Southeast Alaska Inventory and Monitoring Network
National Park Service - U.S. Department of the Interior

Terrestrial Ecosystems Monitoring Scoping Workshop

Summary Report

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Terrestrial Workshop
31 January - 1 February 2006
Goldbelt Hotel, Juneau, Alaska

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Southeast Alaska Park Network
Terrestrial Ecosystem Monitoring
Scoping Workshop

January 31-February 1, 2006
Juneau, Alaska

Meeting Summary

1.0 Introduction

The National Park Service (NPS) has established an Inventory & Monitoring (I&M) program to provide park managers with high quality information on the current status of the parks' natural resources and long term trends in resources. National parks that are geographically linked and have similar natural resource characteristics have been grouped into 32 monitoring networks. The Southeast Alaska Parks Network (SEAN) includes Glacier Bay National Park and Preserve (GLBA), Klondike Gold Rush National Historical Park (KLGO), and Sitka National Historical Park (SITK). SEAN is in the process of developing the I&M program for these parks.

On January 31-February 1, 2006, 13 scientists with expertise in Southeast Alaska's terrestrial ecosystems gathered in Juneau, Alaska, to assist SEAN in identifying monitoring objectives, questions, and vital signs to include in the I&M program for the network's terrestrial ecosystems.[1] Workshop participants also discussed and refined ecosystem models being developed for the network. The workshop agenda is in Appendix A and the list of participants is in Appendix B. This summary provides an overview of the terrestrial scoping workshop.

The desired outcomes for the terrestrial workshop were to:

1. Understand the national and SEAN I&M program purpose, framework, process and terms.
2. Discuss and refine conceptual terrestrial ecosystem models.
3. Identify the important monitoring objectives and questions for the SEAN parks' terrestrial ecosystem component.
4. Identify candidate vital signs to accomplish monitoring for the terrestrial ecosystem component.
5. Discuss specifics of what and how to monitor.

[1] SEAN hosted workshops focusing on the network's freshwater ecosystems in February 2005 and on its marine ecosystems on February 2-3, 2006.

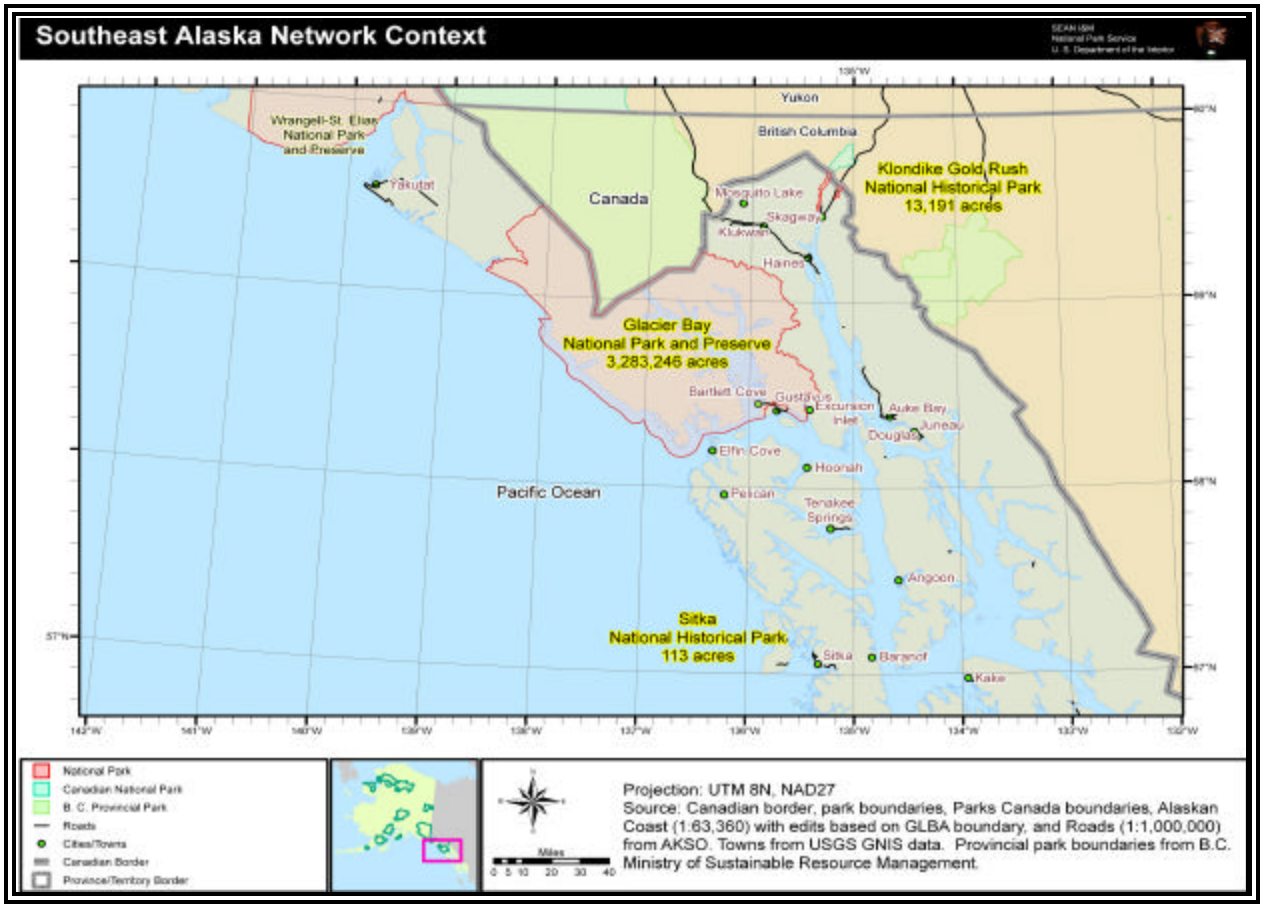
2.0 NPS Inventory and Monitoring Program

The workshop began with an overview of the national I&M Program, SEAN's progress in developing an I&M program for the network, and how the Glacier Bay draft Integrated Science Plan dovetails with the SEAN I&M program. The three speakers for this session were:

- *Sara Wesser, NPS, Alaska Regional Coordinator, Inventory and Monitoring Alaska;*
- *Chiska Derr, NPS, SEAN Coordinator*; and
- *Susan Boudreau, NPS, Chief of Resources, Glacier Bay National Park and Preserve.*

This introductory session set the context for work to be accomplished during the workshop. The Workshop Notebook distributed before the meeting included material to accompany the presentations. The speakers' PowerPoint presentations are available from the SEAN coordinator.

The following figure shows the locations of the three national parks included in the Southeast Alaska Network.



The purposes of the national I&M Program are to:

- ? ***Inventory***: provide a systematic set of baseline information about the condition of park resources, and
- ? ***Monitor***: determine status and long term trends in the condition of select park resources (e.g. "vital signs").

Monitoring efforts are intended to: provide early warning of impending threat to resources and ecosystems; identify and assist in the understanding of meaningful change in natural systems characterized by complexity, variability and surprises; and assess the efficacy of park management efforts. Through monitoring of "vital signs," parks will track 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, or elements that have important human values.

SEAN is following the nationally established three phase planning process to develop its I&M program. The phases are:

- ? *Phase I*: Define monitoring goals and objectives; begin the process of identifying, evaluating, and synthesizing existing data; develop draft conceptual ecosystem models; hold vital signs scoping workshops; and determine preliminary monitoring questions.
- ? *Phase II*: Refine the conceptual ecosystem models and select "vital signs" that will be monitored as indicators to detect change.
- ? *Phase III*: Determine the overall sample design for monitoring; develop protocols for monitoring; and produce a data management plan for the network.

This terrestrial monitoring workshop will help SEAN accomplish elements of both Phase I and Phase II. The discussion and outcomes from the SEAN I&M workshops will also benefit other NPS efforts such as the inventory and monitoring chapter of the Glacier Bay Integrated Science Plan (ISP), the Coastal Cluster Program, and existing park sponsored monitoring.

3.0 Terrestrial Ecosystem Models

3.1 Panelist Presentations

This session focused on the newest additions to the suite of ecosystem models being developed for SEAN. Greg Streveler and Dan Lawson described models that they have been working on with Chris Fastie since the Freshwater Scoping Workshop in April, 2005. In addition, Keith Boggs described the new land cover map and vegetation classification that his group, the Alaska Natural Heritage Program (AKNHP), has developed for Glacier Bay. Keith also described other AKNHP programs that could be useful to SEAN's monitoring efforts.

The Panelists were:

- ? *Chris L. Fastie, Middlebury College* – Introduction and description of the general ecosystem models.
- ? *Greg Streveler, Icy Strait Environmental Services* – Origins of Southeast Alaska's terrestrial environments.
- ? *Dan Lawson, Cold Regions Research and Engineering Laboratory* – Glacial influences on terrestrial environments at SEAN parks.
- ? *Keith Boggs, Alaska Natural Heritage Program* – Land cover classes, plant associations and eco-regions at SEAN parks.

In addition to general refinement and discussion of the models, the desired outcome of this workshop session was to consider:

- ? Are we approaching a consensus that the conceptual ecosystem models depict how the Southeast Alaska ecosystem components work?
- ? How can the models help SEAN identify monitoring objectives and questions, and select vital signs?
- ? How can the models be integrated?

The summary of this session focuses on key points made by the presenters and highlights of the discussion, and presents the models that were the focus of discussion. The Workshop Notebook includes additional models and the speakers' Power Point presentations. Copies of the notebook are available from the SEAN coordinator.

Chris Fastie - Description of a few of the general models

Chris introduced the conceptual models he and others have been developing for the last two years. The models' primary use is their potential to facilitate scientific thinking about the environmental drivers that make SEAN parks the way they are, and the environmental drivers that have the potential to change these parks. The network's modeling focus now is shifting from depicting park ecosystems to how these models and our thinking about environmental drivers can help us to choose vital signs. Chris overlaid the I&M program's six Level I Ecological Monitoring Framework (EMF) categories of vital signs onto the holistic model to introduce this relationship (Figure 1).

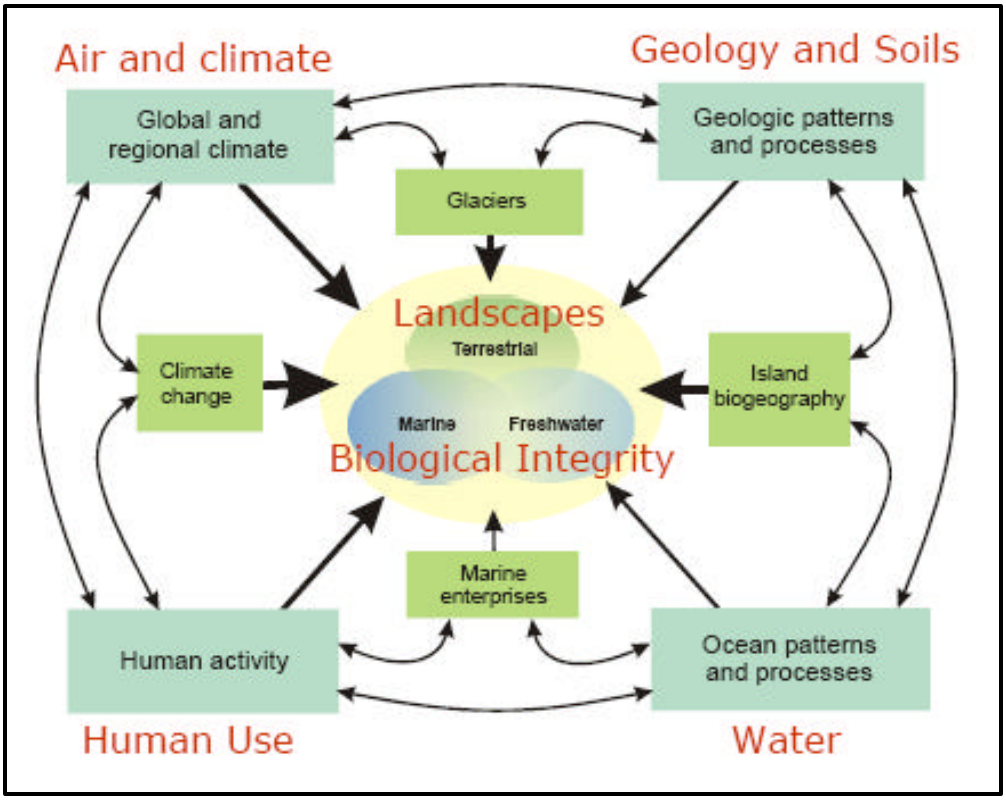


Figure 1. Holistic model: Drivers of change and EMF Level 1 categories. Climate, geologic processes, ocean processes, and human activity are the four major driving forces shaping ecosystem components and ecosystem processes in Southeast Alaska. Thicker radial arrows indicate greater influence. Fastie 2006.

Greg Streveler - Origins of Southeast Alaska's terrestrial environments.

Greg has modified two models which emerged at the SEAN Freshwater Scoping Workshop in April 2005. Both models are now expanded to include effects on both freshwater and terrestrial ecosystems. These updated models were included in the notebook for this workshop and are described separately below.

Origins of SEAN terrestrial and freshwater features. In this model, Greg has captured how geography (e.g., a maritime climate) and geology (e.g., an active plate boundary) interact to produce a physical landscape characterized by an intense glacial history, complex topography, and a long history of sea level change. reg described how this physical environment influences ecological features of three categories of terrestrial environments: near shore (low elevation near seawater), other low elevation and mid elevation, and alpine and subalpine environments.

Near shore communities tend to be the more productive and younger than low and mid elevation, and subalpine and alpine communities. In this most permissive climatic regime (sea level), communities receive more marine resources than any other part of the landscape, and they tend to be youthful because of the near shore dynamism (not only has sea level changed a great deal but there tends to be a lot of other geomorphic activity here). When this dynamism is combined with nutrient availability the result is great productivity.

The other extreme is the alpine. Because of Southeast Alaska's great geographical reach, the subalpine/alpine communities are found in a huge range of altitudes, and community composition therefore differs greatly from place to place. In addition, plant communities tend to vary between sites with different microtopography and small changes in lithology. Successional discussions in Southeast Alaska rarely consider the alpine, but it is one of the most important parts of our ecosystem, disproportionately so compared to most places in North America.

Midelevation zone communities are above the young, dynamic, nutrient rich sea level communities, and below the alpine zone. The mid elevation is the zone that most successional research is focused upon.

Key drivers of terrestrial and freshwater environments. Here is tension between two fundamentals characteristics of Southeast Alaska – disturbance and wetness (Figure 2). The resolution of disturbance and wetness in any one place tends to have a fundamental impact on the particular ecosystem at that point in time and space.

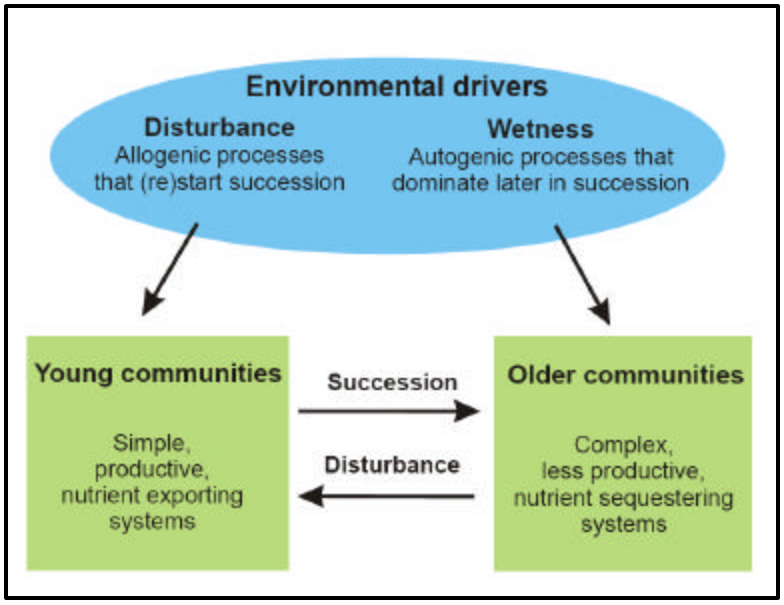


Figure 2. Key drivers of terrestrial and freshwater environments.

Wetness tends to drive things in Southeast Alaska toward accumulation of organic matter and away from the underlying bedrock. It creates a situation where plants are living on the resources that can be provided by rainfall and, to a minor extent, other sources. This results in communities that tend to use minerals very conservatively over time. As time goes on, if not disturbed, plant communities are organized by interactions within the community, and defer less to the dictates of the physical environment. Glacier Bay is probably the most famous place in the world for elucidating that process.

Disturbance is other strong environmental driver. Glaciers are perhaps the most successful disturber. At the other end of the spectrum are single trees falling in the forest, which happens extremely often. Others disturbance events include larger wind throw events, downslope movement of plants and other material, sea level changes, tidal action leaving strands and mudflats, and other subtle and obvious disturbances. Disturbance essentially

sets a system back, communities are made more youthful, the bank of nutrients is opened and bled out into the aquatic and marine system, but also sometimes bled out into the community itself which makes some communities more productive.

Dan Lawson - Glacial influences on terrestrial environments at SEAN parks.

Dan discussed his model which represents the two way interaction between glaciers and their physical environment, and the influences of the glacial environment on ecosystems in marine, terrestrial, and freshwater environments. He focused on the interactions between glaciers and terrestrial environments for this presentation (Figure 3).

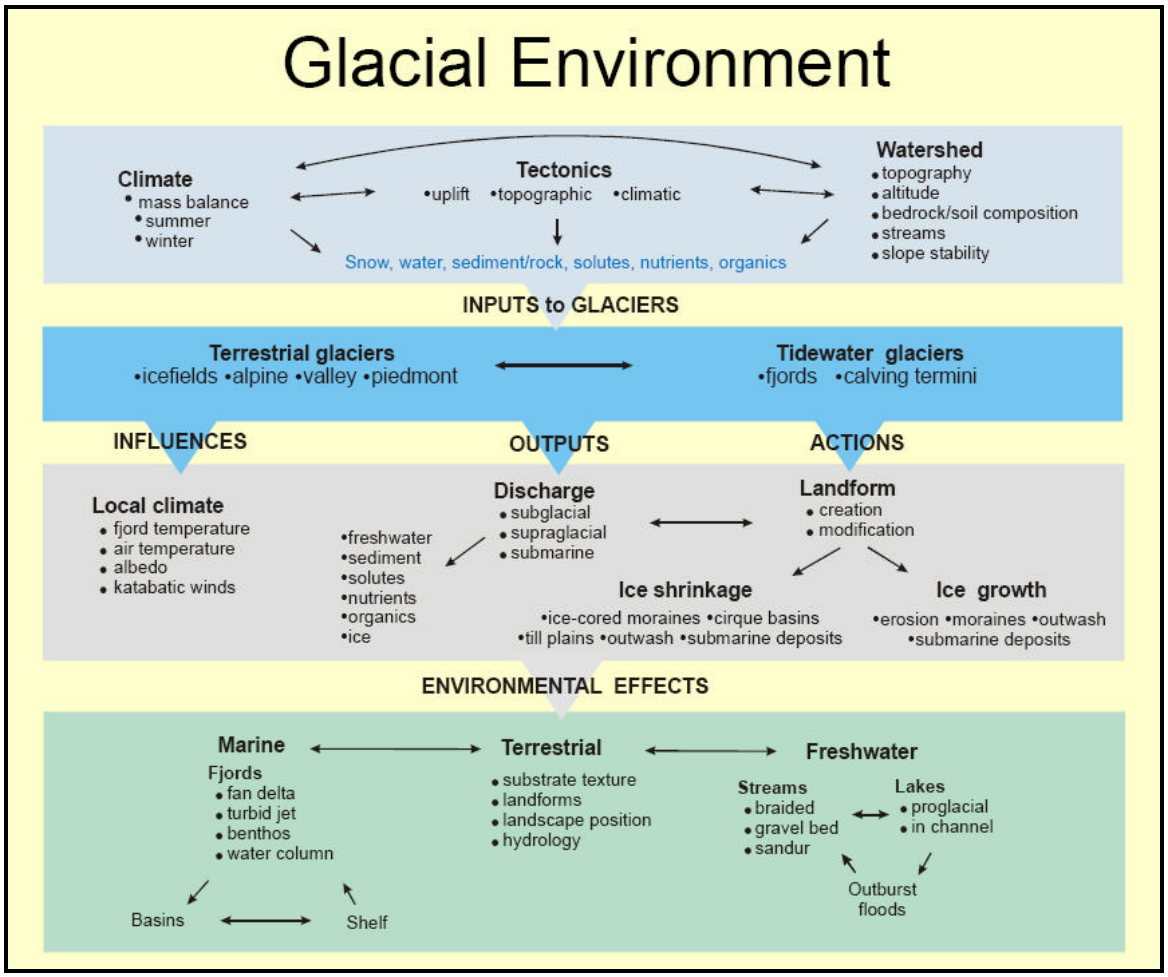


Figure 3. The glacial environment and its effects on the marine, terrestrial and freshwater environments.

Both terrestrial glaciers and tidewater glaciers have important influences on the terrestrial environment. While the tidewater glacier terminates in water, the upper parts of the glacial system are on land. Glaciers influence what is beneath them and what is going on around them. In both cases, these glaciers are eroding down into their beds and creating not only valley systems but fjords. They also cause instability in the slopes overhead, and the combination of slope instability and freeze/thaw action causes the slopes to erode at a fairly rapid rate. Some glaciers in Southeast Alaska have the highest rates of erosion in the world. Both glacial water and sediment discharge affect the freshwater and the marine

environments. Both provide sediments that ultimately form deposits, as well as create landforms when they are advancing. During glacial retreat, discharges create landforms like moraine basins and outwash deposits and also leave behind sediments on mountain slopes that become unstable and subject to high rates of erosion. The result is a series of different types of landscape surfaces upon which ecosystems develop.

Today there are glaciers covering most of Glacier Bay, and they are primarily in recession. Deposits left behind by glaciers become new terrestrial environments. We're thinking about how glacial retreat is going to impact the ecosystems of the parks, over time, and focusing on monitoring that change in the context of a changing climatic regime.

A question was asked about how tectonic uplifting and glacial rebound affect the terrestrial ecosystem. Erosion rates are a response to that uplift rate – the more quickly land is uplifted, the more erosion takes place. In response it was noted that there is a lithospheric response to glaciers. As glaciers are retreating or eroding away substrate, this creates instability in the underlying crust, which causes faster uplift, which creates a greater barrier to moist air masses from the Gulf of Alaska, which enhances glaciation. So, there is potential to expand glacial activity as mountains continue to rise.

Most glaciers today are going from tidewater to terrestrial, so how they interact with the environment is changing over time. A participant noted that what is going on in GLBA significantly affects what is going on in KLGO due to mountain masses and the rain shadow. Recent climatological data and satellite weather imaging suggests that most of the storms in Glacier Bay enter along Icy Strait and turn north into Glacier Bay then are driven to the north. The Chilkat Range blocks the moisture movement into the Klondike area. This is also the reason that glaciation was so extensive inward of the Takhinsha mountains (where Muir and Riggs glaciers begin), which was not otherwise expected. The glaciers are advancing because the mountains are getting precipitation from the Gulf of Alaska, but the ice is moving into a relatively dry area. It is so dry in the Chilkat Valley that spruce did not grow there historically. All the spruce there are in first generation forests. The glaciers flow northward out of the Chilkat Range because of precipitation from the Gulf that does not get over the Chilkat Range. The recessional moraines from the Glacier Bay ice sheet are more than 100 km south of the high peaks of the Chilkat Range, but only half a kilometer north into the Chilkat Valley.

Most areas of Glacier Bay were covered by glaciers at some time in the past 10,000 years. But some areas, such as Dundas Cove, were not glaciated, and trees can be over 600 years old there. In response to a question about when Sitka was ice covered it was noted that it would have been late Glacial Maximum, 20,000 years ago or maybe prior. A question was raised as to whether nunataks would have been at a lower elevation at that time? The answer was yes, during the little ice age. In Cooper's work he has a map showing the forests that were still in existence during the maximum extent of ice during the little ice age. Fastie has sampled tree rings in those ancient forests.

Keith Boggs - Land cover classes, plant associations and eco-regions at SEAN parks.

NPS contracted with the Alaska Natural Heritage Program (AKNHP) to develop a land cover map for Glacier Bay National Park and Preserve. This map is now available in draft form, and was displayed at the workshop. The mapped data is based on 1996 aerial photography which is now 10 years old. The project described and mapped major plant associations and 39 land cover classes. Land cover classes were mapped using the 1:63,360 scale. A vascular plant species inventory was also produced. GLBA staff noted they need a wetlands inventory for Dry Bay in GLBA, Boggs responded that one had been done.

A question was raised as to whether land cover might be considered a vital sign, and if so would a land cover map be a tool for monitoring over time? If yes, at what interval should repeat mapping occur? Repeat mapping is tricky -- technology improves and the accuracy and map scale change over the years. If the goal is to see how dominant vegetation types change over time, vegetation maps can answer that on a very coarse scale. But, if the goal is to record whether you are preserving biodiversity in the park by comparing vegetation maps produced at different times, that would be more difficult. One would have to resample plots on the ground. A land cover map will be a good tool to monitor change from disturbance, such as earthquakes, landslides, or oil spill. It took two years and significant funding to complete the vegetation map Boggs presented, so this is not very repeatable given the time in which park management might want to see changes. It might make more sense to repeat mapping of major land cover classes every 10 years or so.

AKNHP has five other projects that could be useful to the SEAN monitoring program:

1. Rare vascular plant species ecology and distribution
2. Rare animal species ecology and distribution
3. Rare plant associations and ecosystems description and distribution
4. Invasive plant species ecology and distribution (AKEPIC)
5. Plant association structure and species composition change over time

AKNHP is also working on ranking the rarity of bird, mammal, reptile, and amphibian species within the state. They are working with US Fish and Wildlife Service and Alaska Dept. of Fish and Game using a global ranking to determine how rare a species is. The end goal for the project is to rank species for applied purposes, such as for situations where new development is occurring. Information would be useful to consulting firms working for agencies and developers. Nobody has come up with a list of nonvascular species; AKNHP would like to try to get money to rank the lichens. Another database facilitating sharing of information between the Park Service and the Forest Service is basic plant species. So any information collected about invasive plant species goes into this database, then is distributed through AKNHP.

3.2 Discussion Session

In addition to general refinement and discussion of the models, the goal of this session was to consider:

? Are we approaching a consensus that these models depict how the Southeast Alaska ecosystems work?
? How can these models help us identify monitoring questions and select vital signs?
? How can the models be integrated?

A discussion session following the presentations focused on five topics:

3.2.1 *Human Driven Change*

There are a lot of human driven forces that may be causing change in SEAN parks; the models need to capture this well. Understanding or explaining anthropogenic change in the context of the dynamic ecosystem processes at work poses an additional challenge for SEAN. Identifying change is step one, but trying to account for the cause is the ultimate goal. One shortcut might be to monitor some of the anthropogenic drivers, or at least not leave all of those out when we choose our vital signs. We need information about the human caused drivers and not just the natural drivers. It was noted that two other Alaska networks have selected consumptive use as one if their vital signs. In both cases, they don't plan to do any additional monitoring beyond what state agencies are already doing, but they do plan to gather the information that agencies collect and incorporate it into the network reporting.

3.2.2 *Paired Studies*

Once change is detected, the challenge is to interpret that change: how and why are these changes occurring, and what forces are driving the change? Models help us visualize what the drivers or stressors are. Do we monitor the things that are affecting the ecosystem components or do we monitor the system itself? It would be good to have some paired, or series of, monitoring sites, for selected vital signs. These pairs, or series of sites, would be selected to contrast change between sites with varying degrees of actual or anticipated human influences. The network should also monitor across trophic levels, and have both some drivers and some recipients of the driving influences to get as much of a range of influences and effects as possible. Magnusson encouraged us that if we design things with that in mind we could actually start hinting at cause, even though you don't necessarily do that directly in a monitoring program.

3.2.3 *Managers Needs*

In selecting appropriate vital signs, we need to plan for the future, and anticipate which changes park management might expect in the future. We need to monitor current conditions and also be able to predict what physical changes might take place as a result of ecosystem changes. Managers want to now why the changes are happening. Will a biologist be able to tell what the minimum and maximum range of a population is for which a species is being monitored, such as whales? Defining ranges and thresholds forces you into looking at single species. Managers need to know if a population swing is natural or is the effect of an anthropogenic cause. We are trying to understand when things are headed out of the natural range of variability, but articulating this is hard to do, especially if you are

not monitoring single species. Can the models help define the ways in which the ecosystem is going to change?

3.2.4 *Biodiversity versus Naturalness*

There is a suite of species that are becoming increasingly rare in our world. Some 20-30 years from now there is going to be a major collision between two imperatives of the Park Service. One is maintaining biodiversity and the other is maintaining naturalness. Some of the current literature in the publications Science and Nature suggests we are in an era of mass extinction. Consider the red-throated loon, which is uncommon in northern Southeast Alaska, as an example. They primarily nest in proglacial lakes, which are disappearing as glaciers recede, or changing as they become increasingly vegetated and frequented by predators. Do you actively manage the park for a rare species if its habitat is disappearing due to natural causes? Are we managing for naturalness or for biodiversity? It could also pertain to the vegetation community that you're managing in front of your viewshed for your lodge, or it could be the vegetation community at the 1,000-2,000 foot level that holds a complex biota.

3.2.5 *Monitoring Objectives*

Are we monitoring just to detect change or to reach some target goal in a 50-year horizon, for the factors that you can have some level of control over? It is easier to address this in areas where restoration is taking place -- there you monitor until you attain a desired future condition. But in pristine systems it is hard to consider this as an outcome at the end of a monitoring program, versus an outcome at the end of testing a hypothesis.

And, what about a species of management concern? Should there be a target to maintain sustainable populations of a species of concern into the future. But, how much influence do we really have on, for example, humpback whale populations globally?

One participant noted that this and the biodiversity topic raise interesting questions, but are beyond the scope of what this program is doing. We're supposed to be setting up a monitoring program to detect change. When we detect change in 5-10 or 25 years, we say research needs to be done, then it's up to managers to decide what to do.

3.3 Written comments from participants

Written comments from eight participants in the Terrestrial Scoping Workshop were submitted immediately after the session. There was general agreement that the models were a good introduction to some basic environmental relationships in southeast Alaska, and that the models were well suited to generating useful discussion about SEAN parks and the SEAN monitoring effort. One comment addressed the general nature of some models, and suggested that the level of detail in the resource preservation concerns model and the holistic model (Figures 2 and 3 in the workshop notebook, Tab 4) was most useful. One comment suggested that the models could be linked to the needs of other agencies, such as conserving particular species. Another participant made the comment that the relative importance of the two near field drivers (park use and development) in the resource preservation concerns model would differ among the three SEAN parks.

4.0 Insights and Advice from other Alaska Park Networks

Sara Wesser, Alaska Regional Coordinator for the NPS Inventory and Monitoring program in Alaska, gave a presentation on what other national park networks in Alaska have accomplished and lessons learned. The PowerPoint presentation from this session is available from the SEAN coordinator.
As part of the presentation, there was discussion about the tension between the realities of available funding and the need to develop a robust and full list of monitoring vital signs, because future funding levels are unknown. At this stage of SEAN's I&M program development, the goal is to make a full list of potential vital signs and not eliminate things prematurely.

Both the Southwest Alaska Network and Central Alaska Network brought funding considerations into their vital sign decision making quite late in the process; the fact that they have significantly larger annual budgets than the Southeast Alaska Network may have been a factor in this. Sara's advice is that it is smart to bear the budget in mind, as it might lead the network to make different choices about how you would approach program needs. For example, should a network conduct field work to collect primary monitoring information, or rely on data being collected by another entity that could work? On the other hand, if the network identifies vital signs without being unduly limited by concerns about funding, a robust package of vital signs will be in place in case future funding is available.

5.0 Identify Monitoring Objectives, Questions and Vital Signs for the SEAN Terrestrial Ecosystem

As earlier I&M networks identified their vital signs, it became apparent that many vital signs are common among networks. To promote communications, collaboration and coordination among networks and with other programs and agencies, and to combine results for national reporting, vital signs selected by other networks have been organized into an hierarchical Ecological Monitoring Framework table (EMF). This organizational tool nests vital signs within three levels, which progress from general to specific. The broad, Level 1 categories are:

- ? Air and Climate
- ? Geology and Soils
- ? Water
- ? Biological Integrity
- ? Human Use
- ? Landscapes (Ecosystem Patterns and Processes)

In preparation for this workshop, the SEAN technical committee created a draft, or "straw man," EMF of potential monitoring objectives and questions, and potential vital signs. Workshop participants were encouraged to use this straw man EMF to stimulate thinking in key monitoring categories, but to not spend time worrying about the final organization of the tables. Workshop participants spent a full day of the two day workshop filling in and discussing the EMF. They did this by dividing into two smaller groups to discuss and refine the EMF, and then reporting their work to the other group.

All comments from both small groups are recorded in the terrestrial EMF table that follows. As the network holds subsequent meetings to rank, select, and prioritize vital signs, they will use these ideas generated by the scientific experts participating in this workshop, and in the freshwater and marine vital signs scoping workshops. The contents of the EMF will continue to be revised as the SEAN I&M program develops. The table below represents a snapshot in time, not a refined, final product.

Level 1	*Level 2*	*Potential Terrestrial Monitoring Objectives & Questions*	*Potential Terrestrial Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other...*
Air and Climate	**Air Quality**	Objective A. Understand the natural range of variability in air quality across SEAN parks and determine if there are any air quality concerns.		? Focus on a robust baseline first, then consider monitoring later. We assume air is relatively pristine, but we don't know this as a fact. ? Can we define the NRV in air quality? ? Combine an air quality and a weather baseline information gathering program. ? Another way to define the baseline is to identify historic air quality. Consider determining this through by looking at the chemistry of snow and ice in accumulation areas (and correlating with snow stratigraphy). Use the Brady Icefield. This would be expensive, do it once only, use Pb210? ? CAKN has a large air monitoring program run out of Denali. ? Use passive samplers as tools for monitoring. ? "IMPROVE" USFS Station located in Petersburg since 2005; data will be available soon. IMPROVE results can be used to identify potential air pollutants of concern to SEAN. There is not enough information now to select specific measures of air quality. There is no other long-term permanent active air quality sampler in Southeast Alaska. ? Glacier Bay Science Advisory Board is recommending opacity sampling for cruise ship impacts. ? GLBA is a Western Airborne Contaminant Program (WACAP) site. There is one WACAP sampling site at Bear Track Cove. ? Removed ozone as a potential vital sign; judged to be an urban pollutant, not expected to be an issue in SEAN parks. ? Other networks are relying on other air quality monitoring networks to provide data. ? Cautions: 1) Most are air quality standards and thresholds are related to human health, these may not be relevant standards for national parks. Which thresholds make sense? 2) Technology changes and smaller units of contaminants can be detected, but this does not necessarily have ecosystem significance. There is no dose-response relationship for ecosystems. 3) Sources of contaminants will likely be from outside the park and beyond park control.
		What are the levels of airborne contaminants in SEAN parks? What is the baseline air quality? Are airborne contaminants being deposited in the park (status and trends), and if so, which contaminants?	sulphur and nitrogen, mercury, suites of elements specific to different passive samplers, signature pollutants from cruiseship fuel, indices of Asian pollution, persistent organic compounds, foliar damage, lichen tissue (for elemental content)	
		Is visibility being impaired by airborne contaminants?	visibility, opacity	
	Weather & Climate	Objective B. Understand the natural range of variability in climate patterns across SEAN parks to provide context for research.		? There is extremely deficient weather and climate data in GLBA; only available for the southern periphery. ? Paleo-data can be obtained from lake, ice and marine cores. ? There is no weather climate station in KLGO's Taiya Inlet. ? Climate Data Sources -- Use existing climate sampling stations: National Weather Service (NWS) at Skagway; Natural Resource Conservation Service (NRCS) snow course and weather station at Skagway, NOAA station near Sitka, State Climate Centers. There are weather stations in Yakutat, Juneau, Gustavus, Bartlett Cove and Sitka. Fill-in gaps with new stations; be careful about picking sites - scale and site-specific variability should be considerations. ? Alaback and McClellan predict increased blowdown with global warming. ? Possible to use climate monitoring sites established in GLBA by Dan Lawson for glacial studies? Uncertain as to longevity, elevation coverage? ? Sitka has 200 years of historic weather records, Skagway may too. ? Need more weather monitoring stations in GLBA to capture the microclimatic range. ? Noted that weather and climate high service-wide in selection of vital signs.
		What are the current trends in weather patterns? How is climate varying over time and space?	air and soil temp, precipitation, relative humidity, windspeed and direction, radiation, snow cover and longevity of snow beds tree rings	
		How do current trends in climate compare to historical and ancient (paleoclimate) trends? What is the prehistoric climatic baseline (this would extend the timeline of current climate monitoring and give data on the natural range of variability)?	paleoecology, dendrochronology, historical geology	
		How is changing snow pack and permafrost extent affecting vegetation and vegetated	snow bed characteristics, land cover	

Level 1	*Level 2*	*Potential Terrestrial Monitoring Objectives & Questions*	*Potential Terrestrial Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other...*
		community boundaries?		? Very important to have paleoclimatic data, to provide a baseline from which to evaluate current climatic trends. Paleoecology and historical geology are ways of extending the baseline back in time, increasing the power of current monitoring.
Geology and Soils	**Geo-morphology**	Objective C. Understand effects of current and paleo-glacial activity and resultant depositional history		? Objective wording is confusing, it would be better to use active and inactive or current and historic; Little Ice Age glaciation remnants are active systems. ? Small group consensus that most important vital signs relative to glacial effects on terrestrial ecosystem are <u>glacial extent and historical geology (eras).</u> ? Use remote sensing, mapping for current glacial extent.
		How are glaciers moving (retreating and advancing) relative to former eras? How are icefields changing in area and extent? What is the relation of uplift to coastal meadow communities?	glacial extent, glacial lake outburst floods, calving rates, water discharge and sediment load, mass balance, surface elevation profiles, snow cover, sensitive biological communities (supraglacial and riparian), landcover changes, floodplain dynamics as influenced by glaciers, historical geology	
		Objective D. Understand the non-glacial physical processes effecting terrestrial ecosystem stability and change. Understand how geomorphic processes affect the terrestrial ecosystem.		? Geomorphology is a significant driver in the ecosystem, it is linked to climate. ? Some suggest that glacial activity is not geomorphology. ? Is the goal to understand dynamics and changes in the parks or to address impacts in the parks? Answer: both. ? KLGO is interested in the sediment load in park glacial streams; this effects channel movements, flood plain dynamics, and management of infrastructure in the floodplain. The more sediment, the more braided the rivers. The floodplains are where the salmon spawning habitat is and the deciduous riparian forest. ? <u>One small group lists most important vital signs as landcover mapping, channel morphology, floodplains, debris flows and other episodic events.</u> ? <u>Way to monitor episodic/drastic events is to document after they occur.</u> ? <u>Want to document what there is now to have baseline data.</u> ? <u>Document small events on a yearly basis to feed into future models.</u>
		How are lake, river and stream, and wetland processes affecting the terrestrial ecosystem?	land cover mapping, channel morphology parameters, water chemistry (for nutrient input to terrestrial component), measure a suite of selected streams, floodplain dynamics/processes, changing shorelines of waterbodies, alluvial fans, marshes, sediment load in glacial streams, debris flows, episodic events, soil classification	
	Subsurface Geologic Processes	Objective E. Understand the distribution, extent and functions of caves and karst features.		? This is an inventory issue. ? It may be important to the Tongass to monitor a karst environment in a pristine place like GLBA to contrast with karst in the Tongass where there is logging and other risks and impacts. ? Small group consensus that this is a research question, not a monitoring vital sign. Karst is not a major issue at GLBA and not present in KLGO and SITK. Could inventory karst sites, but the work is unrelated to I&M questions. ? Not at risk in GLBA. Leave this off. ? Possible connection with biodiversity? Habitat for (Little Brown) bats? ? Let the Tongass Cave Project personnel do any mapping. ? If any caves are in areas not glaciated during the Little Ice Age, look for human signs.
		Where are the caves and karst features in the parks, and what ecological roles do they play?	geologic mapping (to suggest where karst features may be), known animal den sites utilizing karst caves	
	Soil Quality	Objective F. Understand how soil profiles and development affect the terrestrial ecosystem.		? Need soil map, expect to get one from NPS. ? Soil mapping is planned for GLBA by NPS in the next couple of years. May not be at level of detail necessary for vital sign monitoring. ? Soil quality interacts with vegetation -- reciprocally influenced. Soils influence vegetation, while vegetation can also affect nutrient levels (e.g., nitrogen) in soils. ? GLBA is source for information on early soil and plant development. ? The youngest and oldest soils in Southeast Alaska are in GLBA. ? One small group has consensus that paleontology is not a relevant subject to the terrestrial ecosystem, except in the context of using paleontological information to
		How is soil type distribution changing in SEAN parks?	soil maturation process, bulk density, pH, available nutrients, soil structure, permafrost	
		How is soil quality and vegetation interacting?	soil structure, land cover	

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				ascertain prehistoric climate (see Climate section). ? Other small group recommends deleting.
Water	**Hydrology**	Objective G. Understand how hydrologic processes affect the terrestrial ecosystem.		? Hydrology drives vegetation if landscape doesn't interfere. ? Flow regime is a driver of riparian vegetation. Riparian vegetation is at the intersection of hydrology and the terrestrial environment. ? One small group lists the most important vital signs as flow regime, land cover mapping, floodplain dynamics and ground water processes. ? This whole topic is very linked with freshwater ecosystem. ? Can we answer these questions at a broad scale for lower cost that make it more feasible to accomplish? ? There has been a lot of stream mapping in Southeast Alaska. Obtain stream gauge data. Other sources of basic hydrologic data: monitoring wells, piezometers (Bishop, Streveler). ? We need to monitor the response of the terrestrial environment to these forces (vital signs).
		How are hydric processes affecting the terrestrial ecosystem? How is climate affecting hydrologic systems that in turn impact the terrestrial ecosystem? How does a forest develop on an alluvial surface? Need a question about ground water processes. What is the relationship between lakes (and other still waters) and the adjacent terrestrial ecosystem? Need a question about hydrology in the alpine.	land cover mapping (current distribution then changes over time), channel morphology parameters, isostatic rebound rates, glacial outburst events, other flood events, riparian vegetation, wetland development/ composition/trajectory, soil inventory, floodplain dynamics, riparian vegetation (home to landmark trees), flow regime, ground water and surface water dynamics, water quality and quantity Integrate whatever is here with freshwater vital signs for this category. alpine vital signs: permafrost, features associated with thaw, snowpack, distribution of permanent snowfields	
	Water Quality	(addressed in freshwater and marine tables)		
Biological Integrity	**Invasive Species**	Objective H. Determine if any invasive species are present in the parks.		? A Level 2 category for Biotic Processes is needed. ? Presence of invasive species can be indicative of overall park health. ? Invasive species change with time. One can't predict which plant will become the aggressive invasive. A patch can sit there for six months, then suddenly explode. ? Build on NPS Exotic Plant Management Team (EPMT) work. Note that EPMT may not be sufficient -- it will implement treatment, but parks would be expected to monitor the results of that treatment. ? USFS just completed a white paper on invasive species for the Alaska region -- both current and potential invasive species. Will send that report to the NPS. ? USFS has funding, has done a lot of surveys. They will be a good partner, coordinate with them. ? There is a central databank with USFS S&PF, Alaska Natural heritage Center, and NPS to a smaller degree. ? The definition between exotic and invasive is not straight-forward. It is suggested that exotic is non-native, and invasive is a particularly aggressive non-native. Spatial scale and time are factors in the definition. One groups states that for NPS purposes, "invasives" are species exotic to an ecosystem. ? Distribution is critical. ? Invasives are coming down the Alsek/Tat Rivers. ? Do paired studies-an invasive species and vectors of distribution (boats, boat drop off sites, wind, trucks/cars, ferries/vehicles, rafters, kayakers). ? KLGO is most at risk for plant invasions. ? Can we identify techniques to reduce invasive species transmission (e.g. wash boots in water before coming ashore)? ? To select birds for vital signs, consider species with smaller habitats, nesting success, population status.
		Which invasive species are present in SEAN parks? What is their abundance and distribution? What is the rate of increase in invasive species abundance and distribution? Identify the mechanisms that potentially increase invasive species (research question).	European starlings, pigeons, domestic (and feral?) dogs and cats, rats, rabbits, northern bobwhite, exotic slugs, dandelions, European Mountain Ash, creeping buttercup, wild turkeys (GLBA), moose?, mountain lions, fungus Monitor new invasive species arriving in adjacent areas and on trajectory for SEAN parks.	

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				? What would protocol and sample design be if parkwide inferences were desired on the degree of invasiveness, or the level of exotic species and invasive species that are in the Park, and monitor that over time? This would be a good indicator of how intact the park's native plant community was, whether it was being impacted by a number of different species. There would be interruptions to natural processes, included successional dynamics, if invasive species were having a large impact.
		What are the populations and distribution of native (not invasives) that proliferate in proximity to people?	Corvids, deer, weeds, e.g., *Geum* (broad-leaved avens)	? GLBA is a rapidly changing environment. How do we distinguish an invasive species from something that would normally colonize the area? ? Exotic versus invasive.
	Infestations and Diseases	Objective I. Determine if there are any native insect or disease outbreaks adversely affecting the terrestrial ecosystem.		
		Are there any insect or disease outbreaks affecting the terrestrial ecosystem? Native or non-native? Location/distribution? Frequencies of outbreaks?	Insects: aphids, spruce bark beetle, hemlock looper Disease: avian flu, west nile virus, animal diseases	? In GLBA, spruce bark beetle is currently the only insect pathogen in the park. ? There are native species that go through episodic outbreaks. How to distinguish whether it is a natural infestation or occurrence or part of succession or habitat evolution? ? Hennon et al (FSL) can predict what insects will increase with a warming climate. ? Hennon has noted Sitka spruce weevil, *Pissodes strobei*, are moving north through British Columbia. The weevils infest young spruce leaders, with major impacts to spruce regeneration. ? Sitka and Excursion Inlet (near GLBA) both have aphids. ? It may be harder for invasives to colonize islands so they may be less at risk, but once colonization has occurred, extinctions are more common on islands. ? The MOST important things to do are education and establish a warning system. ? USFS S&PF will be a good partner, has a program. Encourage them to continue their work.
	Focal Species or Communities	Objective J. Understand the distribution, roles and processes of focal species and communities.		
		How will creation of (ephemeral) uplift communities change with declining rebound rates? Are there any terrestrial focal species or communities at risk (including plants)? (One small group recommends deleting this question)	fire communities (KLGO), wetlands and riparian vegetation (GPRA goals) Forest health (GPRA goal), western toad(GLBA), olive-sided flycatcher (KLGO), blackpoll warbler (KLGO), black and brown bear, small mammals, pro-glacial barren communities at risk, oyster catchers. karst communities	? One group recommended replacement questions related to focal species and communities (see new questions). The draft vital signs deleted from this section (to the left) were largely reorganized under focal species/communities or species-at-risk (see new vital signs). This small group recommends monitoring a suite of key species for each "altitudinal band" in the ecosystem: (1) nearshore, low elevation, low slope (most of which is coastal), (2) mid-elevation, and (3) alpine elevation. ? Recommended vital sign species reflects the input of the terrestrial small group from the October 2004 GLBA Integrated Science Plan workshop. These species all "tell you something about the place" and the integrity of the ecosystem; their presence or absence affects a lot of other attributes or users of the ecosystem. Additional species were added to that list during the January 31-February 1 discussion. ? One small groups said to use the list developed as part of ISP, with a few modifications. Vital signs should be: spruce, alder, sphagnum, moose, bear, eagles

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				and in association with Landfire doing the same for the Tongass. These lists will be ranked for species at risk based on sensitivity to disturbance and rarity. A scientist notes that one must worry about plants that can be easily changed by human activities, whether they are rare or not. ? Extreme declines are a big concern.
		In the nearshore/low elevation/low slope altitudinal band, are there keystone species, focal species or communities that are changing their distribution sufficiently to alter the ecosystem?	**Nearshore/Low Elevation/Low Slope**: Sphagnum moss Spruce Alder – Sitka (GLBA), red (SITK) Deciduous riparian forest Moose Bear Beaver Bald Eagles Western toad Black oystercatchers Seed-dispersers	? Monitor bounds of deciduous riparian forest (low elevation, low slope). This is a forest type that is particularly productive. Many more insects, which attract birds for breeding. Relatively uncommon throughout Southeast Alaska. Common for GLBA, but that is changing with vegetative succession.
		In the mid-elevation altitudinal band, are there keystone species, focal species or communities that are changing their distribution sufficiently to alter the ecosystem?	**Mid-Elevation**: Sphagnum moss Spruce Alder – Sitka (GLBA), red (SITK) Yellow cedar Moose Bear Bald eagles Seed-dispersers Resident breeding birds	? Note that yellow cedar added to **mid-elevation** list: It is declining in southern and mid-Southeast Alaska, but not declining in northern SE Alaska (not present in KLGO). It is a long-lived, slow reproducing species in the mid-elevation, and could be a good indicator of change. USFS is currently doing a lot of research into yellow cedar decline. ? There are well-established protocols for breeding songbirds in a statewide monitoring effort. KLGO participates in this program. The reason that breeding birds tend to be monitored in parks is because they are impacted in the rest of their range, and their numbers can be measured in parks as an indicator of how they are faring globally.
		In the alpine altitudinal band, are there keystone species, focal species or communities that are changing their distribution sufficiently to alter the ecosystem? Is the mosaic of alpine vegetation shifting?	**Alpine:** Deer cabbage Bear Mountain goats Resident breeding birds (willow ptarmigan?) Shrub/treeline elevation, and boundaries of alpine vegetation communities	? Noted that mountain goats were introduced to Baranof Island, not native to Sitka park area. ? Noted that shrub-line, and possibly treeline, is moving up in elevation, although this has not been measured. Evidence that this is true for alder, also reasonable evidence for spruce and hemlock. Could be in relation to localized climate change (e.g., general retreat of glaciers affects microclimates), or changes in hydrology, dewatering, less snow, drying out. (Connects to suggestion, under weather & climate section, to monitor snow pack longevity and distribution of snow beds.)
		Is there a change in population or distribution of species that signal substantial change in the environment ("environmental canaries")?	Western toad Black oystercatchers Yellow cedar	
		Is the species composition of key ecological communities changing, compared with the historic characteristics of that community type (e.g., is what is called an "alder thicket" today, ecologically equivalent to the alder thickets of the past)?	Current and historic plant composition and faunal composition in key ecological community types.	? Relevant because how the vegetative community is made up influences the fauna that inhabited it. Land cover (e.g., alder thicket, or supertidal meadows) may be called the same thing on a map over time, but may have very different plant species that make it a very different place from a bear's or a hummingbird's point of view.
		How are species composition and population of breeding birds changing in our parks, in response to local and global pressures?	Breeding bird species composition and population levels	? There are well-established protocols for breeding songbirds in a statewide monitoring effort. KLGO participates in this program. The reason that breeding birds tend to be monitored in parks is because they are impacted in the rest of their range, and their

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				numbers can be measured in parks as an indicator of how they are faring globally.
		How is increasing landscape fragmentation affecting populations of breeding birds?	Breeding bird species composition and population levels Landscape fragmentation in SEAN parks (land use, land cover)	? Landscape fragmentation more of an issue for KLGO and SITK due to their smaller size and proximity to developed environments, than for GLBA.
		One small group was not sure what the key question is re: river otters, but saw value in the species as a vital sign	River otters	? River otters are a species of interest due to the fact they use all environments (freshwater, marine, terrestrial), are transporters of marine-derived nutrients, and are apex predators in the food web. River otter latrine sites represent big spikes in nutrient levels, which create small "biodiversity hot spots." ? Noted that the Tongass National Forest identified river otters as a management indicator species (MIS) for ecosystem integrity. However, group not certain that they are sensitive to the types of changes that might be experienced at SEAN parks, such as changes in visitor use or cruise ship traffic.
		Objective K. Understand trends in biodiversity.		
		What are the trends in biodiversity at a variety of organizational levels (e.g., species diversity, genetic diversity)?	Species richness, genetic variability within species (those with small population levels, such as bears), metapopulation dynamics	? Use data from Alaska Land Bird Monitoring System (ALMS). ? Encourage opportunistic genetic sampling (e.g, harvested bears or defense of life and property kills) – need cooperation and partnering with other agencies. ? Should we be sustaining the health of certain habitats for the sake of bio-diversity (there is a debate pro and con about this).
	At-risk Biota	Objective L. Understand the population trends and distribution of at-risk biota.		
		What are the population trends and distribution of (terrestrial) at-risk biota?	Western toad (GLBA, KLGO): ecosystem integrity indicator and also potentially at-risk Birds on the parks' existing "species of concern" list: peregrine falcon (GLBA), blackpoll warbler (KLGO), golden eagle (KLGO), olive-sided flycatcher (KLGO), Queen Charlotte goshawk (GLBA), wandering tattler (KLGO) Periglacial species, such as the red-throated loon Obligate shore users (note: the semi-palmated plover was suggested as an obligate shoreline species, but Carstensen has seen nests at 3000" on alpine tundra) Rare plants and lichens	? Note: Some species are at risk due to changes in the SEAN park(s) that affect their habitat. Others are at risk due to impacts outside of the park (or even outside of Alaska) that are not within park control. ? The breeding birds listed as "species of concern" are listed due to limited population size, or because their migratory route or breeding grounds brings them to places where they are at risk (e.g., the wandering tattler breeding habitat is in a zone that could be influenced by oil spills, putting breeding population at risk.) ? For breeding birds, use data from statewide breeding bird surveys. There are well-established protocols for breeding songbirds in a statewide monitoring effort. KLGO participated in this program. ? It is noted that there is anecdotal evidence to suggest a decline in the western toad, but there is no research or long-term monitoring data set to substantiate this. ? Collect specimens to understand changes in morphology and genetic diversity over time for select species. ? Choose carefully based on suspected cause (don't monitor two with same suspected cause). BLOY (H_2O), KIMU (H_2O), MAMU ? Do you get the biggest bang for your buck by monitoring prey or predators?
		How do small mammals change with successional changes? (this may belong under a different objective)	select small mammals (mice, voles, shrews)	? Because so little is known about small mammals in the parks, an inventory is needed before monitoring. ? Want to know distribution and abundance, dispersal rates, movement, etc. ? Recent genetic work suggests high likelihood of distinctive lineages appearing in unpredictable places throughout southeast. More small mammal genetic work could address the issue of endemism.

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Human Use	**Point-Source Human Effects**	Objective M. Understand how park and preserve ecosystems are affected by point-source human activities.		? One group suggested no questions or vital signs. While there are undoubtedly within-Park and near-Park point source human activities that could affect Park resources, the group felt that this type of monitoring needed to be conducted through a project-specific monitoring plan, rather than be considered a vital sign for monitoring at the scale anticipated in the SEAN I&M program.
		How are sightseeing overflights affecting human use and enjoyment and animal behavior?	invasive plant numbers and distribution at human drop-off points and campgrounds	
		Are invasive plant species linked to human point sources?	floatplanes, ship traffic, campgrounds, helicopter overflights, noise	
	Non-point Source Human Effects	Objective N. Understand how park and preserve ecosystems are affected by non-point source activities.		? No specific discussion on this objective. It was noted that the CAKN vital signs for this objective related to tracking the population of gateway and adjacent communities (e.g., Gustavus, Yakutat, Haines, Skagway, Sitka.) ? Non-point source human effects are more important than point-source human effects.
		What are the impacts from ship traffic on biota and the terrestrial environment?	Mercury, air quality	
	Consumptive Use	Objective O. Understand if human consumption of natural resources is adversely affecting terrestrial-ecosystem components.	berries (within park) bears and birds (in preserve) gull eggs and seal (resources that it may be important to establish a baseline for due to traditional hunting and gathering) harvested fish, moose, marten, bear (in GLBA Preserve), Sitka: Indian River fish harvests	? This is a low priority. ? Dry Bay - leave to ADF&G ? ADF&G good partner, source for harvest data. ? Use ADFG harvest data; ADFG and NPS data re: defense of life & property kills (bear); State fish and wildlife population data
		One small group deleted this question. Are the current levels of resource harvest sustainable? What are the levels of consumptive use, both within and adjacent to the parks? Are the levels and patterns of consumptive use changing, both within and adjacent to the park?		
	Visitor and Recreation Use	Objective P. Understand the impact of human activities on natural ecosystems. Objective Q. Understand how park and preserve ecosystems are affected by local and regional visitor, recreation and park research/ administrative activities.		? Use park data characterizing users; special use permits; administrative permits, concessionaire data. ? Monitor the human use that's causing the change AND monitor the monitoring resources potentially affected - conduct a paired study. ? One group talked a lot about whether wilderness was or was not included. A scientist shared that he attended a kayak symposium in Juneau about 10 years ago where, due to human impact on animals, Donald Lawrence proposed a system of anchored barges be used for overnights instead of camping onshore. This would lesson impacts to vegetation and wildlife including bear problems. He ventured that he had never spent a night onshore as a researcher on GLBA. When asked to show hands for those that would be willing to spend the night on an anchored barge during trips to GLBA, 5 out of 50 said yes. This suggested it is all about wilderness, not animals. ? Not thought to be a relevant Level 2 topic in the context of monitoring changes to the SEAN Natural Environment (not the Cultural Environment).
		How are methods and locations of human access changing?	For all visitor, recreation, research/administrative users of the Parks, need: numbers, access points, areas of focal use (e.g., camping, cabins, pedestrian trails, kayakers, vessels, hikers, horses(KLGO), dogsleds (KLGO), ORV trails (Dry Bay), mode of transport, areas of dispersed use, method of travel, trends	
		How and why are visitor and other human use (e.g., park research and administration) numbers and activities changing, and which resources are at risk from those changes?	changes to vegetation, physical changes to soil, topography, numbers of trails, types of visitors coming, animal displacements (important but hard to measure -Smith's project on bears, habituation for bears, displacement for oystercatchers and mustelids).	
Landscapes (Ecosystem Pattern and Processes)	**Fire and Fuel Dynamics**	What are the frequency, distribution and intensity of fires? (KLGO)	Fire occurrence, cycles, history(?)	? This is an issue for KLGO: historically, fire is a major organizing feature of the KLGO ecosystem. Over the last 200 years, the entire KLGO system has burned, except for a few gulches and above 2,000 feet elevation. Also a factor in SITK. ? Discussion of whether fire suppression has had an impact on plant succession. This is

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				a research question (KLGO is looking into this via repeat aerial photography), not a monitoring question for vital signs.
	Landscape Dynamics	Objective R. Understand how changes in terrestrial topography affect park terrains. Understand landscape processes well enough to reconstruct the paleo-landscape and project landscapes into the future.		
		One group deleted this question. What are the successional trends of terrestrial communities in relation to changes in marine and terrestrial topography?	State of the landscape. Frequency, seasonality and magnitude of disturbance events. Use land cover maps. Dispersal, habitat and movement of mammals.	
		One group deleted this question. How much (and which) change is attributable to natural successional processes? What are the physical/thermal processes and factors actively causing changes to terrestrial ecosystems and what are their long term effects/impacts?	topographic change, hydrological change, vegetation change/loss	
		What are the changes in the landscape that are having measurable effects on vegetative distribution?	Shoreline morphology Glacial uplift Boundaries of braided streams (channel typing) Geometry of mass wasting	? Aerial photos best source to track landscape changes. ? Most effects on animal species from landscape changes would be indirect, through changes in plant communities/habitats. However, some might be direct, such as uplift draining areas that were breeding ponds for western toads. Or, mass wasting changing a route of a game trail.
		How is vegetation type, stand structure and composition changing across the landscape over time, in response to changes in landscape/terrain?	Land cover Landforms Plant community composition (as indicator of plant succession)	? This question is related to monitoring of vegetative succession. Not sure whether it nests best under Landscape or Biological Integrity. ? We know that we're losing some periglacial habitat and vegetation communities. Will lose some guilds and species that live there. ? Use remote sensing as primary tool for monitoring.
	Extreme Disturbance Events (this is a type of landscape dynamic-above)	Objective S. Understand how extreme disturbance events affect terrestrial communities and processes.		? Seismic stations (one is located in Deception Hills on the fault just southeast of Dry Bay).
		How do extreme disturbance events, such as storms, tsunamis, floods, and earthquakes, affect park lands (especially coastal areas?)	Frequency, seasonality and magnitude of storm events, tsunamis, earthquakes, outburst and other floods, mass wasting, fire, avalanche, volcanic activity, landslides, avalanches (hard to map impacts), fire (KLGO), loss of snowpack, outburst floods, glacial advance and retreat	
	Soundscape	Objective T. Understand how the terrestrial ecosystem responds to human generated sound.		? Above-water sound could play into bear management plan. How does human sound from drop-off sites, camping areas, etc. effect bears. ? Animal behavior can't be a vital sign for this – too difficult to make the connection to above-water sound. ? If dose-response (re: goats for example) is issue, then jet noise does not matter; if wilderness is issue, then all sound matters. ? If studying goats, adopt- don't invent protocols; they are available. ? This is a research question, not a monitoring question applicable on a landscape scale.
		What are the trends in abovewater sound?	Above-water sound (levels at monitored sites), goats?	

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				Or, perhaps targeted monitoring program in specific areas where noise is occurring next to sensitive terrestrial populations (e.g., helicopter overflight paths in mountain goat habitat). ? Monitoring above-water sound could be very expensive because areas are so large, must be selective.
	Viewscape	Delete? How will climate change alter park resources and what people are coming to see? (e.g what if there are no glaciers in GLBA?)		? See no real potential for changes in viewscape to affect terrestrial mammals. This is related to human use. ? This could be a management concern. ? This is a low priority.
	Nutrient Dynamics	Objective U. Understand changes in nutrient dynamics and nutrient flow between ecosystems.		? May be able to use remote sensing of vegetation/carbon as a proxy for soil carbon. ? If you can't use remote sensing, GLBA has a lot of data re: soil carbon and nitrogen. Could calibrate using remote sensing data with that. ? Freshwater group in February 2005 discussed marine-derived nutrient (MDN) cycling. However, MDN is not the most direct measure of riparian productivity or of the integrity of the freshwater ecosystem.
		What are the spatial and temporal patterns of soil dynamics, carbon and nutrients?	Soil carbon, biomass carbon (use remote sensing), marine-derived nutrients obtain baseline isotope data from soils, plants	
	Energy Flow/ Productivity	Objective V. Understand changes in energy flow (productivity).		? One small group did not discuss this topic. ? Changes in productivity and phenology will effect changes in flora and fauna species and in biological communities. If you're going to model or monitor the potential for certain species that haven't occurred in the parks to date, which species will depend on the length of the growing season? hat information may also be relevant to invasive species of concern, as well as species that are native. ? Source of remote sensing data is NDVI – infer productivity or phenology from greenness (looking at different spectral bands). ? USGS data (contact Dave Douglas). ? NPS developing national methodologies for monitoring phenology (per Meg). ? Leverage SEAN network funding to enlist universities to do work on this issue. Get the experts in this to give SEAN a good picture of what is going to happen with park productivity and seasonality, and what to monitor. There are places in GLBA that are going to green up, that were never green before.
		What are the special and temporal patterns of productivity and plant phenology?	Phenology (productivity/seasonality) productivity of vegetation (from remote sensing) Snow free season	

6.0 Identifying SEAN Monitoring and Vital Sign Priorities

During the final workshop session, each invited scientist (i.e. nonmember of the technical committee) was invited to participate in a panel session, and to take five minutes to respond to the following questions:

1. What are the ten most important vital signs to monitor for SEAN?
2. If the SEAN network had $50,000 annually to spend in *each* of the three parks for monitoring of the terrestrial ecosystem:
    - ? What is the most important monitoring information to collect?
    - ? Why?
    - ? What approach(es) should be taken to collect that information?

6.1 Themes Identified

Four particular monitoring themes and/or approaches were mentioned by several panelists. These themes/approaches and the reason they were suggested are explored in more detail in the panelists remarks (below) and in Section 5.2.

- ? **Set up weather stations.** Establish stations to gather weather data, not because the network stations would effectively monitor global warming, but because climate data is important background data needed to interpret the reasons for change. Consider the usefulness of existing weather stations in Southeast Alaska, and locate new ones only where needed to fill a gap.
- ? **Use remote sensing data.** Remote sensing data – whether satellite imagery, LIDAR, or other – can provide important information on land cover, plant succession, glacial extent, mass balance, landscape change, disturbance events, etc. It is important to correlate remotely sensed data with data monitored at strategically selected ground locations.
- ? **Monitor human use.** In addition to weather data, information on human use (access points, types of access, type of use, duration, etc.) is the other key background data needed to interpret the reasons for change in the parks' natural environments. Much data exists already; continue to gather it and make sure it is accessible.
- ? **Monitor a suite of species or communities in each park.** Select a suite of species to monitor in each park, considering invasives, at-risk biota, and/or species that would be important indicators of environmental change.

6.2 Panelists Remarks

Chris Fastie, Dept. of Biology, Middlebury College

Chris Fastie identified the following top priorities for monitoring information related to SEAN's terrestrial environment:

1. Climate (temperature, humidity, etc) – The network and parks need to expand on their existing climate records.
2. Glacial extent.
3. Land cover (vegetation cover), every 10 years.
4. Plant productivity – Remotely sensed index of how vegetation or biomass is changing.
5. Plant succession – Plant succession itself is not a vital sign. To monitor succession, the network would reproduce the AKNHS land cover map in 10 years, and compare the two maps to assess how vegetation is changing. At each point on the landscape the vegetation will have a trajectory. This would be good to know in GLBA, where plant succession is an important part of the research history and is an important component of what the landscape looks like and how it's changing. The network would learn about the change in vegetation composition or structure.

Remote sensing could be used to accomplish much of monitoring listed above. It would be good to have a really good baseline set of remotely sensed data (e.g., glacial extent, land cover, plant productivity). Comparing remotely sensed data with data collected on the ground (where available) would add value to both datasets.

With limited funds, the network will not be able to monitor many vital signs over an entire park, or even a large part of these parks. One approach would be to direct most or all of the funding to one park to obtain key monitoring data, then direct funding to the next park. Monitor each park successively.

Dan Lawson, Cold Regions Research and Engineering Laboratory

Dan Lawson identified the following top priorities for monitoring information related to SEAN's terrestrial environment:

1. Climate – Establish a climate station in each park that doesn't already have one. Sitka may have a close enough station that we don't need to monitor that. Klondike may need one in the upper elevation areas. Climate data are important because the region is undergoing climate change, and it's going to be the primary driver in terms of change in the ecosystem. Cost depends on which data the station collect. If the network installed stations with every major measure, including data collection capability and solar radiation, it would cost about $10,000 per station. If the station was connected to a satellite system (about $3,000) data would be entered directly into a database. The network could have

multiple stations and download data daily.

2. Glacial monitoring and status – Are the glaciers stable, retreating, expanding? Glacial monitoring overlaps with freshwater ecosystem monitoring, because the network would have to monitor mass balance or run Light Detection and Ranging (LIDAR) surveys to get profiles of the glacier. This type of monitoring of glacial extent needs to be done over some periodicity. A monitoring program could select a benchmark glacier(s) to monitor, profile the margins, determine mass balance, and then repeat at three, five or 10 year intervals.

3. Landscape change, as opposed to land cover – This monitoring would detect the dynamics of the landscape over time (not every year). This monitoring would be done with remote sensing and LIDAR. The paraglacial and alpine environment, permafrost and its response are important. All of those are indicators of landscape change, in response to some external factor.

4. Biological integrity (some subset of invasive species, infestations, and focal species and communities).

5. Visitor use – Easy to monitor, low cost.

6. Geomorphic processes – How the terrain and the landscape looked in the past, look now, and how it will develop in the future.

The network should consider a phased approach since there's not a lot of money. For example, establish the monitoring systems in the first several years. If climate is important, use first year funding to establish stations and get them operational, second year funding to develop the next monitoring scheme you want to do, and maybe run it that year. Acquire remotely sensed imagery for each park and look at the current land cover, topography, and other features you can evaluate to get that baseline, so that in the future you have something with which to compare.

Greg Streveler, Icy Strait Environmental Services

Greg Streveler framed his recommendations around three questions:

- ? What are the SEAN parks' major natural attributes?
- ? Which monitoring data would be most likely to inform management decisions?
- ? What are the clearest indices of change?

SITK – Sitka's major natural attribute is its functioning estuary intertidal complex in an urban setting. Maintaining biological integrity in an urban setting like that is important and a challenge. The following monitoring could all be done for $10,000.

1. Intertidal mapping – Detailed repetitive vegetation and geomorphic mapping along the shore and estuary after every major event such as a big storm, a flood that changes the delta, a wind throw event.

2. Sensitive species use – What is the distribution and abundance of mink and otter along the estuary and shoreline? Mink and otter are two of the most sensitive species and, if they were lost or reduced, would signal a problem. Related to this, keep a monitoring system for dog and cat use in the park. Visitors bring dogs and cats, which could lead to loss of these sensitive mustelids.
3. Lichen survey – Iterative lichen surveys, especially lichens on tree trunks, would give an index of air quality in town. This would be a fairly low budget and practical way to see whether SITK air pollution indices must be monitored more specifically.
4. Species inventories – Conduct repetitive species inventories, with particular attention to exotics and scarce natives. Keep an ongoing list of vascular plants, mammals and birds. Watch for species that are declining and are just entering the park. This tickler list could be used to determine if more detailed research is needed into species change.

KLGO - The most significant organizer of the Klondike's environment is the coast to interior transect – biotically, physically and atmospherically. It is the intersection of history and river and vegetation change in the Taiya Valley, and the very interesting sort of low productivity, high diversity ecosystem there. It is a special case. Consequently you have numerous but sparse mammal populations, often low population size, which raises a flag for maintaining biodiversity.

1. Climate data – Install a weather station in Dyea and the upper Taiya River valleys, and if possible, one in the upper Skagway valley. Along with the existing station in Skagway, these new stations would put the park in a good position to monitor climate.
2. Taiya River mapping – High quality, repetitive mapping of the vegetation and geomorphology on the Taiya River valley, which is where most of the historical resources are. Keep track of human use here too.
3. Monitor obligate species – Identify three to six sedentary obligate species from the estuarine area (Dyea), the middle valley, or the uplands. Set up a program to monitor a few "mine canaries" for those three different places (consider estuarine mustelids, obligate riparian nesters, parka squirrels, pikas, blue grass).
4. Air monitoring – For informing management decisions, the Taiya valley is especially useful for its air mass interchange between the interior and the coast. Sophisticated air monitoring of global interest in the Taiya Valley would monitor "half the continent."

GLBA - Environmentally, Glacier Bay is the world class laboratory for study of vegetative succession and glacial processes. The park is a very large intact ecosystem with hugely productive shores around it.

1. Climate data – Weather monitoring is extremely important, in perpetuity. The park should install stations to add a vertical component with two to three upper level stations, one on the outer coast and one in each of the two arms of the bay.

2. Monitor glaciers – Use remote sensing to map the equilibrium line every year for as many glaciers as possible, because the most useful index is change in equilibrium line over time.
3. Shoreline geomorphic mapping – Conduct repetitive geomorphic mapping of the most changeable parts of the shore zone, in a manner that makes use of Lewis Sharman's database and the coast walker shore zone surveys, as these are already established baselines. Because GLBA is so big, the park must think about what subsets of the park are most changeable and focus effort there.
4. Visitor use – There is an excellent visitor use database. Focus monitoring where human use is now and where you project it will be.
5. Vascular plant inventory – Maintain a regularly updated list of vascular plant species.
6. Air quality – Put an air quality monitoring station on the outer coast of GLBA, because these areas are the first line of intercept from Asia. This station would catch pollution coming across of global significance that eventually ends up in the Arctic haze and contributing to the pollution in the mid continent, and would sample the air quality before it is further affected by pollution sources in North America. There are probably no local air pollution issues in GLBA.
7. Vertebrate species monitoring – Monitor two to six vertebrate species (depending on available funding) that as much as possible would cover this range of characteristics: a) low reproductive rates, b) long lived, c) susceptible to human influence, d) GLBA is an important population reservoir for the species, and/or e) that species is ecologically disadvantaged (like red-throated loon).

Use all eyes and ears the parks have to accomplish this; there are a lot of them.

Richard Carstensen, Discovery Southeast

Richard Carstensen identified the following top priorities for monitoring information related to SEAN's terrestrial environment:

1. Remote sensing gives you the most "bang for the buck" because it can be used for so much information. As LIDAR gets more affordable, it will also get more repeatable. Determine worthwhile transects for remote sensing, in all three parks.
2. Monitor western toads in KLGO and GLBA – There is protocol in place for monitoring toads in the Pacific Northwest. Toads give insights into the condition of wetlands and shallow ponds, which aren't being looked at anywhere else in the surrounding Tongass National Forest. In the Tongass, moving waters have been studied intensively for fish; amphibians are the mirror image - they're in waters that aren't accessible to fish and thus poorly understood. Toads fit the criteria recommended by Greg Streveler, except they *do* have high reproductive potential and can lay about 2000 eggs each. They are very long lived, very susceptible to human impact, GLBA is an important reservoir, and they are declining everywhere else in Southeast Alaska. Monitor western toads annually.

3. Oystercatchers – Oystercatcher monitoring can be done in conjunction with visitor monitoring. They are extremely susceptible to visitor disturbance. Monitor nest success. Oystsercatchers use the early successional, rebounding beaches, a rare habitat found in GLBA.

4. Moose – ADFG is already monitoring moose to some extent. Moose may be poised to enter the Taiya River valley. Moose give insight into the deciduous community complex. They affect it and it affects them.

5. Migratory birds – There's a network of migration banding stations elsewhere in Alaska, so spending limited SEAN monitoring dollars probably isn't a good idea. Might be an opportunity to partner with other efforts?

6. Focal communities – Monitoring the obvious focal community for GLBA, glacial barrens community, has already been mentioned. The park may not be losing glacial barrens per se, but the elevation of glacial barrens may be rising so barrens near the coast may be changing, and that will change what species use them. The network could map alder communities, but are those alder communities the same as those of 50 years ago? This question would apply to all other focal community types too. Equally important is the effect of uplift on vegetative communities. In Southeast Alaska, there is more acreage of rebounding land than of glacial barrens or even the whole sequence of glacial successional types. For the KLGO, the obvious thing to monitor is fire. There probably isn't a tree near Skagway up to over 1,000 feet elevation that hadn't either been burned or logged since gold rush times. So it's by far the biggest disturbance in terms of acreage in both the Skagway and Taiya river valleys. For monitoring, it would be interesting to watch how fire affects this transitional forest (coastal to interior). The Canadians have a good handle on what fires looks like in the interior, and KLGO has a research partnership with the Canadians.

7. Invasives – Monitor invasive species in all three parks. There could be invasives poised to enter from just outside the park. Watch change, period, whether it's exotics or scarce species. Dogs are invasive species.

Keith Boggs, Alaska Natural Heritage Program

Keith Boggs identified the following top priorities for monitoring information related to SEAN's terrestrial environment:

1. Invasive species – plants and animals. This is a serious concern for KLGO and SITK, linked to human use. Keep track of human use and invasive species. For GLBA, the park probably can't inventory invasive species every year, but maybe on a five or 10 year basis. KLGO and SITK should be a yearly inventory.
2. Climate – Look at the existing climate stations in the region and fill in gaps, such as alpine or outer coast.

3. At-risk biota – At-risk biota are species that can be disturbed within a park, and the species to monitor would be park specific. Kittlitz's murrelets, river otters or oystercatchers are examples for GLBA.
4. Monitor major disturbances – The network may need to monitor major disturbances only every five to 10 years. Monitor mass wasting, glacial mass balance (at least the recession line and understanding the proglacial environment), flooding along outwash plains, outburst events, changes in shoreline due to isostatic rebound, and disturbance by humans along the shoreline. In KLGO, add fire monitoring. Major disturbances can be mapped by flying around and drawing polygons where disturbances have occurred, relate to remote sensed data, then correlate this monitoring disturbance with plant succession data within the park because they're all related.

5. Correlate remotely sensed data with ground truthing – Ground map 10-20 strategically located plots (more in GLBA, fewer in SITK) to correlate with any remote sensed or LIDAR data. This will result in coarse scale monitoring with a vegetation map and it will show succession or at least change in vegetation over time. For detailed data about species composition or the structure within a vegetative community, the network will need ground mapped monitoring spots (select 10-20 spots, use LIDAR to provide good information from the air, collect plot information on the ground). Some really good vegetative plots were installed in GLBA a number of years ago and if you resample them with the same methods that were used in the past so you have a comparison, you've instantly got some monitoring data from 50-70 years ago. New plots could be monitored around the historic plots, too.

Michael Goldstein, U.S. Forest Service

Michael Goldstein offered the following advice on priorities for SEAN's terrestrial monitoring program. Climate change monitoring is a regional and larger issue that cannot be effectively tackled at the park or network level. Partner with others on a regional or larger basis to improve or use climate data.

1. Landscape dynamics – Collecting data on landscape dynamics is a first priority. That would include landscape change analysis, vegetative succession, and geomorphology. Accomplish either with LIDAR or another way of remote sensing. (An effort on the Kenai now with 1.4 meter LIDAR will be employed over the next 1.5 year for about $1.1 million.)
2. Ecosystem integrity – This is a two part monitoring effort. First, monitor invasive species as a surrogate for climate change. Must look beyond park boundaries, team with others in Southeast and Southcentral Alaska- see what similarities there are. Second, monitor at-risk biota[2].

[2] Goldstein, et al. define seven criteria that qualify something as at-risk: (1) Geographic distribution within the unit of concern; (2) The geographic distribution outside of that, to consider the scarcity or limitations of that distribution; (3) The capability of that species to disperse; (4) Abundances for that species in the area; (5) Any trend in population or habitat that is already known as you begin to settle on which species to

3. Human use – Montoring human use is important in national parks. Monitor use such as focal recreation points (e.g., cabins, campsites, visitor centers). Techniques include aerial surveys (including winter use if that is of interest), questionnaires, gate counts, or other types of remotely sensed and positioned technology to get a look at who or what might be passing through an area, etc. There are individually based models that can pull the SEAN network together for dispersed recreation (developed in the late 1990s). Human use is important to monitor, as the network can anticipate increasing numbers of visitors in future years.
4. Air quality – Monitor air quality parameters with passive samplers and opacity.

Remote sensing and LIDAR is one of the most relevant places to put the money. Dispersed recreation models are also recommended.

6.3 Discussion Points during Question/Answer and Closing Session

6.3.1 *Use the wealth of historic data regarding natural resources.*

SEAN's first priority for monitoring should be gathering the bounty of historic natural resource data collected from GLBA and the Southeast region, and entering it into databases so it is readily available and useful. The existing dataset could help the network make decisions on other monitoring priorities. Existing datasets will increase the power of any and all new inventories or monitoring by extending the time period for which there is a record of information. If the network has access to information that goes back 50 to 100 years on a species, area or habitat, this could inform its monitoring decisions.

Historic datasets should be gathered from past university/researchers projects in the parks, rangers observation notebooks, records of past climate data (tree rings), old aerial photos (for land cover and glacial extent), and other sources. Parks should not put aside earlier research and results as they become excited about a new way of doing things.

The network must give thought to undertaking inventory and monitoring efforts that are compatible with data gathered in the past, so that the timeline of baseline data is extended. As the network moves forward with use of LIDAR, it should compare the new data with data collected in the past by AKNHP, USFS, Dr. Cooper and other researchers.

SEAN parks don't have a box drawn around them. Data collected outside of park boundaries may be useful to network monitoring efforts. For example, for monitoring invasive species, the network should make monitoring boundaries (spatial extent) wider and broader to include research that is collecting compatible data.

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choose; (6) The vulnerability of the habitat from successional change; (7) The life history characteristics, longevity, reproductive rate, mortality rates, etc. There is a fair amount of information for all the species the network might be concerned about.

6.3.2 *Uses and cautions for LIDAR and other remotely sensed data.*

Given limitations in monitoring funding, most workshop participants advocated for the network to use remotely sensed data when possible (e.g., for climate, land cover, glacial extent). The quality of remotely sensed data will improve through time and become less expensive. However, there are considerations with the use of these data sources. LIDAR isn't a standard remote sensing product that is processed easily or affordably. The expense in using LIDAR is in the need to hire a technician to input the data into a local Geographic Information System (GIS), archive it, and use it to answer questions about the landscape. KLGO has a LIDAR dataset for the park, but the NPS does not have the expertise to analyze or manipulate the data. It was noted that the Tongass National Forest is not going forward with the use of LIDAR, and that entities that work in partnership with NASA receive LIDAR data for half price.

Other remotely sensed satellite imagery and similar products are available to allow the network to look at changes in landscapes. For example, a 10-year old land cover map for GLBA is available, so there is already a monitoring program going if that land cover is remapped. (Landfire is going to remap it in the next few years, possibly in association with the Tongass National Forest, and their target is 80% accuracy.)

One concern regarding remotely sensed satellite imaging data is its accuracy. Some of these data are available for free, but the accuracy assessment can be expensive and time consuming. The network can't afford to spend time and money and then have a product that is only 35% accurate. It was noted that other Alaska NPS networks are finding an overall 75% accuracy with Landsat imagery.

It was noted that there are other remote sensing programs being run by NASA and other groups. One data set concentrates only on glaciers at a fairly accurate pixel size that has been accuracy checked. It is suggested that before any money be spent on remote sensing that pros and cons of different datasets and tools be explored.

6.3.3 *Partner with other agency scientists, managers, all park employees and visitors.*

SEAN should partner extensively with other agencies to obtain data, and use existing people on the ground to collect data (local observers offer more "eyes and ears" that can help, especially with such observations as invasive or at-risk species.) Local observers could include naturalists on the boats, staff, and back country visitors. GLBA rangers used to keep a natural history log of all that they saw; this type of information should continue to be collected and entered into a database.

Since SEAN monitoring funding is limited, workshop participants were asked to consider whether the monitoring emphasis should be less "on the ground," and more reliant on collecting and analyzing information gathered by other agencies or entities. In response, several scientists noted that while it is important to collect and use existing data from other sources, many of the monitoring efforts recommended for SEAN in Section 5.2 are not prohibitively expensive. For example, if the network needs to monitor dispersed recreation, there is enough money to collect data over a three year baseline period and then repeat data collection 10 or 20 years later. All of the monitoring projects suggested for

SITK can be done for well under $50,000 per year. There is adequate funding in the network's expected budget to conduct an invasive species inventory every five years and surveys of selected species. Repeat photography is an inexpensive tool that can give a wealth of information. And, a problem with using other people's data is that they may not gather the data you want, and they may not repeat the data that they gathered.

6.3.4 *SEAN uses for climate data*

It is not SEAN's job to detect climate change. However, it is important that the network have access to, and contribute to, regional climatic data. Climate data is needed to help scientists determine whether observed change in the natural system may be due to climate change, at the local/regional level or in a response to global changes. One panelist noted that while he had not recommended climate/weather monitoring as a high priority for the network, climate is the most likely driver for many of the monitoring priorities that he did recommend (e.g., vegetation change, western toad abundance and distribution). An example is observed change in permafrost in interior Alaska. Warming winter air temperatures have led to increased depth of thaw, caused ground temperatures at the interface of permafrost to warm, and led to melting of permafrost. Data from existing climate stations allowed scientists to link observed changes in permafrost depth and distribution to climate change (rather than attributing the change to other possible causes).

6.3.5 *Linking monitoring to park management needs.*

The panelists discussed how closely monitoring data need to be linked with park managers' need for information and data. It was noted that some monitoring questions are closely linked with management actions (e.g., invasive species monitoring is linked to management decisions regarding eradication), while others do not have as direct a link to immediate management decisions, but may still be important to detect long term ecosystem change. However, even information that seems to be less directly related to management, such as climate data, may be important to inform decision makers about whether observed change is anthropogenic and could be addressed through a park management action or is a response to natural processes (e.g., global climate change).

6.3.6 *Monitoring stable versus dynamic sites.*

Scientists discussed the value of monitoring in dynamic versus stable environments. Most panelists recommended monitoring in dynamic environments and documenting major disturbances. However, there is also value in monitoring more stable environments that are not inherently dynamic and not associated with major disturbances (such as a mature old growth forest), as an indicator of longer term and perhaps unanticipated change. When areas that are thought to be stable show evidence of change, that information has a lot of value.

One scientist noted that collecting data about stable areas might be considered to be inventory, not monitoring. It is important to have baseline data for such areas. Ideally, repeat data collection in stable areas should occur after any major disturbance occurs, and at some repeat interval. However, this type of monitoring may not be a priority for the network's limited budget.

6.3.7 *Monitoring design, sampling regime and change detection.*

The network needs to design its monitoring program to detect change, and to be able to attribute observed change to natural variability or other causes. This goal affects the sample design and the required sensitivity of the parameters being measured. For example, in monitoring invasive species, statistical significance of the data may not be important; the fact that species are present is enough information to inform managers that they need to be eradicated. On the other hand, in monitoring harbor seal abundance, the monitoring program must be sensitive enough to detect declines in population, which can be difficult. Carefully crafted sampling design and the selection of sensitive parameters for measurement are essential to being able to detect a change, describe a trend, and judge its significance.

6.3.8 *Monitoring ecosystem drivers versus ecosystem components.*

The panelists discussed the difference between monitoring the potential drivers of ecosystem change (e.g., climate), versus monitoring the resultant change in characteristics of the ecosystem (e.g., changes in focal species populations). If the network spends its time and funding monitoring the principal drivers of change, it may have little time or money to monitor the organisms that are being influenced and at-risk. Using western toads for an example, their decline may be due to many different drivers, so their decline may be the result of synergistic effects among multiple drivers. This may also be the case with other focal species and communities too. If the network focuses on monitoring drivers of change, would they even know that the toad populations are declining?

One scientist expressed the view that the primary purpose of monitoring is to detect change in the environment. It is the job of research and management to then say, "We've detected substantial change, and it's relevant and needs to be addressed," and to focus resources and research on evaluating the cause and significance of the change.

Appendix A. Terrestrial Scoping Workshop Agenda

Southeast Alaska Network (SEAN)
National Park Service
Terrestrial Ecosystems Monitoring Scoping Workshop

31 January - 1 February 2006
Juneau, Alaska – Goldbelt Hotel

Desired Workshop Outcomes

1. **Understand the National and SEAN <u>Inventory and Monitoring</u> (I&M) <u>Program</u> purpose, framework, process and terms.**
2. **Discuss <u>conceptual terrestrial ecosystem models</u>.**
3. **Discuss what the <u>important monitoring objectives and questions</u> are for the SEAN Parks terrestrial ecosystem, and why they are important.**
4. **<u>Identify candidate vital signs</u> to accomplish this monitoring.**
5. **Discuss specifics of what and how to monitor.**

Tuesday, 31 January 2006		
ARRIVAL, CONTINENTAL BREAKFAST AND WELCOME		
7:30-8:15 am		Continental Breakfast Available, Goldbelt Hotel, Cedar Room
8:15 am		Welcome and Introductions *Chiska Derr, Southeast Alaska Network Coordinator*
8:30 am		Review of Agenda and Notebooks *Barbara Sheinberg, Meeting Facilitator, Sheinberg Associates*
SETTING THE CONTEXT *Related Material at Tab 2 in Notebook*		
8:45 am		Overview of: 1. National Park Service mission 2. National inventory and monitoring (I&M) program 3. SEAN vital signs monitoring program and this workshop's purpose 4. SEAN timeline and organization 5. SEAN biological inventories 6. SEAN water quality monitoring 7. Integrating other park programs and the SEAN I&M Plan

		Question and Answer Session. *Sara Wesser, Alaska Regional Coordinator, Inventory and Monitoring Alaska* *Chiska Derr, Southeast Alaska Network Coordinator*
9:45 am		Relationship between Glacier Bay National Park and Preserve Integrated Science Plan (ISP) and SEAN I&M Program. *(see Tabs 2 and 7 in notebook)* *Susan Boudreau, Chief of Resources, Glacier Bay National Park*
10:00 am		Break
TERRESTRIAL ECOSYSTEM MODELS *Review material at Tab 4 in Notebook before January 31*		
10:20 am		Introduction and description of a few of the general models *Chris L. Fastie, Middlebury College* (10 min) The origins of SE Alaska's terrestrial environments *Greg Streveler, Icy Strait Environmental Services* (10 min) Glacial influences on terrestrial environments at SEAN parks *Dan Lawson, Cold Regions Research and Engineering Laboratory* (10 min) Land cover classes, plant associations and eco-regions at SEAN parks *Keith Boggs, AK Natural Heritage Program* (15 min) Questions and discussion (30 min) Participants complete questionnaire (10 min)
12:00 pm		Catered Lunch, Goldbelt Hotel
INSIGHTS ON NPS INVENTORY AND MONITORING PROGRAM WORK *Examples from other Networks at Tab 5 in Notebook*		
1:15 pm		Insights and advice from other Alaskan Park Network's I&M Program (15 min) *Sara Wesser, Alaska Regional Coordinator, Inventory and Monitoring Alaska* Question and Answer Session (15 min)
IDENTIFY MONITORING OBJECTIVES, QUESTIONS AND VITAL SIGNS FOR SEAN TERRESTRIAL ECOSYSTEM *Prior to January 31, please review and enter your ideas onto the draft Terrestrial Ecosystem - Ecological Monitoring Framework Table at Tab 5 in Notebook*		
1:45 pm – 5:00 pm (Break ~ 3:30 pm)		Introduction and Group Exercise to begin filling in draft Terrestrial Ecosystem - Ecological Monitoring Framework (EMF) Table Facilitated large and small group work to identify monitoring objectives, questions and vital signs for SEAN Park's terrestrial ecosystem. For the rest of the day and through early afternoon tomorrow, we will be considering, by Level I EMF Category: 1. What conditions or key elements should be documented to indicate terrestrial ecosystem integrity? 2. What should be monitored to determine the range of variability in the terrestrial ecosystem's response to natural and human drivers? 3. What should be monitored to identify the thresholds that would trigger a need to implement focused research, corrective/adaptive management, and/or mitigation measures?
5:00 pm		Adjourn for day

Wednesday 1 February 2006		
ARRIVAL AND CONTINENTAL BREAKFAST		
7:30-8:15 am		Continental Breakfast available, Goldbelt Hotel
8:15 am		Agenda Update
8:30 am		Facilitated large and small group work to identify monitoring objectives, questions and vital signs for SEAN Park's terrestrial ecosystem.
10:30am		Break
10:50 am		Reassemble as large group. Report out on work completed.
12:00 pm		Catered Lunch, Goldbelt Hotel
1:15 pm		Facilitated Large Group Discussion /summary/fill in gaps.
2:30 pm		Break
2:45 pm		**PANEL DISCUSSION (**2-3 minutes each) *Chris Fastie, Dept. of Biology, Middlebury College* *Dan Lawson, Cold Regions Research and Engineering Laboratory* *Greg Streveler, Icy Strait Environmental Services* *Sara Wesser, Alaska Regional Coordinator, Inventory and Monitoring Alaska* *Richard Carstenson, Discovery Southeast* *Keith Boggs, AK Natural Heritage Program* *Lance Lerum, Admiralty Island National Monument* The Question: If you had $50,000 annually to spend in *each* of SEAN's three parks to accomplish terrestrial monitoring: a) What would you do; b) Why would you do it; and c) Tell a little about the approach you'd take. Question and Answer/Group Discussion.
4:15 pm		Break
MEETING WRAP UP AND ADJOURNMENT		
4:30 pm		Wrap up, What's Next, Closing Remarks
5:00 pm		Adjourn

Appendix B. Terrestrial Scoping Workshop Participants

National Park Service
Southeast Alaska Network
Terrestrial Scoping Meeting

January 31- February 1, 2006 - Juneau, Alaska

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Appendix C. SEAN Annotated Terrestrial Bibliography

Amphibian Monitoring (Meg Hahr)

Carstensen, R., M. Willson, and R. Armstrong. 2003. Habitat Use of Amphibians in northern Southeast Alaska. Report to the Alaska Department of Fish and Game. Discovery Southeast, Juneau, AK. 75pp.

The Alaska Department of Fish and Game funded Discovery Southeast researchers Richard Carstensen, Mary Willson and Robert Armstrong to survey, map and describe potential breeding habitats for amphibians in the Juneau area. This report describes the results of these efforts and contains a great deal of information on features associated with amphibian occurrence and breeding in Southeast Alaska. It is the most descriptive account of amphibian habitat use for our area.
Link to PDF: http://www.discoverysoutheast.org/pdf/amphib-report-low-res.pdf

Hall, R.J. and C.A. Langtimm. 2001. The U.S. national Amphibian Research and Monitoring Initiative and the role of protected areas. The George Wright Forum 18(2):17-25.

Brief Overview. This article provides a overview of the purpose, structure and function of the USGS Amphibian Research and Monitoring Initiative. Case studies of USGS ARMI efforts in several national parks are presented.
Link to PDF: http://www.georgewright.org/182hall.pdf

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.-A.C. Hayet, and M.S. Forster. 1994. Measuring and monitoring biological diversity: Standard methods for amphibians. Smithsonian Institute Press, Washington, D.C. 364pp.

Brief Overview. This book is perhaps the most important reference available for those interested in measuring and monitoring biological diversity in amphibians. It was produced in response to the great need of the establishment of standardized methods and protocols for sampling natural amphibian populations. It covers a vast array of topics including overview chapters on the natural history of amphibians, on the essentials of standardization and quantification of study questions, randomization and bias, replication issues, and assumptions, on research design and planning. It also includes chapters on standard monitoring and inventory techniques, marking and tracking techniques, population estimation techniques, instructions for preparation of amphibians as scientific specimens, tissue collecting protocols for biochemical analysis, and instructions and recommendations for the analysis of biodiversity data.

MacKenzie, D.I., J.D. Nichols,J.E. Hines, M.E. Knutson, and A.B. Franklin. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84: 2200-2207.

Abstract. Few species are likely to be so evident that they will always be detected when present. Failing to allow for the possibility that a target species was present, but undetected, at a site will lead to biased estimates of site occupancy, colonization, and local extinction probabilities. These population vital rates are often of interest in long-term monitoring programs and metapopulation studies. We present a model that enables direct estimation of these parameters when the probability of detecting the species is less than 1. The model does not require any assumptions of process stationarity, as do some previous methods, but does require detection/nondetection data to be collected in a manner similar to Pollock's robust design as used in mark–recapture studies. Via simulation, we show that the model provides good estimates of parameters for most scenarios considered. We illustrate the method with data from monitoring programs of Northern Spotted Owls (*Strix occidentalis caurina*) in northern California and tiger salamanders (*Ambystoma tigrinum*) in Minnesota, USA.
Link to PDF: http://armi.usgs.gov/MacKenzie_et_al_2003.pdf

MacKenzie, D.I., J.D. Nichols, G.B. Lachman, S. Droege, J.A. Royle, and C.A. Langtimm. 2002. Estimating site occupancy when detection probabilities are less than one. Ecology 83:2248-2255.

Abstract. Nondetection of a species at a site does not imply that the species is absent unless the probability of detection is 1. We propose a model and likelihood-based method for estimating site occupancy rates when detection probabilities are 1. The model provides a flexible framework enabling covariate information to be included and allowing for missing observations. Via computer simulation, we found that the model provides good estimates of the occupancy rates, generally unbiased for moderate detection probabilities (.0.3). We estimated site occupancy rates for two anuran species at 32 wetland sites in Maryland, USA, from data collected during 2000 as part of an amphibian monitoring program, Frogwatch USA. Site occupancy rates were estimated as 0.49 for American toads (*Bufo americanus*), a 44% increase over the proportion of sites at which they were actually observed, and as 0.85 for spring peepers (*Pseudacris crucifer*), slightly above the observed proportion of 0.83.
Link to PDF: http://armi.usgs.gov/Site_Occupancy_MacKenzie.pdf

R.D. Semlitsch, Ed. Amphibian Conservation. 2003. Smithsonian Institute Press, Washington, D.C. 324pp.

Leading amphibian biologist Raymond D. Semlitsch (Professor of biology and director of the Conservation Biology Program at the University of Missouri) brings together international amphibian experts to present the most current information on the status of amphibian populations world-wide. Threats to population viability include: disease, pesticides, climate change, habitat destruction, and human exploitation. New information suggests that observed declines in amphibian biodiversity exceed declines noted for other taxa including mammals and birds. This recently released book has been well reviewed being called both "accessible" and "informative".

Biomonitoring and Assessments (Dan Bogan)

Barbour, M.T. 1997. The re-invention of biological assessment in the U.S. *Human and Ecological Risk Assessment,* **3,** 933-940.

Barbour, M.T., W.F. Swietlik, S.K. Jackson, D.L. Courtemanch, S.P. Davies, and C.O. Yoder. 2000. Measuring the attainment of biological integrity in the USA: a critical element of ecological integrity. *Hydrobiologia,* **422/423,** 453-464.

Karr, J.R. 1993. Defining and assessing ecological integrity: beyond water quality. *Environmental Toxicology and Chemistry,* **12,** 1521-1531.

Climate Change (Dan Lawson)

Alley, R.B., 2004, Abrupt climate change. Scientific American, November, p. 63-69.

This article examines the geologic record of abrupt, extremely rapid changes in climate that have taken place in the past. Abrupt change is just that – many degrees C change in decades or less that have affected the climate globally, lasting hundreds or more years before climate returned to a ”normal” state. The author not only examines the environmental consequences of such rapid changes, but also explores the social and economic impacts and how they might affect modern society. This article is written by one of the most knowledgeable scientists working on paleoclimate change and it is written in layman’s terms. A good read and I highly recommend it!

National Research Council, 2003, Abrupt Climate Change: Inevitable Surprises. National Academy Press, 230pp.

Prepared by the Committee on Abrupt Climate Change, this report reviews and analyses available data on climate and paleoclimate from diverse sources on the existence in the past of rapid and sudden changes in climate. Such changes occurred over periods of several years to tens of years with significant cooling (-5 to –10 C) during this time, followed by recovery to warmer climate over a hundred or more years. They examined the paleoclimate record and concluded the inevitability of such changes, as well as the consequences for society. The Committee made recommendations for further research and urge recognition that such changes may occur in the future. This technical treatment is well written and provides an important perspective on potential global changes in climate that might in the short term affect Glacier Bay ecosystems.

Glaciers and Ice Sheets (ice dynamics, processes, environment) (Dan Lawson)

Alley, R.B., Lawson, D.E., Larson, G.J., Evenson, E.B., and Baker, G.S., 2003, Stabilizing feedbacks in glacier-bed erosion. Nature, 424, 758-760.

This article presents a hypothesis on how the configuration of the bed, and in particular the slope of overdeepenings, control glacier hydrology, erosion and deposition and in particular how glacier’s are “graded” like streams.

Lawson, D.E., 1979, Sedimentological analysis of the western terminus region of the Matanuska Glacier, Alaska. CRREL Report 79-9, 121pp.

Detailed analysis of how a modern glacier erodes, transports and deposits sediment in moraines.

Lawson, D.E., 1993, Glaciohydrologic and glaciohydraulic effects on runoff and sediment yield in glacierized basins. CRREL Monograph 93-2, 122pp.

A review and synthesis of the hydrology and hydraulics of glaciers, emphasizing data and analyses of modern glaciers and ice sheets.

Ostrem, G. and Brugman, M., 1986, Glacier mass-balance measurements: A manual for field and office work. Saskatoon, Saskatchewan, Canada; National Hydrology Research Institute, NHRI Science Report No. 4, 224pp.

Everything you ever wanted to know about monitoring glaciers, including mass balance (accumulation, ablation), climate, discharge, sediment yield, surveying, data reduction and analysis, remote sensing and other techniques.

Paterson, W.S.B., 1994, Physics of Glaciers (3rd Ed.), New York, Pergamon Press. Classic text on glacier dynamics.

Glacier Monitoring (Roman Motyka)

Arendt, A.A., K.A. Echelmeyer, W.D. Harrison, C.S. Lingle, and B. Valentine. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. *Science*, **297**, 382-386.

Fountain, A.G., Krimmel, R.M., and Trabant, D.C., 1997, A strategy for monitoring glaciers: U.S. Geological Survey Circular 1132, 19 p.

Mayo, L.R., D.C. Trabant, and R.S. March, 2004. A 30-year record of surface mass balance (1966-95), and motion and surface altitude (1975-95) at Wolverine Glacier, Alaska. *U.S. Geol. Surv. Open-File Report* 2004-1069, 105 p. plus CD.

Motyka, RJ, S O'Neel, C Connor, and K Echelmeyer, 2002. 20th Century thinning of Mendenhall Glacier, Alaska, and its relationship to climate, lake calving, and glacier run-off. *Global and Planetary Change*, ***35***(1-2) 93-112.

Neal, E.G., M.T. Walter, C. Coffeen. 2002. Linking the Pacific Decadal Oscillation to seasonal

Glacial Sediments, Landforms and Terrain (Dan Lawson)

Benn, D.I. and Evans, D.J.A., 1998, Glaciers and Glaciation. New York, Arnold, 734pp.

Extensive treatment on the glacial environment, emphasizing processes of glaciers and their landform/terrain associations.

Menzies, J.(ed.), 1995, Modern Glacial Environments: Processes, Dynamics and Sediments. Boston: Butterworth-Heinemann, 621pp.
Menzies, J.(ed.), 1996, Past Glacial Environments: Sediments, Forms and Techniques. Boston: Butterworth-Heinemann, 598pp.

The previous two books edited by John Menzies consist of multiple chapters by leading scientists in each of the fields so covered by each chapter. In the first book modern glacial and glacial marine environments are covered, with an emphasis on the processes of the glacier and its sub-environments. The second covers the various depositional environments and their products and the types of landforms develop by past glaciers and ice sheets.

Paleoclimate (Dan Lawson)

Bradley, R.S., 1999, Paleoclimatology: Reconstructing climates of the past. New York, Academic Press, 610pp.

The author explains the basic methods, technique and data sources of reconstructing the climate of the past, emphasizing the late Quaternary period of the last 120,000 yrs. The information provides a background on how and why "monitoring and inventorying" of paleoclimatic data are critical to understanding current climatic trends and predicting future changes in climate and how such changes may ultimately affect ecosystems.

Grove, J. M., 1988, The Little Ice Age. New York, Methuen Press, 498pp.

An extensive treatment of the Little Ice Age and in particular how the changes in climate during this recent cold period affected society and its environment. The author discusses evidence and data for the LIA from across the globe. Grove's treatment includes both measured, quantifiable data sources as well as recorded history in literature, journals, paintings and other sources. It is a most complete picture of the life and times of the Little Ice Age, and perhaps a glimpse of the future.

Mackay, A., Batterbee, R., Birks, J., and Oldfield, F. (eds.), 2003, Global change in the Holocene. London, Arnold, 598pp.

Examines changes during the Holocene period that have implications for changes within Glacier Bay that have affected glaciation, habitation and ecosystems of the last ~12,000 years.

Wiles, G., D'Arrigo, R. D., Villalba, R., Calkin, P.C. and Barclay, D.J., 2004, Century-scale solar variability and Alaskan temperature changes over the past millennium. Geophysical Research Letters, 31, paper L15203, 4pp.

Recent article on changes in temperature in south central over the past 1000 years. References cited provide links to other relevant Alaskan studies.

Fritts, H.C., 1976, Tree Rings and Climate. New York, Academic Press.

This is the standard reference for methods of tree ring analysis and its application to delineating climate.

Cook, E.R., and Kairiukstis, L.A., 1990, Methods of Dendrochronology: Applications in the Environmental Sciences. Boston, Kluwer Academic.

The chapters in this book discuss various applications of tree ring studies to environment and ecology.

Surficial Processes and Landforms (Dan Lawson)

Easterbrook, D. J., 1999, Surface processes and landforms. Prentice Hall, Upper Saddle River, NJ (2nd Ed), 546pp.

This is a basic text on geologic processes and landforms that covers those physical environments common to the SEAN. The text is well written and illustrated, and is a good reference.

Terrestrial Vegetation & Processes (Richard Carstensen)

Alaback, P. 1981. Forest community structural changes during succession in Southeast Alaska. in: Forest succession and stand development research in the Northwest: Proceedings of the symposium; 1981, Corvallis, OR.

Alaback, P. 1988. Endless battles, verdant survivors. Natural History, 8/88, 45-48.

In order to resprout after browsing, shrubs store nutrients in their roots. So they respond more slowly to increased light than do *Cornus canadensis* and *Rubus pedatus* that can send out shoots up to several meters per year.

Alaback, P. and J. Tappeiner. 1991. Response of western hemlock (Tsuga heterophylla) and early huckleberry (Vaccinium ovalifolium) seedlings to forest windthrow. Canadian Journal of Forest Research. 21: 534-539.

Bormann, B., H. Spaltenstein, M. McClellan, F. Ugolini, K. Cromack and S. Nay. 1995. Rapid soil development after windthrow disturbance in pristine forests. Journal of Ecology. 83. 747-757.

Podzol formation was thought to require 1000-3000 years. This study found it in 150 years. Age of windthrow microevents can be dated. Three study sites at Hawk Inlet (Deal's plot), Outer Point and Juneau Airport all were affected by a large windthrow event in about 1830. Mounds and their associated pits make up 41%, 53% and 32%, respectively, of these sites. Unmounded areas had O and E horizons 13% thicker than on old mounded surfaces. The amount of soil carbon varies with frequency of windthrow-induced soil disturbance. A long-term downward trend in C accumulation results from higher frequency events because the period of rapid decomposition (0-50 years) is a bigger portion of the cycle. Diseases that cause trees to snap rather than uproot can reduce or eliminate windthrow disturbance leading to thick organic horizons and downward trends in productivity (ie, paludification). Rapidity of immobilization can reduce productivity over a single generation.

Bormann, B. and R. Sidle. 1990. Changes in productivity and distribution of nutrients in a chronosequence at Glacier Bay National Park, Alaska. Journal of Ecology. 78:561-578.

Nitrogen increases very rapidly during the alder stage. Above-ground biomass increases very rapidly as spruce replaces alder, suggesting rapid vegetative uptake, and accompanied by a decline in nitrogen between 100 and 160 years. An asymptote of 300 tonnes ha^{-1} at 110 years, which is almost the world average for temperate coniferous forests, "quite remarkable given the initial soil conditions devoid of organic matter and nitrogen." Under spruce there is rapid podzolization and decrease of 50% in net primary productivity. No iron pan was found on sites in this study. Neither was sphagnum present in any quantity. Nutrient immobilization appeared due to lack of effective decomposers and poorly decomposable litter. Soil disturbance from windthrow may be necessary to increase availability in the long run. Future disturbance regimes will dictate successional pathways.

Brooks, R., E. Peterson and V. Krajina. 1970. The subalpine mountain hemlock zone. Ecology of western North America. 2:2 University of British Columbia, Vancouver. Multidisciplinary studies of mountain habitats – far more intensive than anything we've done in Southeast.

Chapin, T., L. Walker, C. Fastie and L. Sharman, 1994 Mechanisms of primary succession following deglaciation at Glacier Bay, Alaska. Ecological Monographs. 64:149-175.

Cook, J., A.. Bidlack, C. Conroy, J. Demboski, M. Fleming, A. Runck, K. Stone and S. MacDonald. 2001. A phylogeographic perspective on endemism in the Alexander Archipelago of southeast Alaska. Biological Conservation 97: 215-227.

Crocker, R. and J. Major. 1955. Soil development in relation to vegetation and surface age at Glacier Bay, Alaska, Journal of Ecology 43:427-448.

Duncan, S. 2004. Ecological payoffs from red alder in Southeast Alaska. Science Findings. issue 63.

Reports on work of Bob Deal and Mark Wipfli in red alder stands on POW. Red alder is usually overtopped by conifers at about 20 to 25 years, then leaving a legacy of more open stand conditions than in pure conifer second growth. Mixed alder-conifer stands have more variable tree sizes, multiple canopy layers, understory plant diversity, wildlife cover and songbird nesting habitat. More terrestrial invertebrates. Headwater streams are more productive with alder. Downside to pure alder borders is rapid decomposition. This is good as a food base for stream inverts but doesn't provide as much fish cover as do the longer lasting coniferous logs.

Fastie, C. 1995. Causes and ecosystem consequences of multiple pathways of primary succession at Glacier Bay, Alaska. Ecology 76(6): 1899-1916.

Hanley, T. and W. Brady. 1997. Understory species composition and production in old-growth western hemlock-Sitka spruce forests of southeastern Alaska. Canadian Journal of Botany. 75: 574-580.

Soil drainage was the principal environmental factor determining understory species composition. It also determined overstory biomass, and, consequently, total understory production, through control of light penetration. Well-drained sites were more productive of trees and less productive of understory.

Hansen, B. and D. Engstrom. 1996. Vegetation history of Pleasant Island, southeastern Alaska, since 13,000 yr BP. Quaternary Research. 46 article 0056 p. 146-175

Early arrival of PICO and TSME suggest nearby refugia. Expansion of tundra elements 10,600 to 9900 = climatic reversal, Younger Dryas.TSHE and TSME replaced PISI 8500-8000. Open muskeg by 7000. Bog replaced fen 3400 = paludification with cooling neoglacial climate. Correlates with upland TSHE expansion. Edgecumbe eruption lasted 500 to 1000 yrs and ended 10,500. Striking decrease in organic content in upper core zone = Aeolian input from bare outwash in neoglacial Glacier Bay. (so Lem would have got this too)

Lawrence, D. 1958. Glaciers and vegetation in southeastern Alaska. American Scientist 46: 89-122.

Lawrence, D. 1979. Primary versus secondary succession at Glacier Bay National Monument, Southeastern Alaska. pages 213-224 in Linn, R. ed. Proceedings of the first conference on scientific research in the National Parks, New Orleans, 1976. USDI, National Park Service, Transactions and Proceedings Series, no. 5, 2 vols.

Reiners, W., I. Worely, and D. Lawrence, 1971. Plant diversity in a chronosequence at Glacier Bay, Alaska. Ecology 52:55-69.

Shepard, M. 1995. Plant community ecology and classification of the Yakutat Foreland, Alaska. USDA Forest Service, R10-TP-56. 215 p.

Shepard, M. and T. Brock. 2002. Landtype Associations of the Yakutat Foreland, Alaska. USDA Forest Service, R10-TP-109. 215 p.

Willson, M. and J. Nichols, 1997. Breeding landbird survey, East Arm, Glacier Bay. Unpublished report, Forestry Sciences Laboratory, Juneau.

Tidewater Glaciers (Dan Lawson)

Syvitski, J.P.M., D.C. Burrell, and J.M. Skei (1987a). Fjords, Processes and Products, Springer-Verlag, New York, 379 pp.

This is an advanced text on the physical and chemical oceanography of fjords.

Powell, R.D. and Molnia, B. F., 1989. Glacimarine sedimentary processes, facies and morphology of the south-southeast Alaska shelf and fjords. Marine Geology, 85(2-4)359 – 390.

This article discusses the first and second order controls on tidewater glacier dynamics and specifically on processes of sedimentation and depositional systems. Specific examples are presented from Glacier Bay.

Powell, R.D. and Domack, E.W., 1995. Glaciomarine Environments, Chapter 13. In Menzies, J. (ed.), Glacial Environments - Processes, Sediments and Landforms (621 p.). Butterworth-Heinmann, Boston: 445-486.

Book chapter presenting the basic aspects of tidewater glacier environments and that of the immediate fjord environment into which they discharge. Examples cited from Glacier Bay.

Meier, M. F. and Post, A., 1987. Fast tidewater glaciers. Journal of Geophysical Research, 92(B9), 9051 – 9058.

Excellent article on physical aspects of tidewater glacier flow and their advance and retreat.

Post, A., 1975. Preliminary hydrology and historic terminal changes of Columbia Glacier. U.S. Geological Survey Hydrologic Investigations, HA-559.

First discussion of the tidewater glacier cycle by Post.