

Assessing Landscape Dynamics to Understand Ecosystem Service Resilience and Sustainability

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ECOSYSTEM BENEFITS AND RISKS

[Home](#)
[About](#)
[Benefits](#)
[Risks](#)
[The Human Landscape](#)
[Assessments](#)
[Framework](#)
[ApplCC](#)

You are here: Home

Ecosystem Benefits and Risks

Ecosystem services are the benefits people receive from nature. These are abundant in the Appalachians, from clean drinking water and sustainably harvested forest products to nature-based tourism. They also include the sense of home that communities find in rural landscapes and the values that Americans place on conserving biodiversity.

These essential services and the natural resources they depend on are extremely valuable to society, but are placed at risk by processes driving landscape change in the Appalachians such as urbanization and climate change. Some processes, such as energy development, produce both risks and benefits to society. Our challenge is to find a balance that sustains all of the benefits that people value.

To meet this need, the Appalachian LCC has collaborated with the US Forest Service to provide information and tools that fully integrate society's value of ecosystems with future threats to better inform natural resource planning and management. Through links on this page, users can access information, maps, data, and additional resources brought together through this collaboration.

Ecosystem Services Conservation Atlas

Explore Appalachian landscapes through a collection of maps and data layers showing the "lay of the land" from an ecosystem services perspective.

Conservation Design

Access maps and data through the Appalachian LCC's spatial data portal, with a map viewer and download capability.

Benefits

Explore the multitude of benefits that people within and beyond the Appalachian region derive from its diverse ecosystems.

The Human Landscape

Explore social dimensions of Appalachian landscapes including demographic, economic, and land use patterns that influence how people value, use, and impact ecosystem services.

Framework

New assessment research supported by the Appalachian LCC builds on existing knowledge to better understand how ecosystem services change with urbanization, energy development, and other ongoing processes.

Risks

Explore ways in which ecological benefits to people change with societal and environmental change, often associated with drivers like climate change, urbanization, and other factors.

Assessments

Explore findings from a wide range of efforts to assess the use and sustainability of natural resources and ecological benefits across the Appalachians and beyond.

Filed under: [Ecosystem Services](#) [Research](#)

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ECOSYSTEM SERVICES CONSERVATION ATLAS

[Home](#)
[ApplCC](#)

Home > Benefits > Harvested Species

Benefits

Forest Carbon

Harvested Species

Landscape Values and Sense of Place

Water and Soils

Risks

The Human Landscape

Data Atlas

Harvested Species

Nontimber

Nontimber forest products—such as ginseng and ramps—are widely harvested in the Appalachian region, and hunting and fishing are among the most important outdoor recreational activities. All of these practices have high cultural and economic value, and their sustainability depends on the capacity of rural and forest landscapes to support them. While landscape capacity meets societal demand for these resources in many areas, they may be overexploited in areas where harvesting activities are poorly regulated, and climate change effects may exacerbate declines. This may be especially true for nontimber forest plants, and these tend to be the least-studied among harvested species. Stream degradation from multiple causes, and toxic dissolved solids in watersheds with surface mines in particular, are associated with loss of fishing opportunities and represent a strong incentive for stream restoration.

Timber

The sustainable production of wood—from upland hardwood forests in particular—is a key economic activity across the Appalachian region, supporting rural livelihoods and supplying important products at regional, national, and even global levels. Timber markets also create an incentive to keep land forested, and working forests can supply many additional ecosystem services such as clean water, nontimber forest products, carbon storage, and wildlife habitat. Standing timber stocks and production have remained fairly stable in recent decades, but declines may be experienced over the long term. Urbanization and surface mining are expected to reduce the land area available to support working forests, while detrimental effects of invasive species, climate change, and wildland fire on high-value species may have more moderate long-term influences on forest productivity.

See relevant references list here.

Total Basal Area of All Tree Species 2012

Basal area (sq ft) per acre

- 0
- 1-24
- 25-49
- 50-74
- 75-99
- 100-124
- 125-149
- 150-174
- 175-199
- 200-224
- 225-249
- 250-274
- 275-299
- 300-324
- 325-349
- 350-374
- 375-399
- 400-424
- 425-449
- 450-474
- 475-499
- 500-524
- 525-549
- 550-574
- 575-599
- 600-624
- 625-649
- 650-674
- 675-699
- 700-724
- 725-749
- 750-774
- 775-799
- 800-824
- 825-849
- 850-874
- 875-899
- 900-924
- 925-949
- 950-974
- 975-999
- 1000+

Data Atlas

Forest Industry

When properly managed, working forests can provide a wide range of important ecosystem services such as clean water and wildlife habitat.

Forest Productivity and Dynamics: ForWarn Data Products

The capacity of ecosystems to provide services such as carbon storage, clean water, and forest products

UNC ASHEVILLE
NEMAC
NATIONAL ENVIRONMENTAL
MODELING AND ANALYSIS CENTER

USDA
United States
Department of Agriculture

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF AGRICULTURE

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Landscape resilience

Capacity to maintain defining characteristics and functions, even while landscape change is ongoing.

Disturbance &
succession

Resource
management

Land use change

Resource use

Climate change



Ralph Preston

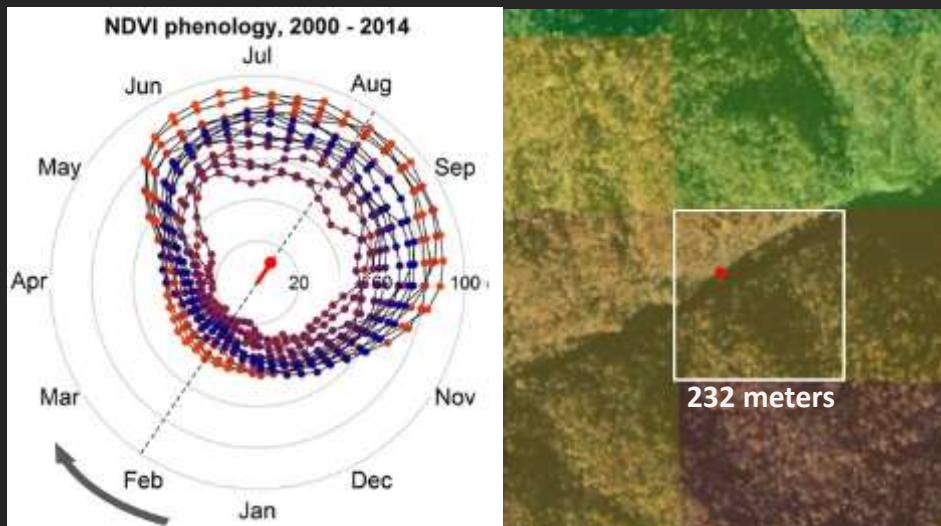
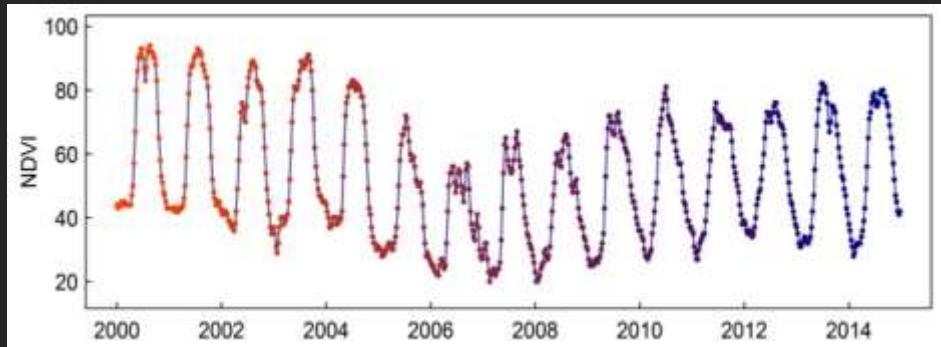


Eric Wood

Landscape dynamics assessment: data source

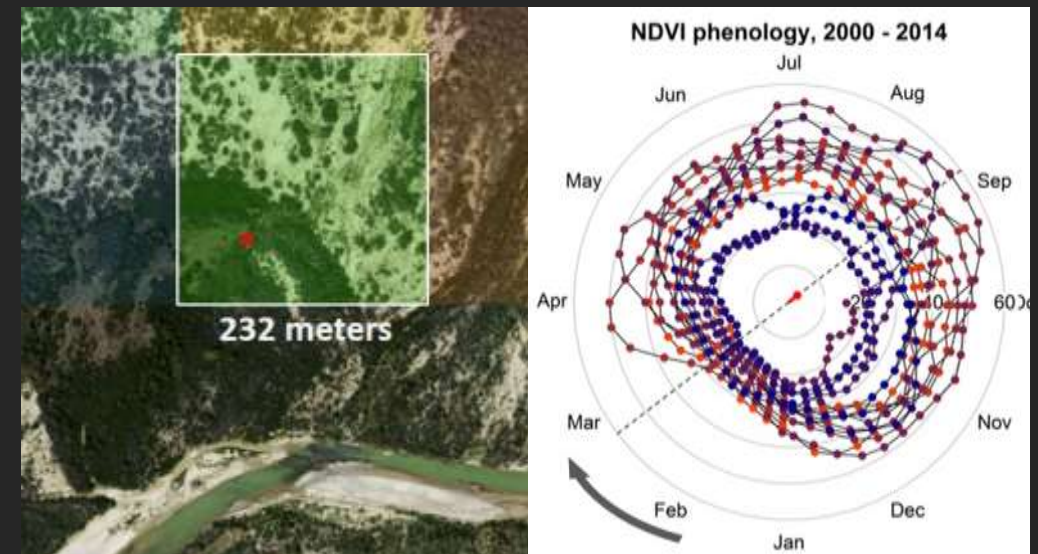
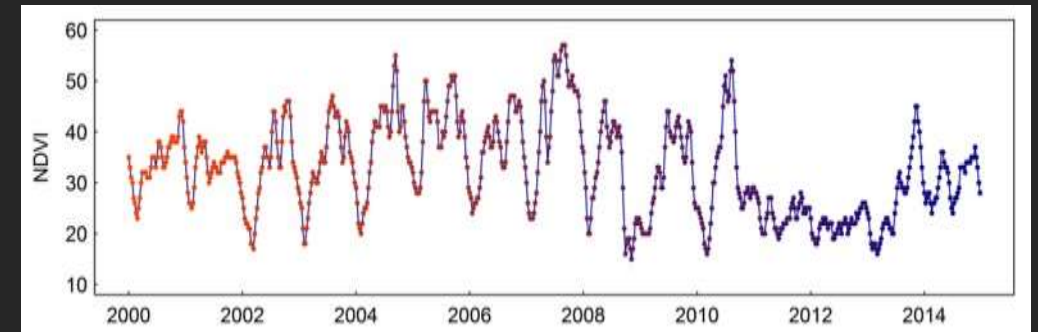
MODIS Normalized Difference Vegetation Index (NDVI), 2000 – 2015

Annual land surface phenology: timing of vegetation change



Appalachian forest pixel, southwestern WV

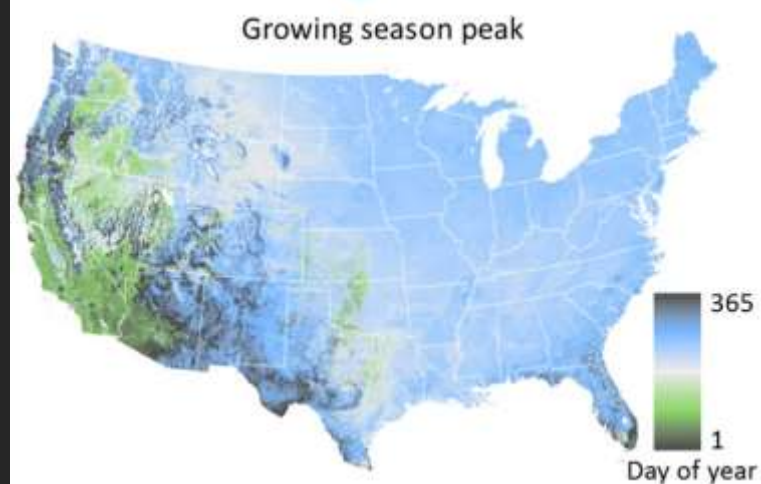
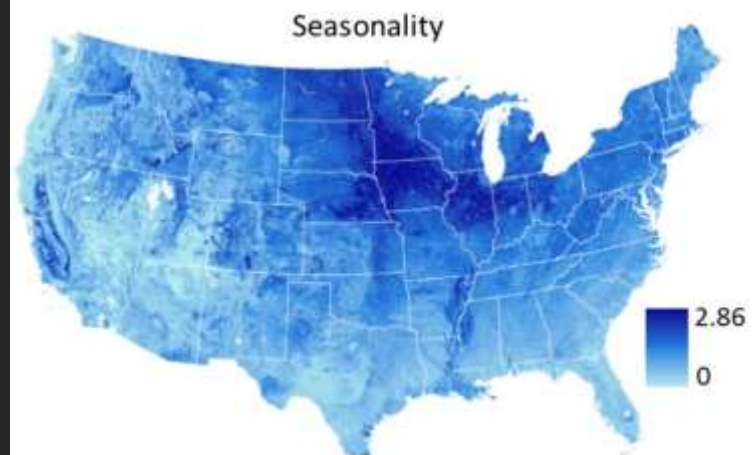
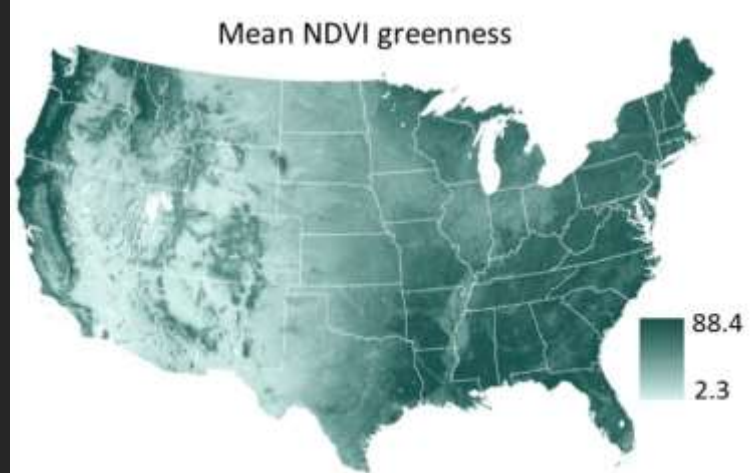
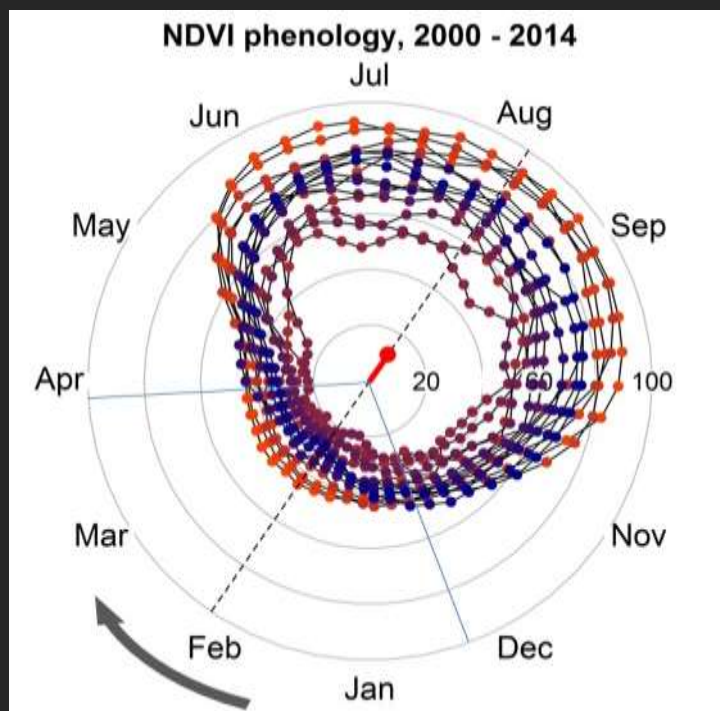
2000
2015



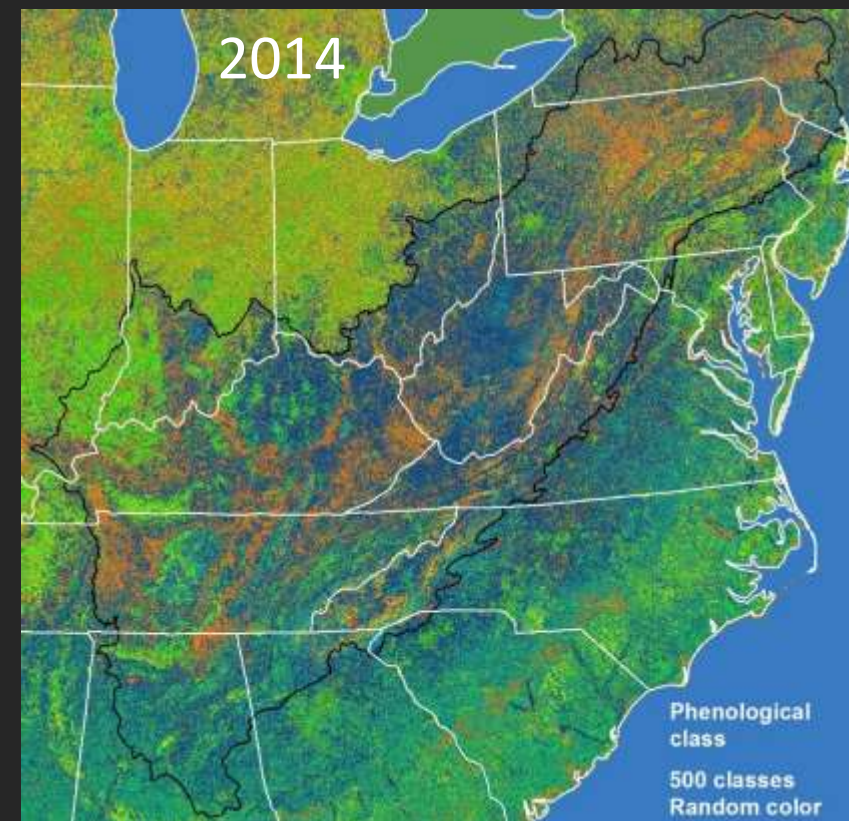
Rio Grande riparian pixel, west Texas

Phenological description: NDVI Within-year variability

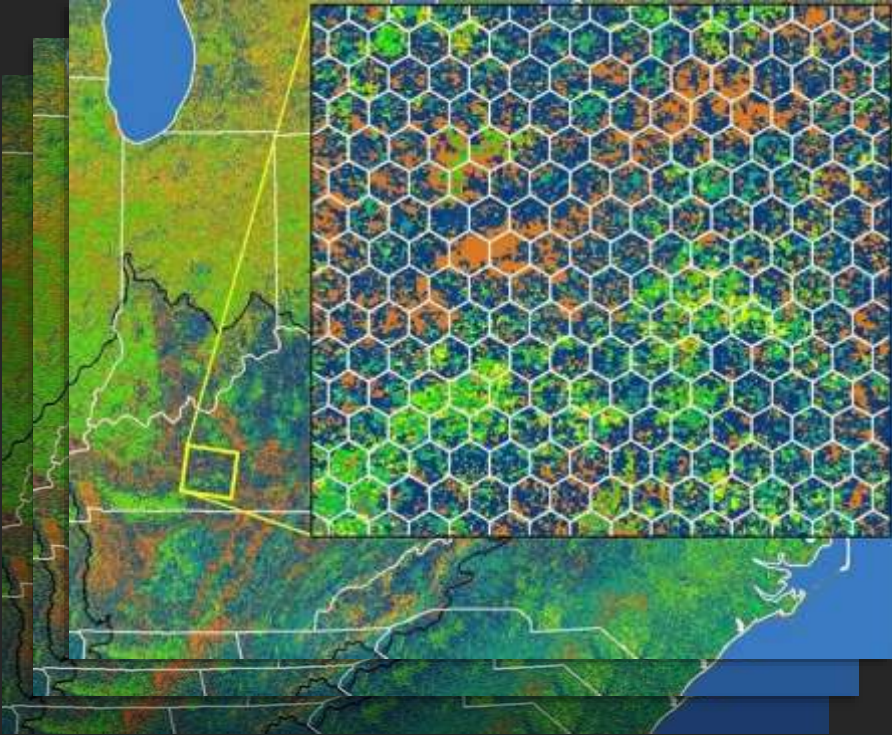
- ★ Mean growing season NDVI (greenness)
- ★ Magnitude of mean vector NDVI (seasonality)
- ★ Midpoint of growing season (peak)
- Beginning of growing season
- Length of growing season
- Growing season NDVI standard deviation



Annual phenological classification



Using information theory to characterize landscape organization and dynamics



Phenological class in 2000, 2001,...2015

Landscape sizes: 81 pixels: ~ 435 ha
450 pixels: ~ 2400 ha

P = Transition probability

H = Shannon diversity

$$H = - \sum_i (P_i \cdot \log_2(P_i))$$

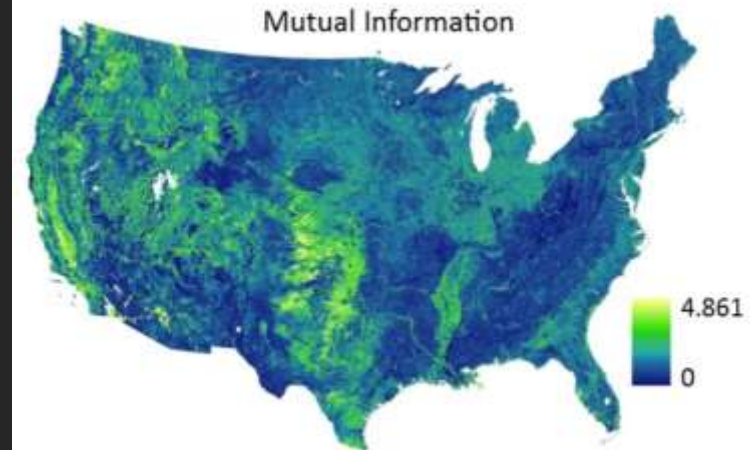
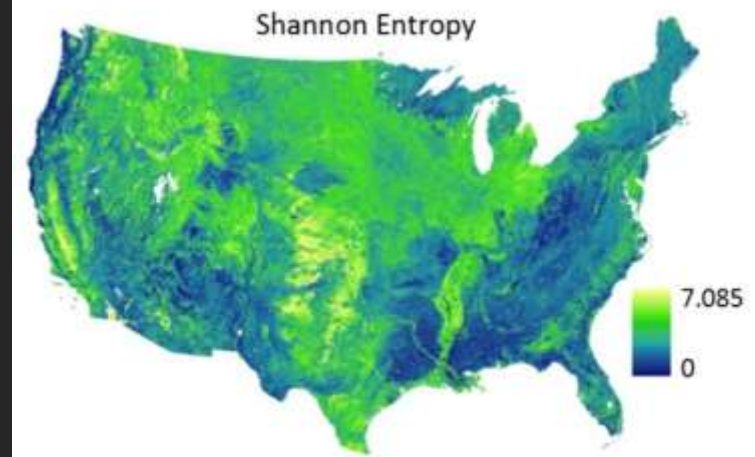
MI = Mutual Information

$$MI = \sum_i \sum_j \left(P_{i,j} \cdot \log_2 \left(\frac{P_{i,j}}{P_{.i} \cdot P_{.j}} \right) \right)$$

Conditional Entropy = mean H - MI

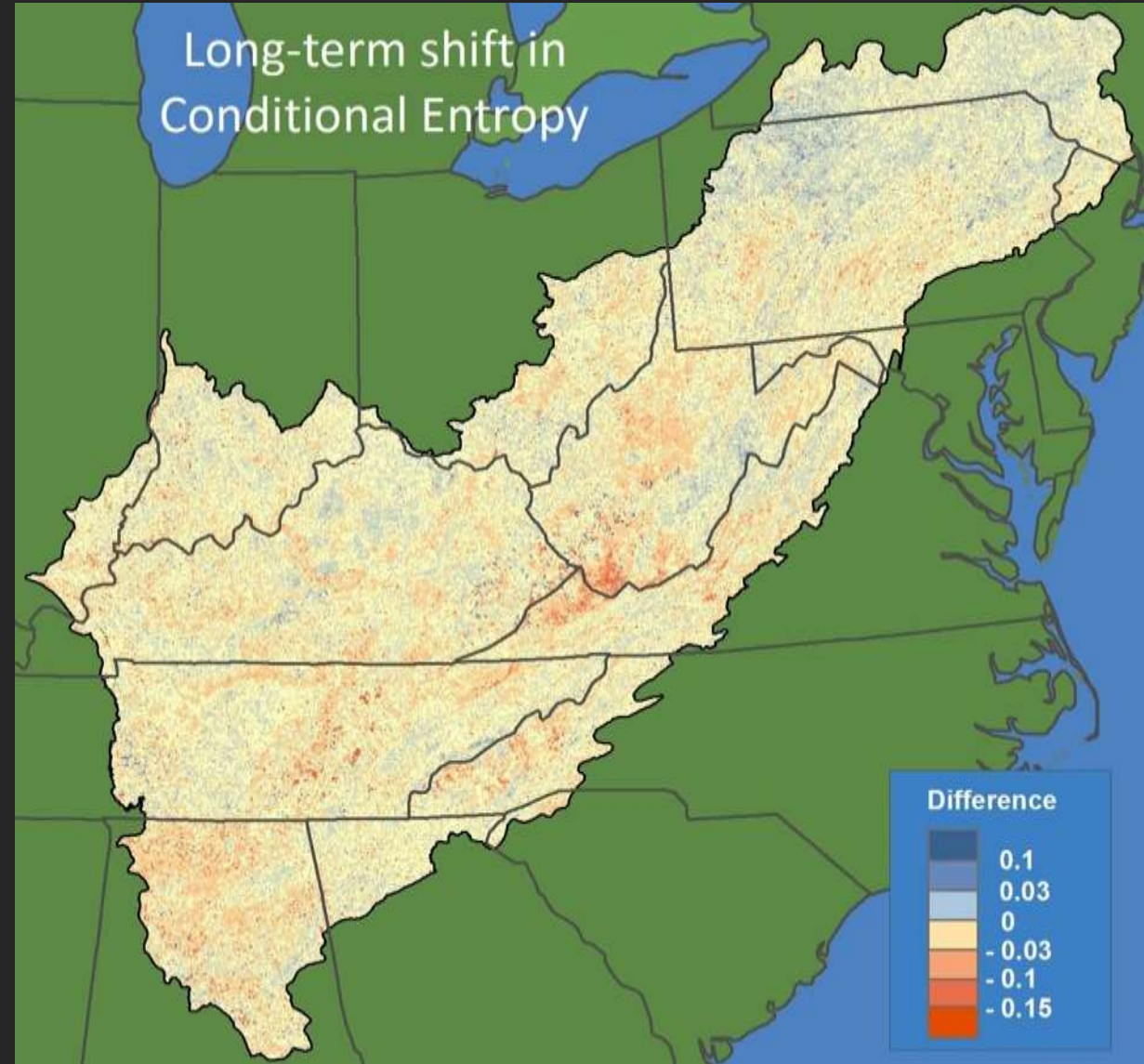
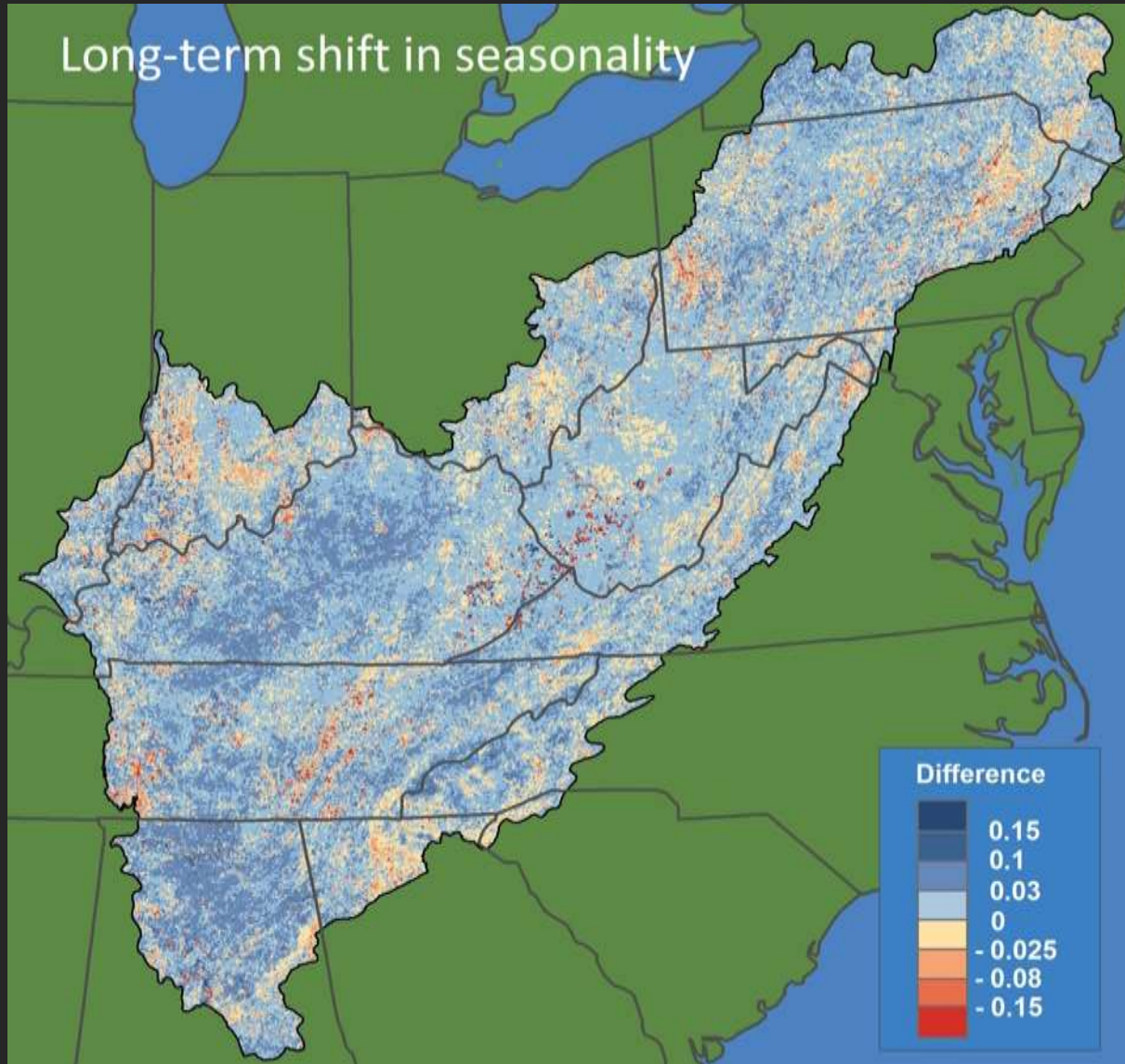
Ascendency = $MI \cdot \text{mean NDVI}$

Overhead = $CE \cdot \text{mean NDVI}$



Mapping long-term landscape change

Difference between current phenoclass composition and projected equilibrium composition

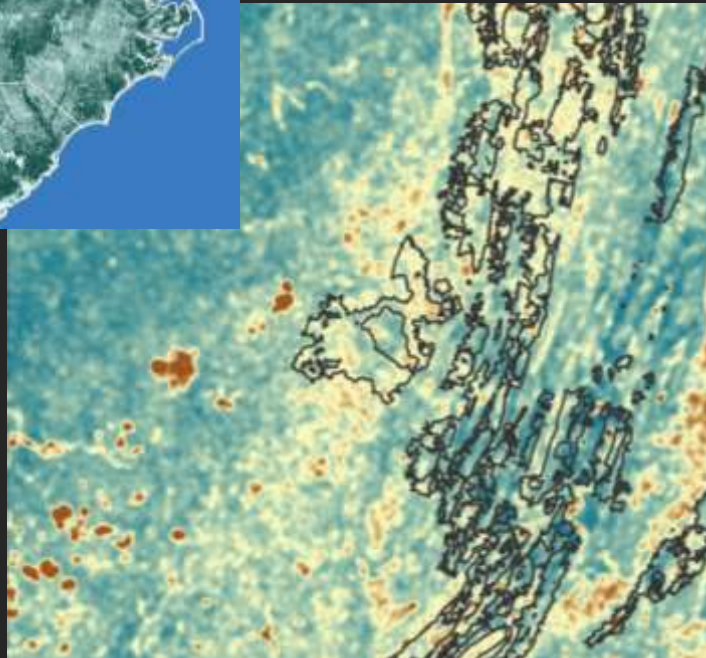


Mapping long-term landscape change

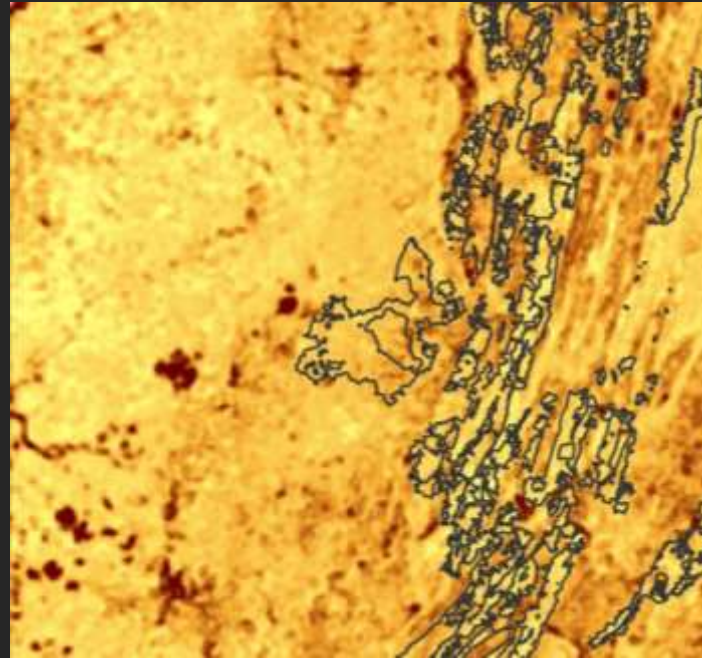
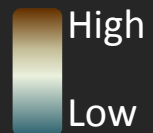


Dark outline = federal protected areas

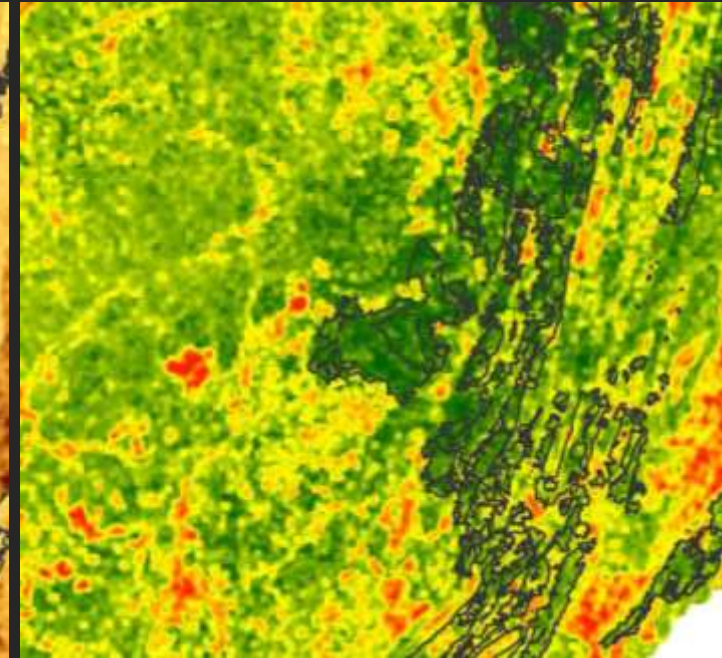
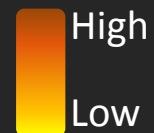
NDVI
vegetation
greenness



NDVI change, 2000-2015



Change type diversity

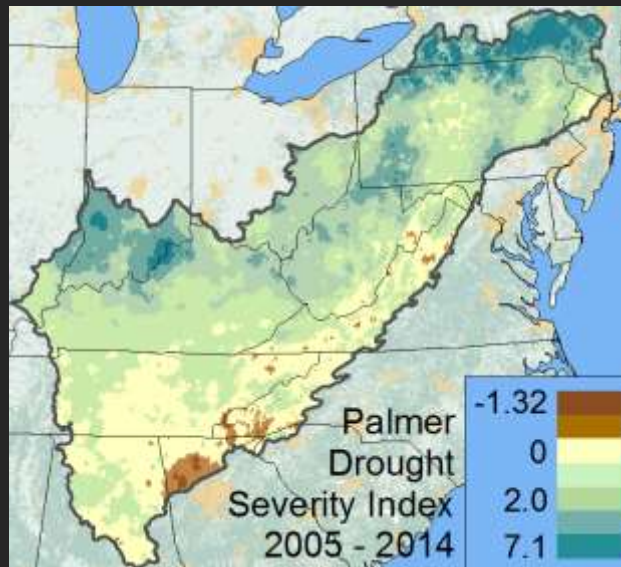
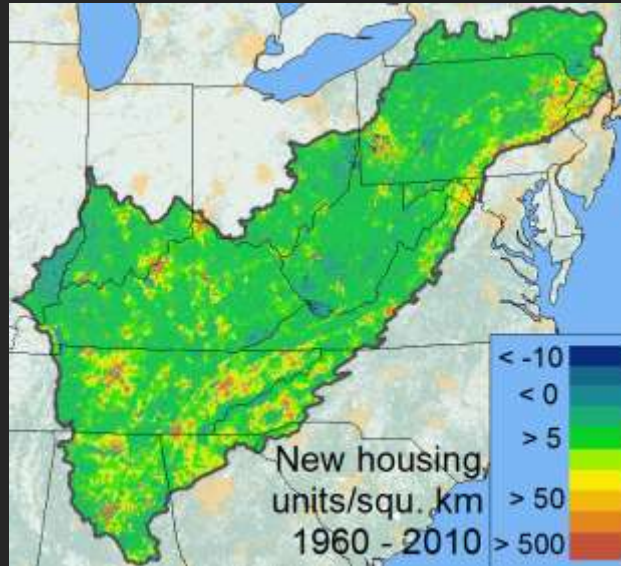


Modeled carbon density



Ecosystem service resilience and vulnerability

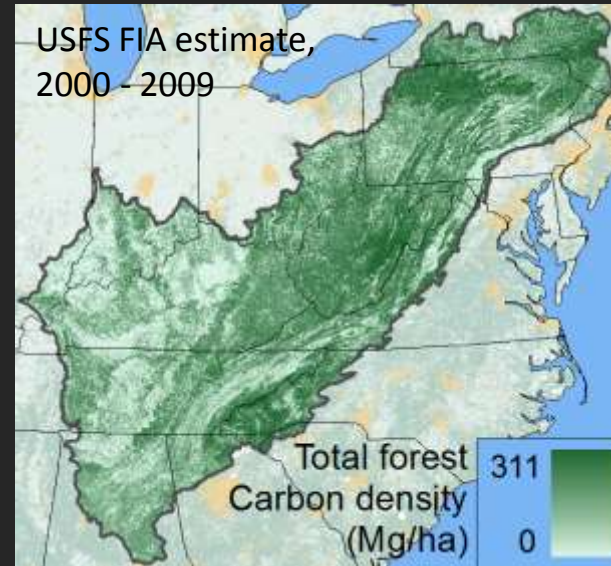
Measuring the changing capacities of large landscapes to sustain ecosystem services



Drivers of change



Landscape capacity

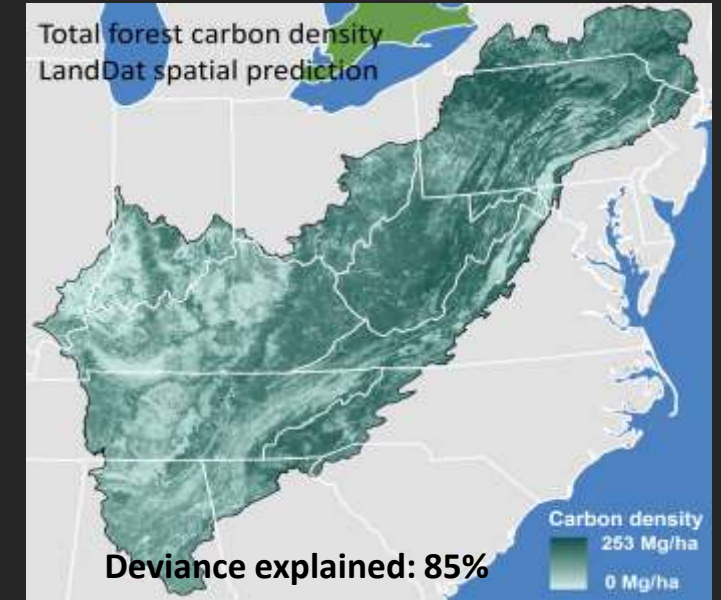
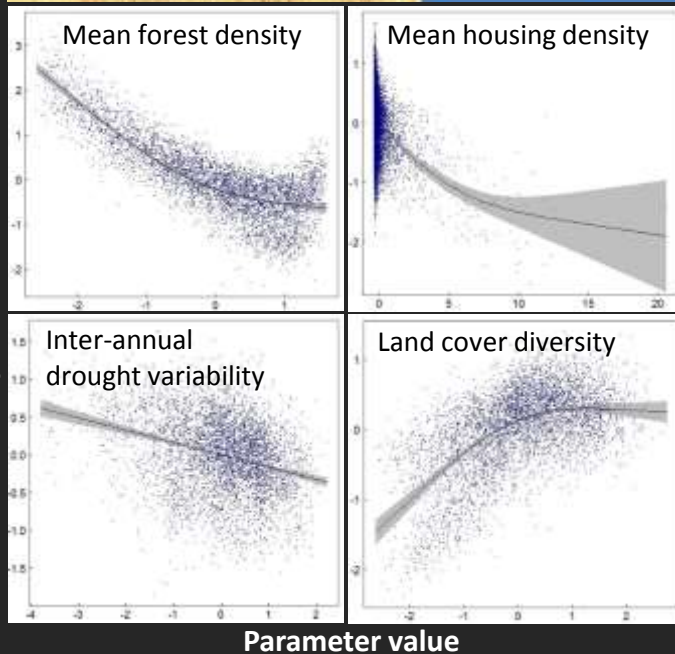
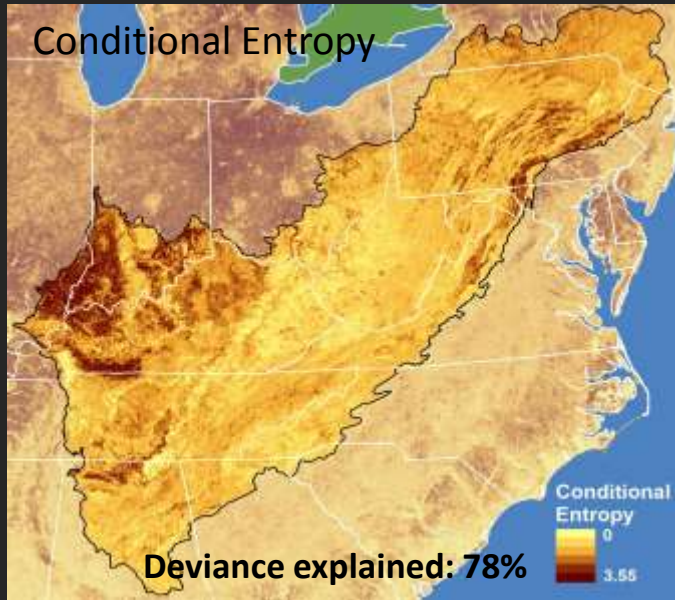


Landscape correlates of the phenology and Information-theoretic measures

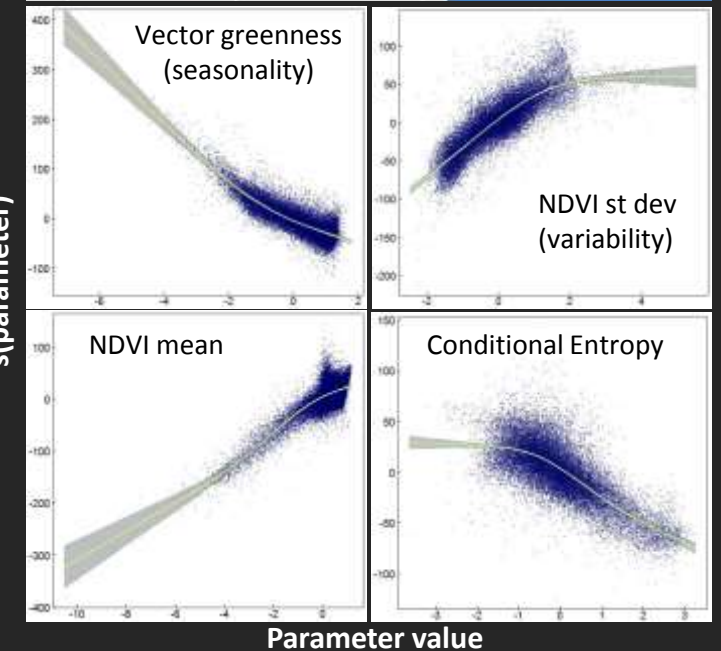
Generalized Additive Models (GAM)
and AIC model selection

Phenology-derived resilience
metrics can link
drivers with resources

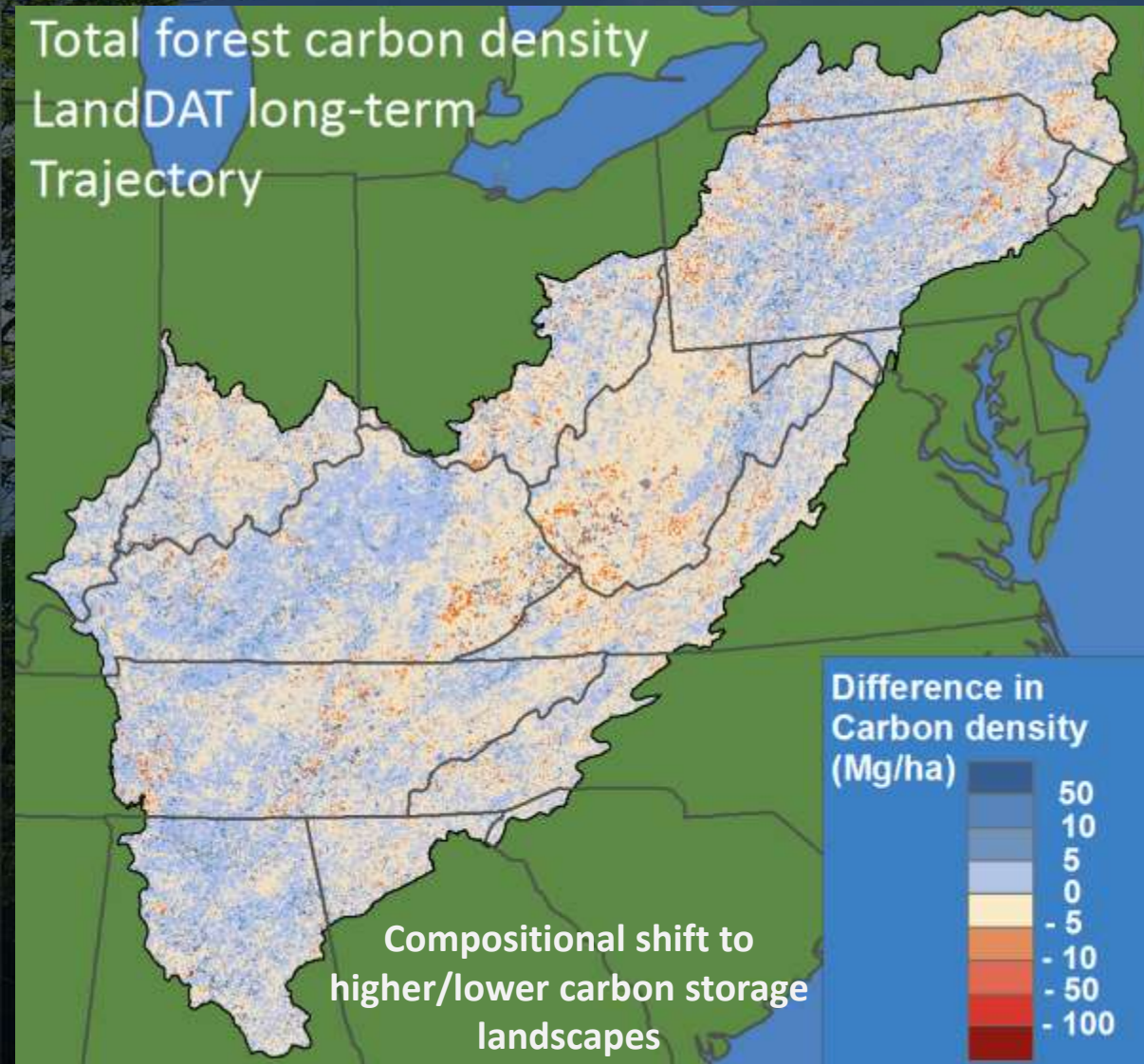
Predictor partial residuals
s(parameter)



Predictor partial residuals
s(parameter)



Mapping long-term landscape change, given the observed dynamics



Applications

- ❖ Spatial planning with respect to resilience and vulnerability
 - Monitor and interpret landscape change
 - Spatial modeling for species and resources of concern
- ❖ Ecosystem management

Understand the shifting landscape mosaic in an integrative context

 - Climate variability
 - Land use change
 - Ecological disturbance regimes
- ❖ Identify opportunities for restoration, other conservation actions

National Environmental Modeling and Analysis Center
University of North Carolina – Asheville



Eastern Threat Center: Stephanie Worley-Firley,
Bjørn-Gustaf Brooks, Bill Hargrove, Steve Norman,
Bill Christie, Kurt Riitters



Thank You!

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