Brief Summaries of Presentations

Symposium January 15 and 16, 2019

Responses of Headwater Streams to Forest Management in the Pacific Northwest

LaSells Stewart Center, Corvallis, Oregon.
Sponsored by: USFS Pacific Northwest Research Station, Weyerhaeuser, United States Geological Survey, Oregon Dept. of Forestry and Oregon State Univ.

Symposium Objective

The objective of this symposium is to present recent research findings on the physical and ecological responses of headwater streams to contemporary forest management on private, state and federal forest lands in the Pacific Northwest. Multiple manipulative studies have been completed throughout the Pacific Northwest recently and because of the similarity in treatments and study designs, the opportunity exists to compare and contrast stream ecosystem responses.

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Agenda

Date/Time	Title	Presenter/Affiliation
	January 15, 2019	
	Introduction and Stream Temperature, moderator: Maryanne Reiter	
9:00 AM	Welcome and goals of Symposium	Sherri Johnson/ USFS PNW
9:05 AM	Landscape context of forest management in the Pacific Northwest	Liz Dent/ ODF
9:25 AM	Stream temperature response to forest harvest – Type N, Washington	Bill Ehinger/ WDOE
9:50 AM	Trask River Watershed Study: using the entire stream temperature data distribution to detect changes from forest management	Maryanne Reiter/ Weyerhaeuser
10:15 AM	**Break**	
	Light, Nutrients and Macroinvertebrates, moderator: Mark Meleason (ODF)	
10:35 AM	Thermal responses to riparian thinning in redwood headwater streams at multiple spatial scales	David Roon/OSU
10:55 AM	Do increases in nutrients lead to increases in algal standing stocks and primary productivity following forest harvest?	Sherri Johnson/USFS PNW
11:15 AM	How the legacies of early forest management in stream riparian zones affect light availability and food webs in headwater ecosystems today.	Dana Warren/OSU
11:35 AM	Effect of experimental riparian buffers on macroinvertebrate export from non-fish-bearing streams	Steph Estrella/WDOE
11:55 AM	How bugs told the story of harvest on the Trask	Judy Li/OSU
12:15 PM	**Lunch**	
	Fish, Aquatic Ecosystem Response, moderator: Bob Bilby	
1:15 PM	A perspective from the interior PNW: A comprehensive assessment of the effects of harvest practices on stream systems – Mica Creek	Tim Link/Univ. Idaho
1:35 PM	Beyond the initial experiment: fish response and other long-term results at Mica Creek, Idaho	John Gravelle/Univ. Idaho
1:55 PM	Connections between headwater systems and downstream fish habitat	Bob Danehy/ Catchment Aquatic Ecology
2:15 PM	Headwater coastal cutthroat trout response to timber harvest in western Oregon	Doug Bateman/ OSU Retired
2:35 PM	Trout in small forested streams	Brooke Penaluna/USFS PNW
2:55 PM	Recovery of fish populations and physical channel characteristics in streams impacted by catastrophic debris flows	Jason Walter/Weyerhaeuser
3:15 PM	**Break**	

	Amphibian Response to Management, moderator: AJ Kroll	
3:35 PM	Amphibian response to variable length riparian buffers in clearcut basins	Aimee McIntyre/ WDFW
3:55 PM	Amphibian response to shade manipulation in reach-level clearcuts	Marc Hayes/WDFW
4:15 PM	Headwater stream buffer effects on animals after two thinnings: the plot thickens!	Dede Olson/USFS PNW
4:35 PM	Timber harvest effects on the demography of Pacific Northwest headwater-stream amphibians	Nate Chelgren/USGS
4:55 PM	**Reception and Poster Session**	

January 16, 2019

	Streamflow, Sediment, and Organic Matter Response, moderator Maryanne Reiter	
8:30 AM	Welcome and brief outline of day	Maryanne Reiter
8:35 AM	Discharge and suspended sediment response to variable length riparian buffers in clearcut basins	Greg Stewart/NW Indian Fish Comm.
8:55 AM	Watershed studies reveal effectiveness of BMPs at reducing delivery of sediment to streams	Kevin Bladon/OSU
9:15 AM	Forest harvest effects on organic matter dynamics in headwater streams at the Trask River watershed, Oregon	Laura Six/Weyerhaeuser
9:35 AM	Wood loading response to variable length riparian buffers in clearcut basins	Reed Ojala-Barbour/WDFW
9:55 AM	**Break**	
	Synthesis of the Science, moderator Ashley Coble	
10:15 AM	Synthesis of current science on temperature	Sherri Johnson/USFS PNW
10:55 AM	Synthesis of current science on amphibians	AJ Kroll/Weyerhaeuser
10:35 AM	Synthesis of current science on fish	Jason Dunham/USGS
11:15 AM	Synthesis of current science on organic matter and food web organization in forest stream networks	Bob Bilby/Weyerhaeuser
11:35 AM	Discussion - remaining questions	Ashley Coble/NCASI
12:00 PM	**Adjourn**	

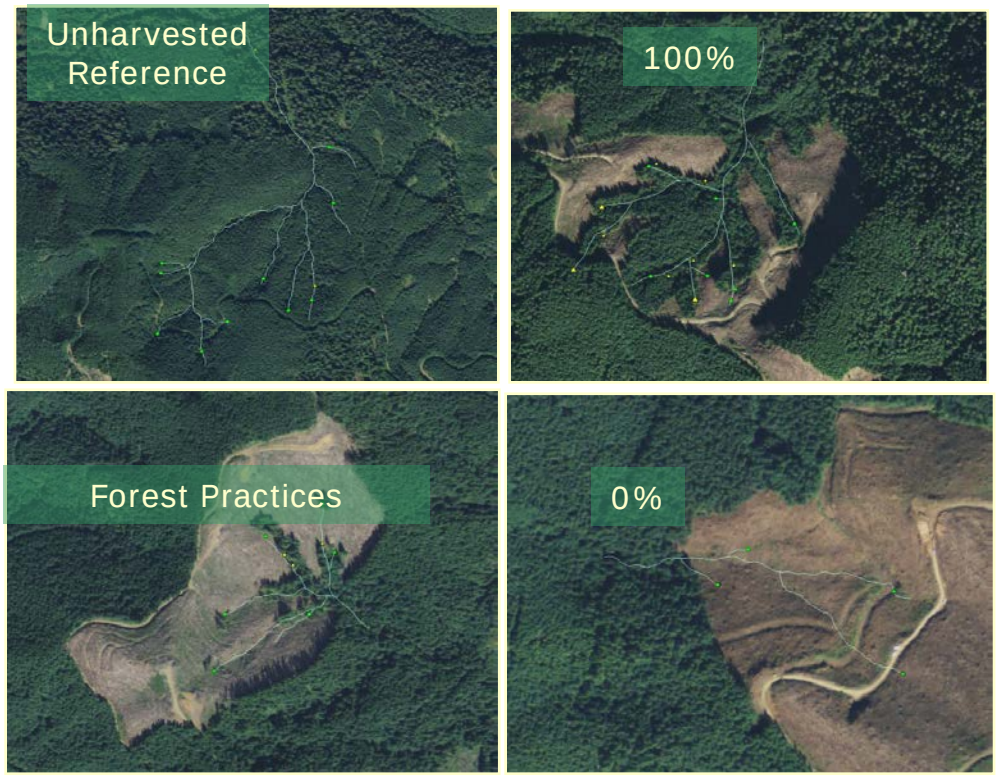
Summaries of Presentations

Stream Temperature

Stream Temperature Response to Forest Harvest: Type N, Washington

Presenter: William Ehinger
Presenter's email and affiliation: william.ehinger@ecy.wa.gov Washington Department of Ecology
Additional coauthors: Greg Stewart, Northwest Indian Fisheries Commission; Stephanie Estrella, Washington Department of Ecology
Study Affiliation: Type N, Washington

A major function of riparian buffers is to reduce the impact of forest harvest on stream temperature. We investigated the effect of variable length, 50-foot width, no-cut riparian buffers on stream temperature in a Before-After-Control-Impact study. Three buffer treatments; one following the current Washington state forest practices (FP) buffering a minimum of 50 percent of the perennial stream channel, one buffering 100 percent of the channel, and one with no buffer – or zero percent, were compared with an unharvested reference treatment. Over the first two years post-harvest, shade loss was nine, 32, and 71 percent in the 100 percent, FP, and zero percent treatments, respectively. Temperature increased by 1.2 °C in both the 100 percent and FP treatments and 3.2 °C in the zero percent treatment. These results are similar to those from other studies of similar sized streams and buffers and may be used to guide further refinements of the forest practices rules.

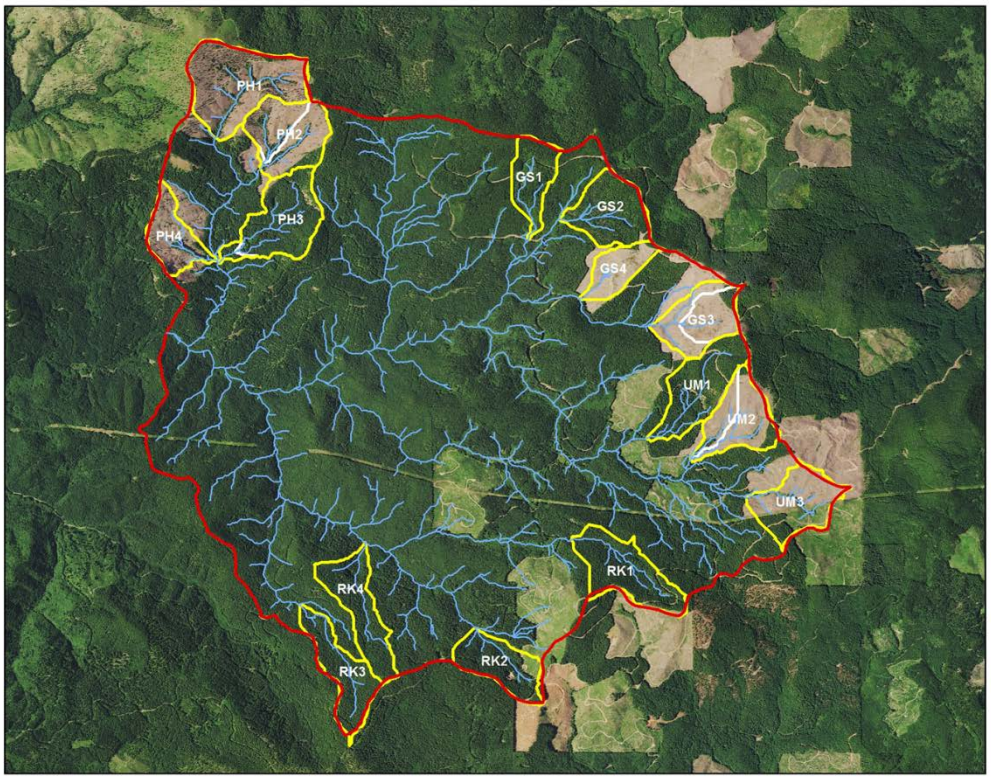


Ehinger et al., Aerial photos of one block of Type N study sites in Washington.

Trask River Watershed Study: Using the Entire Stream Temperature Data Distribution to Detect Changes from Forest Management

Presenter: Maryanne Reiter
Presenter's email and affiliation: maryanne.reiter@weyerhaeuser.com, Weyerhaeuser Company
Additional coauthors: Sherri Johnson (USFS-PNW), Jessica Homyack (Weyerhaeuser), Jay Jones (Weyerhaeuser) and Peter James (Weyerhaeuser)

The Trask Watershed Study, located in the northern Oregon Coast Range, was designed to examine physical, chemical and biological effects of contemporary forest management practices on aquatic ecosystems. One key physical measurement for the study was stream temperature, which was measured for 10 years in 15 small study streams as well as in downstream locations. Half of the small streams were harvested in 2012 with varying riparian buffer requirements depending on landowner. To fully characterize the summer thermal regime experienced by aquatic biota living in these small, fish-less streams, we examined shifts in the entire temperature data distribution before and after harvest. After harvest, sites without buffers showed the greatest shift in the upper end of the temperature distribution and the widest temperature ranges, while sites with narrow buffers showed little change. Using all the data, rather than a single metric to characterize stream temperature changes, allowed us to more accurately characterize shifts in thermal regime, quantify magnitude and duration of exposure to critical and non-critical temperatures, and help researchers and managers to better understand stream temperature responses to streamside vegetation manipulation.



Aerial view of Trask River Watershed Study after harvest of headwater watersheds.

Light, Nutrients and Macroinvertebrates

Thermal responses to riparian thinning in redwood headwater streams at multiple spatial scales

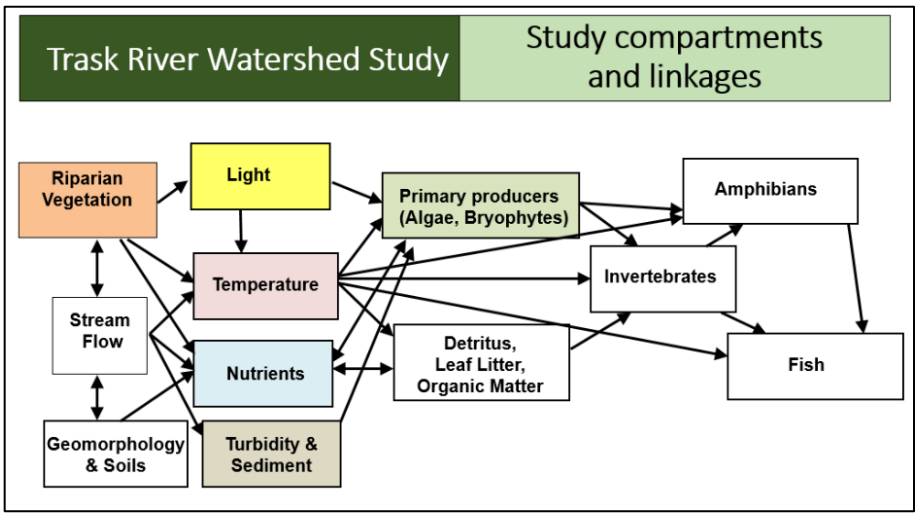
Presenter: David Roon
Presenter's email and affiliation: david.roon@oregonstate.edu OSU
Additional coauthors: Jason Dunham USGS, Bret Harvey USFS, Ryan Bellmore USFS, and Dede Olson USFS

Land managers presently thin second-growth forests in the redwoods of coastal northern California and are now interested in applying these thinning treatments to riparian forests. We evaluated the effects of riparian thinning treatments, using a Before-After Control-Impact, or BACI, design on riparian shade and light conditions and the influences on stream temperature in three redwood headwater stream networks. Preliminary results indicate riparian thinning treatments decreased riparian shade by an average of 25 percent, increased solar radiation by an average of three times, and increased average summer maximum stream temperature by 1.7 degrees Celsius. Local increases in temperature extended further downstream between 100-600 meters and were evident at multiple spatial scales. These initial data suggest that more subtle changes in shade and light associated with riparian thinning treatments can affect thermal conditions of these headwater streams both locally and further downstream. However, the magnitude of these thermal responses and their spatial extent vary with the amount of shade lost. These data provide important information for managers considering riparian management activities in the redwoods.

Do increases in nutrients lead to increases in algal standing stocks and primary productivity following forest harvest?

Presenter: Sherri L Johnson
Presenter's email and affiliation: sherrijohnson@fs.fed.us; US Forest Service, Pacific Northwest Research Station
Additional coauthors: Linda Ashkenas, Department of Fisheries and Wildlife, Oregon State University; Alba Argerich, University of Missouri

Past research on forest-stream interactions has shown that the influence of light and dissolved nutrients on stream algae is highly variable. Our research in the Trask River Watershed, a large experimental study on the effects of forest management on aquatic ecosystems, focuses on the interaction of primary producers, stream nutrients and stream food webs. After five years of pre-treatment data collection, 7 treatment watersheds were clearcut harvested with and without riparian buffers, with 7 reference watersheds not harvested. One additional watershed was thinned. All clearcut watersheds showed increased summer nitrate during the four year post-harvest study period. Downstream of the harvested watersheds, two of the three large basins also showed elevated nitrate following harvest. Concentrations of ammonium, dissolved organic nitrogen, dissolved organic carbon and phosphorus did not increase post-harvest and the molar ratios of essential nutrients varied greatly among watersheds. In the harvested watersheds, the instream primary producers did not show increased standing stocks or chlorophyll *a*, even with the increase in light and nitrogen. These findings fit with prior research results from other studies in the Coast Range of the Pacific Northwest, and suggest that low concentrations of other nutrients, such as phosphorus, could be limiting responses of stream algae to increased light.



Trask River Watershed Study compartments and linkages and view from UM2 stream after harvest

How the legacies of early forest management in stream riparian zones affect light availability and food webs in headwater ecosystems today

Presenter: Dana R. Warren
Presenter's email and affiliation: Dana.warren@oregonstate.edu; Oregon State University, Dept. Forest Ecosystems and Society, and Dept. Fisheries and Wildlife

Light is a fundamental constraint on ecosystem processes in forested headwater streams. Historic forest management practices cleared riparian zones across much of the Pacific Northwest, and today, many regenerating riparian forests are dense second growth stands with uniform shade that cover the stream. In the western Cascades of Oregon, we found that streams with regenerating riparian forests had on-average less light exposure than comparable stream sections that run through late succession forests. Streams bordered by these younger dense regenerating forests also had lower algal biomass, and comparable or lower fish biomass to reference sites bordered by late-successional forests in most (but not all) cases. In light manipulation experiments (both increasing and decreasing light availability) along several forested headwater streams, we found that moderate changes in light availability were generally accompanied by changes in standing stocks of primary producers and fish. Our research suggests that the legacies of early forest management set the stage for current dense canopy second-growth forests along many headwater streams, and that the low light levels that keep these systems cool also have implications for primary productions, nutrient dynamics and biota in these ecosystems.

Effect of experimental riparian buffers on macroinvertebrate export from non-fish-bearing streams

Presenter: Stephanie M. Estrella
Presenter's email and affiliation: Washington State Department of Ecology; stephanie.estrella@ecy.wa.gov
Additional coauthors: William J. Ehinger, Washington State Department of Ecology

Macroinvertebrates exported from headwater streams are an important food source for downstream fish. Timber harvest may influence macroinvertebrate export through changes in organic matter inputs and primary production. We assessed the response of macroinvertebrate export from non-fish-bearing streams treated with the current Washington State Forest Practices buffer (FP), a more extensive buffer (100 percent), no buffer (zero percent), or no harvest (reference). We collected macroinvertebrates using drift nets every six weeks and quantified macroinvertebrate export as numbers and biomass per day. Observed changes in export of parasites, scrapers, and Dixidae (Diptera) in one or more of the buffer treatments were also observed in the reference sites and were not consistent across treatments. Collector-gatherers comprised a large proportion of individuals exported, and export in biomass per day increased in the FP and zero percent treatments. Although we observed some changes after harvest, there were no major reductions in macroinvertebrate export and no major shifts in functional feeding groups associated with the three buffer treatments relative to the unharvested references.

We sampled macroinvertebrate export at the downstream end of the non-fish-bearing stream basins every six weeks over a 24-hour period using a 250-micron drift net.

How Bugs Told the Story of Harvest on the Trask

Presenter: Judith Li
Presenter's email and affiliation: judyli@comcast.net; Department of Fisheries and Wildlife, Oregon State University
Additional coauthors: Janel Sobota[1], Sherri L. Johnson[2], Lisa Ganio[3] and Mark Meleason[4]
[1] Department of Fisheries and Wildlife, Oregon State University, [2] Pacific Northwest Research Station, United States Forest Service, [3] Department of Statistics, Oregon State University, [4] State Forests Division, Oregon Department of Forestry
Study Affiliation: Trask River Watershed Study

Our 10-year study of stream invertebrates before and after harvest in the Trask River headwaters documented tight linkages between headwater biota and adjacent riparian zones. We compared harvested sites individually to reference sites in order to understand trends and year-to-year and site variations. Stream invertebrates at non-buffered sites were significantly more abundant and consisted of different organisms than at sites with riparian buffers. The proportions of midges (chironomids) increased, and representation of mayflies, stoneflies and caddisflies (EPT's) that are often sensitive to disturbances, changed noticeably at non-buffered sites. Also, adult insects (flies and EPT's) emerged earlier and in greater abundance after harvest at non-buffered sites in the first two years after harvest, possibly related to higher temperatures. At a non-buffered site where leave-trees remained near the stream, a dramatic increase in shredding aquatic insects was observed. With the multi-site, repeated sampling design of our study, aquatic invertebrates demonstrated they can be sensitive indicators to a range of riparian buffers associated with the clear-cut harvesting.

Fish, Aquatic Ecosystem Response

A perspective from the interior PNW: A comprehensive assessment of the effects of harvest practices on stream systems

Presenter: Timothy E. Link
Presenter's email and affiliation: tlink@uidaho.edu; University of Idaho
Additional coauthors: John A. Gravelle, Jason A. Hubbart, Diana Karwan, and Enhao Du

Evaluation of the environmental effects of timber harvest is generally lacking for current forest management practices. This is true for industrial forestlands, harvest in second-growth forests, and in particular, the interior Pacific Northwest. The Mica Creek Project in northern Idaho is a comprehensive monitoring program that fills a critical knowledge gap about the environmental effects of contemporary timber harvest practices in the region. The first phase of the project evaluated the effects of forest road construction and both clear cut and thinning harvests applied to 50 percent of watershed areas on aquatic resources. Harvest effects on streamflow, sediment, stream shade, water temperature, nutrients, bugs, and fish were monitored across both large and small watersheds. Increases were observed in streamflows, nutrients, temperatures in harvested areas, and in the number and distribution of fish after harvest. Very small or no changes were found in downstream water temperatures, sediment following the first year after harvest, and in the amount and kinds of bugs. In summary, the results suggest that current forest harvest practices in northern Idaho are effective at protecting stream resources for the given level of land cover change that occurred in this study.

Beyond the initial experiment: fish response and other long-term results at Mica Creek, Idaho

Presenter: John Gravelle
Presenter's email and affiliation: jag@pineorchard.com, Pine Orchard, Inc.
Additional coauthors: Timothy Link

As the longest continuous running experimental watershed focused on contemporary timber harvest management on private land in the western U.S., the Mica Creek Experimental Watershed in northern Idaho has moved beyond the initial experiment to a fully managed watershed. With much of the experimental watershed now harvested and transitioned from mature to young stands, what scientific understanding have we learned from these activities on water quality/quantity and associated aquatic biota? Focusing on fish response, annual density estimates of native westslope cutthroat and non-native brook trout have been collected since 1995. Within treated watersheds, fish densities increased following initial harvest and have remained elevated. In addition, salmonids are now observed occupying previously uninhabitable reaches upstream from pre-harvest extent of fish distribution. How do these fish observations relate to other responses found in macroinvertebrate communities, flow, and temperature? These long-term data provide a unique opportunity to provide longer term perspectives when evaluating effectiveness of Best Management Practices and Idaho Forest Practices Act regulations.

Connections between headwater systems and downstream fish habitat

Presenter: R.J. Danehy
Presenter's email and affiliation: Catchment Aquatic Ecology, danehy@catchmentae.com
Additional coauthors: Many

Headwater systems sustain downstream fish habitat by exporting heat, sediment, nutrients, and organic matter. Organic matter includes particulate matter, instream biota, and large wood. We describe and, where possible, quantify regimes of each in the Calapooia River, Oregon watershed, which has been studied recently (>10 publications). Stream temperatures in summer establish a strong gradient throughout the watershed from headwaters 15-16°C maxima to above 23°C in upper mainstem. Differences are attributable to reach scale shading, as mainstem temperatures are highly correlated with insolation and bedrock substrate. Nutrients were measured in multiple studies, both extensively and intensively. Nutrient export was low — close to detection thresholds — as watershed-scale results found water quality leaving the forest to be high. Fine sediment was measured physically and biologically. Fine sediment was low (< 17%) in tributaries and lower (< 5%) in the upper mainstem, which has substantial bedrock substrates (11.3%). Fine sediment moves through the watershed efficiently. Drift macroinvertebrate biomass was low with 65% in five taxa groups, yet richness was high, including 57 chironomid taxa and 28 terrestrial families. Macroinvertebrate drift concentrations (per m^3) were similar at baseflow in headwaters and mainstem. Large wood regime in fish bearing waters in the Calapooia watershed has been defined by the transport of primary forest logs scouring the channel and flood disturbances (e.g. 1963 and 1996) creating pulses of large wood. Current mainstem wood loadings are very low and future supply unclear. The extent, seasonality, frequency, and duration of each regime is described with Calapooia data and from the literature.

Headwater Coastal Cutthroat Trout Response to Timber Harvest in Western Oregon

Presenter: Douglas S. Bateman
Presenter's email and affiliation: OSU-Retired; Doug_bateman@usgs.gov
Additional Co-authors: Robert E. Gresswell (emeritus) and Christian E. Torgersen (U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Seattle, WA)

The effects of forest management practices on headwater coastal cutthroat trout can be isolated since the fish are non-migratory and are not affected by ocean conditions and other downstream factors, such as agricultural practices, urbanization, and harvest. We sampled the entire fish-bearing portions of 40 randomly selected headwater catchments upstream of barriers to fish movement. Additionally, we sampled nine catchments annually for 3-12 years. Preliminary results show the percent of young forest within a catchment - a measure of disturbance from timber harvest or fire - was not a good predictor of trout abundance in the randomly selected catchments. In annually sampled catchments, change in trout abundance was relative to reference catchments. However, abundance in the annually sampled catchments was within the observed range of the randomly sampled catchments. Results suggest that factors other than fire or timber harvest may be more important in controlling coastal cutthroat trout abundance in small headwater catchments in western Oregon.

Trout in small forested streams

Presenter: Brooke Penaluna
Presenter's email and affiliation: bepenaluna@fs.fed.us; PNW Research Station, USFS
Additional coauthors: Ivan Arismendi (OSU) and Jason Dunham (USGS)

Much of the current forest harvest in the Pacific Northwest occurs around small headwater streams located at and above the upper distribution of fish. It is at this nexus that the focus of questions for contemporary forest practices and responses of fisheries meet. Our work incorporates evidence from empirical studies, semi-natural experiments, eDNA, and mechanistic models based heavily on field data to address questions around forest-fish interactions. We compare eDNA to traditional sampling approaches to identify the end-of-fish. We highlight the importance of instream cover, shade, and instream pools as habitat for Coastal Cutthroat Trout during seasonal low flow. At the Trask River watershed, we find that downstream effects of forest harvest on fish are minimal. This work helps provide critical information for managers to ensure habitat complexity that will allow trout to continue to swim in many streams across the region.

Coastal Cutthroat Trout are the dominant fish at the upper extent of small streams in the Pacific Northwest. Trout shown here are using cover. Photo by Brooke Penaluna.

Recovery of Fish Populations and Physical Channel Characteristics in Streams Impacted by Catastrophic Debris Flows

Presenter: Jason Walter
Presenter's email and affiliation: jason.walter@weyerhaeuser.com; Weyerhaeuser Company
Additional coauthors: Brian Fransen (Weyerhaeuser-retired), Renata Tarosky and Travis Schill (Weyerhaeuser)

Disturbances in headwater streams can impact fish populations. In 2007, a 500-year flood event occurred in the upper Chehalis River basin of southwest Washington. Many streams in the area experienced record high flows, as well as channelized landslides that developed into catastrophic debris flows. Comprehensive data on stream habitat and fish populations had been collected by Weyerhaeuser Company in these streams since the mid-1970s, which provided an opportunity to assess the impact of the storm and debris flows on fish distribution and habitat conditions and to monitor post-storm recovery. The re-colonization of fish populations and recovery of habitat conditions in streams impacted by catastrophic debris flows is currently being monitored in over 29 kilometers of stream channel within 19 individual sub-basins using spatially continuous, single-pass electrofishing and physical stream habitat surveys. As of 2017, fish have recolonized habitats up to or beyond the upper extent of their pre-storm distribution in 12 of the 19 sub-basins. Preliminary results indicate fine-scale physical habitat characteristics including stream gradient, size, and the presence of natural blockages significantly influence the rate and extent of fish re-colonization in these systems.

Example of a stream channel in the upper Stillman Creek basin impacted by a catastrophic debris torrent caused by the December 2007 storm.

Amphibian Response to Management

Amphibian response to variable length riparian buffers in clearcut basins

Presenter: Aimee McIntyre
Presenter's email and affiliation: Washington Department of Fish and Wildlife; aimee.mcintyre@dfw.wa.gov
Additional coauthors: Reed Ojala-Barbour, Timothy Quinn, Marc Hayes; Washington Department of Fish and Wildlife; Jay Jones, Andrew J. Kroll; Weyerhaeuser

In Pacific Northwest, amphibians are more abundant in headwater streams than in larger streams. Amphibians are sensitive to environmental change and are frequently the focus of research in headwater streams, as current forest management practices provide for less protection than for larger streams. We evaluated the effect of clearcut timber harvest in headwater stream basins on three stream-breeding amphibian groups in western Washington. We compared basin-wide timber harvest with variable riparian buffer treatments to unharvested reference basins. The three riparian buffer treatment configurations were no riparian buffer, and riparian buffer retentions of at least 50 percent and 100 percent of the stream length. We measured amphibian density before and after timber harvest. In the eight years following harvest, we observed substantial declines in larval coastal tailed frog density in all riparian buffer treatments, and declines in post-metamorphic tailed frog density in the 100 percent and 50 percent buffer treatments. We also observed a decline in torrent salamander density in the 50 percent buffer treatment. We did not observe a difference in giant salamander density among buffer treatments and the reference in the eight years following harvest. Continued monitoring is needed to verify whether our findings reflect longer-term trends.

Clearcut study site with a two-sided 50-ft riparian buffer along a minimum of 50% of the stream length (50 percent treatment); one of three variable riparian buffer treatments included in an evaluation of the effects of timber harvest on fishless headwater streams in western Washington.

Amphibian response to shade manipulation in reach-level clearcuts

Presenter: Marc Hayes
Presenter's email and affiliation: Washington Department of Fish and Wildlife;
marc.hayes@dfw.wa.gov
Additional coauthors:
James MacCracken, US Fish and Wildlife Service (formerly Longview Fibre)
Julie Tyson; Washington Department of Fish and Wildlife;
Jennifer Stebbings; Port of Tacoma (formerly Longview Fibre)
Study Affiliation: Type N, Washington State

Non-fish-bearing streams in the Pacific Northwest, largely in headwaters, are stream-breeding amphibian rich. As non-fish-bearing streams receive less protection than fish-bearing streams during forest management, concern for their biota has drawn attention. We manipulated shade on reach-level treatments to evaluate the effects of timber harvest on three stream-breeding amphibian groups in western Washington and northwest Oregon. Shade reduction treatments ranged from no shade to two intermediate shading levels, 30 and 70 percent. We compared amphibian, invertebrate, and physical metrics before and after harvest in paired treated and unmanipulated reaches in the same stream. Increased levels of shade reduction resulted in an increase in primary production, but that shift did not translate clearly into stream-breeding amphibian and invertebrate response. However, the 70 percent shade level showed the greatest level of positive responses, implying an underlying hump-shaped response to levels of shading. Site-specific conditions, such as differential ground water inputs, are suspected factor in response complexity. Investigation of site-specific conditions could clarify the basis of response complexity.

Headwater stream buffer effects on animals after two thinnings: The plot thickens!

Presenter: Deanna H. (Dede) Olson
Presenter's email and affiliation: dedeolson@fs.fed.us; US Forest Service, Pacific Northwest Research Station, Corvallis, OR
Additional coauthors: Adrian Ares, Virginia Tech; Klaus Puettmann, Oregon State University.

The Density Management and Riparian Buffer Study of western Oregon examines upland thinning treatments to accelerate development of late-successional forest conditions, while retaining headwater stream habitats and biota. Eight, 40-60-year-old Douglas-fir stands on Bureau of Land Management lands were thinned twice, and we examined 52 stream reaches for the effects of four different riparian buffer treatments on instream and bank vertebrates. The four buffer treatments included one site-potential 200 to 240 foot tree height riparian buffer, 50-foot minimum width variable-width buffer, approximately 20 foot streamside-retention buffer, and a no-entry zone 2-tree thin-through riparian buffer. Analyses showed significant effects of buffer treatments on abundance of all fish species and amphibian species, including stream-breeding amphibians, sculpins, coastal giant salamanders, and both southern and Columbia torrent salamander speices. Animal counts were higher in the one site-potential 200 to 240 foot tree height riparian buffer treatment than in the three other buffers. Analyses of indicator species showed species associations with buffers: torrent salamanders with streams in unthinned uplands; northern red-legged frogs with streamside-retention buffers; and Oregon slender salamanders with thin-through buffers. Possible lag effects on relatively long-lived animals with sensitive status remain key concerns.

Torrent salamanders (*Rhyachotriton species*) are sensitive species found in headwater streams in western Oregon. They have associations with streams in one site-potential tree height (200 to 220 ft) buffers after two upland thinnings, and control streams in unthinned second-forest stands. Photo by W.P. Leonard.

Streamflow, Sediment and Organic Matter

Discharge and suspended sediment response to variable length riparian buffers in clearcut basins

Presenter: Gregory Stewart
Presenter's email and affiliation: gstewart@nwifc.org; Northwest Indian Fisheries Commission
Additional coauthors: William Ehinger and Stephanie Estrella, WDOE

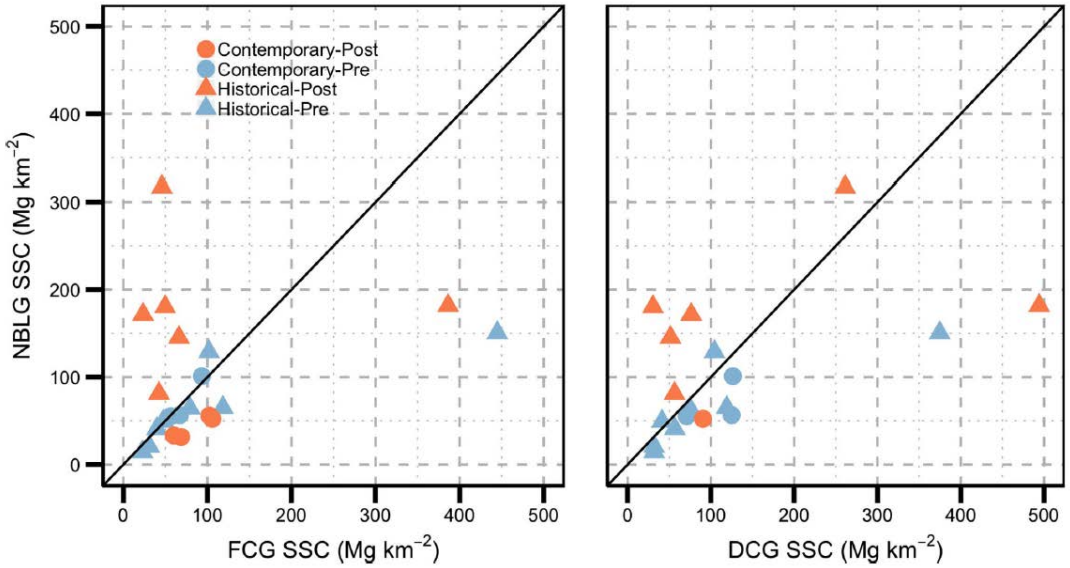
We analyzed water discharge and suspended sediment export following timber harvest in six non-fish watersheds using three riparian buffer scenarios. The buffer treatments included current Washington State Forest Practices requirements, buffering along 100% of the perennial stream network, and no buffer. Water discharge increased for all treatments following harvest, but magnitude varied by season, amount of harvest, and buffer scenario. In general, the largest increases in discharge were observed during moderate storm events in sites with no buffer. Suspended sediment export was greater during harvest or post-harvest periods in four of the six buffer treatment sites but was of similar magnitude to one of the two reference sites. Due to the limited number of monitoring sites and sediment-generating storm events, we were unable to separate treatment effects from natural variability to draw strong conclusions about the relative effectiveness of the buffer treatments on sediment supply or export.

Measuring discharge and suspended sediment at the outlet of a headwater basin.

Watershed studies reveal effectiveness of BMPs at reducing delivery of sediment to streams

Presenter: Kevin D. Bladon
Presenter's email and affiliation: bladonk@oregonstate.edu, Department of Forest Engineering, Resources, and Management, Oregon State University
Additional coauthors: Jeffrey A. Hatten, Catalina Segura, Sharon Bywater-Reyes, Maryanne Reiter, Sherri L. Johnson, V. Cody Hale, George G. Ice, and John D. Stednick

Best Management Practices, or BMPs have been developed and implemented throughout the Pacific Northwest to reduce the effects of forest operations, such as road building, timber yarding, machine trail development, and slash disposal, on erosion and fine sediment supply to stream channels. However, many questions remain about BMP effectiveness at mitigating nonpoint source pollution to protect water quality and aquatic ecosystem health. We compared findings from multiple paired watershed studies from H.J. Andrews, Alsea, and Trask watersheds to evaluate the effects of contemporary harvesting practices on suspended sediment concentrations and yields and to examine the legacy effects of historical harvesting on suspended sediment concentrations. Our results show that contemporary BMPs have decreased suspended sediment concentrations relative to historical practices. We also found that catchment characteristics, such as lithology and physiography, were a dominant control on the high variability in the suspended sediment observed in harvested and unharvested catchments.



A comparison of suspended sediment yield from the harvested watershed (Needle Branch, NBLG) relative to the unharvested reference watersheds (Flynn Creek, FC; Deer Creek, DCG) from both the historical and contemporary Alsea Watershed Study (from Hatten et al. 2018).

Forest harvest effects on organic matter dynamics in headwater streams at the Trask River Watershed, Oregon

Presenter: Laura J. Six
Presenter's email and affiliation: laura.six@weyerhaeuser.com Weyerhaeuser Company
Additional coauthors: Robert E. Bilby, Peter James and Maryanne Reiter, Weyerhaeuser Company

As part of the Trask River Watershed Study, we examined trends in litter input, coarse and fine particulate terrestrial organic matter (OM) transport, and coarse particulate OM storage following harvest under three treatment intensities: clearcut with no buffer, clearcut with buffer, and clearcut with scattered tree retention. The amount of OM delivered to streams decreased only after clearcut with no buffer. Instream OM storage increased after harvest at buffered or scattered tree retention sites. There was no change in storage at clearcut sites. Transport of fine and coarse particulate OM did not significantly differ with any harvest treatment. The results demonstrate that intense forest management practices, such as clearcut, can alter litter delivery to streams but does not appear to affect organic matter storage or transport. The large amount of OM stored in these channels may make them relatively resilient to short-term disruptions in particulate OM delivery. Retention of even small numbers of trees along these streams are sufficient to maintain litter delivery rates after harvest.

Wood loading response to variable length riparian buffers in clearcut basins

Presenter: Reed Ojala-Barbour
Presenter's email and affiliation: reed.ojala-barbour@dfw.wa.gov; Washington State Department of Fish and Wildlife
Additional coauthors: Aimee McIntyre, Timothy Quinn, Marc Hayes; Washington Department of Fish and Wildlife

Wood influences headwater stream channel morphology and hydraulics, storage and transport of sediment and organic matter, habitat formation, and food availability for biotic communities. We evaluated the effect of clearcut timber harvest in headwater stream basins on in-channel wood loading through 8 years post-harvest. We compared basin-wide timber harvest with variable riparian buffer treatments to unharvested reference basins. The three riparian buffer treatment configurations were no riparian buffer, and riparian buffer retentions of at least 50 percent and 100 percent of the stream length. In the two years following harvest, small and large wood loading increased in all riparian buffer treatments, with the greatest increase in small wood in the treatment with no riparian buffer. Harvest resulted in discrete accumulations of in-channel wood especially in the 50 percent and no buffer treatments. In these accumulations, we observed an increase in the proportion of pieces that spanned the channel and contributed to hydraulic roughness, rather than to bank stability or step formation. By eight years following harvest, wood loading in most buffer treatments did not differ significantly from conditions in the reference basins. Overall, riparian buffers reduced harvest-related inputs and were a source of large wood via windthrow. Continued monitoring is needed to determine the persistence of in-channel wood and rates of future wood recruitment to the channel.

A two-sided 50-ft riparian buffer reduced inputs of harvest-related slash and provided a source of large wood recruitment in an evaluation of the effects of clearcut harvest on headwater streams in western Washington.

ODF compliance audit results including headwater streams

Presenter: Paul Clements and John Hawksworth
Presenter's email and affiliation: Paul.R.Clements@Oregon.gov; Oregon Department of Forestry
Additional coauthors: John Hawksworth; Oregon Department of Forestry
Study Affiliation:

This poster will share the overall and headwater-specific results of the Oregon Department of Forestry (ODF) audit of timber harvest practices regulated under the Oregon Forest Practices Act (FPA). Mandated by the Oregon Legislature in 2011, the ODF audit employs a private contractor to collect data according to established protocols: ODF uses collected data to determine compliance according to previously established criteria. This version of the compliance audit focuses on harvest and road rules, and a subset of the water protection rules. Overall compliance rates have been high. Visual estimates of potential and actual delivery of sediment to waters of the state were conducted. A higher rate of sediment delivery was observed to occur with small, non-fish bearing streams than fish-bearing streams. Rules showing lower compliance rates and likelihood to cause damage are targeted for outreach and education programs by ODF and forestry education partners.

Examining downstream thermal responses of streams to contemporary forestry

Presenter: Ivan Arismendi
Presenter's email and affiliation: Ivan.Arismendi@oregonstate.edu; Oregon State University
Additional coauthors: Jeremy Groom; Oregon Department of Forestry
Study Affiliation:

Warmer downstream habitats after timber harvest affect cold-water biota. We developed multifaceted metrics that allow for evaluation of long-term responses from multiple sites. We found greatest thermal effects occurring up to the second year post-harvest. Often, effects converge towards pre-harvest conditions by the fifth year post-harvest. These metrics are transferable to examine downstream effects of other disturbances.

Woody debris in small streams of the northwestern Cascade Mountains: pool spacing, sediment storage, and decay-function relationships

Presenter: Gus Seixas
Presenter's email and affiliation: gseixas@skagitcoop.org; Skagit River System Cooperative
Additional coauthors: Curt Veldhuisen and Mike Olis; Skagit River System Cooperative
Study Affiliation:

Large woody debris (LWD) is known to influence channel morphology in small headwater streams by creating steps in the longitudinal profile, slowing the flow of water, trapping sediment, and fining the bed surface. We used a field dataset of 32 non-fish-bearing stream reaches (1-4 m width, 9-66% gradient) from the northwestern Cascade Mountains of Washington State, USA, to test the hypotheses that 1) pool spacing is reduced by LWD frequency in small channels 2) sediment storage is enhanced in small streams by LWD frequency, and steps formed by LWD are more likely to trap sediment than clast-keyed steps, and 3) past riparian logging has altered the distribution of wood function with respect to decay and piece diameter. We found support for the first two hypotheses and subtle but potentially important differences between LWD function in old growth and second growth stands. Additionally, we found that mean wood frequency in the largest diameter classes was higher in old growth stands. We found no newly-recruited wood in the largest diameter class in second growth reaches, suggesting the possible scenario of a 'wood gap', in which the largest old growth in-channel wood has decayed and been transported away but no new large-diameter pieces have been recruited, in the coming decades. Together, the results support the importance of maintaining adequate wood recruitment from riparian buffers in headwater streams in managed forests.

Influences of riparian forest structure and stand development on stream light availability, habitat, and biota in Cascade Mountain Streams, OR.

Presenter: Matthew Kaylor
Presenter's email and affiliation: Matthew.Kaylor@oregonstate.edu; Oregon State University
Additional coauthors: Dana Warren, Oregon State University
Study Affiliation:

Riparian forests can influence ecosystem processes and biota in adjacent streams via controls on light availability, allochthonous organic matter input and large wood recruitment. Riparian forests are dynamic though. Their influence on light, organic matter or wood recruitment changes through time as a result of stand succession, disturbance events, and anthropogenic actions. In this study, we determine how approximately 40 years of riparian forest stand development following riparian clear-cutting has influenced invertebrate and vertebrate (coastal cutthroat trout and coastal giant salamanders) populations across five Pacific Northwest headwater streams. More broadly, we also explore relationships between forest structure, the stage of stand development (old growth vs. mid-seral), stream light availability, habitat, algal standing stocks, and stream vertebrate populations in nine streams with paired old-growth/second-growth study reaches. Both approaches revealed that temporal changes or spatial differences in canopy cover and light availability were closely associated with algal biomass, trout biomass, and overall stream predator biomass, suggesting bottom-up control on stream consumer populations. In contrast, spatial and temporal trends in stream pool area and large wood

availability did not account for observed trends in invertebrate, trout, or total vertebrate biomass in our study systems. The riparian harvesting that historically occurred at these sites was small-scale (<40 ha) and occurred within a larger, old-growth-dominated basin, which may have reduced the negative habitat effects and associated biotic responses that have been documented in other stream-riparian systems of western Oregon.