Landscape-Scale Indicators

EPA Workshop on Environmental Indicators
Kansas City, MO - May 2004

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U.S. Department of the Interior
U.S. Geological Survey

Geographic Analysis and Monitoring Program

The National Map

COOPERATIVE TOPOGRAPHIC MAPPING	LAND REMOTE SENSING	GEOGRAPHIC ANALYSIS AND MONITORING

Map Monitor Understand Model Predict

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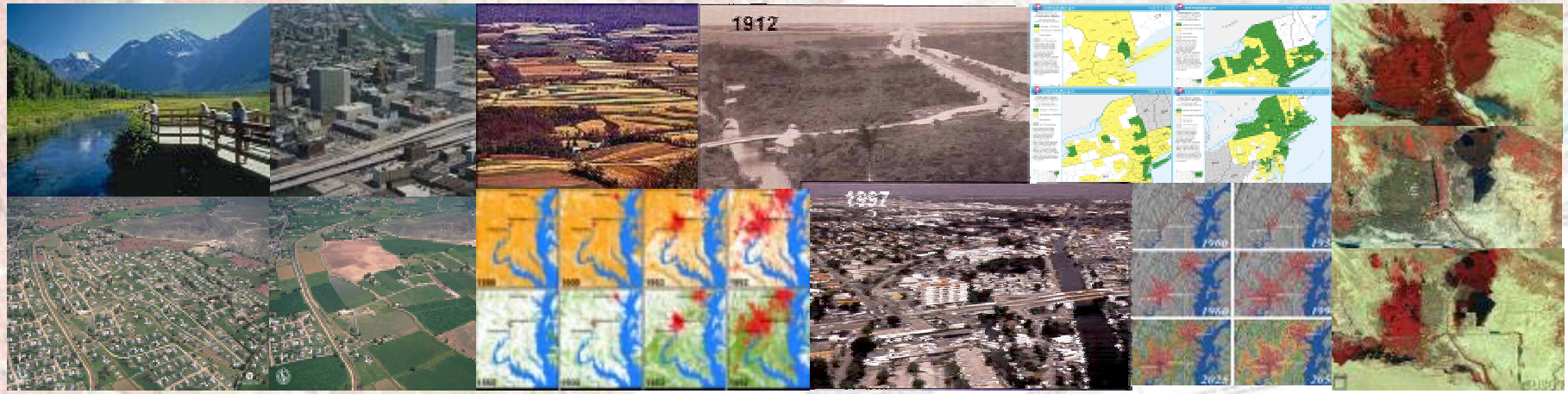
To assess the Nation's land surface at a range of spatial and temporal scales to understand the rates, causes, and consequences of natural and human-induced processes and their interactions that affect the landscape over time.



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Indicators …..

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Definitions

Risk Assessment is the basis for an early warning system. It identifies threats from natural and anthropogenic, and biotic and abiotic sources (hazards). It establishes the degree of vulnerability

Early Detection is the process of using monitoring criteria to discern changes before they become manifest.

Early Warning is the process of alerting that a detrimental situation is imminent

Definitions

Screening is a proactive assessment based on probable risk to reveal whether that risk has become manifest.

Forecasting is the process of using models to develop predictions of future events.

Monitoring is the process of developing formal mechanisms to detect changes that are occurring on the landscape and assessing their real and potential impact. Monitoring systems are based on detecting probable scenarios weighted by their potential impacts.

Screening, Early Detection and Monitoring: examples from other disciplines

Medical - colon and breast cancer screening (risk assessment) and early detection; early asthma attack warning

Education - Students At-Risk

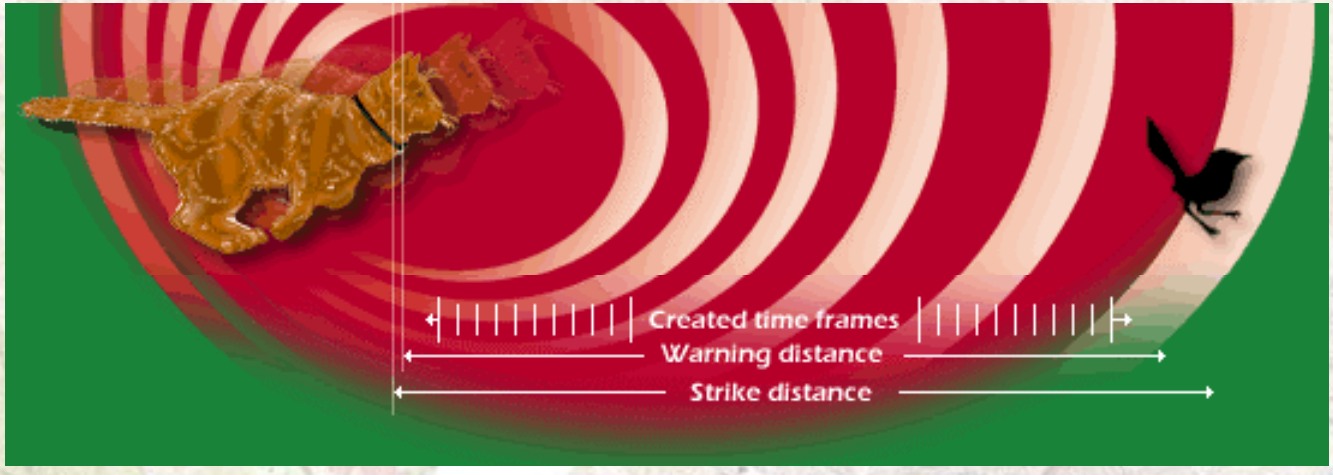
Astronomy - SuperNova Early Warning System

Military - DEW (Distant Early Warning) Cold War system of radar stations in the high arctic.

DEW Line

THE DEW LINE
01 Feb 1962
MAIN STATION
AUXILIARY STATION
INTERMEDIATE STATION
TERMINAL STATION
RELAY STATION

Liberator Cat



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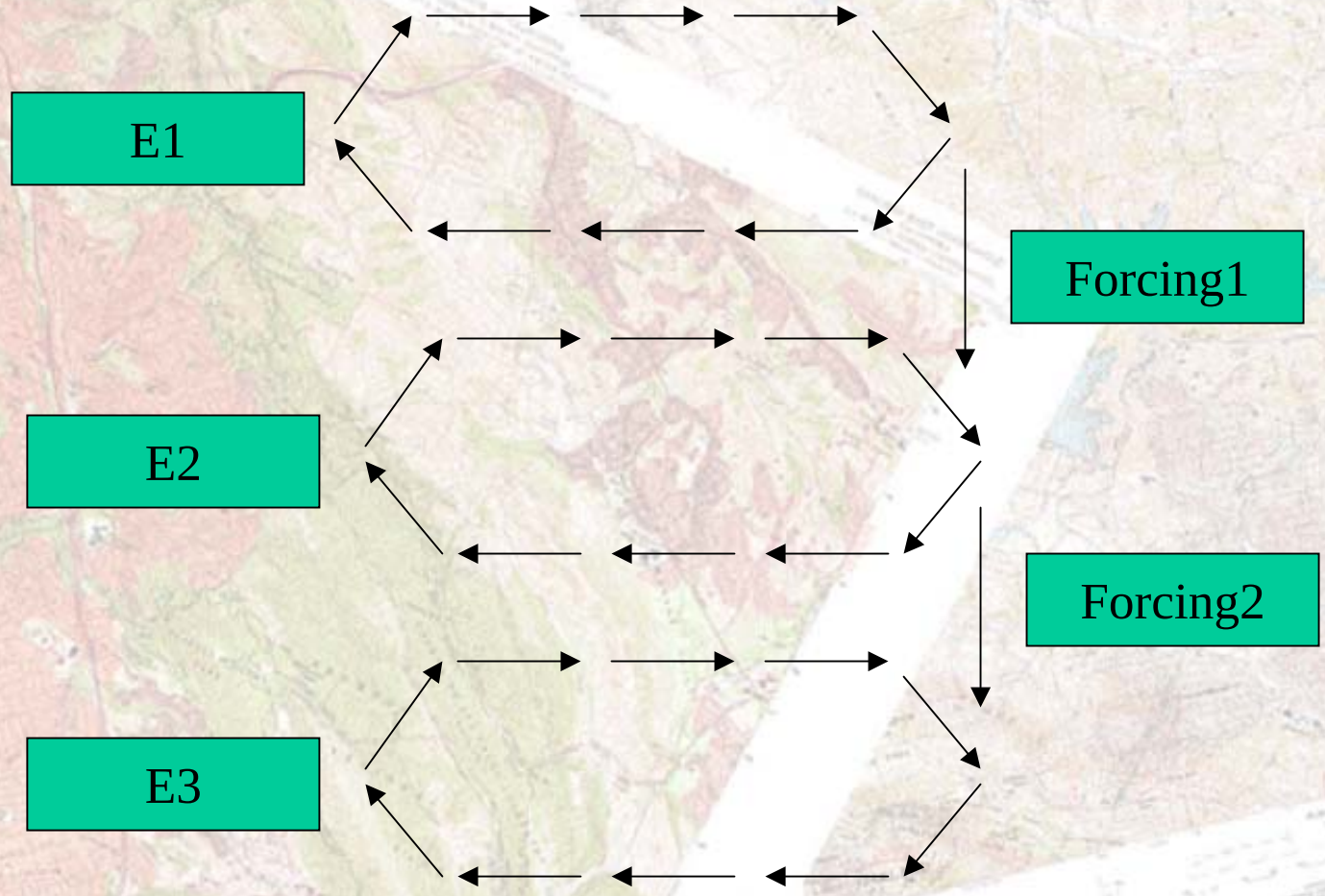
Indicators for Assessment and Monitoring

- Measurable
- Predictive
- Forcings – panarchy (Hollings et al.)
- Modeling Focus
  - Parameterization
  - Sensitivity
  - Scenarios

Dynamic Equilibrium of Landscapes



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Landscape-Scale Indicators

Patch Indicators

- **Patch Size**
- **Patch Integrity**
- **Patch Dimension**

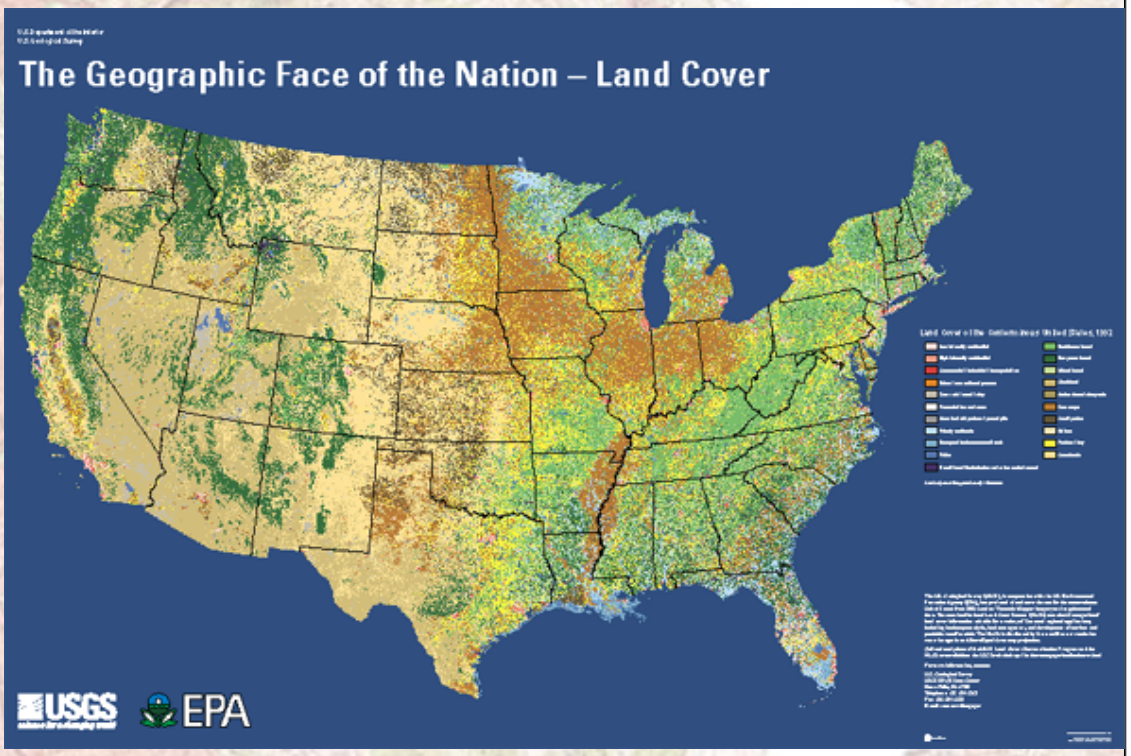
Inter-Patch Indicators

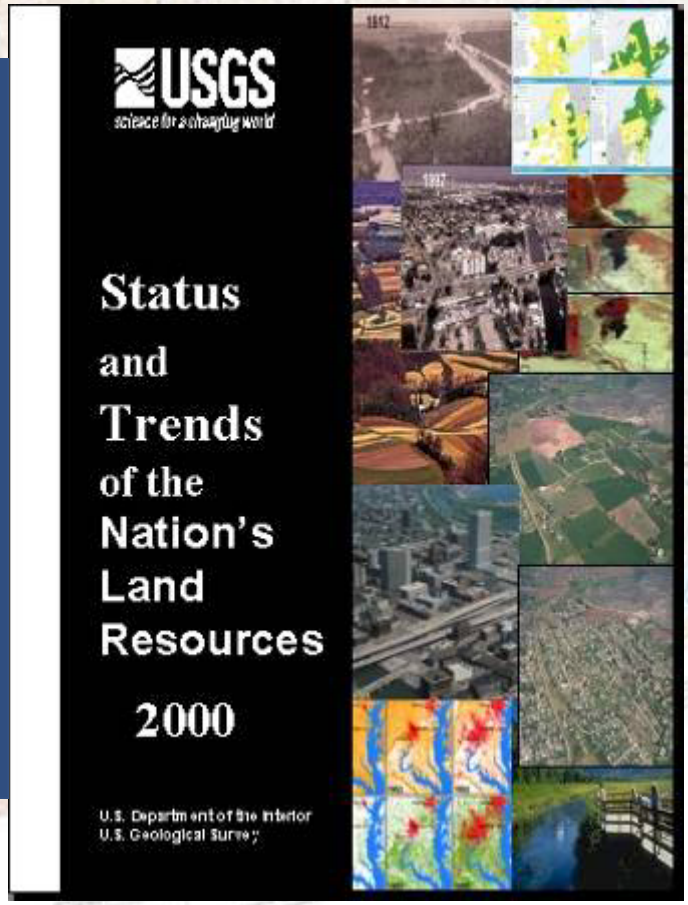
- **fragmentation**
- **connectivity**
- **context**

Land Cover +

USGS Geographic Science

Status and Trends





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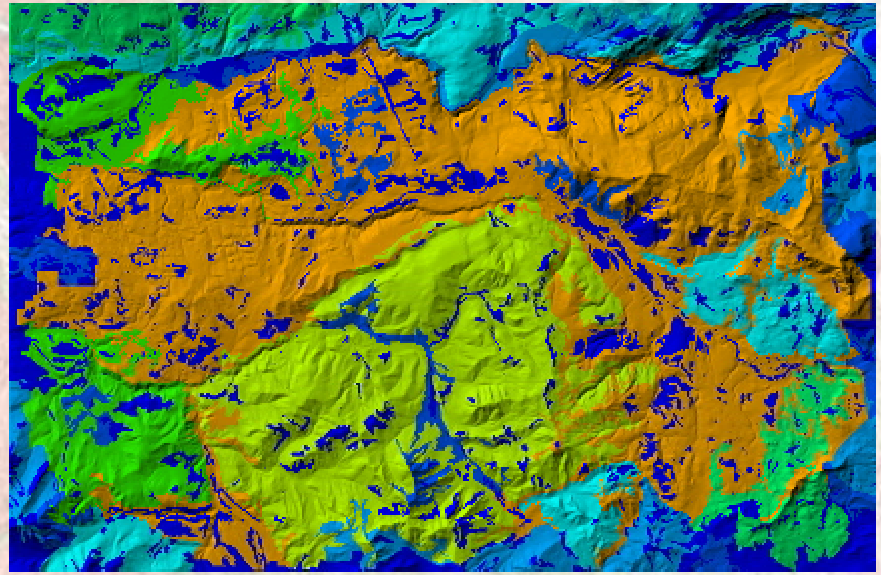
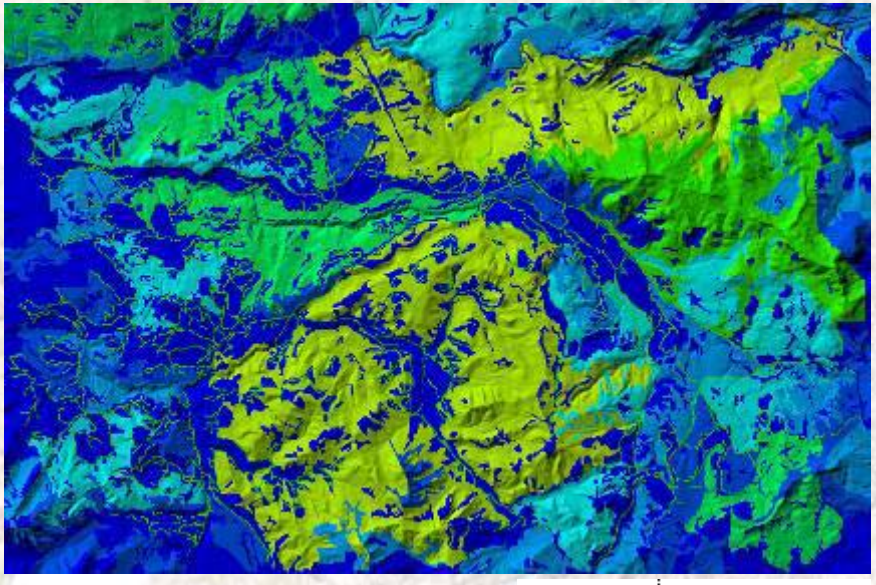
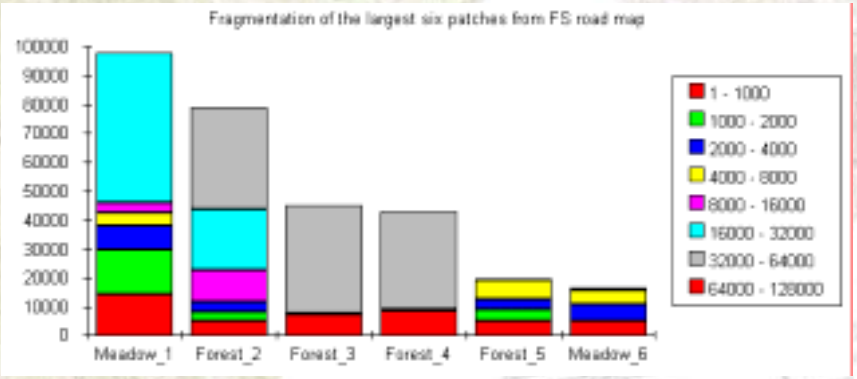
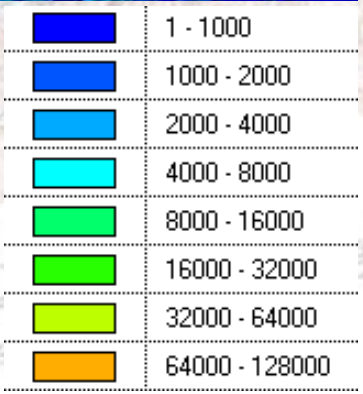
Analyze, understand, model, and predict the consequences of historical and projected land surface changes on ecosystem health, taking into account natural and human-induced stimuli at regional, continental, and global scales.





Patch-size maps





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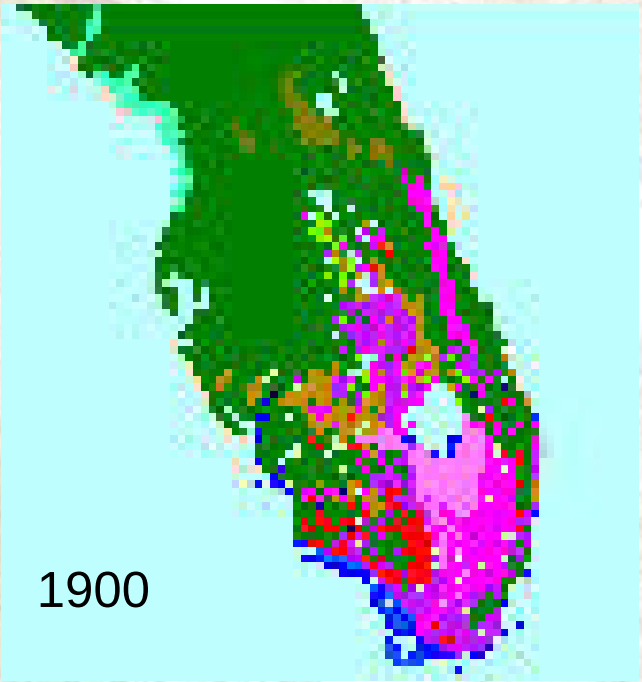
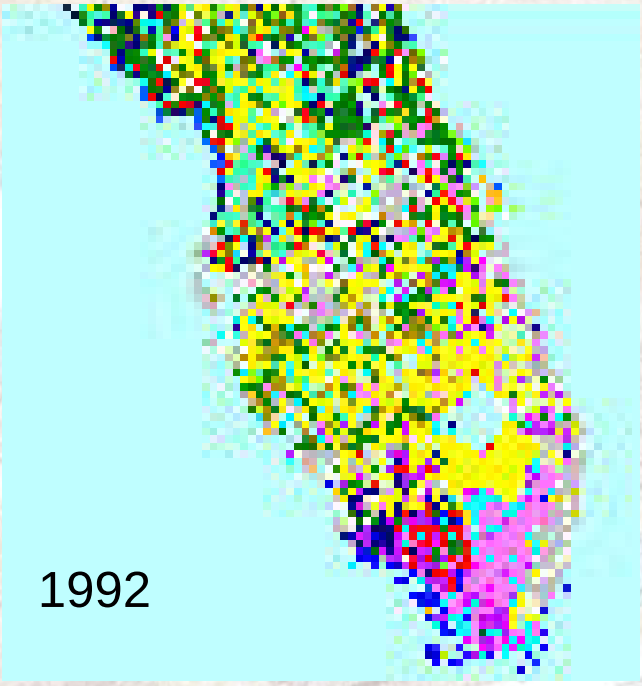
Determine & Quantify the impacts of land use and land cover change on regional climate variability & biochemistry, including potential feedback processes

- What are the feedback loops between land use and land cover change on climate & biogeochemistry?





In 1900 Florida was still largely covered with natural vegetation (green, pink, and blue); by 1992 it was transformed by agriculture and cities (yellow)

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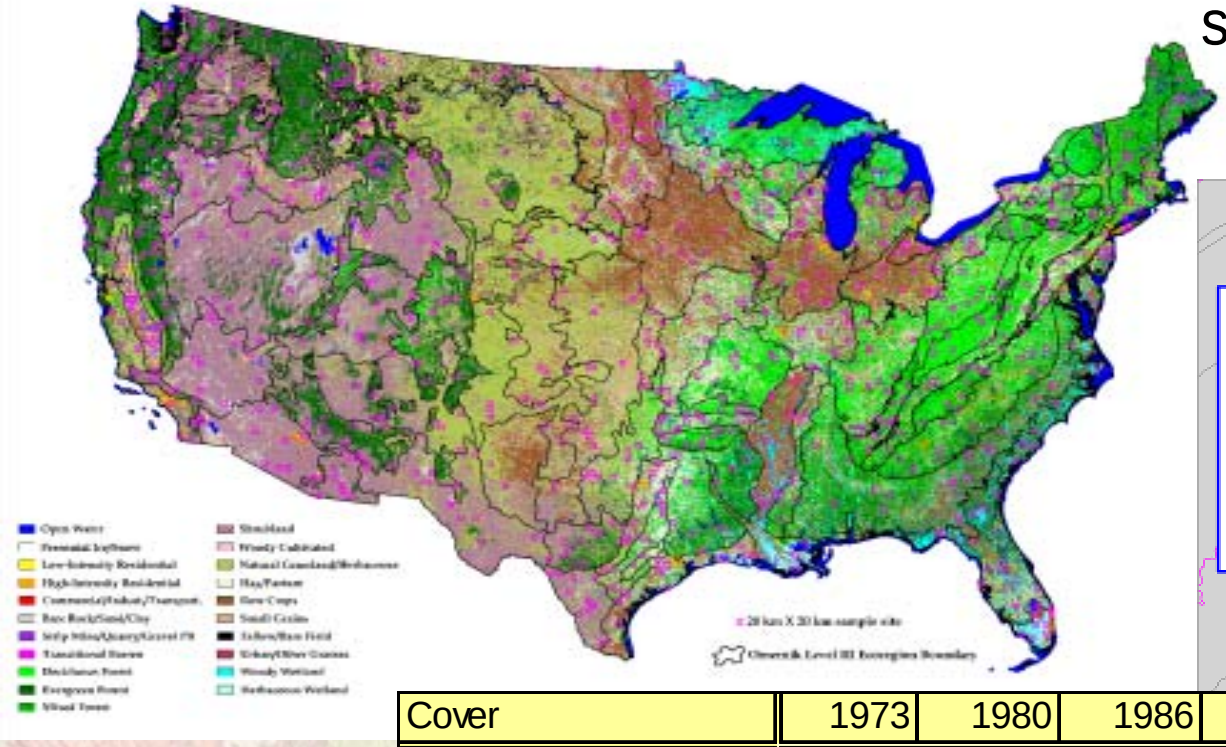
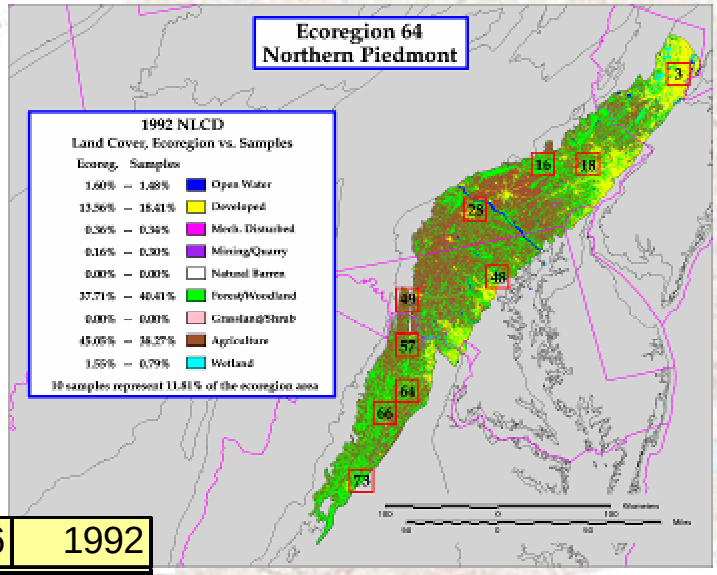
Land Cover Trends

What are the changes in the landscape and how significant are they?

Land cover by Ecoregion





Cover	1973	1980	1986	1992
Water	1.6%	1.6%	1.6%	1.6%
Urban/Built-Up	24.3%	25.1%	26.1%	26.7%
Transitional	0.2%	0.2%	0.2%	0.2%
Mining/Quarries	0.2%	0.3%	0.3%	0.4%
Forests and Woods	33.5%	33.4%	33.2%	33.1%
Agriculture	39.5%	38.7%	38.0%	37.4%
Wetlands	0.7%	0.7%	0.7%	0.7%

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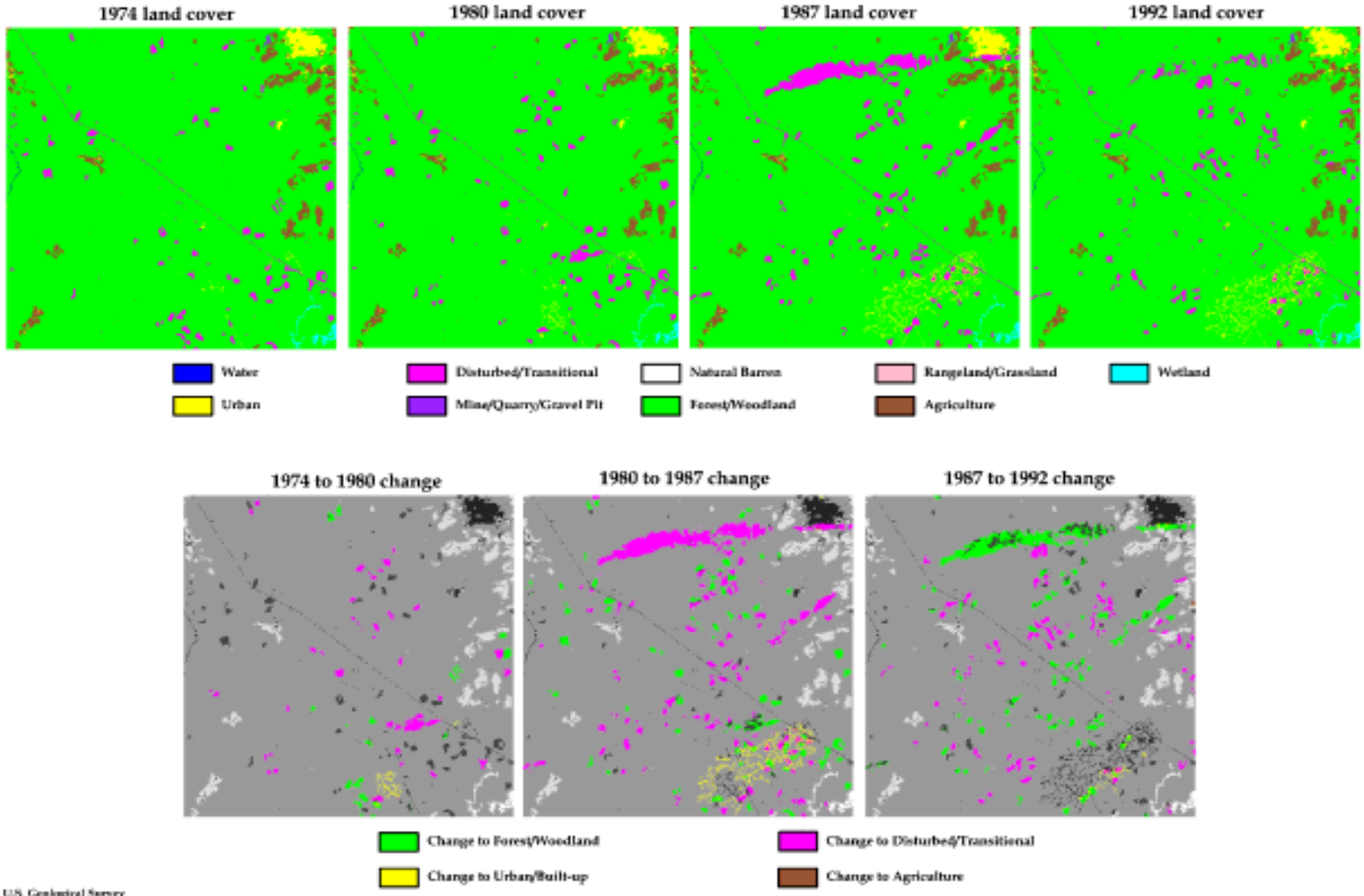
Land Cover Trends Project

Ecoregion 62, Sample 4

1974 to 1992 change



U.S. Geological Survey
National Mapping Division
EROS Data Center
Sioux Falls, South Dakota

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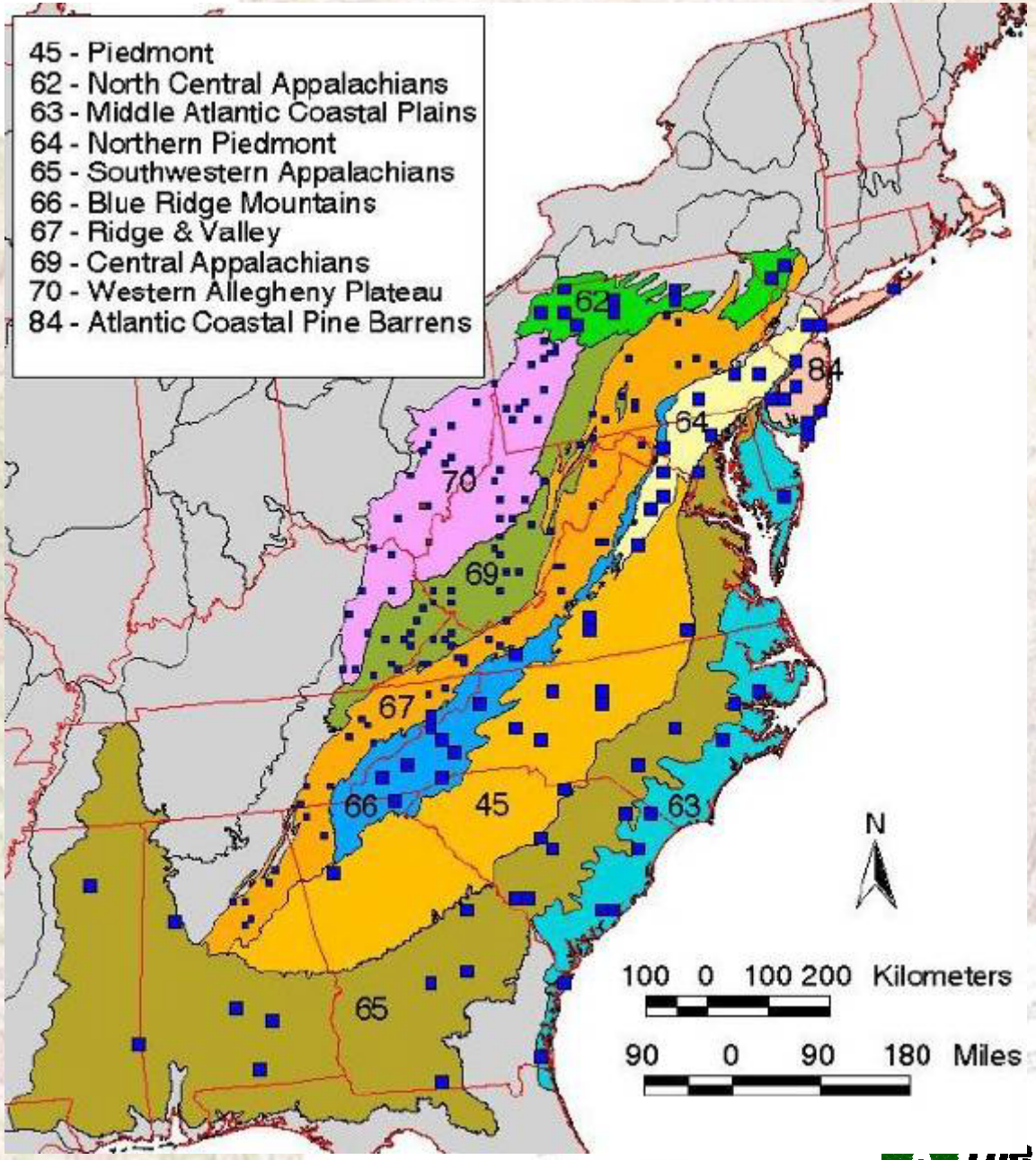
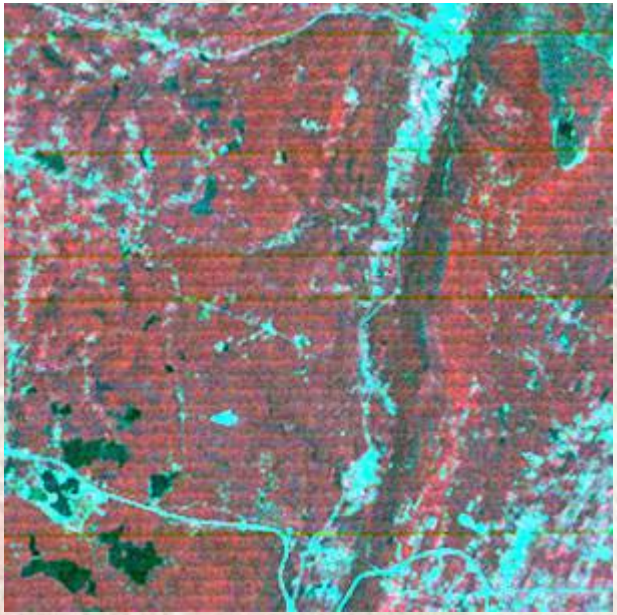
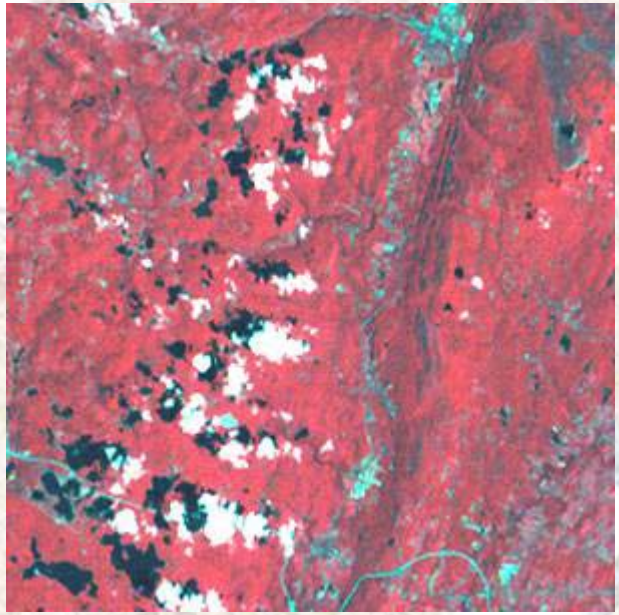


Omernik ecoregions with Trends Samples

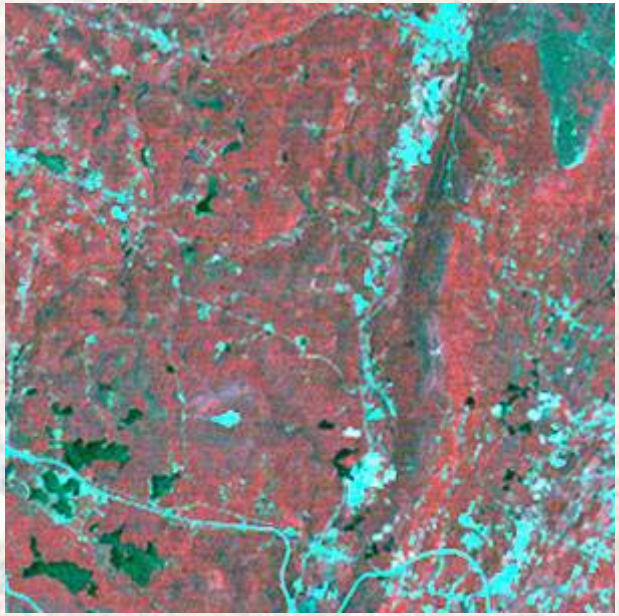
Landsat MSS 1972



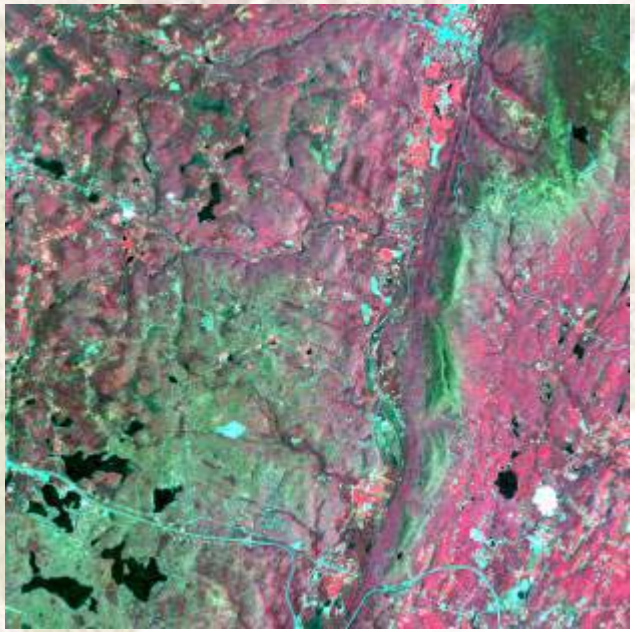
Landsat MSS 1980



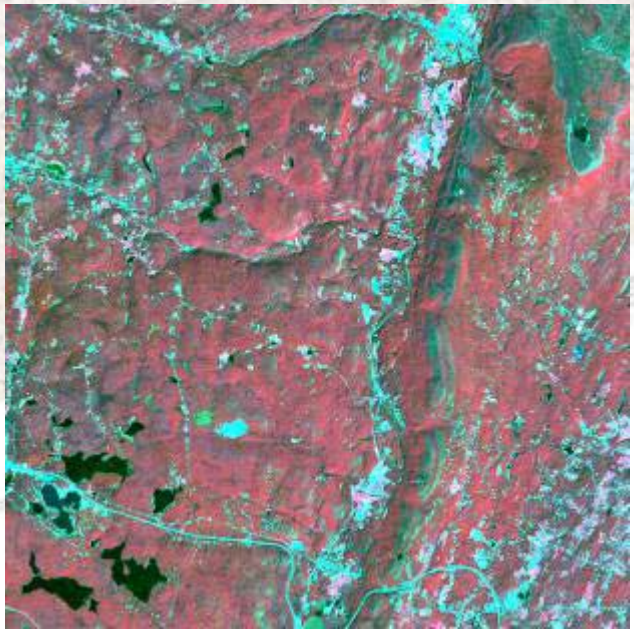
Landsat MSS 1986



Landsat TM 1992



Landsat ETM+ 2000



North Central Appalachia

Sample Site 1

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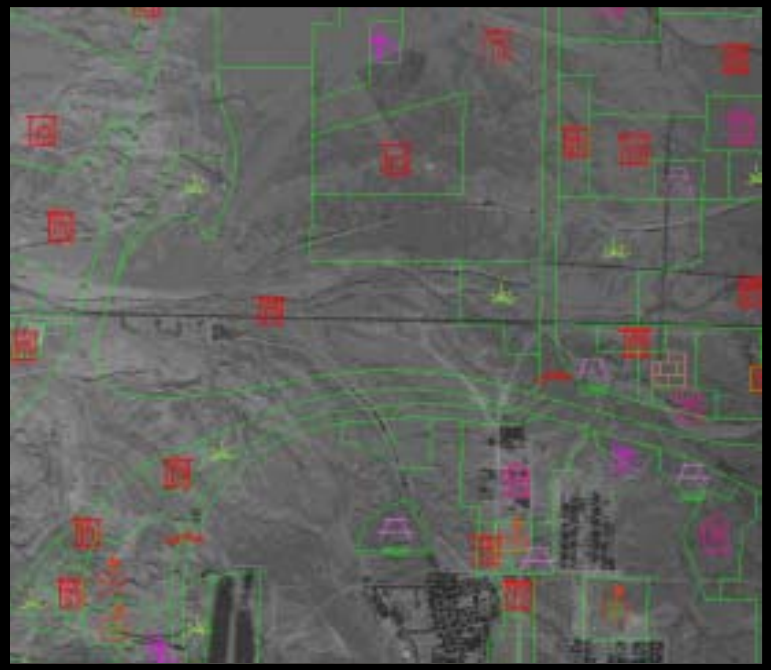
1990s

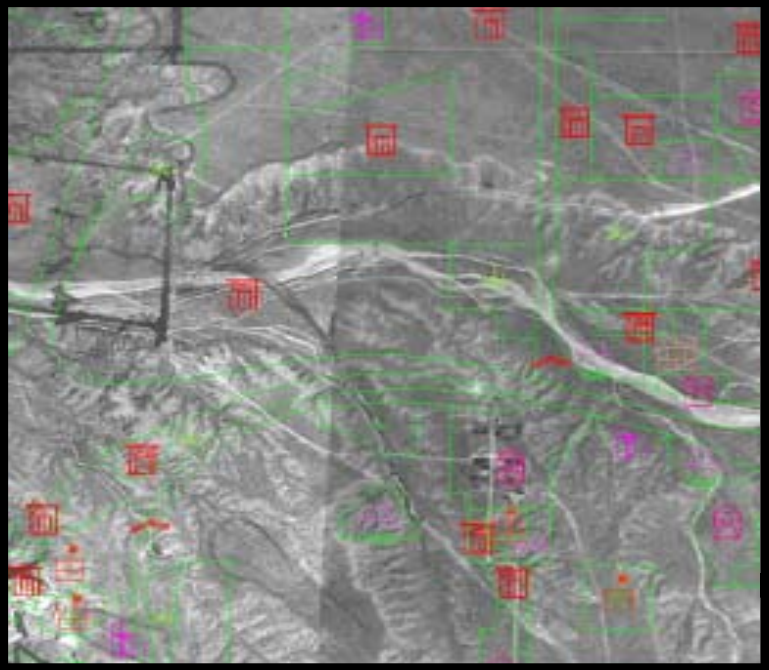
1970s

Albuquerque, NM (I-25 & I-40)

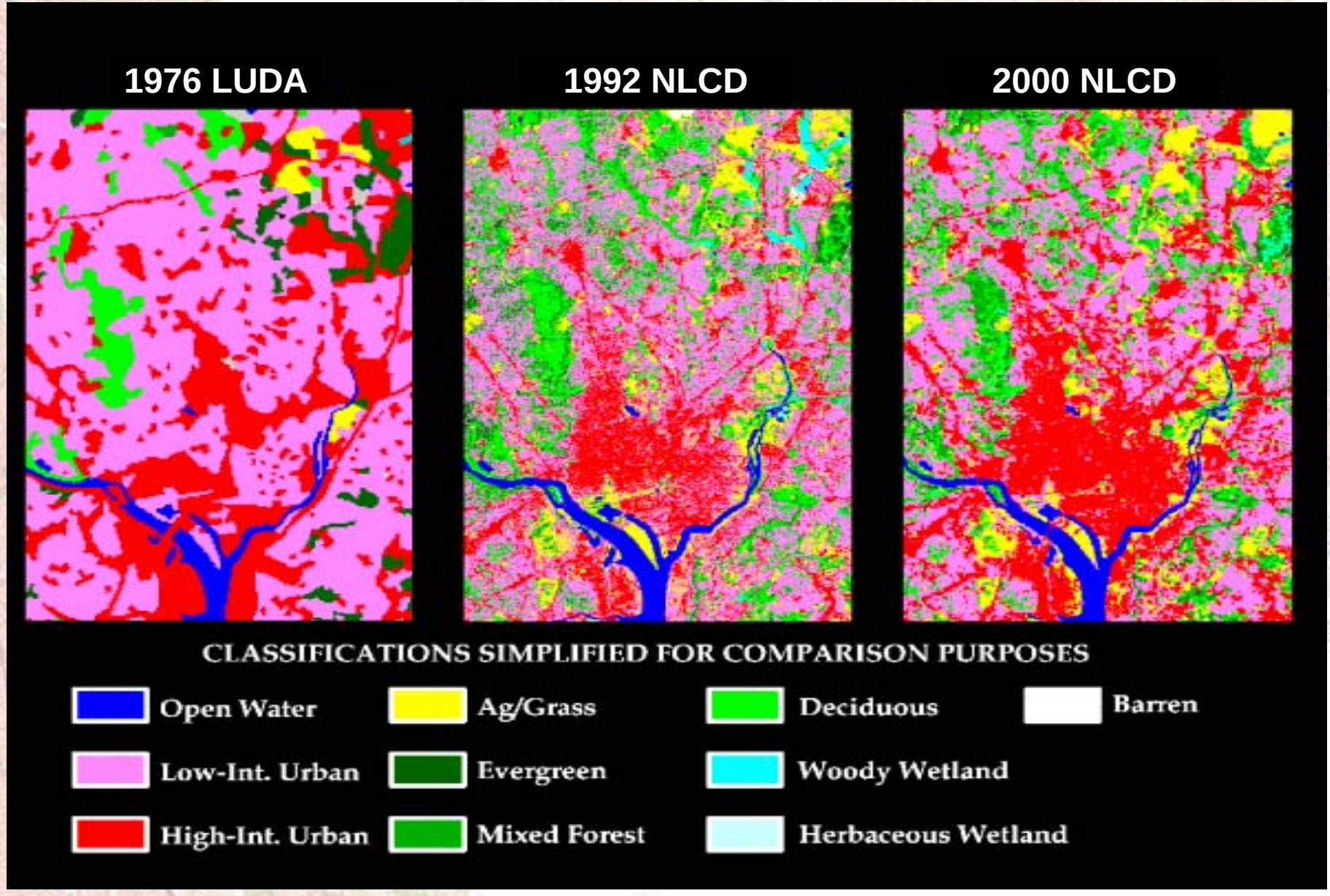
1950s



1930s



Land Cover


1976 LUDA
1992 NLCD
2000 NLCD
CLASSIFICATIONS SIMPLIFIED FOR COMPARISON PURPOSES
Open Water
Ag/Grass
Deciduous
Barren
Low-Int. Urban
Evergreen
Woody Wetland
High-Int. Urban
Mixed Forest
Herbaceous Wetland

MRLC Consortium

http://www.mrlc.gov/mrlc2k.asp

Home | About | Order Data | Events | Publications

Links

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- Publications

Partners

- USGS
- EPA
- BLM
- USFS
- NOAA
- NASA
- NPS
- USDA
- USFWS

Questions or Comments regarding the MRLC project? Please email us.

MRLC Consortium

The Multi-Resolution Land Characteristics (MRLC) consortium group of federal agencies originally joined together in 1992 (MRLC 1992) to purchase Landsat imagery for the nation and to develop a land cover dataset. Beginning in 1999, a second-generation consortium (see logos) has joined together to create a new Landsat image and land cover database for the nation called MRLC 2001.

MRLC 2001 is designed to meet the current need of Federal agencies for nationally consistent satellite remote sensing and land-cover data.

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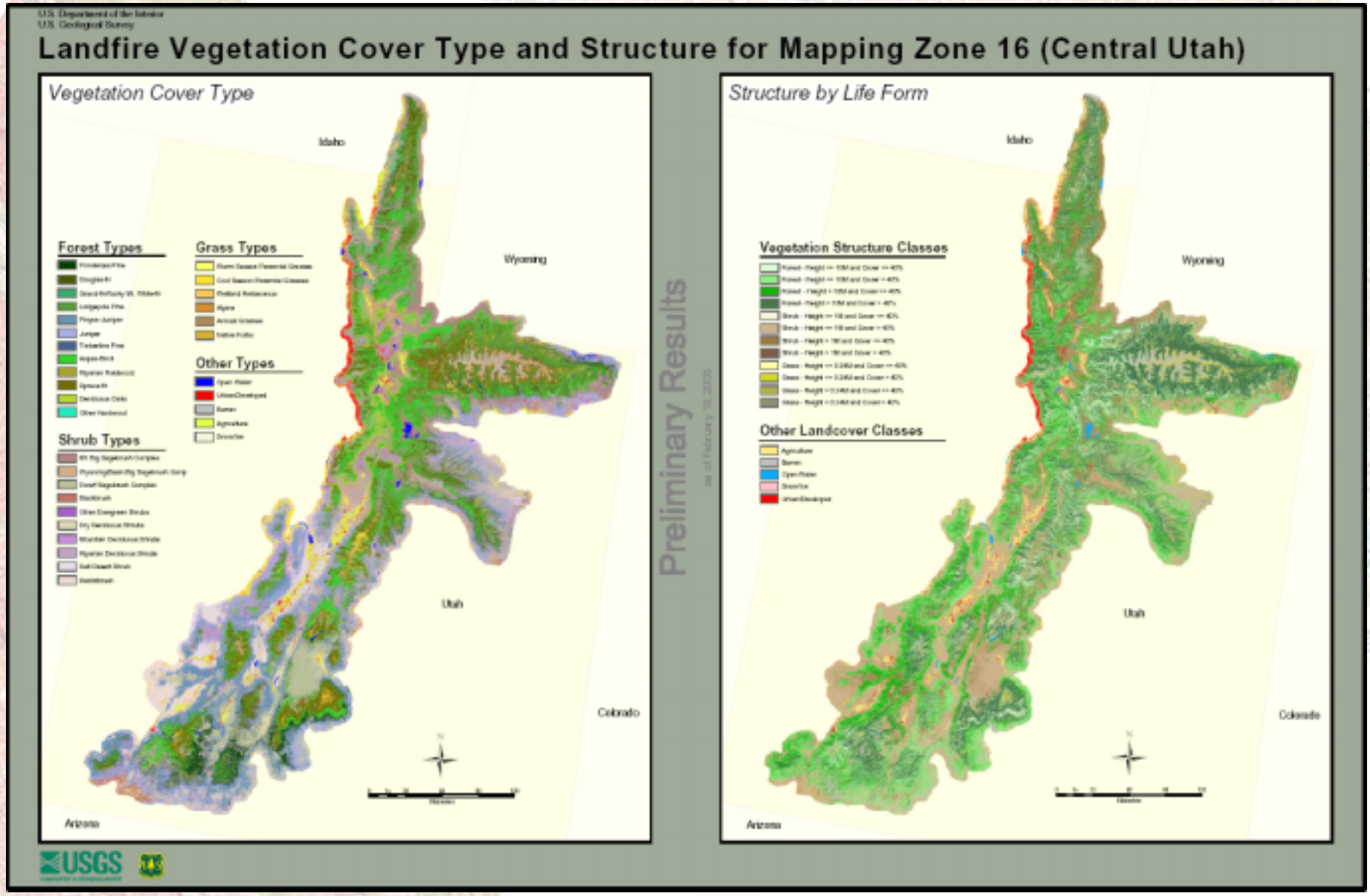
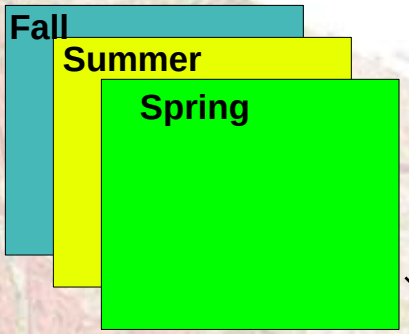
Vegetation Mapping

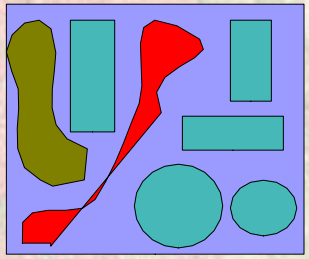


Develop advanced techniques to monitor land surface change & ecosystem structure and function, in a spatially explicit fashion

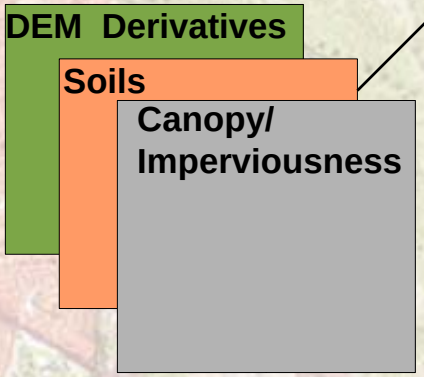
TASSLE CAP IMAGES



LANDSCAPE SHAPE/TEXTURE



ANCILLARY LAYERS



Training Data

CLASSIFICATION RULES

IF
- Spring green 140 - 160
- Fall green 75-100
- Shape Index 0.9 – 1.3
- Slope < 10

THEN HAY/PASTURE

IF
- Spring green 15 - 25
- Summer green 130 -140
- Fall green 130 - 140
- Summer wet 80 -100
- Fall bright 130 - 150
- Slope > 10
- Canopy > 15%

THEN DECIDUOUS

LAND COVER

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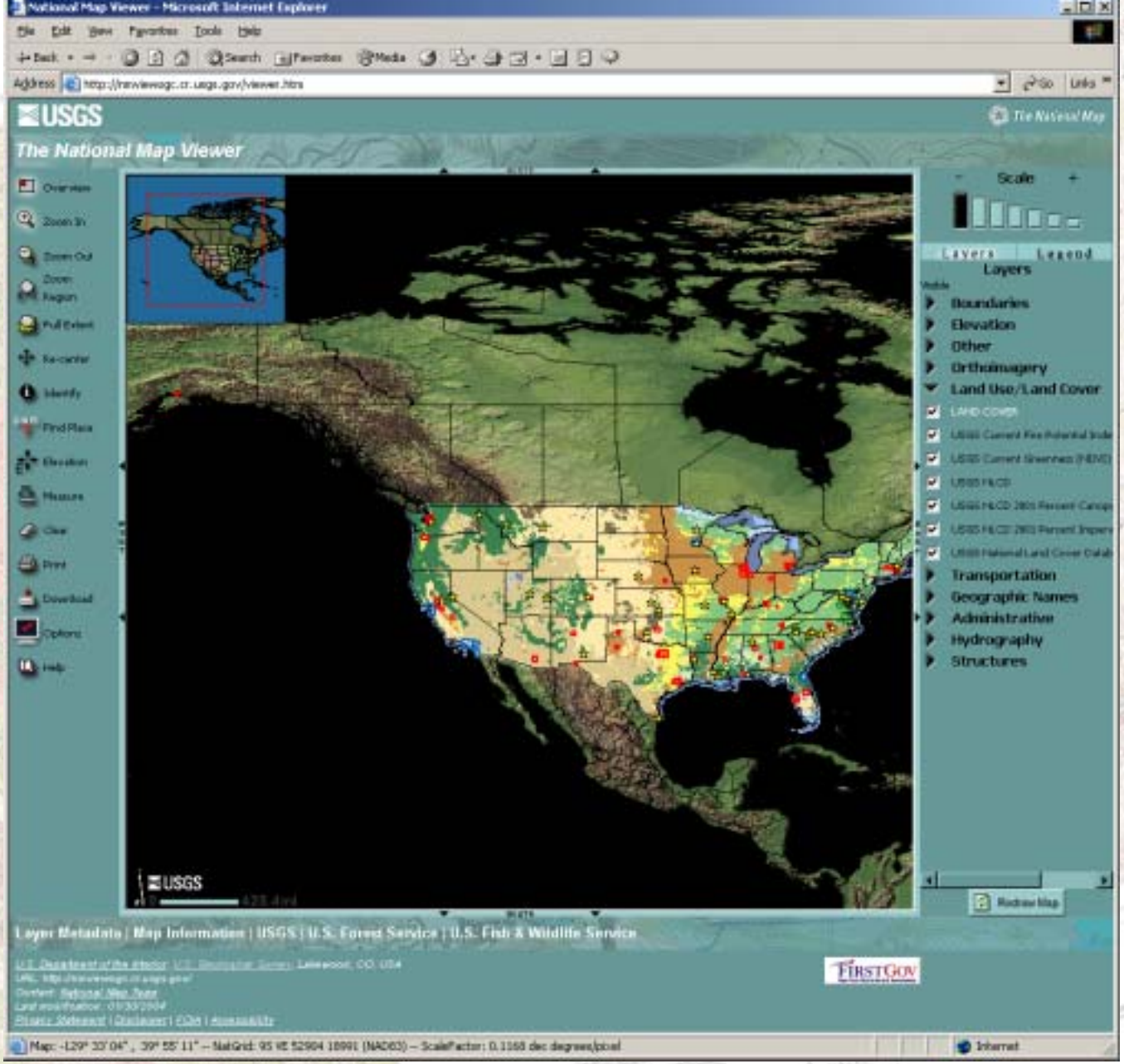

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Washington DC Viewer - Microsoft Internet Explorer

File Edit View Favorites Back Address http://rns2k609.er.usgs.gov/Website/Washington_DC/viewer.asp Go Links

USGS

Geography - *The National Map*

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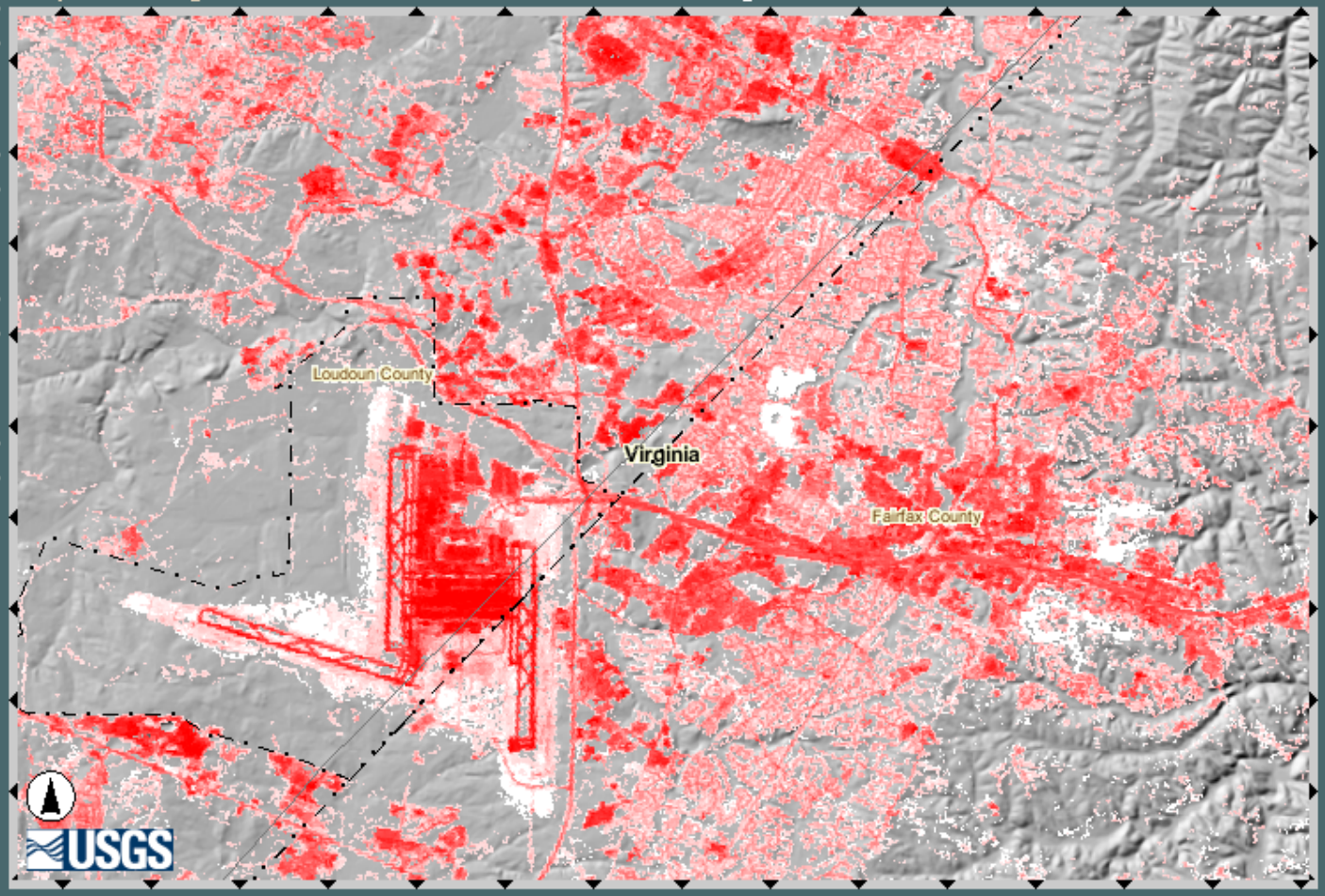
Zoom

Query

Tools

Docs



- Terraservice DRG
- USGS Landsat 7 Satellite Mosaic Spatial Metadata
- USGS Landsat 7 Satellite Mosaic

Land Cover

- NLCD 2001 - Land Cover
- NLCD 2001 - Canopy
- ☑ NLCD 2001 - Impervious Surface
- NLCD 2001 - Confidence Map
- NLCD 2001 - Decision Tree Nodes
- NLCD 1992
- NLCD 1992 Transparent on NED Shaded Relief

Elevation

Pan Down

U.S. Department of the Interior || U.S. Geological Survey || USGS Eastern Region Geography
URL: http://rns2k609.er.usgs.gov/Website/Washington_DC/ || Maintainer: USGS Eastern Region Geography || Modified: October 1, 2003

Map: -77.34 , 38.91 -- Image: 606 , 466 -- ScaleFactor: 0.00028553641697246895 Internet

Washington DC Viewer - Microsoft Internet Explorer

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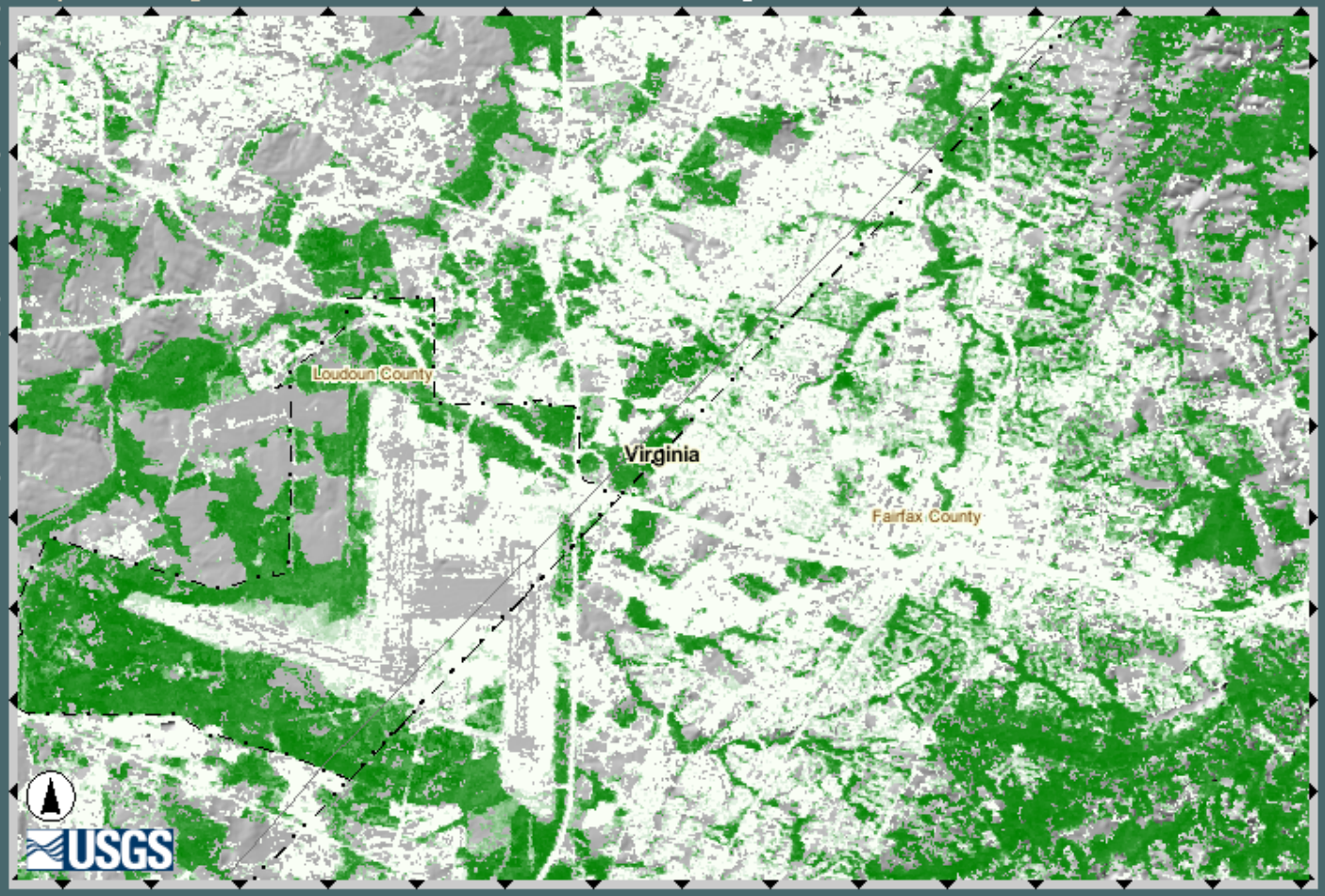

- Terraservice DRG
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Land Cover

- NLCD 2001 - Land Cover
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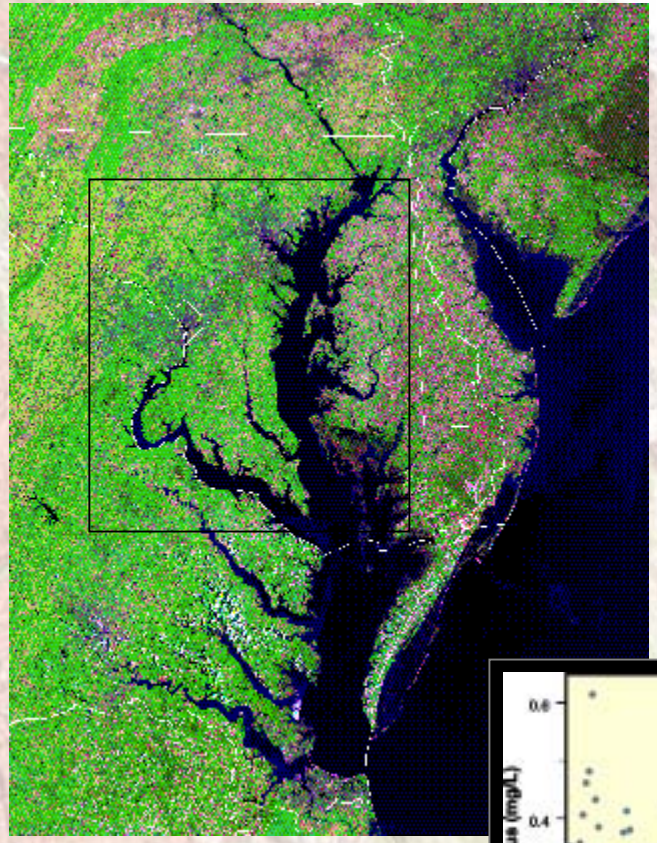
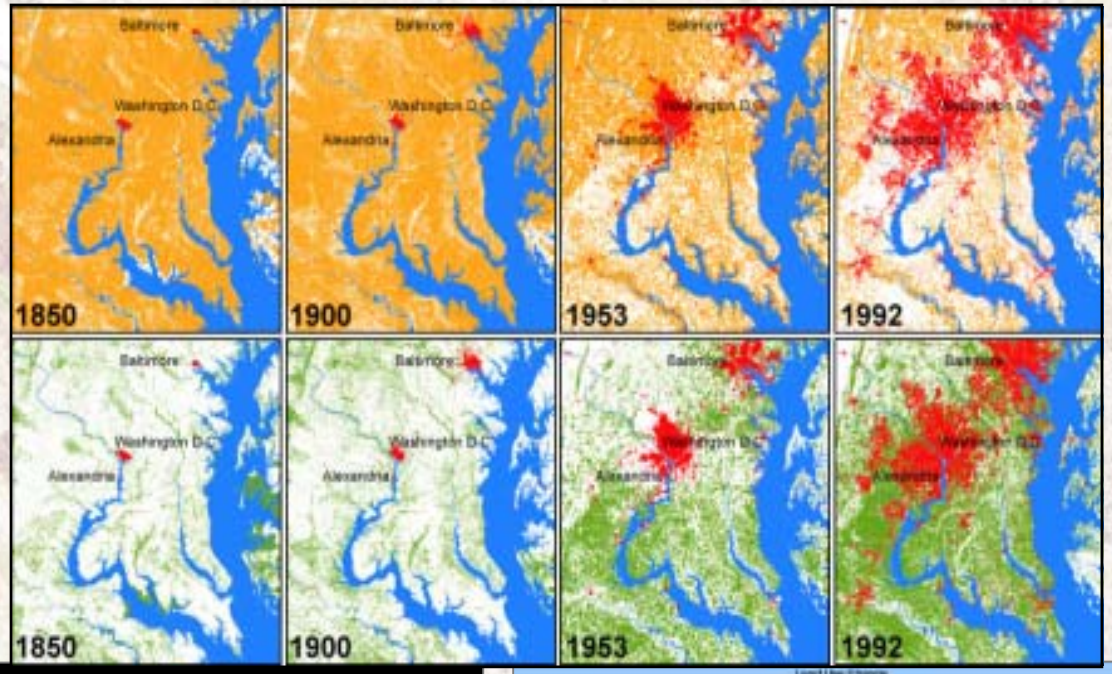
Elevation

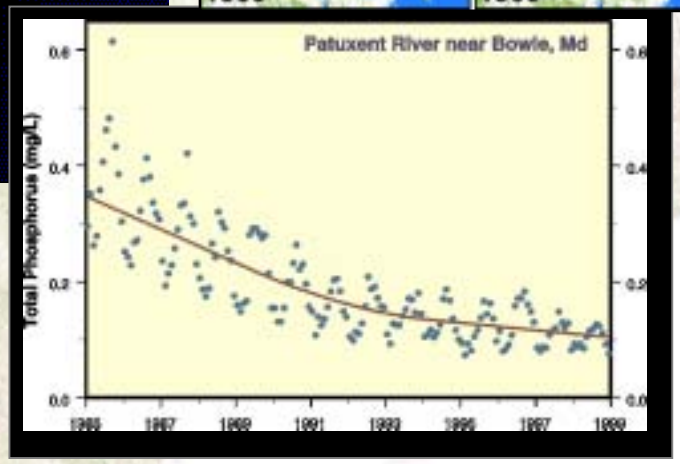
U.S. Department of the Interior || U.S. Geological Survey || USGS Eastern Region Geography
URL: http://rns2k609.er.usgs.gov/Website/Washington_DC/ || Maintainer: USGS Eastern Region Geography || Modified: October 1, 2003

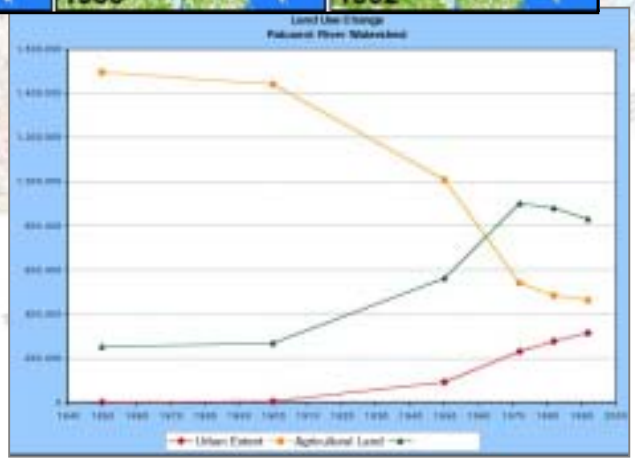
Map: -77.43 , 38.95 -- Image: 284 , 304 -- ScaleFactor: 0.00028553641697246895 Internet

Landscape Dynamics and Forecasting









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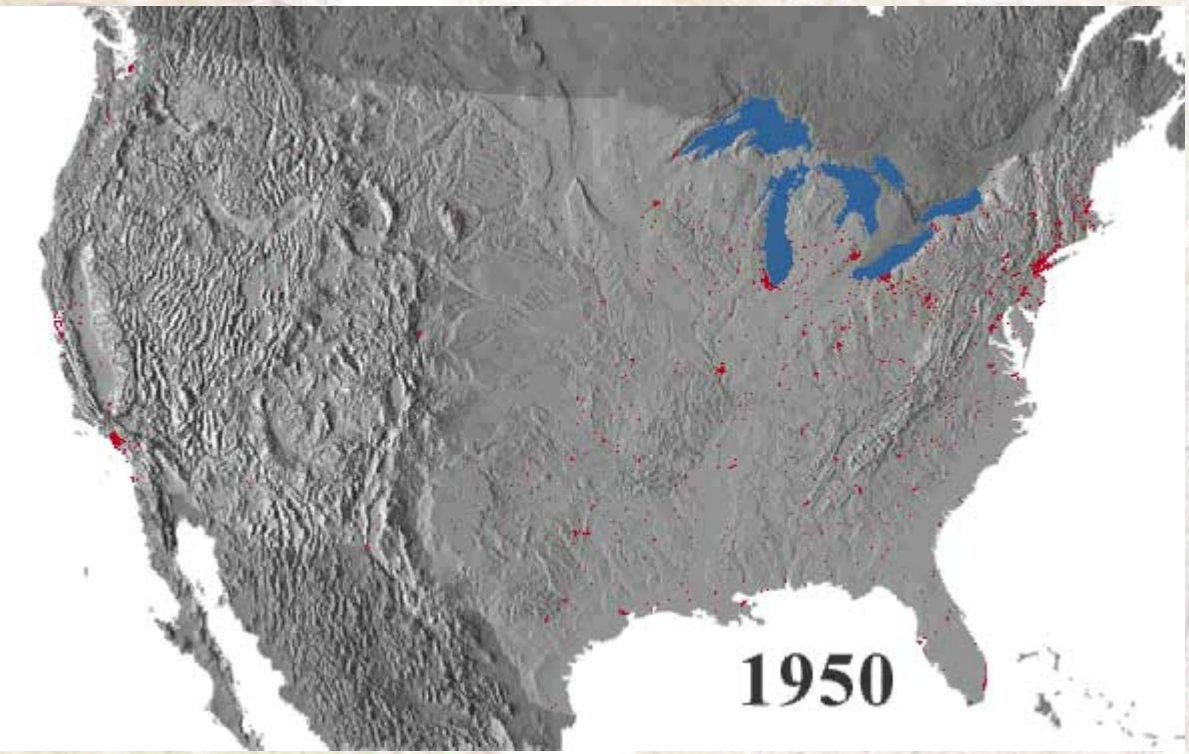
Landscape Dynamics



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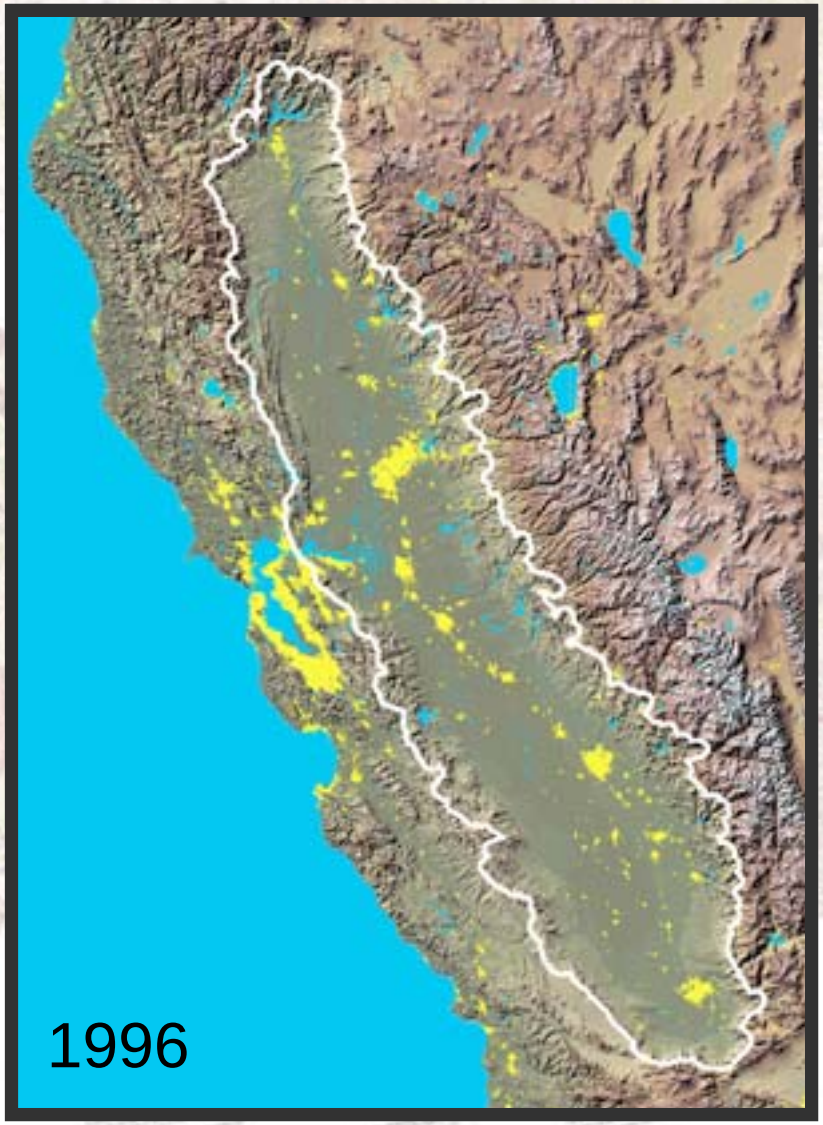
Landscape Dynamics

California's Central Valley

Urban Land Use Dynamics
1900-1996



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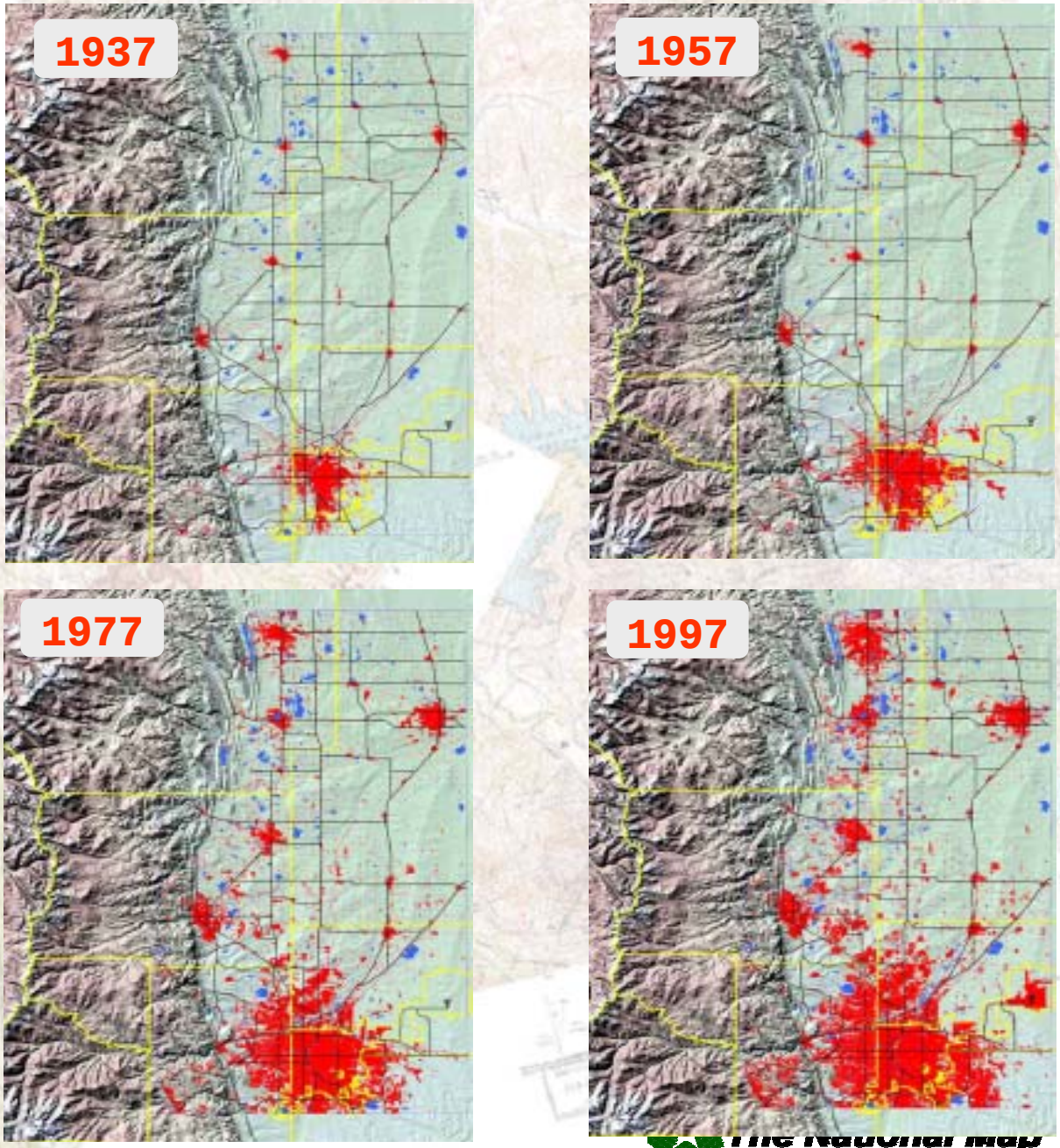
Analyze past landscape change



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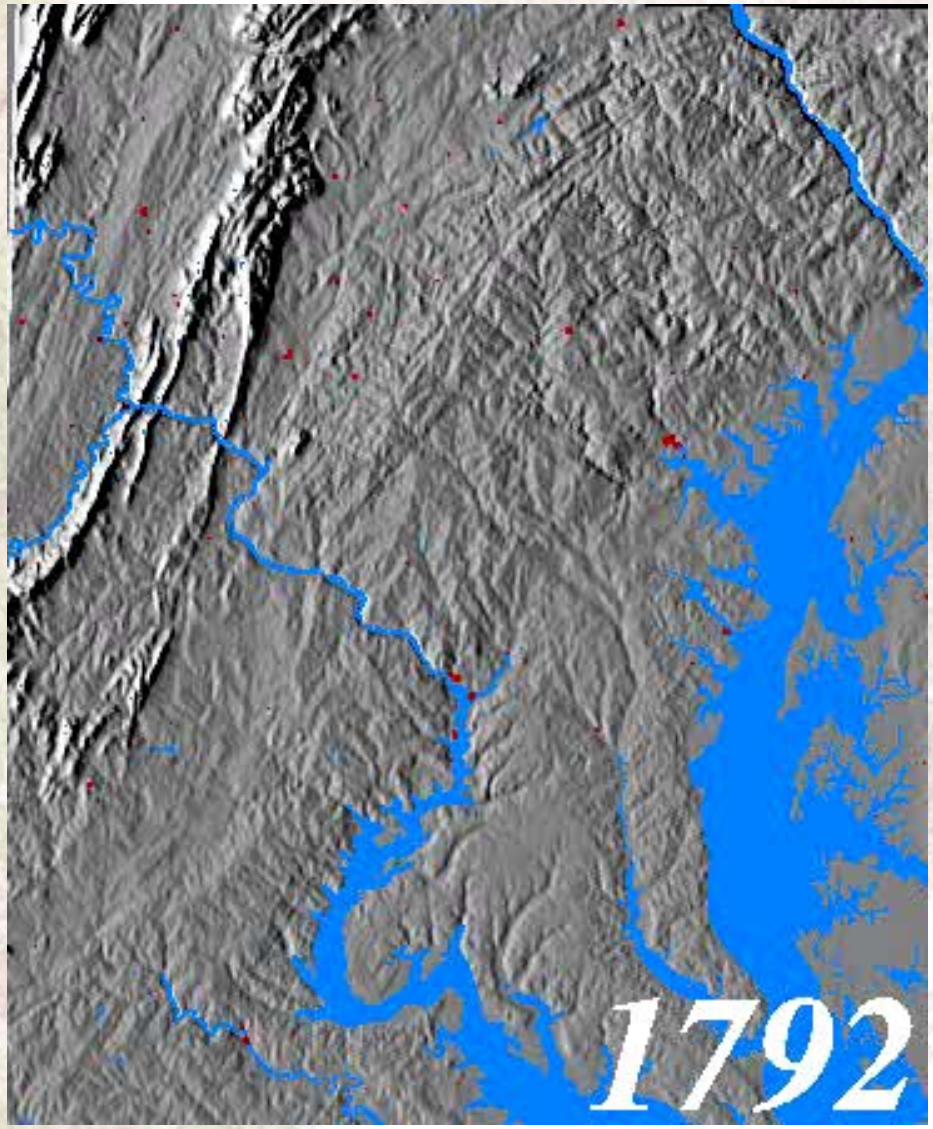
Urban Dynamics



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Address http://ergwms.er.usgs.gov/Website/Washington_DC/erg/

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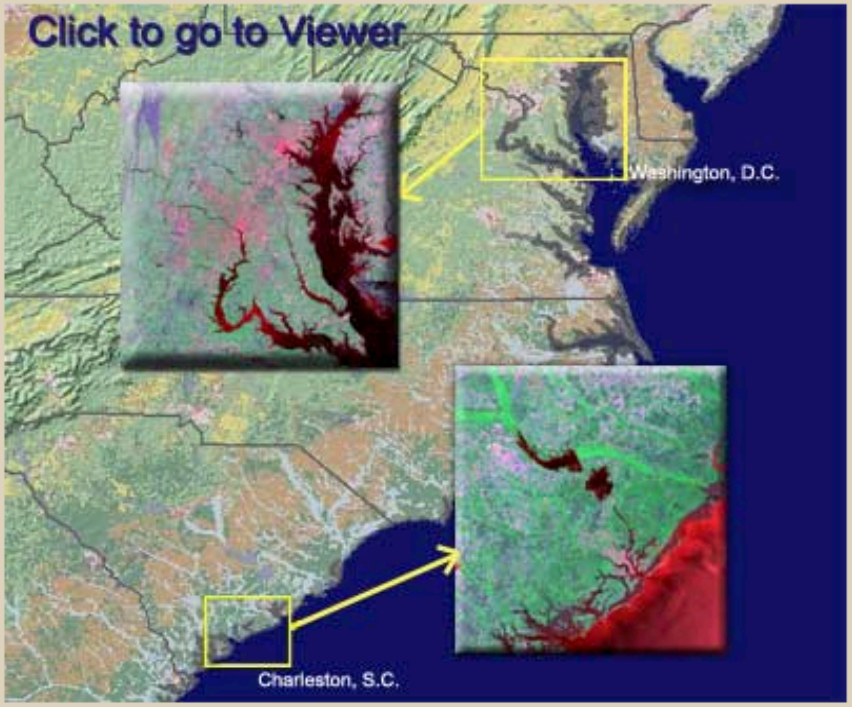
Geography—*The National Map*

Comprehensive Urban Ecosystem Studies (CUES)

Project Content | Map Viewers | Related Links | Documentation

Science Applications to Address Critical Issues in Washington, D.C. and Charleston, S.C.

U.S. cities require a broad range of data and information to address the many issues they confront on a daily basis. These issues include security, economic and community development, hazard mitigation, water supply, and health and safety services. The USGS supports U.S. cities' needs by providing geographic base information, assessments of natural hazards, and information on water and biological resources, among other things. USGS data and information around urban centers also serve Federal emergency management and defense functions, as well as the needs of private industry, nongovernmental organizations, and individual citizens.



This project will utilize ***The National Map*** to bring USGS scientific data and expertise to bear on critical issues facing urban areas in USGS's Eastern Region, including security, vulnerability of water resources, natural hazards, urban sprawl, and the conservation and protection of National parklands and other natural resources.

The sites selected for initial study are Washington, D.C. and Charleston, S.C.

Remote Sensing and Phenology

Phenology: Study of the timing of biological events

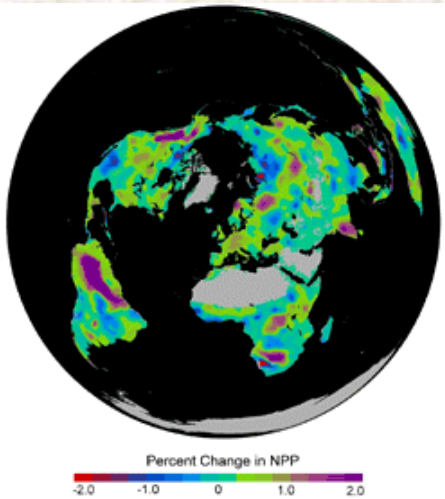
- bird migration
- insect hatching
- plant emergence (crops)
- bud burst
- first leaf

REPORTS

Climate-Driven Increases in Global Terrestrial Net Primary Production from 1982 to 1999

Ramakrishna R. Nemani,[1*†] Charles D. Keeling,[2] Hirofumi Hashimoto,[1,3] William M. Jolly,[1] Stephen C. Piper,[2] Compton J. Tucker,[4] Ranga B. Myneni,[5] Steven W. Running[1]

Recent climatic changes have enhanced plant growth in northern mid-latitudes and high latitudes. However, a comprehensive analysis of the impact of global climatic changes on vegetation productivity has not before been expressed in the context of variable limiting factors to plant growth. We present a global investigation of vegetation responses to climatic changes by analyzing 18 years (1982 to 1999) of both climatic data and satellite observations of vegetation activity. Our results indicate that global changes in climate have eased several critical climatic constraints to plant growth, such that net primary production increased 6% (3.4 petagrams of carbon over 18 years) globally. The largest increase was in tropical ecosystems. Amazon rain forests accounted for 42% of the global increase in net primary production, owing mainly to decreased cloud cover and the resulting increase in solar radiation.



Science, June 6, 2003

Satellite Phenololgy

- **Repeatable observations**
- **Synoptic view**
- **Ability to derive vegetation (greenness) indices**

Symptom of global change

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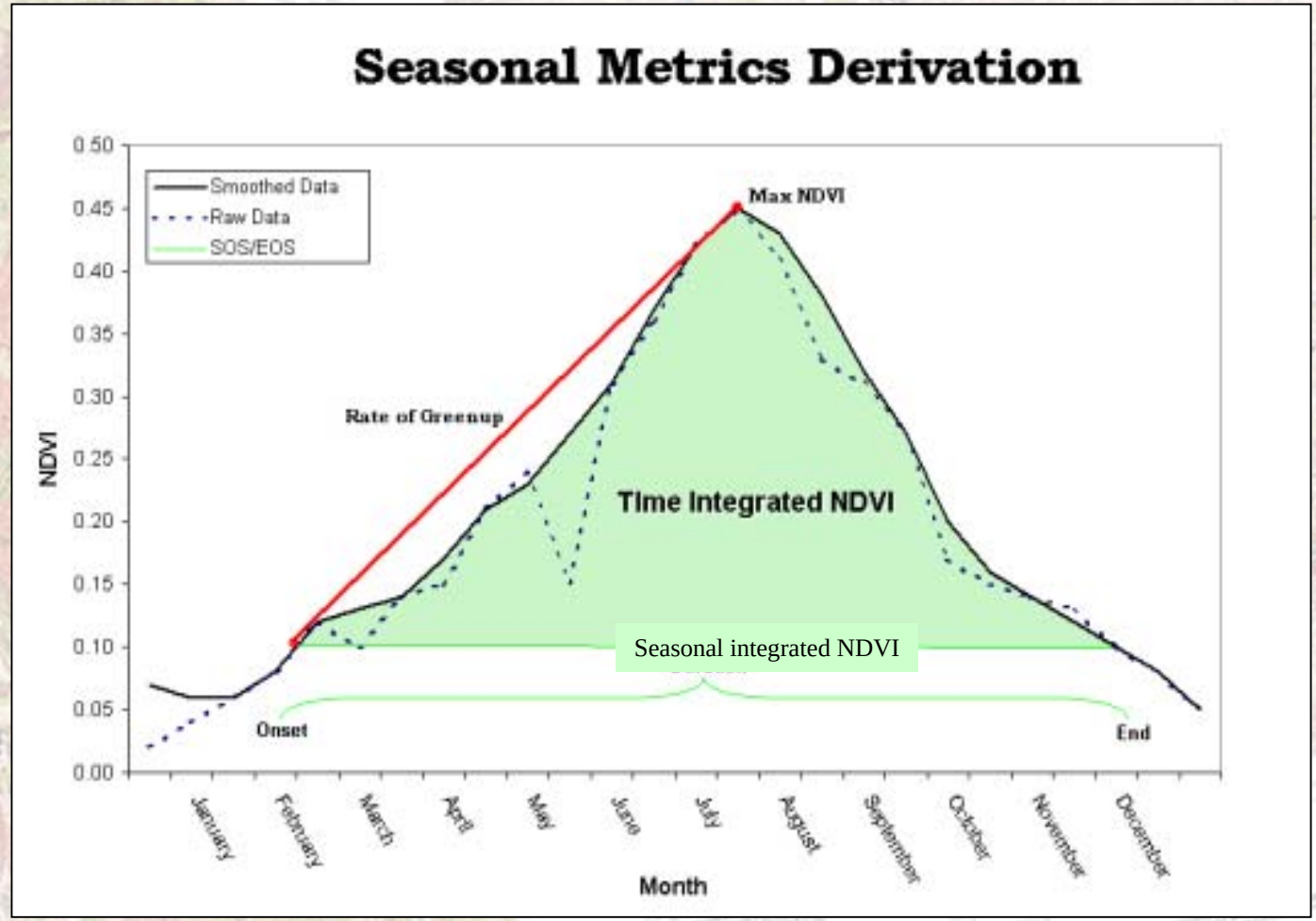
Temporal / Phenologic Vegetation Metrics



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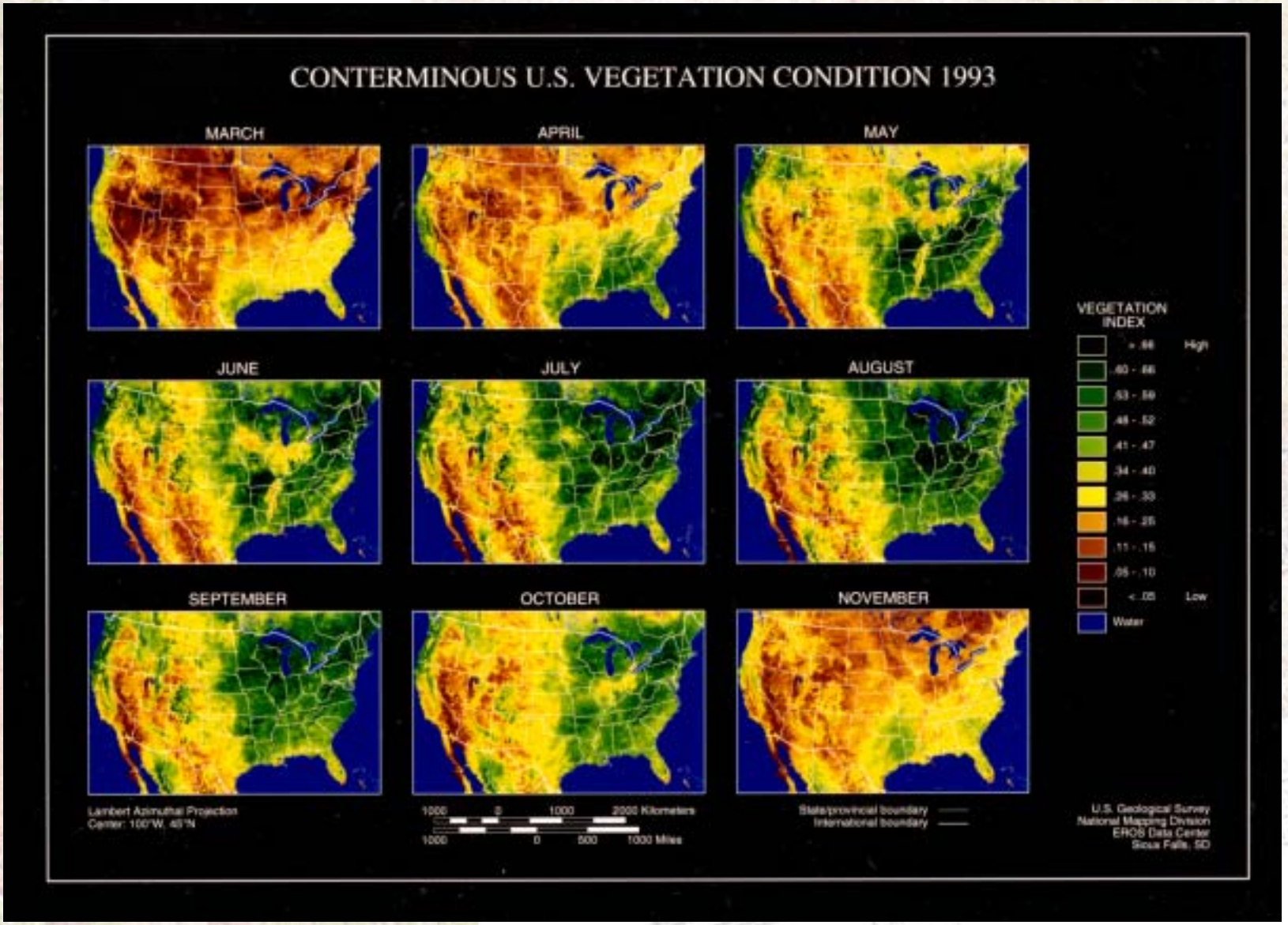
Drought and Fire Monitoring



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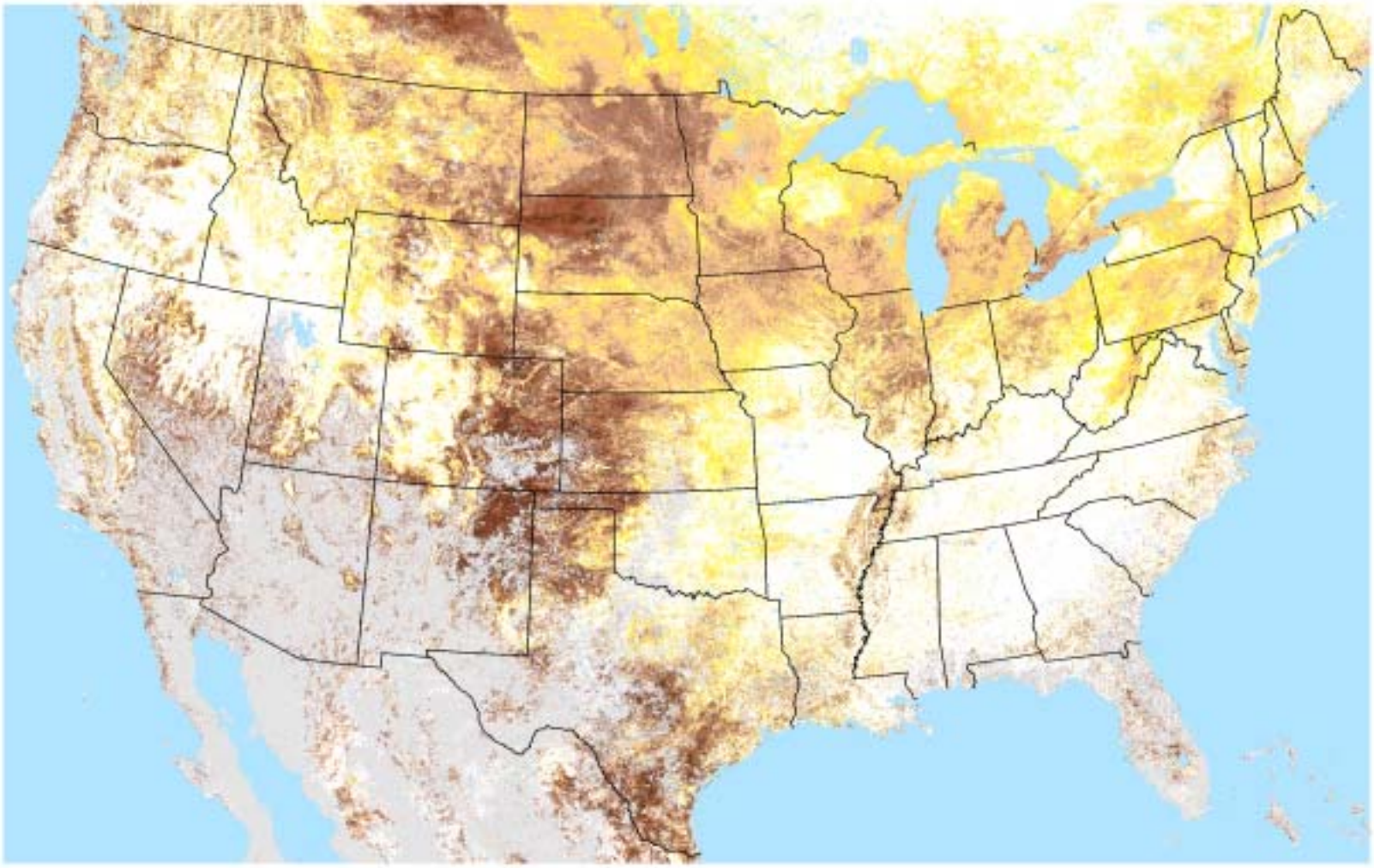
Percent of Average Seasonal Greenness
July 25, 2002



< -80 % | -80 to -61 % | -60 to -41 % | -40 to -21 % | -11 to -20 % | - 10 to >100 %

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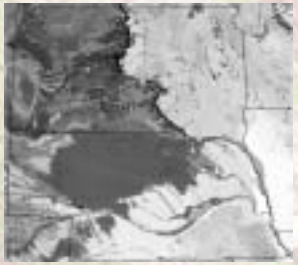
Methodological Approach - Drought

Model Input

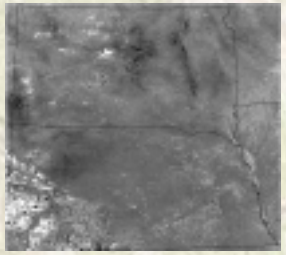
SPI 7/18/02

Available Water Capacity

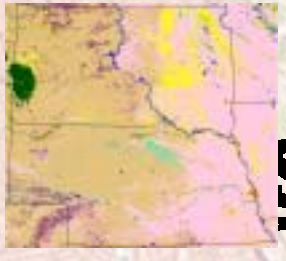


Percent Irrigated Farmland

Start of Season Date



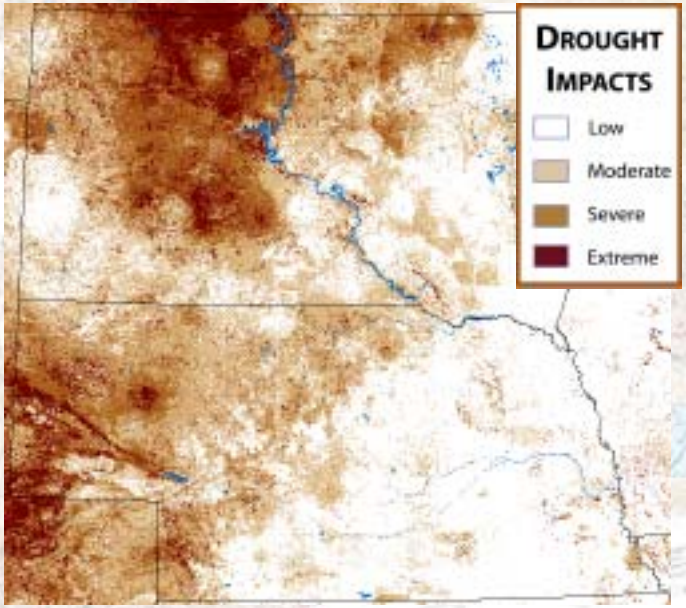
Land Cover



% Avg Seasonal Greenness

Identify variables contributing to drought impact

Regression Tree Modelling



Drought Impact Index

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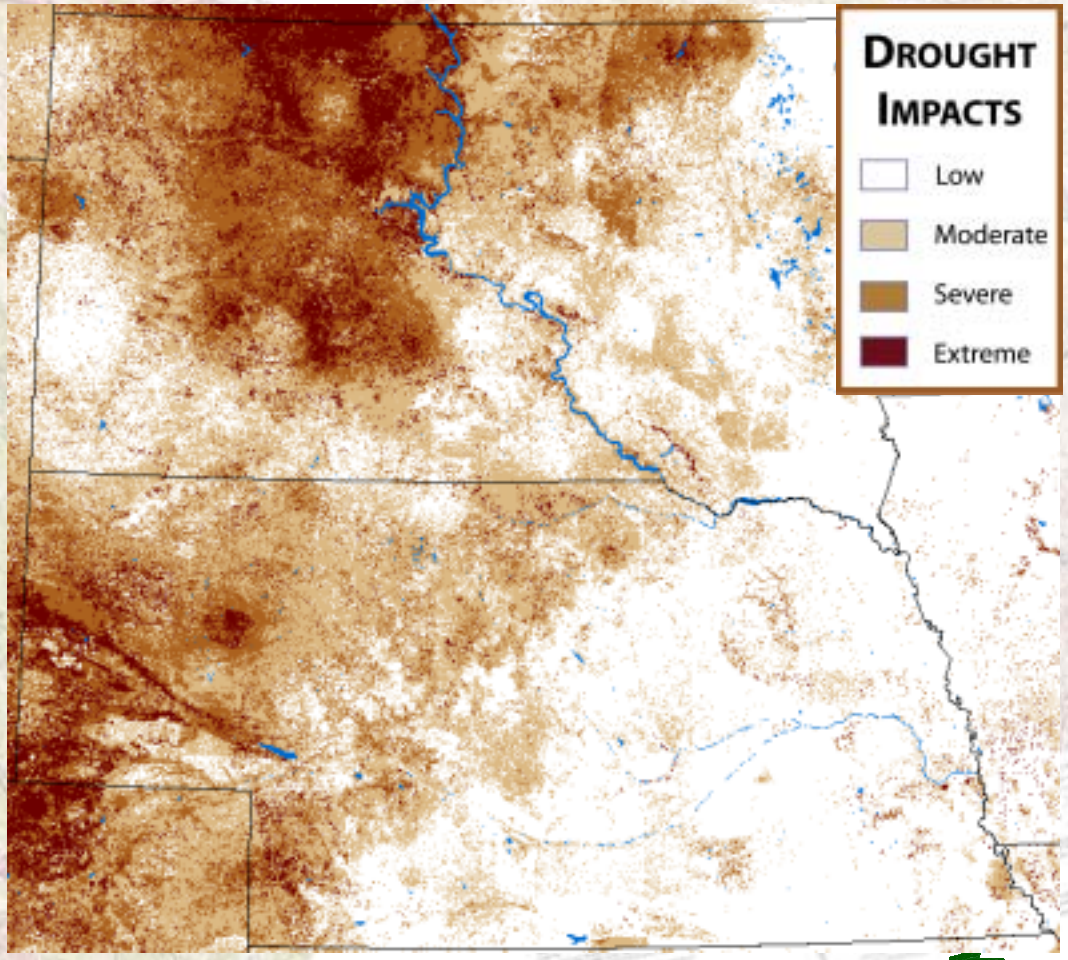
Prototype Drought Impacts Index
July 19, 2002



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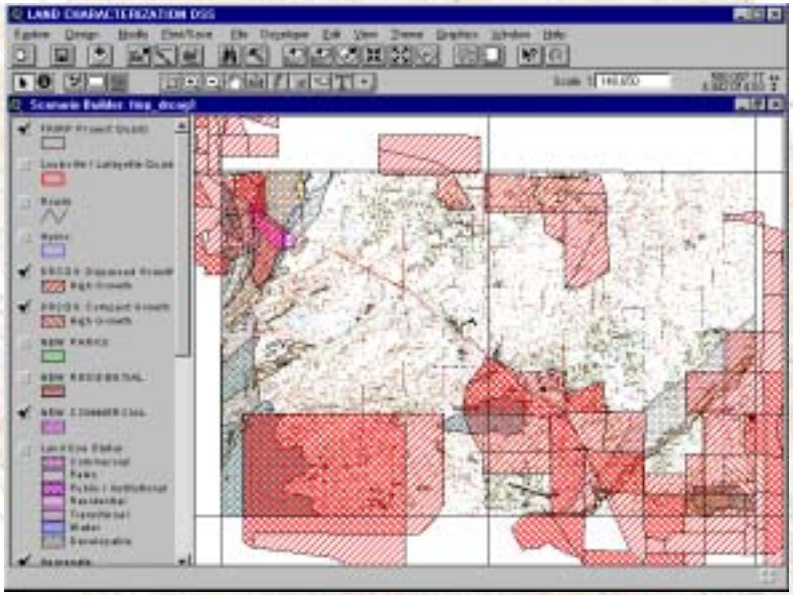
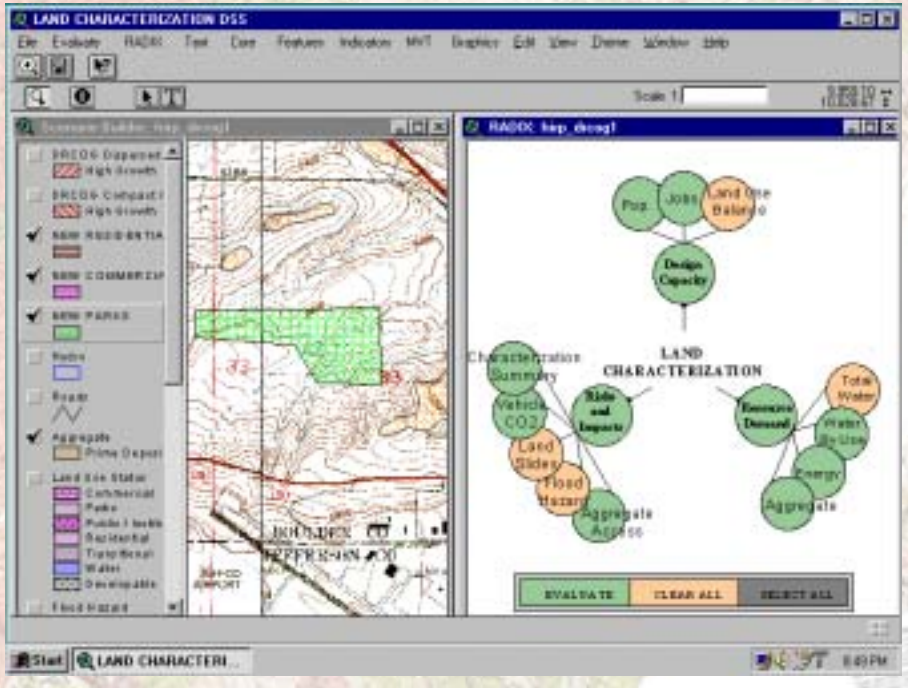
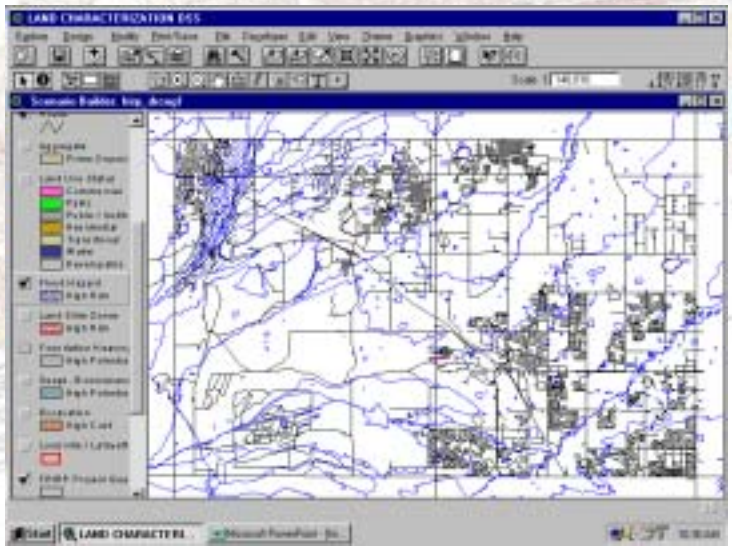
Decision Support Systems

- What tools can the scientific community provide to allow decision-makers to view the environmental impacts of local land use decisions?
- What tools allow decision-makers to weigh the effectiveness of different policies?







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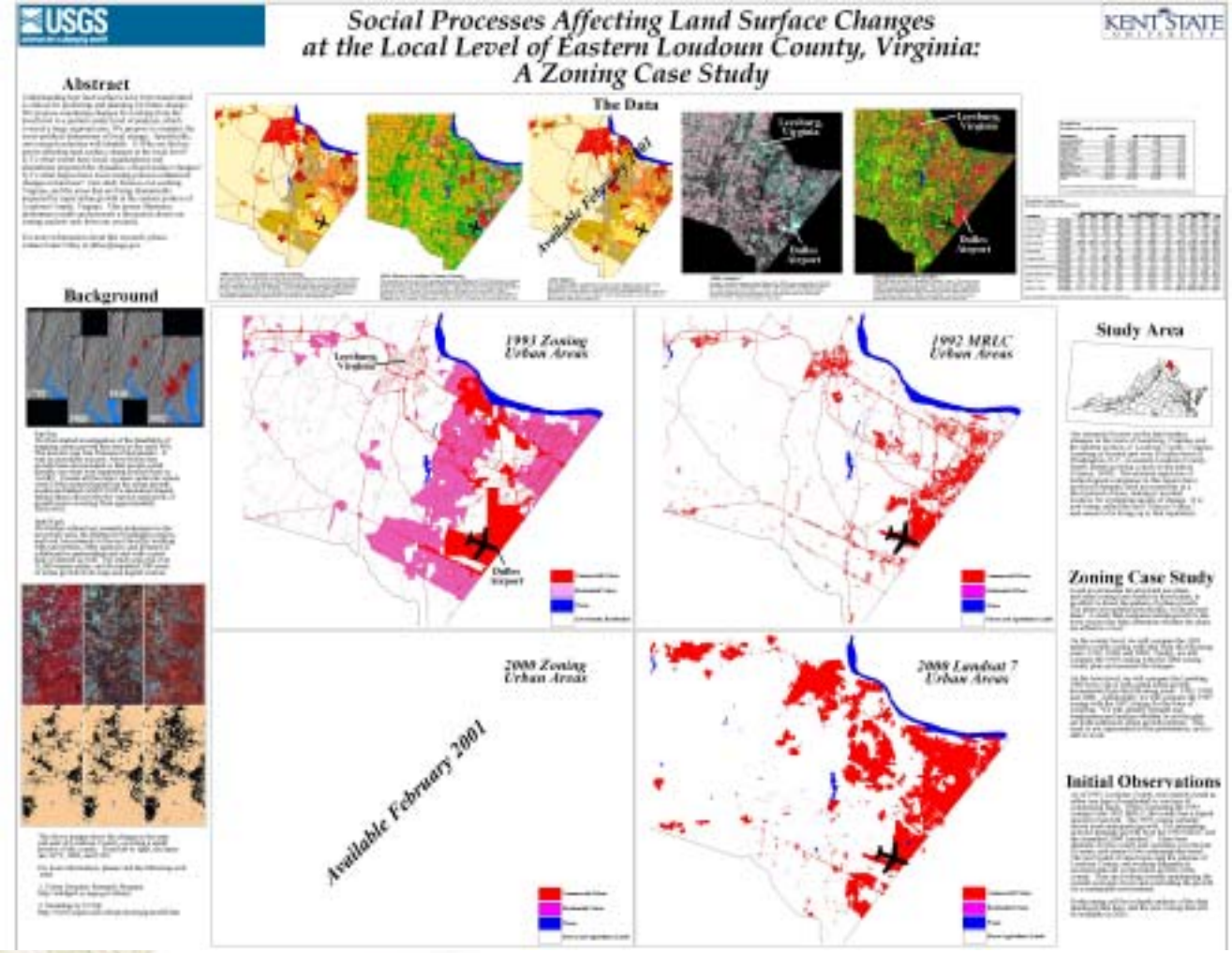
Land Use Policy

Analyze and interpret the record of land use dynamics that includes land use and land cover change to enhance understanding of the physical and social drivers of land surface change.

Influences of Local Zoning Regulations



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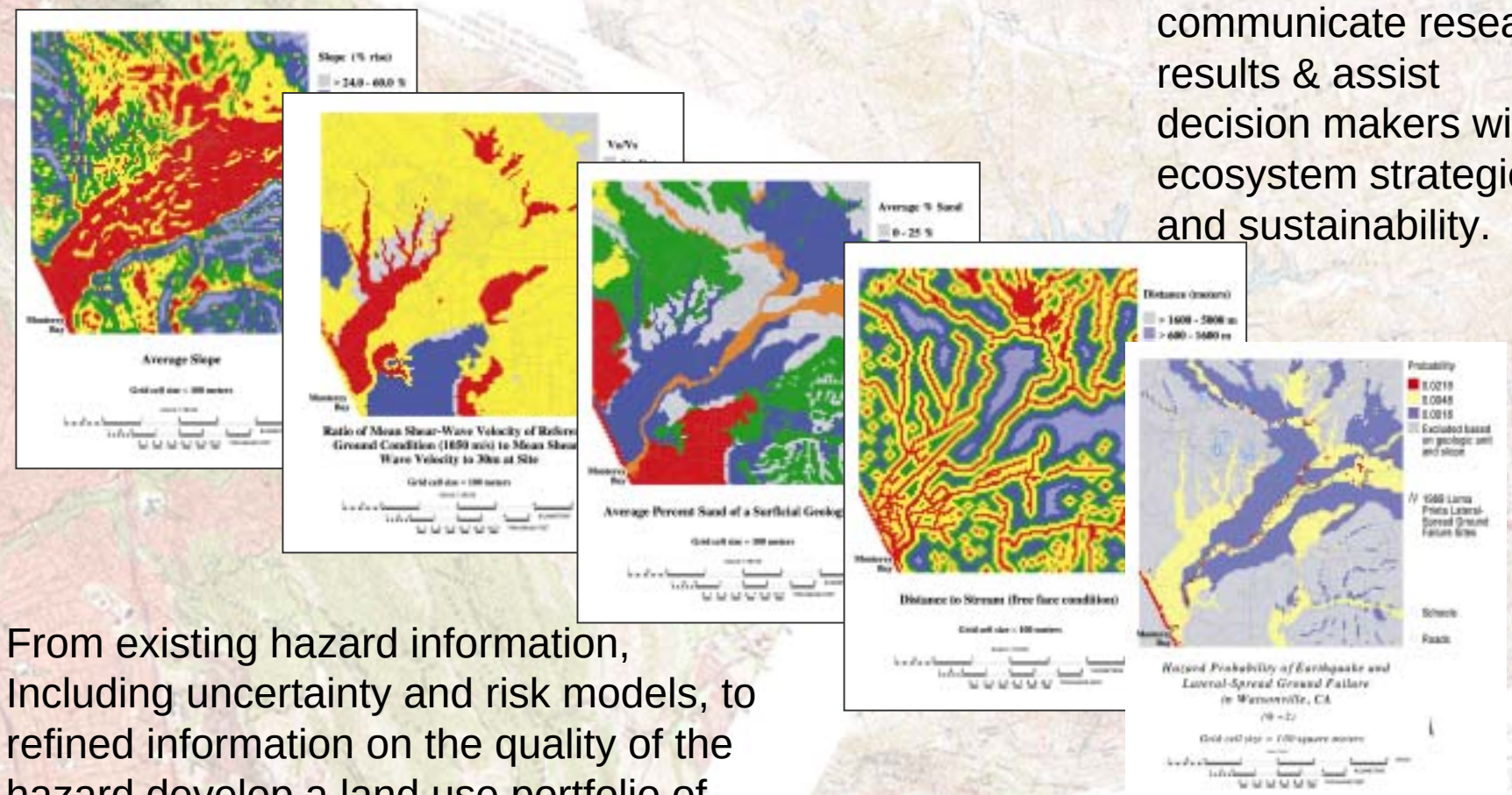
A Portfolio Approach to Analyzing Environmental and Natural Hazard Risks

Develop methods to communicate research results & assist decision makers with ecosystem strategies and sustainability.



From existing hazard information, Including uncertainty and risk models, to refined information on the quality of the hazard develop a land use portfolio of expected value of risky assets.

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Applications of *The National Map*

- Link to Viewer
- Link to Website

The National Map provides the national geographic reference frame that is crucial to the development of scientific applications. These applications utilize both the data and technology of *The National Map* to support scientific customer-based applications that range from monitoring/response to natural hazards to Homeland Security support. Development of these applications not only furthers the scientific goals of USGS, but also contributes to the development of additional *The National Map* partnerships.

Applications

- *Natural Hazards Support System*
- *Interagency Operating Picture*
- *Dynamic Web Atlas*

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Dynamic Web Atlas

Link to Viewer

The Dynamic Atlas provides web-enabled dissemination of the information contained in the Land Status and Trends topical reports. The Land Status and Trends topical reports will provide resource managers and the American public with a reliable reference tool and source of information to understand the dynamic nature of the Nation's landscape. Initial reports will describe the current state of the land surface, factors driving land use change, and environmental, social, and economic effects of land surface change. Future reports will reflect a true national assessment of key landscape indicators and include projected trends. The Dynamic Atlas will not only provide access to the complete series of Land Status and Trends topical reports, but also the underlying data and scientific information used to develop the reports.

Applications

- *Natural Hazards Support System*
- *Interagency Operating Picture*
- *Dynamic Web Atlas*

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Natural Hazards Support System

Link to Viewer

The United States is exposed to a wide range of natural hazards due to its natural, climactic, and geographic diversity. Hazards disrupt nearly every sector of the United States, including industry, transportation, schools, hospitals, water and power. Providing public agencies, communities and individuals with knowledge is vital in reducing hazard vulnerability and responding effectively after a hazard event. Increasing this knowledge means focusing science and technology to improve hazard response. USGS scientists are currently developing a Natural Hazards Support System (NHSS) web application to aid in the monitoring, supporting, and responding to natural hazards in the United States. NHSS demonstrates the power of integrating *The National Map* with specific hazards information to provide a one-stop approach to accessing critical data used in monitoring hazards and reducing hazard risks.

Applications

- *Natural Hazards Support System*
- *Interagency Operating Picture*
- *Dynamic Web Atlas*

U.S. Department of the Interior | U.S. Geological Survey
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Interagency Operating Picture

Application not publicly accessible

Link to Viewer

Interagency Operating Picture

One of the key aspects to Homeland Security is tracking and evaluating potential threats in the United States. The Interagency Operational Picture (IOP) is a real-time interactive web-based application that supports incident reporting for the United States Northern Command's (USNORTHCOM), Interagency Coordination Group (ICG). This application provides the tools, data and national perspective to enhance situational awareness in the command's area of responsibility. Incidents and associated information, including situation reports, are added to the IOP to provide a real-time visual context. The ICG can use the IOP as an operational tool to present situational awareness to both Department of Defense (DoD) and non-DoD participants.

Applications

- Natural Hazards Support System
- Interagency Operating Picture
- Dynamic Web Atlas

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Example using Sleuth

INPUTS:

- Slope
- Transportation
- Urban extent
- Urban exclusion
- Hillshade
- Land cover

INPUT

PARAMETER	urban/developed land cover	exclusion (urban)	LULC (multi-class)	transportation network	slope	hillshade
Data model						
geospatial	X	X	X	X	X	X
raster	X	X	X	X	X	X
Projection						
any (all inputs consistent)	X	X	X	X	X	X
Raster format						
GIF	X	X	X	X	X	X
Spatial resolution						
any (all inputs consistent)	X	X	X	X	X	X
Temporal resolution						
minimum # of dates	4	1	2	2	1	1
maximum # of dates	n/a	1	n/a	n/a	1	1
DATA SOURCE						
USGS data						
DEM - 7.5', 10-meter					X	X
DLG - 7.5'				X		
other	X	X	X			

	SLEUTH	SPARROW	TCOM	LUPM
Atmosphere				
atmospheric deposition		X		
Climate				
precipitation		X		
temperature		X		
Cultural/Socioeconomic				
assessors parcel			X	X
census			X	
cultural assets				X
emergency services				X
Environmental				
fertilizer inputs		X		
livestock waste inputs		X		
point source inputs		X		
Geology/Soils				
depth to groundwater		X		
flood hazard probability				X
sediment contribution			X	
site failure susceptibility				X
soil drainage		X		
Hydrology				
drainage density		X		
streams/lakes		X		
stream reach and catchment		X		
watershed boundary			X	
Land Use/Land Cover				
agricultural land cover		X		
urban/developed land cover	X	X		
exclusion (urban)	X			
impervious land cover			X	
irrigated lands		X		
LULC (multi-class)	X			
transportation network	X	X		
wetland land cover		X		
Topography				
elevation			X	
hillshade	X			
slope	X	X	X	

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Web Sites

The National Map
http://nationalmap.usgs.gov

Geographic Analysis and Monitoring
http://gam.usgs.gov

Land Cover
http://landcover.usgs.gov

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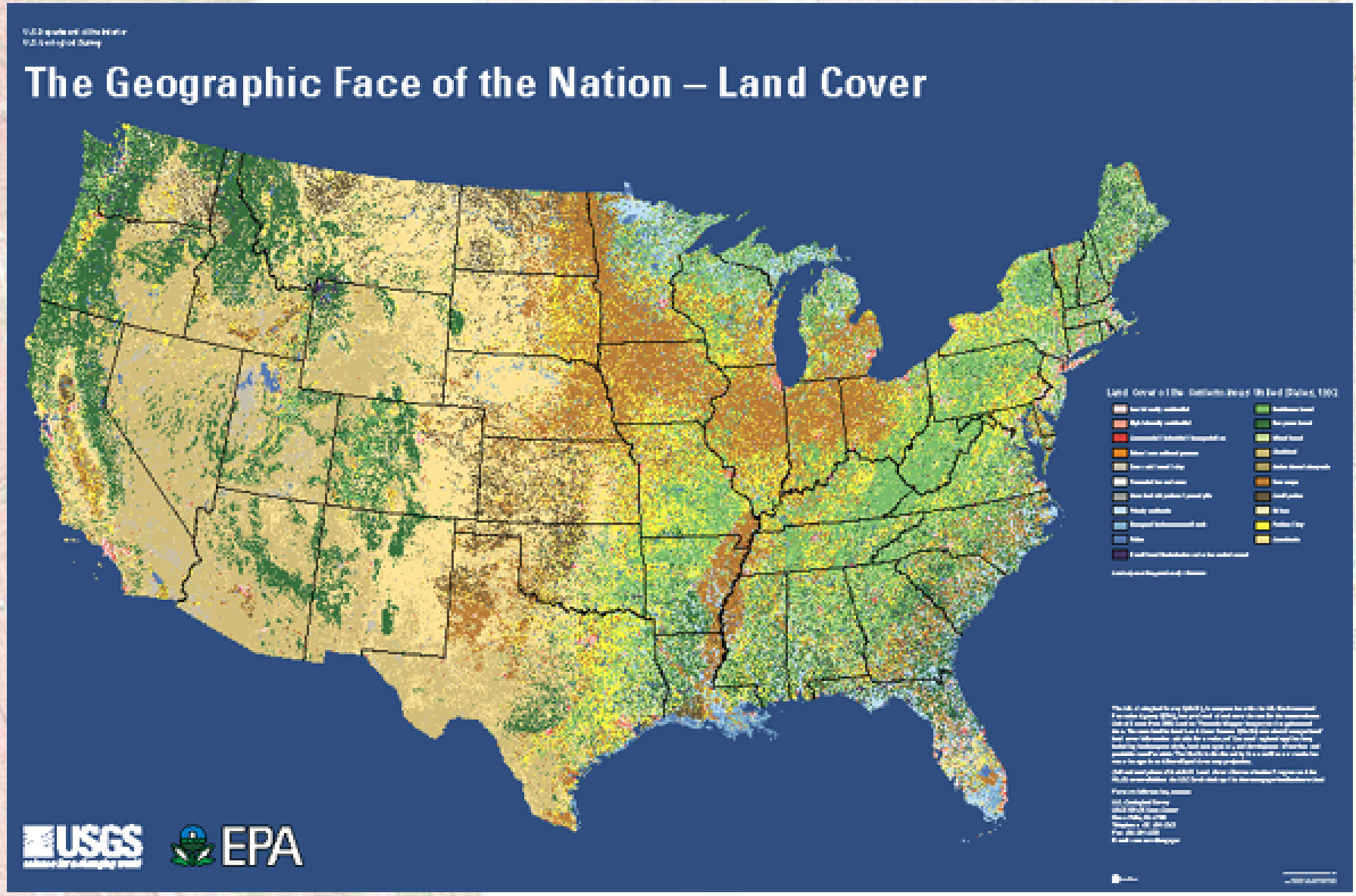
For more information: dmuchoney@usgs.gov