by salmonids. In collaboration with others, historic riparian stand condition, specifically canopy cover related to stream shading, has been investigated as well as the role of geomorphic variability in affecting stream temperatures. This paper summarizes the results from WCI studies initiated over the past four years.

KEYWORDS: Center for Streamside Studies, Center for Water and Watershed Studies, riparian research, rivers.

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INTRODUCTION

Through the Wood Compatibility Initiative (WCI), the Center for Streamside Studies (CSS) (now the Center for Water and Watershed Studies) at the University of Washington has undertaken a series of research efforts addressing production and protection of forest, fish, wildlife, and other aquatic and riparian resources. These efforts consist of micro-habitat and habitat unit-scale mechanistic studies, trans-scale studies exploring hierarchical linkages of structure and function, as well as the development of a landscape classification model (Berman^c) linking physical and biological processes across scales and integrating terrestrial and aquatic ecosystem components. Information derived from these efforts provides information to support natural resource management decision-making. Projects focus on the interactive effects of structures and processes across ecosystem elements and scales and at different places within the stream network. It is these synthetic studies that are necessary to respond to today's complex management landscape.

Center for Streamside Studies projects examined the distribution of large woody debris in streams across various ecoregions in Washington, and hydraulic and biologic functions of natural versus engineered wood. Other studies investigated freshwater habitat condition and its relation to salmonid productivity and the role of hyporheic flux in redd selection by salmonids. In collaboration with Upper Columbia River timber growers** and the U.S. Department of Agriculture, Forest Service district forests and supervisor's offices, historic riparian stand condition, specifically canopy cover related to stream shading, was investigated as well as the role of geomorphic variability in affecting stream temperatures. Wood Compatibility Initiative funded projects have involved collaboration with scientists at the Pacific Northwest Research Station, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), the city of Seattle, the Weyerhaeuser Company, the Lummi Nation, and others. This paper summarizes the results from WCI studies initiated over the past four years.

FINDINGS AND MANAGEMENT IMPLICATIONS

Managers' and regulators' research needs are complex and require a detailed understanding of multi-scalar landscape processes as well as the interactive components of the stream ecosystem. Therefore, it is not unusual for CSS projects to address longitudinal, lateral, and vertical connectivity across multiple spatial and temporal scales. In fact, this approach is required to view the river system holistically and to understand the implications for management decisions.

CONCEPTUAL MODEL

The interactive components of a river system form a template on which abiotic and biotic processes unfold. These interactive components exist across spatial and temporal scales and establish a heterogeneous and dynamic system. To conceptualize linkages between stream components, Ward (1989) recognized four dimensions, a longitudinal, lateral, vertical, and temporal dimension. Wood Compatibility Initiative funded projects

^c Berman, C. [N.d.] Assessment of landscape characterization methods. Manuscript in preparation. On file with: Cara Berman, Center for Water and Watershed Studies, Box 352100, University of Washington, Seattle WA 98195-2100

describe these stream linkages and interactions across spatial and temporal scales allowing managers to better predict the consequences of disturbances (natural and human-induced) on aquatic systems. To the four dimensions we add a fifth, a policy-science-management dimension that assesses and informs attitudes and actions that affect resource protection and recovery.

Longitudinal Dimension (Elements of the Landscape)

The longitudinal dimension reflects upstream-downstream linkages affecting stream processes and patterns. Projects investigating the longitudinal dimension address landscape variability and the distribution and pattern of resources along the longitudinal axis of the stream system.

Large woody debris (LWD) quantity- LWD characteristics in unmanaged basins vary according to climatic, geomorphological, and hydrological differences (Fox 2001; Fox 2002; Fox et al. 2002.). Instream wood is recognized as an important feature linked to channel processes that benefit salmonids and various LWD targets exist to help resource managers assess restoration needs. However, existing wood targets do not adequately account for variations in LWD quantity or volume due to longitudinal differences in geomorphology, ecoregion, or disturbance regime. Data analysis suggests that current wood targets are not appropriate for all streams within Washington State. Data indicate that LWD amounts vary by bankfull width (BFW) class and region (Tables 1-3). Project findings provide a baseline for managers interested in assessing existing conditions and establishing recovery targets. This information is useful for modifying existing wood targets established by Washington State's Watershed Analysis as well as other management and recovery programs within the Pacific Northwest.

Eastside forests and stream temperatures- Riparian forests also vary along the longitudinal axis according to biophysical factors. However, a paucity of information exists on riparian stands and historical shade levels for eastern Washington forests. Johnston (2002) used air photos, field investigation and General Land Office Surveys to characterize historical riparian forest conditions in eastern Washington taking into account the historical fire regime and fire suppression. This project also received funding from a coalition of Upper Columbia River timber growers.

Historical riparian conditions are compared to current conditions to evaluate the effects of various management activities (e.g., fire suppression, timber harvest). Findings will allow resource managers and regulators to better understand landscape appropriate strategies for managing eastside riparian forests. Active management within riparian stands raises complex issues, particularly considering the potential reduction of shade along temperature sensitive streams. An understanding of the pre-harvest and pre-fire suppression riparian condition is important for determining appropriate levels of shade and other related riparian forest characteristics.

Longitudinal changes in landform and physical and biological processes also give rise to longitudinal and temporal variation in stream temperature. The natural range of thermal conditions as well as temperature variability at the landscape and watershed scales were

examined by Scholz (2001). Findings indicate that temperatures in the Wenatchee National Forest are influenced at the landscape scale by several factors including air temperature, drainage area, elevation, and stream shading. Many of these factors are correlated and these factors affect acute and chronic conditions to different degrees. The physical factors that determine stream temperatures at the landscape scale are not necessarily good predictors of smaller scale temperature regimes. Stream temperatures in several watersheds are perhaps influenced primarily by their high geologic potential for groundwater upwelling, especially in basins with little managed area. This study also received funding from the Wenatchee Supervisor's Office and the U.S. Environmental Protection Agency. (The hyporheic studies discussed under the vertical dimension heading are examining the relative role of groundwater on stream temperature compared to other characteristics such as shade, buffer width and composition, and elevation in urban, agricultural and forested landscapes (Reidy^d; Monohan^e) and complement these landscape studies on stream temperature and riparian conditions.)

Understanding system potential and the mechanisms that establish thermal pattern will also assist those designing restoration measures. This research supports and complements work undertaken by the U.S. Department of Agriculture, Forest Service. The **Center for Streamside Studies** will continue to interact with Pete Bisson on his temperature work in eastern Washington.

Fish habitat- The interactive components of a river system form a template on which abiotic and biotic processes unfold. The longitudinal dimension is a patchwork of resource availability including habitat for aquatic biota. Physical processes affecting bedload scour, such as flow regime and sediment load as well as behavioral processes, are examined in the context of bull trout spawning habitat development, disturbance, and selection (Shellberg^f).

Three primary research questions are addressed. First, what general factors influence spawning site selection (substrate, depth, velocity, cover, hyporheic flow) and what are the patterns of scour and fill in these microhabitats? Second, how does the reach scale channel morphology (channel type, sediment transport regime, LWD) affect scour and spawning habitat availability? Finally, what influence does watershed hydrology (runoff timing, frequency, magnitude and duration) have on bedload scour and bull trout distribution? Study results will shed light on the potential influence of physical habitat

^d Reidy, C. [N.d.] Extent of hyporheic zones in Puget Sound Lowland streams. M.S. thesis in preparation. On file with: Center for Water and Watershed Studies, Box 352100, University of Washington, Seattle, WA 98195-2100.

^e Monohan, C. [N.d.] Responses of various riparian buffers to nitrogen loading: nitrogen retention mechanisms, Ph.D. thesis in preparation. On file with: Center for Water and Watershed Studies, Box 352100, University of Washington, Seattle, WA 98195-2100.

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Shellberg, J. [N.d.] Hydrologic and geomorphic conditions in selected bull trout spawning streams in western Washington. M.S. thesis in preparation. On file with: Center for Water and Watershed Studies, Box 352100, University of Washington, Seattle, WA 98195-2100.

conditions on bull trout population integrity and distribution and help resource managers identify restoration strategies for this threatened species.

Nutrient dynamics vary longitudinally in river systems as a function of a number of physical and biological processes. In cooperation with NMFS and the City of Seattle, CSS has participated in studies in the Cedar River to investigate the effects of salmon carcasses on nutrient dynamics and resident fish populations (Kiffney et al. 2001). Results from this study will provide information on the rate at which anadromous salmon naturally colonize newly available habitat and the means by which they redistribute themselves into fresh water spawning areas--information currently not available for any research. Water quality information is being collected and components of stream food webs are being sampled for nitrogen and carbon isotopes. Findings will elucidate linkages between anadromous and resident population dynamics and stream productivity.

The Vertical Dimension (Reach Elements)

The vertical dimension reflects interactions between the channel and contiguous groundwater. Projects investigating vertical connectivity address hyporheic flux across variable landscapes and land uses. Hyporheic zones influence chemical, hydrological, zoological, and metabolic functions at various scales and thereby affect channel physiochemical gradients, nutrient availability, and biotic productivity (Brunke and Gonser 1997). Previously, CSS researchers (e.g., Clinton 2001; Coe 2001) investigated hyporheic flux in large alluvial river systems in forested settings. Collaborative research between CSS and USFS scientists Rick Edwards and Steve Wondzell and NMFS scientist Peter Kiffney was initiated to study hyporheic processes in urban and agricultural streams across variable landscapes. This research will focus on hyporheic transient storage in urban and agricultural areas in comparison to forested areas and potential effects on stream temperature and nutrient cycling (Reidy^d; Monohan^e; Clinton^g). These three studies will investigate how transient storage, nutrient retention and invertebrate distribution vary within an array of urban, agricultural, and forested streams. Information derived from this work is important for understanding potential changes in stream temperature and productivity under differing land-use practices.

Temporal and Lateral Connectivity

In addition to longitudinal and vertical connectivity, the above projects incorporate aspects of temporal variability and lateral connectivity. The temporal and spatial patchiness of **resources structures** biotic communities. Temporal fluctuation of process dynamics and resource response variables was investigated in projects addressing LWD delivery (Fox 2001), riparian characterization (Johnston 2002), and thermal patchiness (Scholz 2001). The lateral dimension reflects interactions between the channel and the adjacent riparian/floodplain system. Interactive pathways along this dimension facilitate the exchange of matter and energy. Lateral connectivity was investigated in projects addressing LWD input processes (Fox 2001), groundwater recharge/discharge (Scholz

^g Clinton, S. [N.d] . Isotopic and invertebrate signatures in hyporheic zones in the Puget Sound lowlands. Manuscript in preparation. On file with: Center for Water Watershed Studies, Box 352100, University of Washington, Seattle, WA 98195-2100.

2001; Reidy^d; Monohan^e; Clinton^g), and habitat-forming processes (Shellberg^f) including a literature review of riparian soil studies (Mikkelsen and Vesho 2000).

Policy-Science-Management Dimension

The policy-science-management dimension reflects attitudes, behaviors, and actions related to riparian and aquatic protection and recovery. Projects address policy, information transfer, stream restoration and resource management related topics and are designed to assess attitudes, behaviors, and activities related to riparian and aquatic protection and recovery. In 1998, CSS provided organizational help to the Society of Restoration Northwest for the annual meeting in Tacoma, Washington. The meeting drew over 600 registered attendees and was a great venue for disseminating information. In addition to the organization assistance, CSS organized a concurrent symposium on riparian ecology and management. Abstracts of the symposium are out-of-print but the Center for Water and Watershed Studies will provide copies upon request.

Non-point source (NPS) pollution programs- Successful control of NPS pollution depends in large measure on intervention programs that inform participants and create public awareness in communities where the programs operate. One component of this project (Ryan et al. 2001) identifies the motivations of rural landowners to participate in conservation-oriented land management programs that assist landowners in adopting land management practices. Results of the research (Ise 2001) indicate that (1) self-interest, such as the need for technical assistance and the threat of future regulations, is the strongest motivation for participation; (2) land use decisions are often based on factors related to the land's utility for commodity production or personal aesthetics; and (3) attitudes about upholding private property rights are frequently stronger than attitudes about protecting the environment. This research did not indicate that conservation-oriented programs could instill a conservation ethic or significantly influence change to individual conservation attitudes and behaviors. Findings will assist regulators in devising techniques to improve nonpoint source control.

Extent of monitoring- In addition to research related to behavior and attitudes, monitoring practices of various stream restoration groups and projects was evaluated. Specifically, the perceived shortcoming in the evaluation of stream restoration and fisheries enhancement projects in Washington State was examined (Bash 1999). While project goals include restoring and improving stream health, it was not known to what extent projects were monitored or evaluated to determine if goals are being met. Findings revealed that monitoring of stream restoration and fisheries enhancement projects may be occurring at higher rates than resource managers thought. However, the level and quality of monitoring activities was highly variable across the sample. Barriers to monitoring included funding, time, personnel, and lack of cooperation from property owners. Monitoring related topics for managers to consider include: appropriateness of objectives and monitoring measures, need for long-term monitoring, development of funding specifically for monitoring, methods for encouraging or requiring monitoring, and implementation and quality of project monitoring. Information from this study may help those managing and funding projects to better understand the current strengths and limitations of project evaluation, and allow them to adjust their policies accordingly.

Restoration projects- Concern for the health of aquatic systems in the Pacific Northwest encouraged research on new methods to enhance freshwater spawning and rearing habitat and to assess habitat related to salmon productivity. Lack of LWD in streams has reduced the complexity and quality of fish habitat. A project designed to compare the hydraulic and biological performance of native LWD and an organic, engineered alternative to LWD (ELWdTM) was undertaken (O’Neal 2000; O’Neal et al. 2000a; O’Neal et al. 2000b; Savery 2000) and received additional support from the Weyerhaeuser Company.

Fish response was not significantly different for the two types of wood. Values of invertebrate metrics were generally higher for samples collected from ELWdTM surfaces than from traditional LWD. Invertebrate samples were also evaluated in terms of the production of available food resources for salmonids. The results showed greater food availability from the ELWdTM structures. In all sampling, benthic samples did not show a clear difference between the wood types. Therefore, innovative sampling methods were created to assess invertebrate production on LWD.

Savery (2000) compared the hydraulic effects of native LWD and an engineered alternative. The physical differences between the native LWD and the ELWdTM had an effect on the ability of the installed structures to maintain channel position. Engineered LWD did not maintain original bank position as well as native LWD. Although some of the differences between pairs is explained by local hydraulics and bank position, the low mass of engineered wood allows the structure to be moved by the stream. Additionally, engineered roots on the ELWdTM structures improve their stability, but are not as stable as native LWD with attached rootwads. The mean scour produced by the two log types was not statistically significant. However, the engineered structures created a comparatively large amount of turbulence on the upstream side of the log. Research results related to engineered wood performance provide an evaluation of the effectiveness of an engineered alternative compared to traditional LWD for stream enhancement projects before engineered structures are widely placed (O’Neal et al. 2000b).

Management models- Current recovery efforts lack a clear understanding of the relationship between freshwater habitat conditions and salmon response. This information is critical to the successful design of salmon recovery plans. To evaluate the distribution of expected salmon production resulting from alternative restoration strategies in Oregon’s Willamette River Basin, CSS, in cooperation with NMFS, is developing a model (Brauner^h) relating restoration activity to changes in habitat. The resulting model will be linked to a NMFS model relating habitat characteristics to the survival rates of salmon. This project will develop analytical tools to assist resource managers designing or evaluating restoration actions intended to increase salmonid fitness and ultimately productivity.

^h Brauner, J. [N.d.] Decision-making under uncertainty: prioritizing freshwater habitat restoration for salmon recovery. Ph.D. thesis in preparation. On file with: Center for Water and Watershed Studies, University of Washington, Box 352100, Seattle, WA 98195-2100

Riparian forest restoration- In January of 1999, Lummi Natural Resources and the University of Washington Center for Streamside Studies began to analyze the vegetative and environmental data collected in the three years since the Riparian Zone Restoration Project's inception and to evaluate the project's success to date. One of the products of this analysis (Wishnie et al. 1999a; Wishnie et al. 1999b) was the establishment of new data collection protocols, field sheets, and comment and damage codes to improve the accuracy and utility of data collection. These materials are an example of an effective approach to data collection: initial survey protocol, initial data sheet, initial survey codes, damage codes, annual survey protocol, annual survey codes, annual data sheet.

CONCLUSION:

WCI funded projects address the following resource management issues and information needs: (1) increase understanding of physical and biological processes across variable landscapes; (2) develop conceptual models allowing inferences within and across regions; (3) explore disturbance processes and implications for management; (4) design multi-scalar monitoring programs; (5) develop linkages between management actions and site-scale alterations; and (6) design and calibrate broad scale monitoring metrics. These projects form the basis for a synthetic approach to understanding and managing complex ecological systems. A recent WCI grant award to develop a landscape classification model linking physical and biological processes across scales and ecosystem components will allow us to integrate research findings and meet current resource challenges and data needs.

To ensure access to CWWS research, efforts are underway to increase the efficiency and effectiveness of our information transfer activities. Efforts undertaken through the WCI program are important to resource managers throughout the Pacific Northwest. We are committed to ensuring broad dissemination of research results as well as fostering dialogue to address issues important to resource managers.

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Table 1: Large woody debris piece quantity: number of pieces per 100 m of channel length (Fox 2001)

Region	BFW Class	Good Condition	Fair Condition	Poor Condition
Western WA	0-6 m	>38	26-38	<26
	>6-30 m	>63	29-63	<29
	>30-100 m	>208	57-208	<57
Alpine	>0-3 m	>28	15-28	<15
	>3-30 m	>56	25-56	<25
	>30-50 m	>63	22-63	<22
^a DF/PP	0-6 m	>29	5-29	<5
	>6-30 m	>35	5-35	<5

^a Douglas-Fir/Ponderosa Pine Ecoregion

Table 2: Large woody debris volume: cubic meters per 100 m of channel length (Fox 2001)

Region	BFW Class	Good Condition	Fair Condition	Poor Condition
Western WA	0-30 m	>99	28-99	<28
	>30-100 m	>317	44-317	<44
Alpine	>0-3 m	>10	3-10	<3
	>3-50 m	>30	11-30	<11
^a DF/PP	0-30 m	>15	2-15	<2

^a Douglas-fir/Ponderosa pine ecoregion

Table 3: Key piece quantity: number of pieces per 100 m of channel length (Fox 2001)

Region	BFW Class	Good Condition	Fair Condition	Poor Condition
Western WA	0-10 m	>11	4-11	<4
	>10-100 m	>4	1-4	<1
Alpine	>0-15 m	>4	0.5-4	<0.5
	>15-50 m	>1	0.5-1	<0.5
^a DF/PP	0-30 m	>2	0.5-2	<0.5

^a Douglas-fir/Ponderosa pine ecoregion