Chapter 3 – Vital Signs

INTRODUCTION

In September 2001, the Technical Committee laid out a plan for identifying and prioritizing Vital Signs. The plan called for scoping workshops with park staff to generate lists of monitoring issues and questions, development of conceptual models to examine important ecosystem attributes and linkages, focus workshops to get input and review from science peers, and an iterative process of management and science review (Figure 3.1). To maximize efficiency, the Committee expected the monitoring program to emphasize Vital Signs common to all or most of the nine parks. Efficiencies in study design, data collection, data management, and reporting are greatest at the base of the effort pyramid (Figure 3.2) and Network monitoring of these common issues will benefit most from consistent designs that produce comparable data. Conversely, the Committee expected that the least amount of Network effort would go towards single park issues. These issues often require park-specific knowledge, are frequently short-term, and due to economies of scale, are most efficiently conducted by park staff. Nonetheless, some critical single-park monitoring needs may be best met by Network efforts.

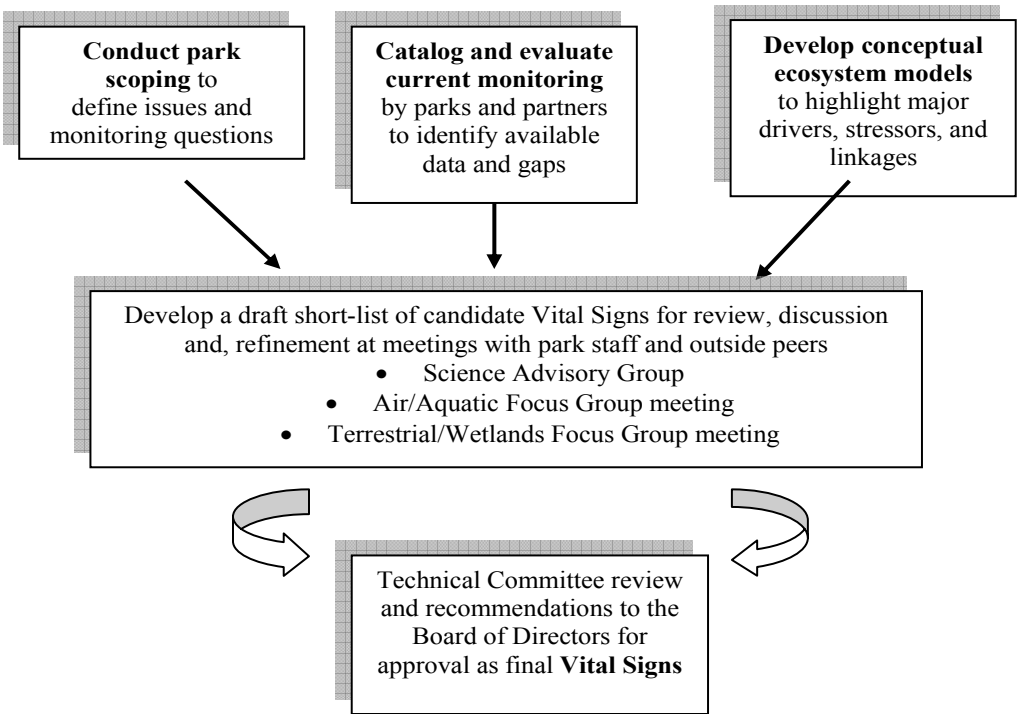

Figure 3.1. The Great Lakes Inventory and Monitoring Network's process of defining issues, gathering information, and drafting a list of candidate indicators for review.

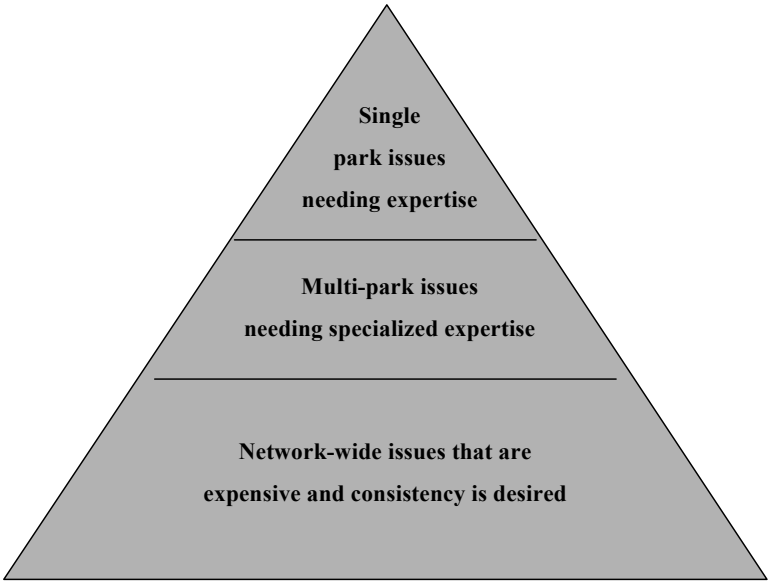

Figure 3.2. Effort pyramid showing the envisioned application of funding and staff time towards monitoring in parks of the Great Lakes Inventory and Monitoring Network.

STEPS TAKEN AND RESULTS

The process for determining Vital Signs was recommended by the Technical Committee and adopted by the Board in September 2002. The Network and partners completed the process via seven steps, which are described briefly below and in more detail in Route (2004):

1. Conducted park scoping workshops and gathered partner information
2. Developed conceptual models of park ecosystems
3. Drafted a list of candidate Vital Signs
4. Refined the candidate list and assigned initial priorities
5. Obtained peer review of the Vital Signs selection process
6. Conducted focus workshops to further refine and score the candidate Vital Signs
7. Prioritized the Vital Signs for Network monitoring

Step 1 - Park Scoping and Information Gathering

The Network began holding park scoping workshops in January of 2002. At these workshops, we engaged 150 park staff and local partners and developed a list of over 200 monitoring issues and 140 monitoring questions (Route 2004, Route 2003). Park scoping helped engage and inform park staff; grounded the process in the parks, where data will be collected and used; and helped Network staff better understand the issues. It also helped identify conceptual modelers and members of the Science Advisory and Focus Groups. Most importantly, the themes and monitoring questions identified at these scoping workshops, together with the conceptual models, formed the basis of the Network's candidate Vital Signs list.

Step 2 - Conceptual Modeling

Following the park scoping workshops, the Network commissioned the development of six conceptual models to examine major ecosystems and processes in the nine parks. The authorship, purpose, and approach to the conceptual models are summarized in Chapter 2. All models were peer-reviewed and published as an in-house technical report (Gucciardo et al. 2004).

Step 3 - Developing a Candidate List

Network staff used the conceptual models, results of park scoping workshops, and information on partner monitoring to draft a list of candidate Vital Signs. Initially, we considered 80 indicators under development by the EPA and Environment Canada for assessing progress towards goals of the Great Lakes Water Quality Agreement (Bertram and Stadler-Salt 2000). Although we used some of the indicators, many did not apply. The draft list of candidate indicators drew most heavily from the park scoping workshops and the conceptual models.

Step 4 - Refining the Candidate List and Assigning Initial Priorities

In October 2003, the Committee adopted criteria and weighting factors for scoring Vital Signs (Table 3.1). Candidate indicators were scored on: Management Significance, Ecological Significance, Measurability/ Sensitivity, and Legal/Policy Mandate. Participants scored them for each criterion in Table 3.1 using a point scale of: very high = 5 points, high = 4 points, medium = 3 points, low = 2 points, very low = 1 point, no value = 0, or unable to score = null. We weighted Management and Ecological Significance equally because ecological integrity is a primary management concern in all national parks (NPS 1991). Management Significance was scored only by park staff, as the use of the monitoring data will be used to make management decisions. Ecological Significance was scored by both parks and Focus Groups; however, Focus Group scores were provided to parks as peer review and not used in final score calculations. The Measurability/Sensitivity criterion was scored only by Focus Groups, because the scientific community generally has the best knowledge of the quantitative measures and ecological linkages critical for judging this criterion. Although 20% seems low for this important criterion, the Committee believed more in-depth information would surface as the Network and its partners analyzed available data and developed protocols. Thus a low weighting at this juncture allowed a Vital Sign to remain viable until more complete information became available. For each criterion, four or five statements were provided to help participants apply the criteria consistently (Table 3.1).

After adopting the criteria, the Committee discussed the candidate list and made minor adjustments. The nine park representatives on the Committee then conducted an initial scoring of the Vital Signs. (Network staff facilitated and participated in discussions but did not score them). The criteria, scoring process, and initial scores were brought to the Board for their concurrence in October 2003. The result was a draft, prioritized list of candidate Vital Signs.

Table 3.1. Four criteria used to score Vital Signs for the Great Lakes Inventory and Monitoring Network by NPS and external scientists who ranked each Vital Sign as very high (5 points), high (4), medium (3), low (2), very low (1), none (0), or null in regards to its importance for monitoring in Network parks. The value "none" equaled zero in calculations, while null was valueless (i.e., no opinion). Adapted from Dale and Beyeler (2001).

1) Management significance (Weight = 40%; scored only by park staff) • Has direct application to one or more management decisions or helps assess management actions. • Helps anticipate or predict impending change in an important resource that could be averted by management action. • Contributes to increased understanding of important resources or ecological processes that ultimately leads to better management. • Data are of high public interest. • Involves resources that are harvested, consumed, endemic, alien, threatened, endangered, or of special concern.
2) Ecological significance (Weight = 40%; scored by both park staff and focus workshop participants; however, focus workshop participant scores were used only as a recommendation to park staff) • Has a strong defensible linkage with the resource it is intended to represent. • The resource or process the attribute represents has high ecological importance based on conceptual models and ecological literature. • The attribute responds to change in a predictable, ecologically explainable manner. • The attribute is integrative over time and provides ecological context or supporting evidence to data from other indicators being monitored by the park or others.
3) Legal/Policy mandate (No weighting - tie breaker; scored only by park staff) • Scored as "5" if mandated by federal law, "4" if by state law or NPS policy, and "n/a" if no laws or mandates apply.
4) Measurability and sensitivity (Weight 20%; scored by focus workshop participants only) • Reliable and effective methods exist for collecting and analyzing data in a consistent and repeatable manner. • The cost of collecting a significant sample is not prohibitive. • Measurements are sensitive to change such that a trend will be apparent if present (high signal to noise ratio). • Human errors in measurement are either low or can be explained.

Step 5 – Review of the Vital Signs Selection Process

In October 2003, Network staff convened a 10-member Science Advisory Group to get peer review of the Network's program with emphasis on the process of choosing and prioritizing Vital Signs. This advisory group includes scientists with many years of experience in long-term ecological monitoring as well as experts in **focal resources** of the Great Lakes and Upper Mississippi River Basins. A list of the SAG members and details on the findings of this meeting are reported by Route (2004).

Prior to the meeting, Network staff provided group members with background information on the program, objectives of the meeting, an outline of the selection process,

the candidate Vital Signs list, and the criteria for scoring the Vital Signs. The group felt the Network had a valid process that allowed both managers and scientists sufficient opportunity to scrutinize the Vital Signs. Members of the SAG reviewed the candidate list and had no immediate suggestions for improvement. Each member identified their top "best bets" and those they felt the Network should not monitor. Results of this straw poll were summarized and provided to the parks for consideration in adjusting their scores.

Step 6 - Conducting Focus Workshops

In February of 2004, GLKN held two workshops – one focusing on Vital Signs related to aquatic and air resources, and one focusing on terrestrial and wetland resources. The Air/Aquatic Focus Group consisted of 14 invited scientists and the Terrestrial/ Wetland Focus Group had nine invited scientists. Participants were selected for their knowledge and experience with monitoring natural resources in the region. Prior to each workshop, Network staff provided participants with background information on the program, meeting objectives, web access to the conceptual models, the candidate Vital Signs list, and the criteria for scoring the Vital Signs. At each meeting, participants discussed each Vital Sign and refined and added to the list, but did not delete Vital Signs. Network staff facilitated the meetings and prompted discussion on the ecological significance, measurability, and sensitivity of each Vital Sign.

At each of the two 1½ day-long meetings, participants spent approximately eight hours discussing the Vital Signs and about one hour scoring them. The two groups added nine Vital Signs, combined four others into two, and made some minor name changes. These changes were documented in a summary narrative (Route 2004).

Step 7 – Prioritizing Vital Signs for Network Monitoring

Network staff summarized scores and discussions from the Science Advisory Group and the two focus groups, and then provided the summary to the parks for consideration. Committee members then engaged their park staff with this new information to confirm or adjust their original scores. Six of the nine parks adjusted their scores.

Final weighted scores were then calculated as:

$$\text{Weighted Score} = (MS \times 0.4) + (ES \times 0.4) + (SM \times 0.2)$$

Where: MS = average adjusted park scores for Management Significance
ES = average adjusted park scores for Ecological Significance
SM = average of focus workshop participant scores for Measurability and Sensitivity

The Committee discussed the draft weighted scores in March 2004 and recommended that it advance to the Board without further adjustment. The Board met in April of 2004 and approved the list and priority order (Table 3.2). Following the Vital Signs process, we organized the Vital Signs into the Servicewide "Vital Signs Monitoring Framework" (Table 3.3). This framework illustrates the ecological breadth of the Vital Signs – from species health to geological processes – and facilitates consistency among the NPS's 32 monitoring networks across the nation.

Table 3.2. Prioritized list of Vital Signs for the GLKN. Scores (5 = very important) reflect input by NPS and outside scientist (see text). Green shows 21 selected for early development.

Vital Signs name	Priority ranking	Models that identified VS as a potential metric[1]
Plant and Animal Exotics	4.3	FO,GL,IL,LR,WE
Core Water Quality Suite	4.3	GL,IL,LR,WE
Terrestrial Plants	4.0	FO,LR
Bird Communities	3.9	FO,IL,LR,WE
Problem Species (White-tailed deer)	3.8	FO
Land Use / Land Cover Coarse Scale	3.8	EP,FO,GL,IL,LR,WE
Threatened & Endangered Species	3.7	
Water Level Fluctuations	3.6	EP,GL,IL,LR,WE
Advanced Water Quality Suite	3.6	GL,IL,LR,WE
Aquatic/Wetland Plant Communities	3.6	GL,IL,LR,WE
Weather, Meteorological Data	3.5	EP,FO,GL,LR,IL,LR,WE
Amphibians & Reptiles (Amphibians)	3.5	IL,LR,WE
Mammal Communities	3.5	FO,WE
Fish Communities	3.5	GL,IL,LR,WE
Land Use / Land Cover Fine Scale	3.5	EP,FO,GL,IL,LR,WE
Trophic Bioaccumulation	3.4	GL,IL,LR,WE
Special Habitats	3.4	FO,LR
Mussels & Snails	3.3	GL,LR
Harvested Species	3.3	FO
Sediment Analysis	3.3	EP,GL,LR,WE
Terrestrial Pests, Pathogens	3.3	FO
Succession (forests, wetlands)	3.2	FO,WE
Toxic Concentrations in Sediments	3.2	GL,IL,LR,WE
Biotic Diversity	3.1	FO,WE
Stream Dynamics	3.1	EP,LR,WE
Trophic Relations	3.0	FO
Air Contaminants	3.0	
Phenology	3.0	FO,IL
Toxic Concentrations in Water	2.9	GL,IL,LR,WE
Terrestrial Invertebrate Communities	2.9	WE
Soils	2.8	FO,WE
Health, Growth and Reproductive Success	2.8	FO,IL,WE
Benthic Invertebrates	2.8	GL,IL,WE
Diatoms	2.7	WE
Aquatic Pathogens	2.7	GL,IL
Air Quality Related Values (AQRV)	2.6	
Algae	2.6	GL,IL,LR,WE
Lichens & Fungi	2.5	
Nutrient Dynamics/Biogeochemistry	2.5	FO,GL,IL,LR,WE
Geological Processes	2.5	EP
Aeolian, Lacustrine Geomorphology	2.5	EP,GL
Primary Productivity	2.5	FO,GL
IBI (index of biotic integrity)	2.4	GL
Zooplankton	2.4	GL,IL
Soundscapes, Light Pollution	2.3	
Freshwater Sponges	2.1	

1= EP= Earth Processes; FO=forests; WE=wetlands; GL=Great Lakes; LR=large rivers; IL=inland lakes

Table 3.3. Vital Signs for nine national parks in the Great Lakes Inventory and Monitoring Network within the NPS National Vital Signs Framework (see text). Green shows those Vital Signs for which the Network will design protocols and fully implement, while yellow indicates those monitored by parks and partners where we intend to collaborate and report on the data.

National Level[1]		Great Lakes Network[2]									
Level 1	**Level 2**	**Vital Sign name**	**APIS**	**GRPO**	**INDU**	**ISRO**	**MISS**	**PIRO**	**SACN**	**SLBE**	**VOYA**
Air and Climate	Air Quality	Air Quality	•	•	•	•	•	•	•	•	•
		Air Quality (AQRV)	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
	Weather	Weather	•	•	•	•	•	•	•	•	•
		Phenology	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Geology and Soils	Geomorphology	Aeolian, Lacustrine Geomorphology	Δ	–	Δ	–	Δ	Δ	Δ	Δ	–
		Geological Processes	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Stream Dynamics	Δ	Δ	Δ	Δ	+	Δ	+	Δ	Δ
	Soil Quality	Soils	+	+	+	+	+	+	+	+	+
		Sediment Analysis	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Water	Hydrology	Water Level Fluctuations	+	+	+	+	+	+	+	+	+
	Water Quality	Core Water Quality Suite	+	+	+	+	+	+	+	+	+
		Advanced Water Quality Suite	+	+	+	+	+	+	+	+	+
		Toxics in Water	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Toxics in Sediments	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Pathogens in Water	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		IBI	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Benthic Inverts	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Freshwater Sponges	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Phytoplankton	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Diatoms	+	–	+	+	+	+	+	+	+
Biological Integrity	Invasive Species	Plant and Animal Exotics	•	•	•	•	•	•	•	•	•
	Infestations and Disease	Terrestrial Pests and Pathogens	+	+	+	+	+	+	+	+	+
	Focal Species or Communities	Aquatic Plant Communities	+	+	+	+	+	+	+	+	+
		Mussels and Snails	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Mammal Communities	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Problem Species (White-tailed deer)	+	+	+	+	+	+	+	+	+
		Special Habitats	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Lichens and Fungi	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Terrestrial Plants	+	+	+	+	+	+	+	+	+
		Fish Communities	+	+	+	+	+	+	+	+	+
		Zooplankton	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Terrestrial Invertebrate Communities	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Amphibians and Reptiles	+	+	+	+	+	+	+	+	+
		Bird Communities	•	•	•	•	•	•	•	•	•
		Biotic Diversity	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
	At-risk Biota	Species Health, Growth and Repoductive Success	+	+	+	+	+	+	+	+	+
		T&E Species	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Human Use	Non-point Source Human Effects	Trophic Bioaccumulation	+	+	+	+	+	+	+	+	+
	Consumptive Use	Harvested Species	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
	Visitor Use	Land use Fine Scale	+	+	+	+	+	+	+	+	+
Ecosystem Pattern and Processes	Land Use and Cover	Land use Coarse Scale	+	+	+	+	+	+	+	+	+
	Soundscape	Soundscapes and Light Pollution	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
	Nutrient Dynamics	Nutrient Dynamics	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Trophic Relations	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
	Productivity	Primary Productivity	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
		Succession	+	+	+	+	+	+	+	+	+

+ = The Network plans to develop a monitoring protocol or SOP

• = Park or partner monitoring will continue with Network collaboration

Δ = Time and funds are currently not available

– = Not applicable in this park

1 = Level names are from the National Park Service's Vital Signs Ecological Framework

2 = Park acronyms appear in Table 1.4

Short List

In Phase 3 of development, we examined more closely the logistics and costs associated with monitoring each Vital Sign. We also considered that parks would continue to be involved in monitoring their resources and that the Network's role is to monitor a core subset of Vital Signs using statistically robust designs with a centrally-located team approach (see Chapter 1, Goals For Vital Signs Monitoring, provisions #1 and #3; Figure 3.2). We concluded that some important Vital Signs are best left to the parks for monitoring. For example, the Vital Signs 'Threatened and Endangered Species', and 'Harvested Species', will vary greatly across the Network and it would be more efficient for parks to implement them. We also found that some Vital Signs, even if ranked low, could be easily incorporated in to the protocol of a higher ranked Vital Sign. For example, 'Succession' and 'Soils' can be monitored with little additional cost while conducting 'Terrestrial Vegetation' monitoring. Finally, both 'Diatoms' and 'Health, Growth, and Reproductive Success' were originally considered both as individual Vital Signs *and* as part of a suite. We will monitor 'Diatoms' as the biotic component of the 'Advanced Water Quality Suite' and we will monitor the 'Health, Growth, and Reproductive Success' of the species being sampled under the 'Trophic Bioaccumulation' protocol. The final short list for the Network, then, follows the overall prioritization (Table 3.2) with a few adjustments for efficiency and effectiveness (green and yellow highlighting in Tables 3.2 and 3.3).

The short list presented in Table 3.4 represents 21 Vital Signs that we expect to monitor with 16 different protocols. When fully implemented each park would have between 19 and 21 Vital Signs monitored by the Network. This list is our best attempt to determine the Vital Signs that are important across the parks, yet efficient and affordable for the Network to monitor. Nonetheless, the remaining Vital Signs are on a waiting list for consideration as we develop each protocol and gain experience and efficiency in monitoring. Vital Signs such as 'Mammal Communities', 'Sediment Analysis', 'Special Habitats', and 'Phenology' continue to be investigated for potential development either individually or as part of another protocol. Other more mature monitoring programs such as at Channel Islands National Park have found that indicators can often be added in years following initial implementation (G. Davis, personal communication). We hope to be able to incorporate several other Vital Signs in future years.

Table 3.4. Final list of 21 Vital Signs that the Great Lakes Inventory and Monitoring Network plans to begin monitoring during the initial six years – 2006 through 2011. For efficiency, these Vital Signs will be monitored under 16 different protocols.

Protocol	Vital Sign name	APIS	GRPO	INDU	ISRO	MISS	PIRO	SACN	SLBE	VOYA
Air Quality	Air Quality	•	•	•	•	•	•	•	•	•
Climate and Weather	Weather	•	•	•	•	•	•	•	•	•
Water Quality (3 protocols - inland lakes, large rivers, and wadeable streams)	Core Water Quality Suite	+	+	+	+	+	+	+	+	+
	Water Level Fluctuations	+	+	+	+	+	+	+	+	+
	Advanced Water Quality Suite	+	+	+	+	+	+	+	+	+
Diatoms	Diatom Community	+	–	+	+	+	+	+	+	+
Wetlands	Aquatic / Wetland Plant Communities	+	+	+	+	+	+	+	+	+
Fish	Fish Communities	+	+	+	+	+	+	+	+	+
Aquatic Nuisance Species (early detection) Exotic Plants (early detection)	Plant and Animal Exotics	•	•	•	•	•	•	•	•	•
Land Use / Land Cover (2 protocols - coarse-scale and fine-scale)	Land Use/Cover Coarse Scale	+	+	+	+	+	+	+	+	+
	Stream Dynamics	Δ	Δ	Δ	Δ	+	Δ	+	Δ	Δ
	Land Use/Cover Fine Scale	+	+	+	+	+	+	+	+	+
Terrestrial Vegetation	Terrestrial Plants	+	+	+	+	+	+	+	+	+
	Problem Species (W.t. deer)	+	+	+	+	+	+	+	+	+
	Terrestrial Pests and Pathogens	+	+	+	+	+	+	+	+	+
	Succession	+	+	+	+	+	+	+	+	+
	Soils	+	+	+	+	+	+	+	+	+
Landbirds	Bird Communities	•	•	•	•	•	•	•	•	•
Bioaccumulative Contaminants	Trophic Bioaccumulation	+	+	+	+	+	+	+	+	+
	Species Health, Growth and Repoductive Success	+	+	+	+	+	+	+	+	+
Amphibians	Amphibians and Reptiles	+	+	+	+	+	+	+	+	+
Total to be monitored (of 21 possible)		**20**	**19**	**20**	**20**	**21**	**20**	**21**	**20**	**20**

+ = The Network plans to develop a monitoring protocol or SOP

• = Park or partner monitoring will continue with Network collaboration