NARSEC 2007

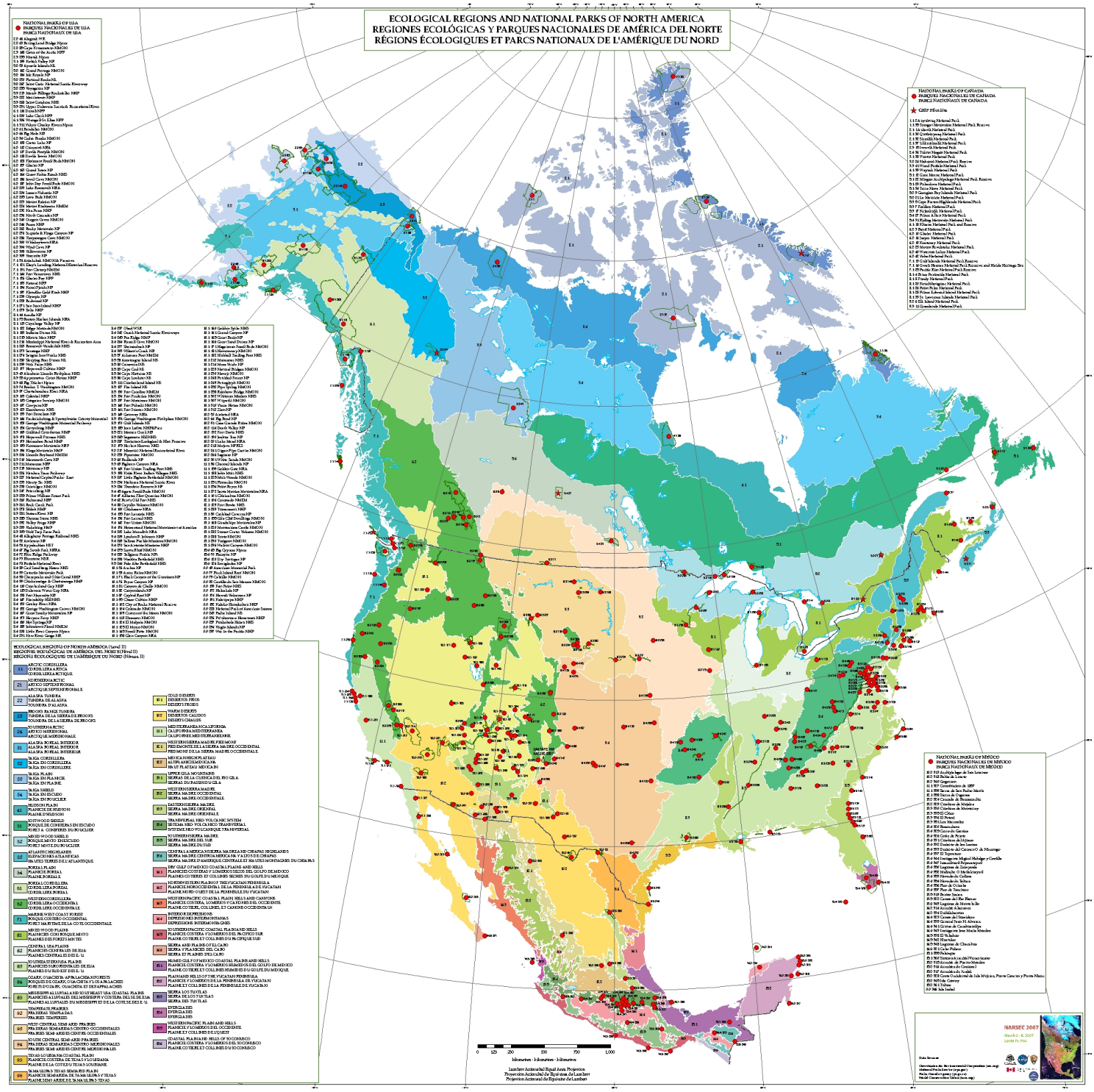
North American Network for Remote Sensing Park Ecological Condition

Satellite Remote Sensing for Monitoring and Reporting the Condition of National Parks

March 6-8, 2007

Santa Fe, New Mexico

Natural Resources Canada



NARSEC 2007 Organizing Committee

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NARSEC 2007 -- AGENDA

March 6-8, 2007, Hotel Santa Fe, Santa Fe, New Mexico

Time	Title	Presenter	Location / Room
Day 1 – Tuesday Mar 6, 2007: ***THEME 1 - Remote Sensing for Monitoring Land Surface Change in Parks***			
8:00	**Registration**		Kiva ballroom
8:30	**Opening session**	Josef Cihlar	Kiva ballroom
8:30	Objectives, meeting format, logistics	Josef Cihlar	Kiva ballroom
8:45	NPS and PCA Monitoring Programs - Use of RS and Establishment of Desired Condition for Park Landscapes	John Gross, Donald McLennan	Kiva ballroom
9:15	**Theme 1 Presentations (RS for Monitoring Land Surface Change in Parks)**	Donald McLennan	Kiva ballroom
9:15	Challenges in developing Landsat- based monitoring protocols in national parks	Robert Kennedy	Kiva ballroom
9:50	Land cover change protocol developed for a Park Ecological Integrity Observing System (Park-EIOS)	Robert Fraser	Kiva ballroom
10:15	Health Break & Poster viewing		Kiva ballroom
10:30	Observing and modeling land use change from urbanization across the Mid-Atlantic region and its ecological implications	Scott Goetz	Kiva ballroom
10:55	MRLC land cover products	Collin Homer	Kiva ballroom
11:20	Status of the Landsat Data Continuity Mission and related activities	James Irons	Kiva ballroom
11:40	Key poster messages (3-5 min each)	Authors	Kiva ballroom
12:00	Lunch & Poster viewing		
13:30	**Theme 1 Breakout Groups** (Including Health Beak)	Donald McLennan	Kiva A, B, C* Canyon Library
15:45	Breakout #1 Plenary reporting and discussion	Donald McLennan	Kiva ballroom
16:45	North American Land Change Monitoring System	Collin Homer	
17:30	Adjourn		

**Kiva A, B, and C are subdivisions of the Kiva ballroom.*

Time	Title	Presenter	Location / Room
Day 2 – Wednesday Mar 7, 2007: ***THEME 2 - Landscape Pattern and Biodiversity in Parks***			
8: 00	Introduction	Woody Turner	Kiva ballroom
8:00	Evaluating landscape connectivity in an eastern US network of parks	Todd Lookingbill	Kiva ballroom
8:25	Remote sensing based products applicable to National Park (ANP) monitoring in México	Rainer Ressl	Kiva ballroom
8:50	Pattern metrics and significance of changes in land use and cover for park resources	Dave Theobald	Kiva ballroom
9:15	FragCube: An ecologically scaled landscape index for monitoring habitat area and landscape connectivity in Canada's national parks	Paul Zorn	Kiva ballroom
9:40	Multi-scale assessment of biodiversity in Mexico – new approaches to a national gap analysis	Melanie Kolb	Kiva ballroom
10:05	Health Break & Poster viewing		Kiva ballroom
10:30	State of the science for modeling focal species distributions using RS inputs	Jeremy Kerr	Kiva ballroom
10:55	Landscape-scale indicators of protected area quality and effectiveness.	Kristina Rothley	Kiva ballroom
11:20	Effects of land use and land cover change on park biodiversity	Andy Hansen	Kiva ballroom
11:45	Key poster messages (3-5 min each)	Authors	Kiva ballroom
12:00	Lunch & Poster viewing		
13:30	**Theme 2 Breakout Groups** (Including Health Break)	Woody Turner	Kiva A, B, C* Canyon Library
16:00	Breakout #2 Plenary reporting and discussion	Woody Turner	Kiva ballroom
17:00	Cash bar		

Time	Title	Presenter	Location / Room
Day 3 – Thursday Mar 8, 2007 ***THEME 3 – Desired Conditions for Protected Landscapes - Setting Targets and Thresholds***			
8:00	Introduction	John Gross	Kiva ballroom
8:05	Landscape-scale thresholds and desired conditions for parks: synthesis of break out groups and an example from Parks Canada.	Donald McLennan, Paul Zorn, John Gross	Kiva ballroom
8:50	Plenary discussion	Steering Committee	Kiva ballroom
10:30	Health Break		Kiva ballroom
10:50	Workshop summary and follow-on actions	John Gross, Donald McLennan	Kiva ballroom
11:45	Closing comments	Donald McLennan, John Gross	Kiva ballroom
12:00	Adjourn		

Background and Objectives - NARSEC 2007

NARSEC was established to promote and facilitate the use of remotely sensed data for monitoring and managing national parks and other protected areas in North America. The US National Park Service (NPS), Parks Canada Agency (PCA), and Mexico's National Commission for Natural Protected Areas (CONANP) are charged with protecting and restoring ecological values in a diverse array of protected areas in their respective countries. Recognizing the critical importance of landscape dynamics in and around the protected areas, and the potential value of satellite earth observations for gathering environmental information, these agencies have sponsored a number of proof-of-concept projects over the past several years. These projects have focused on developing protocols to generate useful, cost-effective information on park landscape condition.

Because of the significant progress over the past two years, this is an opportune time to evaluate existing products and current needs, and to chart a path forward. The objectives of NARSEC-2 are:

1. To review and evaluate EO-based methods presently being developed by NPS, PCA and their partners for monitoring land cover, landscape patterns, and biodiversity - including their suitability, readiness and best practices for use in different ecological conditions across North America.
2. To identify successes, challenges, and additional needs with respect to these methodologies, in particular regarding their performance, testing/evaluation, and/or operationalization.
3. To identify specific opportunities for addressing these needs through existing or new cooperative initiatives, both national and international.
4. To identify areas and mechanisms for increased collaboration among North American agencies and scientists.
5. To provide a forum for exchanging experience and ideas about the effective use of EO in ecological monitoring, management and reporting.

Workshop participants will receive presentations by leading researchers from the US and Canada engaged in the development of EO-based products, as well as from park professionals responsible for the ecological integrity of protected areas. Through presentations and breakout discussion groups, the progress made will be critically evaluated and assessed in relation to needs of park managers and for reporting. Particular attention will be focused on the critical issues of using EO-derived information to identify and measure 'desired condition' and to identify 'management assessment points'..

Given the topic and stage of development, four groups of specialists are both needed and will benefit from participation in NARSEC-2: park (and other) biologists/ecologists/scientists, park managers, EO specialists, and landscape ecologists. The Organizing Committee has received expressions of strong interest from both the US and Canada, and the participation of Mexican park professionals is also expected. The meeting should therefore be an excellent opportunity to become informed of state-of-the-art monitoring practices, to influence the evolution of these practices, and to contribute ideas to further development, including joint projects crossing national boundaries.

OUTPUTS

1. A workshop report including a summary of presentations and discussions.
2. Original presentations accessible on the web.
3. An outline of one or more potential initiatives that could be pursued within countries or through North American collaboration.
4. A synopsis of the workshop to be submitted to Park Science.
5. If there is sufficient interest and commitment, the Organizing Committee will coordinate submission of papers by all participants to a journal, or for publication in the NPS Technical Report series.

Charge to Breakout Discussion Groups

Approach

- Each participant to select the group of most interest to him/her
- Moderators and Rapporteurs to guide discussions in a consistent manner
- Highlights of discussions to be presented to the plenary
- Records of discussions to be used in preparing the meeting report

Breakout #1 Discussion: RS for Monitoring Land Surface Change in Parks
(assume >1 parallel groups on three topics, A, B, C)

BG#1A: Readiness and Applicability of the Land Surface Methods (presented in plenary)

1. Readiness of methods: Which of the presented methods are ready for ongoing use? What are particular strengths and weaknesses of the various approaches, and could hybrid methods be more desirable? Has accuracy (levels achieved, assessment method, communication) been addressed satisfactorily? Are the needs for independent reference data realistic ? What further R&D work is considered essential or highly desirable?
2. Use of methods: For methods that are ready for wider use, what would be the most effective approach to extend their use to other national parks (up to N.A. continent if appropriate)? To which ecoregions should the individual methods be extended? Are standards/ protocols necessary, which ones exist already, and how should additional ones be developed? How can/should the RS- based measures or products be used in establishing targets, thresholds and desired condition? How can/ should they be used for communicating park issues to the target audiences (e.g., are different forms of the products required)?
3. Actions: With reference to the topics discussed by the BG#1, what priority actions should be taken to ensure ongoing use (by method as appropriate; not more than 5-7 action items; consider making use of national or other initiatives)?

BG#1B: Other Highly Promising RS-based Methods and Needs in Land Surface Monitoring

1. What other mature methods exist that are being applied or might be applied to monitoring land surface change in parks? For each method, identify:
    a) The application/ information provided (actual, project/location; or potential)
    b) Key strengths and limitations
    c) Reference(s)/ sources of more detailed information
2. What other types of important information about parks (other than those presented in the plenary) might be obtained from satellite- based RS data e.g., land cover change, disturbances, land use change, phenology, vegetation characteristics such as LAI and crown closure, roads)? Identify a 'short list' where (based on present knowledge) important information requirement can be matched with existing or planned sensors (time horizon = 5 years). For each case:
    a) Define clearly the need to be met and why it is important
    b) Describe the performance requirements that a RS- based method should meet, including minimum requirements (level below which RS would make no useful contribution); and identify other relevant expectations
    c) Identify and characterize scientific or technical challenges to be overcome
    d) Propose specific actions to be taken for that case

2. For methods and approaches in questions 1 and 2: Identify priority actions that should be considered by i) park agencies, ii) satellite agencies, and iii) the scientific community (with respect to topics discussed by BG#2; consider making use of national or other initiatives).

BG#1C: Barriers to Use of RS- based Methods and Products

1. What are the main barriers (consider technical, organizational, resources, cultural)? For each address:
    a. What specifically is the issue (define it clearly)?
    b. Can they be removed and how?
    c. If not, can it be mitigated and how?
    d. What specific actions should be taken and by whom - depending on what constructive role(s) they may play, consider some or all of the following target groups: park staff, park managers, national park agency, national earth observation agency, the scientific community, the public?
2. What priority actions should be taken to significantly enhance the ongoing use of RS- based products and methods in national parks (prioritized, and no more than 5 for each target group; consider making use of national or other initiatives)?

Breakout #2 Discussion: Landscape Pattern and Biodiversity in Parks
(assume >1 parallel groups on two topics, Landscape Pattern and Biodiversity)

BG#2A: Landscape Patterns

1. Which of the presented methods are ready for ongoing use? What are particular strengths and weaknesses of the various approaches, and could hybrid methods be more desirable? What further R&D work is considered essential or highly desirable (by method if applicable)?
2. What other types of important information on landscape pattern (other than those presented in the plenary) might be obtained from satellite- based RS data? Identify a 'short list' where (based on present knowledge) important information requirement can be matched with existing or planned sensors (time horizon = 5 years). For each case:
    a) Define the need to be satisfied
    b) Describe the performance requirements that a RS- based method should meet, and identify other relevant expectations
    c) Identify and characterize scientific or technical challenges to be overcome
    d) Propose specific actions to be taken for that case
3. How can/should the RS- based measures or products be used in establishing targets, thresholds and desired condition (e.g., how should landscape indices be selected and produced)? How can/ should the RS- based measures be used for communicating park issues to the target audiences (e.g., are different forms of the products required)?
4. With reference to the topics discussed by this BG, what actions (prioritized) should be taken to ensure ongoing use (by method as appropriate, not more than 5-7 action items; consider making use of national or other initiatives)?

BG#2B: Biodiversity

1. Which of the presented methods are ready for ongoing use? What are particular strengths and weaknesses of the various approaches, and could hybrid methods be more desirable?
2. What other approaches should be explored to make effective use of RS- based data and methods for biodiversity purposes?
3. What further R&D work is considered essential or highly desirable (by method if applicable)?
4. Identify and prioritize actions for each of a) individual national parks, b) national park agencies, c) satellite agencies, and iv) the scientific community that should be taken to advance the use of RS techniques for biodiversity (also consider making use of national and tri-national initiatives).

Theme 3 Plenary Discussion: Desired Conditions for Protected Landscapes - Setting Targets and Thresholds

1. What are the most promising approaches to defining specific, landscape-scale desired condition? Which of the metrics presented can lead to defensible, quantitative assessment points relevant to management?
2. What role(s) can RS- based technology play? How can the RS based measures of landscape change be converted into indicators of ecological integrity that have measurement scales, thresholds and targets?
3. How can the parks management structure (local to national) ensure/ support effective use of RS technology in this area?
4. What are the most promising near-future opportunities to develop/ test such approaches at local to regional scales (also consider making use of national and tri-national initiatives)?

The Role of Remote Sensing Data in Monitoring and Reporting Ecological Integrity in Canada's National Parks

NARSEC 2007 – Santa Fe, New Mexico (March 6-8, 2007)

D.S. McLennan, P. Zorn, and, J. Poitevin

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1.0 Legislative Need to Monitor and Report Park EI Condition

Parks Canada Agency (PCA) has recently been revitalized through new legislation (Canada National Parks Act, 2000); the Act sharpens the Agency's focus on management accountability for the protection of ecological integrity (EI) in Canada's national parks. Under the revised Act, the "maintenance or restoration of EI" is the "first priority" for all park management decisions. PCA sees this EI mandate as inseparably linked to our larger Agency mandate to provide for public education and memorable visitor experience, and further, that our success in protecting park EI depends in large part on our relations with partners, stakeholders, and visitors. This mandate interaction is particularly relevant to park management issues involving landscapes contained within the greater park ecosystems of our national parks.

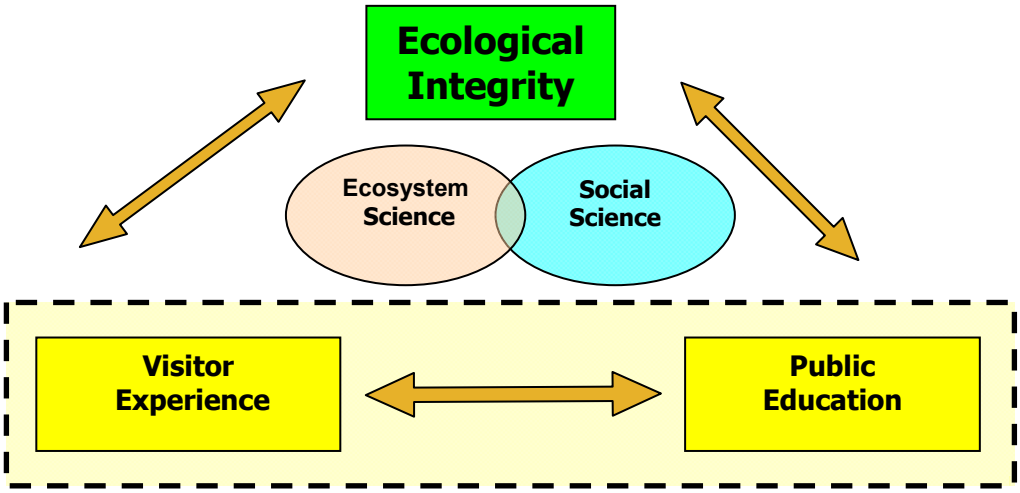

Figure 1: Parks Canada has an integrated mandate to protect and present ecological integrity.

To provide data and information for increased accountability expectations, PCA launched the National EI Monitoring and Reporting Program in 2003, where all national parks will develop improved EI monitoring and reporting systems by 2008. Canada's 42 national parks have been working cooperatively within 6 bioregions (Figure 2) under the guidance of 6 bioregional monitoring ecologists to develop a most desirable set of EI measures for 6-8 EI indicators.

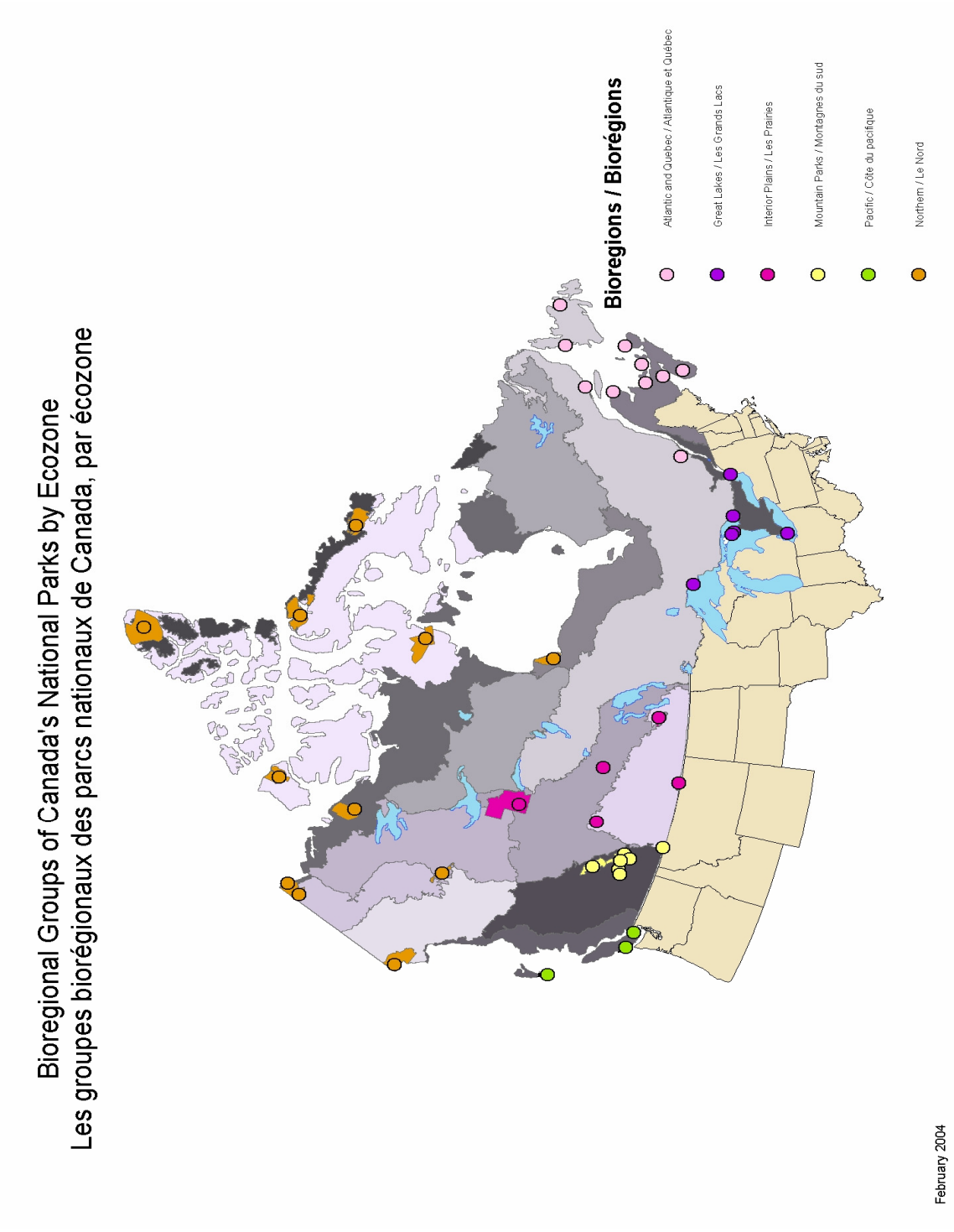

Figure 2: Organization of Canada's 42 national parks into 6 Bioregions

2.0 Parks Canada EI Monitoring Language

Definitions of the key components of the PCA EI monitoring and reporting initiative are summarized in Table 1. We report park EI through a small set of *EI indicators* – summary indices developed from an assessment of several to many *EI measures* that fall within that EI indicator. EI Measures are equivalent to the common science-literature usage of 'biological indicator'. All EI indicators and measures have *monitoring targets* and *thresholds* that compare the state of the EI measures and indicators to predefined desired condition, and management decision points respectively.

Table 1: Parks Canada monitoring language.

Term	Definition	Examples
Field measurements	the fundamental data collected through a monitoring project and which contribute to the suite of EI measures that make up an EI Indicator	fish condition assessment, creel census data, game fish population estimates, electro-fishing; pH, BOD, nutrients, heavy metals; chlorophyll a
EI Measure	monitoring data that contribute to an EI indicator, that are collected over time following a strict protocol, to measure present condition and change since the last measurement; an EI measure may be a single ecological field measurement, or may combine field measurements into an index; all EI measures will have targets and thresholds	*fish population measure* (an index developed from a small suite of fish field measurements such as fish condition index, game fish population estimates, creel census data, electro-fishing sampling) *water quality measure* (a water quality index developed from a suite of water quality field measurements such as pH, metals, nutrients, dissolved oxygen) *chlorophyll a measure*
EI Indicator	one of 6-8 indices, comprised of an internal suite of EI monitoring measures, that are combined through semi-quantitative models to provide a clear message on a key park EI element; all EI Indicators will have targets and thresholds	lake EI Indicator (LEI): in this example, values of the indicator range along a gradient derived from an index that ranges from 0-35
Threshold	levels of an EI indicator or EI measure that represent high, medium and low ecological integrity; trends that cross thresholds invoke a pre-described management response	lake EI > 22 – high EI; LEI 11-22 – medium EI; LEI < 11 – low EI for the lake EI indicator (EI measures will also have thresholds)
Target	desired condition of the EI indicator or EI measure, i.e., the level of the EI indicator or EI measure that represents high EI	target lake EI = 24-28 for the lake EI indicator(EI measures will also have targets)
Baseline	level of an EI indicator or EI measure at the onset of monitoring measurement	lake EI = 25 for the Lake EI Indicator(EI measures will also have a baseline)

3.0 Assessing and Reporting Ecological Integrity

The objective of EI monitoring in national parks is to use the summary EI indicators to provide a clear and well-communicated assessment of park ecological condition, based on a program of well-rationalized EI measures. For the most part the EI indicators are major park ecosystems such as lakes, streams, forests, wetlands, grasslands, tundra, shorelines, and near-shore marine environments (Table 2). EI measures are the ecological factors assessed within EI indicators. For the Forest EI Indicator, for example, a park may sample a small suite of EI measures at a local (forest plot) scale (e.g., species composition, decay rate, stand

structure changes, forest salamanders, forest songbirds), and at regional (landscape) scale (e.g., landscape pattern, productivity, land cover change).

Table 2: EI Indicators for 42 national parks within 6 monitoring bioregions. Although measures vary, all parks in a bioregion report on the same suite of EI indicators**.**

EI INDICATORS					
The North	Pacific Coastal	Interior Plains	Great Lakes	Quebec Atlantic	Montane Cordilleran
Forest	Forests and woodlands	Forest	Forest	Forest	Terrestrial Ecosystems
Tundra	Non-forest	Grasslands	Non-forest	'Barrens'	
Wetlands	Lakes and wetlands	Wetlands	Wetlands	Wetlands	Aquatic Ecosystems
Freshwater	Streams and rivers	Lakes	Lakes	Freshwater (Lakes)	Native Biodiversity
Glaciers	Islets/shorelines	Streams	Streams	Freshwater (Streams)	Geology and landscapes
Coastal	Inter-tidal		Great Lakes Shore	Coast	Climate and atmosphere
Marine	Sub-tidal			Marine	support for EI

The EI measures are assessed together to report the EI condition of the Forest EI Indicator, and are reported in 5-year State of the Park reports (Table 3). A consistent assessment methodology for all parks and indicators is important for comparisons between 5-year reporting cycles within a park, and for wrapping up bioregional or national trends among parks. We are currently in the process of developing this procedure. The main objective of the assessment is to provide managers and stakeholders with a documented assessment of the condition of a park. This inevitably involves the suppression of important detail in the development of the assessment. An important aspect of the park SOP report structure will be to make the assessment process transparent, and to make all monitoring results available. So for example, the summary assessments presented in Table 3 would be supported in the SOP by an explanation of the assessment procedure, important results at the EI measures level not presented in the summary assessment, and the rationale for key decisions.

Table 3: Example summary table showing the state and trend of EI indicators for Gros Morne National Park.

Indicator: Ecosystem Type	Percentage of Park Area	Condition and Trend	Rationale
Forest	44	↓	High moose density - regeneration affected. Habitat loss from forestry. High percentage non-native mammals
Barrens	35	↓	Woodland caribou decline. Increasing human use. Increasing non-native species
Wetland	11	↓	Damage from snowmobiles. Woodland caribou declines.
Freshwater	8.8	↔	Healthy fish and invertebrate populations.Atlantic salmon, brook trout concerns
Seacoast	0.2	↑	Recovering from historic grazing, trampling and human use. Seabird populations healthy
Marine	1	↓	Over-exploitation of fish species, pollution, garbage

4.0 Use and Applications of Satellite Remote Sensing Data

The development of landscape scale EI measures, to be derived from satellite and other remotely sensed data, is recognized as a very important component for long term EI monitoring in national parks in Canada. Remotely sensed data provides critical information for assessment of landscape changes in and around national parks, provides useful information from multi-spectral sensors unavailable from other sources, and can cover wide, often inaccessible areas, at a relatively low cost.

To develop state of the art RS monitoring methodologies PCA is working with the Canadian Space Agency (CSA), and remote–sensing scientists from the Canadian Centre for Remote Sensing (CCRS) and the University of Ottawa, to develop effective, operational protocols to track changes in land cover, landscape pattern and biodiversity, and landscape productivity for the greater park ecosystem of our 42 national parks. At this meeting we will present these approaches for assessment and feedback from workshop participants.

5.0 Conference Questions

At NARSEC 2007 we will present the remote sensing (RS) monitoring methodologies we are developing with CCRS, university and Agency scientists for critical review and constructive input. Examples of products for land cover change and landscape pattern assessment will be presented and contrasted for two pilot national parks. La Mauricie National Park is a medium-sized, well-forested, and largely intact park that has been encroached by industrial harvesting over the last 30 years. St Lawrence Islands National Park is a very small fragmented park, set in matrix of agricultural and semi-agricultural private properties.

Specifically, we are looking for input on a number of key questions:

1. For the RS methodologies we are developing on land cover change, analysis of landscape pattern, and biodiversity modeling:
    a. Are these methods scientifically sound, and do they represent the latest thinking in the landscape ecology and RS technology science communities?
    b. How can the methods be improved to make them more useful, general and/or operational?
    c. What will be the largest problems with the operationalization of these methods across 42 national parks, and a wide range of biomes and greater park ecosystem (GPE) land use?
    d. What will be the effect of changes in RS satellite platforms and other technological developments on measuring landscape change over the long term?
    e. What should be the (optimum) spatial and temporal scale of an EO-RS framework for landscape/ecosystem monitoring considerations?

2. For developing EI monitoring targets and thresholds that will define a ‘desired condition’ for greater park ecosystems (GPEs) in and around parks:

a. What are some key general rules for establishing targets and thresholds for GPEs that will apply across a wide range of natural systems and land use practices?
b. How will these rules change between biomes, and under various intensity and kind of land use?
c. Are the alternatives presented on Day 3 useful, scientifically valid, and can they be operationalized? What are the main roadblocks that you can foresee?
d. What suggestions can be made for further refining our development of targets and thresholds for GPEs?

Remote Sensing and the US National Park Service Vital Signs Monitoring Program

John E. Gross

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NPS Inventory and Monitoring Program and Vital Signs Monitoring
Vital signs monitoring is a key component in the National Park Service's strategy to provide scientific data and information needed for management decision-making and education. Park vital signs are selected physical, chemical, and biological elements and processes of park ecosystems that represent the overall health or condition of the park, known or hypothesized effects of stressors, or elements that have important human values. Monitoring data help to define the normal limits of natural variation in park resources and provide a basis for understanding observed changes and possible management connections. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, or restore the ecological integrity of park ecosystems and to avoid, minimize, or mitigate ecological threats to these systems.

The NPS Inventory and Monitoring Program (I&M) administers vital signs monitoring. Under the program, more than 270 park units have been organized into 32 networks (Figure 1) that share funding and a core professional staff to conduct long-term ecological monitoring. Each network links parks that share similar geographic and natural resource characteristics to improve efficiency and reduce costs. I&M Networks consist of a total of three to 19 parks.

NPS I&M Networks complete a multi-year, 3-phase planning process before they actually implement monitoring. Natural Resource Challenge funding for I&M Networks has increased annually since 2001, and currently 22 (of 32) Networks have submitted their final monitoring plan, while two Networks have not yet received funding for vital signs monitoring. Thus, across the I&M Program, different Networks have achieved very different stages of implementation.

Program Goals
To guide the monitoring program, all 32 networks address the following five Goals of Vital Signs Monitoring as they plan, design, and implement integrated natural resource monitoring:

1. Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress towards performance goals.

Ecological Monitoring Framework
To promote collaboration among networks and with other programs and agencies, and to combine results for national reporting, vital signs being monitored by the parks are organized into a hierarchical Vital Signs Monitoring Framework that will also be used for reporting to the DOI Land Health Goals and for other purposes. Data analysis and reporting will address needs at several different scales (e.g., park, network, national) depending on the level of detail needed for the intended audiences. Examples of vital signs and their relation to the higher-level resource categories, are shown in the Table 1. For this conference, many of

the vital signs of interest are lumped into the Level 1 Category “Landscapes”, although remotely sensed data will clearly contribute to monitoring attributes and processes such as disease infestation, focal communities, and invasive species. The framework illustrates the breadth of vital signs that will be monitored, somewhere, in the 270+ parks. However, funding constraints limit monitoring at any one location to only a small number of carefully selected vital signs. Partnerships are crucial to the success of the I&M Program.

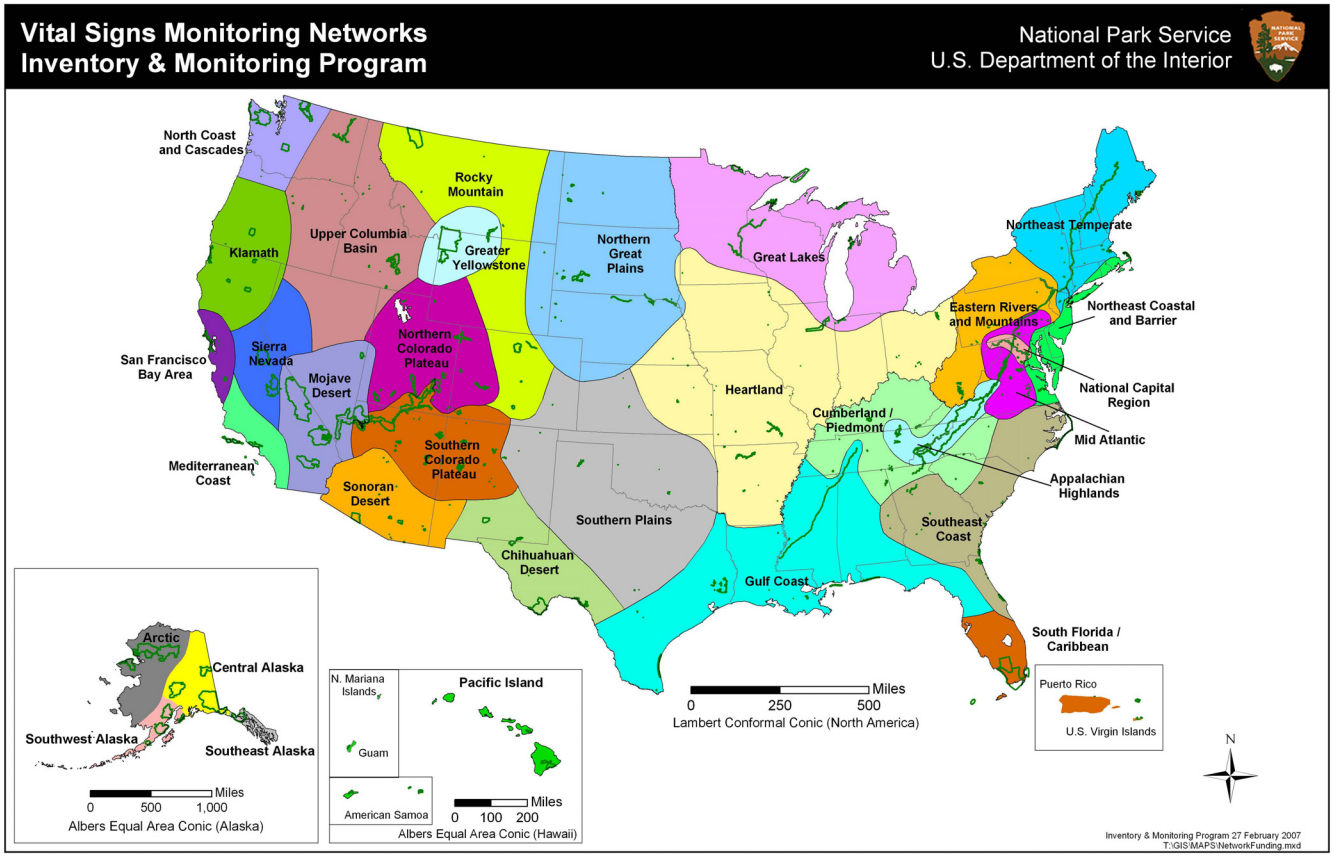

Figure 1. Map of the 32 NPS Inventory and Monitoring Networks. Because of phased funding, not all Networks are at the same stage of development.

Remote Sensing and Vital Signs Monitoring

In our most recent summary, Landscape Dynamics was the most commonly selected priority Vital Sign across the entire Program – selected by 24 networks composed of 257 parks. These numbers will rise as other Networks report. Example landscape Vital Signs that can be addressed using remotely sensed data are provided in Table 2.

Remotely sensed data is clearly important to NPS, and I&M Networks are supporting more than a dozen ongoing studies, not including activities of the vegetation mapping and fire monitoring program. Many other ongoing RS-based studies focused on US parks are supported by NASA, USGS, NSF, individual parks, and a variety of other agencies and foundations. These projects address a very broad range of needs, including use of high-resolution data for vegetation mapping or topography (e.g., LIDAR), to a need for broad-scale, high-temporal frequency monitoring of plant phenology, snow and ice cover, and insect defoliation. For more detail on these and other studies, including study products, see the NPS I&M Landscape Monitoring web site: http://science.nature.nps.gov/im/monitor/lulc/LULC.cfm.

NPS and NARSEC 2007

NPS goals are well aligned with NARSEC 2007 meeting goals – to identify the most appropriate methods for monitoring, challenges to using those methods, and to help prioritize research and development efforts as we

move forward. We need to determine how the use of remotely sensed data will help improve our understanding and management of parks. NPS monitoring networks need partners and expert advice to develop, implement, and make operational the use of remotely sensed data for natural resource monitoring. We are seeking these at NARSEC 2007.

In addition, NPS wants to engage a broad community in the task of helping to convert data into knowledge. At NARSEC 2007, we ask all participants to consider carefully the utility and information that we can obtain by the methods presented. How might we use this information to effectively inform decision-makers? At what scales do the results apply? How can we credibly quantify the impacts of attributes on park resources?

Table 1. The NPS Ecological Monitoring Framework is a systems-based, hierarchical, organizational tool for promoting communication, collaboration, and coordination among parks, networks, programs, and agencies involved in monitoring. Vital signs selected by parks and networks for monitoring are assigned to more detailed Level 3 categories (see http://science.nature.nps.gov/im/monitor/docs/Ecological_Monitoring_Framework.doc).

Ecological Monitoring Framework		
Level 1 Category	**Level 2 Category**	**Examples of Vital Signs Selected by First 12 Networks**
Air and Climate	Air Quality	Ozone, wet and dry deposition, visibility and particulate matter, air contaminants
	Weather and Climate	Weather and climate
Geology and Soils	Geomorphology	Glaciers, shoreline change, channel morphology, physical habitat index
	Subsurface Geologic Processes	Cave air quality, seismic activity
	Soil Quality	Biological soil crusts, soil structure and stability, soil cover, permafrost
Water	Hydrology	Groundwater dynamics, surface water dynamics, stream flow, lake and pond elevation, saltwater marsh water table
	Water Quality	Water chemistry, chloride flux, kettle pond acidification, nutrient loading and eutrophication, pollutant metals, aquatic macroinvertebrates
Biological Integrity	Invasive Species	Invasive/Exotic plants early detection, areal extent of established populations, exotic aquatic assemblages
	Infestations and Disease	Whitebark pine disease, forest insect/disease outbreaks
	Focal Species or Communities	Landbirds, forest vegetation structure & composition, fish communities, intertidal communities, salt marsh vegetation, seagrass communities, wetland vegetation, riparian plant communities, prairie grassland communities, freshwater mussels, cave aquatic fauna, amphibians, white-tailed deer, caribou, wolves
	At-risk Biota	T&E plants, western prairie fringed orchid, northern spotted owl, western snowy plover, Ozark hellbender, Allegheny woodrat, Topeka shiner
Human use	Point-Source Human Effects	Contaminants, illegal roads and trails
	Non-point Source Human Effects	Estuarine nutrient inputs
	Consumptive Use	Fisheries harvest, poaching of native plants and animals
	Visitor and Recreation Use	Visitor usage
Landscapes (Ecosystem Pattern and Processes)	Fire and fuel dynamics	Fire occurrence and extent, fuel loading
	Landscape Dynamics	Land cover and use
	Soundscape	Soundscape
	Nutrient Dynamics	Nutrient cycling
	Productivity	Productivity, plant phenology

Table 2. Examples of priority vital signs and measures selected by NPS I&M Networks that can be addressed using remotely sensed data.

Network Vital Sign	Example of measures
Land cover, landscape pattern, habitat patch dynamics, etc.	Area of dominant land cover types, patch size distribution, connectedness, edge-to-area, fragmentation, etc.
Park insularization	Use of lands adjacent/near park boundaries. Road density, housing density, light, patch size, viewshed composition, etc.
Land use patterns, land use, etc.	Road density, housing density, other development & resource extraction adjacent to parks, impervious surface, structures, etc.
Land condition; vegetation condition and disturbance pattern	Cumulative NDVI; frequency, magnitude, and extent of 'disturbance'; greenness response to rainfall, extent of bare ground,
Insect damage	Presence of insect damage and defoliation, dead, stressed, or disease trees, intensity and rate of spread of pests
Plant phenology, snow pack extent, climate	Snow cover, change in start / end of growing season, change in length growing season,, ice on/off, flowering, PAR, soil surface temperature, soil moisture

NARSEC 2007 Oral Presentation Abstracts

Day 1 Abstracts – Remote Sensing for Monitoring Land Surface Change in Parks

The Role of RS Data in Monitoring and Reporting Ecological Integrity in Canada's National Parks

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Parks Canada Agency (PCA) has recently been revitalized through new legislation (Canada National Parks Act, 2000); the Act sharpens the Agency's focus on management accountability for the protection of ecological integrity (EI) in Canada's national parks. Under the revised Act, the "maintenance or restoration of EI" is the "first priority" for all park management decisions. PCA sees this EI mandate as inseparably linked to our larger Agency mandate to provide for public education and memorable visitor experience, and further, that our success in protecting park EI depends in large part on our relations with partners, stakeholders, and visitors. This mandate interaction is particularly relevant to park management issues involving landscapes contained within the greater park ecosystems of our national parks.

To provide data for increased accountability expectations, PCA launched the National EI Monitoring and Reporting Program in 2003, where all national parks will develop improved EI monitoring and reporting systems by 2008. Canada's 42 national parks have been working cooperatively within 6 bioregions under the guidance of bioregional monitoring ecologists to develop a most desirable set of EI Measures for 6-8 EI Indicators. For the most part the EI Indicators represent major park ecosystems such as lakes, streams, forests, wetlands, grasslands, tundra, shores and near-shore marine environments. EI Measures are the ecological factors assessed within EI Indicators. So for park forests for example, we sample EI measures (species composition, soil humus decay rate, stand structure changes, forest salamanders, forest songbirds) at a local (forest plot) scale, and at regional (landscape) scale, e.g., landscape pattern, productivity, land cover change. These EI Measures are assessed together to report the EI condition of the Forest EI Indicator, and are reported in 5-year State of the Park reports.

Landscape scale EI measures, to be derived from satellite and other remotely sensed data, are recognized as a very important component for long term EI monitoring in national parks in Canada. To develop state of the art methodologies, PCA is working with the Canadian Space Agency (CSA), scientists from the Canadian Centre for Remote Sensing (CCRS), and the University of Ottawa to develop effective, operational protocols to track changes in land cover, landscape pattern and biodiversity, and landscape productivity for the greater park ecosystem of our 42 national parks.

At NARSEC 2007 we will present the remote sensing (RS) monitoring methodologies we are developing with CCRS, university and Agency scientists for critical review and constructive input. Examples products for land cover change and landscape pattern assessment will be presented and contrasted for two pilot national parks. La Mauricie NP is a medium-sized, well-forested, and largely intact park that has been encroached by industrial harvesting over the last 30 years. St Lawrence Islands NP is a very small fragmented park, set in matrix of agricultural and semi-agricultural private properties.

Specifically, we are looking for input on a number of key questions:

1) For the RS methodologies we are developing on land cover change, analysis of landscape pattern, and biodiversity modeling:0
   a) Are these methods scientifically sound, and do they represent the latest thinking in the landscape ecology and RS technology science communities?
   b) How can the methods be improved to make them more useful, general and/or operational?
   c) What will be the largest problems with the operationalization of these methods across 42 national parks, and a wide range of biomes and greater park ecosystem (GPE) land use?
   d) What will be the effect of changes in RS satellite platforms and other technological developments on measuring landscape change over the long term?
   e) What should be the (optimum) spatial and temporal scale of an EO-RS framework for landscape/ecosystem monitoring considerations?
2) For developing EI monitoring targets and thresholds that will define a 'desired condition' for greater park ecosystems (GPE's) in and around parks:
   a) What are some key general rules for establishing targets and thresholds for GPE's that will apply across a wide range of natural systems and land use practices?
   b) How will these rules change between biomes, and under various intensity and kind of land use?
   c) Are the alternatives presented on Day 3 useful, scientifically valid, and can they be operationalized? What are the main roadblocks that you can foresee?
   d) What suggestions can be made for further refining our development of targets and thresholds for GPE's?

NPS Vital Sign Monitoring, Remote Sensing, and the Path to Thresholds and Assessment Points

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The intent of park vital signs monitoring (VSM) is to track a subset 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. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Thirty-two Inventory and Monitoring (I&M) Networks have been set up to implement vital signs monitoring across the 270+ US park units that contain significant natural resources. This large program is being implemented in phases; the first 17 networks are fully implemented, while the monitoring program in final two Networks should be funded in fiscal year 2008.

The broadly-defined vital sign "Landscape Dynanics" has been the most commonly identified priority vital sign across the entire I&M Program. This result is an explicit acknowledgement that factors both inside and outside park boundaries have profound effects on park resources, in every region of the country. The use of remotely sensed data will be critical to the success of the I&M Program, and NPS staff are actively seeking a means to efficiently develop, implement, and make operational the use of fine and coarse scale remotely sensed data.

Looking forward, a key challenge is to interpret and evaluate monitoring data, and communicate monitoring results in a forma that is understandable, relevant to park managers, and informs decision making. As a prelude to Day 3 of this conference, I introduce concepts and issues to routine use of ecological and management thresholds and assessment points. I will invite participants to engage fully in the critical task of identifying ways to develop and provide scientifically credibly guidelines for the use of quantitative, landscape-scale indicators that are relevant to management at the scale of individual park units.

Challenges and successes in developing Landsat-based monitoring protocols for national parks

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Monitoring the condition of many large national parks in the western United States is impractical with ground-based methods alone. Therefore, parks in the North Coast and Cascades Network (NCCN), the Southwest Alaska Network (SWAN), and the Northern and Southern Colorado Plateau (N&SCPN) have sought to develop monitoring protocols based on Landsat remote sensing data to complement other monitoring efforts. In many ways, park needs push the bounds of traditional remote sensing change detection approaches: all resources must be tracked everywhere every year, using methods that can be carried out in-house, with minimal ancillary reference data for training and validation. The process of goal-setting and prioritization involved significant learning on the part of both remote sensing specialists and park scientists and managers. Diverse monitoring goals had to be placed in the context of fundamental remote sensing concepts such as spatial, spectral, and temporal grain and extent, often encouraging re-statement of monitoring goals in new ways more appropriate for remote sensing tools. Cooperative problem-solving showed that this subtle re-framing of goals and needs could lead to solutions that address most needs in most places with reasonable cost. The challenges and constraints have resulted in novel likelihood-based approaches for characterizing full suites of landscape change, validated with opportunistic sources of reference data that can range from satellite imagery itself to airphoto interpretation or field data collection.

Land cover change protocol developed for a Park Ecological Integrity Observing System (Park-EIOS)

R.H. Fraser, I. Olthof, and D. Pouliot

Canada Centre for Remote Sensing, Earth Sciences Sector, Natural Resources Canada. (authors listed in alphabetical order)

Parks Canada Agency (PCA), under the Canada National Parks Act, is responsible for managing Canada's National Parks through the "maintenance or restoration of ecological integrity (EI)". This requires a *State of the Park Report* be produced every 5 years for each park that describes EI in the context of the greater park ecosystem and the progress made toward achieving the goals of the previous park management plan. To help meet this obligation, PCA initiated collaboration with the Canada Centre for Remote Sensing (CCRS) and University of Ottawa in 2004 to use satellite-based earth observation (EO) as a basis for a Park Ecological Integrity Observing System (Park-EIOS) and an integral component of the overall park EI monitoring framework. Park-EIOS is being developed for operational use in 2008 and includes coarse filter EI measures corresponding to Landscape Pattern (i.e. PCA's Fragcube), Succession and Retrogression, Net Primary Productivity, and Focal Species Distributions.

A primary input to produce all four EI measures will be a time series of land cover and disturbance information derived from 30m Landsat TM and ETM+ imagery. This presentation will describe an end-to-end change detection protocol developed for Park-EIOS, dubbed Automated Multitemporal Updating through Signature Extension (AMUSE). The AMUSE protocol involves the steps outlined below. It will be demonstrated for two pilot parks (La Mauricie NP in Quebec and St. Lawrence Islands NP in Ontario) using Landsat imagery from 1985-2005.

1. Radiometrically normalize baseline (Master) Landsat scenes to 1km SPOT VEGETATION reflectance using robust regression to create seamless mosaic.
2. Produce Master baseline land cover classification using an unsupervised approach (Enhancement Classification Method (ECM) and Classification by Progressive Generalization).
3. Register raw Landsat imagery for other dates to projected Master mosaic using automatic ground control point collection.
4. Apply a Haze Optimized Transform (HOT) to remove spatially variable aerosol effects in each scene.
5. Radiometrically normalize other dates to Master using TheilSen robust regression and mosaic.
6. Identify changed pixels in other dates using Change Vector Analysis (CVA) and interactive thresholding.

7. Update land cover for changed pixels in other dates using constrained signature extension. This involves extrapolating the labelled land cover clusters (i.e. spectral signatures) from the Master baseline and applying minimum distance supervised classification. An expert rule set is used to constrain transitions to feasible temporal trajectories based on knowledge of post disturbance vegetation succession.

Observing and Modeling Land Use Change from Urbanization across the Mid-Atlantic Region and its Ecological Implications

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The contemporary pattern of urbanization is increasingly taking the form of low density, decentralized residential and commercial development. These dispersed development patterns have been linked to degradation of agricultural and forest lands, and resulted in degraded water quality. Land management policies have been formulated in the Mid-Atlantic region and elsewhere to address this exurbanization process, and to mitigate its impacts, but unintended consequences of the policies sometimes result (e.g. “leap frogging”). I will present an overview of our work mapping and monitoring the expansion of dispersed development across the Mid-Atlantic region, including the 168,000 km^2 Chesapeake Bay watershed, and document where and how lands comprising the natural resource base have been replaced by a matrix of the built environment. I will also note how these changes impact stream biota, using extensive measurements collected by collaborators in Maryland. Finally, I will provide an overview of how we have used this information to calibrate models of the urbanization process that effectively capture the rate and pattern of change, and predict expected development into the future under a suite of different policy scenarios. These, in turn, were used to valuate the vulnerability of natural resources in the region to future urbanization. We are now in the process of expanding this analysis to assess the vulnerability of parks and protected areas in the region, including land use change around national parks and their ecological implications.

MRLC Land Cover Products

Collin Homer

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The Multi-Resolution Land Characteristics Consortium (MRLC) consists of 13 programs across 10 Federal agencies that acquire and process Landsat imagery and produce national landcover data. MRLC offers approximately 6,200 terrain corrected Landsat 5 and Landsat 7 ETM scenes spanning growing season dates from 1982-2006 for web-enabled download. MRLC also coordinates the development of the National Land Cover Database (NLCD 2001) for the Nation. The recent completion of NLCD 2001 at 30 m resolution for the conterminous United States (Alaska, Hawaii and Puerto Rico are in progress) provides several independent data layers that can be directed at a wide variety of applications. Completed data layers include: (1) normalized Landsat Thematic Mapper and Enhanced Thematic Mapper Plus (ETM+) imagery for three time periods per path/row; (2) elevation, slope, aspect, slope position, and other ancillary data; (3) per-pixel estimates of percent urban imperviousness and percent tree canopy, (4) a land cover product with 16 land cover classes and (5) and a product that identifies land-cover change between 1992 and 2001. This change product recreates both a 1992 and 2001 Anderson Level I classification, and provides a mechanism for post classification comparison to identify changed areas and assign a “from-to” change classification code. All MRLC imagery and NLCD data layers are available for download at www.mrlc.gov.

Status of the Landsat Data Continuity Mission and related activities

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Participants in the NARSEC 2005 meeting received a briefing on plans to place Landsat-like sensors on National Polar-orbiting Operational Environmental Satellite System (NPOESS) satellites to implement the

Landsat Data Continuity Mission (LDCM). As presented, this strategy was fraught with technical and programmatic challenges that have led to a revised approach. In December, 2005 the Office of Science and Technology Policy directed NASA to abandon the NPOESS strategy and to instead launch a free-flyer LDCM satellite. NASA has since worked to implement this direction. NASA released a request for proposals (RFP) for an Operational Land Imager (OLI) for the LDCM on January 09, 2007. The OLI is specified as a multispectral instrument capable of preserving the continuity of the Landsat data record in the visible, near-infrared, and shortwave infrared portions of the spectrum. Selection of an OLI design is expected by June and will be followed by a request for offers to deliver the LDCM spacecraft. NASA also continues to consider options for placing a thermal infrared sensor on the spacecraft although no decisions have been rendered at this time. These efforts lead to a target LDCM launch date of July 2011.

The delays resulting from the changes in LDCM implementation strategies will likely lead to a Landsat data gap. Landsat 5 and Landsat 7 remain in limited operation and can not realistically be expected to last until the LDCM launch. Several activities are ongoing to mitigate the impact of the impending gap and prevent future reoccurrences. These efforts include the development of a Mid-Decadal Global Land Survey, studies by a Landsat Data Gap Study Team, and recommendations from a Future of Land Imaging - Interagency Working Group.

Day 2 Abstracts – Landscape Pattern and Biodiversity in Parks

Evaluating landscape connectivity in an eastern US network of parks

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Small urban parks can play a vital role as biological refugia, migration rest stops, and dispersal corridors, all of which have been shown to greatly enhance regional biodiversity. The ability of parks to fulfill these functions is influenced by both landscape change within the parks and habitat loss and fragmentation in the surrounding environment. We are using a variety of remote sensing products to monitor changes in forest land cover for parks in and around Washington, D.C. Our analysis of pattern uses graph theory to evaluate impacts on local and long-distance connectivity for forest dwelling species. Two example applications will be described.

Like many of the parks in our region, Antietam National Battlefield Park is a mixture of grassland, forest, and historic structural features surrounded by increasing amounts of development. Effective monitoring of forest resources in this highly heterogeneous and fragmented landscape requires information from multiple property owners. We used a general measure of landscape-level connectivity to identify critical “source” and “pinchpoint” patches within the park for field monitoring of habitat quality. Increasing the extent of the analysis to consider lands outside the park identified new patches for coordinated monitoring with local land owners. A sensitivity analysis with different remote sensing platforms (from Ikonos 4-m resolution to Landsat 30-m) and different analysis extents consistently identified the same group of patches for follow-up field study.

Our study in Manassas National Battlefield Park provides an example of a more focused evaluation of local dispersal potential. We examined whether a forest cut proposed to return a portion of the park to historic battlefield conditions would result in isolation of forest patches containing sensitive amphibian populations. We modeled pre-harvest and post-harvest amphibian dispersal potential using Landsat TM imagery with digitized ephemeral ponds and forested fencerows. The analysis indicated that landscape connectivity will likely remain high following the proposed timber harvest, but at least one high-quality ephemeral pond may become locally isolated. Efforts to mitigate the impacts of the cut on local resources have been taken. These restoration efforts include removal of a small swath of land from an active hay lease to allow a new dispersal corridor to potentially develop across the fragmented landscape.

Pattern metrics and significance of changes in land use and cover for park resources

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Quantifying land use and land cover dynamics surrounding national parks has been identified as an important need by park managers and scientists. Here I present some basic metrics to quantify the dynamics of landscape composition, configuration, and connectivity around parks. These are useful to characterize the spatial context of different parks within their ecoregions, as well as to compare current conditions to historical and possible future landscape scenarios. Preliminary ways to place parks within the context of major processes – water, air, terrestrial, and human -- will also be provided.

Remote sensing based products applicable to National Park (ANP) monitoring in México

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The National Commission for the Knowledge and Use of Biodiversity (CONABIO) in México has been operating the "Operational Program for the Detection of Hotspots Using Remote Sensing Techniques" since 1998. This program uses images from the Moderate Resolution Imaging Spectroradiometer (MODIS) on board of the Terra and Aqua satellites, which are received through the direct broadcast station at CONABIO. This allows the monitoring of near real-time forest fire events in Mexico and the Americas on a daily basis. In addition to the detection of active fires, the fires are classified according to their location with respect to vegetation type, accessibility, and risk to nature protection areas. Special e-mail alerts are sent out several times on a daily basis in near real-time after fires are detected adjacent to national parks in México.

Analysis subsequent to fire events is necessary due to the considerable effects of forest fires on biodiversity and human life. This fire impact assessment is mandatory to support the needs of resource managers and policy makers for adequate fire recovery and restoration measures.

This paper will focus on the achievements of the CONABIO fire program and will give an overview of future activities and system improvements, in particular the development of a "Burnt Area" product for México will be developed to identify and quantify areas affected by forest fires with a special focus on biodiversity relevance. In addition, a fire propagation/risk algorithm is currently being developed and tested using MODIS time series analysis and modelling techniques as part of the monitoring system.

Our MODIS direct broadcast system is also used to develop an automated terrestrial product for land use change detection. This product is being developed in close cooperation with the German Aerospace Centre (DLR) to monitor land use and land cover changes, and will provide change information on vegetation and land cover dynamics several times a year. One of the prime users of this product will be Mexican national parks (ANP) providing multi-temporal remote sensing based information for continuous monitoring of land use and land cover change.

FragCube: An ecologically scaled landscape index for monitoring habitat area and landscape connectivity in Canada's national Parks Canada

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A draft landscape pattern monitoring protocol has been developed for Parks Canada based on ecologically scale landscape indices (ESLI). The procedure involves the creation of species profiles that targets a range of species known to be relatively sensitive to relatively tolerant of landscape fragmentation. These profiles form the basis for ESLI's that represent "effective patch amount" and "effective patch connectivity". Spatial and temporal patterns in these 2 metrics are assessed for monitoring. This ESLI

approach is intended to complement other aspects of a park's monitoring program that include more focused, species-specific monitoring.

Multi-scale assessment of biodiversity in Mexico - new approaches to a national gap analysis

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In the context of bringing together conservation efforts to generate strategies at a national level, numerous researchers and institutions performed a multiple-approach analysis to detect priority areas for conservation and an extensive gap analysis at a national level. Paying attention to the importance of scales in such exercises, analyses were designed at different levels of detail: from ecoregions down to species level. It was decided to separate the marine analysis from the rest because of its various peculiarities, like its intermediate analysis level, mixing regional and local data.

The ecoregional approach is concerned with how well represented are the 75 terrestrial ecoregions identified for Mexico in the 405 natural protected areas (155 federal and 250 state and county), which cover 11% of its territory. Additionally three indices were developed which characterize ecoregions and identify priorities for conservation: (1) biological importance, (2) level of threats and (3) conservation actions being undertaken.

For determining terrestrial priority areas for conservation, we compiled several different types of data for conservation objects, including areas of distribution of terrestrial vertebrates, occurrence data of some plant groups, crucial habitats and plant vegetation types, together with some pressure factors on biodiversity. Workshops were carried out to define the criteria to prioritize the conservation objects (such as endemism, rarity, etc.), and existing or potential threats to biodiversity (such as agriculture, fragmentation, fires, etc.). These parameters were fed into a model (MARXAN) in order to get an integrated view on conservation hot spots and a possible conservation network.

Priority areas for the conservation of coastal and oceanic environments were identified in an expert's workshop. The methodology was to first select priority areas at a national scale for taxonomic groups and to overlap all layers. Each pre-selected site was revised in a regional perspective and evaluated with biological and ecological criteria besides the mayor threats. The selected priority areas were then compared with the protected areas to find the gaps. We created a web page to accomplish a participative peer review among specialists and to have a continuative online tool, which serves for gathering relevant information, so a follow up assessment can be carried out easily.

The integration of various results for marine, island, freshwater and terrestrial priority areas is intended via a meta-analysis, to finally identify key sites for endemic, rare, and threatened habitats and species. Despite these multiple efforts, it has to be considered that a megadiverse country with a huge beta diversity like Mexico implies challenges and practical difficulties in identifying all biodiversity elements of concern in a small number of areas.

State of the science for modeling focal species distributions using RS inputs

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Maintenance of biodiversity is one of the defining objectives of park networks. Despite the importance of species conservation to the maintenance of parks' ecological integrity, poor data on species' distributions hinders effective management. This issue is particularly important in light of the essential roles required of parks to protect endangered species and safeguard native species against negative global change impacts. How can a small

number of observations of where a species occur be turned into an operational model of the species' entire range? A number of techniques now exist to facilitate this task and they have been tested quite extensively. There are no hard and fast rules about what techniques necessarily perform best, although some in particular have proven reliable (e.g. Maximum Entropy). Despite their use with spatial data, running these models through time is essential for management but also fraught with dangerous – or simply false - assumptions. An overview of different species modeling approaches will be presented with evaluations of their utility. New methods that can improve the reliability of these kinds of spatial models will be presented, drawing particularly on examples from Parks Canada-led research.

Landscape-scale indicators of protected area quality and effectiveness

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The creation of protected areas is a common strategy for the conservation of biodiversity. Frequently, protected areas are delineated within landscapes that have been substantially disturbed through resource extraction, development, or both. Information on the "natural" condition of the landscape prior to the disturbance would be helpful to predict whether protected areas established according to the constraints of the current landscape will, in fact, promote the persistence of diversity. We used historical aerial photographs obtained from the Provincial archives to reconstruct the history of disturbance in the Resort Municipality of Whistler, British Columbia. Whistler is in the process of establishing a protected area network that would contain rare, sensitive and unique ecosystems. Included on this list of ecosystems were wetlands, and our focus was to understand how development and timber harvesting had changed their abundance, distribution, and configuration. Wetlands are commonly associated with relatively high biodiversity. Wetlands are also known to be travel corridors for both wetland species and others. We were, therefore, particularly interested in how disturbance had altered the connectivity between the Whistler wetlands. We performed air photo interpretation to create a GIS-based map of the Whistler wetlands, major highways and train tracks, and the expanding development footprint at four different time periods between the 1940's and the present. Using these maps we were able to measure how the wetlands' abundance and distribution had changed, along with other indicators of quality such as the number of wetland patches, their size, and their shape. We also used a graph-based metric of connectivity to quantify how the connectedness of the wetlands was altered over time, and how this change in connectivity might differentially affect organisms with varying dispersal capabilities. Finally, we used the aerial photos in pairs to determine whether changes (primarily losses) in connectivity were due to changes to the wetland patches themselves or due to changes in the traversability of the matrix between the patches.

Ecological theory as a guide to biodiversity assessment and management in national parks

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The wide availability of remote sensing data and geographic information systems allows generation of many landscape pattern metrics for biodiversity assessment. A challenge is to know how to use such data to understand change in biodiversity condition and to prioritize management approaches. We suggest that use of ecological theory provides a guide for more effective monitoring and management of biodiversity in national parks. Two scales of theory will be explored. At the scale of NPS I&M networks, we will report a synthesis of ecological mechanisms linking changes in land use and climate outside of parks with biodiversity within parks. At the continental scale, we will use theory on biophysical controls of ecosystem processes and biodiversity to evaluate which parks have the highest contribution to biodiversity, and which are most vulnerable to land use, climate change, or both. We will close by suggesting that a multiscale (local to continental) assessment of park context and vulnerability provides and effective basis for guiding monitoring, analysis, management of landscape condition for biodiversity.

Day 3 Abstracts – Desired Conditions for Protected Landscapes - Setting Targets and Thresholds

Increasing the relevance of monitoring data – thresholds and assessment points

John E. Gross

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For monitoring data to be widely used in a management context, there must be a scientifically defensible interpretation of the effects of change on resources of interest. While mechanistic conceptual models can articulate the interactions between key variables or functions, there remains a need to identify the point where some action is merited. The use of threshold values is well established in a regulatory monitoring context, and over the past few years ecological thresholds have received considerable attention and promotion as a basis for ecological monitoring and management programs. However, evidence for thresholds or standards related to the composition, structure, and function of landscapes or biological communities remain elusive. Here, I review conceptual models for thresholds, challenges to their use in the context of monitoring and management of protected areas, and suggest using a more general approach of management 'triggers' or 'assessment points'. I briefly review previous work that has influenced discussions by NPS staff, current activities, and collaborative projects with USGS scientists that are just beginning.

Developing ecological integrity monitoring targets and thresholds to define 'desired condition' of terrestrial landscapes in and around national parks

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Canada's national parks, and protected areas in general, are geographically circumscribed areas in which protected areas managers are expected to meet conservation objectives, such as the maintenance of biological diversity, or in Canada's national parks, the maintenance or restoration of ecological integrity. It is clear that, in many parks, success in meeting conservation objectives inside the boundaries of protected areas depends to a large extent on the condition and use of ecological resources in areas surrounding protected areas. We define, for the purposes of meeting our management objectives, a 'greater park ecosystem' (GPE) that includes the protected area, plus a surrounding area where land use and ecological condition directly determine our success in meeting our management objectives inside protected areas. Factors that determine the location and extent of the greater park ecosystem may include the area required to maintain the genetic diversity of metapopulations of forest songbirds, species at risk or wide ranging predators, the watersheds of watercourses that flow into a park, or the main vectors for the introduction of alien invasive species. We are developing methods to use RS, and other ancillary data, to assess changes in the ecological condition of the area in and around the protected area defined by the greater park ecosystem.

Methods for measuring change in landscape variables such as land cover, vegetation pattern, human population trends, and road proliferations are well established, and are discussed in many presentations at this workshop. The challenge for protected areas scientists and managers is to be accountable to the public for the ecological condition of the park, and this means an assessment of landscape condition is required. An approach widely put forward is that the present condition of the landscape be compared against a 'desired landscape condition;' to make this assessment. In this workshop we present some approaches to assessing 'desired condition' of the landscapes of two contrasting parks – St. Lawrence Islands National Park, a small

(<25 sq km) park in a rural/semi-rural/forested matrix within the Thousand Islands-Frontenac Biosphere reserve; and La Mauricie National Park, a medium sized park (535 sq km) where the neighbouring landscape has been largely used for industrial forestry. For discussion and input at the workshop, approaches are put forward for developing EI monitoring targets and thresholds, establishing desired landscape condition, and providing assessments of the greater park ecosystem over 5 year time steps in 1985, 1990, 1995, 2000, and 2005

Speaker Biographies

Robert H. Fraser

Rob is a research scientist at the Canada Centre for Remote Sensing of Natural Resources Canada's Earth Sciences Sector. He did undergraduate studies in biology at the University of Ottawa, and then received Masters and Ph.D. degrees from the School of Forestry and Environmental Studies at Yale University. His doctoral research was supported by a NASA Graduate Fellowship in Earth Systems Science, and involved developing a watershed pollutant delivery model using a geographic information system. Since joining CCRS in 1998, much of his research has focussed on satellite remote sensing of boreal forest fires, including the development of an algorithm for annual mapping of burned forest across Canada. Rob was a member of the Natural Resources Canada team that developed the online Fire Mapping, Monitoring, and Modelling (Fire M3) system, which in 1998 was awarded the Head of the Public Service Award by the Privy Council Office. He has published over 25 journal articles on a wide range of topics including biodiversity, water quality, wildfire monitoring and mapping, and remote sensing based change detection.

Scott Goetz

Dr. Scott Goetz works on the application of satellite imagery to analyses of environmental change, including monitoring and modeling links between land use change of various types (e.g., urbanization, fire disturbance), forest productivity, biological diversity, water quality, and epidemiology. He maintains a long-term interest in ecosystem responses to climate change in high latitude ecosystems. Before joining the Woods Hole Research Center in 2003 he was on the Faculty at the University of Maryland College Park for 6 years, where he maintains an adjunct associate professor appointment. He was a research scientist at the NASA Goddard Space Flight Center from 1985 to 1995. He has authored more than 50 refereed journal publications and book chapters, and has edited special issues focused on applications of satellite remote sensing, including a new one (2007) on estuarine and freshwater systems. He serves on the editorial board of *Remote Sensing of Environment* and the *Journal of Geophysical Research – Biogeosciences*. He graduated from the Pennsylvania State University (BS), the University of California (MS), and the University of Maryland (PhD).

John Gross

John E. Gross has served as an Ecologist with the NPS Inventory and Monitoring Program, based in Ft. Collins, Colorado, since 2003. Before this, he served as a Principal Research Scientist with the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. John also has held a position with the Natural Resource Ecology Laboratory (NREL) at Colorado State University since 1990. His work with CSIRO and NREL included studies of conservation biology, population and disease dynamics, and systems ecology, and his projects have developed, tested, and applied ecological models over a broad range of scales from individual species to regional social-ecological systems. In working with the NPS I&M Program, John is coordinating activities to monitor of landscape dynamics and effects of landscape changes on park resources. John has served on many national and international panels and working group, and his

current appointments include the Implementation Team for the US-National Phenological Network, the Heinz Center working group on national landscape pattern indicators, and the IUCN Species Specialist Group for North American Bison. He obtained his BA from the University of Colorado, Boulder, his MS (Zoology) from Colorado State University, and PhD (Ecology) from the University of California, Davis.

Andrew Hansen

Andrew Hansen is Professor in the Ecology Department at Montana State University. He teaches introductory ecology to undergraduates and landscape ecology to graduate students. His research focuses on interactions among biodiversity, ecosystem processes, and land use, with an emphasis on landscape management. For example, he has examined the effects of land use change on biodiversity in nature reserves in Greater Yellowstone and five regions in the world. His work uses a combination of remote sensing, computer simulation and field studies. This research is funded primarily by NASA, EPA, USDA, conservation organizations, and the timber industry.

Collin Homer

Collin Homer has extensive experience in remote sensing and GIS applications to natural resource and ecological issues. During the past 16 years he has specialized in multi-scale remote sensing applications for land cover characterization throughout the United States. Currently, he is the Land Characterization project manager at the USGS Center for Earth Resources Observation and Science in Sioux Falls, SD. His project responsibilities include managing the National Land Cover Database (the medium-scale land cover database for the U.S.), and serving as the Multi Resolution Land Characteristics Consortium coordinator (MRLC) directing the partnership of 13 programs across 10 Federal agencies that acquire and process Landsat imagery and produce national land cover data. Additionally, he is engaged in directing the USGS Land Cover Institute and in developing new multi-scale remote sensing rangeland-monitoring tools in Wyoming.

Jim Irons

Dr. James R. Irons is the Landsat Data Continuity Mission (LDCM) Project Scientist and has also served as the Landsat 7 Deputy Project Scientist since 1993. He is a physical scientist in the Biospheric Sciences Branch, NASA Goddard Space Flight Center, where he has worked since 1979. Dr. Irons received his B.Sc. degree in environmental resources management in 1976 and the M.Sc. degree in agronomy in 1979 from the Pennsylvania State University. He received his Ph.D. degree in agronomy in 1993 from the University of Maryland.

Robert Kennedy

Robert works as a postdoctoral research ecologist for the Pacific Northwest Research Station of the USDA Forest Service. The central goal of his research is to understand how to best study ecological conditions and processes over large landscapes, using both mechanistic models and empirical observations with remote sensing. Since finishing his PhDon quantifying uncertainties in biogeochemical model outputs for landscapes (2004; Department of Forest Science, Oregon State University), he has worked with several national park system monitoring networks to develop protocols for remote-sensing based monitoring of landscape dynamics. He is also developing the sampling design for a project designed to use Landsat imagery for national estimation of forest disturbance dynamics, and is developing automated approaches for disturbance and recovery mapping in forested areas using dense time-series Landsat imagery.

Jeremy Kerr

Professor Kerr completed his B.Sc. at the University of Ottawa magna cum laude, his thesis addressing (rather overambitiously) human causes of extinction risk around the world. He went on to graduate work at York University, where he won the Governor General's Gold Medal. He accepted a Natural Sciences and Engineering Research Council Postdoctoral position with Professor Lord Robert May in Zoology at Oxford, where he also worked with Sir Richard Southwood and was affiliated with Merton College. Having stubbornly refused to apply for positions anywhere except Canada (which had none) for most of his post-doc, the Canada Centre for Remote Sensing, headed by Josef Cihlar, offered him a research position in September 2000. He moved to the University of Ottawa in mid-2002. His current research is funded through NSERC, CFI,

MRI, INAC, Environment Canada, Parks Canada, and the Canadian Space Agency and contracts handled through uOttawa's Institute of Environment. This work includes some of the first quantitative assessments of species endangerment in Canada, global change research using butterflies as model group, and extensive work in macroecology. He has publications in Nature, PNAS, TREE, and a variety of other significant scientific journals.

Melanie Kolb

Melanie Kolb holds a masters degree in geography of the University of Erlangen-Nürnberg (FAU) with specialization in physical geography and biogeography. In her study period she made several research internships in Mexico and Central America, before moving permanently to Mexico. Since 2005 she has worked in the National Commission for the Knowledge and Use of Biodiversity (CONABIO). Her tasks are mainly related to the modelling of biodiversity data and spatial analysis. As part of the gap team, she is involved in the terrestrial and marine gap analysis of Mexico.

Melanie has participated in various conferences with poster and oral presentations, like the 2005 National Gap Analysis Conference in Reno, Nevada, and other biogeography events. Currently she is participating in a special program from the Netherland's Environmental Agency, which is concerned with applying and adjusting a global model (GLOBIO) developed for the UNEP, on a national scale. In this model, historic and current impacts on biodiversity are used to determine the state of biodiversity and develop future scenarios, and thus can be used as to support decision makers and show them the impact of different policies in the future.

Todd Lookingbill

Dr. Todd Lookingbill is a Research Assistant Professor at the University of Maryland Center for Environmental Science (UMCES) Appalachian Laboratory. Prior to joining the faculty at UMCES, he worked on a postdoctoral research project with the National Capital Region of the NPS Inventory and Monitoring Program to (1) develop the monitoring protocol for landscape pattern analysis using remote sensing data, (2) organize information from all the protocols in conceptual models to inform logistics of sampling and assist in interpretation of monitoring data, and (3) create tools for synthesizing data and communicating findings to broad audiences (newsletters, conceptual diagram booklets, web pages). His primary research interests are in forest community ecology, including the effects of climate change and forest management; landscape ecology and spatial analysis of urban ecosystems; and ecohydrological modeling of the effects of land use change. He received his B.A. (1995) in Ecology and Evolutionary Biology from Princeton University and his Ph.D. (2003) from Duke University's Nicholas School of the Environment.

Donald McLennan

Donald McLennan is the National Ecological Integrity Monitoring Ecologist at Parks Canada. He heads up a team of bioregional monitoring scientists and park ecologists who are in the process of establishing effective EI monitoring programs across Canada's 42 national parks, to meet an agency deadline for 2008. Donald's training is in terrestrial ecology, where he worked as a private consultant working in terrestrial ecosystem mapping, ecosystem restoration, and riparian ecosystem management in British Columbia until 4 years ago when he joined Parks Canada. Donald has a Ph.D. in Forestry Ecology from the University of British Columbia, and an M.Sc. in palynology from Simon Fraser University."

Rainer Ressl

Dr. Ressl is the Director of Geomatics at the National Commission for the Knowledge and Use of Biodiversity (CONABIO) in Mexico City and is head of the GIS, remote sensing, and data georeferencing teams. His main tasks are the development and maintenance of a satellite remote sensing-based operational fire detection system for Mexico and Central America as well as the development of GIS and remote sensing based products and cartography for the monitoring of Mexican ecosystems with a special focus on biodiversity relevance. In addition, his group is developing methods for georeferencing large databases of specimen and species collections of México.

Dr. Ressl holds a masters degree in geography from the University of Munich (LMU) and received his PhD at the German Aerospace Center (DLR-DFD) in the year of 1999. During his time at DLR he headed the group for process automation for satellite image processing.

Dr. Ressl was project leader and co-investigator of several international research projects funded by NATO, UNESCO, USAID and BMBF.

His main fields of expertise are GIS, satellite remote sensing, ecosystem monitoring and modeling.

Kristina Rothley

Kristina Rothley has been an Assistant Professor at Simon Fraser University in the School of Resource and Environmental Management since 2001 and is interested in the design of protected areas. She has worked with quantitative decision support models that are used to select sites to be included in bioreserve networks and done field research that questions the criteria used for site selection in these models. She is also interested in how animal behavior is accommodated into the design of bioreserve networks.

Dave Theobald

David Theobald is a conservation planner interested in understanding patterns of landscape change and their effects on wildlife habitat and biodiversity, especially in the Rocky Mountain west. He received his Ph.D. from the Department of Geography, University of Colorado, Boulder, and his M.A. from Department of Geography, University of California, Santa Barbara. Currently David is an Associate Professor in Human Dimensions of Natural Resources and a Research Scientist at the Natural Resource Ecology Lab at Colorado State University.

In the past, David has helped to develop the Colorado Natural Diversity Information Source (NDIS), an online source of information on wildlife, habitat, natural communities and plants in Colorado. He also has written and lectured extensively on landscape change in the West, including contributions to the *Atlas of the New West*, *Forest Fragmentation in the Central Rocky Mountains, Rocky Mountain Futures*, and the *Forests on the Edge* project.

David's current research includes developing ways to measure landscape connectivity as part of the Linking Colorado's Landscape project, how land use changes in watersheds effect freshwater ecosystems (for EPA), and the dynamics of the wildland urban interface.

Woody Turner

Woody Turner is the Program Scientist for Biological Diversity and Program Manager for Ecological Forecasting in the NASA Headquarters Science Mission Directorate. As program scientist, he oversees the agency's basic research efforts to use satellite-derived information to understand the relationship of biodiversity to climate, landscape change, and ecosystem function. The NASA Ecological Forecasting Program is an applications activity seeking to bring together satellite observations and ecological models to support decision making for conservation biology and sustainable regional development. Born in Nashville, TN, Woody graduated from the University of North Carolina, Chapel Hill in 1982 and earned master's degrees in public affairs from Princeton University in 1987 and in conservation biology from the University of Maryland in 2001. He lives in Chevy Chase, Maryland, with his wife Jennifer and their two children.

Paul Zorn

Paul Zorn has worked for Parks Canada for 14 years as a park ecologist for Georgian Bay Islands National Park and a conservation biologist for the Ontario Service Centre. His current position is monitoring ecologist and coordinator for the Great Lakes Bioregion. He holds a Master's degree in environmental planning from York University and is a PhD candidate in landscape ecology from Carleton University. Paul has 3 daughters, including an 8 week old, and is generally quite tired.

Poster Abstracts

Bergen, S. and E. W. Sanderson. Using High Spatial Resolution Satellite Imagery to Census Wildlife in Wild Places

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With the advent of commercially available high spatial resolution space based imagery identifying and enumerating wildlife, Pacific walrus (Burn and Weber 2002), orca and humpback whales (Alibeah *pers comm*), and African elephants (African Elephant Trust 2002). Our studies have quantified the type of fauna able to be detected and identified within which range of habitat types (Bergen and Sanderson, in review). Our projects use high spatial resolution satellite imagery (Quickbird-2) to identify wildlife at the Bronx Zoo, Ruaha National Park, Tanzania, National Elk Refuge, Wyoming USA, and coastal Patagonia, Argentina.

Verifying mobile wildlife in wild conditions for validating the use of high spatial resolution satellite imagery poses unique logistical challenges, since it is necessary to explicitly locate individual animals in space and time. Using data collected at the National Elk refuge in Jaskson, WY, we show how ground census procedures document the location of over 6,000 elk and 800 bison occurring on the refuge on February 12th, 2006. These ground census procedures use digital photography that can cross-reference digital ground photography with individual elk reflectance spectra in the satellite imagery. This cross referenced database allows us to test hypotheses concerning individual animal attributes (sex, size), behavioral attributes (grazing, resting, walking) and contextual attributes (orientation relative to sun angle) on reflectance spectra.

We compared ground counts, photo-panoramic counts, manual interpretation, supervised classification and object-oriented classification procedures in means of their accuracy for counting elk and bison. Our results find that manual interpretation is the most accurate with object-oriented classification, ground counts, supervised classification, and photo-panoramic counts trailing in their accuracy. The efficiency of these different methods will be discussed in relation to monitoring large populations. Object-oriented classification can distinguish different species accurately based on spatial, reflectance, and contextual information. For some species, it is possible to identify sex and social rank using these techniques.

Dubayah, R., M. Hofton & J. Bryan Blair. The Use of Airborne Lidar for Biodiversity Studies and Large Area Habitat Characterization

University of Maryland, College Park (RD, MH), NASA Goddard (JBB)

Lidar remote sensing has emerged as an important technique for quantifying forest vertical and spatial structure at both local and landscape scales. Variables such as canopy height, canopy cover, biomass, basal area, foliar and light profiles, as well as subcanopy topography may be routinely retrieved using lidar. The accuracies obtainable generally exceed (sometimes greatly so) those from other remote sensing methods. The two major limitations most often cited by land managers with regards to lidar are its expense, and the perceived level of expertise required to produce map products. In addition, the novelty of the data, as compared to products managers traditionally use, presents interesting problems related to the actual application of lidar-derived maps of forest structure within existing monitoring and inventory frameworks.

In this poster we summarize some of our efforts for large area mapping of forest structure using a NASA lidar sensor (the Laser Vegetation Imaging Sensor -LVIS) in support of biodiversity/habitat studies. Using LVIS we have mapped parts of national forests, national parks, long-term ecological research areas and wildlife refuges, in some cases more than once. Here we focus on two projects of special relevance to the conference.

In the first, we show lidar mapping of potential California spotted owl habitat in Sierra National Forest. We relate maps of biomass, canopy cover and canopy height to owl nest location and demographic data. In doing so we are able to quantify in terms of structure what types of old growth forests owls prefer. From this we generate a map of potential owl habitat. In our second example, we recently flew over 1 million acres of the Big Woods region in Arkansas in support of the search for the ivory bill woodpecker. In this case management factors thought to be important for the ivory bill were specified a priori, and lidar was used to map appropriate ones. The project is notable for the large area flown, the quick turnaround of map products and the relatively low cost. The map products are being used now to aid the hunt for the species.

Our experiences suggest that a baseline of lidar data for park areas would be extraordinarily useful for habitat characterization, for biodiversity studies, and for long-term monitoring of ecosystem structure dynamics. Considering the richness of the data products, we argue it is both cost-effective and no more complex to use than other types of spatial data. With the recent announcement by the US Geological Survey of a National Lidar Initiative, efforts that help demonstrate and define the efficacy of lidar within parks will be of great importance.

Fraser, R.H. , I. Olthof, and D. Pouliot. The Automated Multitemporal Updating through Signature Extension (AMUSE) for generating land cover time series

Canada Centre for Remote Sensing, Earth Sciences Sector, Natural Resources Canada. (authors listed in alphabetical order)

Land cover is an essential input to the Park Ecological Integrity Observing System (Park-EIOS) used to generate ecological indicators of landscape pattern, succession and retrogression, net primary productivity, and focal species distributions. As a main input to these indicators, the land cover time series must be robust while maximizing the information content extracted from earth observation data. This poster presents details and examples of the current Automated Multitemporal Updating through Signature Extension (AMUSE) protocol for generating land cover time series from Landsat data. The protocol addresses both ends of the processing chain by ensuring high geometric and radiometric quality for input and correcting known limitations in the change and classification algorithms. As these limitations are not constant with data source or region, this often requires some data\region specific processing steps, but overall the AMUSE protocol achieves it objectives in an automated manner. Future efforts are planned to evaluate the protocol for migration to sensors that acquire data in different spectral bands and at higher spatial resolutions than Landsat.

Geller, G.N. TerraLook: Providing Easy, No-Cost Access to Satellite Images for Busy People and the Technologically Disinclined

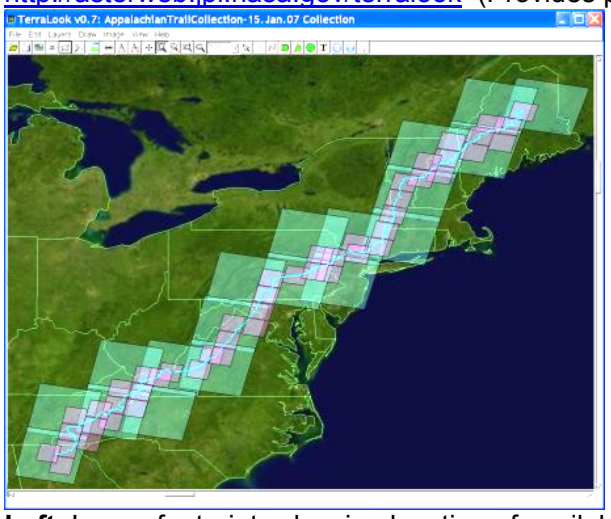
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA USA

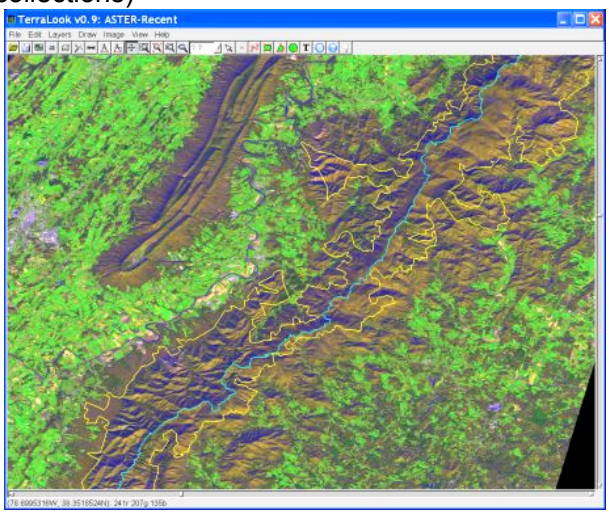
Access to satellite images has traditionally been limited to science communities with specialized tools and expertise, even though other communities could also benefit from them. TerraLook, formerly called the Protected Area Archive, evolved out of discussions with Protected Area managers and removes obstacles to access by providing collections of satellite images along with a simple Viewer/Toolkit for visualization and analysis. The image collections are generated at the US Geological Survey's Data Center for EROS, which provides a website so users can select the scenes they want to include. The images available include recent ASTER data (15 m pixels) and historical Landsat data from about 2000, 1990, and 1975 (30 or 80 m pixels). A collection can contain one, or many hundreds of images, and can cover, for example, a single park, a watershed, or a country; all collections are free. The Viewer/Toolkit is a free, open source, image processing and GIS software package; major capabilities include:

- Image find, roam, and zoom
- Image enhancement
- Distance and area measurement
- Multi-band dataset support (many formats)
- 3-D viewing capability
- Image annotation (adding text, arrows, etc,)
- View, edit, and create overlays
- Image mosaicking
- Image comparison using "flicker"
- Classification

Using the simple and intuitive capabilities of the Viewer/Toolkit (or any GIS software), users can display protected area boundaries and other overlays on the image, annotate the image so it can be used as a communication vehicle, compare images taken at different times, and perform other activities useful for conservation management. More information is available at:

http://edc2.usgs.gov/terralook (Allows users to specify custom collections)
http://asterweb.jpl.nasa.gov/terralook (Provides pre-existing collections)





Left: Image footprints showing location of available images for the Appalachian Trail collection.
Right: Sample ASTER image showing Shenandoah National Park and the Appalachian Trail.

Goetz, S. and Patrick Jantz The Influence of Roads and Buffer Depth on Habitat Core Areas and Connectivity in and around Parks and Protected Areas in the Northeastern USA

The Woods Hole Research Center (SG), University of California, Santa Barbara (PJ)

Land development pressures that threaten habitat core areas and connectivity are intensifying across the nation and extending beyond urbanized areas in the form of rural residential development. This is particularly true in the temperate forests of the northeastern United States, where we used a suite of nationally available data sets to identify roadless (core) areas and associated habitat connectivity metrics. The data sets include road networks and derived road density as well as impervious cover (developed areas) and forest canopy density derived from satellite imagery. We analyzed the influence of different types of unimproved roads and amount of forest cover on identification of the extent and configuration of core areas, and then assessed these areas in terms of land ownership (public, private) and management (parks, refuges, multi-use). Unimproved roads (logging, fire, four-wheel drive) caused a 14% decrease in core area identified whereas requiring a 60% tree cover threshold caused a 4% decrease in core area identified. Most core areas were in multi-use management/ownership regimes that lack strong protection. We derived habitat connectivity metrics using a graph theory approach, making use of cost surfaces that accounted for the above variables and associated landscape metrics. Our results identify key differences in various portions of the study region, e.g., large, restricted-use core areas had more direct connections to surrounding habitat, and core areas in Maine and New Hampshire were intersected by a higher proportion of least cost paths. The derived maps and stratified metrics suggest a starting point for the construction of a more comprehensive and ecologically functional reserve network for the region. Because the data sets used are nationally available, similar analyses could be conducted to assess the extent and status of roadless and protected areas for other regions of the nation. If current trends continue, increased conversion and fragmentation of many areas by exurban development is likely, exacerbating the likelihood of local species extinctions and complicating efforts to preserve intact, functional ecosystems.

Grunblatt. Jess. Alaska National Park Service Base Cartographic Inventory – Orthoimagery

National Park Service

USGS 1:63,360 topographic maps are the only uniform mapping base for most Alaskan Parks. These are based on 1950's photography and often do not accurately reflect significant landscape changes that have occurred over the last 50 years. In addition, with the advent of personal GPS units, the ability of researchers and the public to identify spatial location has exceeded the accuracy of this mapping.

Alaska's National Parks are large and remote. Severe logistical and weather constraints limit opportunities for imaging. Satellite platforms represent an efficient means for imagery collection and subsequent ortho production for Alaska's National Parks.

Grunblatt, Jess. Alaska National Park Service Landcover Inventory

National Park Service

The Katmai National Park and Preserve Landcover Mapping Project was initiated in 2000 and completed in 2002. The study area included over 4,000,000 acres of rugged and remote wilderness. Landsat TM 7 data from four satellite images were used to develop a landcover classification for Katmai National Park and Preserve. Supervised and unsupervised techniques were used to generate a spectral database of over 1300 unique spectral signatures. These spectral signatures were then assigned vegetation cover attributes based on available field data. Map categories were assigned to each signature based on the vegetation attributes using a rule set that was intended to identify the important landcover types encountered in the study area. The 1300+ signatures together with vegetation attributes and 37 calculated map classes were implemented in an ACCESS database as a spectral database and as a GRID geodataset.

Kennedy[1], Robert E., Amy E. Miller[2], Warren B. Cohen1. Landsat-based Monitoring of Vegetation in the national parks of the Southwest Alaska Network (SWAN)

[1] *Pacific Northwest Research Station, USDA Forest Service, Corvallis, OR*
[2] *Inventory and Monitoring Program, Southwest Alaska Network, Anchorage, AK*

We are currently developing methods to monitor vegetation dynamics in the large national parks in the Southwest Alaska Network (SWAN). Key monitoring objectives include detection of localized disturbance (e.g., avalanches and landslides), insect and disease-related mortality, fire, volcanic eruptions/ash deposits, succession in vegetation after change in snow and ice cover, change in river channel morphology and vegetation, and various encroachment processes in shrub and lichen-dominated communities. The underlying methodology is a likelihood-based fuzzy classification of change that characterizes spectral change in terms of a handful of simple physiognomic land cover classes. The method has been applied to vegetation change mapping in Lake Clark and Katmai national parks, using historical Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) data. Through analysis of change images and field visits, we have shown that many monitoring objectives can be tracked with relatively high confidence, while some important monitoring goals involve subtle spectral change that will likely require incorporation of high-temporal-resolution imagery (Moderate Resolution Imaging Spectroradiometer) or additional historical imagery (Multispectral Scanner) for increased confidence in change detection.

Margriter[1], Sandy , Fritz Klasner[2], Page Else[3], and Viet Doan[3] Landscape change monitoring in the tropical Pacific

[1] *National Park Service, Pacific West Regional Office*
[2] *National Park Service, Pacific Island Network*
[3] *Pacific Cooperative Studies Unit, Pacific Island Network*

A long-term Vital Sign monitoring protocol to detect change in earth surface (land) cover and use, an indicator of ecosystem health, is being prepared for the US National Park Service, Inventory and Monitoring

Program, Pacific Island Network. Encompassing islands and marine waters in Hawaii, Guam, American Samoa, and the Northern Mariana Islands, monitoring will include parks and adjacent areas, complementing other inventory and monitoring efforts such as invasive species detection and vegetation mapping. Land cover monitoring methods use remote sensing, while detailed land use monitoring emphasizes GIS and ancillary data sources (such as census, public infrastructure, zoning, stewardship, and tax maps). Syntheses analyses will document landscape change, interpret observed changes, and evaluate their significance for park managers. Partnerships with University of Hawaii, US Forest Service, and others enhance the value and utility of these efforts, expanding the geographic extent where comparable monitoring is occurring.

McCanny[1], S., D. Kehler[2], P. Lee[3], D. McLennan[1], C. Ouimet[4], S. Rasheed[5], J.Rettie[4], C. Samson[6], and P. Zorn[7]. Drawing lines in the sand: Selecting interim thresholds for reporting on ecosystems

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Thresholds, strictly speaking, represent dramatic shifts in the function of an ecosystem. They provide clear boundaries for managing protected area ecosystems. In reality, thresholds are much fuzzier. In the absence of clear ecological thresholds, ecologists still must interpret data for managers and the public. Hence, ecologists are placed in the uncomfortable position of selecting interim thresholds to serve as decision points for reporting the status of our protected areas. We must provide a rational, unbiased defence for these interim thresholds. This problem is particularly critical for new monitoring programs. Here, we offer a flow chart for choosing thresholds on the basis of the information at hand. The approach focuses on the distribution of the measure and its relationship with known stressors. The approaches for threshold selection include: 1) change detection, 2) stress detection, 3) natural threshold detection, 4) range segmentation, 5) correlation with stressors and 6) natural threshold detection in the context of the entire range. We focus particularly on strategies 1, 2 and 4, as they are the most useful for relatively new monitoring systems. We provide specific threshold values geared to the chosen statistic, the variance of the measure, and the number of locations or individuals sampled. They are a starting place on which ecologists and managers can base their efforts to collect and interpret data. Ultimately, a long term, integrated data set will provide more fertile ground for threshold selection.

Melton[1], F., R. Nemani[2], P. Votava[1], A. Michaelis[1], C. Tague[3], K. Ichii[4], H. Hashimoto[1], C. Milesi[1], B. Kuhn[5], L. Tarnay[5], L. Mutch[6]. Ecological Forecasting for Protected Area Monitoring and Management

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The Terrestrial Observation and Prediction System (TOPS) is currently being applied to automate the production, analysis, and delivery of a suite of data products from NASA satellites and ecosystem models to assist managers of Sierra Nevada Network parks in monitoring ecosystem condition. TOPS uses ecosystem models to combine satellite data with ground-based observations to produce real-time estimates and forecasts of ecosystem conditions. We are utilizing TOPS to deliver data products for SNN parks in near real time with the goal of supporting monitoring and operational decision-making. Current products include estimates of vegetation condition, ecosystem productivity, soil moisture, watershed outflow, evapotranspiration, snow cover, fire occurrence, and others. In addition, the use of TOPS to automate the identification and display of trends and anomalies in ecosystem conditions will assist protected area managers in tracking park-wide conditions daily, identifying changes, focusing monitoring efforts, and improving decision making through infusion of NASA data.

E.L. Montano[1], K. Benedict[2], B. Parmenter[3]. Proactive Grazing Management in the Valles Caldera National Preserve Using Internet Mapping Services and Remotely Sensed Forecast Models

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The Valles Caldera National Preserve (Preserve) is a unique experiment in sustainable management, multiple use, and self-sufficiency. The use of portions of the Preserve as a working ranch is an integral part of the management mandate and continues a long tradition of cattle grazing on the Valles Caldera. The Preserve currently performs active and innovative management of these grazing lands through adaptive stock size and day-to-day monitoring of activity and impacts. This poster explores the Internet mapping service developed by the Preserve in conjunction with the University of New Mexico's Earth Data Analysis Center to address the needs of active management.

The current service is used to deliver daily Normalized Daily Vegetation Index (NDVI) data from the MODerate Resolution Imaging Spectroradiometer (MODIS). To further address the needs of active management and proactive management, the Preserve is implementing a forecast model of NDVI values as part of the internet mapping service. The forecast model is the result of the combination of high-temporal frequency remote sensing products from MODIS with precipitation products from the NEXt Generation RADar (NEXRAD). The model provides a foundation for future research in biomass estimates from NDVI, refinements to the discrete temporal resolution of the model, and season-wide simulation models. The presentation of these spatial tools allows managers to see what is occurring and forecast potential impacts of management practices.

Wang[1*], Y.Q., Joy Nugranad[1], Greg Bonynge[1], Brian Mitchell[2] and Greg Shriver[2, 3]. Impacts of Land-Cover Change on the National Parks of the Northeast Temperate Network

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The Northeast Temperate Network (NETN) was established by the United States National Park Service (NPS) to monitor ecological conditions in 11 parks with diverse cultural and natural resources in eight northeastern states including Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania, as well as the six additional states through which the Appalachian National Scenic Trail (AT) passes. The NETN, together with the other networks of the NPS Inventory and Monitoring Program, has identified landscape dynamics as a high-priority vital sign. This is due to changes both within and adjacent to park properties and the AT that alter water quality and flow regimes, increase invasive plant and animal introductions, reduce contiguous forest, and influence ambient sounds and clear night skies, among other impacts. Most ecosystems in the Northeast have experienced some level of habitat fragmentation, which has been implicated as a principal threat to most species in the temperate zone. The primary objectives of this project were 1) to document general land-cover types within and surrounding selected 8 NETN National Park units and 10 AT segments for 3 time periods from early 1970's, mid-1980's, to 2002; 2) to quantify land-cover change within and adjacent to the selected sites at 5-km buffer area for the three time periods, and 3) to assess the impacts of land-cover change on those units and the neighbouring protected lands with different sized buffer zones.

We acquired and processed thirty-three (33) scenes of Landsat images, eleven (11) scenes for each of the three time periods in 1970s, late 1980s, and early 2000's, respectively. We defined the generalized land-cover classification scheme to accommodate as much of the United States Geological Survey National Land Cover Dataset and NPS Vegetation Mapping Project as the data permitted. We employed supervised, unsupervised, and stratified classifications for data processing. We applied 5-km buffers on the boundary of

each park unit to designate study areas and to subset Landsat images. To understand the pattern of land cover change, we created additional 500-meter and 1-km buffers based on the park boundary and AT segment GIS data, then applied these buffers on the land cover classification data to extract land cover information within the different buffer zones, which included 1) within the park boundary (not applicable for the AT segments), 2) between the park boundary and 500-meter adjacent areas, 3) between park boundary and 1-km adjacent areas, and 4), between the park boundary and 5-km adjacent areas.

The change analysis results revealed how the landscapes had changed and provided about 30 years of background information on spatial and temporal dynamics of the land covers, which will help NETN in resource monitoring and management planning.

Wang[*1], Y.Q., Michael Traber[1], Bryan Milstead[2, 3], and Sara Stevens[2] .Remote Sensing of Terrestrial and Submerged Aquatic Vegetation in Fire Island National Seashore

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The vegetation communities and spatial patterns on the Fire Island National Seashore (FINS) are dynamic as the result of interactions with driving forces such as sand deposition, storm-driven over wash, salt spray, surface water, as well as human disturbances. The Northeast Coastal and Barrier Network of the National Park Service identified two further efforts to enhance the existing vegetation map. Firstly, updating of the vegetation mapping product should be completed on a regular basis to ensure monitoring of the dynamic changes of the vegetation communities in this barrier island. Therefore exploration of new data sources and approaches that could efficiently update the vegetation maps is necessary. Recent development of high spatial resolution satellite remote sensing images can meet the goals of the project. Secondly, a missing component from the existing vegetation map was the information about submerged aquatic vegetation (SAV) such as seagrass species and beds. Seagrass communities are among the richest and most productive coastal systems. Seagrass protect and improve water quality, provide shoreline stabilization, and are important habitats for an array of fish, birds, and other wildlife. Natural and human impacts on these vital resources from population growth, pollution, physical damage and other activities can disrupt the growth of seagrass communities and have devastating effects on their health and vitality. Inventory and monitoring are required to determine the dynamics of seagrass ecosystem and management and restoration for these rich resources. Extraction of information about SAV at the FINS becomes necessary.

We used high spatial resolution QuickBird-2 satellite remote sensing data to map both terrestrial and submerged aquatic vegetation communities of the National Seashore. We adopted a stratified classification and unsupervised classification approach for mapping terrestrial vegetation types. The classification scheme included detailed terrestrial vegetation types identified by previous vegetation mapping efforts of the National Park Service and three generalized categories of high density seagrass, low density seagrass coverage and unvegetated bottom to map the submerged aquatic vegetation habitats. We employed under-water videography, GPS-guided field reference photography, and bathymetric data to support remote sensing image classification and information extraction. This study achieved approximately 82% and 75% overall classification accuracy for the terrestrial and submerged aquatic vegetations, respectively, and provided an updated vegetation inventory and change analysis for the Northeast Coastal and Barrier Network of the National Park Service. The study established a protocol for mapping coastal vegetation communities using high spatial resolution remote sensing data and existing GIS data, in particular for the purpose of long term monitorings.

Young[1], Eric R., and Jeremy T. Kerr[1] .Using high-resolution earth observation satellite data to model wood turtle (*Clemmys insculpta*) distributions in La Mauricie National Park

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The wood turtle (*Clemmys insculpta*) is listed as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Successfully modeling the distribution of wood turtles offers potential in conservation biology, where management plans can be put forth according to the models constructed. Landsat ETM+ land cover and elevation-derived variables were used to model the distribution of the wood turtle in and around La Mauricie National Park with Maximum Entropy computer software. Preliminary results indicate that the models constructed are highly accurate, with an area under the curse value of roughly 0.95. Models constructed from this study will not only allow park managers to potentially locate wood turtles, but will also pinpoint optimum habitat for possible relocation purposes.

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