Geochemical Patterns in Calcareous Fens of Massachusetts

Jamie Morgan
University of Massachusetts – Dept. of Plant, Soil, and Insect Sciences
What is a Fen?

• A fen is a type of wetland

• Water is supplied by *upwelling groundwater*,
  – not solely from surface sources (i.e. rain, streams, etc.)

• By definition
  – A fen is a wetland whose vegetation, water chemistry, and soil development are influenced in a large way by ground water. (Bedford and Godwin, 2003)
Types of Wetlands

Ombrotrophic

Minerotrophic

(Brooks et al., 1997)
Types of Fens

- **Poor Fen**
  - Water pH 3.5-5.9
  - Water Ca 1 - 7 ppm
  - Water Mg 0.4 – 2 ppm

- **Rich Fen**
  - Water pH 6.0 - 8.4
  - Water Ca 7 – 433 ppm
  - Water Mg 2-32 ppm

- **Calcareous Fen**
  - A specialized form of Rich Fen, waters and soils are rich in Calcium Carbonate (attributable to Limestone or Dolostone bedrock in groundwater path). (Bedford and Godwin, 2003)
Carbonate Bedrock in the US

(National Atlas, 2006)
Carbonate Bedrock in the Northeast

(National Atlas, 2006)
Plant Communities

• Calciphiles
  – Can tolerate and/or thrive on unusually high calcium levels

• Rare occurrences of these favorable conditions = rare occurrences of these plants

• Unique/rare plant assemblages

• Endangered/Threatened Species
Unique Plant Assemblages
Rare Plants

- Calopogon tuberosus
- Platanthera huronensis
- Spiranthes cernua
Study Objectives

• Document unique plant assemblages
• Compare species distributions to environmental calcium levels
  – Develop calcium ranges for select species
  – Compare species tissue calcium to environmental calcium
• Understand the hydrogeochemical cycles in the fens
  – And how these relate to calcium dynamics and plant distributions
Materials and Methods

- Site Locations
- Study Layout
- Hydrology
- Water Chemistry
- Soils Properties
Site Locations

Legend
- Star: Jug End
- Triangle: Schenob Brook
- Circle: Shmulsky
- MA State Line
- Blue: Watershed Boundary
- Light Blue: Sub Drainage Basin Boundary
Topographic Setting
Geologic Setting

- Calcitic marble
- Limestone
- Schist or phyllite, locally calcareous
- Dolostone
- Kame
- Outwash
Study Layout

Geographic Location 1

Site 1

Site 2

Three replicate sampling stations per site.
Hydrology

Hydrologic conditions were monitored bimonthly from April to October, 2006

- Wells (at 60cm)
- Nested Piezometers (depth varied)
- α, α dipyridyl was used to identify if reducing conditions were present in surface soils
Water Analysis

- Water was collected from suction lysimeters (at 30cm) and analyzed
  - bimonthly for pH, Calcium, Magnesium
  - monthly for Iron (Total), Nitrogen (NH$_4^+$), Phosphorus (PO$_4^{3-}$), and Potassium

Water chemistry was monitored from May to October, 2006
Soil Analysis

• Soil profiles were described (horizons, depth, color).

• Samples were collected from each major horizon in July and analyzed for
  – Exchangeable Calcium, Magnesium, Iron, Phosphorus, Potassium and Total Nitrogen
  – Texture
  – Organic matter
  – Carbonates
  – pH
Results: Hydrology Overview

Schenob Water Table Depth

April  | May   | June  | July  | August | September | October

Jug End Water Table Depth

April  | May   | June  | July  | August | September | October

Shmulsky Water Table Depth

April  | May   | June  | July  | August | September | October
Results: Hydrologic relationships

Shmulsky Location
Hydrogeochemical Relationships

Water Table Depth

Water Calcium

Vertical Groundwater Gradients

Shmulsky Location
Hydrogeochemical Relationships

Schenob Brook Location

Water Table Depth

April: -5 cm, May: -10 cm, June: -15 cm, July: -20 cm, Aug.: -25 cm, Sept.: -30 cm, Oct.: -35 cm

Water Calcium

April: 0 mg/L, May: 20 mg/L, June: 40 mg/L, July: 60 mg/L, Aug.: 80 mg/L, Sept.: 100 mg/L, Oct.: 120 mg/L

Vertical Gradients

- Mostly flow through
- Discharge conditions throughout the season
- Recharge conditions throughout the season

Schenob Brook Location
Hydrogeochemical Relationships

Vertical Gradients
- □ Flow through
- ▶ Flow through with strong recharge in July followed by Discharge.

Water Table Depth

Water Calcium

Jug End Location
Calcium Trends

Location Water Calcium

ppm


Shmulsky
Schenob
JugEnd
Future Analysis

Calcium values at all study points ranged from 20-120 ppm

- Relate this wide range of fen Calcium values to
  - Species distribution patterns
  - Plant tissue calcium levels by species
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Questions?