Chapter 7 – Analysis and Reporting

ANALYSIS

Overview

The Great Lakes Network will strive to provide reliable information on the status and trend of natural resource indicators in a manner that informs park managers and allows them to assess whether park goals and mandates are being achieved. As we outline later in this chapter, there are many expected audiences for Network information, each with perhaps a different interest in the results and different familiarity with the systems described. Analytical approaches for each indicator (Vital Sign) are described in greater detail in each protocol, but are summarized here as an overview. We also outline some principles for our analytical approaches, and describe the strategy and outlets for communicating progress and results. In contrast to many other spatially extensive monitoring programs, we seek an integrated monitoring vision that encompasses several disparate but linked ecosystem components; correspondingly, analyses and reporting will promote this vision. The extent and depth of analysis in future years depends upon continued programmatic and competitive source funding.

Relationship of analyses to other steps in the monitoring process

Well-developed monitoring strategies have clear connections between questions of interest, appropriate sampling designs, and resulting analytical approaches (Noon 2003). Accordingly, the utility and robustness of our analyses are predicated upon the formulation of biologically meaningful questions and relationships, as expressed in our conceptual models (Gucciardo et al. 2004). While different analytical options exist, well-refined questions will prescribe certain analytical approaches, thereby removing any guesswork.

Increasingly, ecologists seek to elucidate and quantify biologically important phenomena, rather than doggedly pursue statistical significance (Johnson 2002, Anderson et al. 2001, Johnson 1999, Yoccoz 1991). The Great Lakes Network seeks first and foremost to provide a quantitative understanding of the magnitude and direction of change and to provide appropriate measures of precision of the estimate. We are striving to address directed monitoring questions that reflect our prior knowledge of the system and provide useful information for management decisions, rather than test myriad hypotheses about ecosystem change.

In addition to quantifying the status and trends of Vital Signs, a secondary goal is to begin to understand the dynamics and drivers (some of which are Vital Signs themselves, such as weather and land use) of our indicators, following our conceptual models. Although not every trend is a product of local management action or inaction, tests of association that begin to address the underlying 'why' questions behind the 'what' questions in trend analysis will be explored for at least a subset of Vital Signs. We have generally adopted sampling designs that optimize quantification of indicator values across the spatial domain of interest, rather than of the effect of a particular factor on indicator values. Nonetheless, in some cases, we have purposefully allocated samples across a gradient of a stressor (e.g., vegetation sampling at APIS islands at varying

distances from the mainland and with a range of deer density). Such approaches increase the likelihood that our monitoring can lead to correction of trend before the genetic, demographic, and stochastic problems that impinge upon small populations (Caughley 1994) become irreversible.

Finally, in both our analysis and reporting strategies, we are seeking to consistently link monitoring to the decision-making process (Noon 2003, Noon et al. 1999). Thus, in some sampling cycles we may reserve a portion of monitoring effort to address one or two specific, management driven questions in a limited but statistically powerful manner. Such targeted effort would be occasional, have a short duration, and would not replace our routine monitoring. Questions that could be addressed include, for example, assessing whether the cover of ruderal and non-native plant species is higher along newly created road corridors than in other areas of the park, and whether areas with trail closures in certain seasons exhibit higher species richness of amphibians than areas with year-round use.

We expect that results of our monitoring programs will be viewed and interpreted in the context of other Vital Signs, programs of other agencies, and research efforts.

Types of studies to describe and learn about the natural world

Ecologists commonly use three types of studies to describe the natural world – observational studies, manipulative experiments, and natural experiments. Our monitoring will primarily consist of observational study, but we will conduct natural experiments if disturbance occurs in a spatial manner that allows investigation with little or slight modification of our existing designs.

In observational studies (also termed "mensurative experiments"; Hurlbert 1984), treatments (e.g., disease, fire, visitor activities) are not assigned randomly across the population of sampled units (Cochran 1983). Consequently, such studies do not allow for the unequivocal testing of cause-effect relationships, because other (unmeasured) variables may be the cause of any differences observed, rather than the putative treatment. In spite of their drawbacks, observational studies are attractive in the sense that they often have higher external validity (i.e., ability to extrapolate findings) to the system(s) of interest, especially when they have high sampling replication. Because observational studies cannot control environmental and other factors, it is not possible to obtain a replicate independent data set under the same conditions. However, corroboration of an observed phenomenon by other indicators, across different domains, or by different investigators strengthens acceptance of any given result. These last two types of corroboration have been termed "metareplication" and provide some of the strongest indication that an observational result is biologically important rather than an artifact of method, investigators, temporal or spatial domain, or other factors (Johnson 2002).

On the other end of the spectrum are manipulative experiments, in which treatments are assigned randomly to a population of subjects, often under very controlled conditions. Manipulative experiments provide the strongest inference about how changes in the manipulated factor directly (or indirectly) effect changes in the response variable. Because experiments often occur in controlled laboratory conditions or within very spatially restricted areas in the field, they tend to have questionable external validity to

field conditions. Another drawback for NPS-administered lands, particularly those with wilderness, is that manipulative experiments may conflict with the philosophy (e.g., 'naturalness'; Landres 2005) and legislation of NPS management.

Intermediate between these two types are 'quasi-experiments' or natural experiments (Zar 1999, Sokal and Rohlf 1995) in which investigators take advantage of events such as disturbances to investigate the effect of a particular event on one or more response variables. In a sense, these types of investigations merge the positive aspects of both observation and experiment, in that they occur in the areas about which investigators wish to make inference and can be spatially extensive yet treatment has been provided by natural (e.g., catastrophic) process rather than by investigators. The Great Lakes Network will stay alert for these instances, because: a) they allow tests of the effects of both natural and anthropogenic disturbances; and b) their strength of evidence is bolstered by pre-event data, which we expect our sampling design will provide in most situations. This last property makes such monitoring similar to the before-after-control-impact (BACI) designs of environmental impact studies (Benedetti-Cecchi 2001, Schmitt and Osenberg 1996).

Steps in data analysis

Data analysis consists of four steps, including summarization and characterization of data, determination of status, evaluation of trends, and synthesis (Table 7.1). Data summarization and characterization help ensure integrity of the data, and provide the foundation for more comprehensive analyses and for effective communication of results (Reid 2001, Palmer and Mulder 1999). Status refers to the condition of the monitored variables at a single point in time, and should be quantitatively understood across the entire spatial domain of interest. Evaluation of trend requires at least three successive measurements of the indicator, and seeks to quantify change over time. Investigation of interannual (rather than seasonal or diel) trends encompasses the primary goal of the I&M monitoring program, though existence of strong seasonality and diurnal rhythms in ecosystems of the Great Lakes region affect our sampling strategy. Repeated measures will be a common analytical framework for measurements that are replicated across space or have shorter duration of monitoring. In contrast, time-series analysis is applicable for a single unit measured at least 30 times (e.g., 30 yrs), most common with individual climate and air-quality stations. Finally, synthesis involves the interpretation of monitoring results, placing of results within the body of existing knowledge, and discussing potential management implications. We will be using a number of statistical analysis packages including JMP™, SAS®, R, STATISTIX®, and PC-ORD.

Types of analytical approaches

Both across constituencies (natural-resource staff from individual parks, Network staff, and outside scientists) and across indicators, a diverse list of questions has been proposed for focusing monitoring efforts. These questions span a range of temporal and spatial scales, levels of biological organization, types of ecosystem indicators (i.e., structure, composition, and function), and trophic levels (Table 5.2, Table 7.1). Consequently, analytical approaches to such diverse questions are not easily summarized.

Table 7.1. Techniques and persons responsible for analysis of Vital Signs monitored by the Great Lakes Inventory and Monitoring Network. See Table 7.2 for report type (* in column 1); in the central column the analyses or methods used are listed in brackets.

Level of Analysis * report type	**Description and Techniques**	**Lead Analysts**
Data Summarization/ Characterization *Annual Summary Reports	Calculation of basic statistics of interest and initial screening, including: • Measures of central tendency [mean, median, or geometric mean] • Measures of confidence [standard error, confidence intervals], distribution [skew], and variability [standard deviation, variance] • Identification of missing values and outliers [box-and-whisker plots, queries, QA/QC] • Visual inspection of data [tables, appendices] Summarization encompasses both measured and derived variables mentioned in the monitoring protocols, as well as creation of data matrices for community analyses.	Field staff perform QA/QC, and begin characterizing data. Project managers produce summaries, with guidance from the quantitative ecologist. Collaborators and partners may also contribute.
Status Determination *Analysis and Synthesis Reports *Scientific journal articles *Briefings *Conference presentations	Analysis and interpretation of the status of a Vital Sign that seeks to answer: • Do observed values exceed a regulatory standard, or a known or hypothesized ecological threshold? • How do observed values compare with the range of historical variability (when it is known or estimated) for a Vital Sign? • What is the level of confidence (e.g., standard error) in the status estimate? • What is the spatial distribution (within the park, Network, or ecoregion) of observed values at time t_x? • Do these patterns suggest strong relationships with other factors not accounted for in the design? Distributional assumptions about the target population(s) and the level of confidence in the estimates will be assessed during analyses.	Project managers, with guidance from the quantitative ecologist. Participation from collaborators, partners, and subject-matter experts will also be sought. Insights from data collectors may be used to prescribe some tests.
Trends Evaluation *Analysis and Synthesis Reports *Scientific journal articles *Briefings *Conference presentations	Evaluations of interannual trends will seek to address: • Is there continued directional change in values of an indicator over the period of measurement? • What is the estimated rate of change (and the associated measure of uncertainty) for the indicator? • How does this rate compare with rates observed from historical data, other indicators from the same area, or with other comparable monitoring in the region? •Is there significant departure from the originally estimated (or simulated) power to detect trend? If so, why? • Are there unforeseen correlations that suggest other factors should be incorporated as covariates? [correlations, regression analyses] Analysis of trends will initially employ simple graphic portrayals, then repeated-measures, time-series, and other analyses, often with mixed linear models.	Project managers, the Network's quantitative ecologist, and protocol developers. Input will also be sought from cooperators, partners, other park and Network staff, and outside investigators.
Synthesis *Analysis and Synthesis Reports *Scientific journal articles *Briefings *Conference presentations	Examination of patterns across Vital Signs; associations between indicators, stressors, and drivers; and tests of specific management-oriented questions, which will include: • Tests of hypothesized relationships, congruence among indicators, and the importance of covariates • Confirmatory and occasional exploratory analyses in model selection (Burnham and Anderson 2002) • Integrative approaches [ordination of community data, multiple regression, diversity and conservation-value indices, (rarely) path analysis and structural equation modeling] • Evaluation of competing *a priori*-specified models that explain dynamics in indicator; model averaging, variable weights, and forecasting [information-theoretic analyses] Synthetic analyses require close interaction with academic and agency researchers, and may employ myriad approaches as new indicators and questions are included. Integration with existing results from other monitoring and research is critical.	Project managers and the quantitative ecologist will normally perform most synthetic analysis, though input and review will be pursued widely.

Given that financial resources and personnel are limited, we have sought to restrict our attention to a small subset of tractable questions for indicators that: a) can be precisely, repeatably, and relatively inexpensively sampled; b) show a rapid, persistent response to environmental changes; c) have dynamics that reflect the ecosystem or environmental component of interest; and d) have relatively low natural variability, allowing separation of background variation from a change in status (Noon et al. 1999). In addition to estimating magnitude of change and associated confidence intervals, we will use a combination of the four analytical approaches detailed below. Because analyses for each Vital Sign will involve many different analytical approaches, Table 7.1 is not exhaustive. More details on each analysis will be provided in individual protocols.

Hypothesis testing

This category of analysis will largely be reserved for testing whether status of a particular indicator meets a certain condition. This may be used to satisfy a particular congressional mandate or achieve a particular management or performance goal. Previously, nearly all monitoring questions were framed in terms of a statistical null hypothesis of no difference between the estimated value (status) of an indicator and its hypothesized baseline or reference value (Noon et al. 1999, Underwood 1997). However, estimating reference values ('benchmarks') is difficult and imprecise for several reasons (reviewed by Noon et al. 1999), including the recognition that benchmarks for indicators may be better represented by probability distributions rather than a single target value. One alternative to traditional null-hypothesis testing is bio-inequivalence testing, in which the rejection region is split into two sides and the test postulates that the difference between two samples is greater than the 'equivalence interval' (McBride 2005).

Model selection and information-theoretic approaches

Although the concept of multiple working hypotheses (as compared to a single statistical null vs. an alternative; Chamberlin 1890) has long existed, it did not gain broad support in ecological studies until recently. Analytical procedures (Akaike 1974) to handle such a framework are called information-theoretic because they derive from Kullback-Leibler 'information' theory (Kullback and Leibler 1951). In the approach, one seeks to compare the strength of evidence in support of various approximating models (hypotheses) that contain varying numbers of factors, to select the model that loses as little information as possible about truth. Information-theoretic approaches focus on the *relative* strength of the competing models, rather than on the importance of any single variable or model. Nonetheless, importance of individual variables can be obtained via calculation of variable weights, and either r^2 values or the relative weight or rank of the null model indicate how good a given model is at describing variability in the response variable (Eberhardt 2003, Burnham and Anderson 2002).

The competing models are ranked on two criteria – fit of the data to the model, and penalty for having too many variables. Information-theoretic analyses, which are generally discussed in a strength-of-evidence framework, have two properties that match humans' attempts at incremental understanding of natural systems. First, they allow for the potential existence of more than one plausible model, and provide a ratio of how much more likely the best-supported model is than each of the remaining models. Secondly, rather than making inferences on only the best model, it is possible to base

inference on the weighted average of all the models (multi-model inference). For example, in our initial monitoring efforts for amphibians, we will use model selection to determine which biotic and abiotic factors most strongly influence species detectability. We envision that such techniques also hold promise for many of our forthcoming indicators.

Integrative approaches

In addition to trying to understand dynamics of indicators individually, we also envision use of approaches that incorporate many response variables simultaneously. Generally, these approaches either a) concatenate all of the information into a unitless index, or b) try to differentiate between or illustrate relationships among sampling units in a holistic, multivariate sense. Examples of the former approach we are most likely to use include calculation of beta and gamma diversity from alpha diversity across sampling locations, the portfolio of diversity indices available (Magurran 1988), and a floristic quality assessment (Swink and Wilhelm 1994).

The second approach may involve an array of tests, depending on the nature of the data being analyzed. For continuous abiotic properties, two or more types of sites can be compared to determine whether the site types differ in values across all (or many) properties in a multivariate analysis of variance (MANOVA) or, if assumptions are not met, in a nonparametric MANOVA (NPMANOVA). If, instead, the data are abundance or cover or even presence of species at a collection of sites, ordination of the sites in multidimensional space can shed light on the relationships among sites in terms of their species composition. These ordination techniques are needed because of the 'dust-bunny' distribution of species at and across sites, namely, that few species are dominant at any site and instead most species are uncommon or totally absent (McCune and Grace 2002).

Many analytical tools are available to answer a number of specific multivariate questions, and theory and analytical algorithms continue to be developed to address hypotheses from increasingly complex designs. We will rely largely on PC-ORD (McCune and Grace 2002) to analyze community-wide questions; nonmetric multidimensional scaling (NMS) is currently one preferred test. These techniques also lend themselves to tracking of community composition at sites through time, as illustrated by West and Yorks (2002), vector change analyses (Fulton and Harcombe 2002) and replicate *G*-tests (Rooney et al. 2004) for plants. Some authors (Anderson et al. 2001, Rexstad et al. 1988) have posited that many common multivariate techniques have high probability of producing spurious results; however, these critiques are leveled more at the tendency of practitioners to extend inference beyond the analysis rather than at robustness of the tests themselves.

Bayesian approaches

As an alternative to so-called frequentist statistics, Bayesian statistical methods have gained increasing popularity among biometricians (Dorazio and Johnson 2003). In brief, Bayesian approaches quantify pre-existing knowledge or beliefs about the system into what is known as a prior probability distribution. In Bayes' theorem, those existing beliefs are updated as a result of new monitoring data, which produce revised beliefs that are quantified in a probability distribution *a posteriori*. This approach is attractive not only because it allows an informed starting point, but also because it allows a more direct assessment and portrayal about the truth of the hypothesis, rather than relying on a

subjective threshold (*P*-value) that determines acceptance or rejection. In spite of this, the utility of Bayesian statistics in monitoring efforts such as ours seems limited until extensive (> 30 years) data sets are accumulated or unless the Network were to adopt a model-based approach to inference.

Approaches to increase the confidence in and robustness of our findings

QA/QC process

Of the various approaches we plan to adopt, the simplest involves the identification of errors in data collection or recording, data entry, and data transmission. Correction of these errors will lead to greater accuracy and statistical power in tests. Chapter 6 details how we intend to limit such errors.

Testing for observer bias

As mentioned in Chapter 4, observer bias can account for up to 50% of the variability in a response variable. We will test for such biases, and apply correction factors as necessary. To pre-empt such errors, we will train observers before and check their performance in the middle of field season, provide explicit methodological instructions that minimize or eliminate subjective decisions in the field, take voucher specimens (especially plants) or record calls for species that cannot be unequivocally identified, and may use self-correcting methods such as paired-observer variable circular plots for bird surveys (Kissling and Garton 2006) in the near future.

Reduction of sampling error

We will use the various approaches mentioned in Chapter 4 to reduce sampling error in our assessment of change over time in indicators. Unfortunately, it is rarely possible to estimate parameters without some sampling error. Thus, in addition to the true environmental variability that exists over space and time (and is consequently reflected in monitoring measurements), there is also sampling error associated with the measurements. Distinguishing measurement error from real changes in the environment is sometimes difficult, because estimation of 'sampling variance' includes an element of both of these types of error, which are highly confounded. We will attempt to use current or emerging approaches to partition parameter (process) variation from sampling error, through their explicit specification in models that reflect the sampling design. Process variation includes not only temporal variability (e.g., diel as well as within- and among-year variation), but also demographic, spatial, and individual variation.

Avoidance of spurious results

Spurious results are those that are interpreted statistically to indicate an apparently meaningful effect or relationship, but that do not reflect an actual biological phenomenon. The risk of finding such results is greatest when monitoring analyses are not driven by specific objectives determined beforehand, but instead consist of large numbers of exploratory analyses (also called 'data dredging') to find something 'significant' (Anderson et al. 2001, 2000). Such exploratory analyses can be used to identify possible relationships that may warrant further investigation. Problems arise, however, when such analyses are used to test rather than generate hypotheses, and when investigators overstate the biological importance of the test (Eberhardt 2003, Anderson et al. 2001, Cherry 1998, Yoccoz 1991). Two particular analytical techniques that may produce spurious results are stepwise regression and comparison of all possible subsets of models.

Over-reliance on null hypothesis testing to assess significance of results has been increasingly criticized for several reasons. First, nearly all null hypotheses are false on *a priori* grounds (leading to their being termed 'silly nulls'), and rejecting a null hypothesis often does not provide useful insights for management, conservation, planning, or further research (Anderson et al. 2000, Johnson 1995, Savage 1957). Second, arbitrary selection and blind adherence to a specific α-level (e.g., 0.05) that demarcates finding vs. not finding an effect is relatively uninformative biologically and may not reflect the investigators' perceived consequences of Type I and Type II errors (Field et al. 2005, Cherry 1998). Third, *P*-values are dependent on sample size, such that it is always possible to reject a null hypothesis with a sufficiently large sample size, regardless of how trivially small the true difference is. Fourth, *P*-values do not provide information about the magnitude or the precision of an estimated effect. Fifth, *P*-values cannot be used as evidence to accept the null hypothesis, only to fail to reject it. *P*-values indicate the probability of obtaining the data collected, given the null hypothesis, rather than the probability that the null hypothesis (e.g., no change in an indicator) is true given the data (Anderson et al. 2000).

Testing of analytical assumptions

In addition to the fact that certain analyses are not appropriate or easily interpretable when assumptions are not met, the use of appropriate analyses are often a more powerful approach (Sokal and Rohlf 1995, but see Johnson 1995). Two examples are the existence of a particular distributional shape (e.g., normal, Poisson) and the presence of significant interaction between factors. Analyses will be modified appropriately when assumptions are not met.

Consideration of sample sizes

As mentioned above, if we find that variability in a given response variable across our sampling domain is greater than what was estimated or found in previous studies, we will increase our sample size. GRTS-based approaches allow such additions (as well as deletions), yet still maintain a spatially balanced design. Alternatively, if we find that more samples are needed to accomplish our monitoring goals and additional sampling locations cannot be selected for logistical or financial reasons, we will either abandon sampling of that particular response variable or give it less attention analytically.

REPORTING AND COMMUNICATIONS

A primary goal of the NPS Servicewide I&M Program is to ensure that the results and knowledge gleaned are shared with all appropriate parties, especially the parks and their natural resource managers. Because the Network's main focus is to assist parks with monitoring needs, we will strive to provide park managers with clear, meaningful products to convey our findings.

While the Network primarily addresses concerns of the parks, its monitoring program has the potential to serve a much broader community. For example, monitoring projects can provide a starting point for external scientific research (especially to establish cause-effect relationships), and can provide insights for adaptive management on other public lands. The Network is also accountable to multiple organizations within the federal government, including the NPS I&M Program and the U.S. Congress. To provide accountability and to meet the requests of all parties, we will provide multiple

types of reports and communications. These are described below, and summarized in Table 7.2.

Written Reports

Annual summary reports

Summary reports will be produced annually for each Vital Sign monitored during the previous year, with the primary audience being the parks. These summaries will be communications to document our efforts and convey the findings of the previous field season. At a minimum they will provide:

- a brief introduction that describes why that Vital Sign is being monitored,
- an outline of the sampling strategy, including the number of sites sampled, parameters measured, and analyses performed,
- data summaries, including tables and figures to enhance visual presentation, as well as a text explanation of the findings,
- any other relevant or significant findings,
- a limited discussion section in which important results are interpreted.

Drafts of annual summary reports will be completed by January 15 for internal review. The final reports will be provided to parks on March 1 of the year following the monitoring.

Analysis and synthesis reports

Detailed reports in which data are analyzed and synthesized will be produced on a periodic basis, with the frequency depending on the given Vital Sign (e.g., on the re-visit strategy and frequency). They will be written in the format of a scientific journal article (abstract, introduction, methods, results, discussion, literature cited) and will contain in-depth analyses as outlined in the protocol. Further, these comprehensive reports will:

- place the observed results in both a regional and historical context by relating them to other published literature,
- integrate the findings with those of other protocols
- discuss the significance of the results in terms of environmental change,
- provide management recommendations based on the findings.

The target audience of the analysis and synthesis reports will be the parks, the Network, both regional and Servicewide I&M, and the broader scientific community. Drafts will be completed by January 31 of the appointed year with a minimum of three years of data and at least every 10 years (see individual protocols for detailed schedules). These drafts will be reviewed internally and sent to the parks, and possibly outside sources, for further review. The extent of review will depend on how analytically complicated the methods are and the gravity of inference and recommendations. The final reports will be due on April 1 of the year following the monitoring.

Scientific journal articles

Because the protocols are being designed with rigorous standards of sampling design and analysis, monitoring results are expected to be highly defensible and meet the

Table 7.2. Summary table of reports and communications produced by the Great Lakes Network.

Type of Report	Purpose of Report	Primary Audience	Frequency	Review Process
Annual Summary Reports	Describe the Vital Sign being monitored; outline the sampling strategy and analyses; summarize data; present a limited discussion	Superintendents, park biologists and natural resource managers	Annual; published each March 1	Network and park level
Analysis and Synthesis Reports	Provide in-depth analyses, relate results to other published literature; relate results to other Vital Signs, discuss results in terms of environmental change; provide management recommendations	Park biologists, natural resource managers, scientific community, park superintendents	Periodic (every 2 – 5 years, depending on Vital Sign; published April 1	Network, park, and non-NPS peer scientists
Scientific journal articles	Provide in-depth analyses, relate results to other published literature; discuss results in terms of environmental change; provide management recommendations	Scientific community	Periodic, depending on Vital Sign and strength of findings	Juried by journal editor and anonymous peer scientists
Annual Administrative Report and Work Plan	Detail accomplishments of previous year; present objectives for upcoming year; account for Network spending	Inventory & Monitoring Network, Park Service administration	Annual	Network and park level
Briefings to park biologists and managers	Present findings from previous year; Provide synopsis of monitoring results and management considerations	Park biologists and natural resource managers	Annual	Network level
Conference presentations	Provide in-depth analyses, relate results to other published literature; discuss results in terms of environmental change; provide management recommendations	Scientific community	Periodic, depending on Vital Sign and strength of findings	Network level
Extension and outreach -Fact Sheets -Bulletins	Summarize monitoring results, highlighting key findings for a broad audience	General public, NPS administrators and other Divisions, scientific community	Periodic, as the need arises	Network level and with Great Lakes Research and Education Center
Website	Varies, depending on report and Vital Sign	Varies, but includes parks, scientists, and the general public	Periodic	Network level

standards of the peer-review process. The publication of monitoring results in scientific journals will allow the Network to reach the scientific community in a way that internal NPS reports cannot. Further, peer-reviewed publications can promote collaborative investigation by members of the scientific community, either independently or in cooperation with the Network. Ultimately, this process should foster a greater understanding of ecosystem components and processes. For these reasons, the Great Lakes Network will strive to publish analysis and synthesis reports in peer-reviewed scientific journals. We will encourage the preparation of manuscripts by having reviewers of analysis and syntheses reports recommend whether publication is warranted and suggest appropriate journals. The quantitative ecologist and network coordinator will track these recommendations and encourage and provide work time respectively.

Annual administrative report and work plan

This administrative report is produced by the Network every November. It details the accomplishments of the previous fiscal year, presents the objectives for the following fiscal year, and accounts for Network spending. The report is submitted to the Servicewide I&M Program which, in turn, uses it to develop a national report on NPS inventory and monitoring efforts. Because this report is reviewed by both the national program and the U.S. Congress, we must be inclusive yet briefly highlight key findings in a clear and concise manner that is understandable to those without a scientific background.

Other Communications

While reports are a definitive method of documenting the progress of each program, other means of communication can further disseminate information to a broader audience. To this end, we will provide the following additional types of communications:

Briefings to park biologists

Each project manager will present the findings from his or her program to the biologists from the parks in which monitoring was conducted the previous year. These presentations, which will likely occur at the annual technical committee meeting in March, will provide a concise synopsis of monitoring results as well as management considerations.

Conference presentations

When possible, project managers will present monitoring results at regional and national scientific conferences. This will allow the Network to reach the broader scientific community, as well as land managers and conservation practitioners. Potential conferences include those sponsored by the Ecological Society of America, Society for Conservation Biology, The Wildlife Society, the International Association for Landscape Ecology, the Natural Areas Association, and the George Wright Society. At a more local scale, the Western Great Lakes Research Conference, which is sponsored in part by the Network, is a valuable venue for information exchange.

Extension and outreach

Outreach is the primary conduit by which the Network will reach policy makers, educators, and the general public. We are working cooperatively with Minnesota Sea Grant to develop general information articles and fact sheets targeted for handouts to the public, print in local newspapers and regional magazines. These articles will describe the

mission of the I&M Program. Upon completion of one to two years of monitoring, the Network plans to publicize the program via radio outlets (e.g., Wisconsin Public Radio) and regional magazines. Additional periodic opportunities may arise that will allow us to reach the target group above, including participating in the activities of the International Joint Commission, SOLEC (State Of the Lakes Ecosystem Conference), and CoastWatch.

We also wish to ensure effective communication with the general public in the parks. We will develop a series of 'talking points' to explain our program and activities when we encounter the public at parks. We will also provide information to park interpretive staff so that they can explain the activities and findings of the I&M Program. In large part, this latter goal will be accomplished by working with staff from the Great Lakes Research and Education Center stationed at Indiana Dunes National Lakeshore.

Website

The Network's website (www.nature.nps.gov/im/units/glkn/index.htm) is the primary means of communicating information about our activities and findings. We have developed the website so that it is informative both to individuals outside of the Park Service as well as those with a large degree of familiarity with the I&M Program. A section of the Network's website, which is still under development, will be map-based using an Internet Mapping Service (IMS) to provide access to spatially explicit data and allow users to explore Network data in a spatial context. The Network's IMS website will allow users to query and download data for use on local computers. In addition to the standard internet site and IMS site, we will develop an intranet page to disseminate materials to others within the Park Service. All Network products are available for download from the site.