Ecological Conditions of US National Parks: Enabling Decision Support Through Monitoring, Analysis, and Forecasting

or

Park Analysis of Landscapes and Monitoring Support (PALMS)

Andy Hansen and Nate Piekielek, Montana State University

Scott Goetz, Woods Hole Research Center

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Dave Theobald, Colorado State University

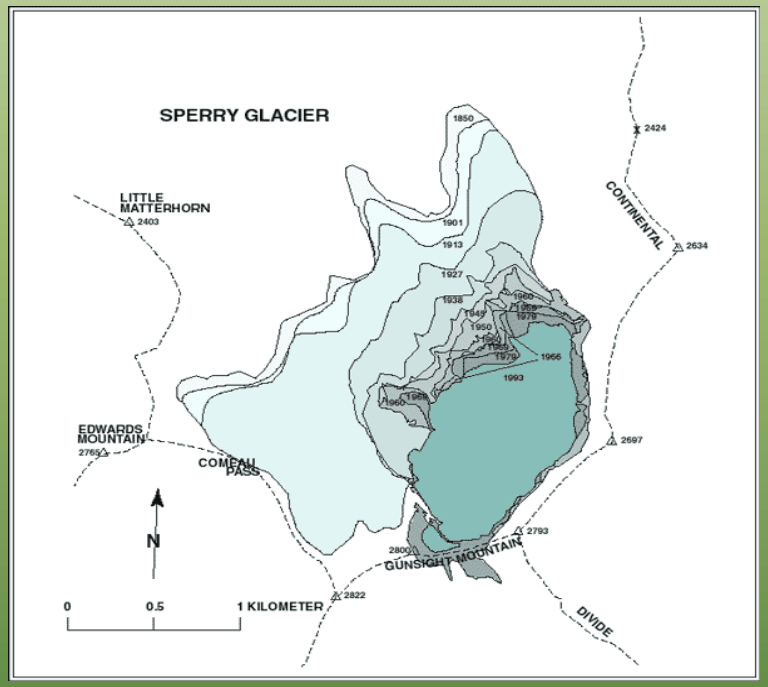
NASA Applications Sciences Program: Decision Support through Earth Science Research Results (DECISIONS)

NPS I&M Program

State of Protected Areas

Many protected areas are undergoing loss of function:

- **Increased pollution**
- **Altered natural disturbance**
- **Weeds and diseases**
- **Extinction of native species**

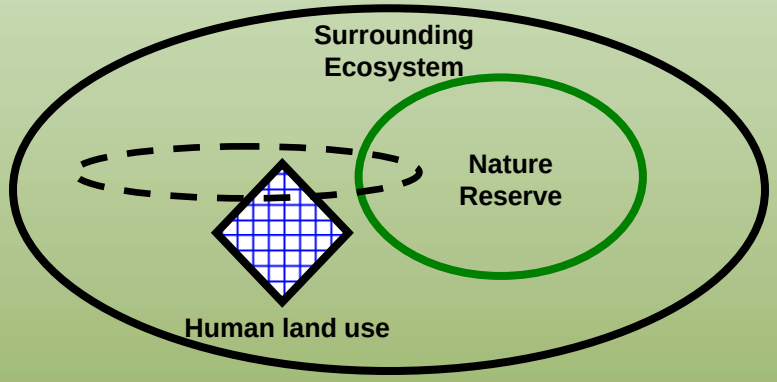


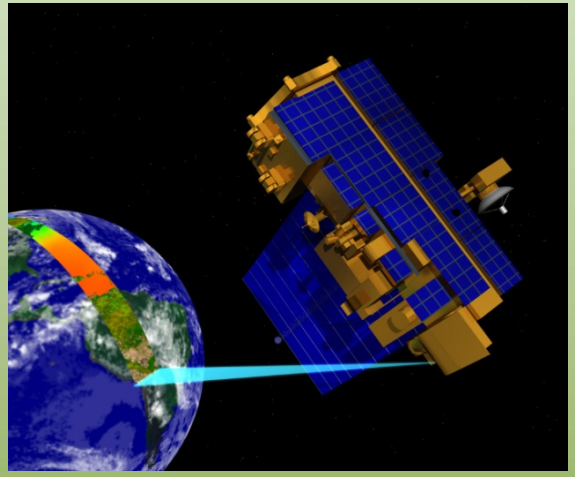
Glacial retreat in Glacier National Park

Agriculture at the boundary of Ngorongoro Conservation Area

Likely due to climate change and to expanding human activity on the lands surrounding protected areas

Maintaining Protected Area Function



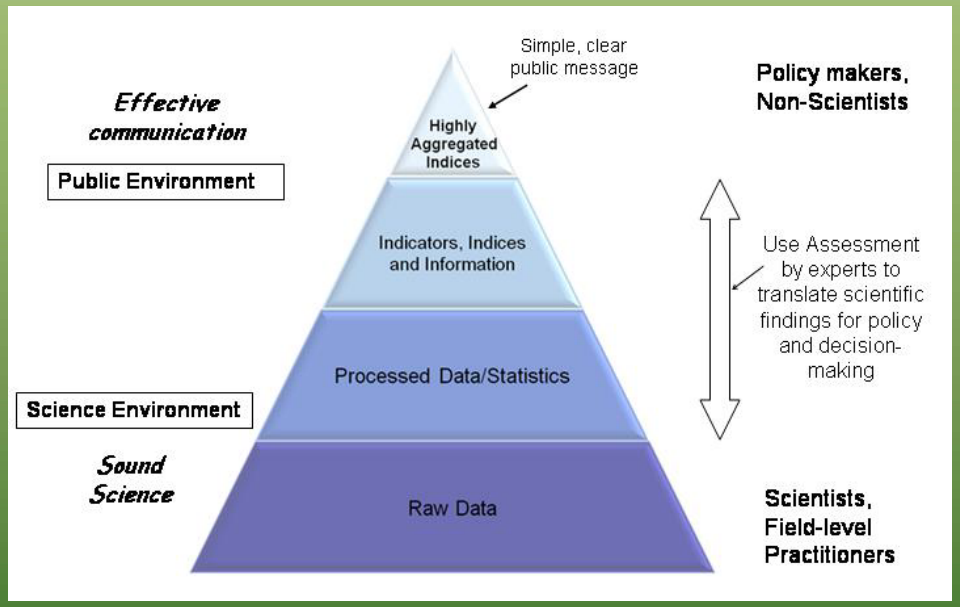


Requires:

- **delineating the boundaries of the park-centered ecosystem**
- **monitoring trends in ecological condition within these boundaries;**
- **understanding the causes and consequences of these changes;**
- **Mitigating, managing under, and adapting to climate and land use change in these ecosystems.**

National Park Service Inventory and Monitoring Program

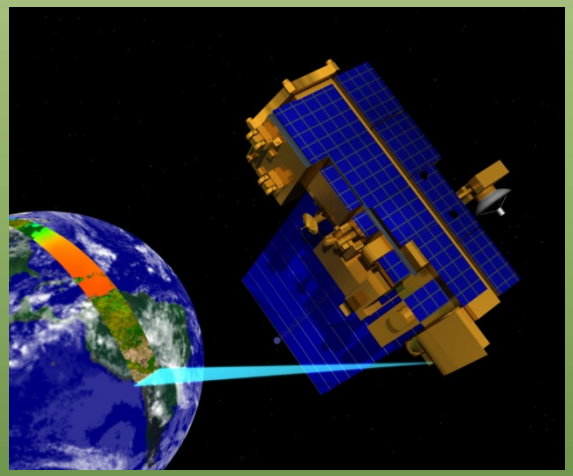
"The overall purpose of natural resource monitoring in parks is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems."



Fancy et al. 2008, Env. Mon. Ass.

Ecological Conditions of US National Parks: Enabling Decision Support Through Monitoring, Analysis, and Forecasting

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

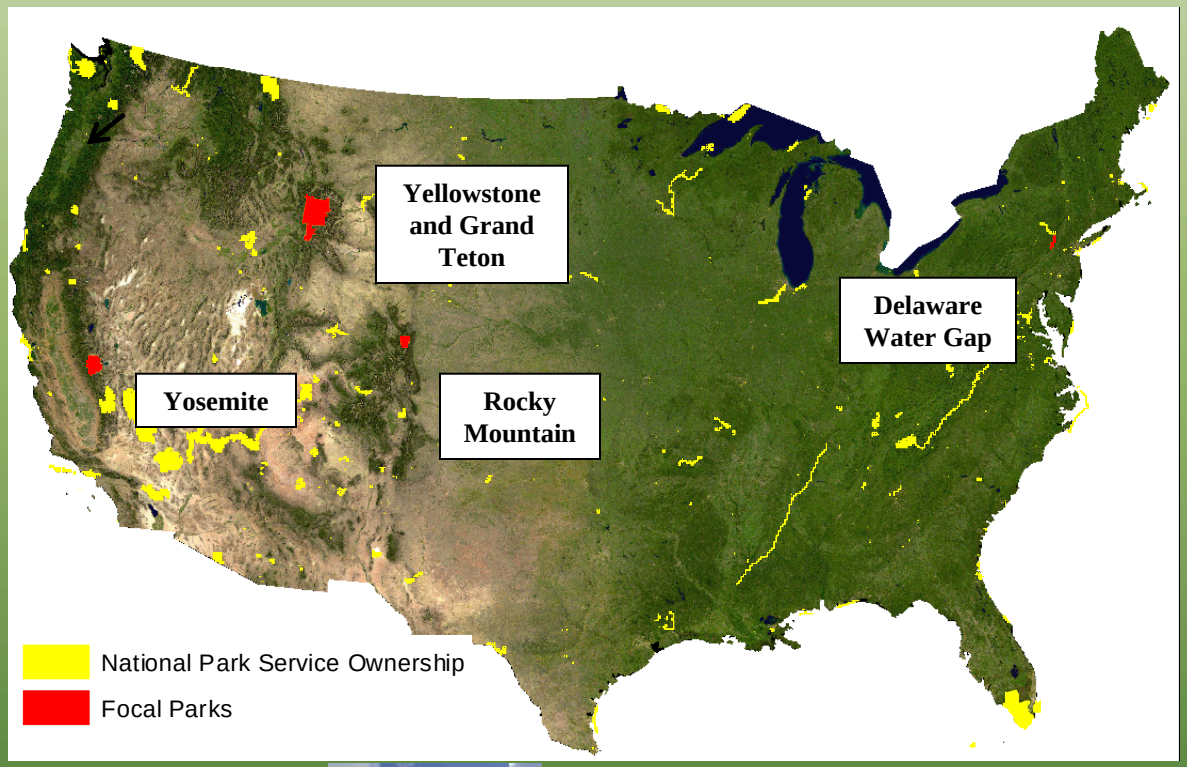


Objectives

- **Identify NASA and other products useful to park monitoring**
- **Delineate the boundaries of the park-centered ecosystems appropriate for monitoring.**
- **Add value to these data sets for understanding change through analysis and forecasting.**
- **Deliver these products and a means to integrate them into the NPS I&M decision support framework.**

Team and Case-Study Parks

John Gross
NPS I&M



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Montana State
University
Cathy Jean,
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Forrest Melton,
Rama Nemani,
NASA Aimes
Linda Mutch,
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Objective 1a: Indicators

1. Evaluate which TOPS and other products are most relevant to parks monitoring.
2. Select potential high priority indicators in context of NPS I&M conceptual models and I&M scientists.

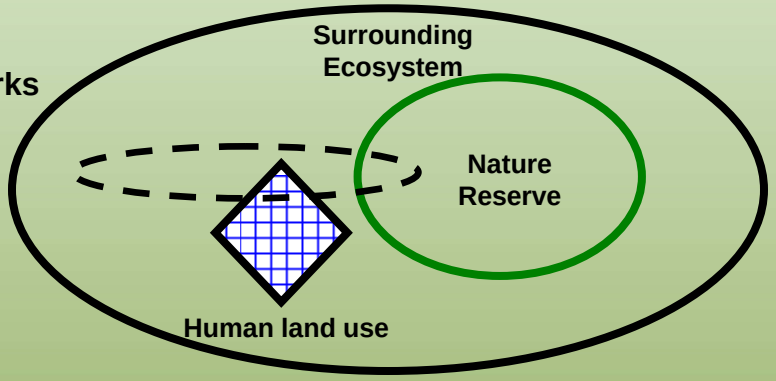
Level 3	Indcator	Delivery	Resolution
Weather and Climate	Phenology - NDVI; Annual anomaly; Date of min/max PAT; Leaf on /off Climate gridded daily 2000 – 2008, per NPClime metrics Long term Climate scenarios, now - 2100	SOP	1 km (all); 8 and 16 day products 1 km 12 km 12 km, monthly
Groundwater	Soil moisture - Monthly/annual trends/anomalies	SOP	TOPS 1 km, daily
Stream health	Sensitive taxa	SOP	1:24K, 1:100K
Visitor Use	Visitor shed boundaries (1 hr travel bands)	SOP	270 m
Biodiversity	Ecosystem type composition	SOP	30 m
	Habitat types; Bird hotspots	SOP	30 m
	Impervious cover change (30 m)	SOP/contract	30 m
	Housing density class	SOP/contract	100 m;
	Landscape connectivity of forests (linkages); Pattern of natural landscapes	SOP/contract	90-270 m
Extreme Disturbance	Fire effects via changes in NDVI/EVI, FPAR/LAI, soil moisture, evapotranspiration, vegetation stress	SOP	1 km; mo. anomalies; annual trends
Primary Production	GPP/NPP TOPS GPP	SOP/contract	1 km daily / mo. summaries
Monitoring area	Greater park ecosystem boundaries	SOP	30 m
Land Cover and Use	Land use – NLCD; Past to future modeling	SOP SOP/contract	30 m 30m-1km

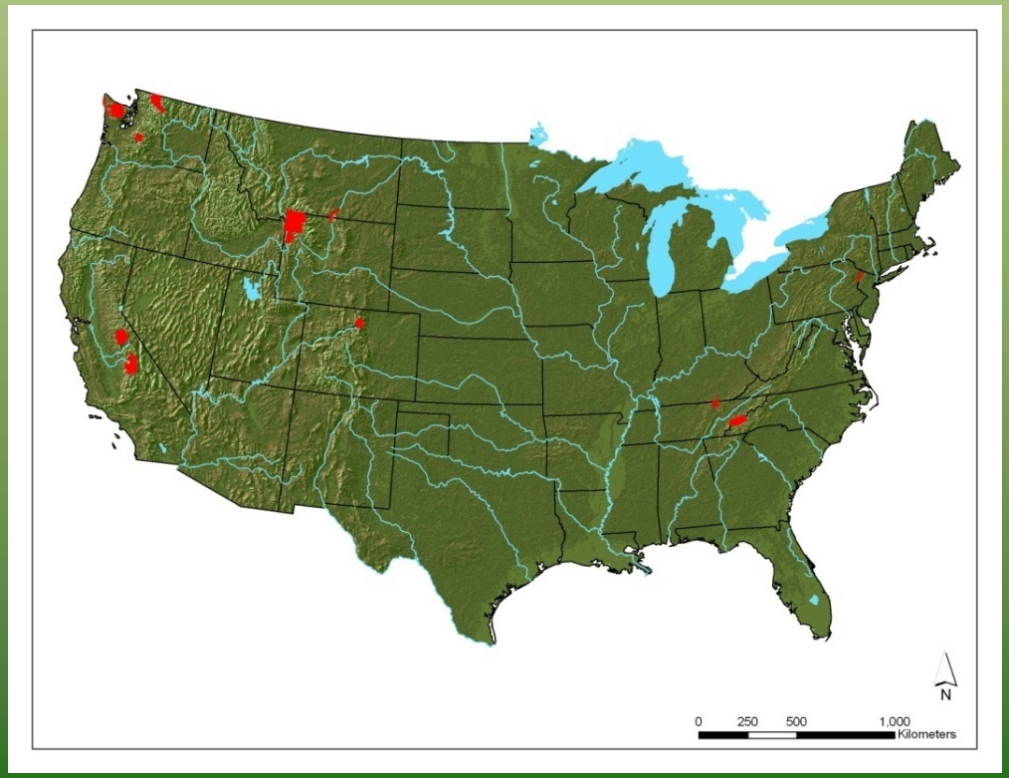
Objective 1b: Delineating Park-centered Ecosystems

Objectives

1) Delineate park-centered ecosystems for each of 12 US national parks based on objective ecological and land-use criteria.

2) Evaluate the results to test the utility of the methods and to ascertain the degree of challenge for maintaining ecological function within these national parks.





Criteria for selection:

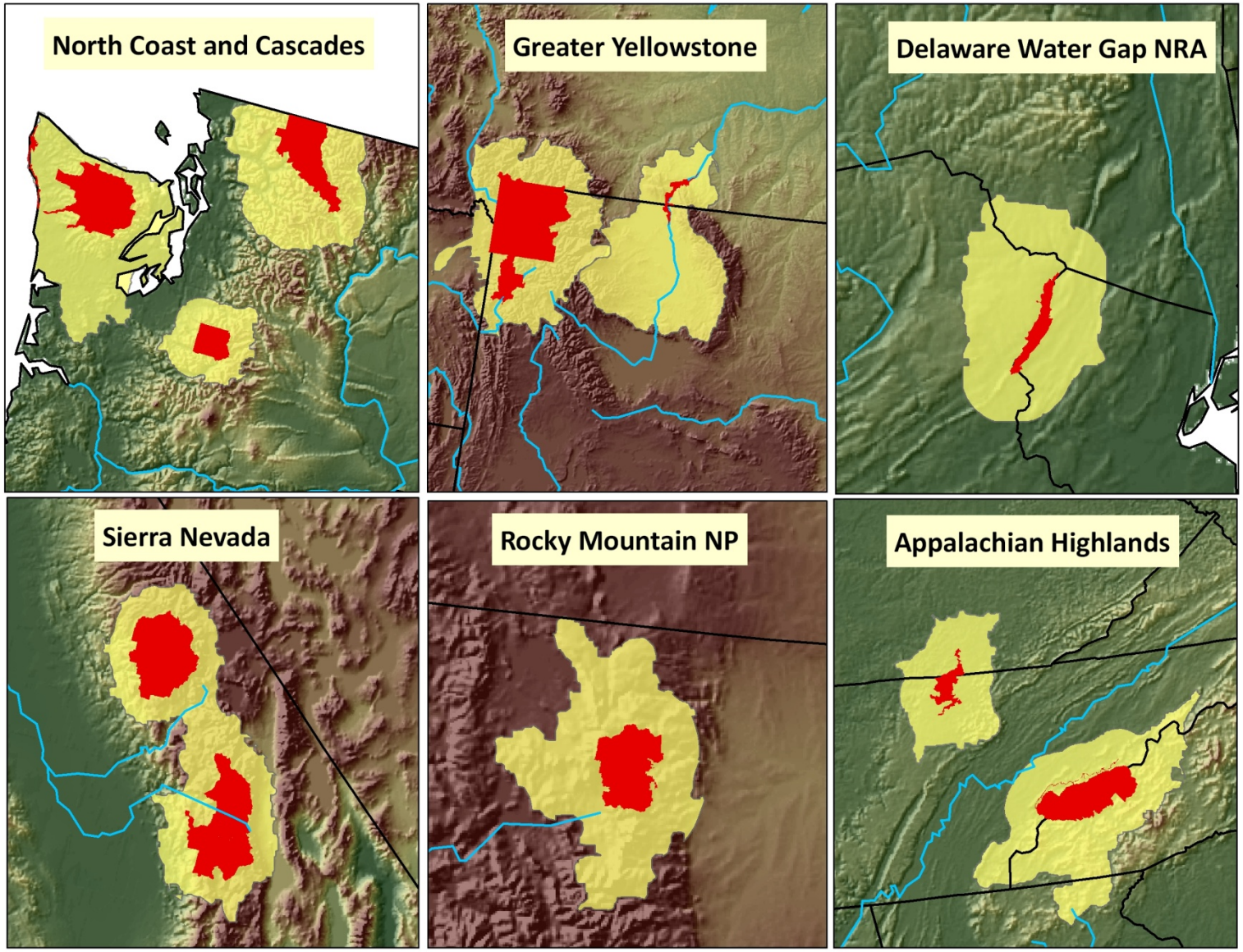
- **wide geographic, ecoregional, and physiognomic distribution;**
- **diverse land allocation types in surrounding areas;**
- **variation in park size and shape; concentration four or fewer NPS I&M networks**

Criteria for Park-centered Ecosystem Delineation

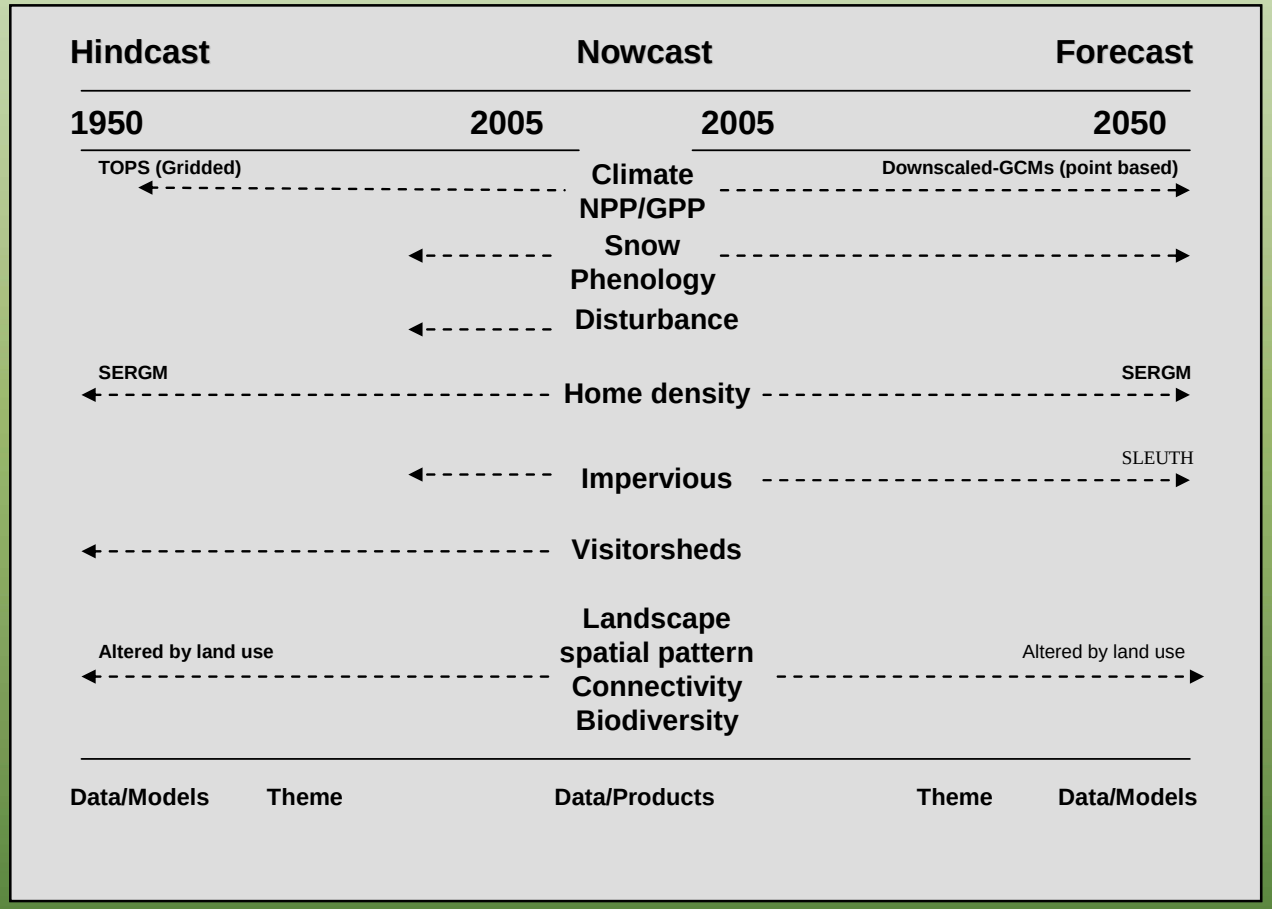
Mechanism	Ecological Effects	Implication for Monitoring and Management	Greater Ecosystem Delineation Criterion
Change in effective size of reserve	Species area effect	Maximize area of functional habitats	Contiguous habitats. Habitat types in proportional representation up to size specified from species area relationship
Change in ecological flows	Water quality and quantity, invasive species	Maintain natural aquatic inputs to protected area	Watersheds. 250K HUCCs intersecting protected area
	Disturbance initiation and runout zones	Identify and maintain ecological process zones	Disturbance. Perimeter around protected area of potential disturbance initiation and run-out
Loss of crucial habitats	Seasonal and migration habitats	Maintain key migration habitats	Crucial habitats. Migration, source-sink, and seasonal habitats
Human impacts	Edge effects	Manage human edge effects	Development. 30-km buffer around protected area

Derived from Hansen and DeFries (2007)

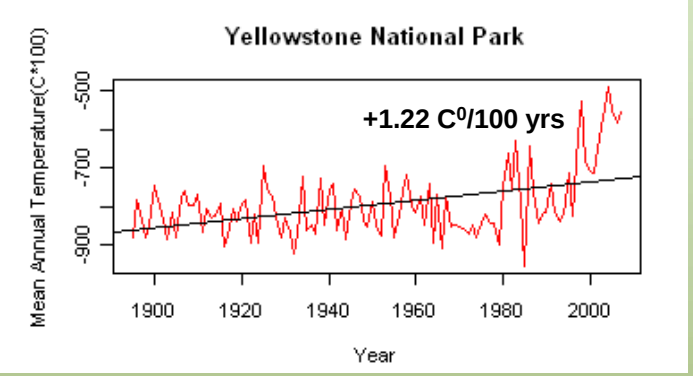
Preliminary Park-Centered Ecosystems

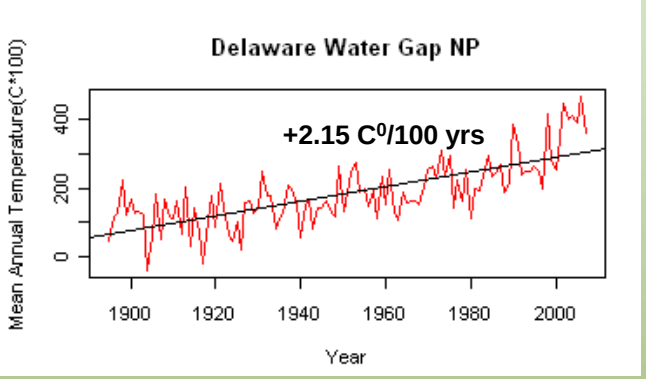


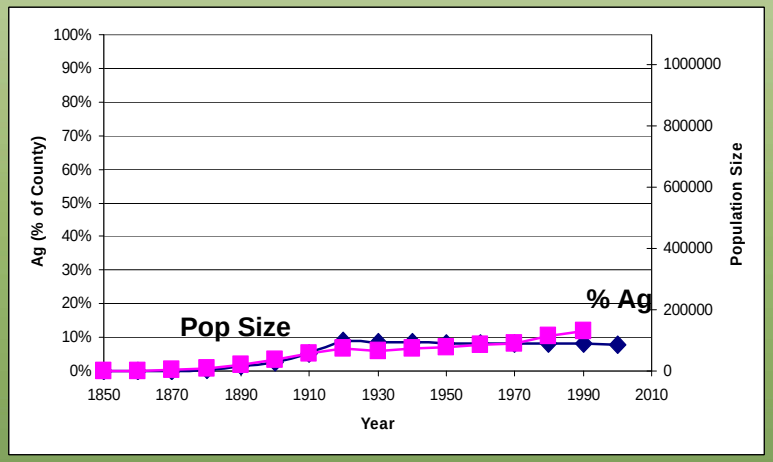
Objective 2: Add value to these data sets for understanding change through analysis and forecasting

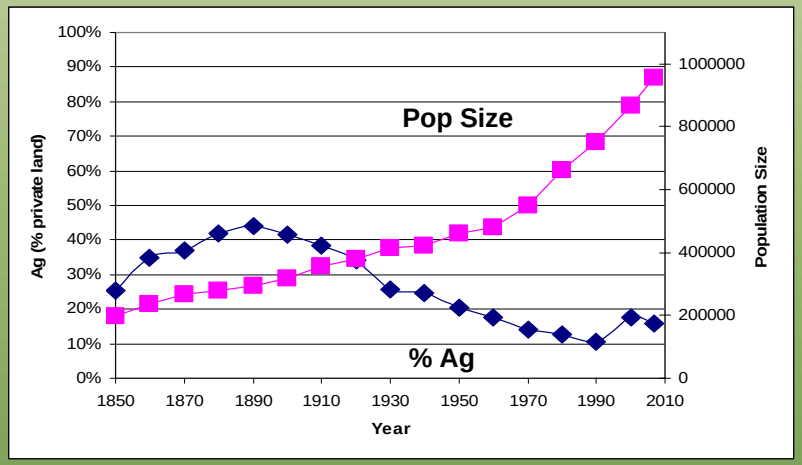


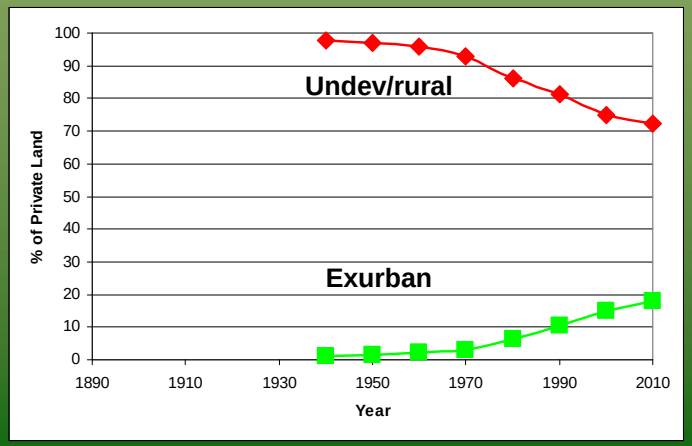
Climate and Land Use Change Past to Present

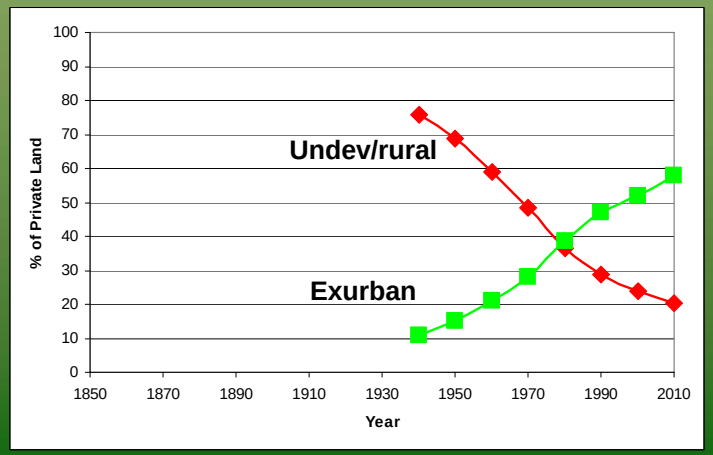








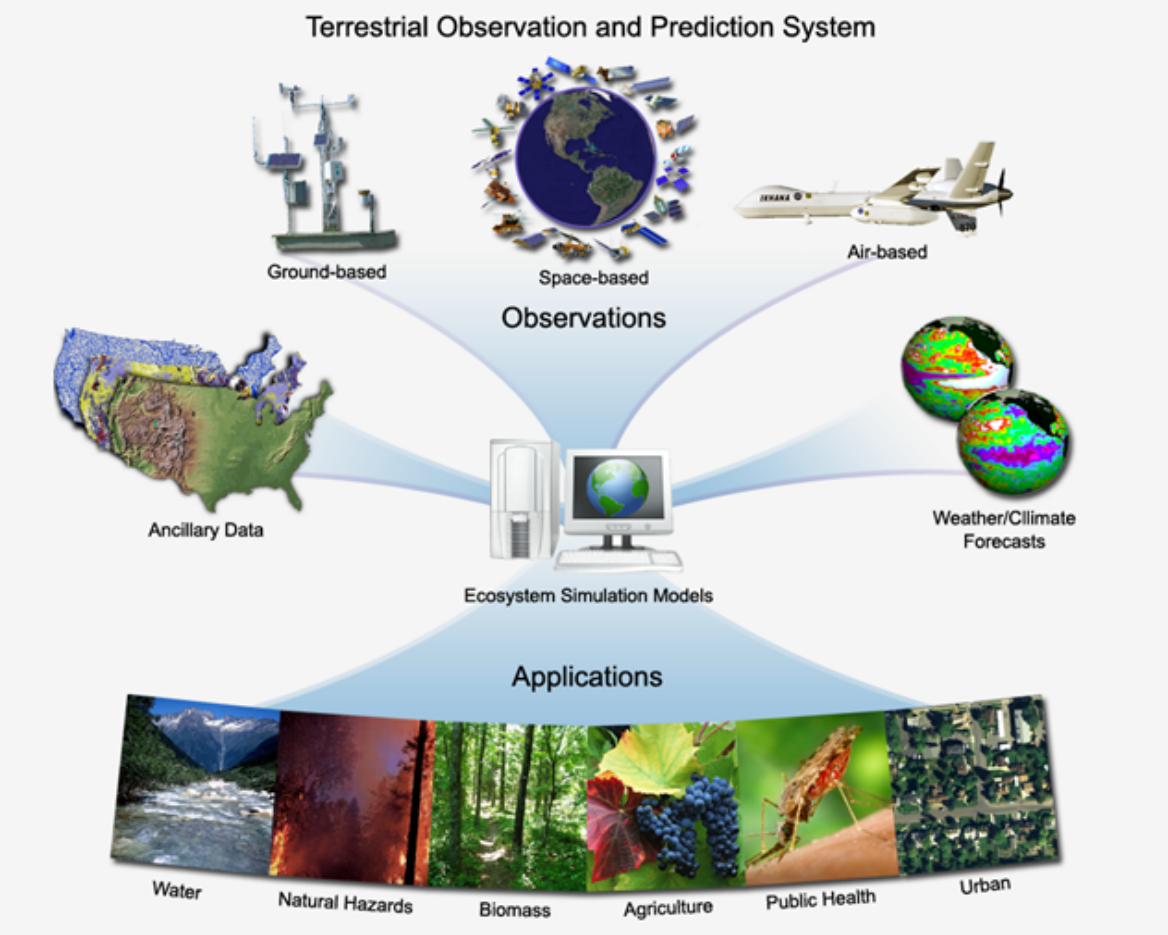




Terrestrial Observation and Prediction System (TOPS)

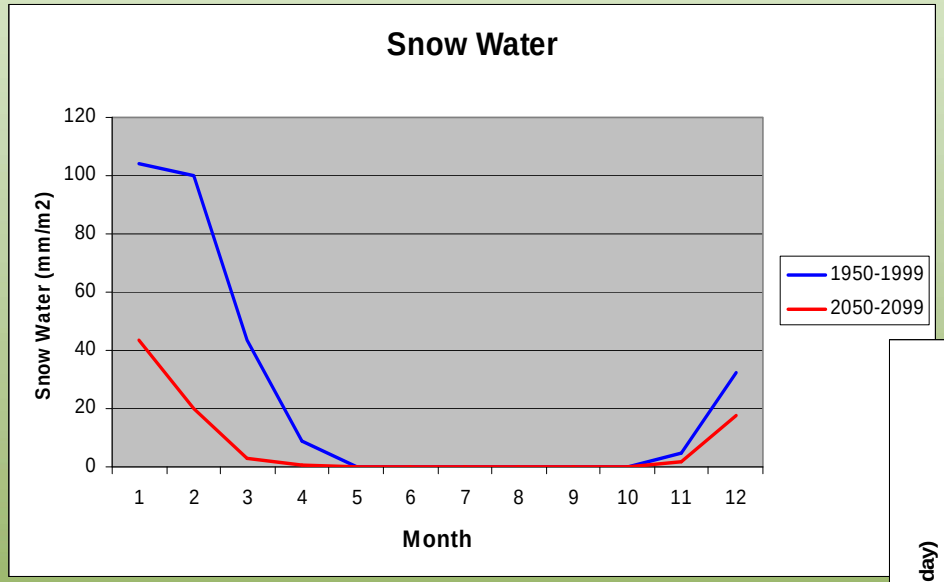
TOPS Products for NPS I&M:

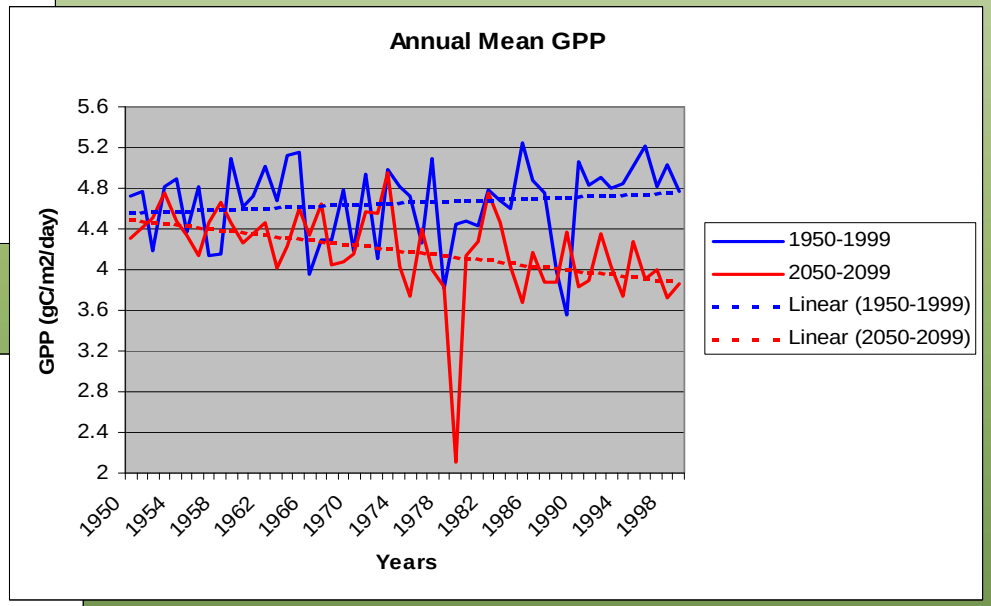
- **Ecosystem productivity / carbon flux**
- **Trends and anomalies in vegetation condition and phenological indicators**
- **Soil moisture / vegetation water stress**
- **Climate and weather surfaces and forecasted impacts of climate change**



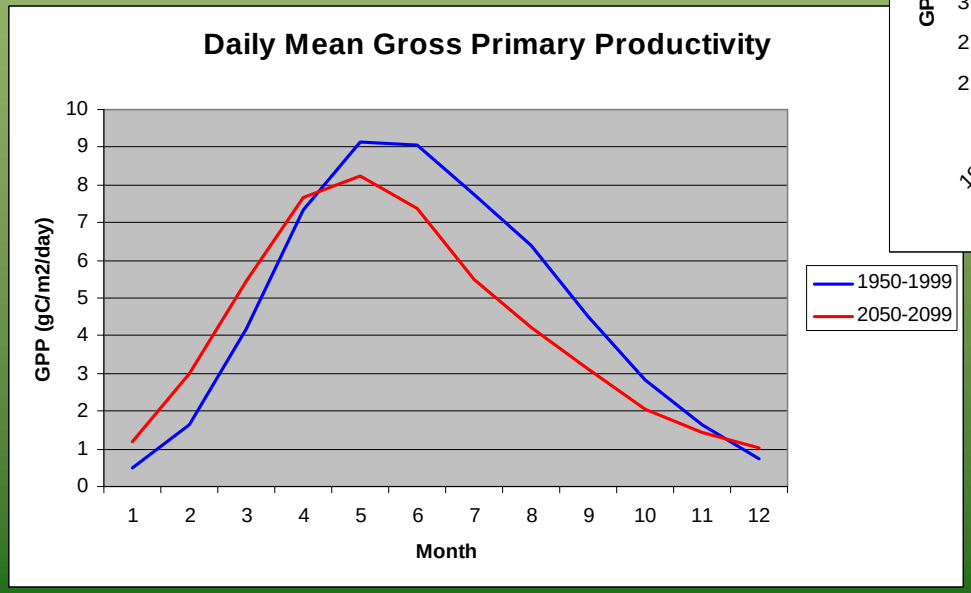
Nemani et al., 2003, 2007, 2008

TOPS Forecasts for 2050-2099, Yosemite



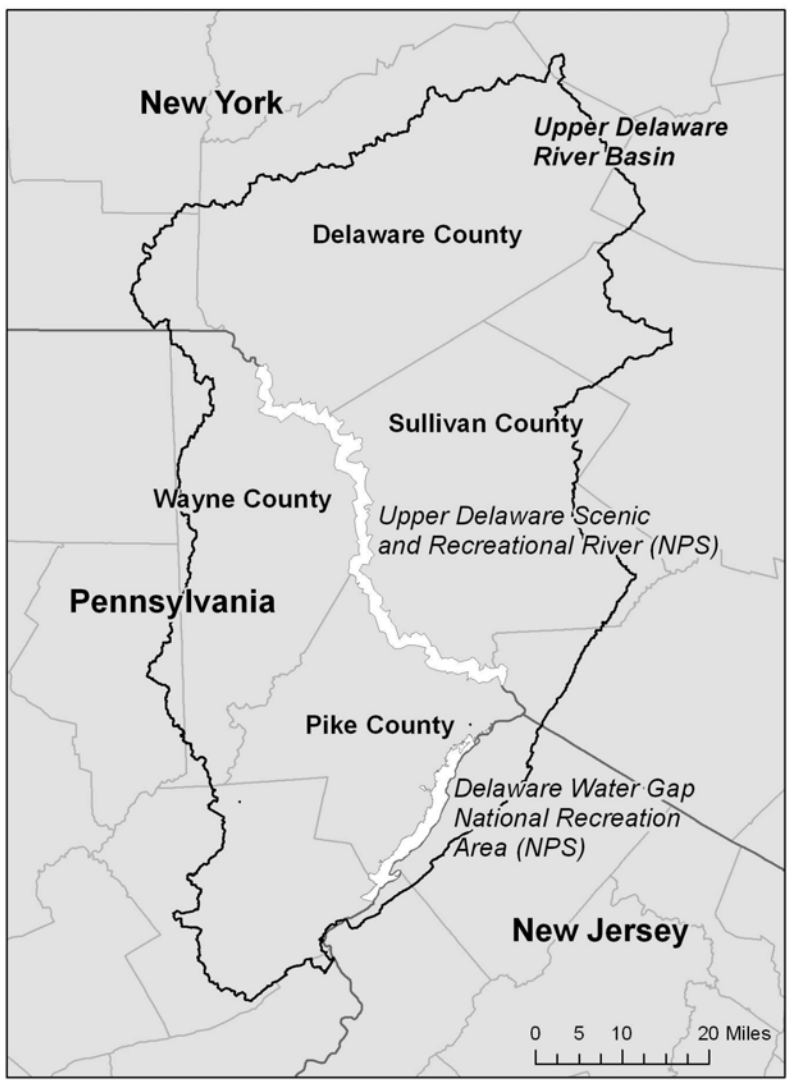


TOPS Forecasted Changes in Snow Water and GPP for 2050-2099, Yosemite



TOPS Forecasted Trends in GPP for 2050-2099, Yosemite Valley

Delaware Watershed: Present to Future
Land Use, Hydrology, Stream Intregity



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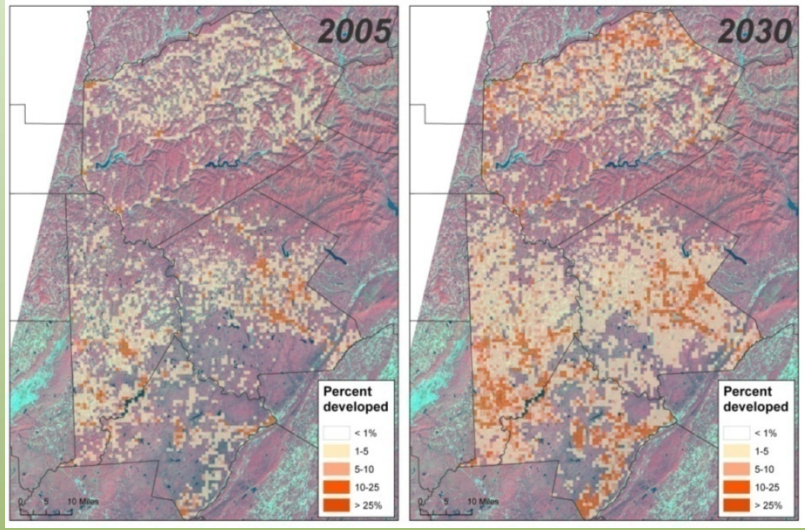
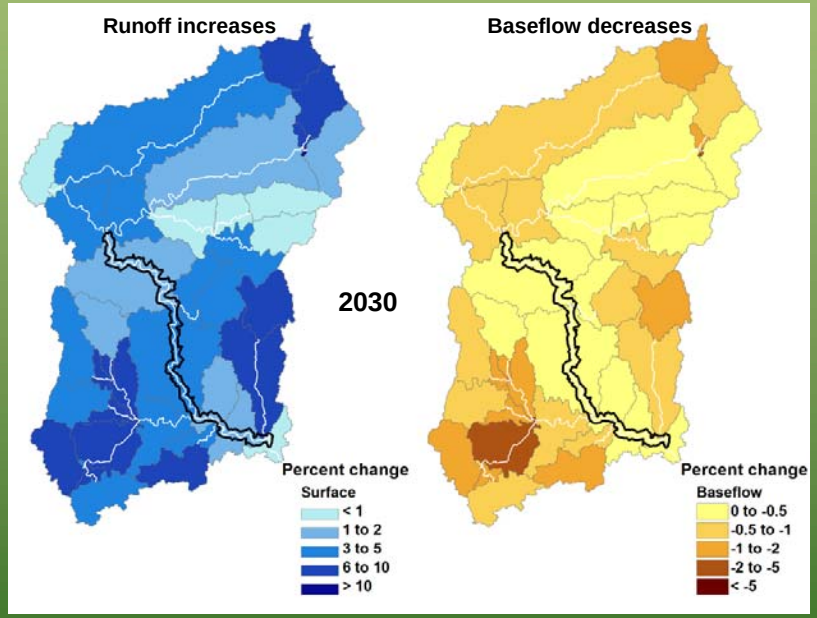
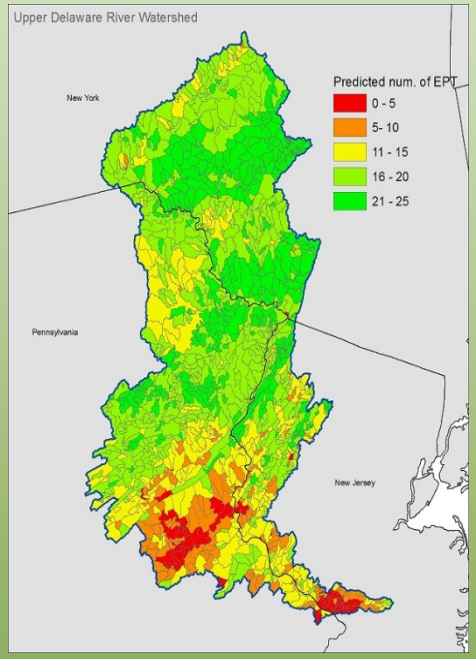


Projected Land Use Change

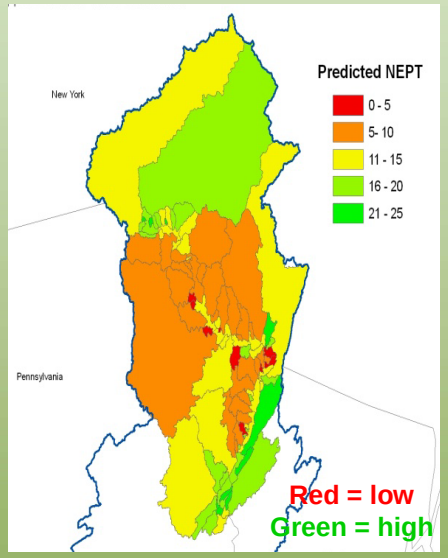


Predicted Hydrologic Change under Future High Urban Growth Scenario

2005



2030



Index of Biological Integrity for Sensitive Taxa (benthic)

Objective 3: Integrate into NPS I&M Framework

- Data
- Summaries - by spatial and temporal scale
- Stories - interpretation of trends and interactions
- Delivery - web-based Interface (Ecocast), Standard Operating Procedures, Model Builder tools, contracts, training

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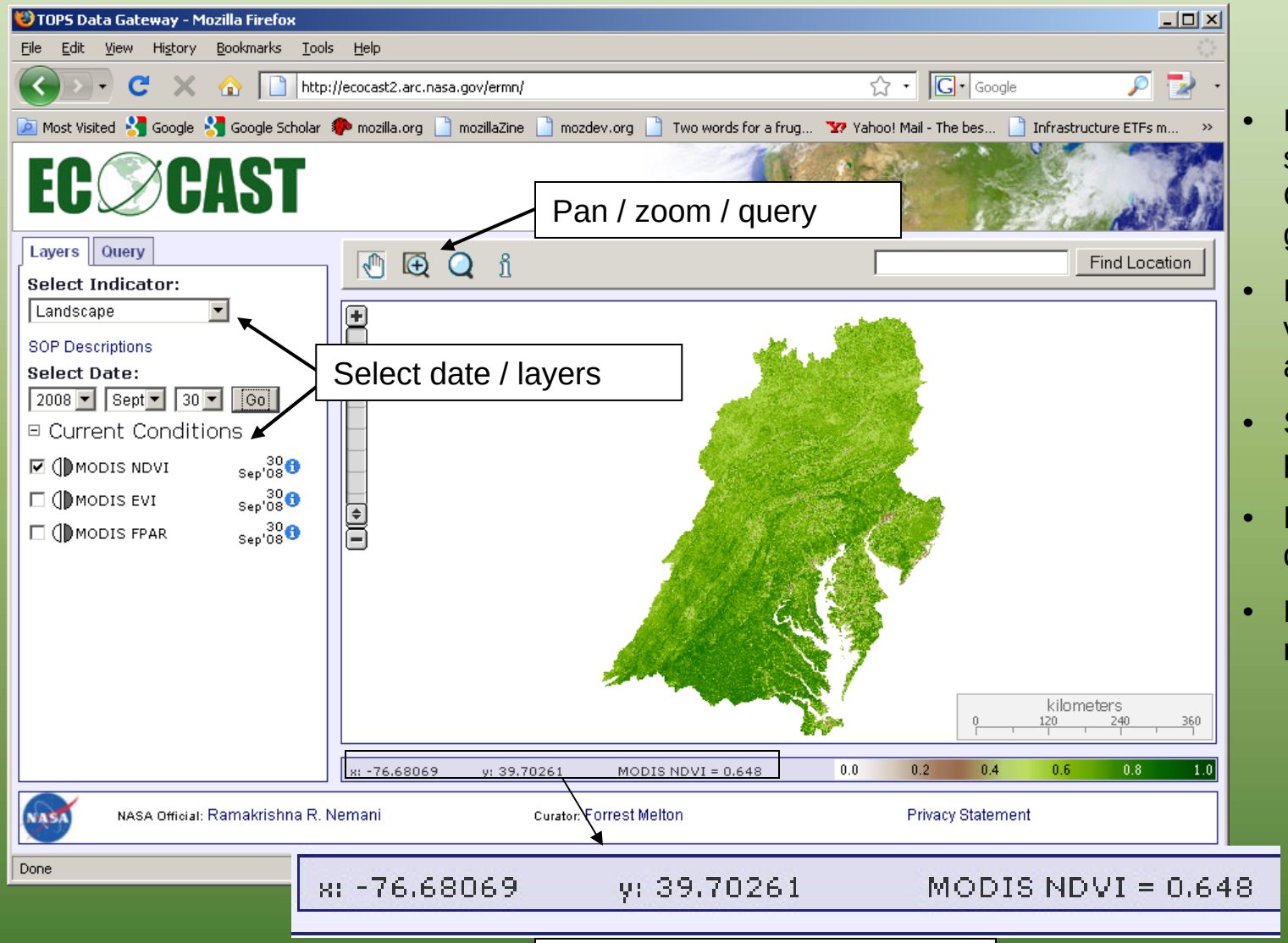
TOPS Data Gateway



- Browser-based, open source (ka-Map / Geoserver) data gateway
- Rapid data access, visualization, query, and analysis
- Supports timeseries plots, data queries
- FTP, WMS, & WCS data access
- Direct access to metadata

Second-Year Assessment

Questionnaire complete by:

Eastern Rivers and Mountains – Matt Marshall and Kristina Callahan
Greater Yellowstone Network – Rob Dailey, Cathie Jean, Stacey Ostermann-Kelm
Rocky Mountain – Jennifer Burke, Mike Britten, Billie Schweiger
Sierra Network - Les Chow, Bill Kuhn, Shawn McKinney, Peggy Moore, Linda Mutch

Summary of Positives

- **Indicators considered relevant, nonduplicative, and valuable for assessing park condition.**
- **PCE concept appealing and methods mostly objective.**
- **Hindcasting and forecasting considered a substantial step forward in providing a context for interpreting current conditions and trajectories of change.**
- **Ecocast and SOPs considered good way to enable decision support.**

Summary of Concerns.

- **PCE methods should be more clearly presented and allow more flexibility for local modification.**
- **Some of our draft SOPs were considered underdeveloped and not repeatable.**
- **Concern about the project related to how to ensure continued access to the products after this project ends.**

Schedule for Final Year

Spring 2009

- Finalize PCE boundaries and SOP
- Continue development of indicator products, analyses, SOPs
- Conduct workshop with the Eastern Rivers and Mountains network
- P.I. team meeting

Summer 2009

- Continue development of indicator products, analyses, SOPs
- Begin delivery of initial products via Ecocast

Fall 2009

- Finalize products, analyses, SOPs
- Conduct workshop with Sierra Network
- Finalize development of Ecocast for product delivery

Winter 2010

- Prepare project final report
- Conduct training sessions with cooperators
- Do a workshop and prepare a white paper on means of incorporation of the projects methods and products into the NPS I&M structure.

Summary

- ✓ Identify NASA and other products useful to park monitoring
- ✓ Delineate the boundaries of the park-centered ecosystems appropriate for monitoring.
- ✓ Add value to these data sets for understanding change through analysis and forecasting.
- ✓ Deliver these products and a means to integrate them into the NPS I&M decision support framework.

Summary

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However, successful decision support requires the human touch: repeated, honest, collaborative face to face time with collaborators in their home environment.