

TITLE

Development of a Wetland Monitoring Protocol for Acadia National Park

PRINCIPAL INVESTIGATORS

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ABSTRACT

Wetlands of Acadia National Park are threatened by a suite of anthropogenic stresses associated with increasing visitor pressure and rapid residential development of watersheds adjacent to the park. A monitoring program is essential to help resource managers document trends in wetland condition, evaluate potential threats, and identify areas of management concern. This project will identify robust indicators of wetland function that are suitable for monitoring the condition of Acadia's predominant wetland types (freshwater emergent wetlands, forested and scrub/shrub wetlands, peatlands, and salt marshes), and determine the sample size necessary to detect change in these variables through routine monitoring. The project will also identify landscape attributes that can be used to assess the susceptibility of park wetlands to anthropogenic stressors as a basis for a stratified sampling design. This information will be synthesized into a wetland monitoring protocol for Acadia National Park that is ready for field implementation.

PROBLEMS STATEMENT

Wetlands at Acadia National Park are exposed to a suite of threats associated with human development of watershed areas outside the Park boundary, such as altered surface and groundwater hydrology, invasive species encroachment, excess nutrient loading, and contaminant inputs (Roman 2000). Over 10% of the park's land area is classified as wetland (Calhoun et al. 1994). A diverse array of wetland types is represented, including forested and scrub-shrub wetlands, freshwater emergent marshes, peatlands, and salt marshes. These systems contribute significantly to the region's biodiversity, productivity, and uniqueness. Some of Acadia's wetlands have already been degraded to varying degrees by anthropogenic stresses (Kahl et al. 2000), and increasing park visitation and external development activities put many more park wetlands at risk. A monitoring program is essential to help resource managers document trends in the condition of Acadia's wetlands, evaluate potential threats, and identify areas of management concern. Both the Resource Management Plan (Manski 1998) and the Water Resources Management Plan (Kahl et al. 2000) for Acadia National Park cite establishment of a monitoring program as a high priority for protecting park wetland ecosystems. In addition, implementation of the Natural Resource Challenge strategy (Fancy 2002) within the Northeastern Temperate network will begin in 2003, and development of a regional wetland monitoring protocol will undoubtedly form an important component of the network's vital signs monitoring program.

A comprehensive assessment of Acadia's wetlands (Calhoun et al. 1994) exists as a basis for development of a long-term monitoring program. Although protocols for monitoring aquatic resources are currently being developed for Cape Cod National Seashore through the NPS prototype monitoring program (Roman and Barrett 1999), none are immediately transferable to the diversity of wetland types and geomorphic setting found at Acadia. Wetland attributes that serve as robust indicators of ecosystem integrity have been identified for other regions of the country (e.g. Guntenspergen et al. 2002). This information offers valuable guidance but is not readily applicable to the northeastern US, where the factors controlling wetland function differ. We have conducted an initial project to select potential wetland monitoring variables by comparing candidate indicators among park wetlands of one type only, herbaceous emergent fens, along a gradient of ecological condition (Guntenspergen and Neckles, in progress). Preliminary results show a set of chemical, physical, and vegetation indicators with promise for monitoring wetland integrity; i.e., in accordance with established guidelines for evaluating ecological indicators (Jackson et al. 2000, Dale and Beyeler 2001), the parameters are related to specific wetland functions, implementation appears feasible, and responses to stress are outside the range of natural variability. To apply this information to long-term monitoring these indicators must be tested more extensively, the spatial and temporal sampling frequency necessary to characterize wetland condition must be defined, and a system must be established for selecting a sub-set of all park wetlands to include in a monitoring program.

We propose a 3-year project (FY 2004-2006) that builds upon our initial wetland indicator selection to develop an operational wetland monitoring plan for Acadia National Park. This plan will have immediate utility for establishing a long-term wetland monitoring program at Acadia, and will provide a basis for expanding to the regional scale required by the Vital Signs program in the Northeastern Temperate network.

DESCRIPTION OF PROPOSED ACTION

Objectives:

The objectives of this project are as follows:

1. Test the proposed suite of monitoring variables emerging from the initial indicator selection study on an independent set of herbaceous emergent fens (i.e. the same type of wetlands used to identify the indicators) to verify indicator robustness;
2. Test this same suite of variables on the range of other wetland types prevalent at Acadia to assure broad indicator applicability throughout all park wetlands;
3. Conduct intensive sampling on a subset of wetlands within distinct types to define the spatial and temporal sampling frequency necessary to characterize wetland condition;
4. Develop a mechanism for identifying those wetlands that are most susceptible to anthropogenic threats and should consequently be considered for long-term monitoring;

5. Produce an operational wetland monitoring protocol for Acadia National Park.

Methods:

Extensive testing and evaluation of the effectiveness of proposed procedures is essential for developing a good, long-term monitoring plan (Fancy 2002). The following approach builds on the results of our initial test of candidate wetland indicators to develop a wetland monitoring plan for Acadia National Park.

1. Test proposed monitoring variables on an independent set of herbaceous emergent fens.

For a parameter to effectively differentiate between unimpacted and degraded systems during routine monitoring, it is critical that responses to stressors can be distinguished from natural variability (Jackson et al. 2000, Fancy 2002). In order to limit the influence of natural variability as much as possible during our initial evaluation of candidate variables, we restricted testing to one of the predominant wetland types in the Acadia region, fens dominated by herbaceous emergent vegetation. During the 2000 and 2001 growing seasons we measured responses of a large suite of chemical, physical, and vegetation characteristics within twenty study wetlands of this type. We are currently summarizing the results of this project (completion date is December 2002). Preliminary analyses reveal a number of parameters that show distinct differences related to ecosystem condition; these parameters will therefore be proposed as monitoring variables. Among these are both stressor variables (e.g. total dissolved nitrogen in surface waters; porewater conductivity) and response variables (e.g. vegetation species composition). The first step to ensuring the robustness of these parameters as monitoring variables is to test them on an independent set of herbaceous emergent fens.

We will initiate field work on the current project in FY 2004. We will identify an additional set of herbaceous emergent fens within and around Acadia National Park using existing wetland inventories (Calhoun et al. 1994, USFWS National Wetlands Inventory). Sites will be classified along a disturbance gradient based on knowledge of local stressors (e.g., landscape position and proximity to roads, parking lots, or other structures with the potential of disrupting local hydrology; information from previous studies and surveys) and site visits. We will measure proposed monitoring variables at each of these sites over the course of two growing seasons (2004-2005), using the same sampling designs developed initially for sampling candidate indicators within the original set of twenty wetlands. We will then compare variables across levels of wetland condition using standard parametric and multivariate statistics. Proposed variables that continue to display statistically significant, ecologically meaningful, and consistent differences related to wetland condition are likely candidates for incorporation into the final monitoring program.

2. Test candidate monitoring variables on the range of other wetland types prevalent at Acadia.

The most useful wetland monitoring program will be applicable to the full range of wetland types found in the Acadia region. Consequently, the next step in developing a comprehensive wetland monitoring program involves evaluating the behavior of proposed monitoring variables under the full range of potential conditions that will be encountered during routine monitoring of

Acadia's wetlands. We will use the gradient approach described above to select and test our proposed monitoring variables on a representative set of woody freshwater wetlands (forested and shrub/scrub dominated), peatlands, and salt marshes in the Acadia region.

3. Define the spatial and temporal sampling frequency necessary to characterize wetland condition.

An important step in designing a monitoring program is determining the sample size needed to detect changes in resource status, which is a function of the variability of the parameters to be measured (e.g. Noon et al. 1999, Fancy 2002). The natural variability of ecological indicators includes temporal (within the field season and across years) and spatial (across sites) components. We will be able to assess across-site and across-year indicator variability from our extensive sampling of herbaceous emergent fens and wetlands of other types (original indicator development study and testing proposed above). The timing and frequency of sampling must also consider seasonal and spatial variability within units of interest (Underwood 1993), which in this case are individual wetlands. We will randomly select a subset of wetlands within each type class for intensive sampling across the wetland and throughout the season. We will apply power analysis techniques to determine the sample size needed to achieve certain confidence limits for each variable (Green 1979, Underwood 1993).

4. Develop a mechanism for identifying wetlands at risk.

A monitoring program is applied to a subset of the available sites in order to make inferences about the condition of the overall population of sites. Simple random sampling is generally not recommended because park resources of interest may not be adequately represented in the sample (Fancy 2002). It is preferable rather to identify areas of special interest for application of a stratified design, so that certain strata may be sampled with higher probability. We propose to develop landscape-scale stressor indicators to identify which wetlands are most vulnerable to anthropogenic threats. Landscape indicators, combined with knowledge of how landscape pattern influences ecosystem condition, can be used to evaluate potential risk to or vulnerability of ecological resources within a given area. Several landscape indicators have been proposed, including the proportion of land use/land cover types and the amount of edge between different land uses/covers, the extent to which a small number of land uses/land covers dominates the landscape, the extent to which a landscape is fragmented, and the amount and type of land use/land cover immediately surrounding and buffering streams and wetlands (Hunsaker et al. 1992, O'Neill et al. 1997, Guntenspergen et al. 2002). We will apply these landscape-scale indicators to classify Acadia's wetlands based on susceptibility to stress. We will then use this information to design a stratified sampling scheme for monitoring park wetlands, so that wetlands with the greatest risk of degradation are sampled with the highest probability. This stratification scheme could be supplemented by results of a study on wetland water sources and hydrologic functions (e.g. ground-water recharge vs. ground-water discharge) currently proposed for Acadia National Park (proposal by M. Nielsen, USGS); if available, these hydrologic results would provide additional information on wetland vulnerabilities to degradation from hydrologic stresses.

5. Produce an operational monitoring protocol.

We will synthesize the results of this project in an operational wetland monitoring protocol for Acadia National Park. The synthesis will follow NPS guidance on characteristics of a good monitoring protocol (Fancy 2002), including a description of the resource issues being addressed, a conceptual model linking anthropogenic stressors, wetland ecosystem components, and wetland responses, a protocol narrative, and a series of standard operating procedures detailing the methods for implementing each component described in the narrative.

Anticipated Results and Products:

This project will identify specific wetland attributes suitable as indicators for monitoring the condition of the predominant wetland types in Acadia National Park (freshwater emergent wetlands, forested and scrub/shrub wetlands, peatlands, and salt marshes). It will also determine the sample size necessary to detect change in these variables, and consequent wetland status, through routine monitoring, and identify landscape attributes that can be used to assess wetland vulnerability to anthropogenic stressors. This information will be synthesized into a wetland monitoring protocol for Acadia National Park. A report describing the protocol will include background and objectives (resource issues being addressed, monitoring questions, conceptual model), detailed description of a stratified sampling design (with strata defined by landscape stressor variables), field methods, data handling and reporting, personnel requirements and training, operational requirements, and standard operating procedures for each sampling component (after Fancy 2002). The report will be reviewed by resource managers and scientists before being finalized. Printed copies of the monitoring protocol will be delivered to park staff and associates. We will also prepare a fact sheet for broad distribution announcing the availability of the monitoring protocol, and will post the complete document for downloading from USGS and NPS web sites. Products will also include presentations to scientific peers at regional and national meetings and two publications in peer-reviewed scientific journals (one on wetland monitoring indicators and one on landscape stressor variables).

When implemented at Acadia National Park, the scientifically-based monitoring protocol proposed here will allow park resource managers to document trends in the condition of Acadia's wetlands, evaluate potential threats, and identify areas of management concern. This information is critical to protecting the long-term integrity of these systems. Because of the importance of wetland ecosystems to the overall health and biodiversity of the Acadia region and the current lack of a protocol to monitor park wetland condition, Acadia's Resource Management Plan and Water Resources Management Plan cite establishment of a wetland monitoring protocol as a high priority. This product will thus meet urgent needs identified by park managers.

In addition, a wetland monitoring protocol for Acadia will form the basis for regional testing and expansion to the scale required for implementing wetland vital signs monitoring in the Northeastern Temperate network. The level of funding available to park networks through the Natural Resource Challenge provides a minimum infrastructure for initiating natural resource monitoring at network parks. It is expected that Natural Resource Challenge funding will be augmented from other sources, and it is hoped that monitoring will be initiated as soon as possible to meet NPS goals and Congressional mandates (Fancy 2002). An existing, intensive wetland monitoring protocol at Acadia will serve as an essential springboard for the wetland

component of a network-wide vital signs monitoring program. This will benefit the vital signs program by facilitating an early start to wetland monitoring throughout the region and by allowing limited resources to be focused on developing protocols to monitor other important ecosystems in the network.

Work Plan and Costs:

Work on this project would begin in FY 2004. Data would be collected for two years, with data synthesis and publication of results occurring in year 3. The following budget request supports field data collection and analysis in Years 1 and 2 (FY 2004-2005) to achieve Objectives 1, 2, and 3, GIS analysis in Years 1 and 2 to achieve Objective 4, and integration of this information into an operational wetland monitoring plan in Year 3 (FY 2006) to achieve Objective 5.

FY 2004 Budget Request

Salaries	
Seasonal field technicians (4 individuals, GS 4, 3 months)	\$23,600
GIS assistant (GS 5, 6 months)	13,000
Field and data manager (GS 11, 4 months)	22,000
Data entry/lab technician (GS 4, 6 months)	11,800
Equipment	
Field equipment	5,000
Supplies	
GIS software licenses	3,000
Expendable	4,000
Laboratory analyses	14,000
Publication Costs	
Travel	
Meetings and coordination (2 Principal Investigators)	7,000
Local to ANP	2,000
Transportation (USGS District Vehicle)	1,000
Seasonal GSA rental vehicles	3,000
TOTAL FY 2004	\$109,400

FY 2005 Budget Request

Salaries	
Seasonal field technicians (4 individuals, GS 4, 3 months)	\$24,800
GIS assistant (GS 5, 6 months)	13,600
Field and data manager (GS 11, 4 months)	23,100
Data entry/lab technician (GS 4, 6 months)	12,400
Equipment	
Field equipment	3,000
Supplies	
GIS software licenses	3,000
Expendable	4,000
Laboratory analyses	14,000
Publication Costs	

Travel	
Meetings and coordination (2 Principal Investigators)	7,000
Local to ANP	2,000
Transportation (USGS District Vehicle)	1,000
Seasonal GSA rental vehicles	3,000
TOTAL FY 2005	\$110,900
 FY 2006 Budget Request	
Salaries	
GIS assistant (GS 9, 6 months)	\$20,600
Research associate (GS 11, 6 months)	35,000
Data entry/lab technician (GS 4, 2 months)	4000
Equipment	
Field equipment	
Supplies	
GIS software licenses	3,000
Expendable	
Laboratory analyses	2,000
Publication Costs	5,000
Travel	
Meetings and coordination (2 Principal Investigators)	7,000
Local to ANP	1,000
Transportation (USGS District Vehicle)	1,000
Seasonal GSA rental	
TOTAL FY 2006	\$78,600
 TOTAL AMOUNT REQUESTED	 \$298,900

In addition, the following other resources have been committed to this project:

Salaries + benefits for principal investigators, USGS Patuxent Wildlife Research Center	
Neckles, GS-13, 6 months per year for 3 years	\$152,000
Guntenspergen, GS-14, 6 months per year for 3 years	165,000
Lodging, Acadia National Park (In-kind for 3 year life of project)	20,000
Information on wetland indicators developed during initial study, USGS	
Park Oriented Biological Support program and USGS PWRC	157,000
GIS wetland and topographic data, USGS WRD and NRPP	52,000
TOTAL OTHER CONTRIBUTIONS	\$546,000

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RANKING CRITERIA

1. Significance of the Resource or Issue to the Park

Acadia's diverse wetland types constitute over 10% of the park's land area and contribute significantly to the health, productivity, and uniqueness of the region. One rare type of peatland in the park, the Coastal Plateau Bog, is restricted globally to a narrow strip along the northeastern coast of North America, and is listed on the Maine Register of Critical Areas (Kahl et al. 2000). Wetlands provide critical habitat for waterfowl and other birds, reptiles and amphibians, mammals, and plants within the park: at least one state-listed rare plant is found in each Acadia wetland type (Kahl et al. 2000). Wetlands also provide essential ecosystem functions (e.g. nutrient cycling, water purification, high primary production) and values (e.g. groundwater recharge). Acadia's wetlands support a variety of recreational pursuits including fishing, sightseeing, canoeing, and birding. Concern for the protection of the ecological, aesthetic, and recreational attributes of water resources has been a dominant theme for Park managers, State agencies, and local communities for nearly a century. Wetlands are protected by federal and state legislation, NPS has established wetland protection guidelines for park units, and Acadia's Resource Management Plan places a high priority on establishment of a wetland monitoring plan.

2. Severity of Resource Threat, Problem, or Need(s)

Increasing visitor pressure to Acadia National Park and an unprecedented rise in residential development of watersheds outside the park boundary are exposing park wetlands to a suite of anthropogenic stressors. Acadia's wetlands are threatened by alterations in surface- and ground-water hydrology, invasive species encroachment, excess nutrient loading, contaminant inputs, and direct trampling. Some wetlands in the park are already showing clear signs of degradation, and many more face immediate risk of anthropogenic impacts (Kahl et al. 2000). A scientifically-based monitoring program is essential to protecting the long-term integrity of these systems; consequently, establishing a wetland monitoring program is cited as a high priority in Acadia's Resource Management Plan. A monitoring program will enable park resource managers to document trends in the condition of Acadia's wetlands, evaluate potential threats, identify areas of management concern, take possible management actions inside the park boundary, and work with local communities to inform land management decisions outside the park boundary. Without the information derived from a monitoring program, existing stressors have the potential to continue to degrade park wetland resources unchecked.

3. Problem Definition and Information Base

An existing inventory of Acadia's wetlands provides the basis for long-term monitoring (Calhoun et al. 1994). Although protocols for monitoring aquatic resources are currently being developed for Cape Cod National Seashore through the NPS prototype monitoring program, none are immediately transferable to the diversity of wetland types and geomorphic setting found at Acadia. Wetland attributes that serve as robust indicators of ecosystem integrity have been identified for other regions of the country. This information offers valuable guidance but is not immediately applicable to the northeastern US, where the factors controlling wetland function vary. Acadia's Water Resources Management Plan (Kahl et al. 2000) highlights the need to identify monitoring variables relevant to all park wetland types and to define thresholds of change that should trigger management actions. These information needs prompted our initial research to identify potential wetland monitoring variables for Acadia National Park (Guntenspergen and Neckles, in progress). Our ongoing study has identified a suite of wetland characteristics with promise for monitoring wetland integrity in the Acadia region. Extensive testing of these proposed variables is required to select indicators applicable to the range of Acadia's wetland types and to define a sampling scheme for long-term monitoring.

4. Technical Soundness

Each principal investigator of this project (Dr. Hilary Neckles and Dr. Glenn Guntenspergen) has over a dozen years of professional experience studying wetlands at various scales. They have published scientific papers and reports related to monitoring and landscape analysis of wetland ecosystems (e.g. Neckles 1994, Grace and Guntenspergen 1999, Guntenspergen et al. 2002, Neckles et al. 2002), and are in the final year of a study to identify potential wetland indicators at Acadia. The approach outlined in this proposal follows widely accepted rationale, objectives, and strategies for monitoring protocol development that have been adopted by the NPS (Fancy 2002) as well as by other prominent monitoring programs (e.g. US EPA's Environmental Monitoring and Assessment Program: Barber 1994, Jackson et al. 2000; US Forest Service-Northwest Forest Plan: Noon et al. 1999). Because this project builds directly on an initial study of wetland indicator development at Acadia National Park (Guntenspergen and Neckles in

progress) and will make use of extensive GIS data acquired in relationship to other USGS projects, we will be able to accomplish the objectives of this project within the proposed, 3-year time frame.

5. Problem Resolution

This project will identify specific wetland attributes suitable as indicators for monitoring the condition of the predominant wetland types in Acadia National Park. It will also determine the sample size necessary to detect change in these variables through routine monitoring, and identify landscape attributes that can be used to assess wetland vulnerability to anthropogenic stressors. This information will be synthesized into a scientifically-based wetland monitoring protocol for Acadia National Park that is ready for field application. The protocol will include background and objectives (resource issues being addressed, monitoring questions, conceptual model), a detailed description of a stratified sampling design (with strata defined by landscape stressor variables), field methods, data handling and reporting, personnel requirements and training, operational requirements, and standard operating procedures for each sampling component. When implemented at Acadia National Park, this monitoring protocol will allow park resource managers to document trends in the condition of Acadia's wetlands, evaluate potential threats, and identify areas of management concern. This information is critical to protecting the long-term integrity of these systems.

6. Transferability

We will develop a monitoring protocol that is immediately applicable to wetlands of Acadia National Park. It will also be applicable to wetlands in similar geomorphic settings throughout the northeastern US, and so will be useful to natural resource managers in other federal and state agencies involved in wetland protection. We will prepare a fact sheet for broad distribution announcing the availability of the monitoring protocol, and will post the complete document for downloading from USGS and NPS web sites. Most important for NPS, the intensive effort devoted to developing a wetland monitoring protocol for Acadia will provide a springboard for development of a regional program for monitoring wetland vital signs throughout the Northeastern Temperate Network. Our results will provide an immediate basis for a network-wide test to evaluate and adapt Acadia's wetland monitoring protocol as needed for regional implementation.

7. Cost Effectiveness

This project uses extensive data and information generated through separate funding sources. Our initial study of wetland indicator development (USGS Park Oriented Biological Support program) reduced a list of candidates to a suite of proposed monitoring variables, and we have acquired GIS data layers for Acadia wetlands and watersheds in association with other projects. By using this information we can develop a wetland monitoring protocol for a fraction of the cost that would otherwise be required. Our previous studies have informed us of the level of effort, supplies, and equipment required to achieve our objectives. About 65% of the costs during years 1 and 2 are for salaries of an experienced field and data manager, and field, laboratory, and GIS technicians, who will work together to collect and analyze data. In the final year, 75% of the

costs are for salaries of an experienced research associate and GIS specialist who will contribute to data synthesis and integration. Remaining costs are for laboratory analyses, travel for field work and scientific meetings, and other operating expenses. Principal investigators will participate in and oversee all aspects of the project, be responsible for final data synthesis, and prepare the monitoring protocol.

8. Project Support

The budget request over the 3-year span of this project is \$298,900. An additional \$317,000 in salary and benefits for two principal investigators (6 months per year each, for a 3-year project period) is committed by USGS Patuxent Wildlife Research Center. An in-kind contribution of field lodging is committed by Acadia National Park for a total value of \$20,000 (calculated as 200 person-nights at an equivalent summer rate of \$100 each per night). This project will also integrate data and information generated through other funding sources. Development of proposed wetland indicators is supported by the USGS Park Oriented Biological Support program in cooperation with Patuxent Wildlife Research Center (\$157,000), and acquisition and creation of GIS data layers is supported by USGS Water Resources Division and the Natural Resource Preservation Program (\$52,000). The additional support for this project (including in-kind contributions) sums to \$546,000, or 65% of the total project cost of \$844,900.

MEASURABLE RESULTS

Acadia National Park's Resource Management Plan and Water Resources Management Plan list establishment of a wetland monitoring program as a very high priority. The proposed project will identify robust indicators of wetland function that are suitable for monitoring the condition of Acadia's predominant wetland types, and determine the sample size necessary to detect change in these variables through routine monitoring. The project will also identify landscape attributes that can be used to assess the susceptibility of park wetlands to anthropogenic stressors as a basis for a stratified sampling design. This information will be synthesized into a scientifically-based wetland monitoring protocol for Acadia National Park that is ready for field application. When implemented, this monitoring protocol will allow park resource managers to document trends in the condition of Acadia's wetlands, evaluate potential threats, identify areas of management concern, take possible management actions inside the park boundary, and work with local communities to inform land management decisions outside the park boundary. Such a monitoring program is critical to protecting the long-term integrity of Acadia's wetland ecosystems.