UNDERSTANDING THE BIO-PHYSICAL CHARACTERISTICS OF A FEN ECOSYSTEM TO INFORM MANAGEMENT AND CONSERVE THE RARE HABITAT

AMY BAUR[1*], JOHN CHRISTY[2], PATRICK HENDRIX[1], GLEN LEVERICH[1], ELAINE STEWART[3], JOHN CATENA[3], AND JEREMY KIRBY[3]

[1]STILLWATER SCIENCES, PORTLAND, OR, [2]PORTLAND STATE UNIVERSITY, PORTLAND, OR, [3]METRO, PORTLAND, OR

INTRODUCTION

Located within a 100-acre Metro-owned natural area along the lower Willamette River, a groundwater-fed lake contains a densely vegetated floating fen or "quaking," peat mat that rises and falls as water levels change. The fen, perched upon a forested basalt terrace above the Willamette River, began as a depression scoured 15,000 years ago by the Missoula Floods and evolved through slow deposition of dissolved minerals and decomposing vegetation eventually forming a layer of peat within the perennial lake. Several seasonal ponds lie near the lake within the forested setting, which is bordered by rural residential properties.

Taking thousands of years to form, fen-wetland ecosystems are rare nationwide (EPA 2021). Their **unique groundwater regime and chemistry**, along with **floating vegetated mats of peat**, support **diverse and rare plant and wildlife communities**.

The fen is the last of its kind in the Willamette Valley and is vulnerable to threats posed by urban influences that could alter its fragile biochemistry. Here we will present how determining a fen's key biophysical factors and understanding their combined sensitivity to external processes is necessary to define and address potential threats to a fen's conservation.

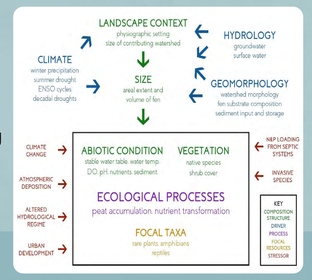
A fen's ecological benefits are considered even greater in urban areas through its **natural attenuation of runoff and pollutants**, though these ecosystem services may diminish should the urban-sourced impacts eventually alter the fen's bio-physical condition.

Urban threats to the fen's health include stormwater runoff, groundwater reductions from local pumping, nutrient input from septic tanks, and invasive species.

Fen Classification
Fens are groundwater-dependent ecosystems classified along a pH gradient. "Poor" fens typically have a pH of 4-5.5, low conductivity, and sphagnum may be common in the moss layer. "Rich" fens have a pH above 6.9, high conductivity, and a layer of "brown mosses" with little or no sphagnum (Vitt et al. 1990).

METHODS

Metro's goal was to assess the fen's watershed inputs and bio-physical characteristics by studying its hydrology, water and soil chemistry, vegetation community, and fen extent and composition. Metrics were developed to measure site-specific Key Ecological Attributes (KEAs), features that if missing or altered would lead to the loss of a particular conservation target over time. Data collection and analyses benefited from input from technical experts.



HYDROLOGY

The quantity and pathways of hydrologic inputs—rainfall, surface runoff, and groundwater discharge—can alter the fen's health and overall existence. Surface-drainage pathways were mapped in detail following a desktop GIS-based exercise ground-truthed by a comprehensive field survey. Water levels and temperatures in the lake, a nearby seasonal pond, and nearby groundwater monitoring points were gaged continuously to further evaluate seasonal inflow and outflow pathways.

WATER QUALITY

Unique water chemistry is a defining characteristic of a fen. To capture seasonal and diurnal fluctuations in lake water quality, a probe (Hydrolab DS5 - Multiparameter Data Sonde) was deployed for 48 hours each quarter to measure temperature, dissolved oxygen, turbidity, and pH levels. Grab samples were collected during the probe deployments and analyzed in the laboratory for constituents considered to signify excessive nutrient loading: ammonium, nitrogen, phosphorus, and chlorophyll-*a*.

SOIL QUALITY

Soil conditions are intrinsically linked to fen health, being both a sink and source of dissolved elements. Assessment of soils included soil textures, bedrock depth, organic content (peat presence and texture), and chemical properties (pH, nutrients, and major cations).

FEN EXTENT

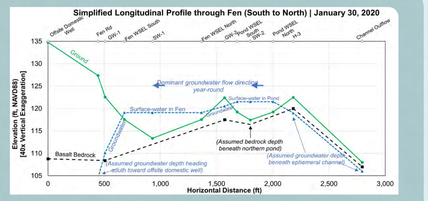
Tracking the spatial extent of the fen system, particularly the lake and its floating mat, are important in detecting fen degradation and ensuring its preservation. An Unmanned Aircraft System (UAS) coupled with targeted field reconnaissance was used to create a detailed baseline map of the fen system and the thickness of the floating mat was measured manually in the field.

VEGETATION

The composition of terrestrial and aquatic vegetation communities is a major KEA of the fen system. Field surveys were conducted to: (1) provide a baseline of existing terrestrial and aquatic vegetation communities, (2) identify rare plant and associations, and (3) identify invasive woody species for eventual removal. Voucher specimens were deposited in the Portland State University Herbarium.

RESULTS

Initial results reveal a **unique ecosystem** with **counter groundwater and surface-water flow directions** due to the geologic setting, **eutrophic** lake conditions from high nutrient loading, **acidic water and soil chemistry** due to the basalt bedrock, and a **diverse plant community** consisting of 22 taxa of plants considered rare in the Portland metropolitan area.

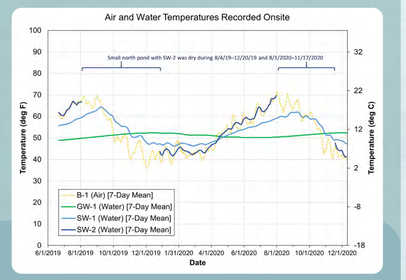


HYDROLOGY

- The study site qualifies physically as a "basin fen", meaning it is fed by both surface-water and groundwater
- The system receives hydrologic input from rainfall, local runoff, and groundwater
- Lake and nearby pond levels fluctuate seasonally
- The longitudinal profile of the fen lake and surroundings (shown above) reveals a unique hydrogeologic profile having counter flow direction
- Surface runoff typically trends to the north (right side of graphic above) while groundwater flow consistently trends to the south (left side of graphic above) parallel to the bedrock inclination

WATER QUALITY

- The fen system is moderately-rich based on its acidity (pH: 6.13–6.24) and phosphorous levels
- The fen system may be considered poor based on TKN values
- The lake may be considered eutrophic due to high nutrient loading
- A three month-long time-lag occurs between peak surface-water temperature and groundwater temperature (shown to the right)

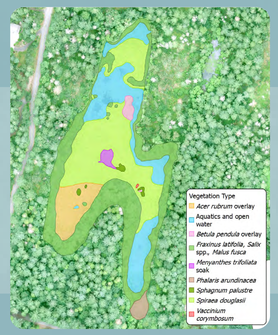


SOIL QUALITY

- Soil in the lake bottom is acidic (pH: 4.9)
- Organic content is very high
- Peat layer is more than 30 inches thick
- Shoreline soils are sandy silts, typical of Willamette Valley floodplains, and contain less organic matter

FEN EXTENT

- Thickness of the floating mat was inconclusive but indicated that the center of the floating mat is at least 6 feet thick, with multiple thin spots present throughout
- When compared to previous studies, the thickness of the floating mat and seasonal recharge of lake levels indicate that the water supply to the fen appears to be relatively stable and the configuration and extent of the mat and open water has not changed appreciably in 85 years



VEGETATION

110 taxa of nonvascular and vascular plants have been reported at the fen. Of these, 1 (1%) is an alga, 33 (30%) are bryophytes, and 76 (69%) are vascular plants. Of the vascular plants, 61 (80%) are native and 15 (20%) are exotic. Twenty-two taxa (14 bryophytes, 7 vascular plants) and two plant associations are considered rare in the metro area. Locally or regionally rare plants documented included *Howellia aquatilis*, *Menyanthes trifoliata*, *Dulichium arundinaceum*, and *Drosera rotundifolia*.

LOOKING AHEAD

Encroachment by woody plants is the most urgent management concern, with *Acer rubrum*, *Betula pendula*, and *Vaccinium corymbosum* the most problematic invaders. Maintenance of future peat-forming processes and fen vegetation could be affected by projected higher summer temperatures and other factors like nutrient input. Ongoing monitoring of the fen is helping to assess its condition, detect future trends, determine sources of potential degradation, and inform preservation of this unique habitat. It may also provide recommendations for restoring disturbed fens elsewhere.

CITATIONS

Environmental Protection Agency (EPA). 2021. Wetlands classification and types of wetlands. U.S. Environmental Protection Agency. Retrieved February 15 2021. https://www.epa.gov/wetlands/classification-and-types-wetlands#fens

Vitt, Dale & Chee, Wai-Lin. (1990). The Relationships of Vegetation to Surface Water Chemistry and Peat Chemistry in Fens of Alberta, Canada. Vegetation. 89. 87-106. 10.1007/BF00032163.