Report as of FY2006 for 2006OR74B: "Evaluating the phosphorus dynamics in response to restoring historic hydrology at reclaimed wetlands along Upper Klamath Lake, OR."

Publications

Project 2006OR74B has resulted in no reported publications as of FY2006.

Report Follows

Evaluating the phosphorus dynamics in response to restoring historic hydrology at reclaimed wetlands along Upper Klamath Lake, Oregon

Principal Investigator: Desiree Tullos
Graduate Student: Carla Stevens
Biological and Ecological Engineering Department
234 Gilmore Hall
Oregon State University
Corvallis, OR 97331-5506
Phone: 541-737-2038
E-mail: tullosd@engr.orst.edu
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EXECUTIVE SUMMARY

According to ODEQ's TMDL analysis (2002) and USFWS Sucker Recovery Plan (1993), elevated phosphorus levels are in part driving severe algal blooms in Upper Klamath Lake (UKL), causing pH and dissolved oxygen to reach toxic levels for fish. Historic lake-fringe wetlands likely played a key role in buffering external P loading to the lake and the draining and conversion of these wetlands to agriculture has had a profound influence on excess nutrient input to UKL (Snyder and Morace 1997; National Research Council 2004). Currently, millions of dollars are being directed toward wetland restoration of the reclaimed agricultural lands with the goals of habitat restoration and reduction of external nutrient input to ultimately improve water quality in the lake. However, the extent and mechanisms of nutrient retention for these restored wetlands actually retain nutrients is not well established (Fisher and Acreman 2004; Graham et al. 2005). Therefore, we developed a coupled laboratory and field study on the P dynamics of restored wetlands around UKL.

While we have no formal results to present from IWW/USGS funding, beneficial outcomes of this support include: (1) submission of three grant applications for additional support of students and sample analysis, (2) expanded study area and intensity, and (3) setup of the laboratory experiment. Laboratory experiments will begin in early July, 2007 to evaluate the patterns and processes associated with P release in four UKL restored wetlands through analysis of P and numerous other relevant properties of soil cores prior to, immediately following, and long after "flooding". The laboratory experiment will be followed by a field study of the sites as they flood during the winter of 2007.

This study design will inform an important management question (Are flooding regimes different with respect to minimizing soil P losses and are those differences significant?) by focusing on advancing the understanding of biotic and abiotic mechanisms of P release related to inundation timing and duration. Thus, the anticipated project benefits are to reduce uncertainties around wetland benefits and inform management decisions that minimize P loading to the lake.

PROJECT DESCRIPTION & RESULTS

This progress summary describes a laboratory and field study to elucidate the effects of timing and duration of restored wetland inundation on forms and concentrations of P. The goal of this study is to improve understanding on how restored wetlands can be managed to minimize P release into UKL by documenting P-source –sink relationships in wetlands restoration projects. The original objective of the IWW/USGS project was to document phosphorus dynamics associated with reflooding of the Williamson River Delta to address (a) whether reclaimed wetlands release phosphorus when reflooded for restoration? and (b) which mechanisms control phosphorus sequestration and release in reflooded wetland soils at UKL? We have expanded that original study scope to include a laboratory study (at the request of the IWW/USGS review committee) and three additional sites. This expanded scope will characterize the properties, including forms and concentrations of P, in water and soil cores collected across four wetland restoration study sites (Wood River Wetland, Agency Lake Ranch Wetland, Williamson River Delta, and South Marsh – **Fig. 1**) with different hydrologic regimes prior to and following (a) soil core inundation in a controlled laboratory study and (b) wetland inundation in a field study

Through these studies, we will evaluate two hypotheses:

1. The timing and duration of inundation does affect the concentrations and forms of P released in study wetlands.
2. The nature of P dynamics in the study wetlands releases primarily labile orthophosphorus (biologically available), as opposed to organically bound P.

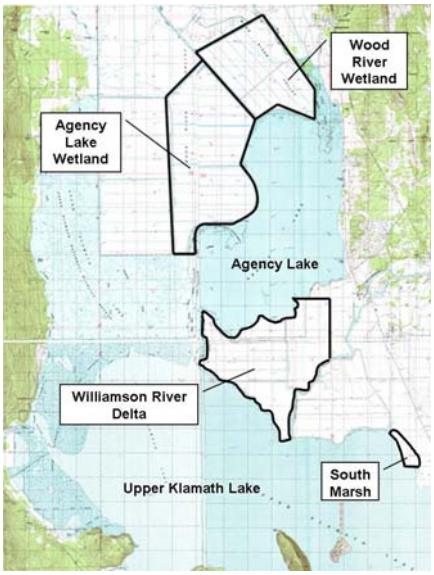


Figure 1– Locations of four study sites around UKL

Figure 2–Locations of soil core and surfacewater sampling locations within those sites

Through the proposed analyses, we will evaluate the four wetland restoration sites characterized by three different hydrologic management methods: (1) active management

through mechanical pumping of an unconnected wetland (Agency Lake Ranch), (2) passive management with direct hydrologic connection (Williamson River Delta, South Marsh), and (3) passive management without direct hydrologic connection (Wood River Wetland). We hypothesize that the difference in timing of wetland filling and draining between these three management approaches will have significantly different outcomes on P forms and concentrations released to the lake, and that these outcomes are driven by differences in the bioavailability of P.

Goals and objectives.

The overarching goal of this project is to reduce uncertainties around wetland benefits and develop the understanding of how management of wetlands and agricultural lands can minimize external P loading to UKL. We will quantify how management of hydrology affects key response variables, including relevant soil properties and forms and concentrations of P in the soil and water. Specifically, we focus this limited research study on evaluating biotic and abiotic mechanisms of P release related to inundation timing and duration. We outline the following **objective** for the project:

(1) characterize the properties, including forms and concentrations of P, in soil cores collected from each of the wetlands prior to and following:

a. inundation in a controlled laboratory study
b. wetland inundation in a field study

This study design will inform an important management question: Are flooding regimes different with respect to minimizing soil P losses and are those differences significant?

To achieve the project objectives, the following general workflow has been defined:

1. *General study design and preliminary soil P characterization-* Initial collection and analysis of soil cores will be used to characterize variability in physical and chemical properties of the soil across each wetland to determine spatial patterns and distributions of P forms and concentrations. Sites were first classified according to wetland types (transitional wetland, emergent marsh, and deep water wetland) and sampling locations were selected from stratified (by wetland type), randomly sampled grid overlays (Fig 2). Three soil cores will be collected at four sampling locations within each of the wetland types for each analysis. Soil cores will be divided into two depths (0-2 cm and 2-15 cm) to evaluate the change in soil features with depth. These cores will be collected during the dry season (arbitrarily defined as the water table at or below the surface >3 weeks) and locations will be mapped with a GPS unit.

2. *Lab experiments to determine breakthrough curves, timing of P cycle and release*

This lab study will "flood" soil cores in a controlled environment to analyze the change in several physical properties of the soil (e.g. phosphorus forms, redox potential, bulk density, organic matter, pH, total N) and water (e.g. temperature, DO, specific conductivity, pH, TP, SRP, CO_2 emission, redox potential) over the current flood season of each of the sites. For each sampling location within each site, three cores will be pulled for: (1) analysis prior to "flooding", (2) analysis immediately after "flooding", and (3) analysis following the "flood" season. To isolate flooding treatments from responses

due to soil properties, the experiment will replicate all flooding regimes with all soils (i.e. individual Agency Lake Ranch wetland cores will be treated with flooding regimes from each of the four sites) for a combination of 16 cores per wetland type. In a two factorial design, cores will be inundated and changes in physical and P soil properties will be analyzed by ANOVA. Further, breakthrough curves (Fig. 3) of P release into the surfacewater will be developed for the soil cores.

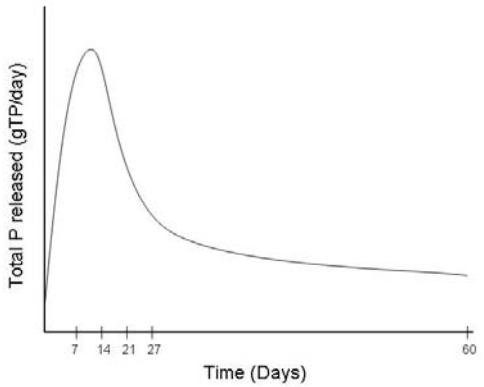


Figure 3 – Theoretical breakthrough curves for increase of P in surface water of cores following inundation

The key differences between the hydrology of the sites that we will simulate in the laboratory study are the timing and duration of flooding. The cores will remain flooded for the same duration that soils are flooded at each of the sites or until soil leaching of P stabilizes. The timing of inundation will be simulated through the following two steps:
(1) pulling all of the cores at the same time of year
(2) controlling temperature, through refrigeration, of the cores to correspond to the time of year that the soils are flooded in the field. Through this approach, we can evaluate patterns of biotic activity in mobilizing organically-bound P and the role of inundation timing in P release at the wetlands

All soil cores will be flooded with the same, well-mixed water drawn from UKL, which will be analyzed for TP and SRP concentrations prior to application on soil cores. Light will be held constant throughout the lab study. Vegetation will be removed from the cores.

3. Collection and analysis of field samples - To compare findings of controlled laboratory experiments with soil P dynamics at the sites, soil cores will be collected from permanent sampling locations (1) shortly before flooding occurs at each site in coordination with management agencies at dates specific to each site, (2) immediately after wetlands are flooded, and (3) prior to draining. Soil cores will be sent to the OSU soil laboratory for analysis. Basic analysis of water quality (e.g., temperature, dissolved oxygen, specific conductivity, pH, redox potential) will be performed at the time of soil coring.

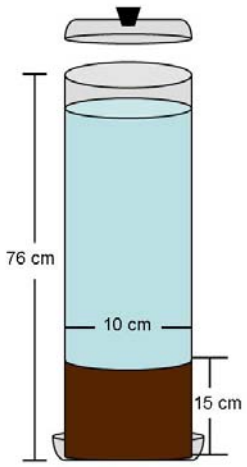
Progress to date.

Additional support

It was necessary to delay the field study proposed to IWW/USGS due to a delay in construction. Thus, substantial efforts were directed towards securing additional funding to replicate the study at several sites at UKL. Three additional proposals were submitted:

1. submitted to the US Fish and Wildlife Ecosystem Restoration Office in Klamath Falls and the PI was recently notified that this proposal has been recommended for funding to support sample analyses and the GRA for year 2. ($58,594)
2. submitted to the Oregon Agricultural Research Foundation to support additional soil and water samples as well as an undergraduate research assistant to help with analysis of soil and water samples. Reviews of these proposals will become available late June, 2007. ($11,840)
3. submitted to the US Bureau of Reclamation in Klamath Falls in partnership with The Nature Conservancy. Funding will support the collection and analysis of additional soil cores at the Williamson River Delta site, including support for an undergraduate research assistant. ($30,000)

Laboratory Experiments



Elevation GIS data layers were obtained and used to determine water depths throughout the summer. Water depths were used to estimate wetland vegetation and classify areas as transitional wetland and emergent marsh. Four sampling locations were then randomly selected from grid overlays within these stratifications (Fig. 2). The lab experiments will be performed in the Klamath Tribes' water quality labs in Chiloquin and setup of these experiments is nearly complete. Cores for the laboratory experiments will be pulled from all four sites and flooded (Fig. 4) during July 2007

Figure 4 – Schematic of experimental setup for laboratory analysis of core inundation.

Timeline

In light of the expanded scope of the project, a new timeline of activities has been developed (Table 2).

Table 2 – Timeline and schedule of proposed activities.

Activity	date of completion
initial core samples pulled	june 2007
permanent sampling locations defined	july 2007
laboratory experiment set-up	august 2007
laboratory experiment completed	september 2007
field sampling for soil dynamics during flooding	august 2007 to may 2008
analysis and reporting	may 2008

literature cited

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