NPS Long-Term Ecological Monitoring Program: Developing a Standard Description for Monitoring Protocols

by Lisa Thomas, Prairie Cluster LTEM Program, April 1998

Problem Statement

We have come to a point in the development of the LTEM programs where it would be useful to define and formalize the fundamental components of a monitoring protocol. Scientific reviews have been completed for monitoring protocols developed by the three original LTEM programs. Protocol development continues at Denali, and new efforts have begun in the Prairie Cluster, Cape Cod and the Virgin Islands. A clear statement of NPS definitions and expectations is more essential now that the researchers responsible for protocol design are housed in a separate agency.

Considerable difference of opinion and room for confusion exist regarding what is meant by the term 'monitoring protocol'. The most obvious component of a monitoring protocol is the sampling methods. Because there is often disagreement among experts concerning the most appropriate sampling approach, getting beyond the choice of sampling methods is a big hurdle, and is often the focus of attention during the design phase. However, if we are to succeed in designing national prototypes for long-term monitoring, protocols must address a more complete range of monitoring issues. In an attempt to write a standard description of the components of a monitoring protocol, I have reviewed the existing LTEM protocols, the NPS/BRD reviews of the Channel Islands, Shenandoah, and Great Smoky Mountain LTEM programs, as well as LTEM Data Management Protocols, and monitoring protocols from other agencies.

Goals and Objectives of the NPS LTEM Program

Noon (1995) suggests that the goal of a park monitoring program should be to assess how well park ecosystems are being sustained by current management practices. More specifically, the goals of the NPS LTEM program are to 1) provide early warning of resource decline, 2) evaluate the effectiveness of resource management practices, and 3) develop a predictive understanding of environmental change.

In order to build a successful monitoring program, monitoring protocols must:

1. Relate directly to park management issues and resource threats
1. Be scientifically credible
1. Generate accessible, high-quality data
1. Feed back into the decision-making process with timely and relevant information
1. Be readily exported to other sites within the same bio-geographic region.

Summary of Review Comments

In 1995 and 1996, NPS and BRD convened review panels to provide technical and programmatic guidance to

the prototype monitoring programs. I have attempted to summarize the most common problems and recommendations brought out by the reviews for Channel Islands, Great Smoky Mountains, and Shenandoah. In my opinion, the most important suggestions fall under seven topics.

Monitoring objectives should address both resource management issues and ecological questions.

According to the reviews, "A successful park monitoring program helps evaluate the effectiveness of management practices and develops a predictive understanding of environmental change". Monitoring objectives should be developed to address both short-term management issues and long-term ecological trends. The reviewers stressed that consensus must be reached between scientists and managers to achieve an appropriate balance of monitoring objectives. When the monitoring objectives are directed toward management questions, they should be tightly linked, demonstrating how monitoring results would influence the decision-making process. Monitoring protocols should also articulate the rationale for why particular taxa, communities, or other attributes were selected for monitoring.

More specific operational objectives and definitions should be developed to ensure that monitoring questions can be answered.

In a few cases the reviewers thought the monitoring objectives were not reflected in the design of the protocols. More commonly, the monitoring objectives were too vague or general to be answered with the data being collected. Paul Geissler (BRD statistician on review panels) suggests that operational objectives must be very specific and stated in terms of measurable quantities. For example, the objective of maintaining biodiversity is too general to be useful. Instead, the objective might be to detect a 50% or greater decrease in black bear bait station indices between a 10-year base period and the current 2-year period with 10% type 1 and 10% type 2 error rates. He also suggests graphing protection levels (detectable differences) as a function of cost (sample size) as one basis for allocating resources. In other words, how much protection can the park afford?

Monitoring protocols must incorporate elements of experimental design.

Geissler emphasizes the need to review survey designs, stratification, and sampling intensity in order to determine an optimal sampling strategy. Noon (1995) suggests that the indicator variable must be estimated with sufficient precision and accuracy so that when a biologically significant change has occurred there is a high likelihood it will be detected. Noon cites several practical statistical issues that should be considered in the design of a monitoring program, including: What is the population to be sampled, and to what larger population is it valid to draw both biological and statistical inferences? How do we define the spatial and temporal scale of the monitoring program? What is the appropriate unit of measurement for the indicator variable? What is the sample size necessary to estimate the value of the indicator? How should the sample units be arranged in space to avoid pseudo-replication and to assure independence of treatment effects? What is the appropriate time interval between samples? What is the tradeoff between gains in precision and power and the additional costs per sample unit?

Monitoring databases should be more integrated and accessible.

The reviewers recommend initiating standard procedures to ensure a high quality of data and data reports. They recommend including procedures for field sampling, quality assurance/quality control, and data handling/reporting, in order to ensure a high quality publishable product. They also stress that to be useful, monitoring data and meta-data must be accessible. The data should be available in a common system that allows

the user to select and export data and summary tables to other applications (word processor, statistical analyses, graphics and GIS software). Databases from different protocols should be related so that integrated analysis can be performed.

Monitoring results should be routinely summarized and reported to management.

The reviewers advise instituting more regular schedules for data summary and reporting. The whole purpose of the LTEM program is to provide managers with timely and relevant information on which to base management decisions. The reviewers recommend running standard analyses on an annual basis. In addition, results of the annual monitoring efforts should be reported regularly and published in technical reports or publications targeted for resource managers. One program review stated that approximately 90% of staff time was spent on data collection. The reviewers recommend scheduling more time for writing, reporting, and transferring of results to resource managers. The process by which monitoring results feed into the management decision making process must be clearly stated and institutionalized.

More attention should be directed toward data analysis.

One reviewer makes the point that even though many aspects of the LTEM programs represent pioneering work, successful implementation is not complete until monitoring results feed back into management decisions. This step cannot be completed until appropriate analyses have been selected and applied. Geissler makes a distinction between monitoring questions that are best addressed through statistical tests, and those that require less rigorous analysis. For instance, if a population decrease might result in regulatory action, hard evidence is required. If monitoring is directed at assessing management actions that the Park might take on its own authority, less rigorous support might be necessary. In the later case he suggests using control charts as a simple tool for screening monitoring data and for identifying species and locations that deserve closer examination.

Noon observes that a common reason to monitor a specific environmental attribute is to detect differences in its value across time at a given location. Changes in the value of an indicator are relevant to the extent they provide an early warning of adverse changes to an ecosystem before irreversible loss has occurred. He describes two specific products from a monitoring program; an estimate of the value of an environmental indicator at a given location at a specific point in time, and an assessment of temporal trend in the indicator.
Noon asserts that detecting and recognizing meaningful change is complex because natural systems are inherently dynamic. He suggests that for a monitoring program to be effective it must be capable of discriminating between extrinsic and intrinsic factors of change. That is, a mechanism to filter out the effects of random variation or cycles (noise) from the effects of human-induced patterns of change (signal) is required.

The reviewers recommend that standard analyses should be run each year. They advise that access to a consulting statistician is required to maximize sampling efficiency and respond to management information needs.

Integration of monitoring components should be improved.

The reviewers stress improving the integration of the monitoring programs. A major value of an environmental monitoring program is the ability to relate trends across protocol areas. One review suggested that none of the projects encompassed monitoring to better understand ecosystem dynamics or to attempt to correlate or support the findings of one area of study with another. The reviewers recommend instituting a formal process which

encourages and ensures the cross-linking of protocols.

Incorporating LTEM Reviews into Protocol Development

Phasing in the implementation of LTEM prototypes gives us the opportunity to learn from earlier efforts and improve the process of developing and initiating long-term monitoring. Channel Islands, Shenandoah and Great Smoky Mountains have led the way, each making unique contributions to the LTEM program. Thanks to their efforts we have a better understanding of ideas such as developing a conceptual model, and the importance of sound data management. We can also learn from the NPS/BRD program reviews. These reviews should be used for more than addressing weaknesses within individual programs. They also provide a framework for strengthening our concept of a monitoring protocol, and refining the process of protocol development. Based upon the existing protocols, the LTEM data management plan, and program reviews, I submit a protocol outline for consideration. My intention is to stimulate discussion so that we may arrive at a consensus view of the essential components of a monitoring protocol. In my opinion, clarification of this issue is necessary to promote a solid and unambiguous relationship with research partners involved in protocol development.

Literature Cited

Biological Resources Division, USGS. 1996. Review of Long-Term Monitoring Program at Shenandoah National Park.

National Biological Service. 1995. Review of Long-Term Monitoring Program at Great Smoky Mountains National Park.

National Biological Survey. 1996. Report and review Recommendations for the Channel Islands Prototype Monitoring Program.

National Park Service. 1996 (draft). Inventory and Monitoring Program; Data Managment Protocols.

Noon, B.R. 1995 (draft). Conceptual Issues in the Monitoring of Ecological Resources.

LTEM Protocol Outline

I. Monitoring Objectives

A. Rationale for selecting species, community, or other attribute for monitoring

B. Resource issues that monitoring will address

Operational objectives of monitoring

II. Protocol Design

A. Sampling methods

1. Rationale for sampling approach

Description of sampling methods

Selection of variables

B. Site selection

1. Criteria for site selection

Stratification

General description of number and location of sampling sites

C. Optimal survey design

1. Sampling intensity

Sampling frequency

Level of change that can be detected for a given cost

III. Field Implementation

A. Field samples and measurements

1. Preliminary tasks and preparation of equipment

LTEM Protocol Outline

Sampling sequence (where required)

Standard measurement procedures (where required)

Synonymy standards

B. Post-collection processing

1. Laboratory samples

Voucher specimens

IV. Data Management

A. Data entry

1. Description of related databases (e.g. sampling sites & events, raw data)

Standard field structure of databases

Building and updating dictionaries

B. Quality assurance

1. Training

a. Description of technical tasks that require regular review

Calculating and reducing investigator estimation error

2. Consistent field forms and data entry screens

C. Quality control

1. Data entry and verification procedures (transcription errors)

Data validation procedures (max/min limits, illogical values)

LTEM Protocol Outline

V. Data summary and Routine Reporting

A. Instructions for calculating indices and other summary variables

Description of statistical summaries, tables and graphs

VI. Data Analysis

A. Description of routine analysis

Detecting resource decline or temporal trends

VII. Integration with other Monitoring Components

Interpretation of Results and Management Applicability

References

Appendices:

II. Protocol Design
A. Location descriptions and map of sample sites
Description and photograph of sample sites
III. Field Implementation
B. Equipment list
Equipment descriptions, calibration instructions, etc.
Field data collections forms
Field aids (e.g. photographs describing categorical variables)
Labels for field samples, unknowns, vouchers, etc.
IV. Data Management
C. Data entry screens
V. Data Summary and Routine Reporting
D. Annual report format with examples of summary tables