# Development of a Protocol for Monitoring Freshwater Wetlands at Acadia National Park

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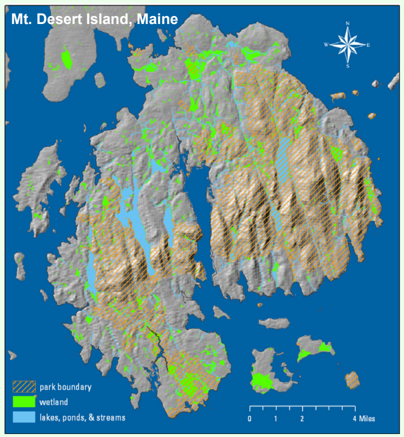
## Background:

Wetlands of Acadia National Park are threatened by a suite of anthropogenic stresses associated with increasing visitor pressure and rapid residential development of watersheds outside the park boundary. Over 10% of the park's land area is classified as wetland. Regular monitoring can help resource managers document trends in wetland condition, evaluate potential threats, and identify areas of management concern.




- Hydrology is the single most important factor in maintaining wetland ecosystem processes.
- Hydrologic alterations to wetlands associated with watershed development include depositing fill material, draining, diking and damming, dredging and stream channelization, diversion of flow, and increasing surface runoff from addition of impervious surfaces.
- Changes in hydrology can alter wetland soil chemistry, plant and animal community composition, primary productivity, organic deposition, and nutrient cycling, with concomitant loss of ecosystem services.

## Wetlands at Acadia National Park


Common palustrine wetlands include herbaceous emergent fens and marshes and forested deciduous and evergreen wetlands.

Roads are a frequent source of hydrological alteration.


## Monitoring Question:

Is hydrologic alteration affecting the condition of wetlands at Acadia National Park?

## Project Goals:

- Identify robust indicators of wetland condition suitable for long-term monitoring
- Determine within-wetland spatial and temporal variability of proposed indicators
- Identify landscape attributes that can be used to assess the susceptibility of Acadia's wetlands to anthropogenic stressors as a basis for a stratified sampling design
- Produce an operational monitoring protocol that is scientifically based, feasible, and cost effective.

## Approach to Indicator Selection:

- Candidate indicators of wetland ecosystem condition were compared between undisturbed wetlands and wetlands that had been disturbed by hydrologic alteration.
- Indicators that showed significant differences between disturbed and undisturbed sites were selected as potential monitoring variables.

### Candidate Indicators

*Hydrology*
Surface water level
Ground water level
Hydroperiod

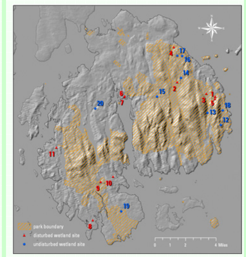
*Water chemistry*
Surface water nitrogen, phosphorus
Shallow groundwater nitrogen, phosphorus
Surface water pH
Shallow groundwater pH
Surface water conductivity
Shallow groundwater conductivity
Shallow groundwater sulfide

*Sediment*
Root zone (15-cm depth) redox potential

*Vegetation*
Species richness
Community composition

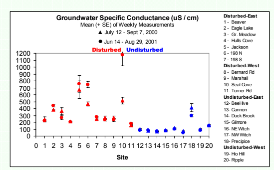
### Study Wetlands

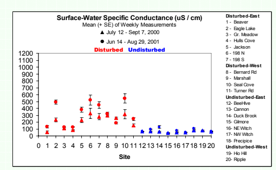
- Herbaceous emergent fens only
- Stratified geographically (east, west)
- Classified as disturbed (red) or undisturbed (blue) based on proximity to hydrologic alteration

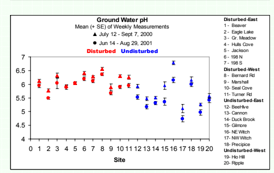


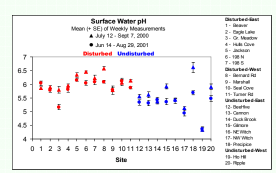

## Potential Monitoring Variables

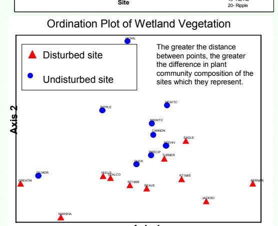
- Several candidate indicators showed significant differences between disturbed and undisturbed wetlands in a 2000-2001 study:
  - o Groundwater and surface-water conductivity
  - o Groundwater and surface-water pH
  - o Vegetation species richness and community composition
- No other candidates tested showed a significant response.




- The average specific conductance and pH of wetland groundwater and surface water was higher in disturbed than in undisturbed sites, but both inter- and intra-site variability was apparent.
- The average plant species richness was higher in undisturbed (30.8 $\pm$3.0 SE) than in disturbed (22.4 $\pm$ 1.9) wetlands. Patterns of species richness were reflected in differences in community composition.

## Approach to protocol development:

- In 2004-2005, water-chemistry and vegetation variables were measured within an independent set of herbaceous emergent fens (3 disturbed, 5 undisturbed) and within forested deciduous wetlands (8 disturbed, 8 undisturbed) to evaluate indicator robustness.
- In 2005, wetland soil profiles were collected to help explain inter- and intra-site patterns in water chemistry variables.
- Relationships between additional landscape-scale factors (proportion development in wetland watershed, distance to coast, etc.) and wetland ecosystem response were also assessed.

## Evaluation of Wetland Indicators

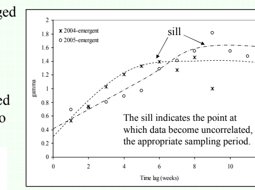
- Water chemistry variables are appropriate indicators of wetland disturbance within emergent, but not forested, wetlands.
- Multiple factors at local and landscape scales affect groundwater chemistry in the forested and emergent wetlands differently.

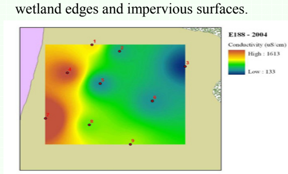
*Factors affecting conductivity within emergent and forested wetlands determined by Aikaike Information Criteria (AIC) analysis*

| Emergent | Forested |
|---|---|
| Proportion of development in a 200-m buffer | Depth of organic matter |
| Percent clay in the soil | Distance to coast |
| Depth of organic matter | Wetland position in the watershed |

## Small-Scale Spatial and Temporal Variability

- Groundwater was sampled from 9 wells arranged in a 3 x 3 grid in 6 emergent wetlands.
- Water chemistry varied consistently from the wetland edge to the center, but also varied by distance to roads and surface-water flow.
- Results indicate that only three wells are needed for sampling per site, arranged perpendicular to wetland edges and impervious surfaces.



*Conductivity interpolated across an emergent wetland using inverse distance weighting.*

- Changes in groundwater chemistry through time were examined to determine temporal variability and optimum sampling periods.
- Temporal variogram analysis (above) suggested a four week sampling period.
- More frequent sampling would result in little information gain due to temporal autocorrelation.

## Landscape-Scale Stressor Indicators

- Landscape-scale metrics are being evaluated for relationships to wetland ecosystem response variables: landscape fragmentation, land use/land cover immediately buffering wetlands, geomorphic setting, hydrology (water source, export), distance to roads, etc.
- Result will be a suite of landscape indicators of wetland susceptibility to stress.
- This information will be used to guide development of a stratified sampling scheme for monitoring park wetlands, so that those wetlands with the greatest risk of degradation are sampled with the highest probability.