Chapter 3
Selection and Prioritization of Vital Signs

3.1 Introduction

In this chapter we describe the process used to identify, organize, and prioritize a final set of vital signs for SWAN. As described in Chapter 1, these vital signs are intended to characterize ecosystem condition and signal change across multiple scales of space and time. We explain how the selection and prioritization of vital signs was linked to park resource management and protection issues, conceptual ecosystem models, and the Network's monitoring objectives and questions.

The NPS has defined "vital signs" as a set of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, and/or are of value to humans. These vital signs represent a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations" and include water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization, including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes) (http://science.nature.nps.gov/im/monitor/glossary.htm).

Conceptual ecosystem models (Chapter 2) demonstrate that a variety of biological, chemical, and physical factors interact to control the abundance, distribution, and productivity of plants and animals in SWAN. Consequently, the overall condition of park ecosystems is determined by the interaction of all its physical, chemical, and biological components. Clearly, it is impossible to monitor all these components, and ecosystem condition, like human health, cannot be measured directly. A key challenge is identifying vital signs that characterize entire park ecosystems, yet are simple enough to be effectively and efficiently monitored (Dale and Beyeler 2001).

3.2 Vital Signs Selection

Candidate vital signs were chosen during a series of scoping workshops held between August 2002 and April 2003 (Chapter 1). These workshops were brainstorming sessions built around three objectives: (i) review and refine draft conceptual ecosystem models, monitoring objectives, and monitoring questions; (ii) identify natural and human-related drivers of change and why it is important to understand them; and (iii) identify candidate vital signs to monitor that provide informative signals about ecosystem condition. Workshop participants included a diverse group of experts (Table 1-2).

Scoping workshop notebooks were a key element of the scoping process and provided background information, context, and guidelines for vital sign selection. Although individual workshops had an ecosystem focus (i.e., coastal, freshwater lakes, and rivers), the fields of discussion and opportunities for choosing vital signs were unbounded. Redundancy was anticipated (encouraged) and both reinforced the importance of specific ecosystem drivers or components across systems and helped to generate an integrated set of vital signs.

Candidate lists of vital signs were summarized after each workshop. In October 2003, the SWAN Technical Committee (TC) assigned three members to review and merge the vital signs into a single list. The TC empowered this vital signs working group to edit candidate vital signs that were not widely supported by experts during the workshops or by technical reviewers of the workshop summaries. The working group

also revised and merged the Network's monitoring objectives and questions to incorporate suggestions by workshop participants and, in some cases, to consolidate questions.

The combined list that emerged from the scoping workshops contained 61 vital signs. This list was reduced to 38 after similar indicators were merged under a single vital sign, and weakly supported or duplicate vital signs were removed. These 38 vital signs were evaluated with respect to clarification and consistency to ensure that each was clearly stated and understandable. We considered this step important because vital signs that are confusing or not readily understood cannot be evaluated or prioritized objectively.

3.3 Vital Signs Prioritization

The SWAN TC met on December 17-18, 2003, to review and prioritize the draft vital signs. In preparation for this meeting, the vital signs working group produced several summary documents:

- List of vital signs by category
- Ecosystem conceptual models from Chapter 2 with vital signs highlighted
- Revised holistic model (Figure 3-1) with vital signs inserted
- Natural resource protection issues paired with vital signs
- Monitoring objectives and questions paired with vital signs
- One-page definition and statement of importance for each vital sign

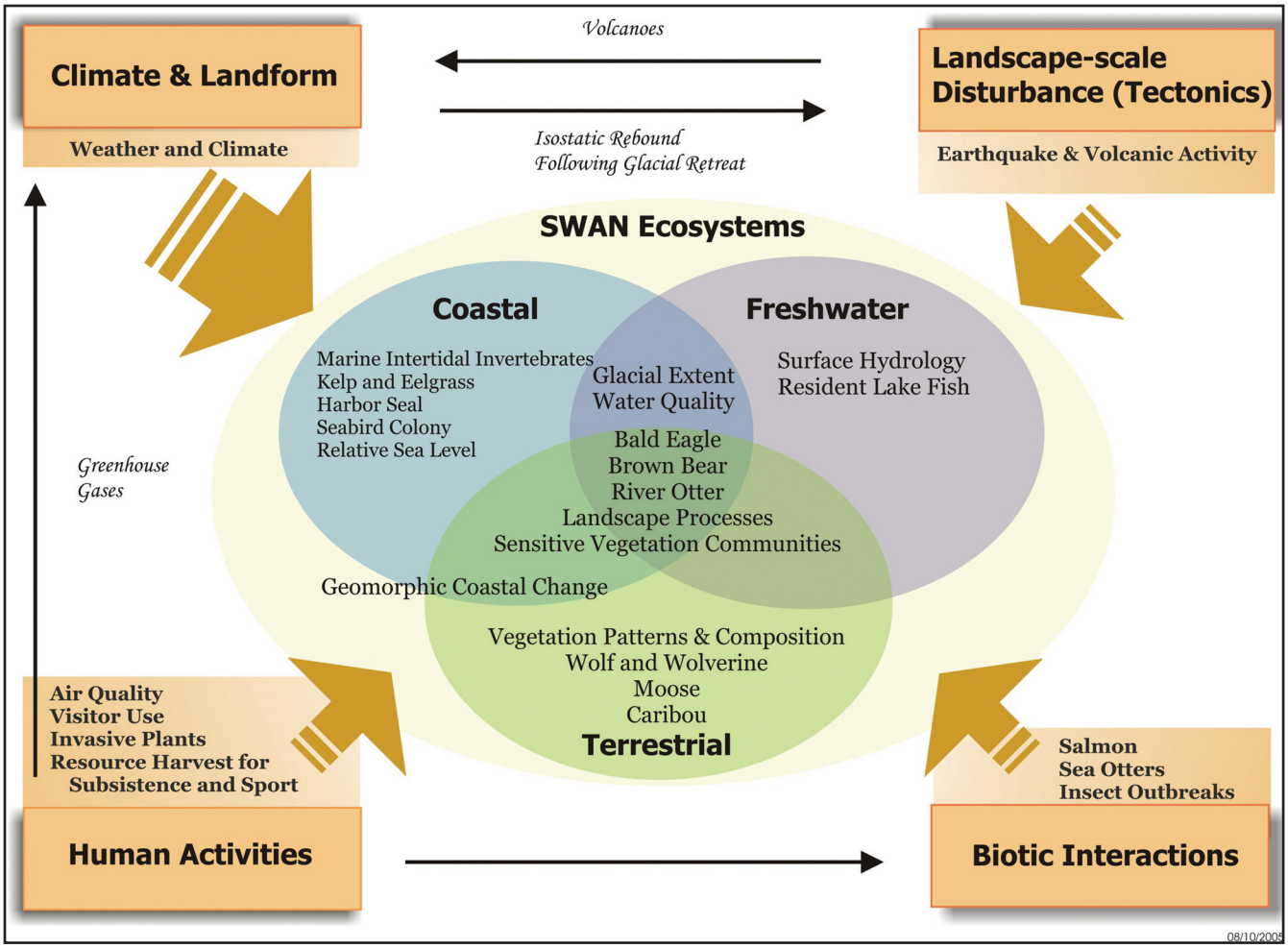

Figure 3-1 *Vital signs as they relate to drivers of change (boxes) and ecosystems (ovals) in SWAN. It is important to remember that these vital signs are not the "real system;" they are valued components of our interpretation of reality, and they may miss many subtleties, relationships, feedback, and other important considerations.*

During session one of the prioritization meeting, the TC reviewed the rationale for selecting each vital sign and how each would contribute to the Network's goals and objectives for monitoring. They also discussed candidate vital signs that emerged from scoping workshops that were not recommended by the SWAN vital signs working group. No additions or deletions resulted from this discussion, and the importance of each vital sign was reaffirmed. In some cases vital signs were renamed or merged. For example, snow cover, lake and coastal ice, and suspended sediments were combined into a single vital sign, Landscape Processes, because they will be monitored by remote sensing using a common protocol.

During session two, Committee members ranked each of the vital signs based on ecological significance and relevance to park resource management and protection. The purpose of this ranking was to identify at the onset vital signs that Network staff considered most important without considering in detail the methods of measurement or their feasibility. The ranking was not intended to establish a numerical order in which vital signs will be implemented. Prioritization criteria used by other national programs, including other NPS-Vital Signs Monitoring Networks (http://science.nature.nps.gov/im/monitor/docs/CriteriaExamples.doc), were modified for use by SWAN (Figure 3-2).

A Microsoft Access database was prepared to summarize scores and produce a numerical ranking. Vital signs were ranked overall and within the categories of drivers and ecosystems depicted in Figure 3-1. Summary statistics were generated to evaluate which vital signs accounted for the greatest deviation among committee members. During the final session (day 2), committee members reviewed and discussed the overall rankings and individual scores. Vital signs were subsequently assigned to three categories: essential, highly desirable, and optional, based on their numerical rankings (Figure 3-3). The 15 highest ranked vital signs include a mix of physical drivers, landscape processes, focal communities and species, and human-related activities. The second and third categories of vital signs primarily contain focal species and landscape processes.

Because financial limitations will restrict the scope of the monitoring program, the TC acknowledged the importance of having a core set of "essential" vital signs at the onset and a plan for building onto that core set in the future as financial resources or partnership opportunities materialize. The true costs of implementing monitoring for many vital signs is difficult to project until after protocols have been developed and tested. Costs are most uncertain for vital signs that require on-the-ground sampling. Preliminary cost estimates suggest that SWAN may be capable of implementing monitoring for the 30

Vital Sign Ranking Criteria

Ecological Significance

1. Importance as a controller or integrator: How important is the vital sign in controlling ecosystem function or structure, or how centrally is it linked to other attributes in the conceptual models? [3=high importance, 2=moderate importance, 1=low importance]
2. Usefulness as an indicator: How useful is the attribute in explaining the condition of network ecosystems; that is, how sensitive would it be as an indicator of change? [3=extremely useful, 2=moderately useful, 1=minimally useful]
3. Linkage: How closely linked is the vital sign to other attributes in network ecosystem models, or is the vital sign linked to important resources regionally? [3=many strong links, 2=few strong links or many weak links, 1=few weak links]

Park Management Significance

1. Legal/policy mandate: How important is monitoring this resource/vital sign for satisfying legal or policy mandates? [3=high importance (required), 2=moderate importance (specifically identified), 1=low importance (generally identified)]
2. Potential to support management decisions: Does monitoring this vital sign directly link to the information needed for carrying out a key management decision or evaluating the outcome of a management decision? [3=strong application, 2=moderate application, 1=weak application]
3. Importance of resource management: How important (for management) is the resource or issue represented by the vital sign, relative to other resources or issues in the park? [3=high importance, 2=moderate importance, 1=low importance]

Figure 3-2 *Criteria SWAN used to rank draft list of vital signs.*

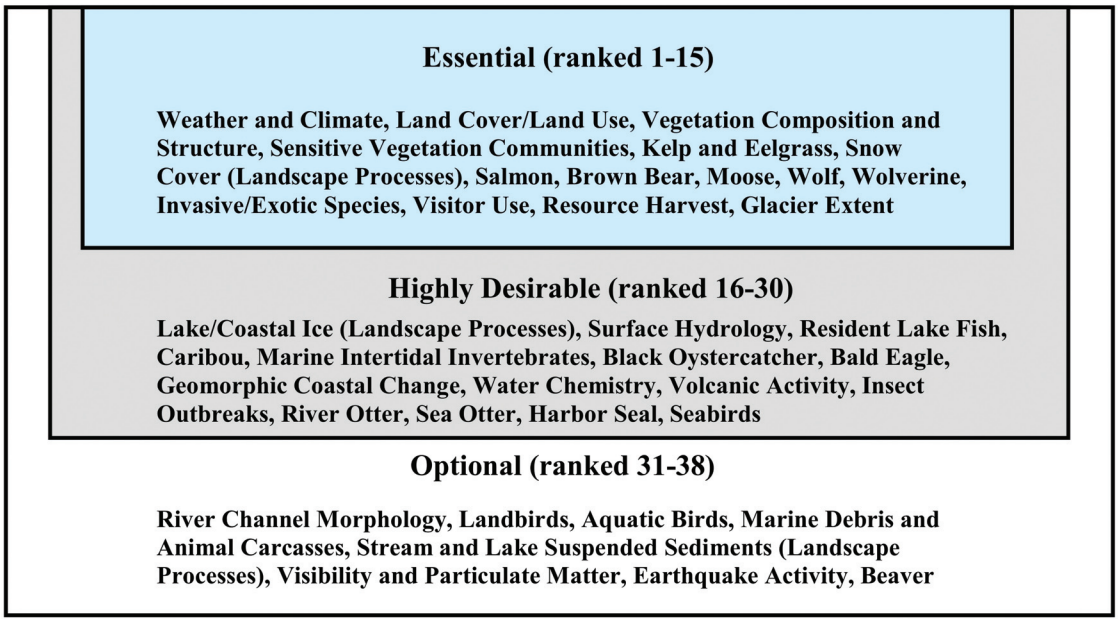

Figure 3-3 *Vital signs prioritization in SWAN. Vital signs ranked as "optional" are not being considered at this time unless the vital sign can be measured using remote sensing or it is currently being monitored by another agency.*

top-ranked vital signs. Consequently, vital signs ranked as "optional" are not being considered at this time unless the vital sign can be measured using remote sensing or is currently being monitored by another agency. For example, we are able to include Earthquake Activity, Visibility and Particulate Matter, and Stream and Lake Suspended Sediments because data can be acquired at little or no cost to the Network.

Following TC approval of the vital signs, a preliminary draft of sections 1 and 2 of this chapter were prepared, including a listing of the final (short list) SWAN vital signs within the National Ecological Monitoring Framework (Table 3-1). The NPS Ecological Monitoring Framework is a hierarchical organizational tool for promoting communication, collaboration, and coordination among parks, networks, programs, and agencies involved in ecological monitoring. SWAN vital signs are assigned to the National Level 3 category to which they most closely align.

The NPS Ecological Monitoring Framework was developed in July 2005 after SWAN had completed its final selection and naming of vital signs. As a result, some SWAN vital signs may be less definitive than a National Level 3 category title. For example, Invasive/Exotic Plants and Invasive/Exotic Animals are treated as one SWAN vital sign, Invasive Species. The SWAN vital sign Sensitive Vegetation Communities, although placed under Level 3 Wetland Communities, includes alpine and other vegetation communities not defined in the framework. A second vital signs framework built around Monitoring Projects (Table 4-1) was developed to present sampling designs and implementation schedules and allocate staff and budgets among program areas. This Monitoring Projects framework is used in tables and figures throughout Chapters 4-10. However, Tables 4-1, 5-1, and 8-4 do not list vital signs that will be monitored independently of SWAN by a park or another agency.

Both vital sign frameworks, along with descriptions of each vital sign, were provided to the Board of Directors (BOD) in early February 2004. During March, a 1-day meeting was held at each of the three parks with the superintendent, chief of resource management, and other staff. The purpose of these meetings was to review the steps that the Network followed in selecting and prioritizing vital signs, discuss individual vital signs, and provide an opportunity for park staff to comment on the process and draft list of vital signs. Park-based meetings were chosen over one meeting at a central location because they allowed more staff to participate and provided greater opportunity for the Network coordinator to review and discuss the program with two superintendents who only recently (December 2003) became members of the BOD.

Table 3-1 *National Ecological Monitoring Framework, including vital signs for which the SWAN is working independently or jointly with a Network park, federal, state, or private partner to develop and implement monitoring protocols.*

Ecological Monitoring Framework								
Level 1	**Level 2**	**Level 3**	**SWAN Vital Sign**	**ALAG**	**ANIA**	**KATM**	**KEFJ**	**LACL**
Air and Climate	Air Quality	Visibility and Particulate Matter	Visibility and Particulate Matter	-	●	-	-	●
	Weather and Climate	Weather and Climate	**Weather and Climate**	-	-	╬	╬	╬
Geology and Soils	Geomorphology	Glacial Features and Processes	**Glacier Extent**	-	-	╬	╬	╬
		Coastal/Oceanographic Features and Processes	**Geomorphic Coastal Change**	-	-	╬	╬	╬
	Subsurface Geologic Processes	Volcanic and Seismic Activity	Volcanic and Earthquake Activity	●	●	●	●	●
Water	Hydrology	Surface Water Dynamics	**Surface Hydrology**	╬	╬	╬	╬	╬
	Water Quality	Water Chemistry	**Marine Water Chemistry**	-	-	╬	╬	╬
			Freshwater Chemistry	╬	╬	╬	╬	╬
Biological Integrity	Invasive Species	Invasive/Exotic Plants and Animals	Invasive/Exotic Species	●	●	●	●	●
	Infestations and Disease	Insect Pests	Insect Outbreaks	-	-	●	●	●
	Focal Species or Communities	Marine Communities	**Kelp and Eelgrass**	-	-	╬	╬	╬
		Marine Invertebrates	**Marine Intertidal Invertebrates**	-	-	╬	╬	╬
		Fishes	**Resident Lake Fish**	╬	╬	╬	╬	╬
			Salmon	●	●	●	●	●
		Birds	**Black Oystercatcher**	-	-	╬	╬	-
			Bald Eagle	╬	╬	╬	╬	╬
			Seabirds	-	-	╬	╬	╬
		Mammals	**River Otter (coastal)**	-	-	╬	╬	╬
			Brown Bear	╬	╬	╬	-	╬
			Wolf	╬	╬	╬	╬	╬
			Wolverine	╬	╬	╬	╬	╬
			Moose	╬	╬	╬	-	╬
			Caribou	●	●	●	-	●
			Sea Otter	-	-	╬	╬	╬
			Harbor Seal	-	-	●	●	●
		Vegetation Complex	**Vegetation Composition and Structure**	╬	╬	╬	╬	╬
			Sensitive Vegetation Communities	╬	╬	╬	╬	╬

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Table 3-1 (continued)

Ecological Monitoring Framework								
Level 1	**Level 2**	**Level 3**	**SWAN Vital Sign**	**ALAG**	**ANIA**	**KATM**	**KEFJ**	**LACL**
Human use	Consumptive Use	Consumptive Use	Resource Harvest for Subsistence and Sport	●	●	●	-	●
	Visitor and Recreation Use	Visitor Use	Visitor Use	●	●	●	●	●
Landscapes (Ecosystem Pattern and Processes)	Landscape Dynamics	Land Cover and Use	**Land Cover/Land Use**	╬	╬	╬	╬	╬
			Landscape Processes	╬	╬	╬	╬	╬

╬ Vital signs that the SWAN is working independently or jointly with a Network park, federal, state, or private partner to develop and implement monitoring protocols using funding from the vital signs or water quality monitoring programs (category 1, also noted with bold text and shading)

● Vital signs that are monitored independently of SWAN by a Network park, another NPS program, or another federal, state, or private agency. (category 2, information is obtained and used by SWAN)

- Vital sign will not be monitored in that park.

Note: Landscape Processes includes snow cover, lake and coastal ice, and suspended sediments.

Board members expressed satisfaction with the Network's vital sign selection process and outcome. Questions centered on the challenges and costs of monitoring in large remote parks, inclusion of vital signs that are currently being monitored by partnering agencies, the relationship between concurrently funded pilot projects and the list of vital signs, and the direction that the planning process would take. Park staff acknowledged that the list of vital signs represents an optimum program, not all of which may be achieved with Network funding, and that additions or deletions may occur during the coming years as new information becomes available. Board members approved the list of vital signs and signed the Phase II Report.