

Summary Report from NPS I&M High Elevation Climate Change Response Workshop

*Gallatin Gateway Inn / Bozeman, MT
May 4-5, 2010*

**Presented 05/27/2010 by the meeting facilitation team from
MountainWorks and the Sonoran Institute**



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Overview

The following report presents highlights from a National Park Service (NPS) Inventory & Monitoring (I&M) workshop titled, "Monitoring Ecological Response to Climate Change in High Elevation Parks in the Great Northern Landscape Conservation Cooperative." The two-day workshop was designed to explore ecological response to climate change, develop criteria and preliminary monitoring priorities, and explore opportunities to expand monitoring partnerships. The workshop sought to engage participants with workshop goals and objectives (see below). Following the workshop, there was a working day for the National Park Service planning group to draft a strategy and work plan for the I&M networks.

The workshop was held May 4-5, 2010 at the Gallatin Gateway Inn near Bozeman Montana. Note that a workshop website providing such information as the agenda, attendee list, and much more can be found at www.greateryellowstonescience.org/CC_workshops/highElev.

Workshop Goal and Objectives

GOAL

The goal of the workshop is to engage parks, Inventory and Monitoring networks, partner agencies and cooperators in gaining critical input for developing multi-year strategies for long-term monitoring of ecological response to climate change relevant to park management and protection.

OBJECTIVES

1. Enhance participants' understanding of projected changes in climate variables (e.g., temperature, precipitation, snowpack, growing season) and resultant effects on ecosystem components (e.g., communities, disturbance regimes, ecological processes, species).
2. Engage parks, networks, and other key staff in developing multi-year strategies and work plans for protocol development and implementing long-term monitoring of indicators of climate change.
3. Work collaboratively across parks, networks, and regions, and engage potential partners to discuss opportunities for collaboration on ongoing and new monitoring of climate change on federal lands.

Attendees

The primary focus of the workshop was the 12 high elevation park units (see below) in and near the Great Northern Landscape Conservation Cooperative (GNLCC), including parks within the Greater Yellowstone, Rocky Mountain, and Upper Columbia Basin networks:

Intermountain Region

Greater Yellowstone Network (GRYN)

- Bighorn Canyon National Recreation Area
- Grand Teton National Park
- John D. Rockefeller, Jr. Memorial Parkway
- Yellowstone National Park

Rocky Mountain Network (ROMN)

- Glacier National Park
- Great Sand Dunes National Park and Preserve
- Rocky Mountain National Park
- Florissant Fossil Beds National Monument

Pacific West Region

Upper Columbia Basin Network (UCBN)

- Big Hole National Battlefield
- City of Rocks National Reserve
- Craters of the Moon National Monument and Preserve
- Nez Perce National Historical Park

Key partners attending the workshop included the U.S. Fish and Wildlife Service (Wildlife Refuge System and Ecological Services), US Geological Survey (USGS Northern Rockies Climate Response Center), Bureau of Land Management (BLM), National Ecological Observatory Network (NEON), and university scientists.

A list of individuals, affiliations, and contact information for workshop attendees can be found at www.greateryellowstonescience.org/files/pdf/HighElevAttendees.pdf.

Background

IMPETUS

Secretarial Order No. 3289 of September 14, 2009 established a climate change strategy to integrate the work of each Department of Interior (DOI) bureau to mitigate and adapt to the effects of climate change in the pursuit of their respective missions (Senate hearing on climate change, October 28, 2009). Given the broad impacts of climate change, management responses to such impacts are expected to be coordinated on a landscape-level basis.

CONNECTION TO LANDSCAPE CONSERVATION COOPERATIVES

Agencies within DOI have proposed use of the U.S. Fish and Wildlife Service (USFWS) twenty-two geographic areas, referred to as Landscape Conservation Cooperatives (LCCs), as an organizing framework for cooperation on addressing impacts of climate change. The USFWS describes LCCs as "conservation-science partnerships between the USFWS, USGS, and other federal agencies, states, tribes, NGOs, universities, and stakeholders within a geographically defined area."

NATIONAL PARK SERVICE STRATEGY

The NPS expects to fully participate with each of the DOI-proposed LCCs. In fiscal year 2010, the NPS will receive up to \$10M service-wide to address climate change impacts to park resources with a comprehensive strategy that includes planning, adaptation, mitigation, and monitoring. The NPS I&M program strategy includes monitoring indicators of climate change impacts to park natural resources within four thematic natural resource areas that include park units at high-elevation, high-latitude, arid-lands, and coastal (on the Pacific, including Hawaii, Atlantic, and Gulf coasts) locations. In fiscal year 2010 six I&M networks will receive initial funding to begin developing work plans for monitoring ecological impacts of climate change within a subset of NPS units across these four thematic areas. In addition, the USFWS Refuge System is receiving new funding in 2010 to begin developing an inventory and monitoring program for refuge lands. The NPS and USFWS expect to collaborate closely on ecological monitoring.

PLANNED 2010 EFFORTS

During this fiscal year, the Intermountain (IMR) and Pacific West Regions (PWR) will cooperate on developing work plans for monitoring indicators of climate change within two LCCs: the Great Northern LCC and the Desert LCC. This year the IMR and PWR I&M programs will focus their planning on high elevation park units (Great Northern LCC) and arid-lands park units (Desert

LCC). Planning for monitoring in parks outside of these two LCCs is expected in subsequent years. Future funding for I&M monitoring of climate change indicators requires working closely with park managers to set monitoring priorities and produce collaborative, multi-year work plans to implement high priority monitoring in parks.

For this year's efforts within the Great Northern and Desert LCCs, the I&M program will establish work plans that must be approved by the WASO to secure the funding necessary to support future NPS climate change monitoring in park units within these two LCCs. Two workshops in the spring of 2010 were scoped to (a) provide critical input from park managers needed for setting priorities, and (b) initiate collaboration among potential partners for developing and implementing climate change monitoring. The first workshop, in April, brought together park managers and partners from three I&M networks within the Desert LCC: Chihuahuan Desert and Sonoran Desert (both in the IMR), and the Mojave Desert (PWR). The current workshop brought together park managers and partners from three I&M networks within Great Northern LCC: Upper Columbia Basin (PWR), and Greater Yellowstone and Rocky Mountain (IMR).

Workshop Products

Four products resulted from the efforts of this workshop, described below and available online at www.greateryellowstonescience.org/CC_workshops/highElev. These products will be used by networks following the workshop for work plan development in response to Secretarial Order No. 3289 of September 14, 2009:

1. An improved understanding of the ecological impacts of climate change on high elevation park units through presentations associated with a newly completed climate change synthesis covering these parks.
2. Increased knowledge of partnership opportunities through partner presentations and input at workout groups.
3. Updated conceptual diagrams for climate change impacts to key high elevation systems.
4. A preliminary prioritization of long-term monitoring projects for climate change response.

The prioritized list referred to in item 5 was used as input during a planning meeting immediately following the workshop that was attended by a subset of workshop attendees. This group strived to establish priorities for a long term strategy for monitoring ecological response to climate change in high elevation park units.

Detailed notes—beyond the scope of this report—from the workshop are available upon request from Scott Bischke (scott@emountainworks.com).

PRODUCT 1: IMPROVED UNDERSTANDING OF CLIMATE CHANGE IMPACTS

Summaries of our current understanding of climate change impacts to key resources within the LCC were detailed in three talks dealing with a synthesis of climate change in the GNLCC, as briefly reviewed below. Presentations can be found at the workshop website; see www.greateryellowstonescience.org/CC_workshops/highElev.

Steve Gray, Wyoming State Climatologist

"Learning from the Past: Paleoclimatic Change and Ecological Responses in the Northern Rockies"

Steve Gray described ecological responses to paleoclimatic variability and change in the context of three areas: migration and vegetation change, ecosystem structure, and characteristics of natural climate variability. He noted that our climate future includes certainty regarding increased

temperatures, uncertainty regarding precipitation, and that under any temperature/precipitation scenario, drought is highly likely due to increased evaporation rates associated with higher temperatures. Through an example of historic juniper migration, Steve demonstrated an important lesson, that migration in response to climate change is messy and does not happen on a linear, well ordered pathway. Similarly, by looking at pinon pine migration, Steve showed that ecosystems can change in “fits and starts”, that we may see long periods with little or no change followed by step-like transitions, and ecosystem change can often show threshold behavior and non-linear response characteristics.

Steve also described how natural climate variability can vary dramatically year-to-year, which is imposed on trends that are occurring over decadal or longer periods. Sometimes the natural variability can enforce the climate change progression; sometimes it might work against it. Thus predicting future climate is complex and will be a combination of human-induced trends and natural climate variability. The inherent uncertainty has management implications, including that standard distribution models give an idea of where climate might allow species to exist, but do not account for historical contingencies, natural variability, competitors, pests, or luck. Steve closed with three major lessons:

- Species/ecosystems will not simply move north or higher in elevation
- Change is not likely to be gradual, steady, or linear
- Inevitably surprises can be expected

Dave McWethy, Montana State University Adjunct Professor

“State of Knowledge of Ecological Responses to Climate Change in the Great Northern LCC”

Dave began with a review of what we know: that historically temperature has tracked the atmospheric concentration of carbon dioxide (i.e., [CO₂]); that as of March 2010, atmospheric [CO₂] = 389 ppm; that warming is greater in spring and summer; that 2009 was the warmest year in the past century; and that spatial variability exists with temperature change (e.g., higher latitudes generally change more rapidly). He noted that while temperature trends were unequivocal (even in the face of yearly variability), that precipitation trends are unclear and future predictions of precipitation in the face of climate change are highly uncertain. Dave further noted that anthropogenic influence will be superimposed on natural climate variability and that while the climate is warming we should expect regional and annual variability. Local variability over short time periods can make climate change hard to communicate to the general public.

Even with uncertainty in predicting precipitation changes in the face of climate change (Wetter to the north? Drier to the south?), a consensus—based on modeling—may be forming that the interior and western United States will face increasing drought conditions with warming temperatures. Numerous hydroclimatic changes can be expected as a result of climate change (and in some case are already happening), including reduced spring snowpack; higher volume of flows in earlier spring snowmelt; and more rain, less snow.

Dave stated that annual changes may be less important ecologically than the affects of spring warming; increases in night-time minimum temperatures; and increased growing season with increased number of frost-free days. Potential ecosystem responses include beetle outbreaks with increased pine beetle-caused mortality; increased drought stress on forests with concomitant decreased resistance to disease and other stressors; greater wildfires; and increased invasion of cheatgrass.

Dave concluded by asking and answering a question: Have we crossed a threshold already? Possibly, but it is too early to tell. But these things seem relatively certain: the West is warming but

we should expect spatiotemporal variability; small increases in temperature can have big impacts; and drying of much of the West is likely, along with increased variability in precipitation. With respect to implications of these changes for resource management, Dave closed by noting that predicting how ecosystems respond will be difficult; monitoring and management of invasive species will be important; and managing ecosystems in transition will require flexibility.

Mike Britten, NPS ROMN Program Manager

“State of Knowledge of Ecological Response to Climate Change in the Great Northern LCC”

Mike provided a review of the section of the synthesis document dealing with ecological response to climate change. He noted that the goal of the study was to provide a base of scientific information compiled from across the region, highlight common themes, and identify system vulnerabilities so that resource managers can identify program needs. The study focused on ecosystem processes and characteristics, communities, and wildlife. Large uncertainties existed in part due to multiple interacting stressors.

With that background, Mike detailed a number of areas of ecological response to climate change. Some highlights are provided here:

- AIR QUALITY
 - o How and why—Changes in precipitation, temperature, and wind patterns will affect chemical production and loss rates, deposition, background concentrations
 - o Likely responses—Increase in ground level ozone, warmer temperatures, increased fires
- WILDLAND FIRE
 - o How and why—Drought, wind, and high summer temperatures
 - o Likely responses—Fire frequency, intensity, severity and area may increase with resultant impacts to vegetation communities
- INSECT INFESTATIONS
 - o How and why—Warmer temperatures may increase overwinter survival
 - o Likely responses—Outbreaks higher north and higher in elevation; increased fires and drought may increase host susceptibility
- PLANT AND WILDLIFE DISEASE
 - o How and why—Warmer temps increase virulence and reproduction of pathogens; mild winters increase susceptibility; disturbance/stress increase host susceptibility
 - o Likely responses—Range expansions of many pathogens, increased prevalence
- INVASION DYNAMICS
 - o How and why—Shifts in suitable environments; increased disturbance may increase spread of invasives
 - o Likely responses—Spread of some invasives and loss of others; spread of native species into new environments; impact of invaders may be altered in degree and scale
- COMMUNITIES
 - o How and why—Shift in suitable environments, increase in disturbance from fire, disease, alteration in herbivore populations, increased prevalence of invasive species
 - o Likely responses—Communities or portions thereof will shift northward and upslope; species will differ in response; potential loss of alpine, subalpine, wetland and sagebrush habitats and woody movement into subalpine

Mike summarized by noting that some species will benefit under climate change and that past trends don't necessarily portend the future. From a management perspective, he noted that reducing other stressors may be the most effective way to manage for climate change.

PRODUCT 2: ON-GOING MONITORING EFFORTS OF PARTICIPATING AGENCIES

Yvette Converse, U.S. Fish and Wildlife Service (USFWS), described the Landscape Conservation Cooperative concept with focus on the Great Northern Landscape Conservation Cooperative (GNLCC). The NPS, USFWS National Wildlife Refuge I&M program, Bureau of Land Management, and U.S. Geological Survey presented their on-going or planned monitoring efforts within the Great Northern LCC. Brief notes from the presentations are provided below. Links to the PowerPoint presentations and contact information for the presenters can be found at the workshop website—see www.greateryellowstonescience.org/CC_workshops/highElev.

Yvette Converse, USFWS Interim Coordinator GNLCC

“Great Northern Landscape Conservation Cooperative”

Yvette described the LCC program, focusing on the idea that this is a burgeoning program that the groups involved can help formulate. Among key points, she noted that LCCs are conservation alliances (federal agencies, state agencies, tribes, others) that seek to bring outcome-based adaptive management into the decision-making process; that LCCs are based on eco-regional scales; and that LCCs will bring a focus on the information needs that are lacking at the landscape-level. Yvette noted that alliances formed by LCC partners will help to implement landscape-level assessments, draw on common goals that may cross jurisdictional boundaries, and share data and science support to achieve common goals.

The draft goal for the Great Northern LCC—recently created by the newly formed GNLCC Steering Committee—is to “coordinate, facilitate, promote, and add value to large landscape conservation to build resource resilience in the face of climate change and other landscape-level stressors through science support, coordination, informing conservation action, monitoring and evaluation, and outreach and education.” The Steering Committee has already drafted a governance structure based on eco-regional forums. While recognizing that the LCCs term efforts will be strategic, the Steering Committee has already begun work on a short term workplan, with first priority funded projects to occur in six areas: climate information (current and projected), land cover (e.g. Landfire, NLCD), data management/interfaces capabilities, habitat connectivity, water resource vulnerability assessments, and biological species monitoring & evaluation.

Yvette closed noting a number of challenges that the GNLCC (and LCC programs in general) face. Those include getting away from programmatic management, steering clear of mission drift, determining best methods for integrating and sharing information, and taking time to develop workable, valuable processes and partnerships.

Steve Fancy, NPS National I&M Program Leader

“The NPS I&M Program’s Efforts to Address Rapid Climate Change”

Steve started by providing background on the NPS I&M program, stating that the program works to provide knowledge on the status and trend in condition for key resources in each park so the information about resource condition is used in management decision-making, planning, and interpretation. As such, the core duties of I&M staff are to determine status and trends in the condition of a few key natural resources for each park, and effectively deliver information to park managers, planners, interpreters, scientists, and other key audiences. Key in the program’s charter is that I&M networks a scientific basis to tell the stories of what is going on in these NPS places that people care about.

Steve stated that the I&M networks need to work with partners and share information with the public. He noted that LCC boundaries were originally developed by USFWS based on USFWS bird and fish conservation areas. I&M network and LCC boundaries align fairly well, because both are

ecologically-based. While Steve noted growing pains in the creations of LCCs and their partnerships, he said that the 32 I&M networks are already carrying out some of the important tasks the LCCs need to be successful, for example boots-on-the-ground data collection, data management/analysis/delivery, and connection/communication between managers and scientists.

Steve discussed how the I&M program is already producing data that is relevant to climate change response, including collecting and reporting on important climate change vital signs that have protocols, websites, resource briefs in place (and can be expanded or added to, as needed). With respect to climate change response, the I&M program is funding six groups of parks this year (10-15% increase in funding) to enhance the existing monitoring program: High latitude AK; Pacific Island; High elevation in ROMN, GRYN, UCBN; Atlantic Coastal in NETN, NCBN, and NCRN (focus on coastal and marine); Atlantic Coastal in SECN (focus on coastal and marine); and SW Desert parks in SODN, CHDN, and MOJN. Additionally, the program has filled two new positions: (1) John Gross—climate change ecologist leading vulnerability assessments and modeling efforts; (2) Shawn Carter—climate change monitoring coordinator focusing on interagency work and acting as liaison between I&M and the Washington office.

Steve closed with a discussion on how the I&M program is focusing on turning data into information, noting several examples and works in progress including:

- Working with NASA, FWS, USGS, and the Smithsonian to use remote sensing & forecasting to build models that are useful for managers;
- NPScope—sharing data sets with parks, BLM, FWS, states, others to provide landscape-level datasets, provide context for what is going on around parks; and
- IRMA (Integrated Resource Management Applications) which helps coordinate methods and allow data exchange service-wide.

Mark Chase, Chief, NWRS Natural Resource Program Center

“National Wildlife Refuge System I&M Program” (presented by Steve Fancy)

Steve noted that the US Fish and Wildlife Service is newly developing their own I&M program for the National Wildlife Refuge system. They have decided to co-locate with the NPS I&M program in Ft. Collins, and to adopt NPS programs/protocols when and where appropriate (a key here is to not reinvent the wheel). The genesis for the program came from the National Wildlife Refuge Social Impact Assessment 1997 which included a mandate to monitor the status and trends of fish, wildlife and plants in EACH refuge. The new Natural Resource Program Center has vacancies that need to be filled.

With respect to the NWRS I&M program and its relationships to the LCC program, Steve noted that they expect to provide the foundation for adaptive management actions at the Refuge level and the monitoring component of the Strategic Habitat Conservation model at the LCC level. Further, the NWRS I&M program will (1) work to integrate LCC priorities for information with Refuge and Refuge System needs for information, and (2) work to provide consistent, credible information about resources across the NWRS to inform the conservation design efforts of the LCCs.

Rick Sojda, USGS Climate Change Specialist, USCS Northern Rockies Science Center

“Inventory Monitoring Activities and Global Change in the GNLCC: A Decision Support Focus”

Rick described how USGS conducts research activities across the LCC that were not designed as I&M programs explicitly, but are providing similar data. Numerous such programs exist, including grizzly bear population monitoring (DNA, radios, females with cubs), whitebark pine monitoring, amphibian population monitoring, water resources (stream gages, water quality), sage/ sharp-tailed grouse (especially in the Columbian Basin), glacier and snowfield persistence work, and many more.

Rick described multiple USGS efforts focused on climate change, including the USGS Global Change Office and its Climate Effects Network. He noted that the first prototype of the Climate Effects Network (CEN) is starting in Alaska. CENs seek to use existing partnerships to collaboratively provide science and data products for responding to climate change to advance outcome-based conservation across the landscape. Additionally, CENs seek to provide decision support tools to address resource manager needs. Those tools need to be timely, useful, responsive, and provide sustained observations, research, and models to support a robust adaptive management framework.

Rick provided a number of examples of conceptual and computer modeling for decision support. These included (1) climate variability and change and water availability (Methow River Basin, Columbia River Basin); (2) climate variability change on fisheries, streamflow and water temperature in the Yakima River Basin; (3) web crawler and social network software to gather and provide personalized global change information; (4) use of Bayesian Belief Networks and Graphical Models for ecological modeling and for understanding scenario planning; and others.

With respect to the critical aspect of decision support, Rick emphasized a number of concepts key to USGS's approach. Principal among these is USGS's emphasis that I&M efforts should stem from a thorough understanding of what management decisions are being considered (i.e., asking "What are you trying to achieve?"). Also critical is the need for scientists and resource managers to collaborate to provide decision support—Rick stated that we always need to keep "...one foot in science, one foot in management...". Rick provided analysis of approaches to decision making in natural resources, and a discussion on determining where a decision falls with respect to management objectives and ecological knowledge. He closed with a recommended process for decision support system development: (1) study the decision process: Identify an important subcategory and question!; (2) determine feasibility of developing a decision support system; (3) flowchart the overall system; and (4) evolutionary prototyping—i. internal verification, ii. Refine, modify and expand the system, iii. conduct additional system repairs, iv. extensive user involvement, v. validation.

Craig MacKinnon, BLM Assessment, I & M Project Manager Washington Office

"Key Attributes of Ecosystem Sustainability: An Approach to Developing Core Indicators and Integrating Monitoring"

Craig began his discussion of BLM's I&M program by describing how the Office of Management and Budget came to the BLM and mandated them to monitor *authorized uses* (natural gas, gold, wild horses etc). He also noted that the 1995 Grazing Rule mandates that every single allotment needs to meet a health standard. He noted that BLM concentrates its analyses on climate change, development, fire, permitted activities and invasives.

After showing a confusing model, Craig stated that a major concern is the difficulty of communication between scientists and managers. He said that one way for the two groups to speak the same language is to group information into three attributes—biotic integrity (vegetation and wildlife), soil resources (soil and site stability), and watersheds (hydrologic function)—similar to NRCS designations. Craig said that managers could better understand and work with discussions focused in just these three "key ecosystem attributes", and that similarly by using just these three we might also better communicate with the public.

With respect to monitoring, Craig described BLM's selection of core indicators, which are used as an index of an attribute. The overall goal for these indicators is to provide consistent comparable data, and to be useful, objective, transparent and reproducible. Craig listed a number of BLM's core indicators, a subset of which follow: (1) Core Terrestrial Indicators—non-native invasive plant species, bare ground, vegetation composition, and soil aggregate stability; and (2) Core Aquatic

Indicators—temperature, bank stability, macro-invertebrates, pool depth, and stream gradient. BLM seeks to create a systematic sampling framework for their indicators including a spatially unbiased, stratified random design that focuses most sampling on areas of greatest concerns.

Programmatically, Craig described several areas that BLM is working on ecologically-based conservation and restoration objectives, for example energy development, wild horses, and species/population vulnerability. Craig concluded by noting that core terrestrial indicators are not always enough to assess status and trends and that other indicators are sometimes needed to understand wildlife species vulnerability and/or habitat requirements. He noted that for BLM the first place where monitoring led to conservation results was in Nevada.

Panel Q&A

Notes on the audience question and panel answer session are available from facilitator Scott Bischke (scott@emountainworks.com).

Margaret Beer, NPS National I&M Data Manager

“Data Integration Across Landscapes”

Margaret began by citing a statement by David Hayes, deputy Secretary of the Interior, who said, “Addressing climate change impacts will require a monumental effort by DOI...The data piece is probably the most important component of all of this.”

Margaret pointed out several major challenges to data sharing: (1) there are large amounts of data at multiple locations in multiple formats; (2) DOI does not control all the data; (3) there are many stakeholders having different needs; and (4) there is an incredible range of data products to create and/or manage (e.g., raw data, GIS, multi-media). She stated that technology and standards are available to address these issues and create a distributed system based on web services and common data exchange standards. The approach is flexible and modular, based on industry standards, and can be phased in over time. The approach to be employed is the OMB and DOI standard promoted for all federal agencies: Federal Segment Architecture Methodology (<http://www.fsam.gov>).

Margaret described NPS’s own IRMA (Integration of Resource Management Applications) program that provides a Service-oriented architecture (build once, use many times) that follows DOI and industry standards. IRMA is available to NPS internal only today; it is expected to be publically available in 2011. One end product of IRMA is the Natural Resource Information Portal, which makes a lot of information available at one place (e.g., bibliographic references, biology, geo-spatial data products). Here NPS uses can link to pdf reports, maps, park species lists and information, taxonomic information (multiple systems), USGS info, USFWS info on threatened & endangered species, ITIS (Integrated Taxonomic Information System) info, National Biological Information Infrastructure info, and so on (Margaret noted that NPS can also provide some of its information to other agencies). REST (Representational State Transfer) services, somewhat like web services, are also available to allow access the data without going through the web portal—in other words one can embed a URL search into a website so that reference lists can be dynamically-created instead of hard coded.

Margaret concluded with some lessons learned from NPS data integration efforts to date: (1) don’t try to solve a large, complex problem all at once (break it down into smaller problems; solutions can be re-usable); (2) separate the who and the what from the how—determine who the user communities are and what they need; (3) a cultural change is required to integrate, (4) that there are responsibilities from the top-down--support, funding, incentives, and leadership and from the bottom-up—defining NPS and user needs, implementing metadata, provide training, enforcing data/metadata standards, and budgeting. The end result of this effort should be greater informational agility, happier users, and less redundancy between agencies.

Tami Blackford, NPS Greater Yellowstone Science Learning Center

Partnerships in Science Communication: Research Learning Centers

Tami began by describing how the ~20 NPS Research Learning Centers (RLCs) nationwide connect Parks, science, and people by facilitating research efforts, supporting science education opportunities (e.g., for classrooms, for volunteers), transferring science information, and facilitating science-informed decision-making. She noted that the RLCs are organized by resources, but also searchable by park unit. Audiences for the RLCs are varied, thus the sites must be accessible at a variety of levels. The RLCs provide such items as websites link to data, project summaries, and resource briefs. The latter is a core product of the website; resource briefs are useful to park managers looking for condensed information and also to the general public.

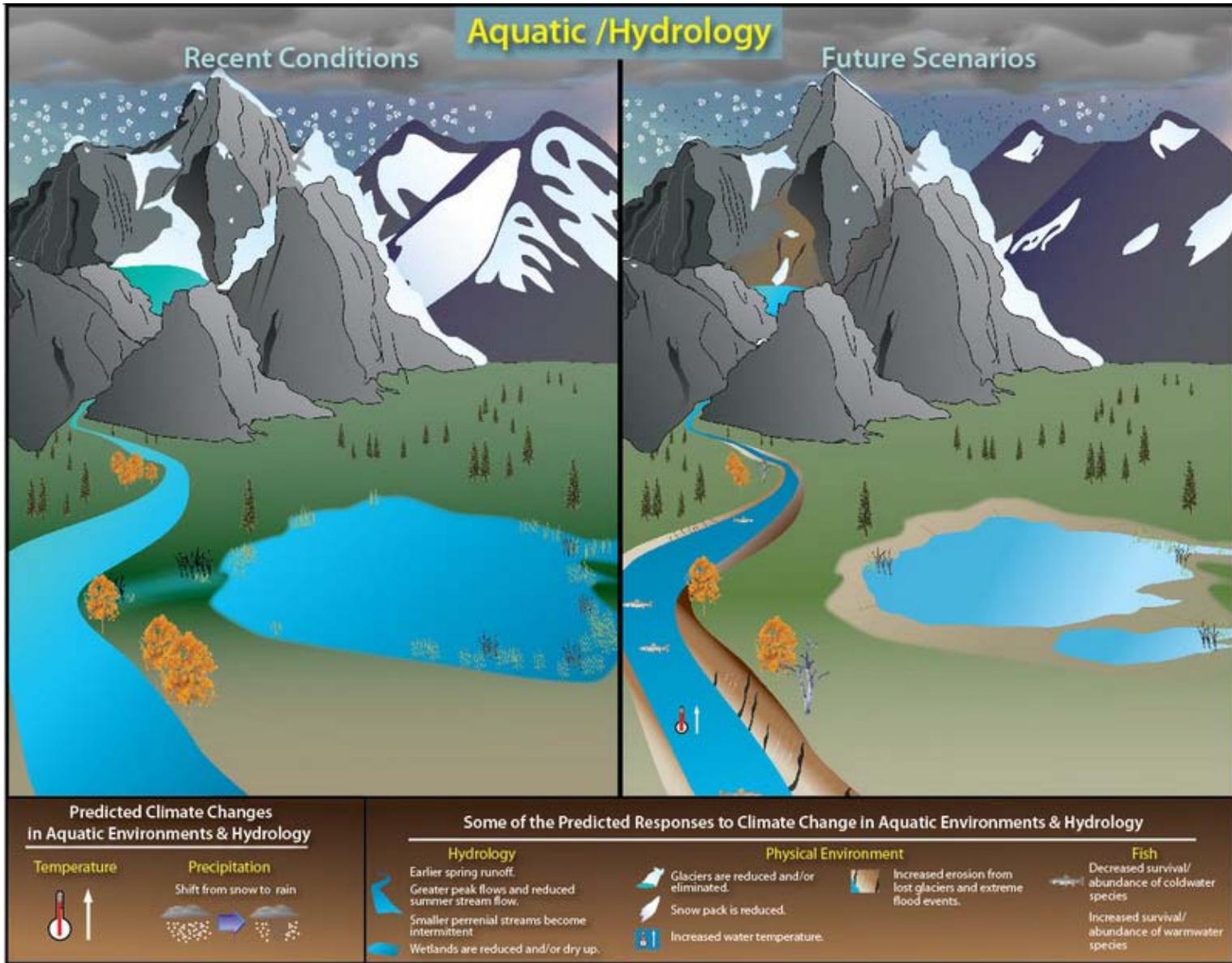
She noted that the RLCs are often supported by internal (e.g., I&M program) and external (e.g., Sonoran Institute) partners. Thus the sites are “.org” sites to better facilitate working with partners.

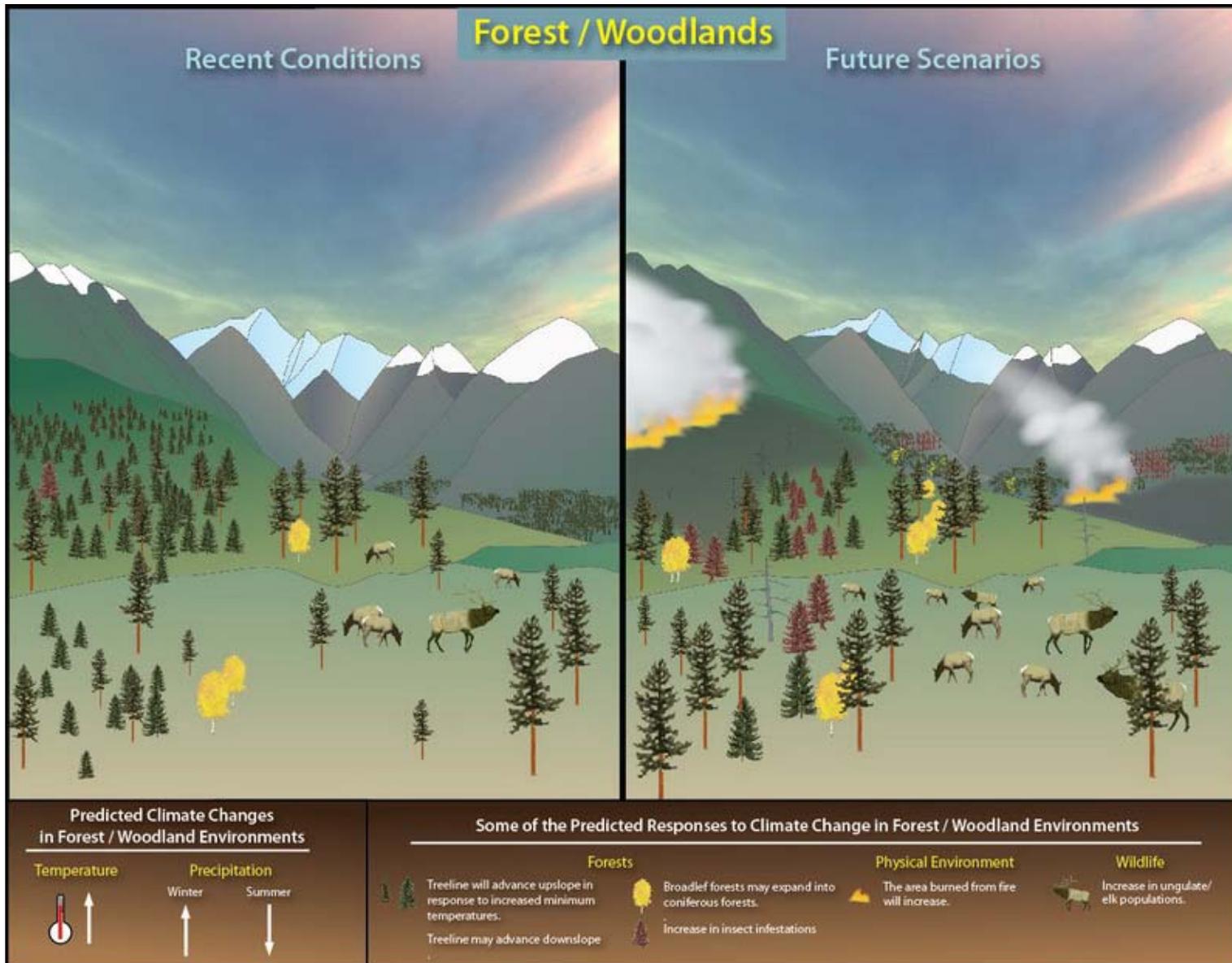
Tami described how GYSLC as a web-based, virtual learning center has many opportunities for partnering with the I&M networks on climate change topics. Such opportunities include acting as a Network partner in information exchange associated with collaborating (including hosting workshop information, as for this workshop), planning, and adapting to climate change, and particularly in communication and outreach on climate change topics. The RLCs can provide an aggregation and interpretation point for information collected by multiple groups (e.g., results of bioblitz and citizen science campaigns). Climate information data is available today on the GYSLC site.

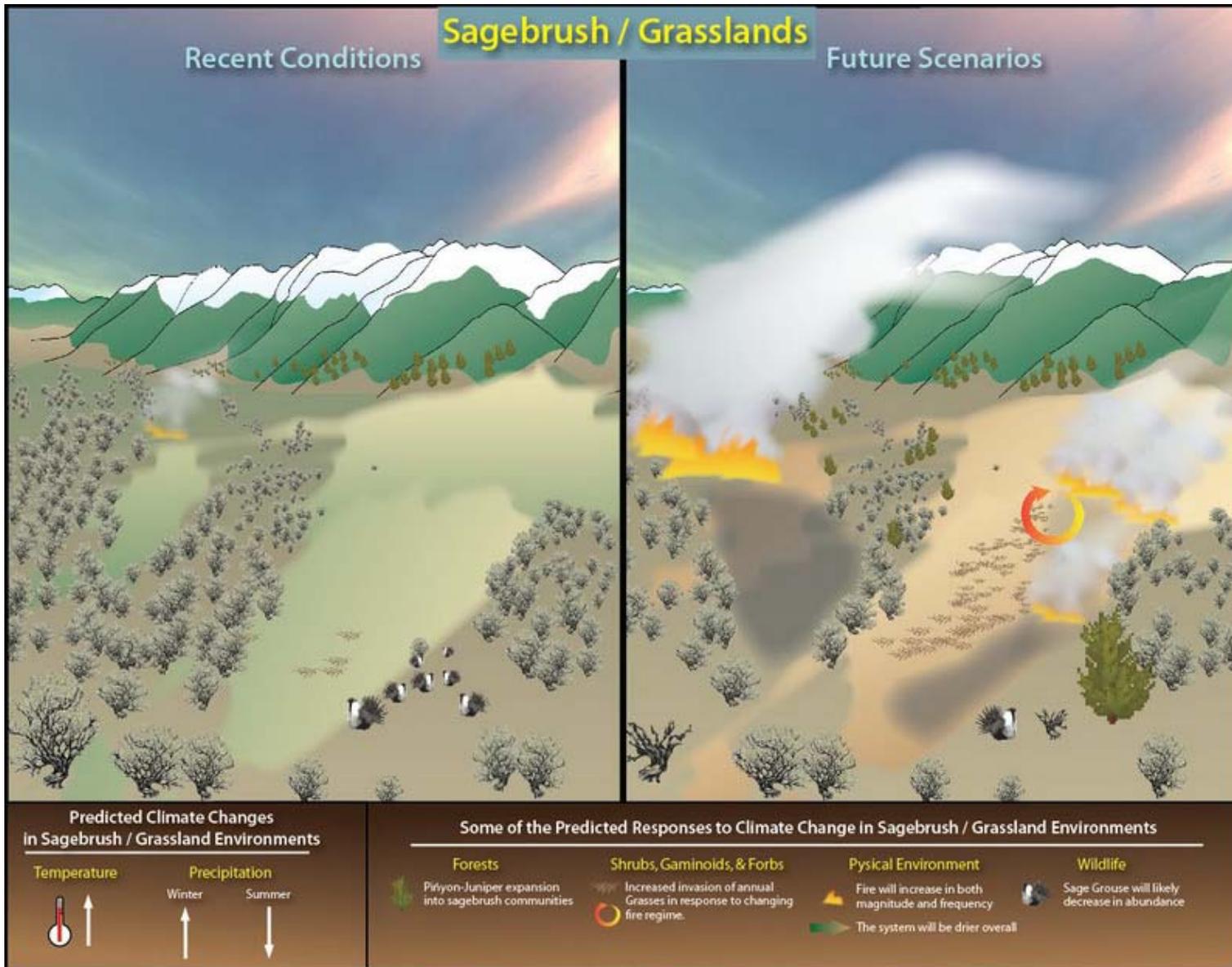
PRODUCT 3: UPDATED CONCEPTUAL DIAGRAMS FOR CLIMATE CHANGE IMPACTS TO KEY HIGH ELEVATION SYSTEMS

Four conceptual diagrams were presented at the workshop to illustrate climate change impacts in key high elevation systems. The conceptual diagrams and the network ecologists who presented them follow: alpine/subalpine (Ostermann-Kelm), riparian/aquatic (Schweiger), forest/woodland (Shorrock), and sage steppe/grasslands (Rodhouse). These diagrams were presented on the morning of Day 2 of the workshop, and used to aid in break out group discussion and understanding of ecological impacts of climate change on the high elevation parks of the Great Northern LCC. The four conceptual diagrams and each ecologist’s talk to support that diagram, can be found on the workshop website www.greateryellowstonescience.org/CC_workshops/highElev.









PRODUCT 4: PRIORITIZATION OF LONG-TERM MONITORING PROJECTS FOR CLIMATE CHANGE RESPONSE

To produce the fourth product of this workshop, the Planning Team first had to develop a set of criteria to be used in rating the vital signs for their responsiveness for monitoring ecological impacts of climate change. Three network managers took on this task, with review of the remainder of the Planning Team, rendering the following result (then used to develop workshop Product 4):

1. Responsiveness to climate change

- a. There is high agreement and much evidence that the vital sign/indicator responds to climate change.
 - i. Highest - 5 - published evidence of observed response to climate change within the last century and hypothesized to continue to respond within the next decade
 - ii. High - 4 - published evidence of response to climate change over the last century and hypothesized to continue to respond over the next 30 yrs.
 - iii. Medium – 2-3 – strong conceptual basis with published hypothesis of responsiveness to climate change
 - iv. Low - 1 – conceptual basis exists but there is no published evidence or hypothesized responsiveness to climate change

2. Applicable spatial scale

- a. The vital sign/indicator is common to all or most high elevation parks across the Great Northern LCC.
 - i. Rankings from 1-5, the highest score for this criterion would be for an indicator applicable to all high elevation parks or applicable to a high percentage of the area within the LCC.

3. Cost effectiveness

- a. Does the vital sign/protocol leverage off of existing (or planned) efforts to reduce cost and improve efficiency?
 - i. Rankings from 1-5
 1. Example: Adding a response parameter (e.g., indicator species) to an existing protocol, thereby leveraging data collection, management, and analysis costs. The existing protocol may be used by others than NPS but has been peer reviewed and meets minimum standards adopted by NPS I&M program.
 2. Example: Adding additional sites (e.g., current ecotone boundaries) or increasing sampling frequency of an existing protocol to achieve better resolution on the climate change effects question.

4. Relevance to management

- a. Information gained from this indicator/vital sign has long-term value and utility to resource management decisions. The scale of relevance should be comparable to the scale of applicability identified in criterion 2.
 - i. Rankings from 1-5, the highest score for this criterion would be for an indicator with long-term utility to managers (e.g. informing desired future conditions). Highest ranking should be supported by prior management use of the information to inform management decisions or actions.

Vital Signs Prioritization

On the second day of the workshop, participants broke into six work groups focused on the four conceptual models (Product 3—riparian / wetland / aquatic; sage steppe / grassland; forest / woodland; alpine / subalpine), another group focused on physical resources / broad scale processes, and a final work group looking at partnering opportunities. Each of the first five work groups was tasked with developing a coarse-filtered prioritized list of recommendations associated with monitoring ecological response to climate change in high elevation parks. The process employed follows:

During development of each network's monitoring program, teams created lists of vital signs (through rigorous review, conceptual models, expert input, etc.) that were initially prioritized against the overall program goal of monitoring conditions of natural resources in parks. Prior to this workshop, network and regional program managers reviewed these network lists for Vital Signs that potentially include climate change aspects. They eliminated vital signs that appeared not to be climate change related, plus organized the vital signs based on ability to monitor climate change under the five breakout areas noted above. Each breakout group started their prioritization effort with their section of this managers' monitoring table (note that the table can be found on-line at the workshop website; see www.greateryellowstonescience.org/CC_workshops/highElev).

Prioritization Steps:

1. Each breakout group reviewed the vital sign and potential impact columns (i.e., in the monitoring table) for thought and discussion with emphasis on management implications and management relevance. The groups were free to modify, add to (are there any critical gaps?), or delete the managers' monitoring recommendations as the group thought warranted.
2. Using a subset prioritization criteria established to facilitate the workshop process (see previous section), each group rated (via filling in spreadsheet cells) each recommended vital sign against four areas 1) responsiveness to climate change, 2) applicable spatial scale, 3) cost effectiveness, 4) relevance to managers. Groups were told that for this exercise all four areas are weighted equally.
3. Then, each group compiled a list of opportunities, concerns, ideas, and prioritization logic for report to the full workshop. They considered issues of integration across ecosystems, created a listing of critical thoughts and outcomes for the workgroup and selected spokesperson to report back to the entire conference.
4. Groups provided conference facilitators with spreadsheet results for overall compilation and sorting.

The combined results of the breakout groups are presented in the table below. This prioritized list served as input to the Planning Day following this workshop, held by a subset of NPS attendees to this workshop (see Next Steps, below).

Sorted results of breakout group exercise to prioritize vital signs for monitoring ecological response to climate change in high elevation parks (5 = most important, 1 = least important).

Group	Vital Sign	Responsiveness to Climate Change	Applicable at Appropriate Spatial Scales	Cost Effectiveness	Relevant to Park Management	Average
Alpine	5 Needle Pine	5	5	5	5	5.0
Physical	Wildland Fire	5	5	5	5	5.0
Aquatic / Riparian	Water Quantity	5	5	5	4.5	4.9
Physical	Climate	5	5	4	5	4.8
Sage / Grasslands	Disturbance (Fire) Dynamics	5	5	4	5	4.8
Alpine	Forest Insects and Disease	4	5	5	5	4.8
Forest	Forest Insects and Disease	5	5	4	5	4.8
Forest	Invasive Plants (Status and Trends)	4	5	5	5	4.8
Forest	Aspen	3	5	5	5	4.5
Forest	Wildland Fire	4	5	4	5	4.5
Aquatic / Riparian	Physical Characteristics / hydrology / groundwater	5	5	3.5	4.5	4.5
Sage / Grasslands	Productivity/ Phenology	5	5	4	4	4.5
Physical	Land cover and use	5	5	3	5	4.5
Sage / Grasslands	Sagebrush Steppe Vegetation	5	4	4	5	4.5
Sage / Grasslands	Vegetation Composition and Soil Structure: Grassland, Shrubland, and Woodlands	5	4	4	5	4.5
Physical	High Elevation Lakes	5	3.5	4.5	4	4.3
Forest	Invasive Plants (Early Detection)	4	5	3	5	4.3
Forest	Limber Pine	4	5	4	4	4.3

Sorted results of breakout group exercise to prioritize vital signs for monitoring ecological response to climate change in high elevation parks (5 = most important, 1 = least important).

Group	Vital Sign	Responsiveness to Climate Change	Applicable at Appropriate Spatial Scales	Cost Effectiveness	Relevant to Park Management	Average
Aquatic / Riparian	Native fish	4	4.5	3	5	4.1
Aquatic / Riparian	Vegetation	4	5	2.5	5	4.1
Alpine	Pika Monitoring	4	5	3	4	4.0
Alpine	Invertebrate Pollinators	4	5	3	4	4.0
Alpine	Vegetation Composition and Soil Structure: Alpine Tundra	5 veg, 4 soil	4	4	4	4.0
Forest	Forest Structure and Composition	4	5	3	4	4.0
Alpine	Invasive Plants	3 alpine, 4 subalpine	5	3	4	4.0
Sage / Grasslands	Invasive Plants (Early Detection)	3?	5	2	5	4.0
Sage / Grasslands	Sage grouse	4	2	5	5	4.0
Aquatic / Riparian	Amphibians	3.5	5	3	4	3.9
Aquatic / Riparian	Invasive Plants-(Early Detection)	2	5	3	5	3.8
Aquatic / Riparian	Invasive Species	2	5	3	5	3.8
Alpine	Landbirds	4	5	3	3	3.8
Aquatic / Riparian	Vegetation - Camas Lily	4	1	5	5	3.8
Aquatic / Riparian	Water Chemistry	3	5	4	3	3.8
Sage / Grasslands	Woodland Ecotone Shift	5	3	2	5	3.8
Aquatic / Riparian	Aquatic Macro-invertebrates	4	5	3	3	3.8
Aquatic / Riparian	Bats	3	5	3	4	3.8

Sorted results of breakout group exercise to prioritize vital signs for monitoring ecological response to climate change in high elevation parks (5 = most important, 1 = least important).

Group	Vital Sign	Responsiveness to Climate Change	Applicable at Appropriate Spatial Scales	Cost Effectiveness	Relevant to Park Management	Average
Aquatic / Riparian	Periphyton (algae & diatoms)	3	5	3	3.5	3.6
Sage / Grasslands	Bats	3	4	3	4	3.5
Forest	Landbirds	2	5	4	3	3.5
Sage / Grasslands	Landbirds	4	4	2	4	3.5
Aquatic / Riparian	Stream / river channel characteristics	3	4	3	4	3.5
Physical	Snow Chemistry	2	4	4	3.5	3.4
Aquatic / Riparian	Soils	4.5	4	2	3	3.4
Alpine	Rare Plants	4	4	2	3	3.3
Aquatic / Riparian	Seeps and Springs	5	2	2	4	3.3
Alpine	Bighorn Sheep	2	4	3	4	3.3
Forest	Clark's Nutcracker	2	5	2	4	3.3
Aquatic / Riparian	Landbirds	2	5	2.5	3	3.1
Alpine	Ptarmigan	3	3	2	3	2.8
Physical	Ozone	3	2	3	3	2.8
Forest	Bats	2	2	3	3	2.5
Alpine	Mountain Goats	2	2	3	3	2.5

Partnership Group

Work group participants a) brainstormed the values of partnerships; b) talked about the role the NPS could play as co-lead in the Great Northern Landscape Conservation Cooperative; c) talked about how to network; and d) discussed some next steps for the GNLCC. The group discussed the need for the GNLCC to get the Steering Committee going, so other efforts don't get out ahead of them, and to allow them to build their governance structure as a solid foundation for the GNLCC to work from. The GNLCC Steering Committee is currently considering eco-geographical forums to facilitate collaboration and information sharing.

Key points from the four areas discussed follow.

Value of partnership

- Data integration and information sharing
- Opportunities to work together in inventory and monitoring to be more effective
- To look at and understand the big picture
- To present one voice; a single message of a coordinated effort. This increases efficiency, effectiveness, accountability, transparency, and credibility.
- Increased access to useful tools. Efforts to address climate change are so fragmented that it is helpful for partnerships to pull information together and make it accessible to all.
- The LCC structure of large landscapes helps leverage resources, opens up more opportunities for funding, and facilitates action at the landscape level.

NPS role in the GNLCC

- Contribute expertise and information on cultural resources
- Leverage NPS program expertise
- Shared capacity—to get it kicked off
 - I&M coordination with USFWS refuges and NPS I&M networks, and other programs as mechanisms to get tangible outcomes.
 - Find shared landscapes to do some pilot projects

Networking—connect existing efforts and identify common goals

- Shared data sets, platforms
- High priority, shared values in the landscape:
 - Water vulnerability
 - Data integration
 - Habitat connectivity
- Network with other partners in the region to identify common goals; build successes through tangible projects—connect with and leverage existing efforts
- Build commitment to overcome obstacles
- Think through outreach and communications strategy

Next steps for the GNLCC

- Get projects going with current year funds
- Develop a long-term strategy
- Take the synthesis document and break it into useful information to communicate to others
- Gap analysis—a science needs assessment has been done, continue assessment process, identify gaps and design new ideas collaboratively
- Firm up governance and strengthen the steering committee
- Identify mechanisms to pull groups together; how others can participate
- Develop a prototype to develop data integration system—build on existing systems

Next Steps and a Heartfelt “Thanks”

The attendees assembled for this workshop helped create a set of draft priorities (Product 4) for monitoring ecological response to climate change in high elevation parks. This table served as input to the Intermountain and Pacific West Regions I&M programs for a workshop follow-up effort scoped at developing work plan and long-term strategies in response to Secretarial Order No. 3289. This follow up effort occurred May 7, 2010 and included a subset of the attendees to the workshop. Notes and results from the discussions that occurred at the May 7 planning meeting are available upon request to Bruce Bingham (Bruce_Bingham@nps.gov).

The workshop Planning Team greatly appreciates the input from participants during the workshop and feels that the NPS gained critical input toward its goal of developing multi-year strategies for long-term monitoring of ecological response to climate change relevant to the conservation and management of park natural resources. The workshop Planning Team wishes to extend a heartfelt “thanks” to all participants for their time and effort.

Appendix—Acronym List

Acronym	Definition
BLM	Bureau of Land Management
CO ₂	Carbon dioxide
DOI	Department of the Interior
GNLCC	Great Northern Landscape Conservation Cooperative
GRYN	Greater Yellowstone Network
I&M	Inventory and Monitoring
IMR	Intermountain Region
LCC	Landscape Conservation Cooperative
NEON	National Ecological Observatory Network
NGO	Non Government Organization
NPS	National Park Service
PWR	Pacific West Region
ROMN	Rocky Mountain Network
UCBN	Upper Columbia Basin Network
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WASO	Washington Support Office