Title: Evaluating the effects of prescribed fire and fuels treatment on water quality and aquatic habitat.

Principal Investigators: **Cooperating Federal Unit**:

Caty Clifton,
Forest Hydrologist
Umatilla National Forest

Steven M. Wondzell,
Research Aquatic Ecologist
PNW Research Station

Deanna Stouder,
ALI Program Manager
PNW Research Station

Contact Information:
Steve Wondzell
Olympia Forestry Sciences Lab
3625 93rd Ave., S.W
Tumwater WA 98512

Phone: (360) 753-7691
FAX: (360) 956-2346
E-mail: swondzell@fs.fed.us

Duration of Project: 3 Years

Annual Funding Requested from JFSP: FY 2002: $99,820; FY 2003: $99,673; FY 2004: $99,658

Total Funding Requested from JFSP: $299,151

Total Value of In-Kind and Financial Contributions*:* $719,294

Abstract: A variety of treatments have been proposed to reduce long-term risks to forests from wildfire. In the interior Columbia Basin, the proposed treatments are often motivated by potential threats to water quality and threatened or endangered salmonids. Management plans for the basin assume that the direct effects of wildfires, as well as wildfire-related erosion and sedimentation of streams, are greater threats to water quality and fish habitat than are the effects of fuels treatments. However, there is a critical lack of empirical data to support this assumption. Further, little data are available from areas of volcanic parent materials or volcanic-ash-derived soils – the soil types most common in central and eastern Oregon – that can be used to design management treatments or provide science support for updating forest plans. Current planning and assessment tools are limited, utilizing surface erosion predictions developed for other regions and based on data from studies of past logging and road building practices. The lack of data limits the ability of USFS units to plan and implement fuels reduction treatments in municipal watersheds that supply drinking water or in watersheds with listed salmonids.

This study is designed to examine the effects of mechanical fuel treatments and prescribed fire on surface erosion and stream sedimentation. Study sites will be located in the Skookum Experimental Watersheds and the Mill Creek Municipal watershed where fuels reduction and prescribed burning treatments are already planned. The Skookum watersheds have been gauged and baseline data are available for stream discharge and sediment yield. The Mill Creek watershed is a highly controlled environment where other forest management activities are extremely limited. We will measure hillslope erosion, surface-sediment transport, and sediment delivery to streams on control and treatment sites within these watersheds for one year prior to treatment, and for two years post treatment. Data will be used to refine erosion and sediment delivery models used in planning and assessing management activities.

This proposal addresses Task #3, JFSP RFP2001-3.

Evaluating The Effects Of Prescribed Fire And Fuels Treatment On Water Quality And Aquatic Habitat

Introduction:

This proposal addresses Task #3, JFSP RFP2001-3: *Address local knowledge gaps that are significant to fire management plan development and implementation.* Scientific research support is needed to develop better understanding of water quality and stream habitat issues associated with fire management planning and program implementation in municipal watershed and watershed containing critical habitat for listed salmonids in eastern Oregon.

<u>List of Collaborators:</u>

Les Holsapple, Forest Fuels Specialist, Umatilla National Forest, Pendleton OR.
Phil Howell, Fisheries Biologist, PNW Research Station, La Grande OR.
Pete Robichaud, Research Engineer, Rocky Mountain Research Station, Moscow ID.

<u>Project Justification:</u>

The composition and structure of many interior-continental forests of western North America has changed dramatically since Euro-American settlement. These changes, combined with wide-spread tree mortality from recent insect outbreaks and extensive areas burned by recent, stand-replacing wildfires, are perceived as risks to long-term forest health (Gast et al. 1991, Mutch et al. 1993, Hessburg and Smith 1999, Hessburg et al. 2000). The changes in forest composition and the catastrophic mortality of forests in the interior west have been the focus of bio-regional assessments (Everett et al. 1994, Hessburg et al. 1994, Quigley and Arbelbide 1997) and forest health problems have been targeted by management strategies aimed at reducing long-term risks to forests from wildfire, insects and disease (ICBEMP 2000). These management strategies often include prescribed fire and other fuels reduction treatments, and are often motivated by concerns over threats to water quality and species listed as threatened or endangered under the Endangered Species Act. However, the widespread use of prescribed fire as a management tool to reduce the risk of stand-replacing wildfires assumes that the direct effects of wildfires, as well as wildfire-related erosion and sedimentation of streams, are greater threats to water quality and fish habitat than are the effects of fuels treatments.

The lack of empirical data to support this assumption has led to difficulty in resolving many recent natural-resource management conflicts (Tiedman et al. 2000, Wondzell *in press*). For example, the Mill Creek watershed is the municipal water supply for the city of Walla Walla, Washington. The watershed is managed to limit human-caused disturbances and thereby protect the city's water supply. Forests within the watershed are dominated by dense stands of shade-tolerant conifers and are considered to be at high risk from catastrophic wildfire. The Forest Service has proposed using fuel treatments and prescribed fire to reduce the risk of wildfire and related increases in suspended sediment that might threaten water supplies. There is concern that these restoration activities will lead to stream sedimentation and degrade water quality.

Similarly, the wide-spread use of prescribed fire to treat extensive forest-health problems in forests throughout the interior Columbia Basin evokes concern for a variety of threatened or endangered species. For example, the streams that drain the northern Blue Mountains provide critical habitat for listed steelhead, Chinook salmon, and bull trout. Concerns over short-term risk to stream habitat limits management activities in these basins. A recent inventory of the Umatilla National Forest found that only 25% of the densely-stocked forest stands could be treated, which leaves approximately 200,000 acres, excluding wilderness, in densely stocked conditions (Wilson et al. 2001), and presumably at increased risk from catastrophic wildfire.

These specific examples focus on local management issues, but they are not isolated or unusual cases. Millions of acres of US Forest Service, Park Service and Bureau of Land Management lands located throughout the western United State are in similar condition and share similar management problems. There is a clear need for scientific data to provide answers to these management problems:

- to improve existing predictive models so that the impact of fuel treatments and prescribed fire on water quality can be evaluated;

- to provide relevant data to guide management choices when making trade-offs between the short-term risks of active restoration strategies versus the potential, but poorly understood long-term risks to stream habitat posed by passive management strategies, especially where threatened or endangered fishes are present.

Relatively little data are available to help resolve water quality and stream habitat conflicts over the use of prescribed fire in the forested mountainous landscapes of central and eastern Oregon. Most studies of fire impacts have focused on areas burned by stand-replacing wildfires (Helvey 1980, Medina and Martin 1988, Marston and Haire 1990, Robichaud and Brown 1999, Simon 1999). Studies of prescribed fires have usually examined effects of fires prescribed to control slash accumulation and prepare seedbeds following clear-cut harvesting or include the effects of salvage logging (Beschta 1978, Clayton and Kennedy 1985, Bennett 1982, Beschta 1990, Gill 1994, McIver and Starr 2000). Few published studies have been conducted in areas of volcanic parent materials or volcanic-ash-derived soils – the soil types most common in central and eastern Oregon. The literature is dominated by studies from the west-side forests of the Pacific Northwest (Beschta 1978, Swanson 1981, Morrison and Swanson 1990, Beschta 1990, Grant and Wolff 1991, Lewis 1998) or by studies conducted in the central Idaho mountains where soils are poorly consolidated, having weathered from the granitic bedrock of the Idaho batholith (Clayton and Kennedy 1985, Megahan et al. 1995). Consequently, current planning and assessment tools for central and eastern Oregon, and other areas with similar geology and soils, are limited because they are based on data from studies conducted in other regions and usually from studies of past logging and road building practices and mitigation measures. Empirically derived data is badly needed by USFS units to plan fuels reduction treatments, particularly in municipal watersheds that supply drinking water or in watersheds with listed salmonids. In the future, empirically derived data from within the region will be needed to provide scientific validity for revisions and updates of forest plans.

Project Objectives:

Objective 1. Quantify hillslope erosion rates before and after prescribed fire and fuels treatments: compare erosion rates under varying fuel conditions, hillslope factors (slope, aspect, soil depth), vegetation types, and treatment prescriptions.

Products: Estimated erosion rates under different environmental conditions and treatment prescriptions.

Applications: Prediction of on-site effects for project-level planning, model calibration.

Objective 2. Measure routing and delivery of sediment to stream channels as affected by treatments.

Products: Estimated sediment delivery to streams, downstream delivery ratios, detention behind obstructions, identify mechanisms for the mobilization and transport of activity sediment.

Applications: Prediction of downstream effects, model calibration, estimation of detection limits and thresholds.

Objective 3. Evaluate changes in streamflow and water quality (suspended sediment, water temperature) associated with prescribed fire and fuels treatments.

Products: Measured changes in streamflow, and impacts to water quality associated with prescribed fire and fuels treatments.

Applications: Prediction of project effects in planning, model calibration, estimation of detection limits and thresholds, improve Forest monitoring strategies.

Objective 4. Evaluate impacts of treatments on stream channel morphology.

Products: Measured changes in residual pool depth, bank erosion, channel incision and stream-channel cross sections in selected monitoring reaches.

Applications: Prediction of treatment effects on channel morphology and stream habitat.

Background:

Fire and Erosion: The effect of fire on erosion depend on the size of the area burned, the intensity of the fire, and in some cases, on the frequency of fires (Swanson 1981, Gresswell 1999, Wilson 1999). Under current fire management practices, most wildfires are quite small (Turner et al. 1994) even when allowed to burn without interference (Romme and Despain 1989). Thus, even if intense, the typical fire is unlikely to have severe effects in most watersheds. In contrast, fires ranging in size from the site/stand (1,000 ac) to the subwatershed (8,000-20,000 ac), or larger, may have a large effect on stream sediment budgets (Swanson 1981). While such fires are rare, land management practices over the last century, including selective harvest, fire exclusion and grazing have converted open-forest stands into denser stands dominated by shade tolerant mid- and late-seral species (Mutch et al. 1993, Belsky and Blumenthal 1997, Hann et al. 1997, Tiedemann et al. 2000). Thus, there is growing concern that interior Columbia Basin forests may be increasingly vulnerable to large, stand-replacing fires (Agee 1993, Mutch et al. 1993, Hessburg et al. 1994, Hann et al. 1997).

Surface runoff is the factor that generates most concern when considering potentially accelerated erosion following fires, but the actual amount of sediment eroded depends on fire intensity, time since fire, storm intensity, and the availability of erodible sediment. Fire intensity is a critical factor determining soil infiltration rates because temperature and duration of fire determine the degree to which soil properties are changed (Beschta 1990). Intense fires burn surface litter layers and combust soil organic horizons, which, combined with the loss of the forest canopy, exposes the surface soil to raindrop impact that can disperse soil aggregates, allowing fine sediment to clog soil pores and reduce infiltration (Beschta 1990). Similarly, combustion of organic matter in the mineral soil can lead to the loss of soil structure, reducing both porosity and infiltration rates (DeBano et al. 1998). Finally, heating can convert soil organic matter into hydrophobic compounds that also limit infiltration rates (DeBano et al. 1998). Recovery of soil properties occurs at varying rates. Most hydrophobic soil layers break down in weeks or months, although in rare cases they persist for longer periods. Recovery of litter layers and soil organic matter takes longer, and is highly dependent on vegetative recovery. For example, in dry-forest types of central Idaho high erosion rates persisted for at least 10 years following helicopter logging and prescribed burning on dry, south-facing slopes because recovery of overstory vegetation was slow. In contrast, vegetation regrowth on nearby north-facing slopes was rapid and erosion returned to background rates within three years (Megahan et al. 1995).

Accelerated surface erosion following severe wildfire is well documented in areas that receive intense rainfall from thunderstorms, especially where infiltration rates are limited by changes in soil properties (Helvey 1980, Beschta 1990, Scott and Van Wyk 1990, Scott 1993, Rinne 1996, Robichaud and Brown 1999, Wilson 1999). The amount of sediment eroded after fires is dependent upon the resistance of sediment particles to detachment, and the amount of sediment available to be eroded. In the Idaho batholith where soils are coarse and poorly consolidated, erosion rates are high because soils are easily eroded once surface litter is removed (Megahan et al. 1995). Such high erosion rates are not observed in most places because fires, especially those of low to moderate severity, typically cause minimal surface disturbance so that relatively little sediment is available to be eroded. In these situations accelerated erosion is typically observed only where the soil surface is heavily disturbed – for example from tree fall, fire-fighting activities, pre-fire land use, or post-fire salvage logging (Swanston 1971, Beschta 1990, Marston and Haire 1990, Gresswell 1999, Wilson 1999, McIver and Starr 2000), both because more sediment is exposed to erosional processes and because sediment from disturbed soil is usually more easily detached.

Extreme weather events soon after severe fires can lead to unusually severe erosion. For example, an intense thunderstorm one year after a stand replacing wildfire led to the deposition of as much as one meter of sediment on the valley floor of N. Cable Creek in the Blue Mountains, Oregon (William Russell, *pers. comm.*, Oregon State University, Corvallis, OR). In another case, Helvey (1980) documented major landslides and debris flows two years after a severe stand-replacing fire on the Entiat Experimental Forest in central Washington. The landslides were triggered when unusually deep snow packs combined with rapid warming pushed stream discharge to three times the maximum observed during the previous 10-year calibration period. It is not known whether these landslides would have occurred without the preceding fire, but, increased rates of land slides and debris flows have been observed following timber harvest in western Washington and Oregon (Swanson and Dyrness 1975, Nakamura et al. 2000). Although land slides and debris flows have also been studied in mountainous landscapes of the Interior Columbia Basin, these are mostly case studies of isolated events. The overall effects of fire regimes on geomorphic processes and long-term stream sediment budgets are poorly documented in most landscapes (Swanson 1981, Meyer et al. 1995).

The effects of small, low-severity fires, such as prescribed fires, and the cumulative effects of many small fires are also largely unknown. In general, a single, site-scale event is thought to have little effect on the larger watershed because the effects are attenuated as they move downslope and/or downstream. For example, much of the sediment eroded from burned areas may be stored in tributary valleys and the sediment that does reach the mainstem will be a relatively small proportion of the mainstem sediment load. Nevertheless, headwater streams are important sources of sediment for mainstem channels and the morphology of mainstem channels is often sensitive to sediment inputs (Montgomery and Buffington 1997, Montgomery 1999). Erosion from hillslopes fills small channels with sediment that is entrained by floods or debris flows and transported down the stream network (Meyer and Wells 1997, William Russell, *pers. comm.*, Oregon State University, Corvallis, OR). These episodic events are often categorized as catastrophic disturbances at the site/stand scale. Over the long term, sediment from tributary streams is important in maintaining channel morphologic features (Salo and Cundy 1987, Meehan 1991, Benda et al. 1998) and may also be important for maintaining stream habitat (Reeves et al. 1995).

Accelerated surface erosion can occur in the absence of rainfall and surface runoff (Beschta 1990). Dry-ravel erosion can increase to rates that greatly exceed background following the loss of physical structures on steep slopes (e.g., large logs laying across slopes) and release large quantities of stored sediment (Bennett 1982, Beschta 1990). Although much of the eroded sediment will be redeposited further downslope, over time, dry ravel will transport substantial amounts of sediment from hillslopes to valley floors (Swanson et al. 1982). Death of bank-side vegetation in severely burned riparian areas should eventually lead to decreased bank stability as roots decompose, increasing susceptibility to bank erosion (Helvey 1980, Beschta 1990, Lewis 1998). However, bank erosion may be limited by the rapid recovery of understory vegetation, especially grasses and sedges growing along streams where moisture is readily available during the growing season. Similarly, riparian hardwoods adapted to frequent disturbance resprout from roots and rapidly recolonize disturbed areas. Thus, the speed of riparian recovery will be critical in determining the risk of accelerated bank erosion following fire.

Erosion, Sediment Transport and Delivery to Streams: Most research and published literature has focused on hillslope erosion processes at the site and small-watershed scale (Grant and Wolf 1991, Ketcheson and Megahan 1996, Lewis 1998) and measure either erosion rates on small plots or sediment transported out of small watersheds. Few studies have quantified the amount of sediment eroded from hillslopes that is delivered to stream channels and stored in those channels. Assuming that all sediment eroded is rapidly delivered to stream channels may overestimate stream sedimentation (Gill 1994, Trimble and Crosson 2000) because much of the sediment eroded from hillslopes is either redistributed downslope (Ketcheson and Megahan 1996, Davenport et al. 1998, Reid et al. 1999, Trimble and Crosson 2000) or stored on alluvial fans and floodplains (Costa 1975, Trimble 1983, de Ploey and Yair 1985, Nakamura et al. 1995). Because stored sediment may remain on valley floors for 10s to 100s of years (Bunte and MacDonald 1995, Nakamura et al. 1995, Nagle and Ritchie 1999), continued erosion of stored sediment may maintain elevated sediment loads in streams long after restoration activities have reduced accelerated rates of erosion on upland sites (Trimble 1983, Trimble and Crosson 2000). Nagle and Ritchie (1999) showed that surface erosion appears to contribute little to current stream-sediment loads in three streams in eastern Oregon, regardless of dominant land use within each of the three watersheds. Rather, sediment loading in streams dominated by agriculture or grazing of domestic livestock was primarily from bank erosion. The sediment load of the stream draining a watershed dominated by forest land use was low. Nagle and Ritchie (1999) suggested that channel meandering and stream avulsions occurring during high discharge rework sediment stored on valley floors, entraining it into stream channels where it may be transported downstream. Of course, rainfall from intense storms (e.g., thunderstorms) can generate extreme surface runoff capable of moving large quantities of sediment, leading to sedimentation of streams and valley floors and other changes in channel morphology (Wondzell and Swanson 1999).

Despite the existing body of literature that describes the effects of fire and other land-management activities on erosion, significant gaps in knowledge remain. Data on hillslope transport and redistribution of eroded sediment and the delivery of sediment to streams is especially lacking in the literature. Only limited data are available to guide planning and implementation of fuels reduction treatments throughout the region. At the local level, insufficient data is available to validate planning and assessment tools currently being used in central and eastern Oregon. As a consequence, there is significant debate over the relative risks of active vs. passive restoration (Kauffman et al. 1997, Tiedemann et al. 2000, Wondzell *in press*), the criteria that should be used to prioritize locations for watershed restoration activities (Howell *in press*) and the role of natural disturbance in ecosystem management (Reeves et al. 1995).

Materials and Methods:

Our study has two components: 1) an intensive small-watershed study of erosion and stream sedimentation that will be conducted in the Skookum Experimental Watersheds; and 2) an extensive component that will examine spatial variability in hillslope erosion rates and sediment delivery to stream channels. Study sites for the extensive component will be opportunistically located within projects proposed for prescribed burning and fuels treatment under the National Fire Plan. There are two reasons for this study design:

- project planning for the Skookum Watersheds is completed and the treatments are scheduled. However, forest stands are dense and much of the standing timber is dead. Consequently, the prescribed fire is expected to reach moderate intensities. Prescribed burning can be conducted safely only under an extremely narrow window of climatic and fuel moisture conditions. There is a possibility that the treatments will not be completed during the course of this study;

- the Skookum Watersheds are broadly representative of forest conditions in central and eastern Oregon. However, they do not contain the full range of site conditions found throughout the Blue Mountains and across the western United States. While intensive, process-based studies of fire and its influence on stream sediment budgets will always be useful, it can be difficult to extend the results of such studies to larger areas.

The incorporation of the “extensive study sites” provides a better context for interpreting the results of this study and also provides insurance that we will accomplish most of the objectives laid out in this proposal. We would like to locate the “extensive plots” in the Mill Creek Watershed because it is little disturbed by other management activities. However, implementation of the Mill

Creek project is uncertain because the project is in the early stages of planning, and several potentially significant issues must be resolved through NEPA and consultation under the Endangered Species Act. If necessary, our extensive study plots will be located within other projects proposed or being planned for treatment with prescribed fire. Candidate projects include: Plenty Bob (planning in progress, decision expected June, 2001), Cabin Creek (planning complete), and Camas (planning complete).

Study Site Description:

The Skookum study area, about 2,000 acres in size, is located in the headwaters of Skookum Creek, a 4th order tributary to Wall Creek, which flows into the lower North Fork John Day Subbasin near the town of Monument, Oregon. Elevations range from 4,000 to 5,700 feet. The watersheds are within the Texas Roadless area and are relatively unaffected by past timber management activities. Two adjacent tributaries were instrumented in 1992, with nine years of pre-activity data on streamflow, suspended sediment, air and water temperature, and channel morphology now available. The project consists of treating Watershed 1 with a landscape underburn designed to reduce high fuel loads, and leaving Watershed 2 untreated.

The upper Mill Creek watershed is managed as the primary water supply for the City of Walla Walla, WA. This watershed is in a protected status and has had no active management. A wildfire and fuel treatment risk analysis recently completed for the 21,500 acres of National Forest lands within the watershed (Beekman, 2000) documented changes in vegetation and fuel conditions, relatively high proportions of high severity fuel types in the upper watershed, and approximately one third of the analysis area at high risk for wildfire based on fuel types and stand conditions. A sediment yield prediction model was used as part of the analysis but our confidence in the modeled results are low because we lack local calibration data on sediment yields and sediment data from prescribed fire and fuel treatments.

Study Design:

Small Watershed Studies: We will use a hierarchically nested sampling design to measure erosion rates at three scales: 1) the plot; 2) the hillslope; and 3) the watershed. The data will be used to develop a sediment budget (Beechie and Boulton 1999) for each watershed that measures hillslope erosion rates, traces the transport and redistribution of sediment along hillslopes, measures the amount of sediment delivered to stream channels, and measures the amount of sediment leaving the watershed. The expense of small watershed studies and the availability of resources limits the number of watersheds to two, a control watershed and a watershed treated with a prescribed burn. The sediment budgets for the treated and control watersheds will be used to determine the effect of prescribed burning on erosion and stream sedimentation.

We will use variable-area erosion plots to measure surface erosion, where the boundaries of the plot are defined by the area of hillslope contributing runoff, surface erosion and dry ravel. Because only budgets of sediment will be calculated, we have no need to measure actual surface runoff. Consequently, individual plots will consist of a 3-m wide sediment trap oriented perpendicular to the hillslope. Sediment traps will be made from black silt-fencing supported by a structure of fence posts and chain-link fencing. The fabric will extend a short distance upslope of the silt fence, and will be anchored with flashing to prevent surface runoff from running under the fabric. Erosion plots will be sampled after intense rainstorms and after peak spring snowmelt. If there have not been major storms, plots will be sampled monthly (when snow free). Plots will be sampled 1 day, 1 week, 2 weeks and 4 weeks after burning. After 4 weeks, sampling will revert to the original schedule. Accumulated sediment will be cleaned from the sediment traps at each visit. All accumulated sediment will be collected unless amounts are too great to carry. In that case, the accumulated sediment will be weighed in the field and a sub-sample will be collected. Collected sediment will be oven dried and sieved to measure size-fractions of accumulated sediment. Large organic debris will be separated by hand to estimate the large-organic fraction of eroded materials. A subsample will be combusted to estimate the amount of fine-organic debris.

Plots provide estimates of erosion rates for variable-sized contributing areas. As described above, small plots often overestimate the amount of sediment delivered to stream channels because much of the sediment eroded from hillslopes is either redistributed downslope, or stored on valley floors. We will directly measure hillslope redistribution and sediment delivery to streams. Plots will be arrayed in groups of 4, with one plot located at upper- mid- and lower-slope positions, and the fourth plot located on the stream bank. Plots will be unbounded, providing an estimate of cumulative erosion rates along the length of the hillslope. Differences between plots will be used to calculate net erosion and deposition rates along the length of the hillslope. The amount of sediment collected in the stream bank plot will measure the gross delivery of sediment to the stream channel. Ten groups of erosion plots will be located in each watershed. The total sediment delivery to the stream channel will be calculated on the basis of the median (n=10) delivery rate multiplied by the length of channel in the watershed. Three groups of erosion plots will be located in headwater swales and the remaining seven groups of plots will be located along hillslopes throughout each small watershed.

The Skookum Watersheds are already gauged and instrumented to measure stream discharge and sediment yield, and therefore provide a way to measure net watershed erosion. Because sediment may be stored on valley floors for long periods of time, continued erosion of stored sediment may maintain elevated sediment loads in streams, even when little erosion is occurring on upland sites. It is critically important to differentiate between the effects of channel erosion and upland erosion. Our study design allows us to estimate both total sediment delivery to the stream channel and net sediment yield from the watershed. The difference between these two values will be the net channel erosion rate, where positive values represent channel aggradation and negative values represent bank erosion or channel incision.

Changes in channel morphology will also be measured directly, by surveying longitudinal profiles and cross sections of streams and floodplains in selected stream reaches. Longitudinal sections and cross sections will be permanently marked and surveyed annually to measure channel aggradation or incision, and rates of bank erosion and lateral channel migration. Some survey sites are already established in the Skookum Watersheds, and will provide base-line data. We expect to establish additional sites to measure changes in channel morphology and fish habitat.

Our data will be used to calculate sediment budgets for both the control and treated watersheds. These budgets will include estimates of hillslope erosion rates, the amount of sediment transported down hillslopes vs. the amount that is simply redistributed lower on the hillslope, and the net amount of sediment reaching stream channels. Our budgets will also estimate the net influence of channel aggradation vs. degradation on total sediment yield from each watershed. Differences between sediment budgets from the two watersheds will be analyzed to identify the influence of prescribed burning. The sediment budgets compartmentalize hillslope erosion, transport, redistribution, sediment delivery to streams, channel storage and net watershed erosion. Budgets also track size-fractions of both organic and inorganic sediment. Therefore, we will be able to identify the influence of prescribed burning on each compartment and on size-fractions of sediment.

Spatially extensive study sites: The spatially extensive sites will use the same variable area plot design for erosion plots, and plots will also be located in groups of four as described above. The difference is that erosion plots will not be located in gauged watersheds. We will be able to measure hillslope erosion rates and net amounts of sediment transported to the stream, but we will not be able to measure rates of channel aggradation or degradation nor will we be able to measure net watershed erosion rates.

Project Duration:

The duration of the project is 3 years. The focus of the first year will be setting up study sites and collecting pre-treatment data. Post-treatment data will be collected in the second and third years of the study. Data analysis and data documentation will be conducted concurrently with data collection. Writing of manuscripts and technology transfer will be concentrated in years two and three.

We realize the study duration is short, relative to the time-scale of physical processes and the response of watersheds to disturbance, but we stress that 9 years of pretreatment calibration data are already available for the Skookum Watersheds. Our experience leads us to expect the greatest erosional responses will occur in the years immediately after prescribed burning, an expectation that is consistent with the results of most published studies. Finally, we will explore future funding opportunities to extend the duration of the study.

Deliverables:

Pacific Northwest Research Station – General Technical Report: <u>Changes in hillslope erosion rates, surface-sediment transport, sediment delivery to streams and net sediment yield from small watersheds in eastern Oregon following fuels treatments and prescribed burning</u>. Publication cannot be completed before the end of the study. Consequently we expect the manuscript will be submitted soon after the end of FY2004 with an expected publication date in FY2005.

Peer-Reviewed Publication: <u>Changes in erosion and stream sedimentation resulting from fuels treatments and prescribed burning in the Blue Mountains, Oregon.</u> (Journal to be determined – Target: J. American Water Resources Association). Publication cannot be completed before the end of the study. Consequently we expect the manuscript will be submitted soon after the end of FY2004 with an expected publication date in FY2005.

Peer-Reviewed Publication: Influence of Fuel Treatments and Prescribed Burning on Channel Morphology and Fish Habitat. (Journal to be determined – Target: Canadian J. Fisheries and Aquatic Sciences). Publication cannot be completed before the end of the study. Consequently we expect the manuscript will be submitted soon after the end of FY2004 with an expected publication date in FY2005.

Administrative Reports: Reports for Management summarizing effects of prescribed fire and fuels treatment on water quality and aquatic habitat.

Technology Transfer:

Forest managers are an integral component of this research project. One PI, Caty Clifton, is the Forest Hydrologist for the Umatilla National Forest and one Major Collaborator, Les Holsapple, is the Forest Fuels Specialist for the Umatilla National Forest. Their participation is crucial to the success of the study and their participation in the study ensures that study results will be quickly incorporated into management decisions at the local level.

Results of the study will be presented at workshops and meetings:

- presentations will be made at annual meetings of national and regional Scientific Associations with expected presentations at the following during the 3-yr duration of the study 1) American Geophysical Union; 2) Society for Ecological Restoration, Northwest Chapter; and 3) Oregon Chapter of the American Fisheries Association.

- presentations will be made at regional meetings and workshops held by the land management agencies, including the annual meeting of R6 Hydrologists and Fish Biologists

Results of this study will be utilized in decision support models being developed by Wondzell and Howell for the Interior Northwest Landscape Analysis System (2001-2004)

Results will be used to reparameterize existing sediment yield prediction models (e.g. R1/R4 sediment yield model) that is currently in use by the National Forests of central and eastern Oregon.

Data will be available to researchers and managers upon request, and at the end of the project, data will be archived and freely available via the World Wide Web (2004)

Literature Cited:

Agee, J.K. 1993. Fire ecology of Pacific Northwest Forests. Island Press, Washington D.C., USA. 493 p.

Beechie, T. and Bolton, S. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwestern watersheds. Fisheries 24:6-15

Beekman, J. 2000. A wildfire and fuel treatment risk analysis for the Mill Creek municipal watershed. USDA Forest Service, Washington Institute Inc, Technical Fire Management report 14, April, 2000. 37 p.

Belsky, A. J. Matzke, A., and Uselman, S. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419-431

Belsky, A. J. and D. M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the interior west. Conservation Biology 11:315-327.

Benda, L. E., D. J. Miller, T. Dunne, G. H. Reeves, and J. K. Agee. 1998. Dynamic landscape systems. Pgs. 261-288. In. R. J. Naiman and R. E. Bilby (eds.) River Ecology and Management: Lessons from the Pacific Coastal Ecoregion, Springer-Verlag, New York.

Bennett, K.A. 1982. Effects of slash burning on surface erosion rates in the Oregon Coast Range. M.S. Thesis, Oregon State University, Corvallis OR. 70 p.

Beschta, R.L. 1990. Chapter 17: Effects of fire on water quantity and quality. Pages 219-231 *In* Walstad, J.D., S.R. Radosevich, and D.V. Sandberg (editors) Natural and Prescribed Fire in Pacific Northwest Forests. Oregon State University Press, Corvallis, OR.

______. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. Water Resources Research 14:1011-1016

Bunte, K. and L.H. MacDonald. 1995. Detecting change in sediment loads: where and how is it possible? Pages 253-261. *In* Effects of Scale on Interpretation and Management of Sediment and Water Quality. Proceedings of a Boulder Symposium, July 1995. International Association of Hydrologic Sciences, Publ. 226.

Clayton, J. L. and Kennedy, D. A. 1985. Nutrient Losses from Timber Harvest in the Idaho Batholith. Soil Science Society of America Journal 49:1041-1049

Clifton, C.A. 1989. Effects of vegetation and land use on channel morphology. Pages 121-129 *In* Gresswell, R.E., B.A. Barton, and J.L. Kershner (editors) Practical Approaches to Riparian Resource Management. U.S. Bureau of Land Management, Billings, MT.

Costa, J.E. 1975. Effects of agriculture on erosion and sedimentation in the Piedmont Province, Maryland. Geological Society of America Bulletin 86:1281-1286.

Davenport, D.W., D.D. Breshears, B.P. Wilcox, and C.D. Allen. 1998. Viewpoint: sustainability of pinon-juniper ecosystems–a unifying perspective of soil erosion thresholds. Journal of Range Management 51:231-240.

DeBano, L.F., D.G. Neary and P.F. Ffolliott. 1998. Fire's Effects on Ecosystems. John Wiley and Sons, Inc.

de Ploey, J. and A. Yair. 1985. Promoted erosion and controlled colluviation: a proposal concerning land management and landscape evolution. Catena 12:105-110.

Everett, R.L., P.F. Hessburg, M.E. Jensen, and B.T. Bormann. 1994. Eastside forest ecosystem health assessment. Vol. 1, executive summary. USDA National Forest System and Forest Service Research, Portland OR. 57 p.

Gast, W.R., Jr., D.W. Scott, C. Schmitt, D. Clemens, S. Howes, C.G. Johnson, Jr., R. Mason, F. Mohr, and R.A. Clapp. 1991. Blue Mountains forest health report: new perspectives in forest health. Executive Summary. USDA Forest Service, Malheur, Umatilla, and Wallowa-Whitman National Forests. 30 p.

Gill, R.E. 1994. Sediment delivery to headwater stream channels following road construction and timber harvest in the Blue Mountains, Oregon. M.S. Thesis, Oregon State University, Corvallis OR.

Grant, G. E. and Wolff, A. L. 1991. Long-term patterns of sediment transport after timber harvest, western Cascade Mountains, Oregon, USA. pgs. 31-40. In: Sediment and Stream Water Quality in a Changing Environment: Trends and Explanation. Proceedings of the Vienna Symposium, August 1991. IAHS Publ. no. 203.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41:540-551.

Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128:193-221.

Hann, W.J., J.L. Jones, M.G. Karl, P.F. Hessburg, R.E. Keane, D.G. Long, J.P. Menakis, C.H. McNicoll, S.G. Leonard, R.A. Gravenmier, and B.G. Smith. 1997. Chapter 3: Landscape dynamics of the basin. Pages 337-1055 *In* Quigley, T.M., and S.J. Arbelbide (editors) An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins. USDA Forest Service Gen. Tech. Rep. PNW-GTR-405. Pacific Northwest Research Station, Portland OR.

Helvey, J.D. 1980. Effects of a north-central Washington wildfire on runoff and sediment production. Water Resources Bulletin 16(4):627-634.

Hessburg, P. F., Smith, B. G., Salter, R. B., Ottmar, R. D., and Alvarado, E. 2000. Recent changes (1930s--1990s) in spatial patterns of interior northwest forests, USA. Forest Ecology and Management 136:53-83

Hessburg, P. F. and Smith, B. G. 1999. Management implications of recent changes in spatial patterns of interior northwest forests. Transactions of the 64th North American Wildlife and Natural Resources Conference 55-78

Hessburg, P.F., R.G. Mitchell, and G.M. Filip. 1994. Historical and current roles of insects and pathogens in eastern Oregon and Washington forested landscapes. USDA Forest Service Gen. Tech. Rep. PNW-GTR-327. Pacific Northwest Research Station, Portland, OR. 72 p.

Howell, P. J. (*in press*). Effects of disturbance and management of forest health on fish and fish habitat in eastern Oregon and Washington. Northwest Science

ICBEMP. 2000. Interior Columbia Basin supplemental draft environmental impact statement. The Interior Columbia Basin Ecosystem Management Plan. USDA Forest Service and USDI Bureau of Land Management. U.S. Government Printing Office.

Kauffman, J. B., Beschta, R. L., Otting, N., and Lytjen, D. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22:12-24

Kauffman, J.B. and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications--a review. Journal of Range Management 37:430-438.

Ketcheson, G. L. and W. F. Megahan. 1996. Sediment production and downslope sediment transport from forest roads in granitic watersheds. USDA Forest Service, Intermountain Research Station, Research Paper INT-RP-486.

Lewis, J. 1998. Evaluating the impacts of logging activities on erosion and sediment transport in the Caspar Creek watersheds. Pages 55-69 *In* Ziemer, R.R. (technical coordinator)

Proceedings of the Conference on Coastal Watersheds: the Caspar Creek Story; 6 May 1998; Ukiah, CA. USDA Forest Service Gen. Tech. Rep. PSW-GTR-168.
Marston, R.A. and D.H. Haire. 1990. Runoff and soil loss following the 1988 Yellowstone fires. Great Plains-Rocky Mountain Geographical Journal 18:1-8.
McIver, J.D. and L. Starr. 2000. Environmental effects of post-fire logging: literature review and annotated bibliography. USDA Forest Service Gen. Tech. Rep. PNW-GTR486. Pacific Northwest Research Station, Portland, OR. 72 p.
Medina, A.L. and S.C. Martin. 1988. Stream channel and vegetation changes in sections of McKnight Creek, New Mexico. Great Basin Naturalist 48:373-381.
Meehan, W.R. (editor). 1991. Influences of Forest and Rangeland Management on Salmon Fishes and their Habitats. American Fisheries Society Special Publication #19. Bethesda, MD.
Megahan, W. F., King, J. G., and Seyedbagheri, K. A. 1995. Hydrologic and erosional responses of a granitic watershed to helicopter logging and broadcast burning. Forest Science 41:777-795
Meyer, G.A. and S.G. Wells. 1997. Fire-related sedimentation events on alluvial fans, Yellowstone National Park, U.S.A. Journal of Sedimentary Research 67:776-791.
Meyer, G.A., S.G. Wells, and A.J.T. Jull. 1995. Fire and alluvial chronology in Yellowstone National Park: climatic and intrinsic controls on Holocene geomorphic processes. Geological Society of America Bulletin 107:1211-1230.
Montgomery, D.R. 1999. Process domains and the river continuum. J. of the American Water Resources Association 35(2):397-410.
Montgomery, D.R. and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109(5):596-611.
Morrison, P. H. and Swanson, F. J. 1990. Fire history and pattern in a Cascade Range landscape. USFS Pacific Northwest Research Station, General Technical Report PNW-GTR-254 77 p.
Mutch, R.W., S.F. Arno, J.K. Brown, C.E. Carlson, R. Ottmar, and J.L. Peterson. 1993. Forest health in the Blue Mountains: a management strategy for fire-adapted ecosystems. USDA Forest Service Gen. Tech. Rep. PNW-GTR-310. Pacific Northwest Research Station, Portland OR. 14 p.
Nagle, G.N. and J.C. Ritchie. 1999. The use of tracers to study sediment sources in three stream in Northeastern Oregon. Physical Geography 20:348-366.
Nakamura, F., H. Maita, and T. Araya. 1995. Sediment routing analyses based on chronological changes in hillslope and riverbed morphologies. Earth Surface Processes and Landforms 20:333-346.
Nakamura, F., F. J. Swanson, and S. M. Wondzell. 2000. Disturbance regimes of stream and riparian systems--a disturbance-cascade perspective. Hydrological Processes. 14:2849-2860.
Nanson, G. C. and E. J. Hickin. 1986. A statistical analysis of bank erosion and channel migration in western Canada. Geological Society of America Bulletin 97:497-504.
Platts, W.S., K.A. Gebhardt, and W.L. Jackson. 1985. The effects of large storm events on basin-range riparian stream habitats. Pages 30-34 *In* Riparian Ecosystems and their Mangement: Reconciling Conflicting Uses. USDA Forest Service Gen. Tech. Rep. RM-120. Rocky Mountain Research Station, Fort Collins, CO.
Quigley, T.M. and S.J. Arbelbide. 1997. An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins. USDA Forest Service Gen. Tech. Rep. PNW-GTR-405. Pacific Northwest Research Station, Portland OR.
Reeves, G. H., L. E. Benda, K. M. Burnett, P. A. Bisson, and J. R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily

significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349.
Reid, K.D., B.P. Wilcox, D.D. Breshears, and L. MacDonald. 1999. Runoff and erosion in a pinon-juniper woodland: influence of vegetation patches. Soil Science Society of America Journal 63:1869-1879.
Rieman, B., and J. Clayton. 1997. Wildfire and native fish: issues of forest health and conservation of sensitive species. Fisheries 22:6-15.
Rinne, J.N. 1996. Short-term effects of wildfire on fishes and aquatic macroinvertebrates in the southwestern United States. North American Journal of Fish Management 16:653-658.
Robichaud, P.R., and R.E. Brown. 1999. What happened after the smoke cleared: onsite erosion rates after a wildfire in eastern Oregon. Wildland Hydrology: American Water Resources Association June/July:419-426.
Romme, W.H., and D.G. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. BioScience 39:695-699.
Salo, E.O., and T.W. Cundy (editors). 1987. Streamside management: forestry and fisheries interactions. Univ. of Washington, Inst. of Forest Resources, Contribution #57. Seattle, WA.
Scott, D.F., and D.B. Van Wyk. 1990. The effects of wildfire on soil wettability and hydrological behaviour of an afforested catchment. Journal of Hydrology 121:239-256.
Scott, D F. 1993. The hydrological effects of fire in South African mountain catchments. Journal of Hydrology 150:409-432.
Smith, D. G. 1976. Effects of vegetation on lateral migration of anastomosed channels of a glacial meltwater river. Geological Society of America Bulletin 87:857-860.
Simon, R. J. 1999. Observed channel response to wildfire -- Moose Creek, Idaho. Journal of the American Water Resources Association 429-436
Swanson, F.J. 1981. Fire and geomorphic processes. Pages 401-420 *In*: Mooney, H. A. (Ed.) Proceedings of the conference on fire regimes and ecosystems. USDA Forest Service Gen. Tech. Rep. WO-26.
Swanson, F.J., and C.T. Dyrness. 1975. Impact of clear-cutting and road construction on soil erosion by landslides in the western Cascade Range, Oregon. Geology 3:393-396.
Swanson, F.J., R.L. Fredriksen, and F.M. McCorison. 1982. Material transfer in a western Oregon forested watershed. Pages 233-266 *In* Edmonds, R.L. (editor) Analysis of Coniferous Forest Ecosystems in the Western United States. US/IBP Synthesis Series 14. Hutchinson Ross Publishing Company, Stroudsburg, PA.
Swanston, D.N. 1971. Principal mass movement processes influenced by logging, road building, and fire. Pages 29-39 *In*. Krygier, J.T, and J.D. Hall (editors) Forest Land Uses and Stream Environment. Oregon State University, Corvallis.
Tiedemann, A.R., J.O. Klemmedson, and E.L. Bull. 2000. Solution of forest health problems with prescribed fire: are forest productivity and wildlife at risk? Forest Ecology and Management 127:1-18.
Trimble, S W. 1983. A sediment budget for Coon Creek Basin in the Driftless Area, Wisconsin, 1853-1977. American Journal of Science 283:545-474
Trinble, S.W., and P. Crosson. 2000. U.S. Soil Erosion Rates: Myth and Reality. Science 289:248-250.
Turner, M.G., W.W. Hargrove, R.H. Gardner, and W.H. Romme. 1994. Effects of fire on landscape heterogeneity in Yellowstone National Park, Wyoming. Journal of Vegetation Science 5:731-742.

Wilson, C.J. 1999. Effects of logging and fire on runoff and erosion on highly erodible granitic soils in Tasmania. Water Resources Research 35(11):3531-3546.

Wilson, D., D. Maguire, and A. Ager. 2001. Effects of forest planning regulations on potential small-diameter timber harvest from overstocked stands on the Umatilla National Forest. Umatilla National Forest, Misc. Report.

Wondzell, S. M. (*in press*). The Influence of Forest Health and Protection Treatments on Erosion and Stream Sedimentation in Forested Watersheds of Eastern Oregon and Washington. Northwest Science.

Wondzell, S. M. and F. J. Swanson 1999. Floods, Channel Change and the Hyporheic Zone. Water Resources Research 35:555-567.

Budget:

Budget Justification:

Caty Clifton and Steve Wondzell will be responsible for the overall direction and supervision of this project. Their time commitment to the project will be approximately 1 month per year. Their time is considered an In-kind Contribution.

Major collaborators working on this project are Les Holsapple, Phil Howell, and Pete Robichaud. Les Holsapple is the Forest Fuels Specialist, Umatilla National Forest, Pendleton OR; Phil Howell is a Fisheries Biologist, PNW Research Station, La Grande OR; and Pete Robichaud is a Research Engineer, Rocky Mountain Research Station, Moscow ID. The time commitment of each major collaborator will be approximately 2 weeks per year. Their time is considered an In-kind Contribution.

A three-year term employee or post-doc will be hired to conduct the day to day research described in this proposal. The Term/Post-Doc will work with the PIs and other collaborators to locate erosion plots and choose spatially extensive study sites; organize field work; hire and supervise field crew during summer field season; collect erosion samples from erosion plots throughout the year; analyze collected samples; organize, analyze and archive project data and work with PIs and other collaborators to publishing results of the study. We request funds for salary and benefits for the term/post-doc. We budget their time as a GS-11 position with a 4% cost of living increase in salary each year. Office space for this employee will be provided at the SO of the Umatilla National Forest and is considered an In-kind Contribution.

We budgeted $5,000 per year for travel to and from field sites. A portion of this is budget for PIs and collaborators to travel to study sites from their home offices.

We budgeted $1,000 in each year to support the travel by one PI to the annual workshop.

We budgeted a total of $12,000 for supplies, most to be spent in the first two years of the project.

We budgeted $2,000 for a one-time purchase of a computer.

We budgeted $12,000 in wages and benefits in each year to hire a 2-person field crew, with a 4% cost of living increase in the second and third years of the study.

We used an indirect cost rate of 15%. The Pacific Northwest Research Station will incur actual indirect costs of 18.08%. The difference, 3.08% is considered an In-kind Contribution from the PNW station.

Project planning is complete for the Skookum Watersheds and treatments are expected to cost $82,000. We estimate treatment cost for the Mill Creek Watershed at $540,000. The costs of planning, site preparation, and prescribed burning are included as In-kind Contributions from the Umatilla National Forest.

Table 1. Breakdown of annual budget and 3-year total of **funds requested from the Joint Fire Sciences Program**.

	FY02	**FY03**	**FY04**	**TOTAL**
Term or Post-Doc (salary and benefits)	$59,800	$62,192	$64,680	$186,672
Travel to/from field sites	$5,000	$5,000	$5,000	$15,000
Annual PI workshop	$1,000	$1,000	$1,000	$3,000
Supplies and sample analyses	$7,000	$4,000	$1,000	$12,000
Computer purchase	$2,000	$0	$0	$2,000
Field Crew (2 people - wages and benefits)	$12,000	$12,480	$12,979	$37,459
TOTAL DIRECT COSTS	**$86,800**	**$86,672**	**$86,659**	**$260,131**
TOTAL INDIRECT COSTS (rate = 15%)	**$13,020**	**$13,001**	**$12,999**	**$39,020**
PROJECT TOTAL	**$99,820**	**$99,673**	**$99,658**	**$299,151**

Table 2. Breakdown of annual budget and 3-year total of funds as **In-kind Contributions**.

	FY02	**FY03**	**FY04**	**TOTAL**
PI: Wondzell (1 month/year)	$5,808	$5,808	$5,808	$17,424
PI: Clifton (1 month/year)	$5,808	$5,808	$5,808	$17,424
Collaborator: Howell (0.5 month/year)	$2,784	$2,784	$2,784	$8,352
Collaborator: Holsapple (0.5 month/year)	$2,904	$2,904	$2,904	$8,712
Contributed Indirect Costs	$2,630	$2,626	$2,626	$7,882
Contributed Office Space	$12,500	$12,500	$12,500	$37,500
SUBTOTAL	**$32,434**	**$32,430**	**$32,430**	**$97,294**
Skookum Underburn				$82,000
Mill Creek Watershed Restoration				$540,000
TOTAL IN-KIND CONTRIBUTIONS				**$719,294**

Caty Clifton

Pacific Northwest Region
Umatilla National Forest
2517 SW Hailey Ave
Pendleton, OR 97801

Phone: (541) 278-3822
FAX: (541) 278-3730
E-mail: cclifton@fs.fed.us

Education:

1987 University of Wisconsin, M.S., Geography.
1984 University of Oregon, B.S., Geography.

Professional Experience:

1994-present	Forest Hydrologist, USDA Forest Service Umatilla National Forest, Pendleton, OR
1993-1994	Hydrologist, USDA Forest Service Umpqua National Forest, Roseburg, OR
1991-1993	Zone Hydrologist**,** USDA Forest Service Payette National Forest, McCall, ID
1989-1991	District Hydrologist, USDA Forest Service Payette National Forest, McCall, ID
1988-1989	Hydrologist, USDA Forest Service Payette National Forest
1988	Hydrologic Technician, USDA Forest Service, Int. Res. Station (spring only)
1986-1987	Teaching Assistant, Department of Geography, University of Wisconsin
1984-1987	Biological Technician, USDA Forest Service, Malheur NF, (summers only)

Publications

Clifton, C., Harris, R, and J. Fitzgerald, 1999. Flood effects and watershed response in the northern Blue Mountains, Oregon and Washington. In: Proceedings of the Wildland Hydrology conference (Olsen, D. and J. Potyondy, eds), American Water Resources Association, Bozeman, Montana, pp 175-182.

Harris, R. and **C. Clifton**, 1999. Upper Umatilla River sediment analysis. In: Proceedings of the Wildland Hydrology conference (Olsen, D. and J. Potyondy, eds), American Water Resources Association, Bozeman, Montana, pp 157-64

Fitzgerald, J. and **C. Clifton**, 1998. Flooding, land use, and watershed response in the Blue Mountains of northeastern Oregon and southeastern Washington. Stream Notes, January, 1988, Stream Systems Technology Center, USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Clifton, C. and A. Hansen, 1991. Stream channel and vegetation recovery in a high elevation sheep-grazed meadow. In: First Annual NPS Water Quality Monitoring Workshop Proceedings, Boise, ID, poster paper.

Clifton, C. 1989. Effects of vegetation and land use on channel morphology. In: Proceedings Practical Approaches to Riparian Resource Management, (Gresswell, Barton, and Kershner, eds), USDI Bureau of Land Management, Billings, MT, pp 121-129

Clifton, C., and A. E. Thomas, 1988. A bibliography of riparian and related topics with emphasis on the intermountain west. USDI Bureau of Land Management, Idaho State Office, Boise, ID, Technical Bulletin 88-2, 69 pp

Steven M. Wondzell

Pacific Northwest Research Station
Olympia Forestry Sciences Lab
3625 93rd Ave., S.W.
Olympia WA 98512

Phone: (360) 753-7691
FAX: (360) 956-2346
E-mail:swondzell@fs.fed.us

Education:

1994 Oregon State University, Ph.D., Forest Ecology.
1984 New Mexico State University, M.S., Biology.
1981 New Mexico State University, B.S., Range Science.

Professional Experience:

2000-present	Research Aquatic Ecologist, USDA Forest Service Pacific Northwest Research Station, Olympia WA.
1996-2000	Research Assistant Professor, Department of Forest Science, Oregon State University, Corvallis OR.
1995-1996	Temporary Assistant Professor, Department of Natural Resources, University of New Hampshire, Durham NH (sabbatical replacement)
1994-1995	NSF-NATO Post-Doctoral Fellow, CNRS, Centre d'Ecologie des Systemes Fluviaux, Toulouse, France.
1988-1994	Ph.D. Candidate, Dept. of Forest Science, Oregon State Univ.
1984-1988	Research Assistant, Dept. of Biology, New Mexico State Univ.
1982-1983	Graduate Assistant, Dept. of Biology, New Mexico State Univ. Research
1981-1982	Technician, Dept. of Biology, New Mexico State Univ.
1980	Range Technician, USDA, Forest Service (summer only).
1979	Research Technician, NM Dept. of Agriculture (summer only).
1977-1980	Range Aid, Dept. of Animal and Range Science, New Mexico State Univ.

Publications:

Wondzell, S. M. (*under revision*). Channel Morphology Controls Hyporheic Exchange Flows in Small Mountain Streams. Submitted to Water Resources Research.

Wondzell, S. M. (*in press*). The Influence of Forest Health and Protection Treatments on Erosion and Stream Sedimentation in Forested Watersheds of Eastern Oregon and Washington. Northwest Science.

Nakamura, F., Swanson, F. J., and **S. M. Wondzell**. 2000. Disturbance regimes of stream and riparian systems—a disturbance-cascade perspective. Hydrological Processes 14:2849-2860

Johnson, S. L., F. J. Swanson, G. E. Grant, and **S. M. Wondzell**. 2000. Riparian forest disturbances by a mountain flood—the influence of floated wood. Hydrological Processes 14:3031-3050.

Wondzell, S. M. and F. J. Swanson 1999. Floods, Channel Change and the Hyporheic Zone. Water Resources Research 35:555-567

Pinay, G., C. Ruffinoni, **S. M. Wondzell**, and F. Gazelle. 1998. Change in groundwater nitrate concentration in a large river floodplain: Denitrification, uptake, or mixing? The Journal of the North American Benthological Society 17:179-189.

Wondzell, S.M., G.L. Cunningham, and D. Bachelet. 1996. Relationships between landforms, geomorphic processes, and plant communities on a watershed in the northern Chihuahuan desert. Landscape Ecology 11:351-362.

Wondzell, S.M. and F. Swanson. 1996. Seasonal and storm dynamics of the hyporheic zone of a 4^{th}-order mountain stream. I: Hydrologic Processes. Journal of the North American Benthological Society 15:3-19.

Wondzell, S.M., and F. Swanson. 1996. Seasonal and storm dynamics of the hyporheic zone of a 4^{th}-order mountain stream. II: Nitrogen Cycling. Journal of the North American Benthological Society 15:20-34.

Wondzell, S.M. and J.A. Ludwig. 1995. Community dynamics of desert grasslands: Influences of climate, landforms, and soils. Journal of Vegetation Science 6:377-390.

Swanson, F. J., **S. M. Wondzell**, and G. E. Grant. 1992. Landforms, Disturbance, and Ecotones. pgs. 304-323 In: F. diCastri and A.J. Hansen (eds.) Landscape boundaries: Consequences for biotic diversity and ecological flows. Ecological Studies, Vol. #92. Springer-Verlag.

Wondzell, S.M., G. L. Cunningham, and J. M. Cornelius. 1990. Fine grained environmental patterns and the vegetation of a Chihuahuan desert playa. Journal of Vegetation Science 1:403-410.

Wondzell, S. M., G. L. Cunningham, and D. Bachelet. 1987. A Hierarchical Classification of Landforms: Some Implications for Understanding Local and Regional Vegetation Dynamics. pp. 15-23. In: Strategies for Classification and Management of Native Vegetation for Food Production in Arid Zones. United States Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-150.

Grants Funded:

Interactions between streams and groundwater along the river continuum: Scaling up to a stream network. NSF - Hydrologic Sciences Program. Original-PI: Wondzell.
Co-PI: F. J. Swanson. May 2000 - April 2003, $300,000.

Influence of natural processes and human modifications of river channels on stream-groundwater interactions in the hyporheic zone of mountain streams. June 1998 - June 2001, $23,000. Frederick J. Swanson Co-Principle Investigator. Funded by NSF and paired with a proposal from Futoshi Nakamura funded by the Japanese Society for the Promotion of Science (JSPS).

Interactions between streams and ground water along the river continuum: Influence of stream size, geomorphology, and catchment wetness. NSF - Hydrologic Sciences Program. Co-PI: Fred Swanson. June 1996 - May 1999, $183,500.

Influence of human modifications of river channels on ground-water processes and surface-water quality. NSF-NATO Postdoctoral Fellowship in Science and Engineering. March 1994 - March 1995, $42,800. Centre d'Écologie des Systèmes Fluviaux, Toulouse France.

The role of riparian forests in regulating nitrogen flux between ground water and surface water in third order stream valleys of Oregon. 1990 - 1992, $16,410. Doctoral Dissertation Improvement Award, National Science Foundation.

Philip J. Howell

USDA Forest Service
Pacific Northwest Research Station
Forestry and Range Sciences Lab
1401 Gekeler Lane
La Grande, OR 97850

E-mail: phowell@fs.fed.us
Phone: 541-962-6559
Fax: 541-962-6504

Education

1976 M.A., University of Missouri, Fisheries, wildlife, and journalism
1972 B. A. cum laude, English, Rockhurst University

Professional Experience

1997-present	Fisheries Biologist/Aquatic Ecologist, USDA Forest Service, Pacific Northwest Research Station, La Grande, OR
1992-1997	Fisheries biologist, Umatilla National Forest, Ukiah, OR
1979-1992	Supervisory Fisheries Biologist/Research Project Leader, Oregon Department of Fish and Wildlife, Research Section, Corvallis, OR
1979-1982	Instructor, Oregon State University, Corvallis, OR

Publications

Howell, P. J. (*in press*). Effects of disturbance and management of forest health on fish and fish habitat in eastern Oregon and Washington. Northwest Science

Rieman B., J.T. Peterson, J. Clayton, **P. Howell**, R. Thurow, W. Thompson, D. Lee. *(in press*). Evaluation of potential effects of federal land management alternatives on trends of salmonids and their habitats in the interior Columbia River basin. Forest ecology and management.

Spreull, P., A. R. Hemmingsen, **P. J. Howell**, N. Kanda, F.W. Allendorf. (*in review*). Conservation genetics of bull trout: geographic distribution of variation at microsatellite loci. Conservation genetics.

Peterson, J., J. Dunham, **P. Howell**, R. Thurow, S. Bonar. (in review). Protocol for determining bull trout presence. Western Division of the American Fisheries Society.

Stowell, R., **P. Howell**, B. Rieman, and J. McIntyre. 1994. An assessment of the conservation needs for bull trout. USDA Forest Service, Missoula, MT.

Ratliff, D.E. and **P.J. Howell**. 1992. The status of bull trout populations in Oregon. Pages 10-17 *in* **Howell, P.J.** and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. American Fisheries Society, Corvallis, OR.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Kendra and D. Ortmann. 1985. Stock assessment of Columbia River anadromous salmonids. 2 vols. Bonneville Power Administration, Portland, OR. 1,032 pp.

Bottom, D.L., **P.J. Howell** and J.R. Rodgers, 1985. The effects of stream alterations on salmon and trout habitat in Oregon. Oregon Department of Fish and Wildlife, Portland, OR. 109 pp.

Lester J. Holsapple

Umatilla National Forest
Supervisors Office
2517 SW Hailey Ave.
Pendleton, OR 97801

phone: (541) 278-3729
FAX: (541) 278-3750
email: lholsapple@fs.fed.us

Education:

1980 University of Montana, B.S., Forest Management

1985 Graduate Credits from Northern Arizona University, Utah State University, Colorado State University. Obtained during Silvicultural Certification process through the Tri-Region Education in Ecology and Silviculture.

Professional Experience:

1998-present Forest Fire/Fuels Specialist, USDA Forest Service, Umatilla National Forest, Pendleton, OR.
1991-1998 Forest Fire Planner/Fuels Specialist, USDA Forest Service, Umatilla National Forest, Pendleton, OR.
1988-1991 District Silviculturist/Fire Management Officer, USDA Forest Service, Snow Mountain Ranger District, Ochoco National Forest, Hines, OR.
1985-1988 Forester, USDA Forest Service, Cascade Ranger District, Boise National Forest, Cascade, ID.
1981-1985 Forester, USDA Forest Service, Lucky Peak Nursery, Boise National Forest, Boise, ID.
1973-1981 Smokejumper, USDA Forest Service, Aerial Fire Depot, Northern Region, Missoula, MT.
1969-1973 Forestry Technician, USDA Forest Service, Various Locations in California, Oregon, and Montana (Summer only).