USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Flood regime and nutrient limitation in three Pine Barrens savanna plant communities

Graduate Student Name: Matthew Palmer

Degree sought: Ph.D. in Ecology and Evolution

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Amount Requested: $3000

Priority Issues Addressed by research

This research will address the integrity of aquatic and water-associated ecosystems, particularly the link between hydrology and ecosystem structure and function.

Hydrology is one of the dominant controlling features in wetland ecosystem structure (Mitsch and Gosselink 1993). The frequency and duration of flooding affects a range of soil characteristics, including pH, redox chemistry, decomposition rates, and nutrient availability. Theoretically, flooding slows decomposition rates and nutrient cycling, limiting both productivity and diversity (McKnight et. al. 1981). On the other hand, flooding also raises the pH of acidic soils (Ponnamperuma 1972) and increases the solubility of phosphorous (Patrick and Khalid 1974). These competing processes will affect wetland ecosystems differently depending on whether they are nitrogen or phosphorus limited. Therefore, an investigation into the effects of different inundation regimes on soil chemistry will contribute to our understanding of variation in ecosystem structure.

Pine Barrens savannas are a unique and largely unstudied ecosystem type that occur along the river corridors of the New Jersey Pine Barrens. A preliminary community classification (Walz and Palmer, unpublished data; see Olsson 1979 for an earlier classification) describes several plant communities which fall along an apparent hydrological gradient. At the wet end of the gradient is a relatively low biomass/low

diversity system dominated by aquatic or semi-aquatic vegetation (typically *Orontium aquaticum*, *Juncus pelocarpus*, and *Drosera intermedia*). At the dry end of the gradient is a relatively high biomass/moderate diversity system dominated by shrubs and grasses (typically *Andropogon glomeratus*, *Gaylussacia dumosa*, and *Pinus rigida*). In intermediate areas, a moderate biomass/high diversity system dominated by sedges, grasses, and forbs (typically *Rhyncospora alba*, *Muhlenbergia uniflora*, and *Lophiola aurea*) occurs. These savannas are associated with several rare species, including two federally listed species (*Rhyncospora knieskernii* and *Narthecium americanum*) and are a very high conservation priority for the state of New Jersey (Tom Breden, NJ Natural Heritage Program, pers. comm.).

While the majority of the savannas are on protected state land, they are still vulnerable to changes in hydrology. One of the major perceived threats to the system is succession to shrubland or forest (McCormick 1979). Historical records (Stone 1911, Harshberger 1916) indicate savannas may have been more widespread than their current distribution. Air photo interpretation by the New Jersey Natural Heritage Program (Walz and Palmer, unpublished data) is underway to assess the changes in the extent of savanna habitat in the last 70 years. If savannas are being converted to other habitat types, the proposed research would explore one of the likely mechanisms for that change.

This research will begin to establish a detailed hydrologic record for a rare and unique wetland ecosystem in the state of New Jersey and relate that hydrology data to one of the primary determinants of ecosystem structure: soil chemistry. By examining soils exposed to different frequency and duration of flooding and relating that data to the vegetation growing on those soils, we will gain a better understanding of the factors that influence ecosystem structure in these wetlands. This research will advance scientific understanding of the relationship between flooding, nutrient status, and community structure (including diversity). Further, it will aid future conservation and management decisions concerning New Jersey wetlands.

The specific objectives of the study are to:

Relate the hydrology of savannas to the soil chemistry and plant community structure by

• establishing a detailed hydrograph for three different community types within Pine Barrens Savannas

• measuring a range of soil characteristics (pH, E_H, NO_3-N, NH_4-N, P, Fe, K, Ca, Mg, Cu, Mn, and Zn)

Assess the role of nutrient limitation in the structure of savanna plant communities by

• measuring the N:P ratios of plant tissues for several dominant species in each community type to establish patterns of nutrient limitation

• measuring field decomposition of litter across the range of community types

Proposed Methods

Site selection: Extensive reconnaissance work in 1998 (Walz, unpublished data) and the establishment of permanent monitoring plots in 1999 (Walz and Palmer, unpublished data) have identified the best representatives of each savanna community type in each of five Pine Barrens watersheds (Batsto, Mullica, Nescohague, Oswego, and Wading). Three sites for each of the three community types under investigation will be selected such that the data will complement the ongoing research of the New Jersey Natural Heritage Program. The proposed sites all lie within Wharton State Forest.

Hydrology: Install PVC water table wells and piezometer clusters at each of 3 replicates per community type. Water tables well are slotted along the length and inserted >50 cm into the peat. Piezometers are inserted to 25, 50, 75, and 100 cm as depth of peat permits. Relative well heights will be surveyed at the time of installation and again after the spring thaw to correct for any frost heaving. Water levels in each well will be measured monthly from January through mid-March, biweekly from mid-March until October, and monthly from October through December. Judging by the gauging station records for the rivers associated with these wetlands, the expected results are to find prolonged flooding in the spring and storm related flooding at all community types with a flood frequency and duration gradient corresponding to the observed difference in community structure.

Soil Chemistry: Collect soil samples from 0-15 cm from each community type at each site using a large serrated knife. Samples will be immediately stored at field moisture in plastic containers and transported in a cooler to the Rutgers Soils Laboratory for analysis. The first round of collection will be in late spring/early summer as the spring floods recede, after a time of prolonged inundation. The second collection will be in late summer/early autumn, after a time of prolonged exposure. These sampling periods are based on the observation that the savannas are wettest in the spring and driest at the end of the summer (Ted Gordon, pers. comm.). The expected results are to find nutrient limitation in all soils, with the possible amelioration of low pH and phosphorus deficiency after flooding.

Tissue Nutrient Analysis: For each community sampled, three dominant and/or frequent species will be selected for tissue nutrient analysis at the time of peak biomass for each individual species. If time and resources permit, a cosmopolitan species such as *Cladium mariscoides* or *Rhyncospora alba* may be sampled at all three community types to compare intraspecific variation of tissue chemistry between different flood-regime habitats. All tissues will be dried, ground, and analyzed for nitrogen and phosphorus content in the Ehrenfeld lab at Rutgers University. The expected results are to find high N:P ratios, indicating phosphorus limitation (following Bedford et. al. 1999), with the possibility of lower N:P ratios in the more frequently flooded sites.

Decomposition Rates: Known amounts of plant litter of resident species will be placed in a series of nylon litter bags and left in the field for the course of the growing season. One litter bag from each series will be brought back to the lab and weighed each month from June to October. The expected results are to find slow rates of decomposition in the flooded habitats and relatively higher rates in the drier habitats.

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Literature Cited

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