The Institute for Water & Watersheds (IWW)
Annual Technical Report
FY 2009

Introduction

Oregonians are witnessing the difficulties caused by water limitations. Water quantity and quality issues in the Willamette, Klamath, and Umatilla basins are the Governor's top environmental and water allocation priorities. This situation is paralleled around the world, and points toward a strong emerging area for growth in research, education, and outreach. These challenges are particularly relevant given that Oregon is one of two states without a long-term water plan - the other state is Alaska - and is currently in the process of developing an Integrated Water Resources Strategy (http://www.oregon.gov/OWRD/LAW/Integrated_Water_Supply_Strategy.shtml).

Oregon State University is ideally positioned to assume a leadership role in addressing water problems, with about 125 faculty in six colleges who teach and conduct research in areas related to water and watersheds. OSU is renowned for its landscape-scale ecosystems research and continues to grow five new graduate degree programs in Water Resources. These research and education efforts have all occurred without the benefit of programmatic coordination or strategic vision.

Oregon's Water Institute, called the Institute for Water and Watersheds (IWW), coordinates interdisciplinary research, education, and technology transfer on issues related to water and environmental sustainability. The IWW program focuses on The Water Resources Program by assisting faculty within the Oregon University System (OUS) to provide outreach and research related to water resources issues on an "as-requested" basis. Partners and constituents of Water Resources Program include educational institutions, state and local governments, watershed councils, and the general public. While the Water Resources Program supports research through USGS funding, the new model for IWW is to support grant preparation as opposed to providing grants to facilitate research.

The IWW is involved in promoting the effective and sustainable use of water resources in the State of Oregon. IWW serves as a hub for water resources activities, for example:

-- IWW is part of the OSU's Graduate Water Resources Graduate Program(http://oregonstate.edu/gradwater/).

-- IWW staff serve as expert "volunteers" to state agency advisory committees, county water committees, and local watershed councils.

-- IWW initiates and coordinates interdisciplinary water resource research projects and through the USGS water institutes program, it funds seed grants on critical water issues for the state.

-- IWW sponsors a regional water resources seminar each winter/spring term on topics such as drinking water, instrumentation, stream restoration, water quality, and water conflict. Speakers from Oregon, the United States, and abroad participate in the program which has a different focus topic each year.

-- Staff at IWW assist faculty at the state's institutions of higher education in research and outreach efforts related to its mission.

Staff resources have been reduced to part-time status with the downturn in Oregon's and the nation s economy. While the budget reductions have forced some re-defining of priorities within the IWW, it remains committed to the NWIR mission and providing research, education and outreach in water for the residents of Oregon. In many ways, these reductions have helped sharpen our knowledge of what is most critical in this regard and we are pursuing this with increased intensity with our world-class faculty in water within the Oregon higher educational system.

Research Program Introduction

None.

The Influence of Sediment Deposition on the Emergence Success of Juvenile Salmonids

Basic Information

Title:	The Influence of Sediment Deposition on the Emergence Success of Juvenile Salmonids
Project Number:	2008OR103B
Start Date:	3/1/2008
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	5th
Research Category:	Climate and Hydrologic Processes
Focus Category:	Sediments, Ecology, Geomorphological Processes
Descriptors:	
Principal Investigators:	Stephen Lancaster

Publications

There are no publications.

The Influence of Sediment Deposition on the Emergence Success of Juvenile Salmonids
Progress Report, May 2010
by, Christine May and Stephen Lancaster

Research Objectives

The objective of this study is to quantity how the depth and composition of fill affects the emergence success of juvenile salmonids. Our approach uses experimental channels to vary the depth and composition of sediment overlying incubating eggs in a series of two experiments. By quantifying these relationships the critical depth of fill, and the effect of fine sediment on that depth, can be established. This information can then be used to develop monitoring and risk assessment strategies that can aid in habitat conservation and setting restoration goals.

Research Approach

Experimental stream channels at the Oregon Hatchery Research Center (OHRC) will be used to directly test the effect of fill depth and composition on salmonid egg survival using a series of two experiments. In coordination with the state Department of Fish and Game, fertilized eggs from the local Alsea fish hatchery will be buried in a mixture of fine sand and gravel. The most readily available salmonid eggs of hatchery origin will be used for this study, being steelhead trout (*Oncorhynchus mykiss*). The **first experiment** will test the effects of varying fill depths using clean gravel. The gravel composition already in place in the OHRC channels is equivalent to the caliber of gravel used in natural stream channels by the salmonid species. Pockets of eyed eggs will be buried to a 20cm depth, equivalent to the mean burial depth of salmon and trout observed in previous studies. Each pocket will contain an equal number of eyed eggs (n = 100). Five replicates of three treatments that represent a gradient of conditions (2x, 3x, and 4x increases in egg burial depth) will be compared to a control (1x), resulting in a total of 20 randomized experimental units.

A **second experiment** will test how the composition of fill affects fry emergence through varying depths of fill. Results from the initial experiment will be used to inform this experiment by setting the upper limit on the depth of fill investigated. Fine sediment will be added to the gravel used in the initial experiment, equivalent to 10% by volume of fine sand. Four replicates of three treatments that represent a gradient of conditions that increase in equal increments up to the 85% lethal limit identified in the previous experiment (e.g., 1x, 1.5x, 2.0x and 2.5x increases in egg burial depth) will be compared to a control (1x, no fine sediment), resulting in a total of 16 experimental units.

During both experiments, buried egg baskets will be monitored for the duration of the incubation period. Newly emerged fry will be counted daily in each channel in order to determine the proportion of emergent fry relative to the original number of eggs. Each fry will be weighed and measured. Data on the timing of emergence, size of emergent fry, percentage of emerged fry, entrapped fry, and un-hatched eggs by treatment will be summarized. The combined effects of fill depth and composition on egg survival and fry emergence will be analyzed with regression analysis. The resulting regression equation can then be used to infer survival rates from field-based measurements of fill depths and fine sediment concentration, thereby providing a predictive tool that can be used for monitoring and assessment.

We anticipate that increases in fill depth will result in substantial mortality by entrapping juvenile salmonids in the subsurface environment. The critical depth at which substantial mortality occurs is important to quantify because the risk of sediment deposition often poses a greater risk than streambed scour (the common assumption) during floods. We further anticipate that fine sediment will decrease the depth at which mortality occurs.

Project Update

In early March of 2009 the **first experiment** to test the effects of varying fill depths using clean gravel was initiated at OHRC. Twenty artificial redds were implanted in the channels using a hollow rodd and pounding core to access various depths in the substrate. Each channel contained a separate, randomly assigned burial depth treatment (20cm, 40cm, 60cm, 80cm). Within each of the four channels, five artificial redds were created. One hundred eyed eggs were buried in each redd, for a total of 2,000 eggs used in the experiment. Eyed-eggs were from a common ancestry and were spawned at Alsea hatchery. A 'laboratory control' batch of eggs was also raised in the lab at OHRC to quantify cohort survival in a hatchery environment.

Juvenile fish emerging from the artificial redds were captured in emergent traps that were built on-site. Each emergent trap was placed directly over an artificial redd, and covered a 0.5m radius around the egg pocket. Emergent traps were made from fine-mesh aluminum screens, with lids to reduce avian predation. The bottom edge of each emergent trap is buried in the substrate in order to create a tight seal and minimize escapement. Fish screens at the end of each channel were also installed to catch any fish that may escape the traps. Traps were checked daily and data on the number, size, timing, and condition of each fish were reordered. All fish were preserved for future laboratory analysis. Juvenile fish emergence in the channels was completed by the end of May, 2009. At the end of emergence a three-pass snorkel survey, followed by elecroshocking was conducted to quantify any escapement from the traps into the channels.

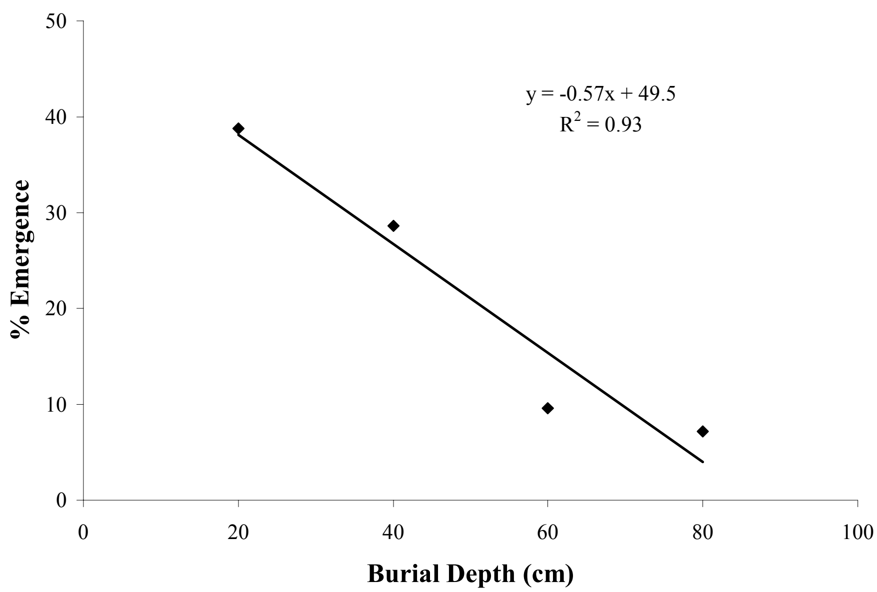

Figure 1. Preliminary results from the first experiment in 2009, indicating a strong linear decrease in survival by burial depth.

Preliminary results indicate a strong linear decrease in survival by burial depth (Figure1). However, it is important to note that overall survival in the experimental channels at OHRC was very low despite high survival of the laboratory cohort (>90%).

In addition to implanting eyed eggs to various depths and trapping emergent fish, we installed a monitoring well immediately downstream of each redd (n = 20). In-situ measurements of substrate permeability were taken the week prior to egg burial. During the egg incubation period, continuously recording sensors monitored surface and subsurface water temperature at 15 minute intervals. Dissolved oxygen and pressure head in the standpipe were measured weekly.

The **second experiment** was conducted in the spring of 2010 at OHRC and tested how the composition of fill affects fry emergence through varying depths of fill. Results from the initial experiment were used to inform this experiment by setting the upper limit on the depth of fill investigated (60cm) and provided insight for building an improved emergence trap. Subsurface burial chambers were used in the 2010 to encapsulate the desired sediment mixtures in the experimental channels and to provide a more effective means of trapping emergent fish.

Channels were randomly assigned to treatments, consisting of a control (in-situ gravel and 1x burial depth) and fine sand addition of 10% by volume at varying burial depths (1x, 2x and 3x). Because of low overall survival in the experimental channels during the first experiment, large-scale troughs were used in a complementary experiment that refined the testing of sediment composition effects on natural burial depths. Four replicates of four treatments were used, consisting of ‘clean’ gravel, gravel with 10% fine sand, gravel with fine silt and clay (proportion relative to turbid inflow from the OHRC water source), and gravel with both sand and very fine sediment additions. All eggs were buried to a depth of 20 cm in the troughs. Both experiments were completed on May 20, 2010 and analysis of the results will be completed by September, 2010. Manuscript submission will occur in 2011.

Detecting Heavy Metal Contamination in the Umatilla River of Eastern Oregon

Basic Information

Title:	Detecting Heavy Metal Contamination in the Umatilla River of Eastern Oregon
Project Number:	2009OR110B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Biological Sciences
Focus Category:	Agriculture, Non Point Pollution, Hydrogeochemistry
Descriptors:	None
Principal Investigators:	Sandra DeBano

Publications

There are no publications.

Detecting Heavy Metal Contamination in the Umatilla River of Eastern Oregon

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Report Period: 03.01.2009 to 02.28.2010

Submitted to IWW: 05.26.2010

EXECUTIVE SUMMARY

Heavy metal contamination of streams and rivers is a major threat to the health of humans and aquatic organisms. A variety of human activities can result in increased heavy metal concentrations in water, sediments, and aquatic organisms. The impact of increased heavy metal concentrations in aquatic systems is a threat not only to the organisms living in the water, but also to terrestrial consumers at higher trophic levels, including humans. However, little research has been conducted examining the extent to which various agricultural practices, such as the use of fertilizers, result in significant increases in heavy metal concentrations in stream and river systems. This project examined whether agricultural land uses are associated with increases in the presence of biologically active heavy metals in an Eastern Oregon watershed that is heavily impacted by agricultural activity.

We compared the usefulness of two aquatic invertebrate taxa as indicators of the amount of biologically active heavy metals in the system, with the aim of allowing us to determine the degree to which heavy metals may represent a threat to aquatic systems in agricultural areas in the Umatilla Watershed of Eastern Oregon, and to relate concentrations of heavy metal in invertebrate tissue to local land uses. The specific objectives of this study were to: 1) quantify heavy metal concentrations in tissues of an indigenous crayfish and aquatic insects at sites spanning the upper, middle, and lower Umatilla River, 2) determine which invertebrate taxa may be the most useful indicator for heavy metal contamination, and 3) examine the relationship between heavy metal levels in these aquatic invertebrates with known and perceived input sources of heavy metals on the Umatilla River.

Signal crayfish and *Pteronarcys* stoneflies from sites along the Umatilla River were collected in the summer of 2009. Crayfish and stonefly tissues were digested and analyzed for heavy metals using inductively-coupled plasma mass spectrometry (ICP-MS). Preliminary results thus far suggest that levels of cadmium and lead in crayfish and stoneflies in the Umatilla River are low, while chromium, copper, and zinc occur at relatively higher concentrations. No obvious increase in concentration is observed along the upstream/downstream gradient. However, further analyses will examine the relationship of metals with regard to known and perceived sources of heavy metals.

The results of this project will be useful in allowing stakeholders in the region, including local tribes, soil and water conservation districts and watershed councils, and agricultural producers to assess the potential threat posed by heavy metals to living organisms in the Umatilla River and humans who eat them, and to develop best management practices aimed at reducing heavy metal contamination.

PROJECT DESCRIPTION AND RESULTS

Many watersheds in Eastern Oregon are impacted by large-scale crop production. The impacts of crop production on aquatic systems are increasingly an important point in the context of developing sustainable agricultural systems. In particular, measuring the cumulative impact of agriculturally-derived nonpoint sources of heavy metals (from fertilizers, manure, and other sources) on river ecosystems is an important research challenge to our understanding of agricultural impacts (Tracy and Baker 2005). Indeed, this challenge is an integral component of understanding the contamination of surface waters, cited as one of the "unsolved technical questions related to water resource management" in the IWW report to the USGS. In particular, there is a pressing need to understand the distribution of heavy metals in watersheds impacted by agricultural production, and to identify the major sources. This knowledge will not only aid in quantifying the threat posed by heavy metals to aquatic systems and the human populations dependent upon them, but also in understanding the best management practices needed to reduce or prevent further heavy metal contamination.

This project investigated the degree of heavy metal contamination in two invertebrate groups in an important salmon-bearing river in Eastern Oregon – the Umatilla River. The salmonid fish and lamprey of the Umatilla River are important food sources for members of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The river is also an important source of water for producers of irrigated agriculture in the region. In addition, the river is home to a listed steelhead population. Recent work has suggested that heavy metals are an issue of concern in the Umatilla Watershed. The objectives of this project were to 1) quantify heavy metal concentrations in tissues of an indigenous crayfish and aquatic insects at sites spanning the upper, middle, and lower Umatilla River, 2) determine which invertebrate taxa may be the most useful indicator for heavy metal contamination, and 3) examine the relationship between heavy metal levels in these aquatic invertebrates with known and perceived input sources of heavy metals on the Umatilla River. The results of this project will aid stakeholders in the region, including local tribes, soil and water conservation districts and watershed councils, and agricultural producers in beginning to understand threats that might be associated with heavy metals in the river and to develop best management practices aimed at reducing this contamination.

Heavy metals are a persistent form of pollution due to their accumulation in animal (vertebrate and invertebrate) and plant tissues. Assessment of heavy metals in rivers, a finite and stressed freshwater resource, relies on sampling and testing of aquatic invertebrates that accumulate these metals through their diet and/or proximity to contaminated sediments. Multi-source inputs of heavy metals (i.e., agriculture, urbanization, etc.) are increasing more rapidly than our understanding of their impacts on river ecology. A prevalent and easily studied invertebrate may improve our understanding of heavy metal detection and ecological impact. Although various aquatic invertebrates have been used as indicators of heavy metal pollution in the last decade, crayfish (subphylum Crustacea) have been largely ignored. However, crayfish may be a particularly useful group to use as bioindicators of heavy metal contamination. They are freshwater omnivores found on every continent except Antarctica. They are omnipresent in river ecosystems, and occupy the main river habitat types (riffles, runs, and pools). They can be found from the headwaters of streams to the lower reaches of major tributaries. They often occur in very high abundances and can be, from a bioenergetics perspective, a key component of river food webs (Hobbs 1991). North American crayfish belonging to the family Cambaridae (found in the eastern United States) have been found to bioaccumulate heavy metals (Anderson and Brower 1978; Alcorlo et al. 2006), but the capacity of crayfish belonging to the family indigenous to the western United States (Astacidae) to bioaccumulate heavy metals is less well understood. Thus, there is a clear need to examine the usefulness of this group and to compare it to other potential invertebrate bioindicators of heavy metal contamination, such as stoneflies.

In addition, an understanding of the degree to which heavy metals bioaccumulate along the river continuum has not been fully explored. Human impacts in watersheds tend to accumulate in a downstream direction (Allan and Castillo 2007). However, whether this is true of heavy metals is not known. It is possible that heavy metal accumulation in the environment and in organisms occurs locally where the input occurs or that heavy metals travel downstream (either in the environment or bioaccumulated in organisms) such that the highest levels of accumulation are found in lower river areas. Understanding how heavy metals travel through river environments is essential to our understanding of their likely impacts, both to the environment and to human health. In addition, this project is one of the few studies examining heavy metal accumulation in a river impacted by crop production per se, and thus will provide insights to crop production's role in heavy metal pollution in regional watersheds.

This project quantified the presence of five heavy metals (cadmium, chromium, copper, lead, and zinc) in tissue of native omnivorous crayfish and detritivorous stoneflies at sites located along the Umatilla River, with the goal of using these aquatic invertebrates as indicators of the amount of biologically active heavy metals in the system. This work is the first step towards understanding the degree to which heavy metals represent a threat to aquatic systems in agricultural areas of the Umatilla Watershed of Eastern Oregon, and to relate the concentrations of heavy metal in invertebrate tissue to local land uses.

Sampling occurred along the Umatilla River in Eastern Oregon during the summer of 2009. The Umatilla River is 89 miles long with headwaters originating in the Blue Mountains. Land use in the Umatilla Basin is largely agricultural with approximately 40% of the basin in cropland and 42% in rangeland. A total of 15 sites were located along the Umatilla River mainstem from near the headwaters (a control area which should have little anthropogenically-derived heavy metal input) to near the mouth of the river. Sites along the river were situated above and below points of potential heavy metal input. These points include tributaries of the Umatilla River known to have large amounts of agriculturally-derived sediment runoff and waste water treatment plants associated with two cities the river flows through. This design will allow an examination of specific sites of potential heavy metal bioaccumulation as well as providing a longitudinal distribution of sites to examine cumulative, downstream impacts of heavy metals. At each of those 15 sites, we collected the native omnivorous crayfish, *Pasifastacus leniusculus* (family Astacidae) using kicknets and conducting targeted searches under cobbles and boulders.

At the seven most upstream sites, we also collected *Pteronarcys* stoneflies (family Pteronarcyidae, order Plecoptera) using the same methods. Nymphs of *Pteronarcys* stoneflies are detritivores that feed on shredded leaf material and algae. *Pternonarcys* stoneflies were not found at the eight downstream river sites. A total of 140 crayfish from 15 sites and composite samples of 5-10 individual *Pteronarcys* stoneflies from seven sites were collected from June 26 to July 24 2009. Individual crayfish and all stoneflies from each site were ground and digested with diluted hydrochloric acid and hydrogen peroxide. Digested tissue samples of crayfish and stoneflies were analyzed by Dr. Jeffrey Layton Ullman for cadmium, copper, lead, zinc, and chromium using inductively-coupled plasma mass spectrometry (ICP-MS).

Preliminary analyses of heavy metals in crayfish and stoneflies are presented in Figures 1 and 2. In general, cadmium and lead occurred at relatively low levels (<0.15 µg per g) in both crayfish and stoneflies (Figs. 1 and 2). Although some studies have found relatively high levels of cadmium and lead in crayfish tissue (e.g., Stinson 1983; Lopez et al. 2004), others have found similarly low levels (Lawrence 1998). In contrast to cadmium and lead, chromium occurred in relatively higher levels in crayfish (Fig. 1). However, stoneflies only showed detectable levels of chromium at two sites, and levels at these sites were relatively low (<0.10 µg per g). Copper levels, although often higher than 2 µg per g in crayfish, were particularly variable in that taxon. Copper levels in stoneflies were generally higher than levels of copper in crayfish (Fig. 1). Zinc showed high levels in both crayfish and stoneflies (Fig. 2), a result consistent with other studies in crayfish and insects (Anderson and Brower 1978; Lawrence 1998; Lopez et al. 2004).

Although metal accumulation in crayfish and stonefly tissue did not show a strong increase relative to a downstream gradient, some metals showed peaks at different points. Further analyses of the data relative to known and potential sources of heavy metal pollution will be conducted in the months ahead.

Future Directions. Current efforts are focusing on 1) relating patterns in selected metals to local land use along the Umatilla River, 2) investigating relationships between sex, size, and microhabitat of crayfish and metal concentrations, 3) examining relationships between metals in crayfish and stoneflies in more depth. We plan to produce technical reports for our partners (including CTUIR, UBWC, SWCD, and local growers) outlining the results of this study relative to the degree of threat which heavy metals pose in the Umatilla River and to continue to present results to our stakeholders in presentations. Finally, the formal analyses of these results will be used for one masters student's thesis, and will be published in a peer-reviewed journal article. We also plan to pursue additional funding to conduct more thorough research on the topic from agencies such as the Oregon Department of Environmental Quality, the US Environmental Protection Agency, and the National Science Foundation.

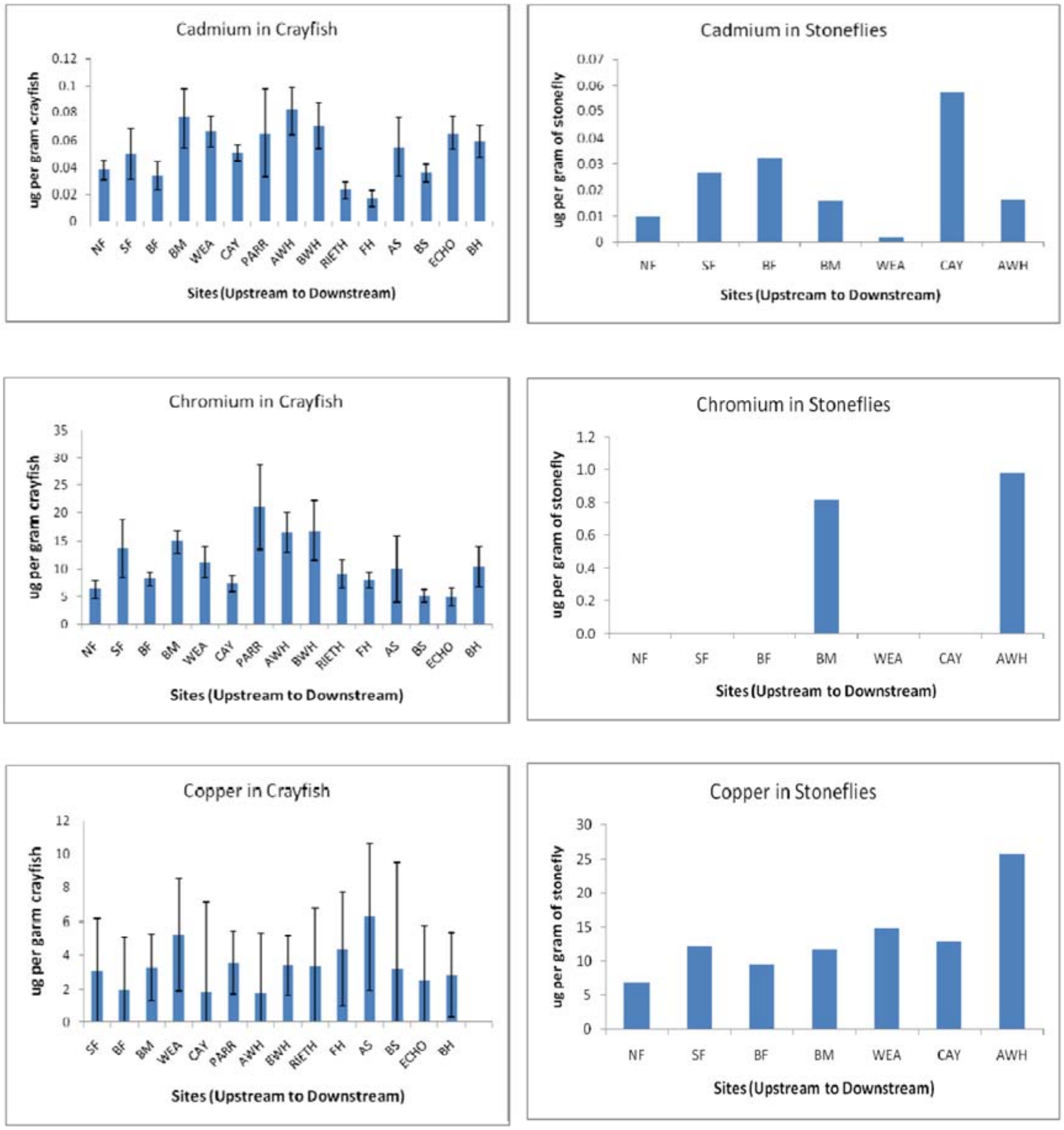

Figure 1. Levels of cadmium, chromium, and copper in crayfish and stoneflies (reported in µg per gram dry weight) collected from the Umatilla River in summer 2009. River sites are organized from upstream to downstream locations. Error bars for crayfish values represent ± SE and values for stoneflies represent a single composited sample.

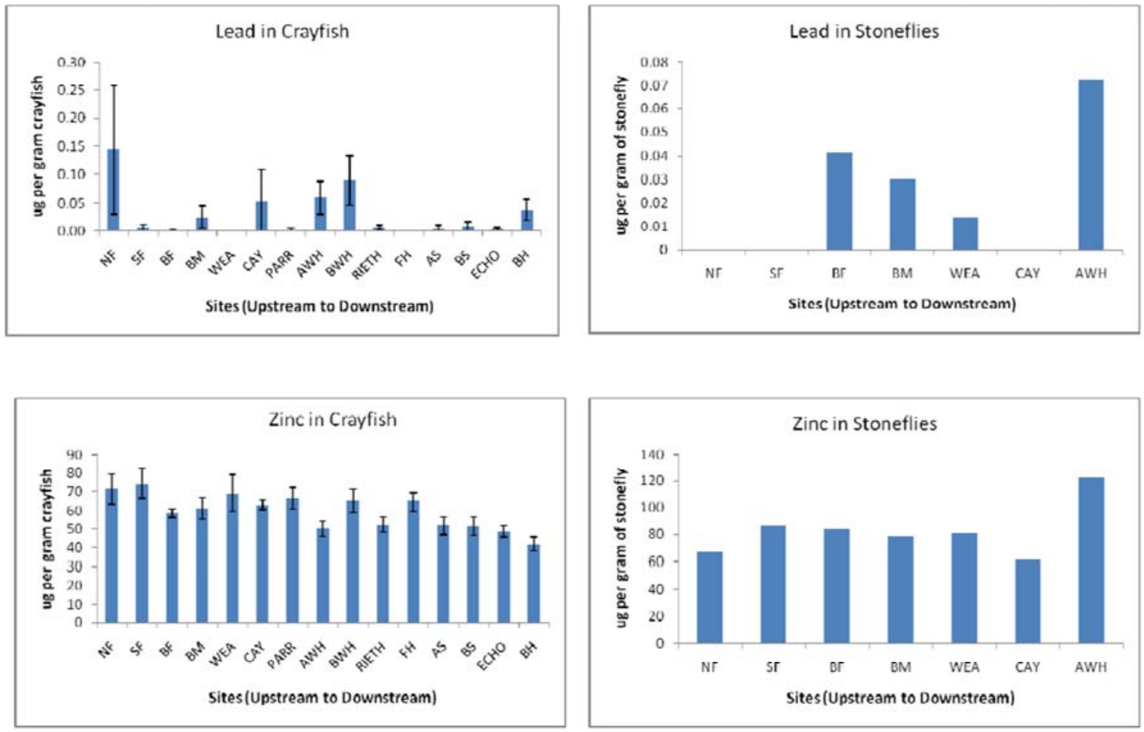

Figure 2. Levels of lead and zinc in crayfish and stoneflies (reported in µg per gram dry weight) collected from the Umatilla River in summer 2009. River sites are organized from upstream to downstream locations. Error bars for crayfish values represent ± SE and values for stoneflies represent a single composited sample.

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Vegetation and Soil Processes in Restored Wetlands

Basic Information

Title:	Vegetation and Soil Processes in Restored Wetlands
Project Number:	2009OR112B
Start Date:	3/1/2009
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	5th
Research Category:	Water Quality
Focus Category:	Wetlands, Conservation, Management and Planning
Descriptors:	None
Principal Investigators:	Mary Santelmann

Publications

There are no publications.

Progress Report
May 26, 2010

Vegetation and Soil Processes in Restored Wetlands

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Project period: March 1, 2009-February 28, 2011
Report Period: March 1, 2009-May 26, 2010

EXECUTIVE SUMMARY

Wetlands have been identified as critically important for provision of a number of ecosystem services such as water quality improvement, flood protection, and conservation of native plant and animal diversity (Mitsch and Gosselink 2007, Costanza et al. 1997). Wetland restoration is being considered as a watershed-scale tool for assisting in the meeting of these ecosystem services (Primovich 2008; Willamette Partnership 2008). Several recent reviews have discussed the need to incorporate information concerning provision of ecosystem services into tools that help decision makers evaluate alternative policies for land use and management (Kentula 2007). However, the most commonly used methods used to evaluate wetland functions often rely on site characteristics assumed to be associated with particular functions (such as denitrification, or other forms of nitrogen removal) in the absence of actual data concerning the level to which a particular wetland site actually performs such a function. For example, currently used hydrogeomorphic (HGM) assessments score wetlands for certain observed variables and relate these variables semi-quantitatively (on a scale from 0 to 1 relative to reference sites) to specific functions (Smith et al. 1995; Adamus and Field 2001), producing a site-level score related to estimated site quality or ability to perform functions as compared to reference sites. There is a need for research on how wetland vegetation, soil characteristics, and soil microbial communities interact in wetlands to influence processes such as denitrification, and to understand how these environments compare to agricultural fields, which may also provide some of the same ecosystem services. In addition, we need to better understand how different methods used in restoration may influence these processes.

Results of this project have assisted in advancing our understanding of vegetation and soil responses to various restoration scenarios, and will assist in the development of further research for evaluation of the ability of restored wetlands to provide ecosystem services such as conservation of native plant diversity and nitrogen removal through various soil processes such as N2O evolution and denitrification. An improved understanding of the range of values and natural variability in soil nitrogen processing is an important first step in development of benchmarks for evaluating restoration success.

We investigated relationships among wetland restoration methods, establishment of native vegetation and soil characteristics (such as soil organic matter content, soil water content) in influencing three endpoints for evaluating wetland restoration success: (1) per cent cover of native plants and plant diversity (2) soil potential for denitrification/ N-processing as measured by denitrifying enzyme activity (DEA), and (3) soil microbial communities at three restored wetland sites, three natural wetland sites, and three agricultural sites that were being used for crops, but resembled sites that have been restored to wetland vegetation prior to their restoration.

The project addressed issues of long-term water and watershed management with an emphasis on sustainable solutions that balance stewardship of resources with economic viability. We partnered with the USDA NRCS and the Portland Metro wetland mitigation programs to assist them in evaluating the degree to which wetlands are fulfilling their intended role. We promoted education about and implementation of sustainable practices for improved watershed management by presenting our findings at meetings, and plan to publish the project results in peer-reviewed journals such as Restoration Ecology. The results of the project will also provide materials for lectures in courses taught by the PI and co-PI.

PROJECT DESCRIPTION

Project results and benefits

The project described here was intended to result in an improved understanding of wetland vegetation and soil processes in restored wetlands as compared to natural wetlands, or the agricultural fields that are converted to wetlands through programs, and to provide baseline information for preparation of a follow-up research proposal to a funding agency such as the National Science Foundation or EPA. In addition, the project helped to build collaborative relationships as well as identifying hypotheses and research questions for follow-up proposals.

Nature and scope of project

We hypothesized that denitrification enzyme activities (DEAs) would be related to soil properties such as soil organic matter (SOM) and nitrate in soil water, and that recently restored wetlands and adjacent cropped areas would have more homogeneous soils than natural wetlands. We expected that recent restorations and cropped areas would have relatively low and less variable potential for denitrification as measured by DEAs (cf. Bruland et al. 2006). We also anticipated that native plant species might respond differently to variation in soil processes, and that both the legacy of prior use on soils of restored wetlands and feedback between vegetation and soils in these wetlands over time would influence the rate at which these restorations achieve the goals of enhancing native plant diversity and providing habitat for native species.

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We addressed three project objectives with the research reported here:

1. To determine rates of DEA in wetland soils and explore the potential relationships among vegetation, soil characteristics, and soil processes such as denitrification.
2. To measure wetland site response to different restoration methods and evaluate these methods for their relative success in establishing native plant cover and native plant diversity
3. To measure wetland site response to different restoration methods, and compare soil microbial communities in wetland remnants, restored wetlands, and adjacent cropland.

All three objectives have been met and both of the students whose research comprised the project have made presentations to their peers concerning their research results.

METHODS

Study Region

The NRCS is currently working on several wetland restoration projects in the Tualatin River Basin near Forest Grove and in conjunction with The Nature Conservancy and other partners have established a wet prairie restoration at Gotter Prairie. We selected reference sites from wet prairie remnants in the region with the assistance of Kathy Pendergrass of the USDA NRCS, and agricultural field sites for comparison with the assistance of Portland Metro, the USDA NRCS and the US Fish and Wildlife Service. All but the Green Mountain reference site and the Westbrook agricultural field are within the Tualatin River Basin. The Green Mountain wet prairie remnant is just north of the Tualatin River Basin near Camas, Washington and the Westbrook site is just south of the Tualatin River Basin near Rickreall, Oregon.

Vegetation analyses

At each study site, a set of three 10 x 10 m vegetation plots were placed within the wetland at randomly selected coordinates, with nested 1 x 1 m vegetation plots at the northwest and southeast corners of the plot. In each plot, all vascular plant species were identified and visual estimates of the per cent cover of each species as well as the portion of the plot which was bare ground or water were recorded. Verification of field identifications (especially for grass and sedge species) is being conducted in cooperation with the Dr. Richard Halse of the Oregon State University herbarium. Once these verifications are complete (estimated completion data June 15, 2010) the data will be analyzed using the ordination program PC-ORD and the groupings of sites according to different ordination methods (DECORANA and NMDS) will be evaluated to see whether restorations and remnants are similar to each other, and to compare cover of graminoids and forbs in the vegetation characteristic of the site.

In addition, at one restoration site where an experiment with different seeding treatments had been established (grass only, forbs only, grass + forbs together), three replicate 1 x 1 m plots were located in each of the three replicate treatment plots, for a total of nine 1 x 1 m plots per treatment and 27 overall, to investigate effects of seeding treatment on plot diversity. The USDA NRCS is fully-funding all aspects of the seeding treatments at the Hutchinson restoration, but has no funding dedicated to monitoring or evaluation of restoration success. Our project provided initial monitoring of the first year results of these seeding treatments with respect to species diversity, as well as data from additional sites in the region for comparison. A second year of vegetation analysis of the seeding treatment experiment plots at the Hutchinson site is planned for July 2010.

Soil sampling

Soil sampling occurred seasonally to capture the major changes in soil water content and temperature. Soils were sampled seasonally, at four dates throughout one year: in September 2009 prior to the rainy season, in November 2009 at the start of the rainy season, in February 2010 in the height of the rainy season, in April 2010 towards the end of the rainy season. Five soil samples from each plot were collected at approximately 10 m intervals, starting at about 1 m from the northwest corner of the plot. All samples were collected within 25 m of the boundary of the plot. Each sample was collected using a metal soil core (2.5 cm diameter), collecting the top 15-20 cm of soil. The five soil cores from each plot were composited into a plastic bag and refrigerated until processed. This provided three composite samples of about 500 g (wet weight) of soil from each study site at each sampling date.

Soil analyses

Each composite soil sample was measured for potential N_2O and denitrification enzyme activity. Samples were also processed for extraction of DNA for analysis of the size and composition of the denitrifier community (Rich and Myrold, 2004). Analyses of these DNA extracts will be conducted by the undergraduate student over the summer of 2010. Ancillary measurements of soil water content, nitrate concentrations, and soil organic matter content were also made using standard methods.

Denitrification Enzyme Assays (DEAs)

Soil (~20 g wet weight) from each sample was weighed into a 125-ml Erlenmeyer flask amended with 25 ml of a solution containing final concentration of 240 μg glucose-C ml^{-1} glucose and 40 μg KNO_3-N ml^{-1}. Flasks were sealed with rubber stoppers. The headspace of the flask was flushed with Argon gas for 1 minute. All flasks were placed onto a shaker table for 1 hour on speed 2 to allow the soils to reach room temperature and thoroughly mix with the glucose-nitrate solution. After the hour, 500-µl samples were removed from the flask via gas-tight syringes and injected into a Varian 3700 Gas Chromatograph equipped with a ^{63}Ni electron capture detector. Eight 500-µl samples were injected (once every 30 minutes). After the first three injections, 12 ml of acetylene gas was added to each flask (acetylene was added immediately after injection three so each flask had 30 minutes of exposure to acetylene before injection four).

Nitrate

Soil (~10 g) was weighed into screw top containers and 50 ml of 0.05 M K_2SO_4 was added to the containers. These were shaken for 60 minutes and the contents were poured into filter-lined funnels and filtered (Whatman #2) into small screw cap vials. An Astoria Pacific authoanalyzer was used to measure NO_3^- concentration by the cadmium reduction method.

Water content

Approximately 20 g of soil were weighed into metal tins. These tins were placed into a drying oven at 100 degrees Celsius for 24 hours. The tins were removed and re-weighed to determine the water content of each soil sample.

RESULTS

Here we present the initial results from the first year of field and laboratory work on the project.

Soils analyses

Average moisture content of the soils varied among sites, with the lowest values in September (15% to 38%) and the highest values in November (25 to 46%). The Knez site was the wettest of our study sites, and samples from that site had the highest soil moisture content, ranging from 38 to 46 % (Table 1). Soils from the wet prairie remnant sites tended to have higher soil moisture content (17 to 46%) than the restorations (15 to 32%), whereas the lowest soil moisture content was found in samples from the agricultural field sites (11 to 27%).

Measurements of soil organic matter content and soil texture will be conducted in June 2010. Processing of the DNA extracts to identify composition of the soil microbial community will also be done over the summer of 2010.

Data on soil moisture content (the average of the three samples collected at each of the study sites in each sampling period) are presented in Table 1 below.

Table 1. Average soil moisture content in samples collected at project study sites				
Site	**% Moisture (September)**	**% Moisture (November)**	**% Moisture (February)**	**% Moisture (April)**
Wet Prairie Remnants				
Knez	0.38	0.46	0.42	0.39
Gotter Prairie S	0.17	0.48	0.39	0.33
Green Mountain	0.26	0.42	0.45	0.36
Wet Prairie Restorations				
Hutchinson	0.20	0.32	0.31	0.25
Lovejoy	0.18	0.32	0.27	0.24
Gotter Prairie N	0.15	0.26	0.30	0.26
Agricultural Fields				
Zurcher	0.19	0.26	0.26	0.22
Westbrook	0.11	0.27	0.28	0.26
Gotter Prairie	0.18	0.25	0.25	0.18

Rates of N_2O evolution from soil samples were available for samples from all sites collected in February and April (Figures 1 and 2 below). Technical difficulties with the analytical equipment resulted in poor quality data for samples collected in September and November, however, these issues were soon resolved, and we were able to obtain data for the final two sampling periods.

Highest rates of N_2O evolution were found for the Knez remnant site, the Gotter Prairie South remnant, and the Hutchinson restoration in February. In April, soils from the Knez site again had a relatively high rate of N_2O evolution, as did soils from the Green Mountain prairie remnant site, followed closely by the Gotter Prairie agricultural site and Hutchinson restoration. The Gotter Prairie N and Lovejoy Restoration, Westbrook and Zurcher agricultural sites tended to have lower rates of N2O evolution in both sampling periods. Once data on soil organic matter content and on microbial communities are available from summer 2010 analyses, we will have the information we need to investigate the relationships among soil characteristics and nitrogen processing.

Figure 1. Rates of N2O release from February sampling period.

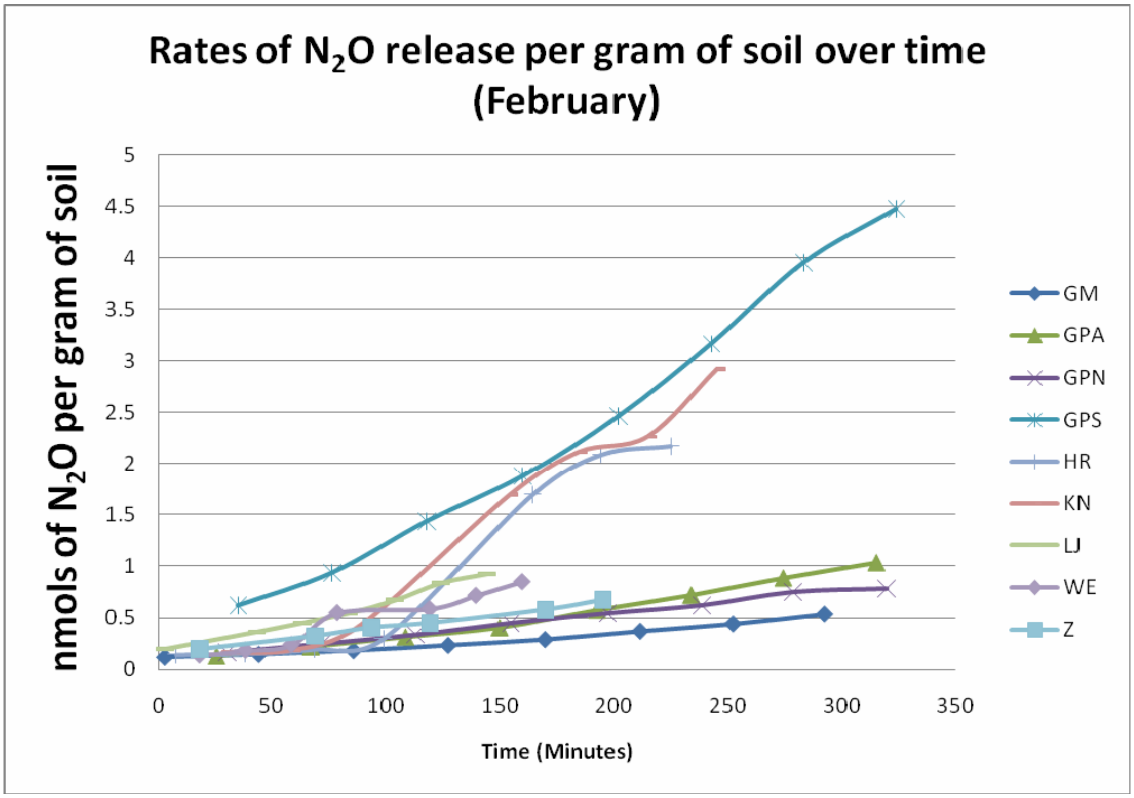
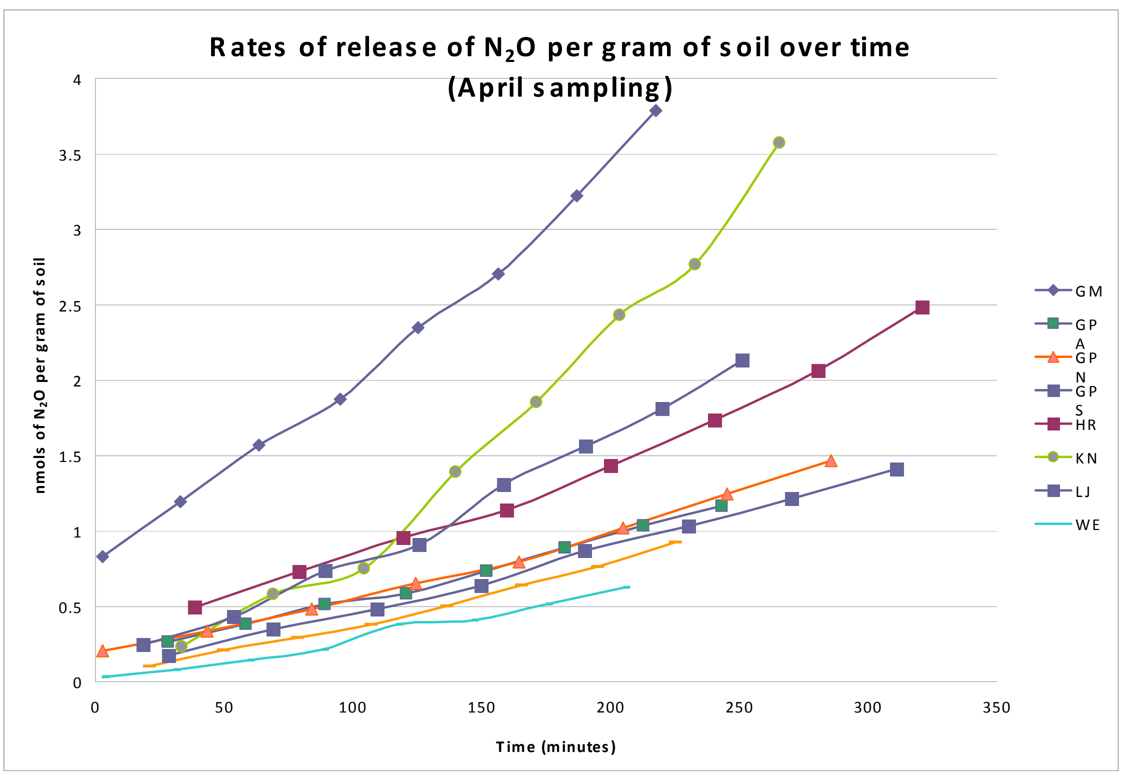


Figure 2. Rates of N2O release from April sampling period



Vegetation analyses

Data presented here are preliminary, since the final verification of all field identifications has not yet been completed for about 10% of the specimens collected. However, our expectation is that the additional data will not result in any qualitative changes to the results presented below.

As expected, the agricultural sites have no native species present, and were dominated by crop plants (rye grass or corn) and a few non-native weed species. The wet prairie remnant sites tended to have the highest proportion of native species richness (58 to 88 % of the species present were native species with an average of 73% native species over all). The % native species richness of the plots sampled at the Hutchinson and Gotter Prairie North restoration was comparable to that found in the wet prairie remnants at Knez, Gotter Prairie South, and Green Mountain, indicating that the substantial efforts made by the USDA NRCS, The Nature Conservancy, Portland Metro (and numerous volunteer organizations) to plant native species and maintain conditions that favor native wet prairie species at these sites have been relatively successful. The Lovejoy restoration had the lowest proportion of native species of any of the remnants or restorations.

Plans for continued work over the summer include completion of verification of the field identifications from the 2009 sampling season, ordination of the data and exploration of the relationships between soils and vegetation data, as well as return visits to the Hutchinson restoration site in July to continue monitoring of the experimental plots in which the three different seeding treatments were used (grasses only, forbs only, and grasses plus forbs).

Table 2. Native Species as a Proportion of Species Richness at Wet Prairie Sites*

Remnant Prairie (Reference)	
Knez	58%
Gotter Prairie South	88%
Green Mountain	72%

Restored Prairie	
Hutchinson	58%
Lovejoy	41%
Gotter Prairie North	82%

Agricultural Sites	
Zurcher	0%
Westbrook	0%
Gotter Prairie Ag	0%

*These are preliminary data, since several unknown species still need to be identified and recorded. Values for the percentage of species richness due to native species may change slightly when the list of the complete set of species from each site has been verified.

Outreach and Information Dissemination

One graduate and one undergraduate student have benefited directly from the work in this project, which is the subject of the MS thesis for an Environmental Sciences graduate student, Sara Taylor, and an honors thesis for Elizabeth Leondar, an undergraduate in BioResource Research degree program.

Taylor presented her initial results at the student competition organized by the Oregon Chapter of the Air and Waste Management Association held on April 8th, 2010 at Portland State University. The presentation won second place in the competition and the student received a prize of $150.

Leondar presented her work at the annual student symposium for the BioResources Research degree program in May.

Both students will be preparing papers individually, and project participants will collaborate on an article for potential publication as a research article targeted to a journal such as Wetlands or Restoration Ecology. In addition, a short note on the soils data and results of the microbial community analyses will be prepared for publication in an appropriate journal such as Soil Biology and Biochemistry.

CONCLUSIONS

Soils analyses

While our results to date are preliminary, there is some indication that soils with higher soil moisture content were associated with higher rates of N_2O evolution. Further progress on the project over the next few months should allow us to obtain data on microbial communities in the soils from our study sites, and allow us to compare nitrogen processing to soil characteristics such as soil organic matter content, soil moisture and soil nitrate concentrations, and possibly to total plant cover or proportion of cover in graminoids as compared to forb species.

We will use these data to develop additional hypotheses concerning the important drivers of nitrogen cycling processes in these types of soils, and to prepare proposals to follow up on this initial investigation of vegetation and soil processes in wet prairie wetlands.

Vegetation analyses

Our preliminary results indicate that while plant species richness in wet prairie restorations can approach that found in native wet prairie remnants, some restorations are less diverse. Information about the effectiveness of different restoration practices and management efforts may help improve restoration design and implementation. Efforts will be undertaken in the summer of 2010 to obtain the data that will allow us to explore relationships between historic legacies of site use prior to restoration, methods used to establish the sites as wetland restorations, and practices used to manage the different wetland remnants and restorations on establishment and persistence of native species. In addition, we will analyze the data to look for relationships between soils, vegetation, and nitrogen processing in order to develop hypotheses about these relationships to guide future proposals concerning provision of ecosystem services by wetlands and agricultural fields.

Building relationships with other organizations and individuals

Through activities conducted as part of this project, we were able to make connections with key partners in the northern region of the Willamette Valley including staff from the USDA NRCS, Portland Metro, The Nature Conservancy, the US Fish and Wildlife Service, and some private landowners. These connections can provide additional opportunities for collaboration on future projects. In addition, our project has increased the visibility of Oregon State University researchers and provided valuable assistance to those conducting wetland restoration as well as research on restoration outcomes in Oregon.

ACKNOWLEDGEMENTS

We thank Kathy Pendergrass and her colleagues at the USDA NRCS in Portland, as well as Kurt Zonick and Portland Metro for their assistance in locating restoration, agriculture, and some remnant study sites and in the field. We thank the staff at the Wetlands Conservancy, the US Fish and Wildlife Service and the Nature Conservancy for their assistance in locating some of the wet prairie remnant and agricultural study sites as well. We are especially grateful to the private landowners who allowed us to sample soils and establish vegetation plots on their properties, and to Dr. Richard Halse for assistance with verification of species identifications for plant specimens collected from the vegetation plots.

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Synthesis of Traceable Nanoparticles for Studying the Fate and Transport of Engineered Nanomaterials in Aquatic Systems

Basic Information

Title:	Synthesis of Traceable Nanoparticles for Studying the Fate and Transport of Engineered Nanomaterials in Aquatic Systems
Project Number:	2009OR113B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Water Quality
Focus Category:	Methods, Toxic Substances, Water Supply
Descriptors:	None
Principal Investigators:	Jeff Nason

Publications

There are no publications.

Synthesis of Traceable Nanoparticles for Studying the Fate and Transport of Engineered Nanomaterials in Aquatic Systems

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Report Period: 3/1/2009 – 2/28/2010

Submitted to IWW: 5/26/2010

Executive Summary

Engineered nanomaterials hold great promise for technological innovation due to unique properties that emerge at the nanoscale. As a result, nanomaterials are increasingly being incorporated into consumer products ranging from electronics to cosmetics, and are being evaluated for novel drug delivery and treatment of contaminated water. Unfortunately, the boom in nanoscience and nanotechnology research has not been paralleled with an equal effort investigating the environmental implications of nanomaterials. Concerns about the environmental health and safety aspects of nanomaterials are global; production, distribution, use and disposal of nanoparticles will undoubtedly result in their release into the environment, including the surface water and groundwater of Oregon. Yet, little is known about the prevalence, behavior and risks of nanomaterials in the environment.

At present, very few analytical techniques are capable of unambiguously identifying and characterizing nanomaterials in environmental matrices. As such, investigations into the fate and transport of nanomaterials have been limited to simplified systems that do not accurately reflect true environmental conditions. The proposed work in the funded proposal aimed to bridge this current gap in understanding by:

1. Synthesizing titanium dioxide nanoparticles doped with one or more elements such that they can be quantified by prompt-gamma activation analysis (PGAA) in complex, environmental matrices; and

2. Demonstrating the utility of doped nanoparticles in preliminary, bench-scale experiments targeting the fate and transport of engineered nanoparticles in aquatic systems.

We have made substantial progress on both of these objectives over the last year. Titanium dioxide nanoparticles have been synthesized in our laboratory and several attempts have been made to dope those particles with different “tracer” elements. We have characterized those particles and utilized them in preliminary experiments probing environmental fate and transport. Preliminary data in these areas were incorporated into a proposal to the National Science Foundation in the fall of last year. Although not funded, the favorable comments received as a result of that submission have fueled our continued research. We are continuing to make progress on both objectives with the aim of resubmitting the proposal this coming fall or spring.

Project Description

An important field of environmental research that has emerged recently is the understanding of the transport and fate of engineered nanomaterials (NMs) in the environment. NMs are defined as manmade objects with at least one dimension less than 100 nm; nanoparticles (NPs) are a subset of NMs that have two or three dimensions smaller than 100 nm. At these length scales, materials exhibit unique and enhanced properties in comparison with their macroscopic counterparts. It is due to these enhanced properties that NMs are being increasingly exploited in a multitude of applications ranging from semiconductors, solar cells and advanced composite materials (Nakade et al. 2002) to drug delivery, sunscreens and cosmetics (Nohynek et al. 2007). At present, the development, production and incorporation of engineered NMs into consumer products is proceeding at a rapid rate. Unfortunately, little is known about the environmental impacts of NMs (Klaine et al. 2008; Wiesner et al. 2006). Therefore, since NMs hold tremendous promise, it is critical that we understand if, when and how these materials enter the environment; what happens to them when they do enter the environment (fate and transport); what risks they pose to organisms they come in contact with; and when necessary how best to remove these from water streams treated for human consumption. In this work, we are developing a novel tool that has the potential to facilitate research in all of these areas.

One of the major challenges associated with studying the fate and transport of engineered NMs is the current inability to accurately and unambiguously detect and characterize NMs in environmental matrices. Low ambient concentrations of engineered NMs, coupled with high background concentrations of naturally occurring elements, make quantification in the environment extremely difficult. Similar problems plague efforts to design laboratory experiments that more accurately simulate the behavior of engineered NMs in environmental systems. For example, experiments focused on the fate and transport of engineered NMs have neglected the presence of aquatic colloids due to the difficulty in separating them from the target NMs. In an effort to bridge this current knowledge gap, we propose to develop a new research method coupling purposefully synthesized NPs that are labeled with elements towards which prompt gamma ray activation analysis (PGAA) has extremely high sensitivity, such as rare earths (lanthanides). Against the low environmental background concentrations of the rare earth metals, we will be able to detect the concentrations of these “labeled” NMs in complicated matrices using PGAA.

We are working to develop methods for the synthesis of well characterized labeled titanium dioxide (TiO_2) NPs. Once synthesized, we aim to demonstrate their utility in bench-scale tests examining the association of NMs with naturally occurring aquatic colloids and their removal from surface water via conventional drinking water treatment.

Progress to Date

Nanoparticle Synthesis: Several batches of "unaltered" and "doped" TiO_2 nanomaterials have been synthesized in our laboratory. Initial trials focused on familiarizing ourselves with, and fine-tuning the established sol-gel methods for preparing TiO_2 nanoparticles. Briefly, a solution of $Ti(nBuO)_4$ was prepared in ethylene glycol containing approximately 0.3 M Triton X-100 as a surfactant. The solution was cooled to 3°C and water was slowly added to a total concentration of 10% to induce the precipitation of nanocrystalline TiO_2. Following precipitation, excess water and nBuOH was evaporated and the solids were washed with ultrapure water and centrifuged.

Hafnium and europium have been investigated as possible dopants. Synthesis procedures were similar to those described above. For the Hf-doped particles, $Hf(nBuO)_4$ was added to the ethylene glycol solution along with the $Ti(nBuO)_4$. For the Eu doped particles, $EuNO_3$ was added to the ethylene glycol solution prior to precipitation. In both cases, the hope was that the Hf or Eu would be incorporated into the crystalline structure of the TiO_2.

Initial attempts to synthesize virgin titania and doped titania nanoparticles have been successful in terms of controlling particle size. Through the use of the surfactant (Triton X-100) to the water solution, we have been able to synthesize nanoparticles with Z-average diameters (as measured by DLS) of approximately 10 nm. We have also been successful in synthesizing TiO_2 nanoparticles doped with europium; again, average hydrodynamic diameters were less than 50 nm. Intensity weighted particle size distributions as measured by DLS are shown in Figure 1. Similar results have been achieved for Hf-doped particles. Although we have yet to characterize these particles in terms of their chemical composition or crystalline form, these initial successful attempts to synthesized doped particles are quite promising. Ongoing work is focused on further characterization, gaining increasing control of nanoparticle size, and developing methods for removing excess dopant from the suspending solutions.

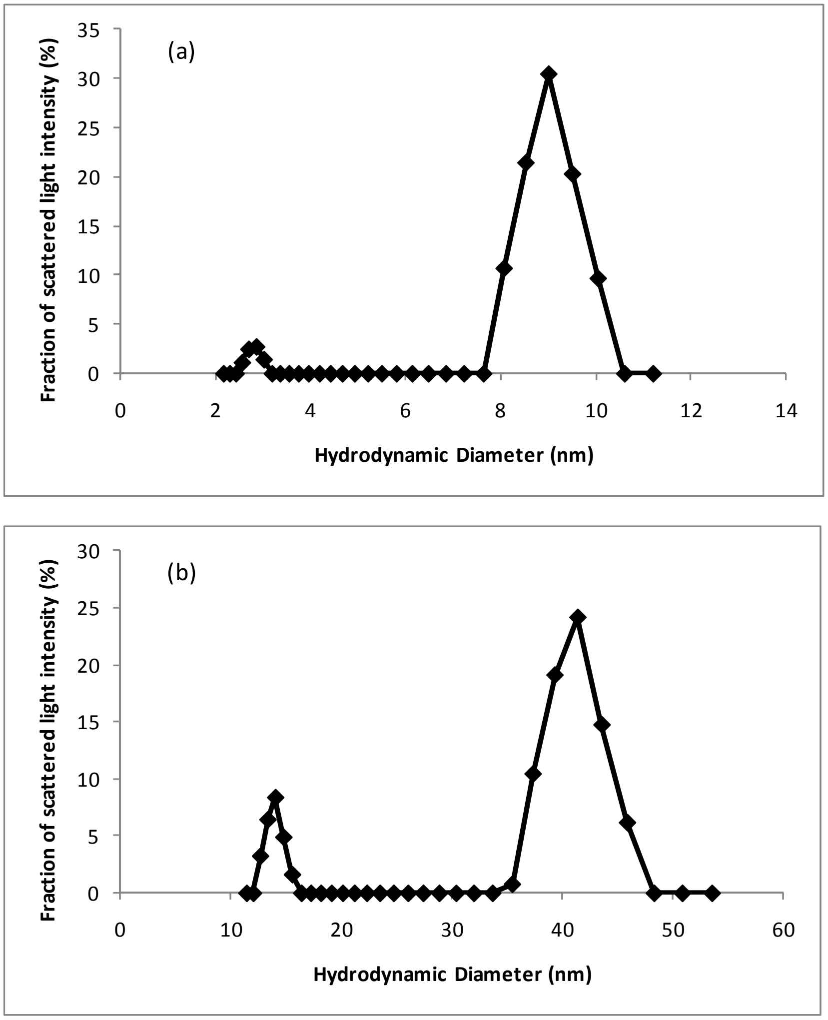

Figure 1. Intensity weighted size distributions for synthesized virgin TiO_2 nanoparticles (a) and TiO_2 nanoparticles doped with europium (b).

Probing Environmental Behavior: Preliminary experiments have been performed examining aggregation behavior of the synthesized TiO_2 nanoparticles, as well as removal of the particles during simulated drinking water treatment.

Aggregation kinetics for the synthesized NPs have been quantified using time-resolved DLS following a procedure similar to that employed by Elimelech and co-workers (Chen and Elimelech 2006; 2007; Chen et al. 2006; 2007). In short, aliquots of the NP suspensions were added to solutions of known pH and ionic strength (adjusted with monovalent or divalent salts) in 3 mL cuvettes. The intensity weighted hydrodynamic diameter (Z-average diameter) were monitored at regular intervals (~15 s) for a period of minutes to hours resulting in data like those shown in Figure 2, measured in our lab for synthesized TiO_2 NPs suspended in $MgSO_4$. The initial slope of the resulting lines are proportional to the absolute aggregation rate coefficient as shown in Equation (1) (Chen et al. 2006):

$$\left(\frac{d\left(a_h\right)}{dt}\right)_{t\to 0} \propto k_{11}N_0 \qquad (1)$$

Where a_h is the hydrodynamic radius as measured by DLS, k_{11} is the absolute aggregation rate coefficient and N_0 is the initial number concentration of primary particles.

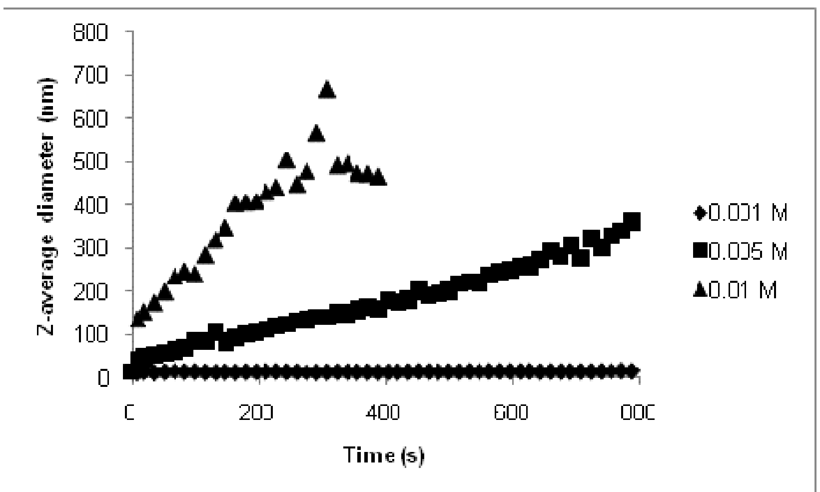

Figure 2. Aggregation of synthesized TiO_2 nanoparticles in $MgSO_4$.

Once quantified, the absolute aggregation rate coefficient for virgin and doped NPs will be compared to verify similarity. In instances where differences between the virgin and doped particles warrant further investigation, aggregation behavior will be examined at a range of pH and ionic strength. By performing time-resolved DLS experiments at a range of ionic strength, the dependence of the attachment efficiency on solution conditions (including the critical coagulation concentration) can be determined and compared between virgin and doped NPs (Chen and Elimelech 2006). Comparison of these characteristics and behaviors will confirm whether or not the virgin and doped nanomaterials behave similarly under a variety of water chemistries.

We have also examined the removal of doped TiO_2 nanoparticles during simulated conventional drinking water treatment. Synthesized nanoparticles were added to water and the pH adjusted to approximately 6.5 with sodium bicarbonate. Aliquots of the pH adjusted suspension were added to a series of beakers and varying doses of alum ($Al_2(SO_4)_3 \cdot 18\ H_2O$) were added to induce coagulation. Samples were rapidly mixed at 100 rpm for 30 seconds followed by 30 minutes of slow mixing at 30 rpm and 1 hr of quiescent settling. Samples of the settled supernatant were analyzed for Ti and the dopant as a measure of removal of the nanoparticles. Results comparing the removal of virgin TiO_2 and TiO_2 doped with 20 % Hf are shown in Figure 3. Interestingly, the removal of the Hf-doped nanoparticles occurs at a lower alum dose than the virgin TiO_2. This suggests that the doped particles did not behave in the same manner as the un-doped nanoparticles. Continued work is necessary to developed doped nanoparticles that behave in a similar manner as their un-doped counterparts.

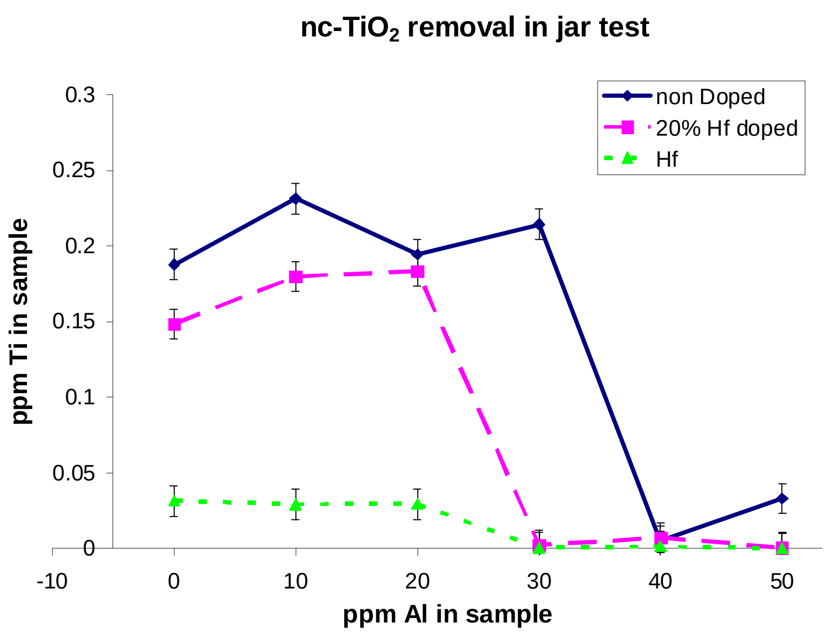

Figure 3. Removal of virgin and Hf-doped TiO_2 nanoparticles during jar tests simulating drinking water treatment.

Continuing Work

We are continuing to work on the synthesis, characterization and demonstration of doped nanoparticles. Continuing with the TiO_2 platform, we are investigating alternative dopants. In keeping with our preliminary work, initial tests will focus on cheaper dopants such as aluminum and strontium to perfect synthesis and characterization methods. Once perfected, doping procedures will be extended to lanthanides and rare earth elements that will be sensitive to PGAA analyses. Characterization will consist of dynamic light scattering, zeta potential, scanning electron microscopy, transmission electron microscopy and x-ray diffraction. Again, the aim is to develop nanoparticles that have a sufficient concentration of the dopant for detection in the environment. However, in order to serve as a useful probe, the particles must have similar characteristics and behavior as the un-doped particles.

Once synthesized and characterization confirms the doped nanoparticles are close surrogates of virgin TiO_2, synthesized nanoparticles will be utilized in additional experiments probing environmental transport and fate. Fundamental studies will focus on aggregation behavior and interactions with natural organic matter and natural particulate matter. Additional experiments will focus on the removal of nanoparticles during simulated drinking water and wastewater treatment. In these trials, doped and non-doped nanoparticles will be utilized simultaneously to demonstrate the ability to distinguish the doped nanoparticles from a natural background of Ti. In the end, we hope to deploy the doped nanoparticles in a simulated environmental transport situation (treatment process, wetland, groundwater flow, etc.).

Timeline

Activity	**Date of Completion**
Finalize TiO_2 synthesis/doping procedures	August, 2010
Nanoparticle Characterization	October 2010
Fate and Transport Experiments	December 2010
NSF Proposal Submission	March 2010

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Oregon Water Resources Department (OWRD): Developing an Integrated Water Resource Strategy

Basic Information

Title:	Oregon Water Resources Department (OWRD): Developing an Integrated Water Resource Strategy
Project Number:	2009OR114B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Social Sciences
Focus Category:	Water Quantity, Water Supply, Water Use
Descriptors:	
Principal Investigators:	Greg Perry

Publications

There are no publications.

The matching funding for this project was withdrawn due to the downturn in the state and national economy. The Principal Investigator returned the funding to the Institute for Water and Watersheds for reallocation. The funds have not been reallocated, but it is anticipated that the funds will be used for Technology Transfer.

Colloidal transport in variably saturated porous media: A detailed evaluation of colloid mobilization mechanisms

Basic Information

Title:	Colloidal transport in variably saturated porous media: A detailed evaluation of colloid mobilization mechanisms
Project Number:	2009OR115B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Not Applicable
Focus Category:	Groundwater, Solute Transport, Radioactive Substances
Descriptors:	None
Principal Investigators:	Dorthe Wildenschild

Publications

There are no publications.

The graduate student that was targeted for this funding left Oregon State University. The Principal Investigator returned the funding to the Institute for Water and Watersheds for reallocation. The funds have not been reallocated, but it is anticipated that the funds will be used for Technology Transfer.

Information Transfer Program Introduction

None.

Technology Transfer

Basic Information

Title:	Technology Transfer
Project Number:	2009OR107B
Start Date:	3/1/2009
End Date:	2/29/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Social Sciences
Focus Category:	Education, Law, Institutions, and Policy, Management and Planning
Descriptors:	None
Principal Investigators:	Todd Jarvis, Todd Jarvis

Publications

There are no publications.

For 2009-2010, the Institute for Water and Watersheds (IWW) participated and sponsored many events. IWW expanded their website and changed to a weekly newsletter which can be viewed at **http://water.oregonstate.edu**.

IWW discontinued its sponsorship of a fall seminar series on water policy and changed to a winter/spring seminar series focusing on science and technology as related to water resources with invited scholars from across the United States. Participation continues to grow in all sponsored events. For example, approximately 40 students in disciplines ranging from engineering, geosciences, and economics attended the weekly sessions in 2009-2010.

IWW also sponsored a water film series each week during the winter term of 2010. The film series was open to the public, and was regularly attended by 10 people with the bulk of the attendees being the general public.

IWW has also sponsored two grant writing seminars for junior faculty with an average attendance of 16 participants.

SHORT COURSE ON ISOTOPE HYDROLOGY AND ISOTOPE BIOGEOCHEMISTRY: DEVELOPING A CRITICAL MASS OF KNOWLEDGE AND EXPERIENCE

Basic Information

Title:	SHORT COURSE ON ISOTOPE HYDROLOGY AND ISOTOPE BIOGEOCHEMISTRY: DEVELOPING A CRITICAL MASS OF KNOWLEDGE AND EXPERIENCE
Project Number:	2009OR109B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrogeochemistry, Hydrology, Methods
Descriptors:	
Principal Investigators:	Anne W. Nolin, Anne W. Nolin

Publications

There are no publications.

FINAL REPORT:

SHORT COURSE ON ISOTOPE HYDROLOGY AND ISOTOPE BIOGEOCHEMISTRY: DEVELOPING A CRITICAL MASS OF KNOWLEDGE AND EXPERIENCE

Principal Investigator: Anne Nolin, Associate Professor, Department of Geosciences, Oregon State University, nolina@geo.oregonstate.edu, 541-737-8051;

Co-Investigator: Jeffrey McDonnell, Department of Forest Engineering, Oregon State University, Jeffrey.mcdonnell@oregonstate.edu, 541-737-8720;

Co-Investigator: Eric Sproles, Ph.D. student, Department of Geosciences, Oregon State University, sprolese@geo.oregonstate.edu, 541-729-1377;

Collaborator: Carol Kendall, Research Hydrologist, USGS, Menlo Park, CA, ckendall@usgs.gov, 650-329-4576.

SHORT COURSE DESCRIPTION

Summary: We held a two-day short course on isotope hydrology and biogeochemistry on June 8-9, 2009 at Oregon State University. There were 65 participants from government agencies, universities, and private industry. We had 30 graduate students from 7 different universities, 10 participants from government agencies (EPA, USGS, USFS, Makah Tribe), 9 participants from private industry, and international participants from Canada, United Kingdom, Cyprus, and Sweden.

The short course was structured to include introductory presentations on fundamentals of stable isotope analysis followed by more in-depth case studies. There was also poster session with about 50 posters as well as a hands-on computer course on Endmember Mixing Analysis (EMMA). We also had instrument demonstrations from two suppliers of Laser Cavity Ring-down Spectrometers. The presentations and poster session were held in the LaSells Stewart Conference Center and the computer course was held in the Geosciences Digital Earth Lab. Please see the attached agenda (Appendix A) for a list of invited speakers and presentations.

Budget: The budget provided from IWW/USGS for this short course was modest: $1,250. However, this seed funding provided a key leveraging opportunity and with this we were able to obtain additional funds of about $10K from the Graduate School that allowed us to proceed with the short course and expand it from a small, local course to a national/international effort taught by leading experts.

Learning objectives: We established specific learning objectives for the short course. Participants completing this short course should be able to:

(1) Describe the fundamentals of isotope hydrology and isotope biogeochemistry;
(2) Explain and use an end member mixing model (EMMA);

(3) Understand age-dating methods;
(4) Explain the various uses of isotopic tracers for hydrology and biogeochemistry;
(5) Describe appropriate project design, collection methods, and laboratory quality assurance.

<u>Topics</u>: Presentations covered a wide range of topics including watershed hydrology, vegetation/soil water use, water residence times, tropical glaciers, midlatitude glaciers, carbon & nitrogen cycling in soils, nitrogen in streams, foodwebs, "isoscapes", fish habitat, and techniques such as cavity ring-down spectroscopy and endmember mixing analysis.

<u>Evaluations</u>: Evaluation forms for the short course were prepared and given to all participants. Evaluation results are summarized in Appendix A. In summary, the overall score was Very Good (4.1 out of 5). Overall, the attendees thought the organization was very good, they loved the venue & food. The presentations, especially introductory material and breakout groups, were well received. The computer lab portion had the most mixed reviews -- some excellent some not very good.

To conclude, the short course attendance was excellent with representation from a wide range of users. The topics were diverse and were presented by experts in the field. There was a good mix of fundamentals, technical/practical, and cutting-edge material. Evaluations indicated that it was interesting and worthwhile to the participants.

APPENDIX A. AGENDA

Isotope Hydrology and Biogeochemistry Workshop
Oregon State University
LaSells Stewart Conference Center
June 8-9, 2009

AGENDA
Monday, June 8

8:00-8:30 AM	Breakfast (provided) and sign-in at LaSells Stewart Conference Center
8:30-9:00	Anne Nolin: Introduction and overview (Anne Nolin)
9:00-10:00	Jeff McDonnell: Isotope tracers and watershed hydrology Introduction
10:00-10:15	Coffee Break
10:15-12:00	Carol Kendall: Isotope fundamentals: terminology, fractionation, lab QA/QC; Brief overview of major isotope tools and their applications to hydrology and biogeochemistry
12:00-1:00 PM	Lunch (provided)

Isotope hydrology case studies

1:00-1:30	Renee Brooks: Two water worlds: Isotope evidence that trees and streams return different pools of water to the hydrosphere
1:30-2:00	Taka Sayama: Modeling isotope residence times
2:00-2:30	Jeff LaFrenierre: Using stable water isotopes to evaluate tropical glacier hydrological changes.
2:30-3:00	Manish Gupta: Latest advances in isotope studies using laser spectroscopy: High frequency, increased precision, and new applications
3:00-3:15	Coffee Break

Isotope biogeochemistry case studies

3:15-3:45	David Myrold: C and N Cycling in Soils: Learning a Lot with a Little Label

3:45-4:15	Dan Sobota: Tracking the fate of nitrogen in stream ecosystems using isotope additions: the Lotic Intersite Nitrogen eXperiment (LINX)
4:15-4:15	Aaron Van Pelt: Wavelength-Scanned Cavity Ring Down Spectroscopy-Based Analyzers:
	Applications in Stable Isotope Analysis
5:00-6:30	Cocktail reception/poster session/instrument demonstration (with Los Gatos Research, Inc. and Picarro, Inc.)

Dinner – on your own

Tuesday, June 9

8:00-8:30 AM	Breakfast (provided)

Isotope hydro/biogeochemistry case studies

8:30-9:00	Carol Kendall: Isotope applications to foodweb, food adulteration, and other forensic studies
9:00-9:30	Carol Kendall: Isoscapes: eye-candy and effective tools to address large-scale environmental challenges
9:30-10:00	Robbins Church: Stable isotopes of sulfur and oxygen in fish as indicators of habitat use
10:00-10:15	Coffee Break
10:15-12:00	Rick Hooper: End Member Mixing Analysis (EMMA)
12:00-1:00 PM	Lunch (provided)

EMMA Computing Session (Geosciences Digital Earth Lab, Wilkinson 210)

Tuesday, June 9	
1:00-3:00 PM	Rick Hooper: EMMA In-Depth: How do I do it?
3:00-3:15	Break
3:15-4:30	Rick Hooper: EMMA on computer
4:30-5:00	Wrap-up, synthesis, seque to beer

A Local Assessment of Abandoned Wells in Linn and Benton Counties

Basic Information

Title:	A Local Assessment of Abandoned Wells in Linn and Benton Counties
Project Number:	2009OR117B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	5th
Research Category:	Ground-water Flow and Transport
Focus Category:	Education, Groundwater, Management and Planning
Descriptors:	None
Principal Investigators:	Deron Carter, Deron Carter

Publications

There are no publications.

A Local Assessment of Abandoned Wells in Oregon's Linn and Benton Counties

Will Fulton, Crop and Soil Science, Oregon State University; Deron Carter, Geology and Physical Science Faculty, Linn-Benton Community College; Adam Stebbins, Benton County Water Projects Coordinator, Benton County Community Development.

Abstract

The purpose of this project is to locate and map unused wells in the Linn and Benton Counties of Oregon's Willamette river basin. Sections of these largely rural counties have as many as 50% fewer registered addresses as they have registered wells. The State Water Resources Department has approximately 10,000 recorded water well logs for Benton County and approximately 19,000 recorded water well logs for Linn County on record. High density water well sections are within older settlements that had established municipal water systems relatively late in their histories. Others contain unincorporated developments which, for various reasons, have had to drill new wells as the originals went dry, sometimes more than once. A few may be areas where extinct industries supported larger populations than exist today. Unfortunately, the precise locations of these defunct wells are often unknown.

Older, unused wells can conceivably be located too close to newer installations, such as feedlots or septic tank drain fields, or in areas since rezoned to industrial. If an unblocked passageway exists to the capture zone of such an unused well, whether on the surface or beneath it, then the opportunities for contamination of the groundwater and, eventually, the surface waters, also exists. The percentage of these unused wells that are improperly sealed, and thus a possible source of groundwater contamination, and the precise locations of such wells, comprise the critical information that this project is documenting.

Introduction

The Willamette Valley terraces of Benton and Linn Counties are composed of layers of alluvium brought in primarily by the Missoula Floods. Beneath these are layers of tuffaceous sandstones and siltstones extending fifteen hundred meters. The mountainous portions of the counties to the east and the west are underlain by igneous bedrocks, sometimes capped with layers of sedimentary rocks. Nearer to the valley floor, these bedrocks tend to be fractured basalts with depths of about one thousand meters. The faulting of these basalts is only partly understood. Wells in the hills yield high quality water, when and if they are productive; while wells in the valley sands and gravels are more reliably productive, but often give low quality water.

Landowners have had the right to dig wells on their properties since before statehood. As surface waters became polluted, more and more landowners dug wells. It wasn't until the Groundwater Act of 1955 that a principle of prior rights, which had already regulated surface water, was extended to groundwater. The primary concern of the Act was whether, how and when groundwater appropriation affected surface water flows. The Act did require landowners to log their wells, i.e., file a water supply well report upon completion of a new well; and after a slow start, citizens began to comply.

The Oregon Groundwater Act of 1989 empowered the state to monitor aquifers for contamination, and when specified thresholds were broken, appoint, through the Department of Environmental Quality, groundwater management committees. One of the three such appointed oversees the southern Willamette Valley and includes Linn and Benton counties in its jurisdiction. Requirements for legal abandonment of wells are described in Oregon Revised Statute 537.775, last edited in 2009. The same clause also empowers the Water Resources Commission to order well abandonment.

Although there are State Water Resources Department laws requiring abandonment (specific sealing) methods for unused wells, enforcement has been problematic. Many abandoned wells have simply been bulldozed from sight during land development projects (Bastasch, 248). Others are plainly visible, but their function is not understood by the property owners or tenants. Some are sealed, but have been done so inadequately relative to the specifications of the Oregon Revised Statutes.

The public has a poor understanding of unused and improperly abandoned wells and the harm they represent. In fact, the term itself is not well understood even within the water science and policy community. In Oregon governmental lexicon, to 'abandon' a well is to legally abandon a well, i.e. according to state specifications. For the purposes of this project an abandoned well was an improperly abandoned well. To the public, an abandoned well is a gaping hole in the ground into which a little girl might fall.

Materials & Methods

The first order of business was to decide how to efficiently and effectively locate the abandoned wells of Linn and Benton Counties. We decided to publish an announcement in all of the local papers inviting citizens to tell us about their wells (*Attachment 1*). First, though, we would need to write a rubric for prioritizing respondents' wells, so that we could concentrate on mapping those wells most likely to present a risk to the groundwater.

We did a search through the literature, to see how other communities prioritized unused well field assessments. Although we found no other projects exactly like our own, a few states had programs designed to prioritize among abandoned wells for the purpose of determining qualification to receive assistance from a state fund set up to help pay for sealing. The states with such programs were all in the upper Midwest. South Dakota provided the most information. We based our rubric on the South Dakota worksheet, adjusting here and there, and fashioning a questionnaire from the finished product. (*Attachments 2 & 3*)

The next step was to write the press release. We started with the Corvallis *Gazette Times*, thinking we would gauge the response from that release before going to the Albany, Lebanon and Sweet Home newspapers, in case we determined that rewording was necessary. At the same time we uploaded our prioritization rubric to a webpage so that we could refer citizens to it (see http://www.co.benton.or.us/boc/water/quest_09wwg.php). We braced ourselves for the rush.

It turned out that rewording was necessary. A few people did respond to our first appeal, but we certainly did not need to filter them through our prioritization rubric. In fact, we wound up rewriting our release twice, the last featuring the somewhat misleadingly enticing header: "Grant Money Made Available Locally for Finding Abandoned Wells."

Still, responses only trickled in. Our rubric gathered dust. We visited all of the respondents: between 30 and 40, but very few of the wells were actually illegally abandoned. Some people thought they might have a well, but didn't know where it was. So we wandered their properties, occasionally cutting our way through blackberries, twice so finding hidden wells, but usually just collecting abrasions.

We decided that we would have to do a door to door canvass. Now it was time to prioritize neighborhoods. Using state and county data, we went township to township comparing known total registered wells against wells legally abandoned. This approach enabled us to determine which neighborhoods were most likely to have illegally abandoned wells and were also conducive to a door to door canvass, i.e., we wouldn't have to walk a half mile between homes. Generally, these were relatively newly incorporated areas of cities. They were neighborhoods which existed before city water and sewage was extended to them.

Some of the field assessment choices proved fertile, such as south Corvallis and most of older Lebanon. Sweet Home, which we had thought would be littered with wells, had very few. Or, at least, so the residents claimed. In Lebanon, we noticed that the density of illegally abandoned wells often coincided with an increase in pit bull and Rottweiler density. We also discovered that many Lebanon residents intensely dislike their city's water department.

This is not to say that illegally abandoned wells exist only within a specific demographic. We also found illegally abandoned wells on properties owned by a municipality, a large hospital, and a major university.

One curious phenomenon was that a large neighborhood in Lebanon, near to the Lebanon Santiam Canal, had shallow hand dug wells apparently drawing from the hyporheic zone, all of about twenty years in age, and all used for domestic irrigation. We also spoke to two households within the Lebanon city limits who admitted that they used their private wells for drinking water and claimed that their well water had tested cleaner than the city water.

The equipment used to map the unused wells included a Trimble Pathfinder Pro XR sub-meter mapping grade GPS, a Garmin handheld GPS, and a Trimble Nomad field computer with ArcPad 8.0.

Results

We have mapped about 120 wells, which are fairly evenly divided into four categories: 1) improperly abandoned wells, 2) properly abandoned wells, 3) wells still in use for irrigation purposes, despite hookup to municipal water systems, and 4) wells for which we were unable to determine conclusive improper abandonment, for one reason or another. We have also visited several properties where owners believe, or records indicate that abandoned wells exist, but the wells were not readily located. *(attachments: maps 1-4)*

We broke these types of abandoned wells out according to their underlying geology, which is often layered, giving us total percentages over 100 for the properly and improperly abandoned well categories.

Table 1. Occurrence percentages of abandoned wells by hydrogeologic features.

Well condition	Principal hydrogeologic units		
	alluvium	sedimentary	volcanic
Properly abandoned	82%	9%	14%
Improperly abandoned	79%	14%	36%
Status uncertain	100%	0	0

* Percentage totals over 100% result from overlaying principle hydrogeologic units

Conclusions

Funding was used to purchase GPS units for well drillers, pump installers, and Linn-Benton Community College Geosciences students to continue to actively gain latitude and longitude (X,Y) coordinates for unused and used well heads within Benton and Linn Counties. Linn Benton Community College will make some of these GPS units available to local well drillers, who have agreed to report latitudes and longitudes of any abandoned wells encountered during the course of their regular work. These coordinates will be reported by email to Deron Carter at LBCC, who will record them in Excel and as GIS layers on the maps shown (Maps 1-4), along with data collected by his students.

An additional benefit which this strategy should impart to LBCC will be a perception by the community of service given to the community.

Recommendations

Door to door 'canvassing' of properties should concentrate on those established outlying neighborhoods where either annexation to a municipality, or development of a community water district occurred after a sizeable amount (20-100 plus) of a neighborhood's domestic wells had been installed. Those neighborhoods located on known hydrogeologic units with water quality and aquifer supply issues should be given priority, when a canvass is conducted. GPS locating and GIS database updates/mapping should occur in counties actively working to improve groundwater quality and supply issues. As western Oregon and the Willamette Valley county rural populations increase, the understanding, tracking, and supporting of proper abandonment of unused water wells will only increase in importance to protecting the shared beneficial uses of groundwater and surface water resources.

As noted in the introduction, the meaning of 'abandoned well' is differently understood by different stakeholders. Most of those homeowners who do understand the terminology, also understand that unused wells are to be sealed according to government mandated specifications at a typical cost not inexpensive to most. Some states currently provide assistance to landowners whose property may include abandoned wells, but for whom proper sealing would be a hardship. Targeted properties are usually located in areas recognized as having vulnerable hydrogeology. Given our less than comprehensive understanding of the network of fractures in the underlying basalts of much of our region, given our wealth of surface waters, given the economic pinch in which many of our citizens find themselves, and given the need to protect our groundwaters and the public health, programs to assist landowners to legally seal their unused wells should be considered.

Acknowledgements
Institute for Water and Watersheds, 210 Strand Agriculture Hall,Oregon State University, Corvallis, OR 97331-2208
Sackinger, Doug, GIS Coordinator, Benton County, Oregon, 360 Avery Ave., Corvallis, OR 97333

References

Bastasch, Rick, *The Oregon Water Handbook,* 2006, Oregon State University Press, Corvallis, OR.
Frank, F.J., *Ground Water in the Corvallis-Albany Area, Central Willamette Valley, Oregon,* 1974, United States Department of the Interior, U.S. Government Printing Office, Washington, D.C..
Gilbertson, J., Abandoned Well Sealing Demonstration Project Final Report, South Dakota Department of Environment and Natural Resources, Watershed Protection Project, 2002, 51 pages.
Nealson, E.N., Thompson, C.A., and Van Dorpe, P.E., Guide to Conducting a Wellhead Contaminant Source Inventory, 2001, Iowa Department of Natural Resources, Geological Survey Bureau, 21 pages.
Institute for Water and Watersheds, Oregon State University, *Willamette River Water Quality Map*.

Attachment 1: example of town specific news release, this one for Sweet Home.

Grant Money Made Available Locally For Finding Abandoned Wells

A grant from Oregon State University Institute for Water and Watersheds has been awarded to assist in locating unused wells in Linn and Benton Counties. Citizens who think that there may be unused wells on their property should fill out the short 2009 Well Water Grant Questionnaire online at http://www.co.benton.or.us/boc/water/index.php . Click on "Water Well Grant Questionnaire".

Unused or abandoned wells can become an entryway for contaminants to reach our groundwater, the source of drinking water for many Linn County residents. State records show that in many areas there have been many more wells dug than there are homes. This is particularly true in Sweet Home.

Not all abandoned wells look like holes in the ground

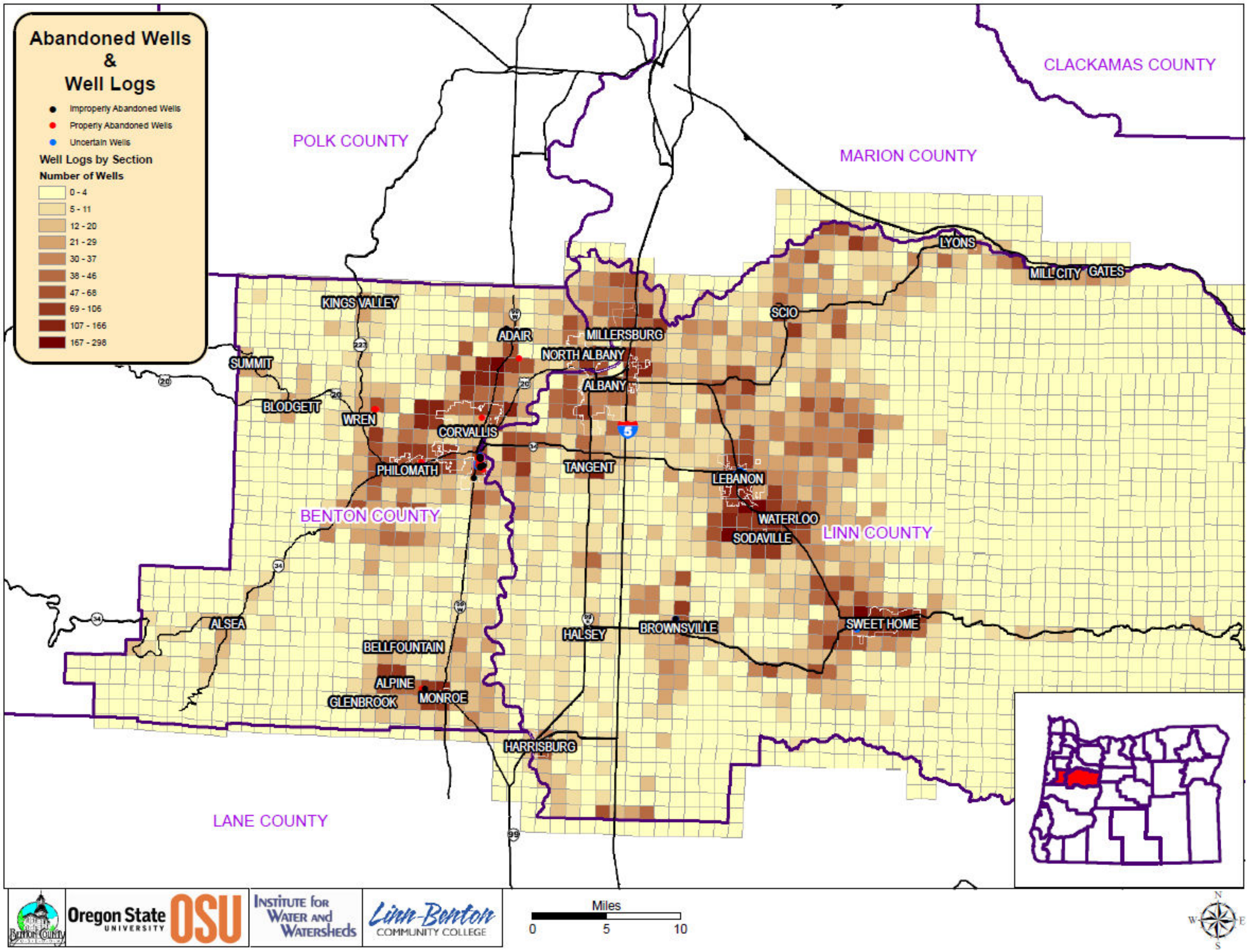
Attachment 2: rubric for prioritizing unused wells:

Targeting Priorities			Value:
<u>Proximity of contaminating sources</u>			
known			(10 for < 10m, 1 for >100m)
possible			(5 for < 20, 1 for > 100m)
age of homes:	before 1974		10
	after 1974		5
zoning:	always residential		0
	currently ag		(1-10, based on crops and methods)
	previously ag		(1-10, based on crops and methods)
	currently livestock		(1-20, based on animal density)
	previously livestock		(1-20, based on animal density)
	currently industrial		
		light	5
		heavy	10
	previously industrial		
		light	3
		heavy	10
ratio of wells to homes			(2 x #)
<u>Hydrogeology</u>			
Media	porous		10
	medium		5
	retarding		0
Topography	flat		0
	gentle slope		5
	steep slope		10
<u>Location, locating</u>			
Undeveloped residential within urban growth boundaries			10
Population declining			10
Population static			0
Well density	high		10
	average		5
	low		0
well pairing with septic tanks			5
within source water protection area			10
riparian			
proximity of wetlands			
reliability of existing records			(1-5, 5 high)
Cooperativeness of landowner			(1-20, 20 enthusiastic)
History of health problems			10
Is DEQ already addressing?			-8

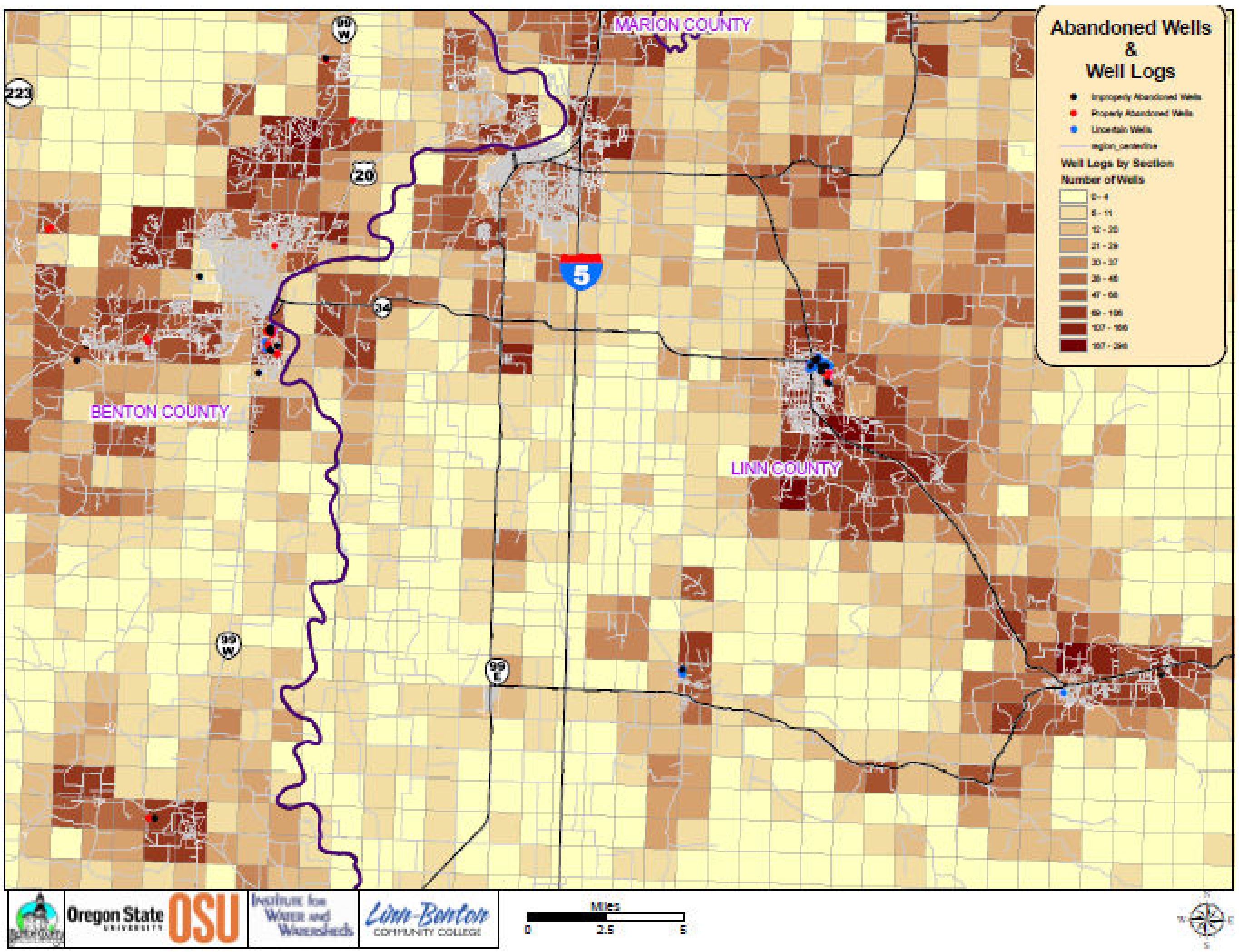
Attachment 3: the questionnaire

	Yes	No	Uncertain
Do you get your drinking water from a well on your property?			
Is there a septic tank on your property?			
How old is the septic tank?			
There are ____ unused wells on my property.			
Are any of the following within 100 feet of an unused well?			
petroleum/heating oil tank			
buried gas line			
fertilizer/chemical storage or handling area			
septic tank/drain field			
buried sewer			
wastewater lagoon			
livestock feeding/confinement area			
manure storage area			
livestock waste lagoon			
poultry building			
Graveyard			
Class V injection well			
Are there any streams or ponds on within 100 feet of an unused well?			
Is the opening to the unused well greater than 24"?			
When was the unused well drilled?			
How deep is the unused well?			
Have there been any tests done?			
Do you have any well reports?			
Are there any unused wells on a neighbors property?			
Would you like us to come look at unused wells on your property?			

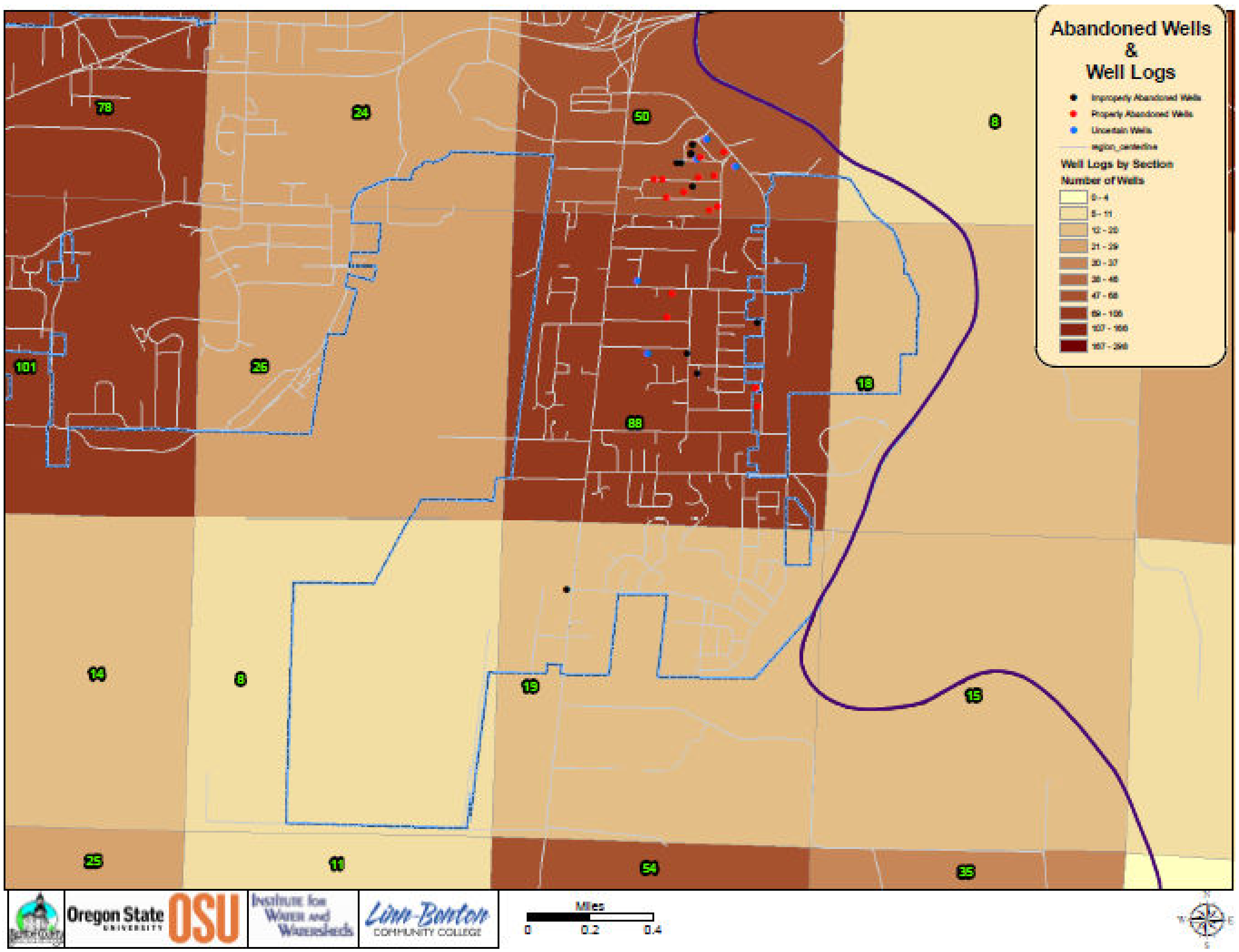
Map 1. Benton County & Linn County, Oregon



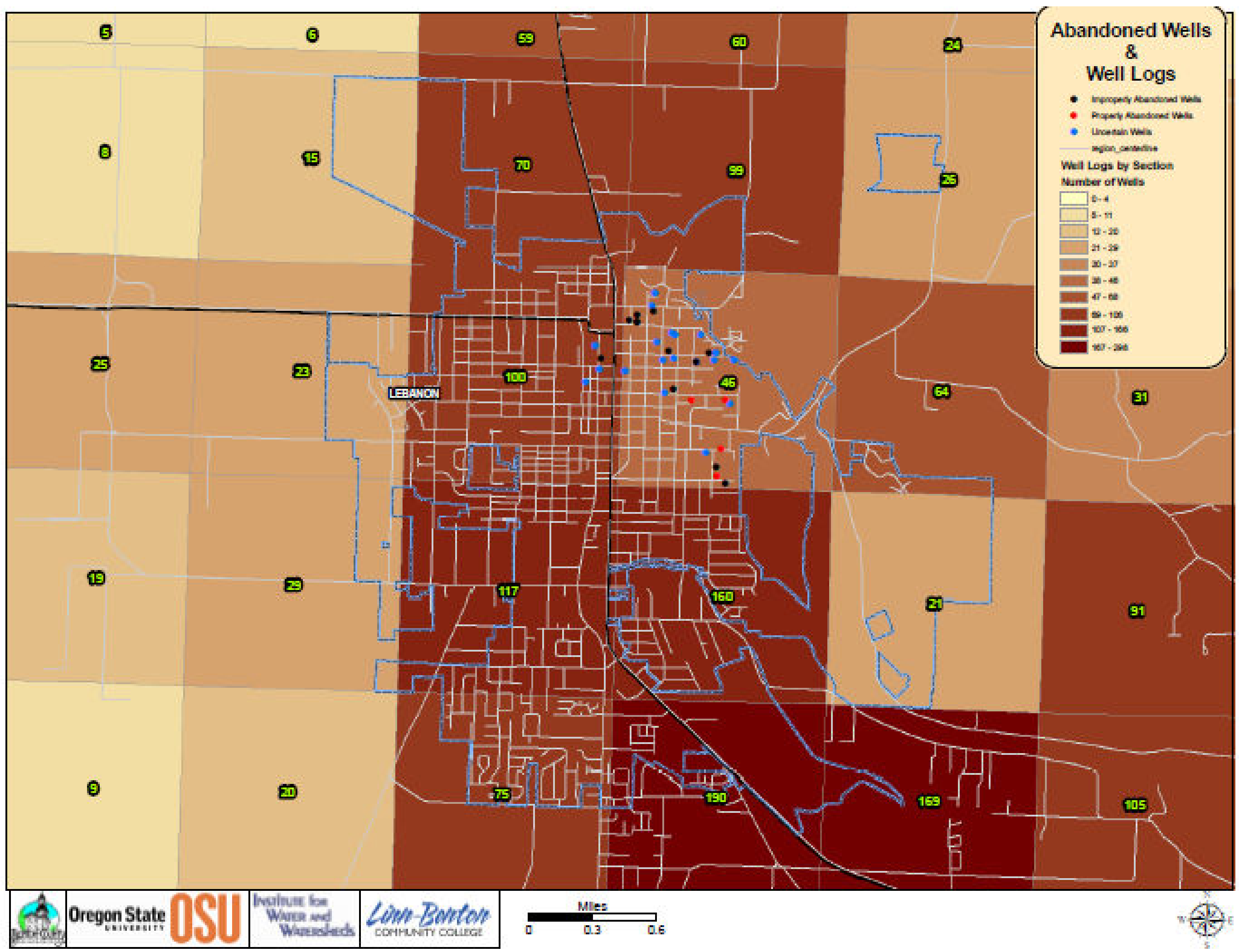
Map 2. City of Corvallis & Lebanon, Oregon



Map 3. South Corvallis, Oregon



Map 4. City of Lebanon, Oregon



Dams and Development: Ecological, Socioeconomic, and Policy Dimensions

Basic Information

Title:	Dams and Development: Ecological, Socioeconomic, and Policy Dimensions
Project Number:	2009OR123B
Start Date:	3/1/2009
End Date:	5/1/2010
Funding Source:	104B
Congressional District:	Oregon 5
Research Category:	Social Sciences
Focus Category:	Law, Institutions, and Policy, None, None
Descriptors:	Dams, Hydropower
Principal Investigators:	Bryan Tilt, Desiree D. Tullos

Publications

1. Brown, Philip H., Darrin Magee, Bryan Tilt, Desiree Tullos and Aaron T. Wolf. 2009. “Modeling the Costs and Benefits of Dam Construction from a Multidisciplinary Perspective.” Journal of Environmental Management 90 (Supplement 3): S303- 311.
2. Tullos, Desiree, Bryan Tilt and Katherine Reidy-Lierman. 2009. “Introduction to the Special Issue: Understanding and Linking the Biophysical, Socioeconomic and Geopolitical Effects of Dams.” Journal of Environmental Management 90 (Supplement 3): S203-207.
3. Tullos, D., P.H. Brown, K. Kibler, B. Tilt, D. Magee, and A. Wolf. 2010. “Perspectives on Salience and Magnitude of Dam Impacts for Hydrodevelopment Scenarios in China.” Water Alternatives, Special Issue on WCD + 10. (In Press, Accepted for Publication).

Dams and Development: Ecological, Socioeconomic, and Policy Dimensions (Research Workshop)

Principal Investigators:

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Report Period: 03/01/2009 – 05/07/2010

Workshop Description and Goals

Funding from the USGS Small Grants Program, via the Institute for Water and Watersheds Oregon State University, was used to support an international workshop entitled, "Dams and Development: Ecological, Socioeconomic and Policy Dimensions." This report provides a brief description of the project goals and outcomes. The objectives of this workshop were to (a) provide a forum for scholars to communicate their knowledge and expertise on the impacts of dams on ecology, society and culture in the context of contemporary development policy; (b) solicit critical review of a proposed tool for the interdisciplinary analysis of dams; and (c) develop research collaborations and publications on the topics of sustainable hydrodevelopment. The workshop built on three years of multi-institutional collaboration by an interdisciplinary team of scientists, and an ongoing research grant from the National Science Foundation. This workshop contributed to the improvement of the Integrative Dam Assessment Model (IDAM), a multidisciplinary assessment tool to analyze the costs and benefits of dam construction.

Background

Natural scientists and social scientists have traditionally used their own disciplinary training to study the effects of dam construction, yet dams lie at the nexus of biophysical, socioeconomic and geopolitical relations, and an impact in one area is thus likely to have repercussions for others. For example, the adverse effects of dams on ecosystems, hydrology and water quality (Poff and Hart 2002; Salazar 2000) often disrupt cultural conditions and economic institutions (Cernea 2003), and also impact the relationships between communities, regions or nations (Wolf, et al. 2003).

As a result, the impacts of dams (both positive and negative) are not readily captured through the analytical lens of any single discipline. Dams should rather be analyzed from a comprehensive, interdisciplinary, and systems-based approach built upon both historic and contemporary data. What factors drive conflict over hydropower? How do conflict and cooperation evolve over time? What governing mechanisms are conducive to equitable and sustainable hydropower? Our interdisciplinary research team has spent the last several years developing a decision-support tool called the Integrative Dam Assessment Model (IDAM), which helps policymakers understand the impacts of dams from a holistic perspective.

The objectives of this workshop were to (a) provide a forum for scholars to communicate their knowledge and expertise on the impacts of dams on ecology, society and culture in the context of contemporary development policy; (b) solicit critical review of the IDAM tool for the interdisciplinary analysis of dams; and (c) develop research collaborations and publications on the topics of sustainable hydrodevelopment.

Progress to Date

Our proposal received only a portion of the funds that we had initially sought, which meant that we had to scale-down our plans and objectives. Rather than hold the workshop at Oregon State University, as previously planned, the principal investigators traveled to Coeur d'Alene, Idaho, to participate in an international conference entitled "Transboundary River Governance in the Face of Uncertainty: The Columbia River Treaty, 2014," which was held April 2-4, 2009. Our research team held a special workshop session at the conference on the impacts of dams. The workshop included the following activities:

1. Presentations on the state of current knowledge regarding the ecological, socioeconomic and policy dimensions of dams;

2. A discussion of similarities and differences between international cases in terms of dam development;

3. A discussion on disciplinary and interdisciplinary approaches to evaluating dam impacts; and

4. A presentation of the IDAM tool and solicitation of critical feedback from scientists. This included an evaluation of the structure and operation of the model, selection of appropriate indicators to inform the model, and potential limitations.

Outcomes

This workshop resulted in two significant outcomes, as described briefly below.

1. Peer-Reviewed Publications. Members of the IDAM research team were able to refine their thinking on the best approaches for modeling the effects of dams, including the selection of appropriate indicators. We published a special issue of the *Journal of Environmental Management* in December 2009 on dam assessment, which included a number of papers from IDAM researchers whose papers were improved by this scientific exchange. These papers include the following:

Brown, Philip H., Darrin Magee, Bryan Tilt, Desiree Tullos and Aaron T. Wolf. 2009. "Modeling the Costs and Benefits of Dam Construction from a Multidisciplinary Perspective." *Journal of Environmental Management* 90 (Supplement 3): S303-311.

Tullos, Desiree, Bryan Tilt and Katherine Reidy-Lierman. 2009. "Introduction to the

Special Issue: Understanding and Linking the Biophysical, Socioeconomic and Geopolitical Effects of Dams." *Journal of Environmental Management* 90 (Supplement 3): S203-207.

Tullos, D., P.H. Brown, K. Kibler, B. Tilt, D. Magee, and A. Wolf. 2010. "Perspectives on Salience and Magnitude of Dam Impacts for Hydrodevelopment Scenarios in China." *Water Alternatives*, Special Issue on WCD + 10. (In Press, Accepted for Publication).

2. International Conference on Dam Assessment. Building on the lessons learned from the Idaho conference, our research team held an additional conference (using non-USGS funding) on dam assessment in China. The conference was held on July 27-28 in Kunming, China, and included three groups of stakeholders: government officials, hydropower company representatives, and conservation NGO personnel. We used a similar approach to the one developed at the Idaho workshop, which involved presenting the IDAM model and soliciting feedback via survey questionnaires and focus groups from these stakeholders.

References Cited

Cernea, M.M., 2003. For a New Economics of Resettlement: A Sociological Critique of the Compensation Principle. International Social Science Journal 55(175), 37-45.

Poff, N.L., and D.D. Hart, 2002. How Dams Vary and Why It Matters for the Emerging Science of Dam Removal. Bioscience 52(8):59-68.

Salazar, J.G., 2000. Damming the Child of the Ocean: The Three Gorges Project. The Journal of Environment and Development 9(2):160-174.

Wolf, A.T., S.B. Yoffe, and M. Giordano, 2003. International Waters: Identifying Basins at Risk. Water Policy 5(1):29-60.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	3	0	0	0	3
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	5	0	0	0	5

Notable Awards and Achievements