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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION RESEARCH

The Influence of Geomorphic Structure and Hydrology on Denitrification Potential in the Willamette River Floodplain

Research Perspective

Nitrate-nitrogen is a pollutant that threatens ecosystem and human health. Floodplains are critical habitats that support elevated nitrogen retention, particularly denitrification. Restoring hydrologic connectivity can enhance denitrification and the overall ecological condition of nitrogen-polluted stream and river ecosystems, including but not limited to the Willamette River floodplain. Identifying and connecting biogeochemical hot spots hydrologically can create large nitrogen sinks because denitrification increases when flooding connects river and the floodplain. Previous research shows that geomorphic structures and habitats, such as floodplain water-bodies (Forshay and Stanley 2005) and inchannel macrophyte beds (Forshay 2007), are capable of supporting elevated denitrification rates due to elevated organic carbon. Identifying geomorphic structures and improving connectivity with these hotspots should be a goal of restoration in nitrogen-polluted systems.

Research Objectives

For the Willamette Ecosystem Services Project, the research objectives are to:

- Identify floodplain habitats that enhance nitrogen-retention ecosystem services through denitrification and quantify nitrogen retention
- Assess biogeochemical benefits of restoring floodplains
- Develop ecological guidelines for stream and river floodplain restoration

Proposed Approach

The Willamette River floodplain contains diverse habitats and land use that includes agriculture, forests, and ongoing restoration to reconnect the floodplain to the river hydrologically. These factors are likely to have diverse effects on the patterns and drivers of biogeochemical nitrogen processing. To determine the pattern and drivers of nitrogen retention and denitrification in the floodplains and ultimately in the riparian corridors of the Willamette, researchers measure denitrification in habitats common to the Willamette floodplain that can potentially be promoted to improve and enhance naturally occurring nitrogen-retention ecosystem services.

These figures showing the Green Island floodplain outlined in red, a depressional area of a historic channel at Green Island, and agricultural irrigation of grass seed fields.

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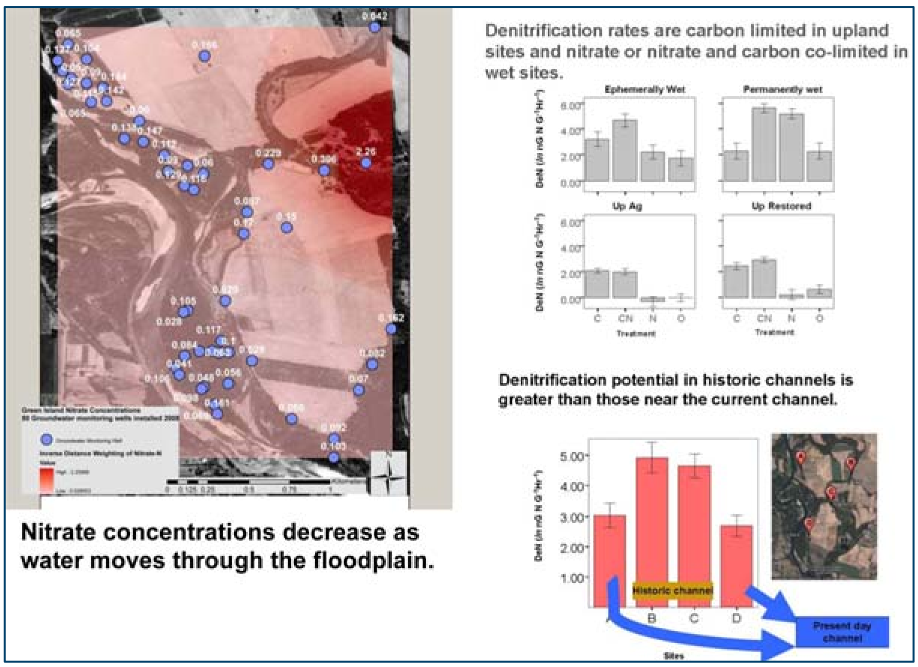
The approach for research will combine field and lab studies to determine rates and drivers of denitrification. Techniques include the use of denitrification bioassays, stable isotopes, mass balance, and hydrologic modeling. Improvement in our understanding of these nitrogen transformation rates and drivers will help in developing appropriate and sustainable practices to retain nitrogen by the Green Island floodplain (an archetypical floodplain of the Willamette River undergoing restoration), as well as provide a means for estimating the nitrogen-removing ecosystem services provided by floodplains in the Willamette Valley.

Currently, EPA researchers are implementing a comparative design that includes evaluation of nitrogen retaining ecosystem services, primarily denitrification, within the Green Island site near the confluence of the Willamette and McKenzie Rivers. The Green Island floodplain is composed of common land use in the Willamette River watershed, primarily grass seed agriculture with restored forest and wet depressional areas. The area is also undergoing levee removal to reconnect the floodplain to the river hydrologically. To determine nitrogen retention, scientists:

- Apply multiple techniques to estimate both surface and subsurface denitrification rates and drivers (e.g., organic carbon)
- Monitor water chemistry both surface and subsurface along with isotopic indicators of nitrogen processing
- Determine hydrologic connectivity between surface water and shallow ground water

Researchers intend to combine these biogeochemical and hydrologic results to estimate nitrogen retention and dynamics at a small scale. The results will help to estimate capacity for nitrogen removal and provide recommendations to enhance nitrogen removal in the larger floodplains of the Willamette River.



Denitrification rates are carbon limited in upland sites and nitrate or nitrate and carbon co-limited in wet sites.

Denitrification potential in historic channels is greater than those near the current channel.

Nitrate concentrations decrease as water moves through the floodplain.

Questions Regarding the Willamette Ecosystem Services Project

1. How are nitrogen, carbon, and hydrology linked in the river, ground water, and floodplain ecosystems?
   a. What controls denitrification in floodplain and river ecosystems?
   b. How does hydrology influence denitrification and nitrogen biogeochemistry?
   c. Can restored or reconnected floodplains retain nitrogen the same way as established floodplains?
   d. How do bio-geomorphic structure or topography alter nitrogen biogeochemistry?

2. How does nitrogen retention differ with habitat types (e.g., restored agricultural, agricultural, permanently flooded alcoves, or ephemerally flooded wetlands)?
3. How can biogeochemical drivers of nitrogen retention in floodplains and riparian ecosystems be used to manage nitrogen pollution?
4. How much nitrogen is retained by floodplains of the Willamette River, particularly through denitrification?

References

Forshay, K.J. (2007). "The Influence of Macrophytes, Disease, and Restoration on Freshwater Ecosystems." Ph.D. Dissertation, The University of Wisconsin-Madison.

Forshay, K. J. and E. H. Stanley. (2005). "Rapid Nitrate Loss and Denitrification in a Temperate River Floodplain." *Biogeochemistry*, 75: 43–64.

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