PALMS: Monitoring, Evaluating, and Forecasting the Condition of Park Landscapes

John Gross, Andrew Hansen, Scott Goetz, David Theobald, Forrest Melton, Nathan Piekielek, and Rama Nemani

Funded by NASA and NPS

Yosemite and Sequoia-Kings Canyon NP

Big South Fork NRRA and Great Smoky Mtns NP

George Wright Society
March 2011

Overall Project Goal

Integrate the routine acquisition and analysis of NASA products and other data sources into I&M and use these NASA products to evaluate and forecast ecological condition of US National Parks.

Make operational the use of NASA data and products by NPS I&M

Conceptual issues -> objectives

- What area should be monitored?
- What aspects of land cover and use are the highest priorities for monitoring and management?
- How do we assess the effects of change in land cover and land use on park resources, such as biodiversity?

Focal Parks

North Coast and Cascades
Rocky Mountain
Yellowstone
Upper Columbia Basin
Northern Great Plains
Great Lakes
Northeast Temperate
Klamath
Greater Yellowstone
Grand Teton
Eastern Rivers and Mountains
Delaware Water Gap
Upper Delaware
Northeast Coastal and Barrier
Northern Colorado Plateau
Rocky Mountain
Sierra Nevada
San Francisco Bay Area
Yosemite
National Capital Region
Heartland
Cumberland / Piedmont
Sequoia / Kings Canyon
Mojave Desert
Southern Colorado Plateau
Mid Atlantic
Mediterranean Coast
Southern Plains
Appalachian Highlands
Sonoran Desert
Southeast Coast
Chihuahuan Desert
Gulf Coast

NPS Collaborators

Name	Lead I&M Network
Cathie Jean, Rob Daley, Tom Olliff, Rob Bennetts	Greater Yellowstone Network
Mike Britten, Billy Schweiger, Brent Frakes, Ben Bobowski	Rocky Mountain Network
Matthew Marshall, Richard Evans, Dorothy Hamilton, Leslie Morlock	Eastern Rivers & Mountains Network
Linda Mutch, Bill Kuhn, Andi Heard, Alice Chung-MacCubrey	Sierra Network

Objective 1. Landscape-level indicators and Protected Area Centered Ecosystems

- Select appropriate indicators of change.
- Build on conceptual framework linking national parks to land use change on surrounding lands to identify area for monitoring (Hansen and DeFries 2007).

Selecting Indicators

- Practical
- Relevant
- Iterative process

PALMS Indicators

Category	# of Indicators
Climate and Weather	3 (4)
Biodiversity (stream health)	1
Land Cover	7
Extreme Disturbance	1 (2)
Primary Production	1 (3)
Monitoring Area	1
Land use	1

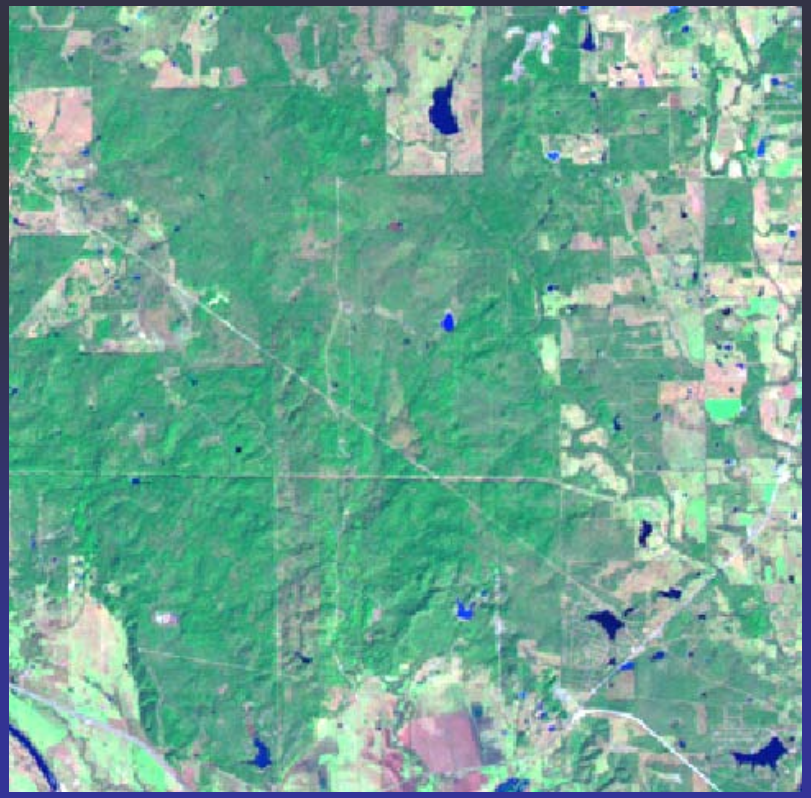
Land cover and land use

Category	Indicator	Extent	Resolution
Weather and Climate	Phenology (NDVI), annual anomaly	CONUS	1 km; 8 & 16 day
	Climate gridded daily 1980-2010	Focal parks	1 km
	Climate scenarios (monthly)	CONUS	12 km
Stream health	Sensitive taxa	DEWA	1:24K, 1:100K
Land Cover	Ecosystem type composition	Focal parks	30 m
	Bird hotspots and key habitat types	GYE	1 km
	Impervious cover change	DEWA	30 m
	Housing density (1940 – 2100)	CONUS	100 m
	Landscape connectivity of forests	Eastern US	270 m
	Pattern of natural landscapes	CONUS	270 m
	Past to future land cover modeling	DEWA	30 m

Category	Indicator	Extent	Resolution
Extreme Disturbance Events	Fire effects via changes in phenology and related measures	Focal parks	1 km
Primary Production	Gross and Net primary productivity (via simulation model results)	Focal parks	1 km
Monitoring area	Protected area centered ecosystem (PACE) boundaries	Focal parks (+ others)	30 m
Land use	Land use	CONUS	90 m

What's the appropriate area for monitoring?

- Human edge effects
- Habitat area
- Crucial habitats
- Ecological flows
- Sustain dynamic processes



(Hansen and deFries 2007; Hansen et al in press)

Land Use Intensification

- Alter material and energy flows
  - Air, water pollution → Nutrient, chemical, & sediment runoff
  - Altered flow regime → Dams, runoff from less permeable surfaces
- Habitat conversion
  - Isolation
  - Loss
  - Pattern
  - → Residential development, roads, crops, grazing, flooding
- Human density, land use intensity
  - → Direct impacts, edge effects
  - → Activity level and disturbance

Edge effects

- Buffer areas (25, 5 km)
- Private lands

Habitat area

- Species-area curves

Critical habitats

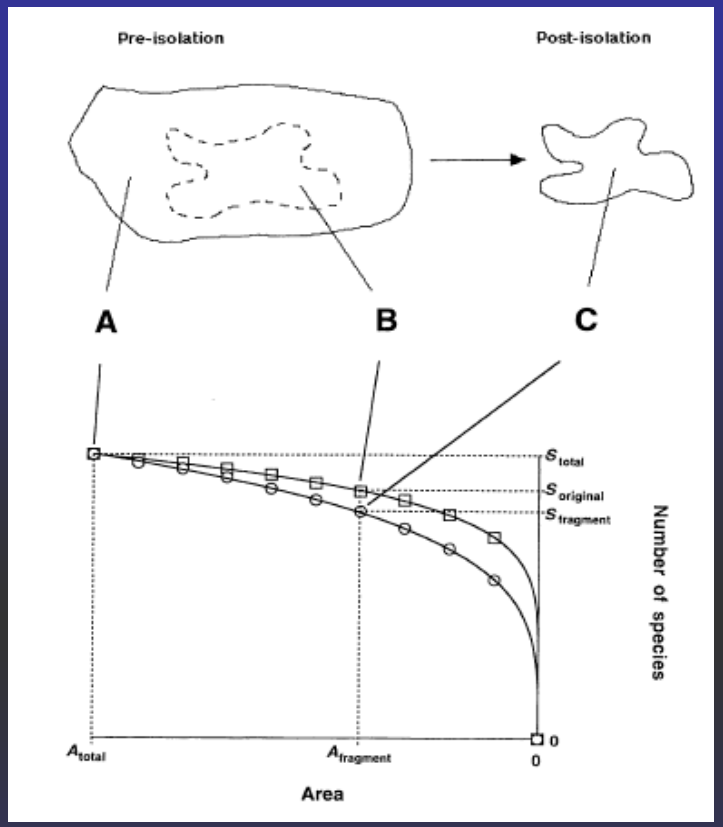
- Local knowledge

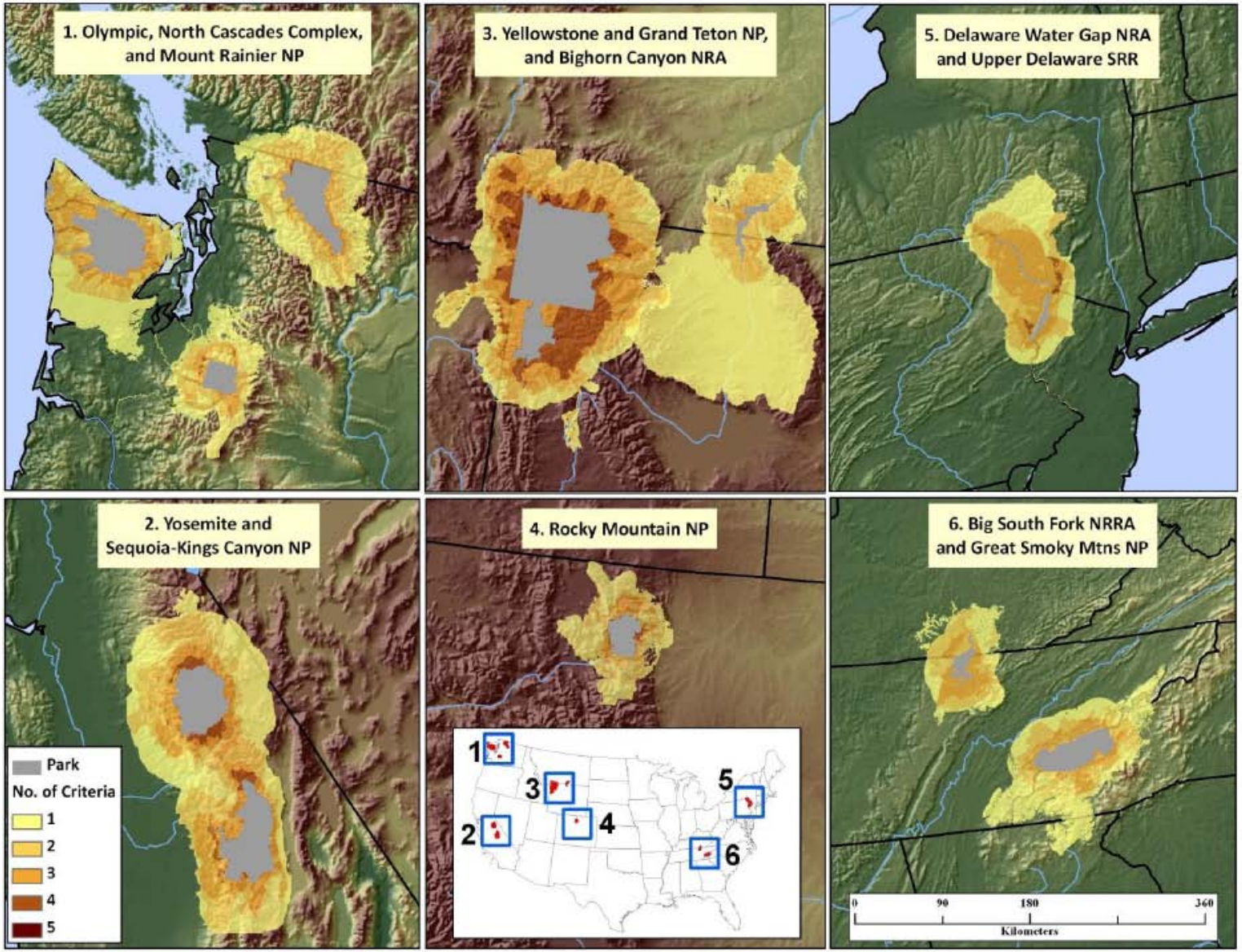
Ecological flows

- Watershed boundaries
- (air sheds)

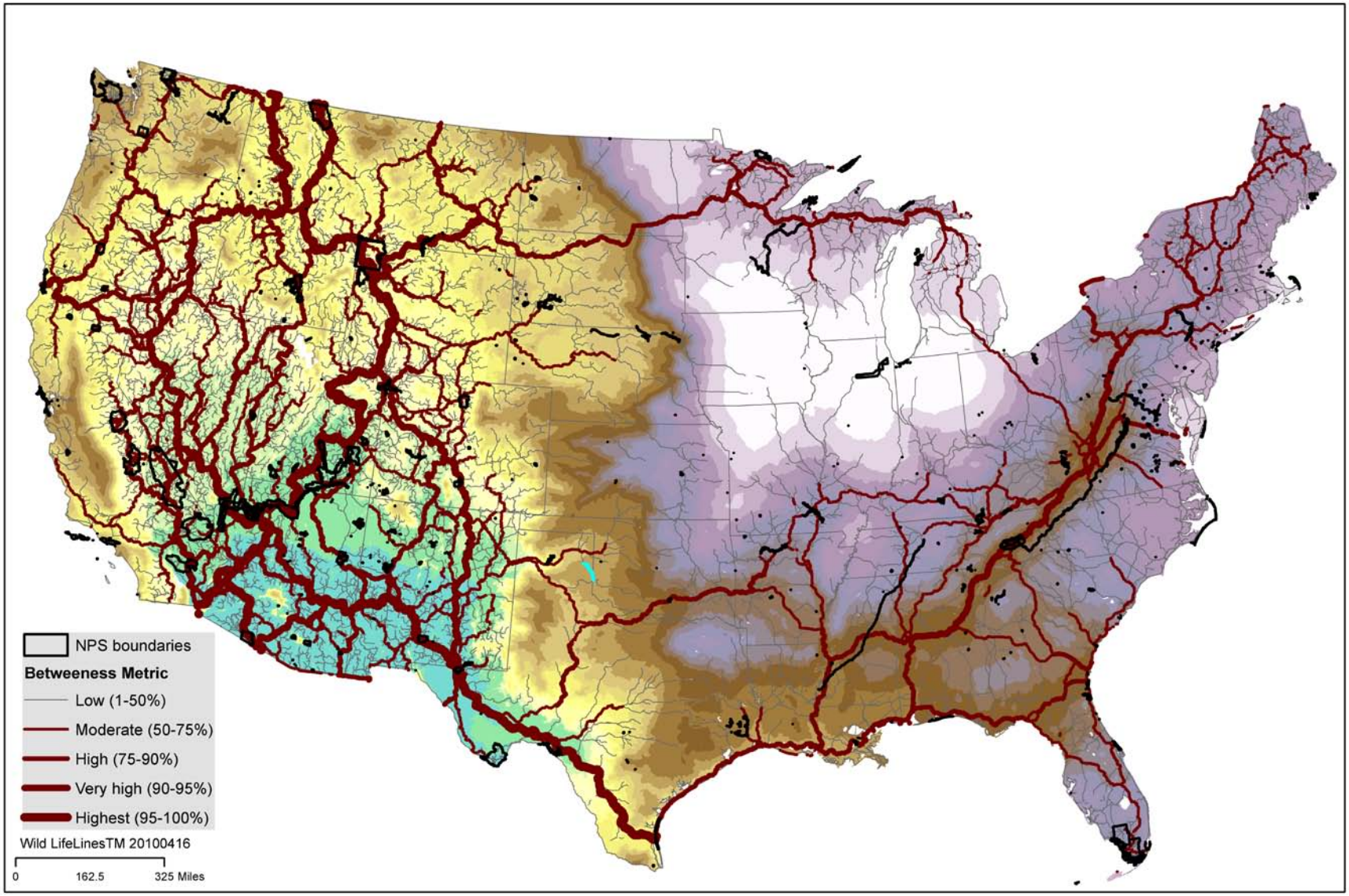
Sustain dynamic processes

- Disturbance records




1. Olympic, North Cascades Complex, and Mount Rainier NP
3. Yellowstone and Grand Teton NP, and Bighorn Canyon NRA
5. Delaware Water Gap NRA and Upper Delaware SRR
2. Yosemite and Sequoia-Kings Canyon NP
4. Rocky Mountain NP
6. Big South Fork NRRA and Great Smoky Mtns NP
Park
No. of Criteria
1
2
3
4
5
0
90
180
360
Kilometers

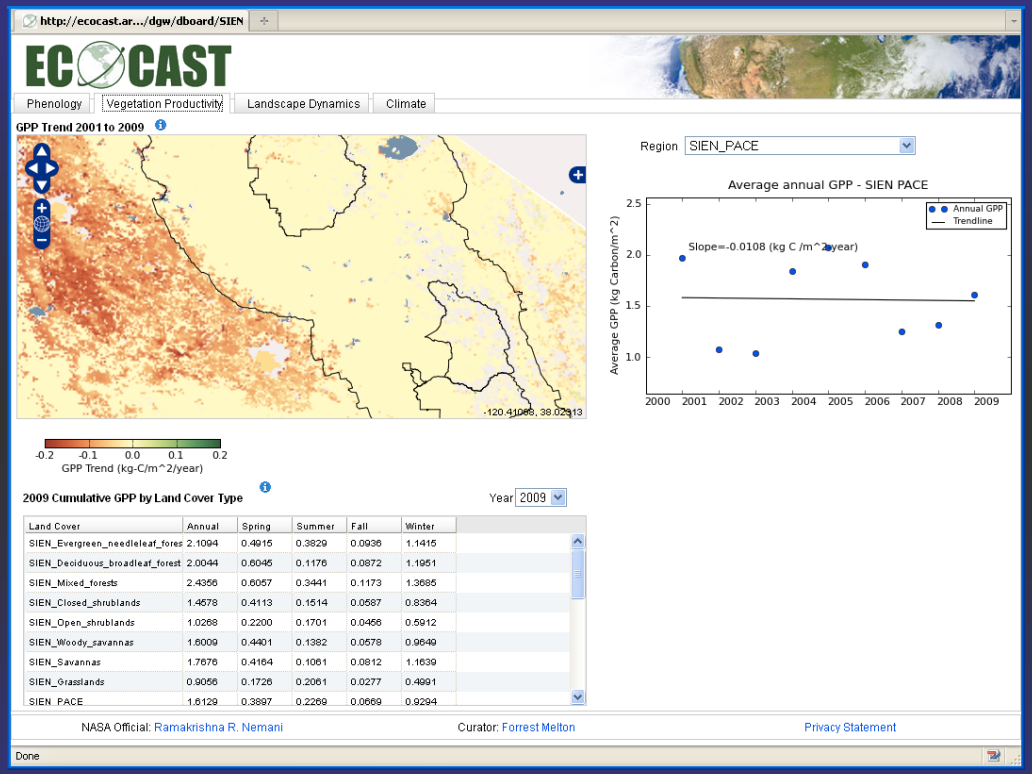
Connectivity of natural habitats



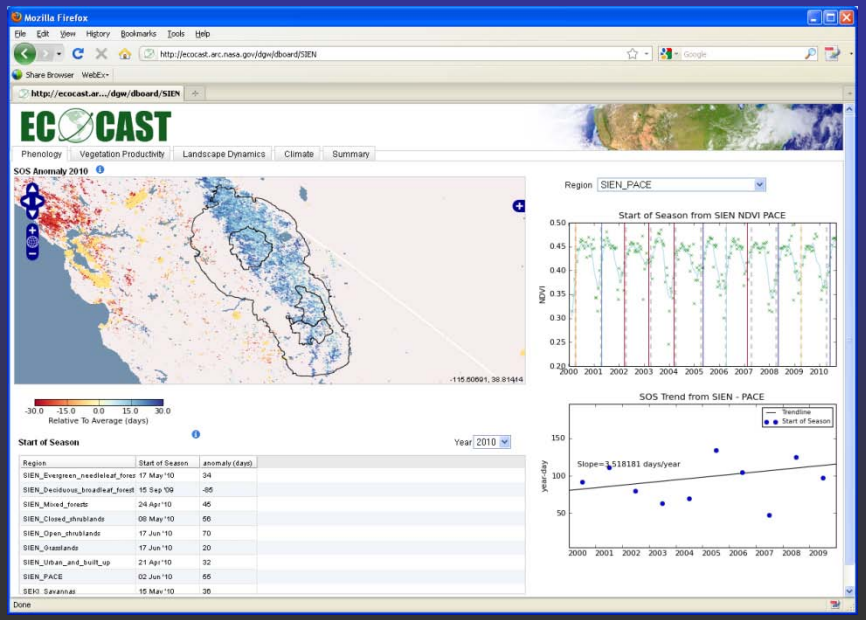
TOPS – Terrestrial Observation and Prediction System

Full-on data integration & ecosystem modeling system

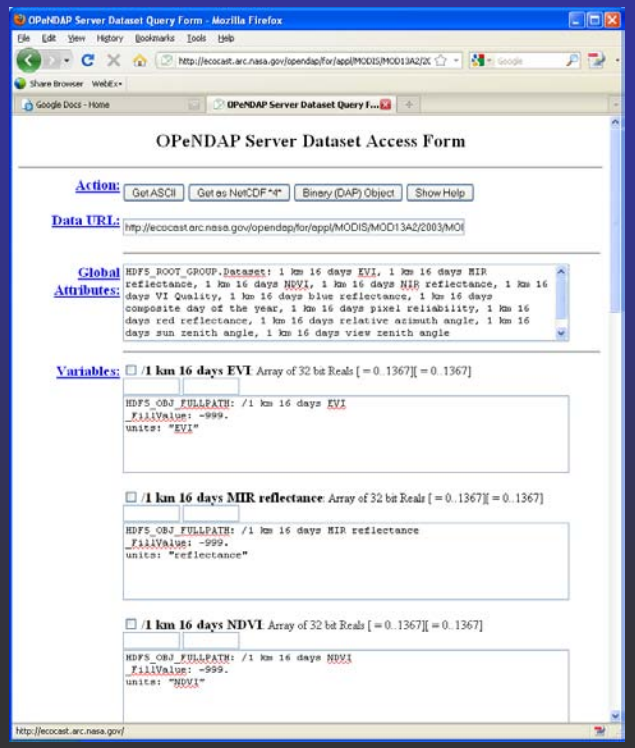
- Productivity
- Soil moisture
- Phenology & LAI anomalies
- Gridded climate data
- Imagery and derived products



TOPS Data & Interfaces



http://ecocast.arc.nasa.gov/dgw/dboard/SIEN



http://ecocast.arc.nasa.gov/opendap

- interfaces built on open source software tools
- provide automated summaries of ecological indicators
- rely on NASA for maintenance and customization.

- data services use open source data access protocols (OPeNDAP)
- provide direct access to TOPS data
- additional effort for summaries from data time series.

Technology Transfer

Expectations

- Regular engagement; consistent staff
- "tech transfer" to
  - Ecologists – analyses and interpretation
  - GIS/Tech – workshops / documentation

Our 'adaptive management' strategy

- Sustained work w/ Networks and parks to evaluate results
- Develop park-specific integrative 'story'
- Emphasize SOPs to facilitate transfer to I&M protocols
- Lots of conference calls (meetings were a challenge)
- Delivery via web site and NPS archive (NRInfo)

PALMS Products

http://science.nature.nps.gov/im/monitor/lulc/palms

Will migrate to NRInfo

National Park Service
Nature & Science

National Park Service
U.S. Department of the Interior

Inventory & Monitoring
- I & M Home
- NR GIS
- Monitoring Contacts
- Monitoring Site Map
- PALMS home page
- Landscpale Scale Monitoring
- NARSEC 2007 Home
- IRMA Landscapes (NPS only)
- NPScape Site (NPS only)

Parks: Nature & Science

NPS » Nature & Science » Inventory & Monitoring » Vital Signs Monitoring » Land Cover Land Use

PALMS - Park Analysis and Monitoring Support

Ecological condition of US National Parks: Enhancing decision support through monitoring, analysis, and forecasting

PALMS is a joint project between the NPS, Montana State University, Woods Hole Research Institute, Colorado State University, and NASA Ames Research Center. The project was launched by a grant from the NASA Applied Sciences Program and support from the NPS Inventory and Monitoring Program.

This site provides access to project products and related and supporting publications. The project is now largely completed, and project collaborators are finishing up documents, data sets, methods, and are in the process of cataloging and posting materials on NPS servers for long-term storage and access. This site provides the easiest access to PALMS products. As products are finalized, they will be uploaded and be permanently available via the NPS NRInfo portal.

PALMS Products

Indicator Briefs

(3 February 2011 versions)
Aquatic macroinvertebrates (example from Delaware Water Gap and Upper Delaware watersheds)
Impervious cover (example from Delaware Water Gap and Upper Delaware watersheds)
Surface water (example from Delaware Water Gap and Upper Delaware watersheds)

Natural landscapes
Ecosystem type (example from Yellowstone)
Land use (example from Yellowstone)

Final Summary Reports

Indicator briefs and Summary Reports

PALMS Products

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(3 February 2011 versions)

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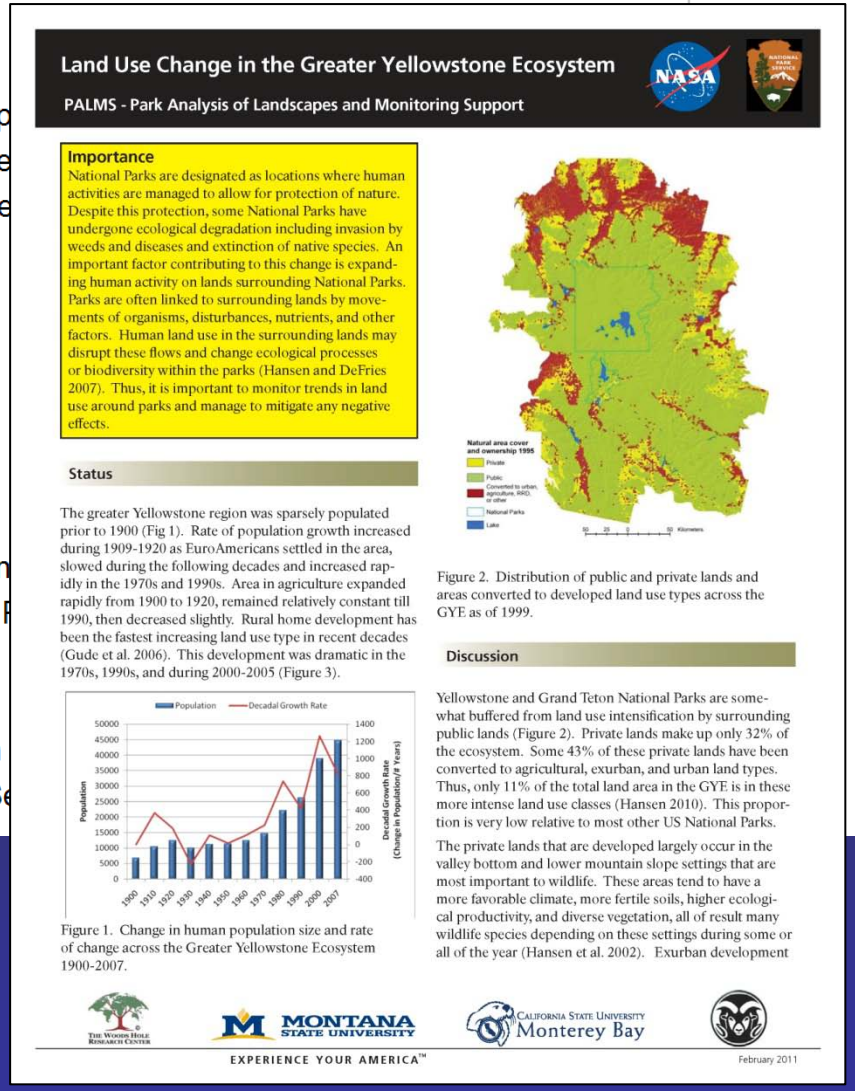

Land Use Change in the Greater Yellowstone Ecosystem

PALMS - Park Analysis of Landscapes and Monitoring Support

Importance

National Parks are designated as locations where human activities are managed to allow for protection of nature. Despite this protection, some National Parks have undergone ecological degradation including invasion by weeds and diseases and extinction of native species. An important factor contributing to this change is expanding human activity on lands surrounding National Parks. Parks are often linked to surrounding lands by movements of organisms, disturbances, nutrients, and other factors. Human land use in the surrounding lands may disrupt these flows and change ecological processes or biodiversity within the parks (Hansen and DeFries 2007). Thus, it is important to monitor trends in land use around parks and manage to mitigate any negative effects.

Status

The greater Yellowstone region was sparsely populated prior to 1900 (Fig 1). Rate of population growth increased during 1909-1920 as EuroAmericans settled in the area, slowed during the following decades and increased rapidly in the 1970s and 1990s. Area in agriculture expanded rapidly from 1900 to 1920, remained relatively constant till 1990, then decreased slightly. Rural home development has been the fastest increasing land use type in recent decades (Gude et al. 2006). This development was dramatic in the 1970s, 1990s, and during 2000-2005 (Figure 3).

Figure 1. Change in human population size and rate of change across the Greater Yellowstone Ecosystem 1900-2007.

Figure 2. Distribution of public and private lands and areas converted to developed land use types across the GYE as of 1999.

Discussion

Yellowstone and Grand Teton National Parks are somewhat buffered from land use intensification by surrounding public lands (Figure 2). Private lands make up only 32% of the ecosystem. Some 43% of these private lands have been converted to agricultural, exurban, and urban land types. Thus, only 11% of the total land area in the GYE is in these more intense land use classes (Hansen 2010). This proportion is very low relative to most other US National Parks.

The private lands that are developed largely occur in the valley bottom and lower mountain slope settings that are most important to wildlife. These areas tend to have a more favorable climate, more fertile soils, higher ecological productivity, and diverse vegetation, all of result many wildlife species depending on these settings during some or all of the year (Hansen et al. 2002). Exurban development

The Woods Hole Research Center · Montana State University · California State University Monterey Bay

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February 2011

Methods, data, and supporting technical documents

Indicator Standard Operating Procedures (SOPs) and Technical Documents

Biotic Integrity - eastern watersheds

Goetz, S.J. and G. Fiske. 2009. PALMS SOP – GIS Methodology for mappir watersheds in the eastern USA. National Park Service, Fort Collins,

Goetz, S.J. and G. Fiske. 2008. Linking the diversity and abundance of strea USA. Remote Sensing of Environment 112:4075-4085.

Impervious Cover

Goetz, S.J. and G. Fiske. 2010. PALMS SOP – Estimating Impervious Cove Collins, CO.

Theobald, D.M., S.J. Goetz, J.B. Norman, and P. Jantz. 2009. Watersheds at in the conterminous United States. Journal of Hydrologic Engineerin

Phenology and Climate

Melton, F, S. Hiatt, G. Zhang, and R. Nemani. 2010. PALMS SOP – Estimati Satellite Observations: Start of Season. National Park Service, Fort

Sherrill, K., and B. Frakes. 2010. Climate grid analysis toolset - tools for ssse standard operating procedure. Fort Collins. Unpublished Report-21

White, M.A., K.M. De Beurs, K. Didan, and 18 others. 2009. Intercomparison phenology in North America estimated from remote sensing for 198 2359.

Ecosystem type and fragmentation

Piekielek, N.B., C. Davis and A. Hansen 2011. PALMS SOP - Ecosystem ty Euro-American settlement to present day. Inventory and Monitoring Center, National Park Service, Fort Collins, CO. Ver 1.4.

Ecosystem type and change Arc tools

Protected Area Centered Ecosystems (PACE)

Hansen, A.J. and R. DeFries. 2007. Ecological mechanisms linking protected areas to surrounding lands. Ecological Applications 17:974-988.

Piekielek, N.B., C. Davis and A. Hansen 2010. PALMS SOP - Analyzing Protected-area Centered Ecosystems. Inventory and Monitoring Program, Natural Resource Program Center, National Park Service, Fort Collins, CO. Ver 1.2 (3.3 MB)

Piekielek, N.B., C. Davis and A. Hansen 2011. PALMS SOP - Estimating Protected-area Centered Ecosystems. Inventory and Monitoring Program, Natural Resource Program Center, National Park ervice, Fort Collins, CO. Ver 1.6 (10 MB)

Hansen, A.J., C. Davis, N.B. Piekielek, J.E. Gross, D.M. Theobald, S.J. Goetz, F.M. Melton, R. DeFries. In press. Delineating the ecosystems containing protected areas for monitoring and management. BioScience.

Protected-area centered ecosystems (PACE) Arc tools
PACE example results xls sheets
The PACE data sets are too large to serve here - contact Nate Piekielek or John Gross.

Natural Landscapes

Theobald, D.M. 2009. PALMS SOP – Landscape dynamics, pattern of natural landscapes. Natural Resource Inventory and Monitoring Program. National Park Service, Fort Collins, CO.

Theobald, D.M. 2010. Estimating natural landscape changes from 1992 to 2030 in the conterminous US. Landscape Ecology.

SOPs shared with NPScape - population, housing
Population from census data; housing density

As of early 2011, many NPScape SOPs and scripts are undergoing revision. The current version of NPScape products, including SOPs, scripts, and data, can be obtained via the public NPScape web site: http://science.nature.nps.gov/im/monitor/npscape/index.cfm or the NPS NRInfo portal.

Shared NPScape products include:

Population Metrics
Census 1990 data
Census 2000
Census 2000 for islands
County-level population projections
Housing density

Publications

Other Relevant PALMS Publications

Gross, J.E., A.J. Hansen, S.J. Goetz, D.M. Theobald, F.M. Melton, N.B. Piekielek, and R.R. Nemani. In press. Remote sensing for inventory and monitoring of the U.S. National Parks. Chapter 2 in Y.Q. Yang (ed.), Remote sensing of protected areas. Taylor & Francis, Boca Raton, FL.

Gude, P.H., A.J. Hansen, and D.A. Jones. 2007. Biodiversity consequences of alternative future land use scenarios in greater Yellowstone. Ecological Applications 17:1004-1018.

Jantz, P., Goetz, S.J., and Jantz, C. A., 2005. Urbanization and loss of resource lands in the Chesapeake Bay watershed. Environmental Management 36:808-825.

Jones, D.A., A.J. Hansen, K. Bly, K. Doherty, J.P. Verschuyl, J.I. Paugh, R. Carle, and S.J. Story. 2009. Monitoring land use and cover around parks: a conceptual approach. Remote Sensing of Environment, 113:1346-1356.

Nemani, R.R, et. al. 2009. Monitoring and forecasting ecosystem dynamics using the Terrestrial Observation and Prediction System (TOPS). Remote Sensing of Environment 113:1497-1509.

Theobald, D.M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10.

… and other stuff:

- Presentations
- Project reports
- Fact sheet

http://science.nature.nps.gov/im/monitor/lulc/palms

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Theobald, D.M., S.J. Goetz, J.B. Norman, and P. Jantz. 2009. Watersheds at risk to increased impervious surface cover in the conterminous United States. Journal of Hydrologic Engineering 14:363-365.

Phenology and Climate

Melton, F., S. Hatt, G. Zhang, and R. Nemani. 2010. PALMS SOP – Estimating Landscape Indicators of Phenology from Satellite Observations: Start of Season. National Park Service, Fort Collins, CO.

Sherrill, K., and B. Frakes. 2010. Climate grid analysis toolset - tools for assessing regional climatological trends - standard operating procedure. Fort Collins. Unpublished Report-2165775

White, M.A., K.M. De Beurs, K. Didan, and 18 others. 2009. Intercomparison, interpretation, and assessment of spring phenology in North America estimated from remote sensing for 1982-2006. Global Change Biology 15:2335-2359.

Ecosystem type and fragmentation

Piekielek, N.B., C. Davis and A. Hansen 2011. PALMS SOP - Ecosystem type change and fragmentation: from pre Euro-American settlement to present day. Inventory and Monitoring Program, Natural Resource Program Center, National Park Service, Fort Collins, CO. Ver 1.4.

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PACE example results xls sheets
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Lessons Learned

Execution and implementation

We needed more time than anticipated

- Hard to schedule meetings
- Managers may not control their time
- Staff turnover

Everyone needed "further education" about:

- methods, jargon, technology – *What's NPP?*
- cultures and decision environments

The more focused the scope, the better the chances of success.

The path to success ….

- Share ownership and risks
- Provide (only) key information
- Conform to and enhance existing systems
- For operational use, persistence is critical

Where we successful?

Next steps:

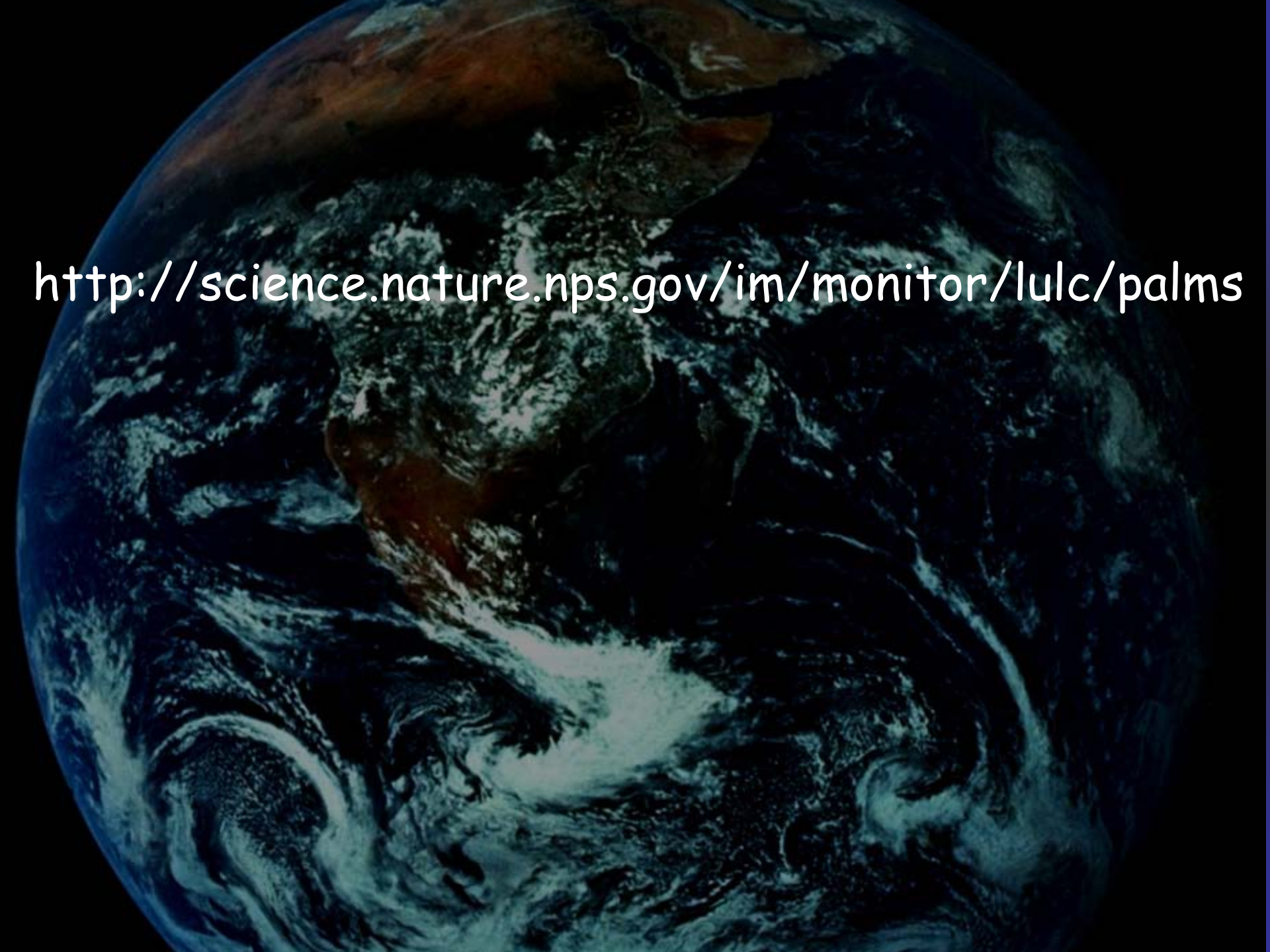
- Potential for NASA-sponsored workshops with other Networks/parks – let us know!
- TOPS team working with APPA; continued evolution of data portal
- New proposals and projects

More information:

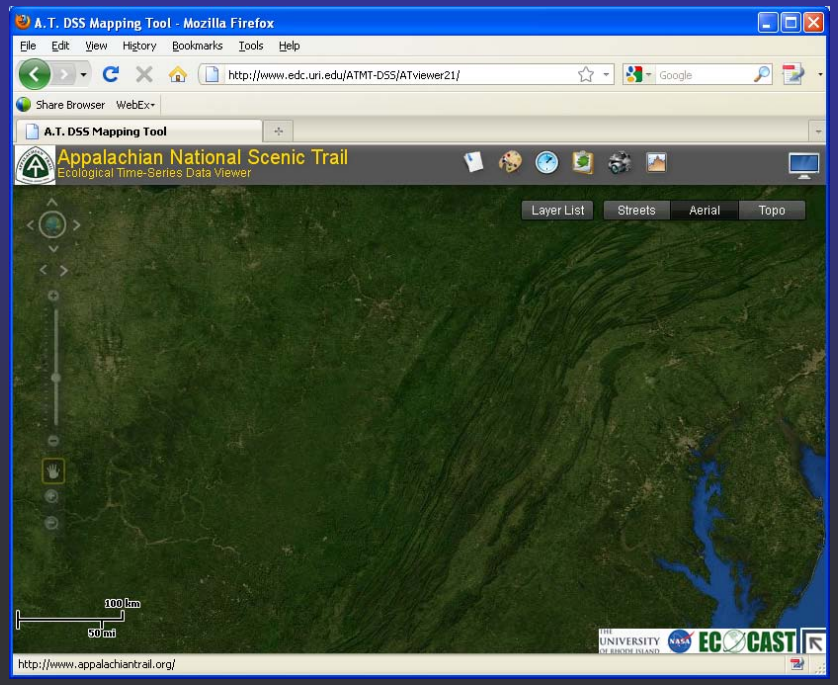
PALMS NPS (eventually to NRInfo)
http://science.nature.nps.gov/im/monitor/lulc/palms

EcoCast / TOPS

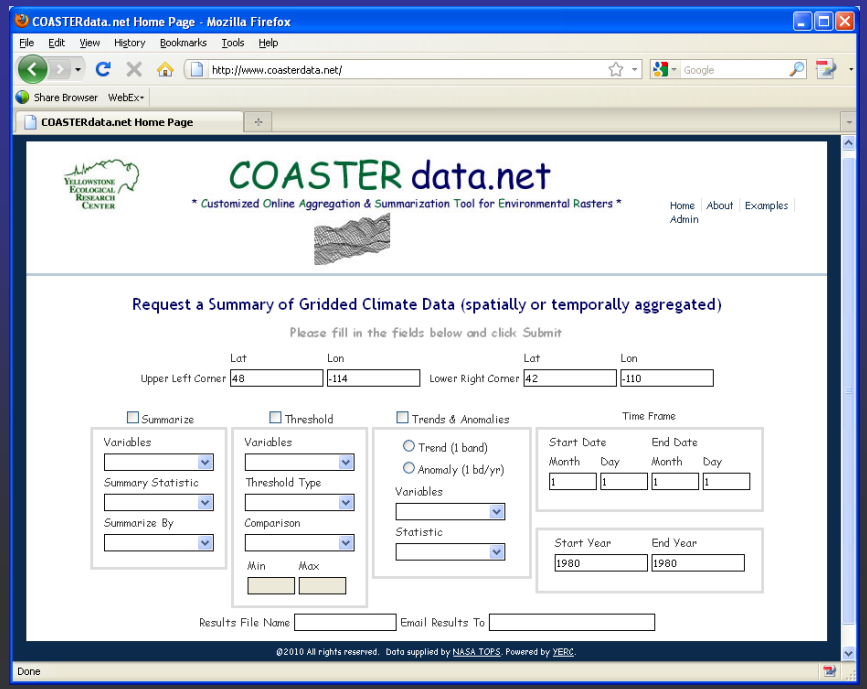
NPScape site
http://science.nature.nps.gov/im/monitor/npscape


http://science.nature.nps.gov/im/monitor/lulc/palms

Integrating TOPS Data Services with GIS Tools



Appalachian Trail Ecological Monitoring DSS http://www.edc.uri.edu/ATMT-DSS/



COASTER Data Summaries: http://www.coasterdata.net/

- Current efforts focused on providing TOPS data services that support development of GIS tools and data systems operated by partners
- Leverages TOPS data pre-processing and modeling power, while ensuring GIS tools can be operated and maintained by partners
- GIS tools can be supplemented by libraries of scripts and plug-ins for calculation of custom summary metrics

Related Efforts

Project	Scope	Data	Measures	Comments
PALMS	Focal parks	Multi-source & all scales	Sophisticated; park-specific	State-of-the art products, methods, interpretation
NPScape	All I&M parks	National; multi-scale	NR-related; common products	Focus on data, methods, & interpretation
SocioEcon Atlases	Some fee-demo; 2 watersheds	National; county-level only	Social/econ focus; NLCD land cover	Great presentation; no methods or interpretation
NR Condition Assmnt.	Eventually all NR parks	Any available	Park-specific	Synthetic evaluation; no methods or new data.

Technical Issues

- Many NASA products require considerable effort to make them useful to NPS.
- Monitoring data are most useful in the context of change over time or analyzed in conjunction with other data to reveal effects relevant to management objectives.
- Data must be converted into suitable formats and used to conduct integrated assessments that consider land cover types and other landscape attributes.
- Results of analyses need to be offered in formats that are accessible and useful to decision-makers.

NASA Applied Sciences Program

- ‘to expand and accelerate the societal and economic benefits of NASA research in Earth science, information, and technology.”

- enables use of Earth-Sun System measurements, models and research results in operational decision support systems

- primary outputs include:

  1) prototypes to demonstrate integration of results in the decision support tools, and

  2) benchmark reports to document the improved performance of the decision support tools through the Earth-Sun research results.

Study Objectives

1. Select landscape indicators consistent with NPS I&M needs
   - Identify the area appropriate for monitoring

2. Establish procedures to incorporate existing spatial data and products from the NASA Terrestrial Observation and Prediction System (TOPS) & other sources into I&M.

3. Use ecological knowledge to add value by guiding the analysis, evaluation, and communication.

4. Integrate the data acquisition, analysis, forecasting, and display of ecosystem changes into the NPS I&M's decision support framework.

Lessons from the TOPS software development team

Transition from research to operations requires a long-term commitment. Efforts to apply research products for operational use often find more research is needed.

The more narrowly focused the scope, the higher the chance of success.