# Interpreting drought and disturbance impacts to natural systems from remotely observed change: Uses and challenges of "big data"


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*William Hargrove*

Eastern Forest Environmental Threat Assessment Center


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Tools for Climate Change Information and Decision Making

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# Acknowledgements

- USDA Forest Service Eastern Forest Environmental Threat Assessment Center (EFETAC) – (W Christie, D Lee, others)
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- Analysis Center (NEMAC)—(D Morgan, M Hutchins, others)
- USGS Earth Resources Observation and Science (EROS) Center
- USDA Forest Service Remote Sensing Applications Center (RSAC)
- USDA Forest Service Forest Health Technology Enterprise Team (FHTET)
- US NOAA National Climatic Data Center (NCDC)

# Challenges

- **<u>Challenge 1</u>:** Systematic monitoring the condition of US forest landscapes is a herculean goal–the “coarse filter” solution
- **<u>Challenge 2</u>:** Raw “big data” can be too unwieldy for interpreting and understanding phenomenon—the classification solution
- **<u>Challenge 3</u>:** **“**Big data” needs to be made available on the terms of those who seek to solve specific problems—accessibility solutions

**Challenge 1**: Systematic monitoring the condition of US forest landscapes is a herculean goal

**THE COARSE FILTER**: Fundamental observations, truths or concerns that apply to regional decisions or subject matter generalities.

**THE MEDIUM FILTER:** More focus for moderate-scale problems or issues such as landscape prioritization or characterization of risk.

**THE FINE FILTER:** The details or specifics that are needed for addressing local problems within the *context* of medium and coarse resolution.

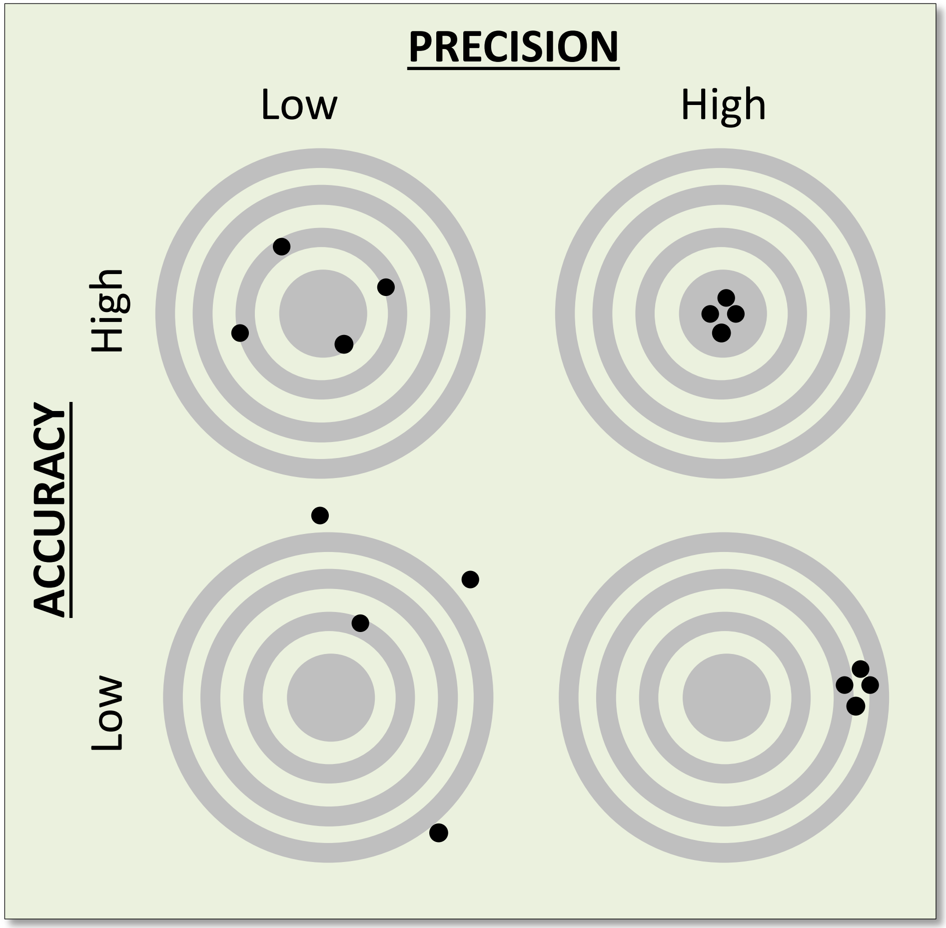
# The precisionist's fallacy:

*The belief that fine resolution or detailed data is always better for addressing a problem than is coarse or generalized information.*

***Precise*** ***Imprecise*** ***Classified***

# The case for less precision

- Accuracy is not precision, and often only coarse, accurate knowledge is needed to make a robust decision.
- Precise, but inaccurate information can be dangerous, as it shifts expectations of data quality.



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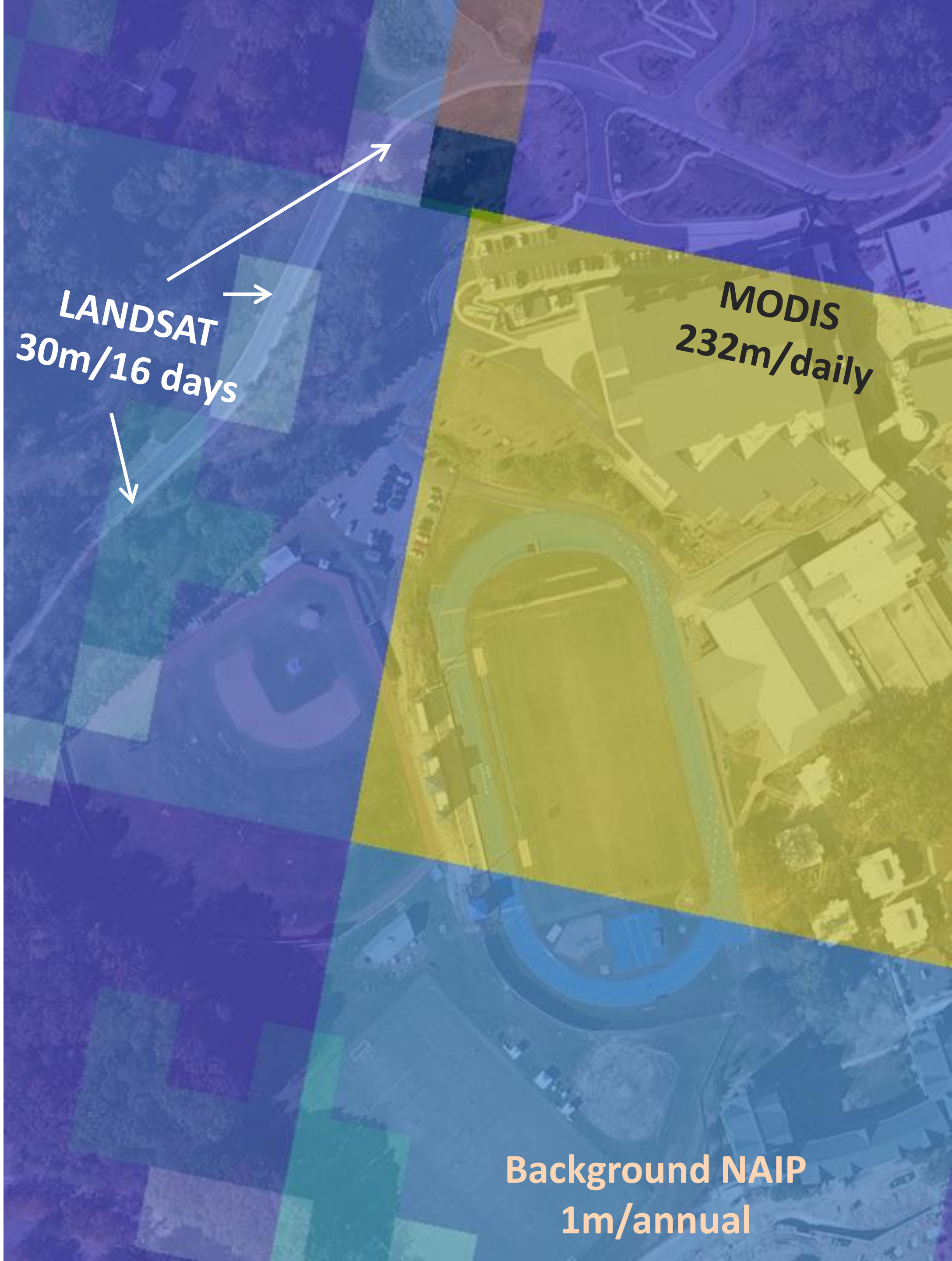

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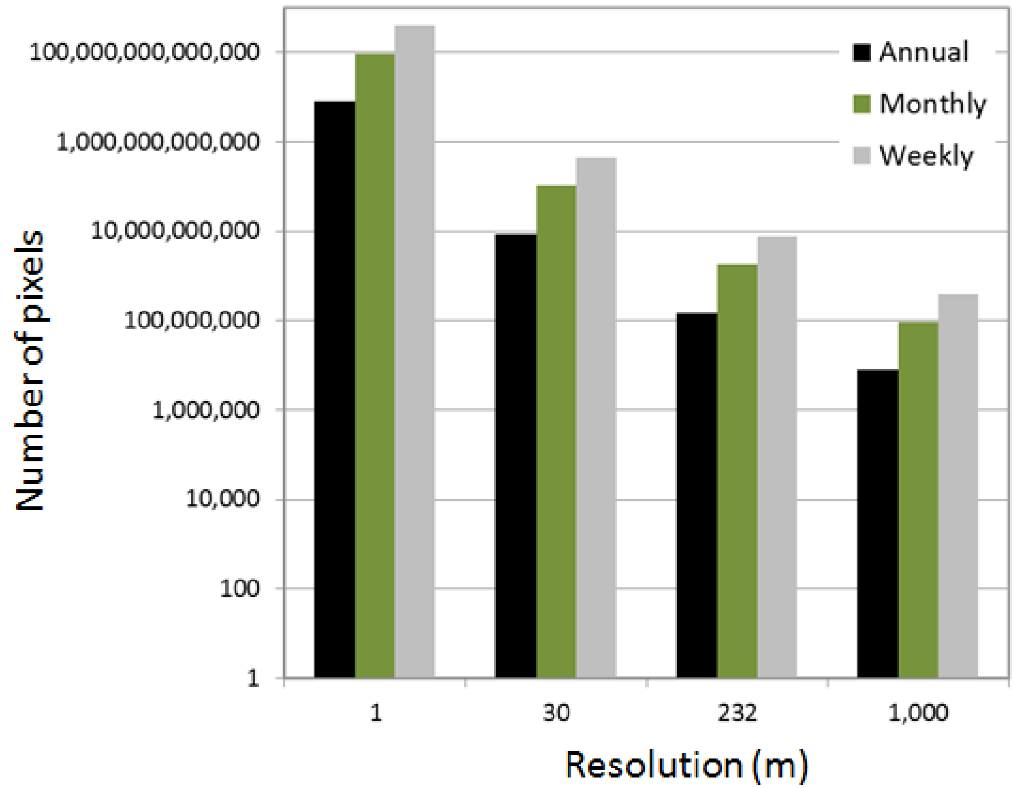
- Precise, but inaccurate information can be dangerous, as it shifts expectations of data quality.
- Precise information is often simply not available, while coarse data is.
- With precision comes bigger data management issues and processing. Tradeoffs can include extent/ coverage, frequency or uniformity.

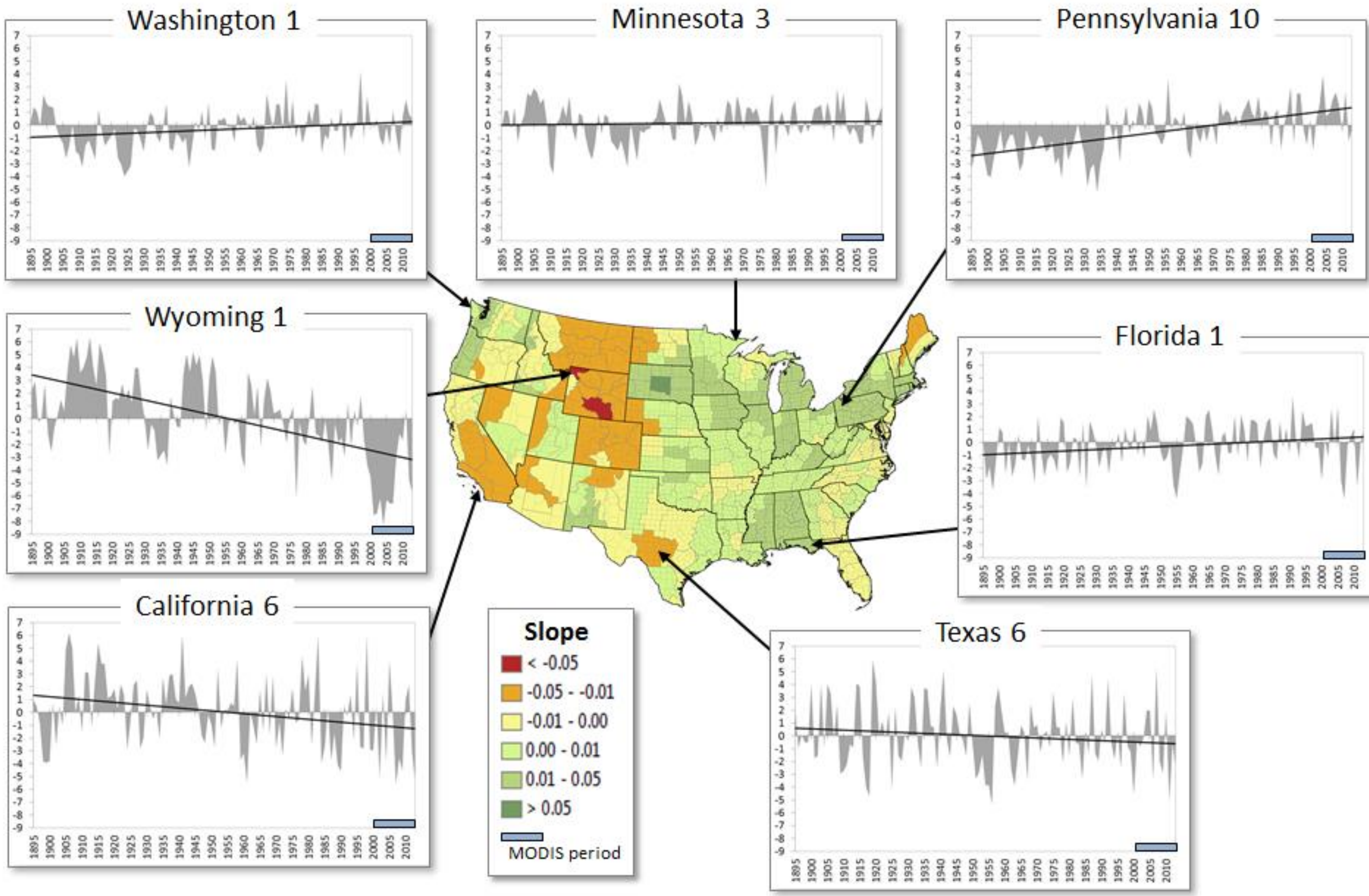
Different satellite spatial and temporal resolutions affect data management requirements for the conterminous US




**Precision needs to be aligned to the task at hand or the decision to be made. Ask, would my decision really be different with more information?**

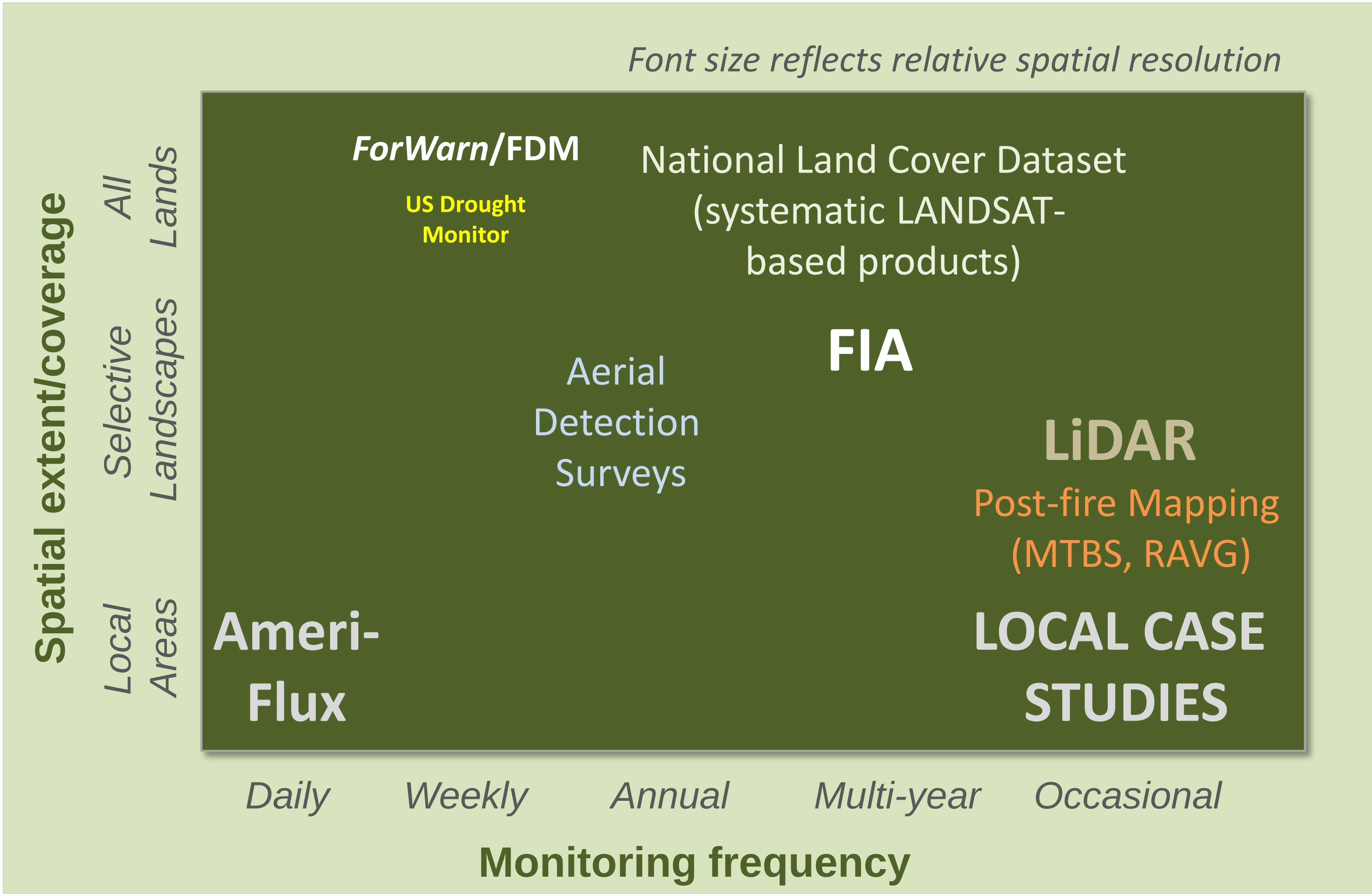
# Coarse-filter climate trends suggest coarse impacts

Mean Apr. to Sep. Palmer Modified Drought Index 1895-2013, by NCDC Climate Division

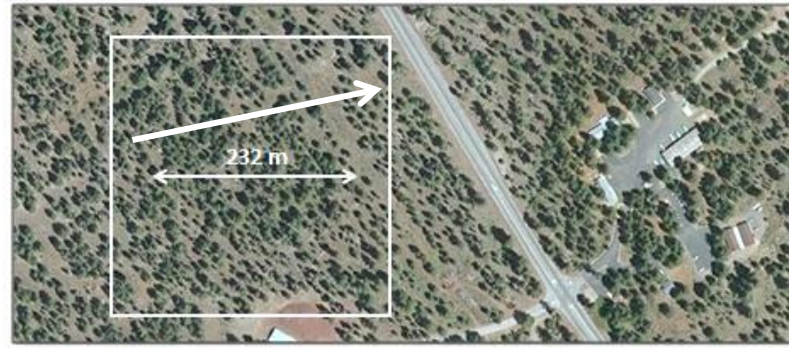


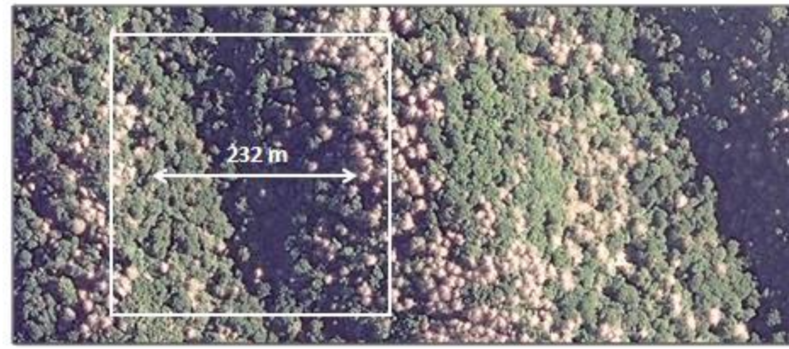

*Source: Norman, Koch and Hargrove 2015*

# Existing coarse and fine-filter approaches to forest monitoring in the US

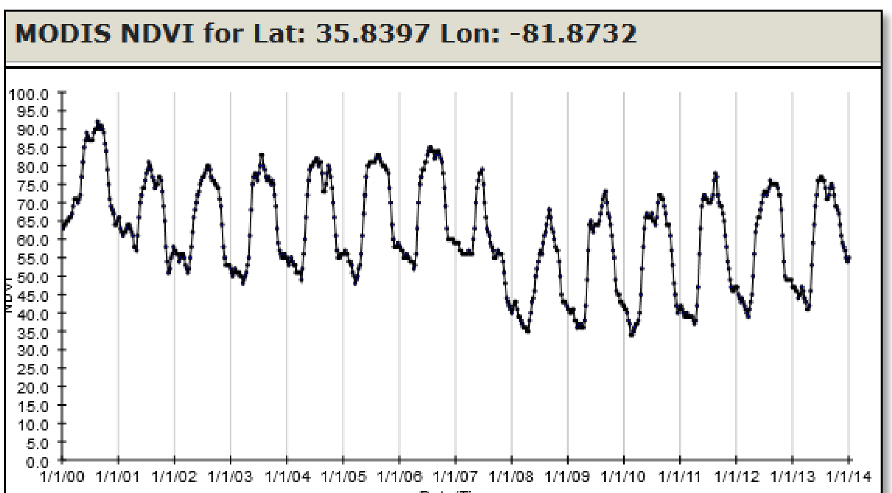


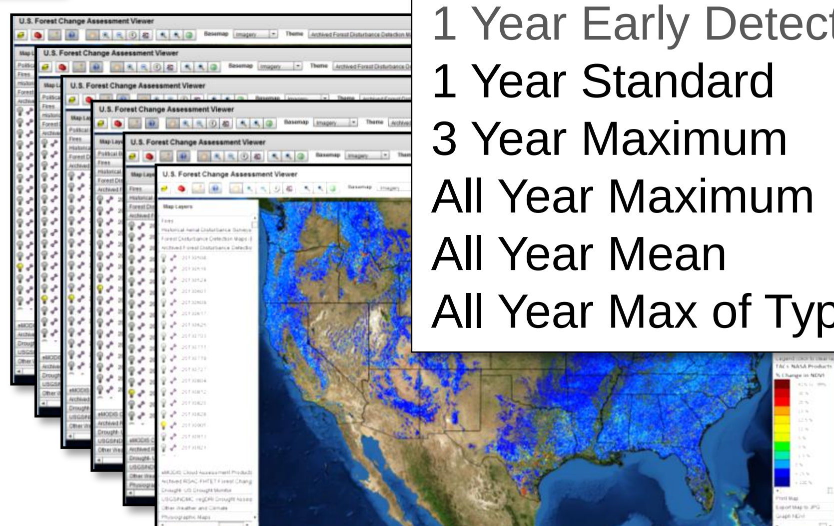
# The *ForWarn* system




- Online at http://forwarn.forestthreats.org
- Measure is the Normalized Difference Vegetation Index (NDVI) from MODIS
- 232 meter resolution (5.4 ha/13 ac)
- 8-day frequency (46 periods/year from 2000)
- Since 2010, 276 near-real-time change maps /year using 6 seasonally-adjusted baselines
- Derived and long-term monitoring products



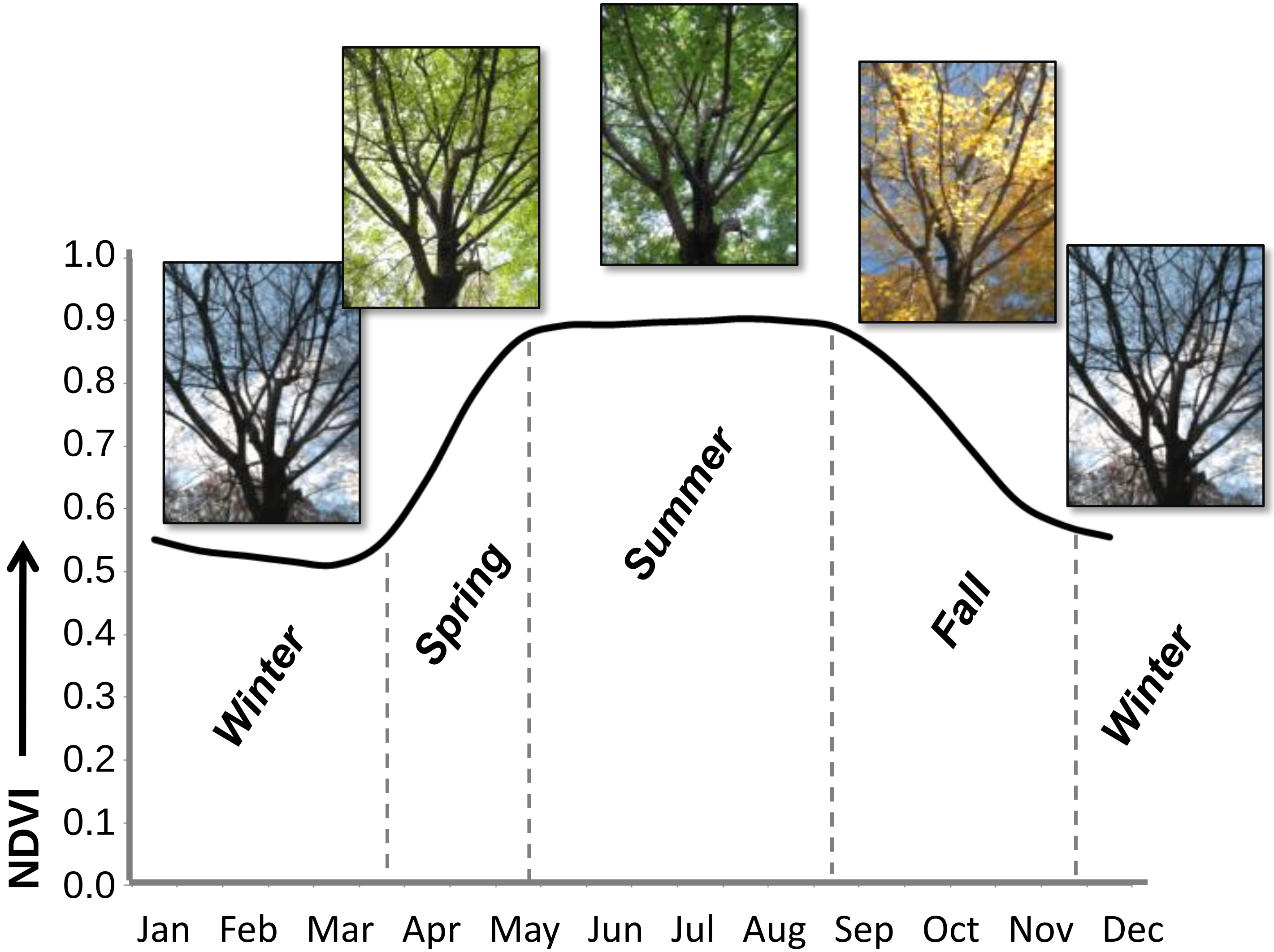




**Baselines**

1 Year Early Detect
1 Year Standard
3 Year Maximum
All Year Maximum
All Year Mean
All Year Max of Type

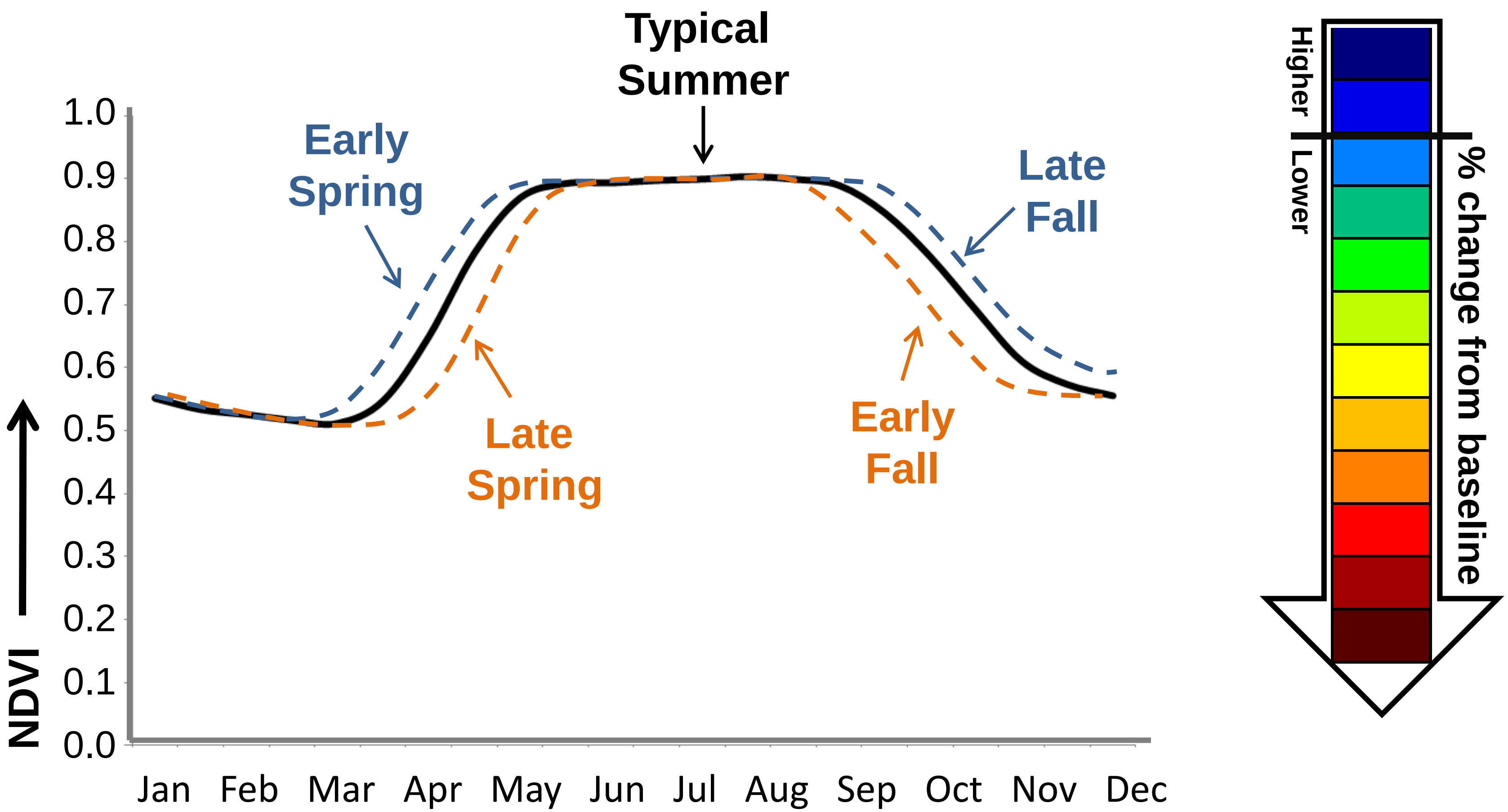
# The *ForWarn* system

## Seasonal change in NDVI reflects vegetational phenology



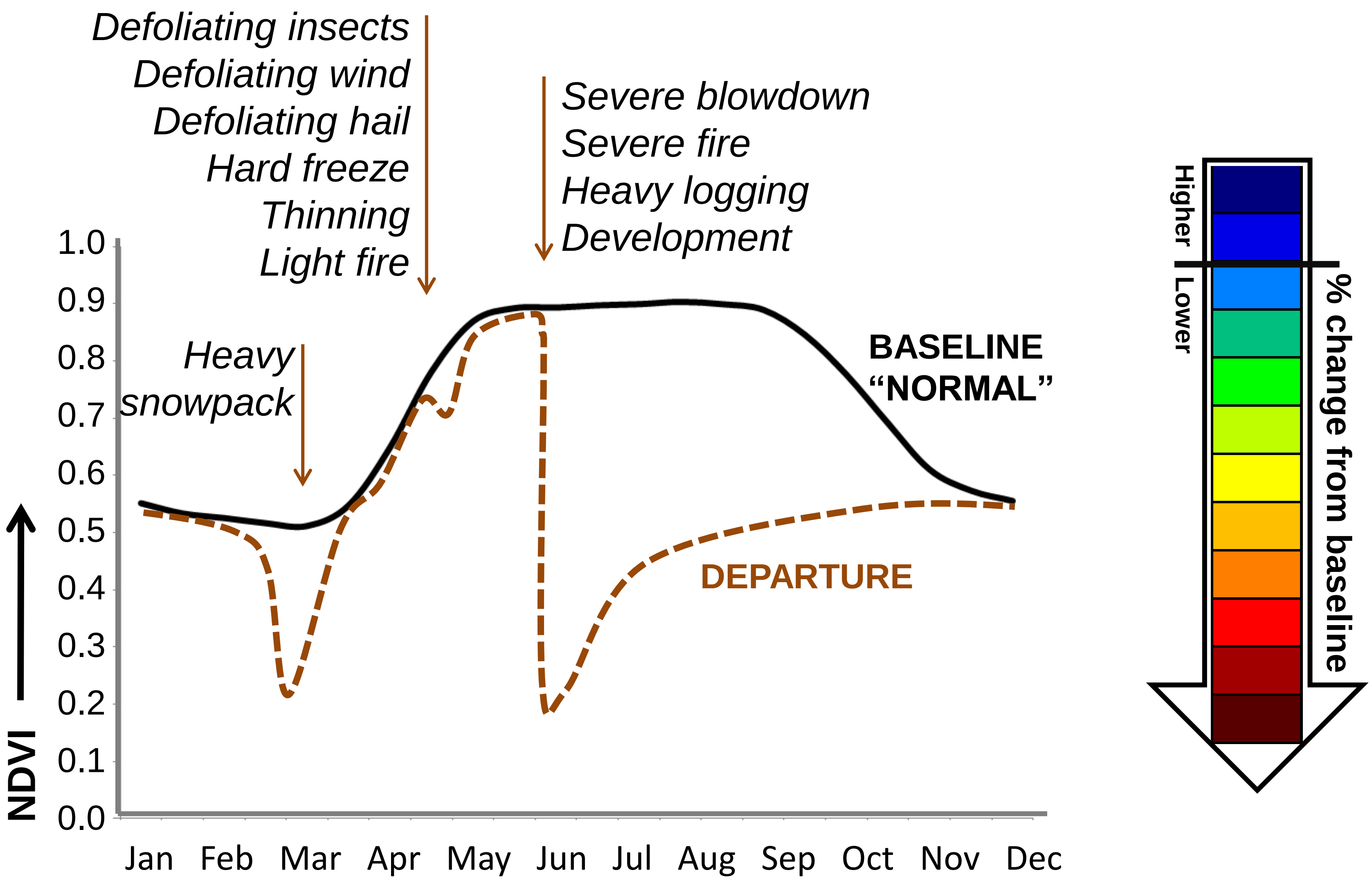
# The *ForWarn* system

## Baseline phenology compared to variation in Spring and Fall



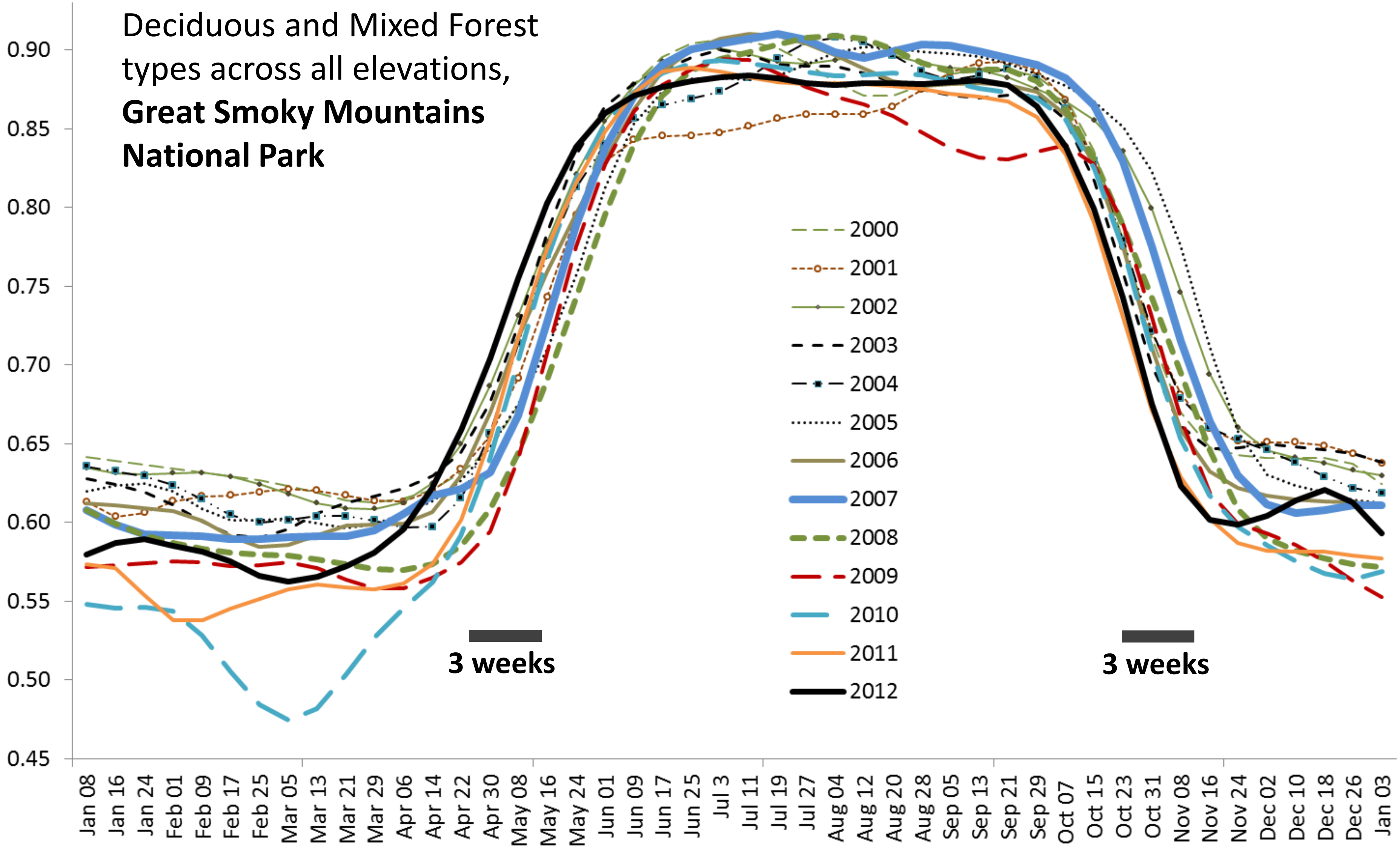
# The *ForWarn* system

## Baseline phenology compared to disturbance effects

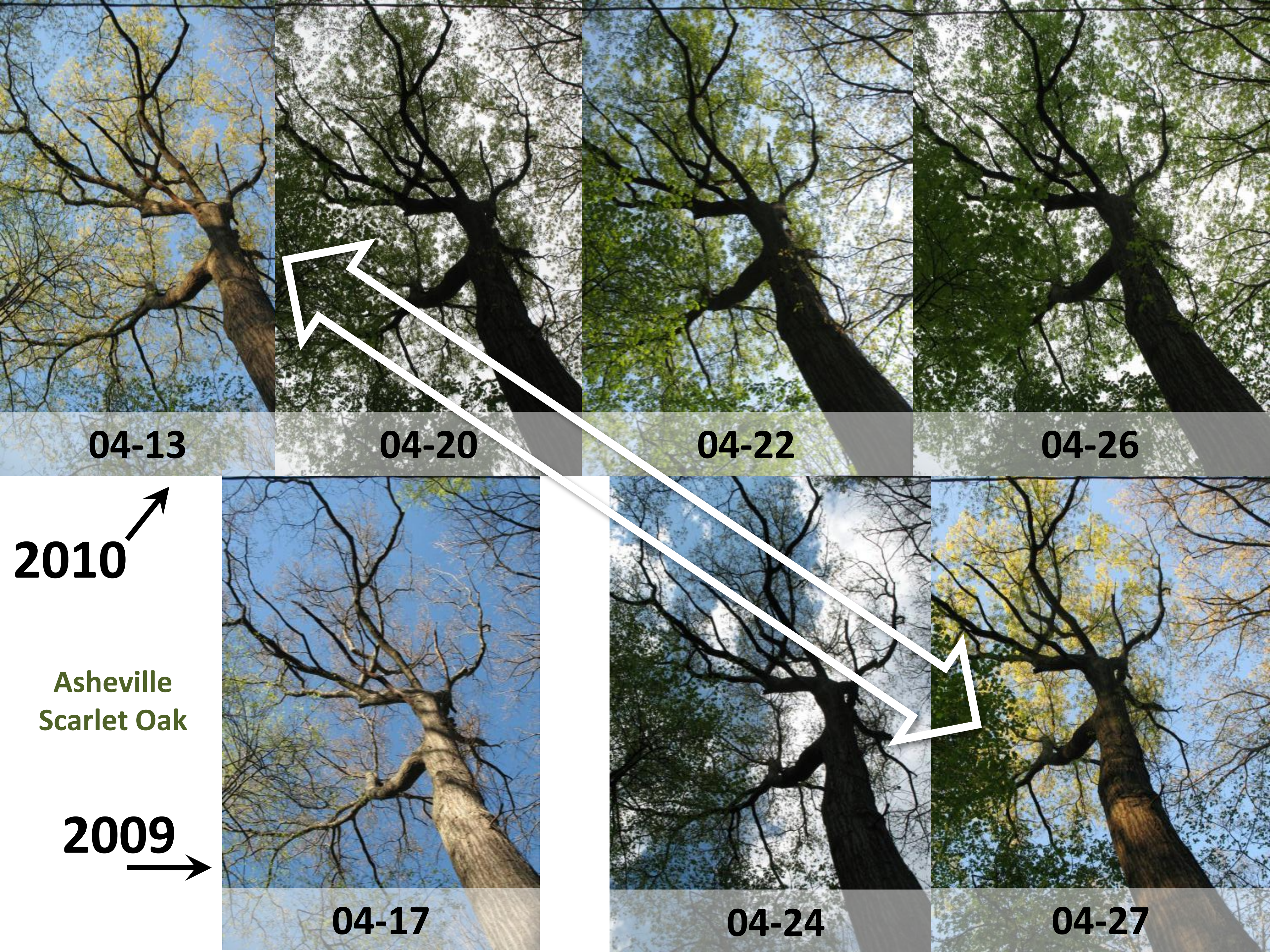


# The *ForWarn* system

## Capturing year-to-year variation in NDVI

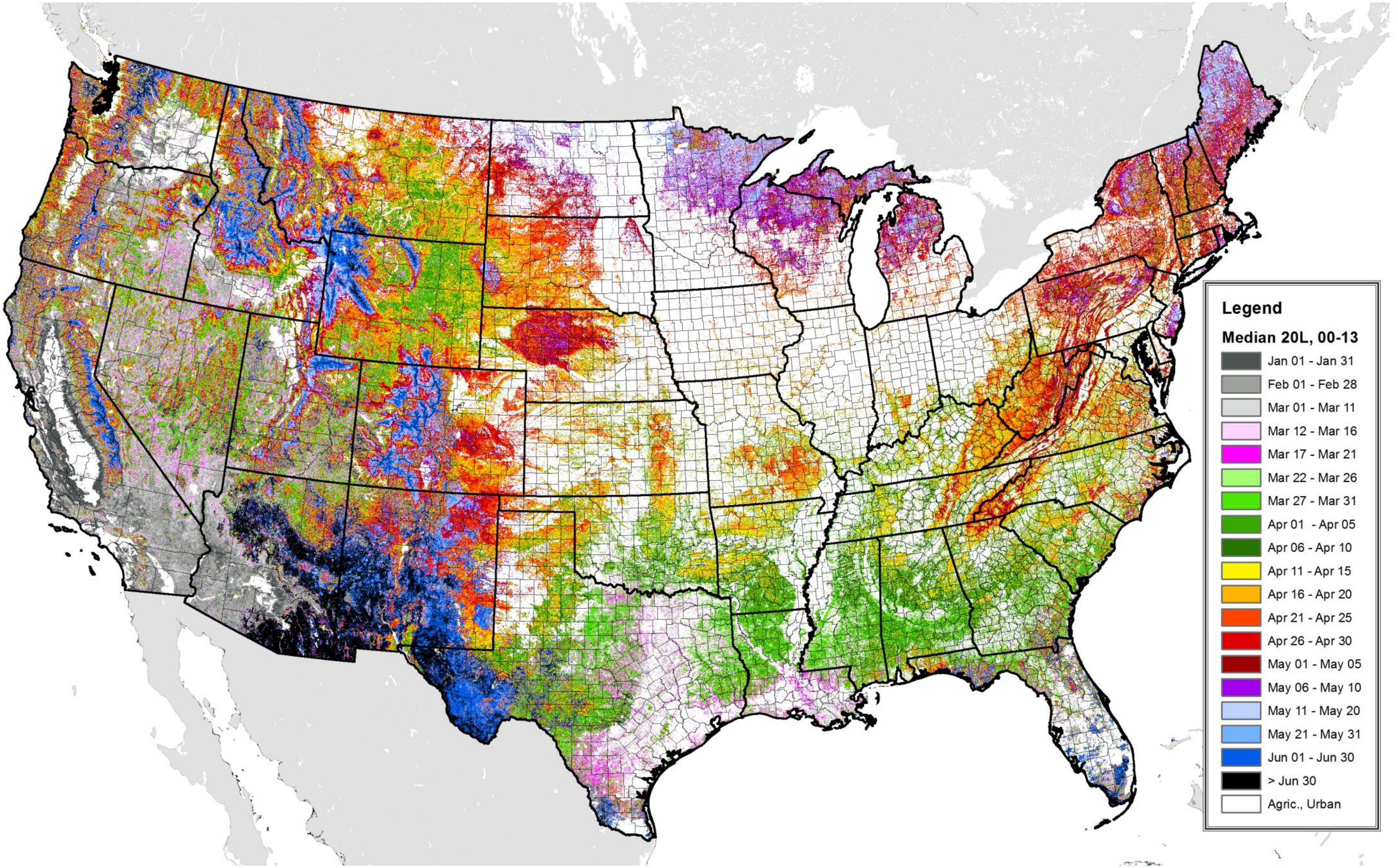



Mean of 38,318 MODIS cells


04-13
04-20
04-22
04-26
2010
Asheville
Scarlet Oak
2009
04-17
04-24
04-27

# *ForWarn*'s Median Start of Greenup Date for Natural Vegetation, 2000-2013

Eastern Forest Environmental Threat Assessment Center, March 2015



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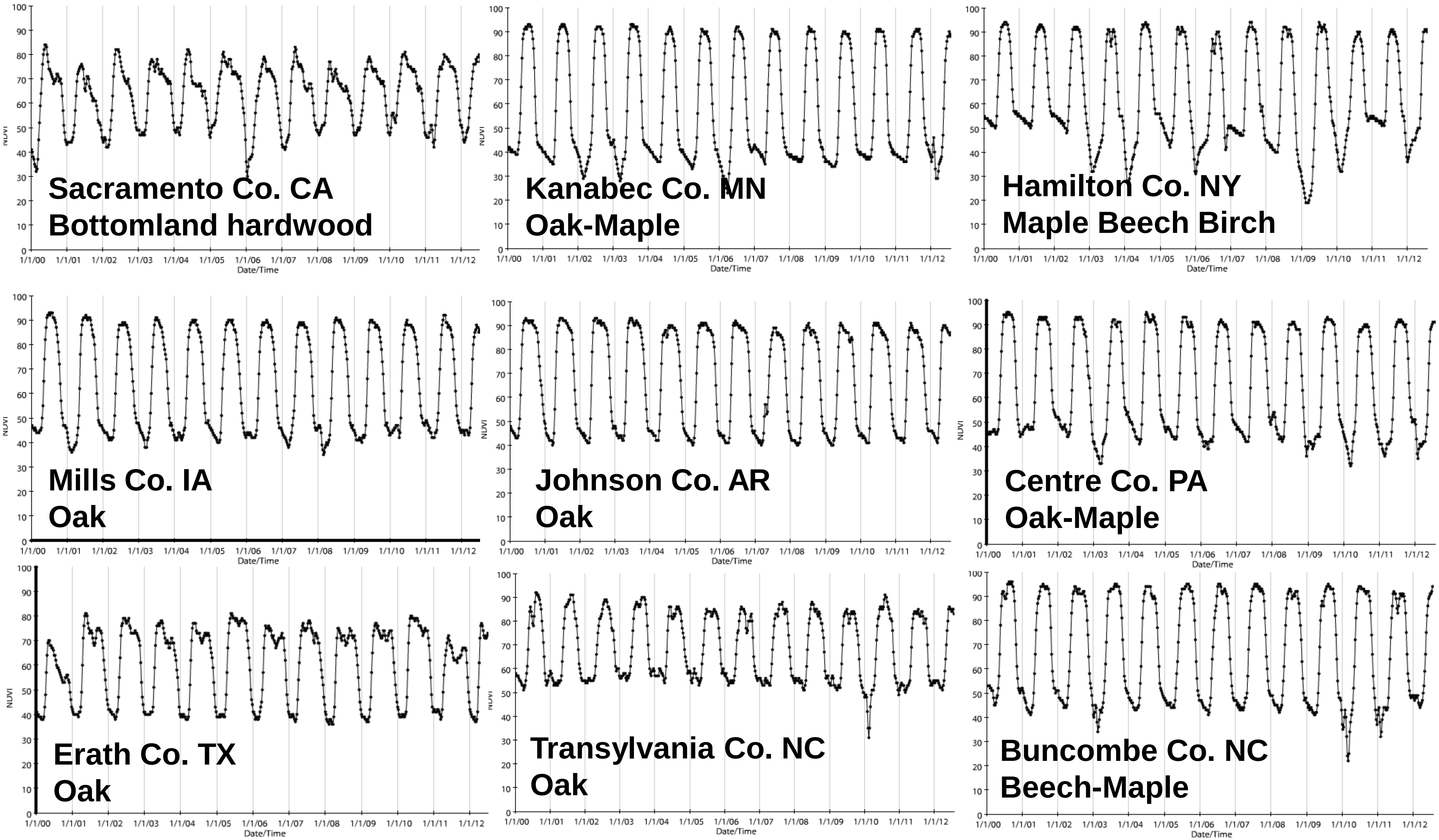
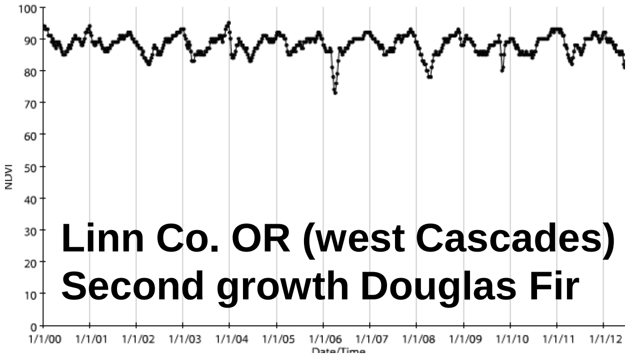
# Land Surface Phenology-based vegetation types

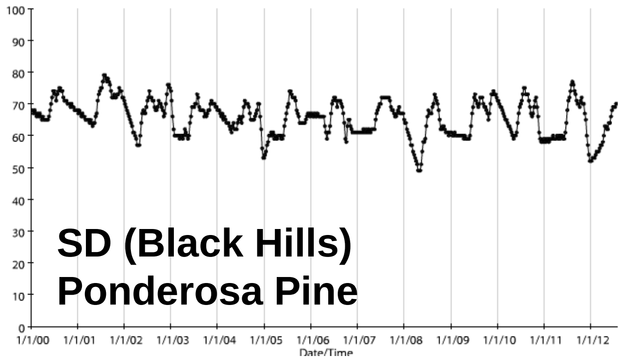
## Hardwood forest-dominated pixels

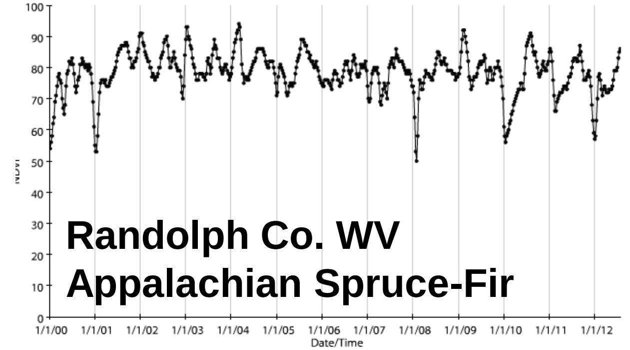


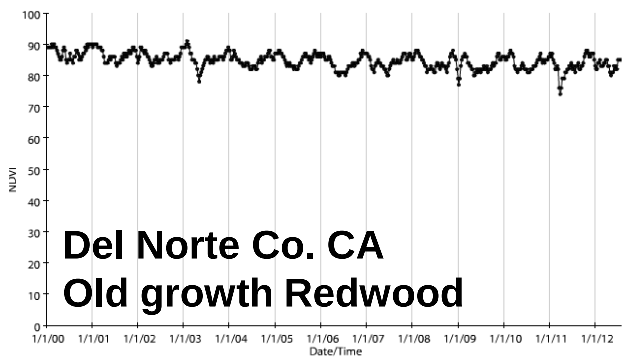
# Land Surface Phenology-based vegetation types

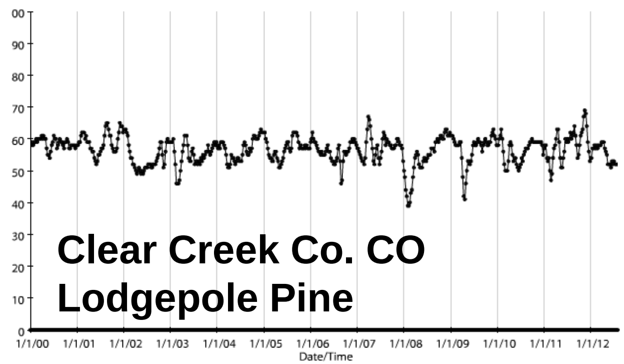
## Evergreen conifer forest-dominated pixels

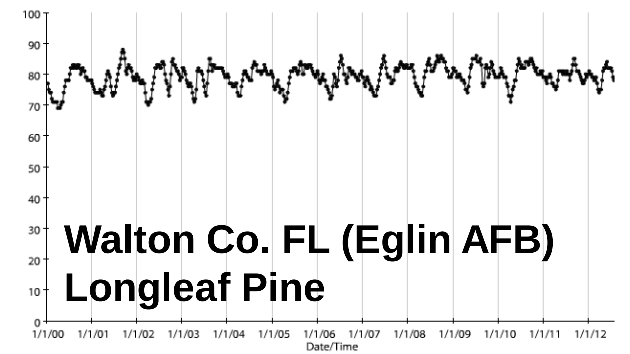


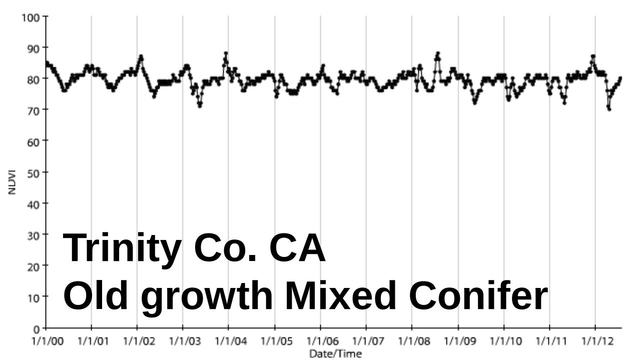



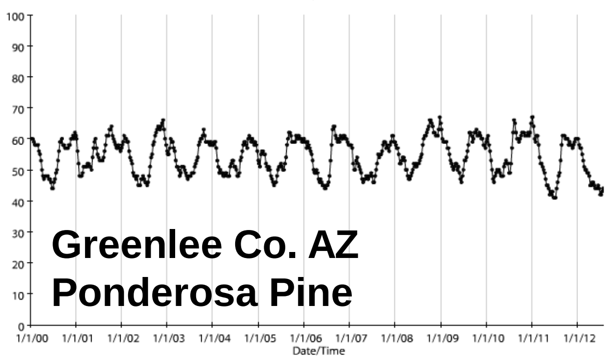



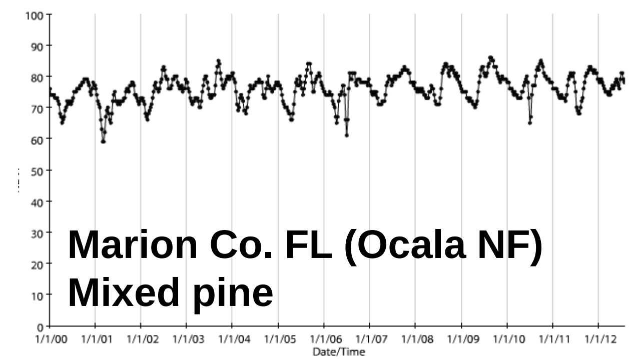



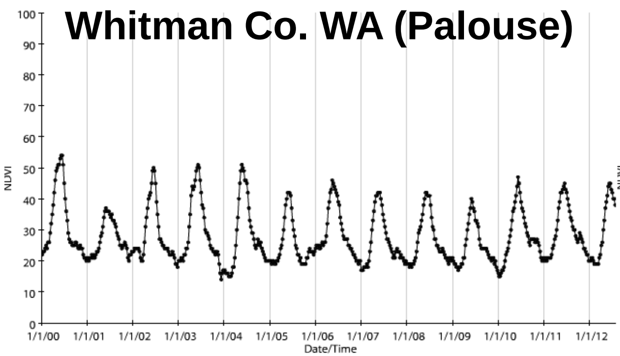



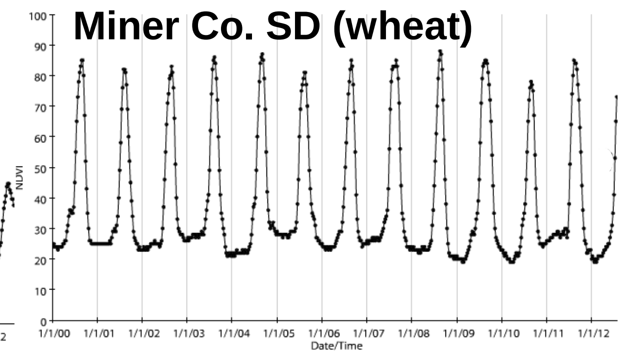



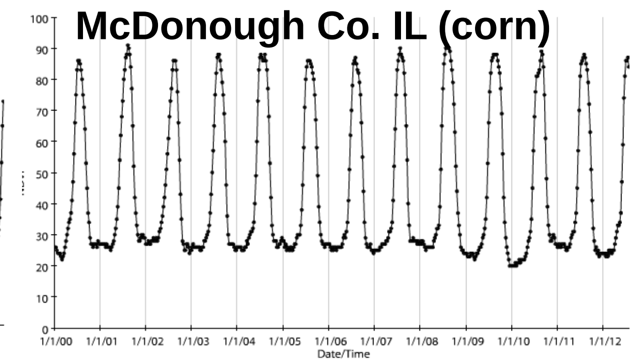



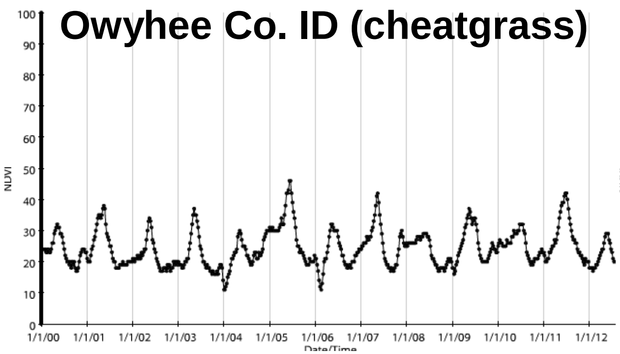
# Land Surface Phenology-based vegetation types

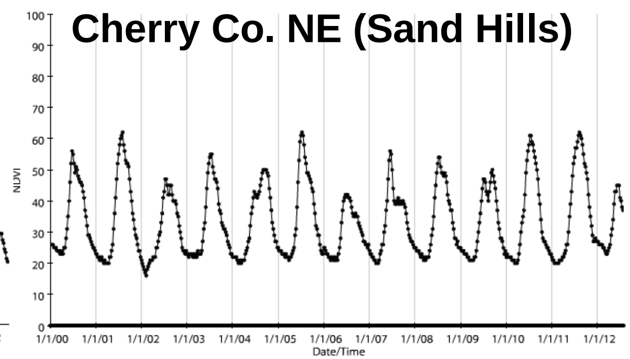
## Grass-dominated pixels

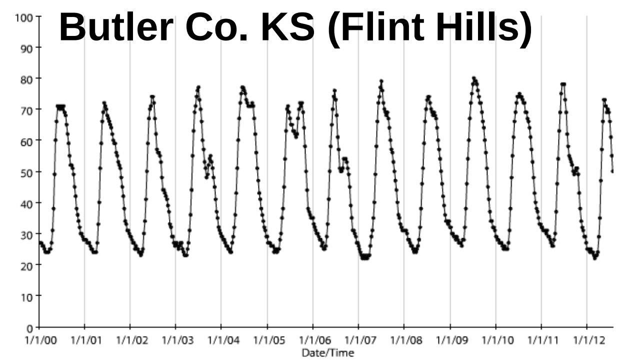


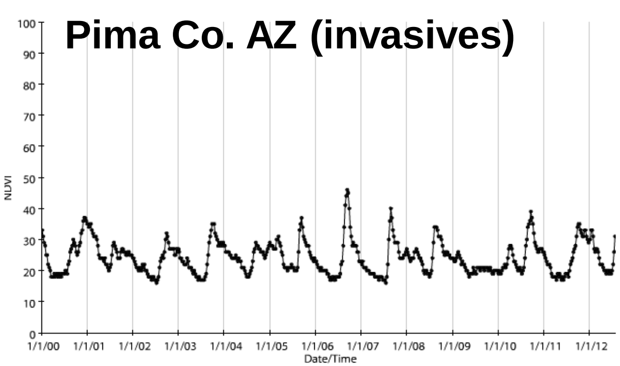



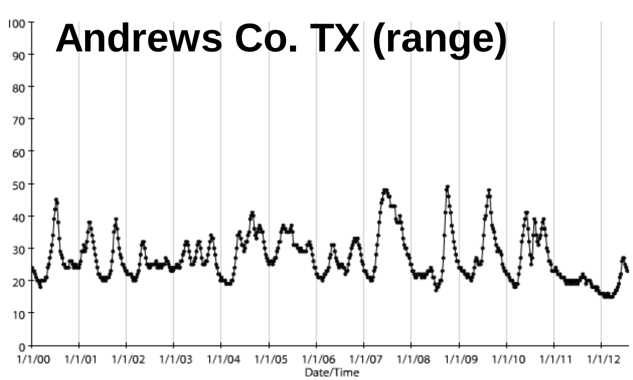



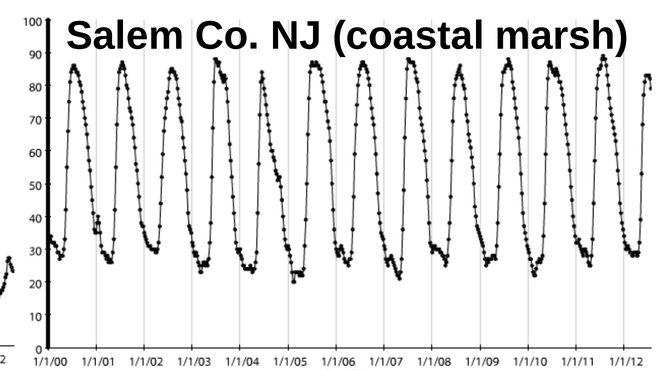



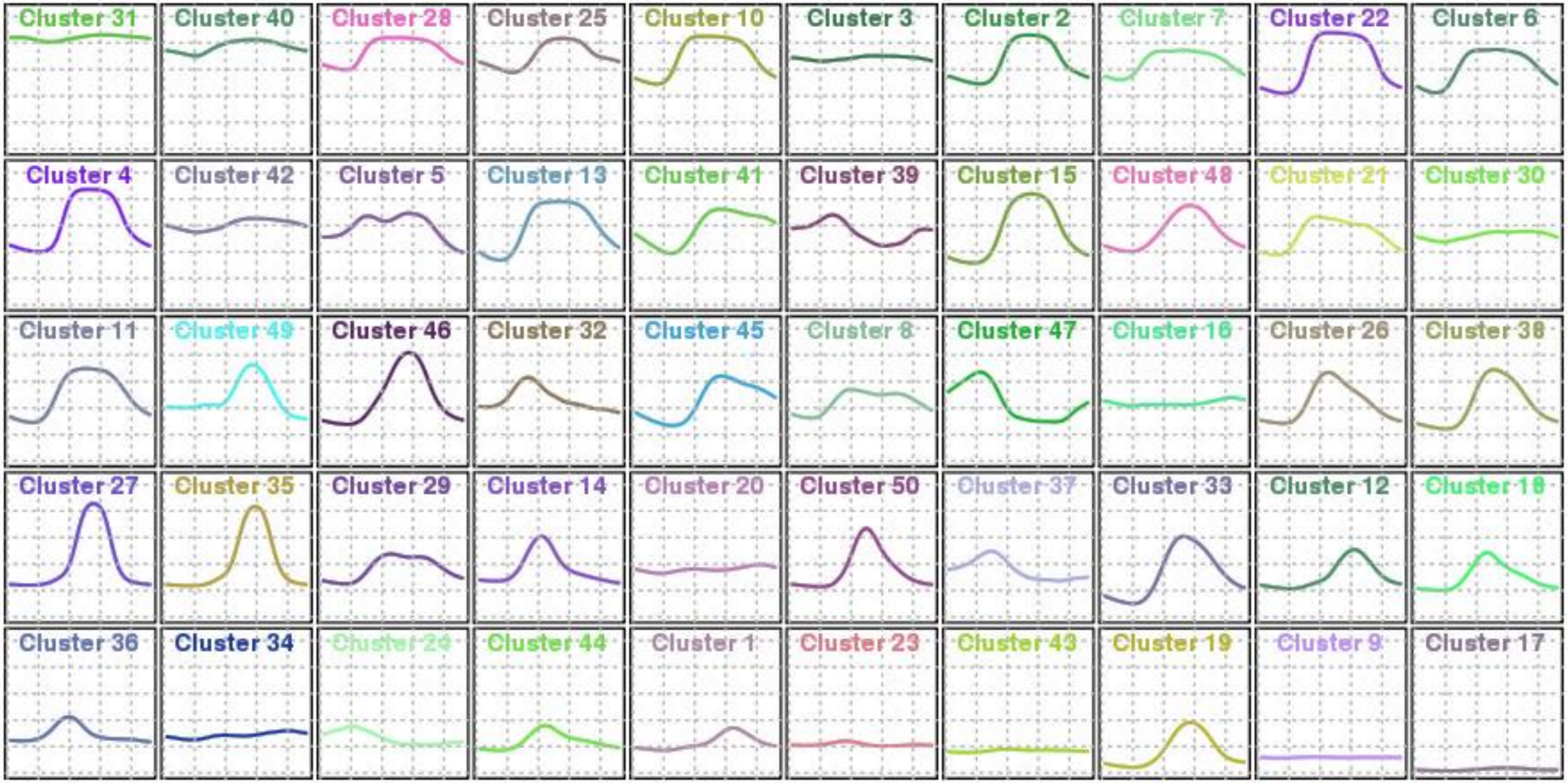



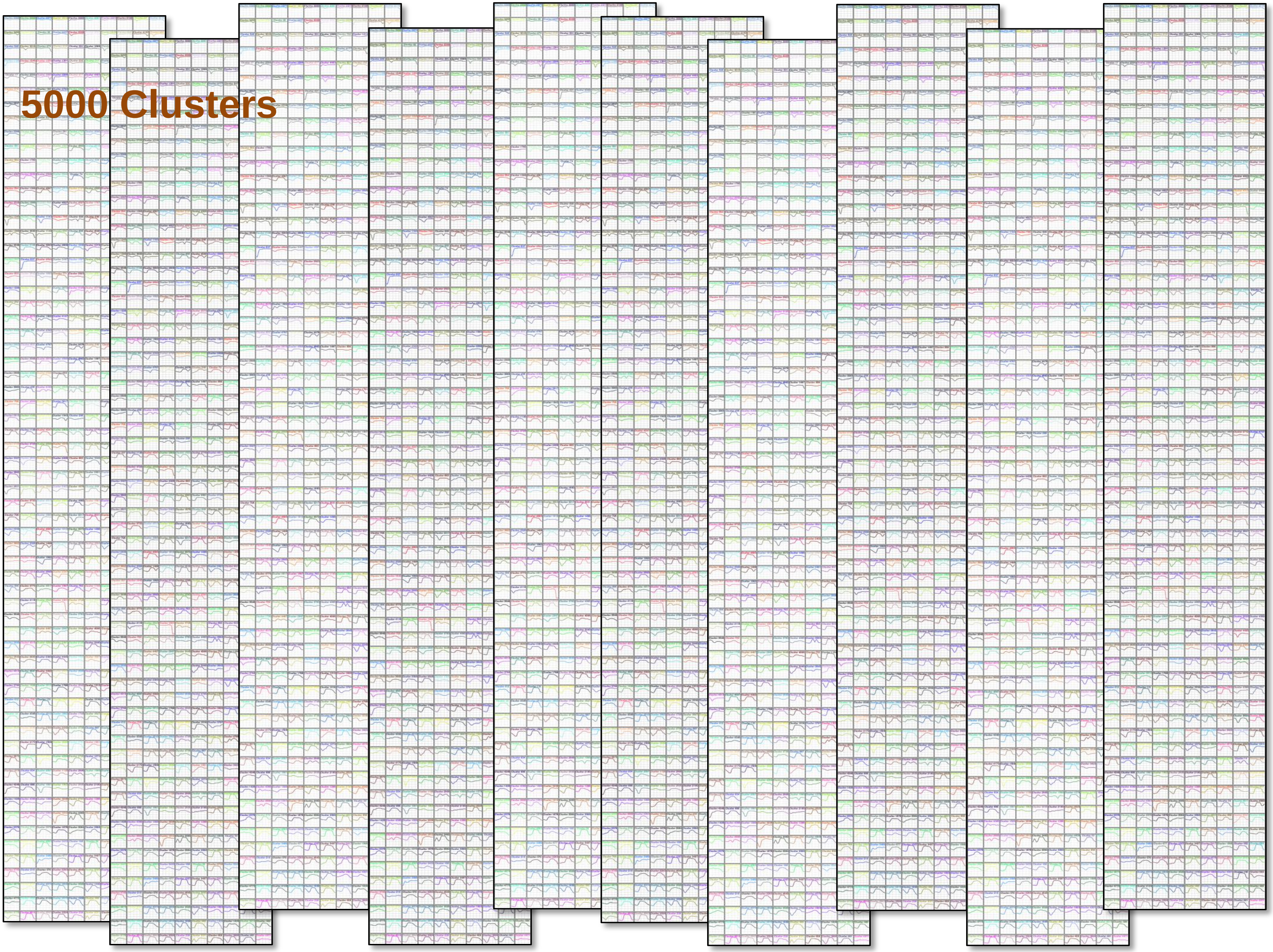
# Land Surface Phenology-based vegetation types

## 50 Clusters

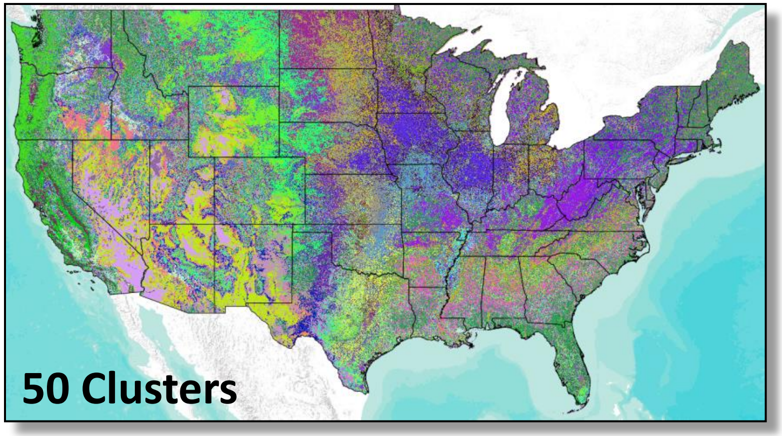
**2000-2012**
**Max Mode**
**Phenoregions**

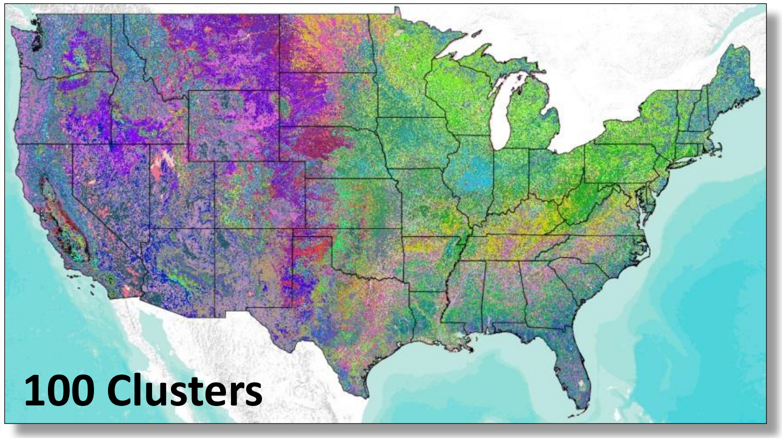
Note the variety of evergreen, deciduous and non-vegetative forms



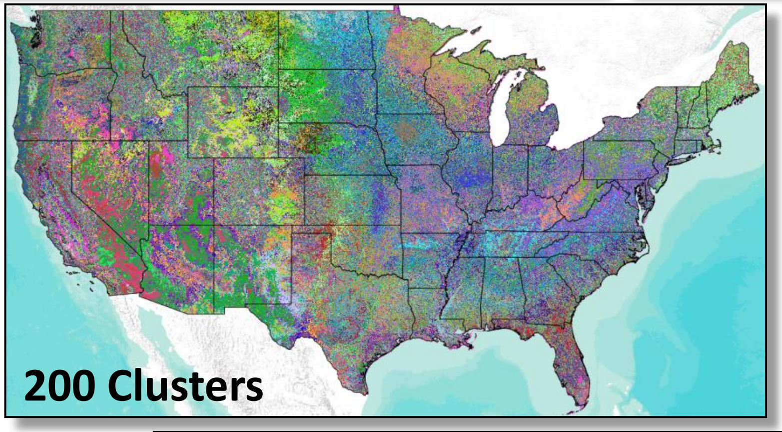

5000 Clusters

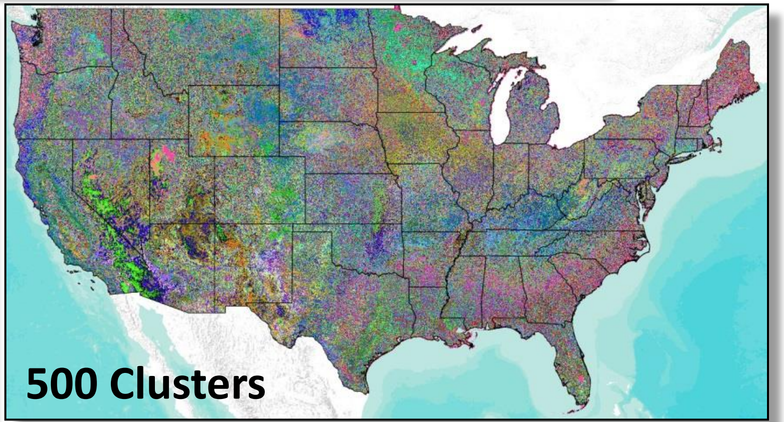
# Land Surface Phenology-based vegetation types

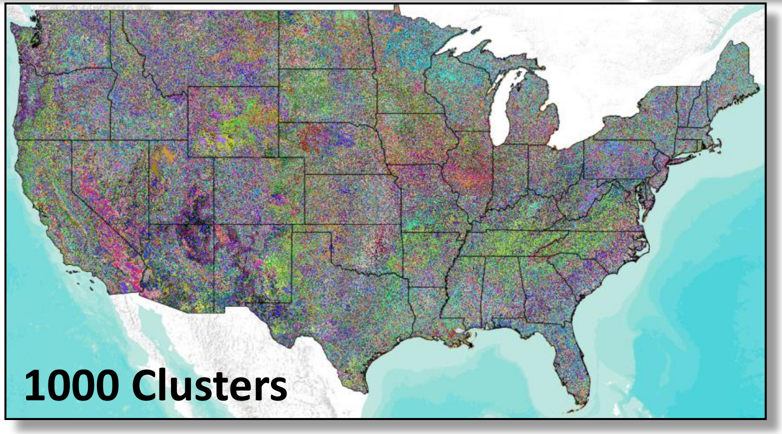


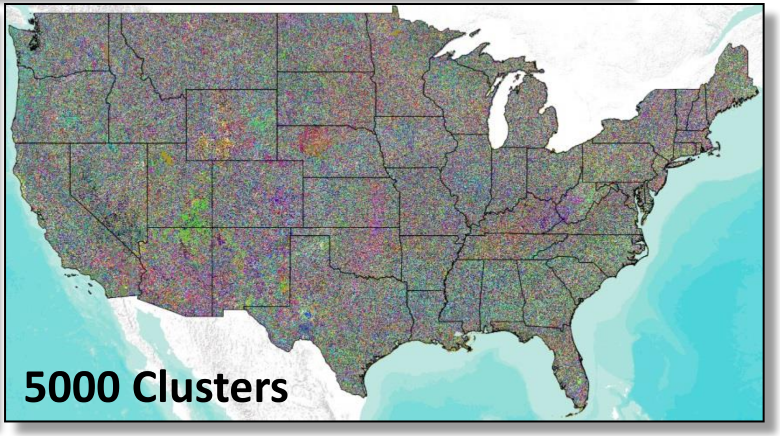




2000-2012
Max Mode
Phenoregions



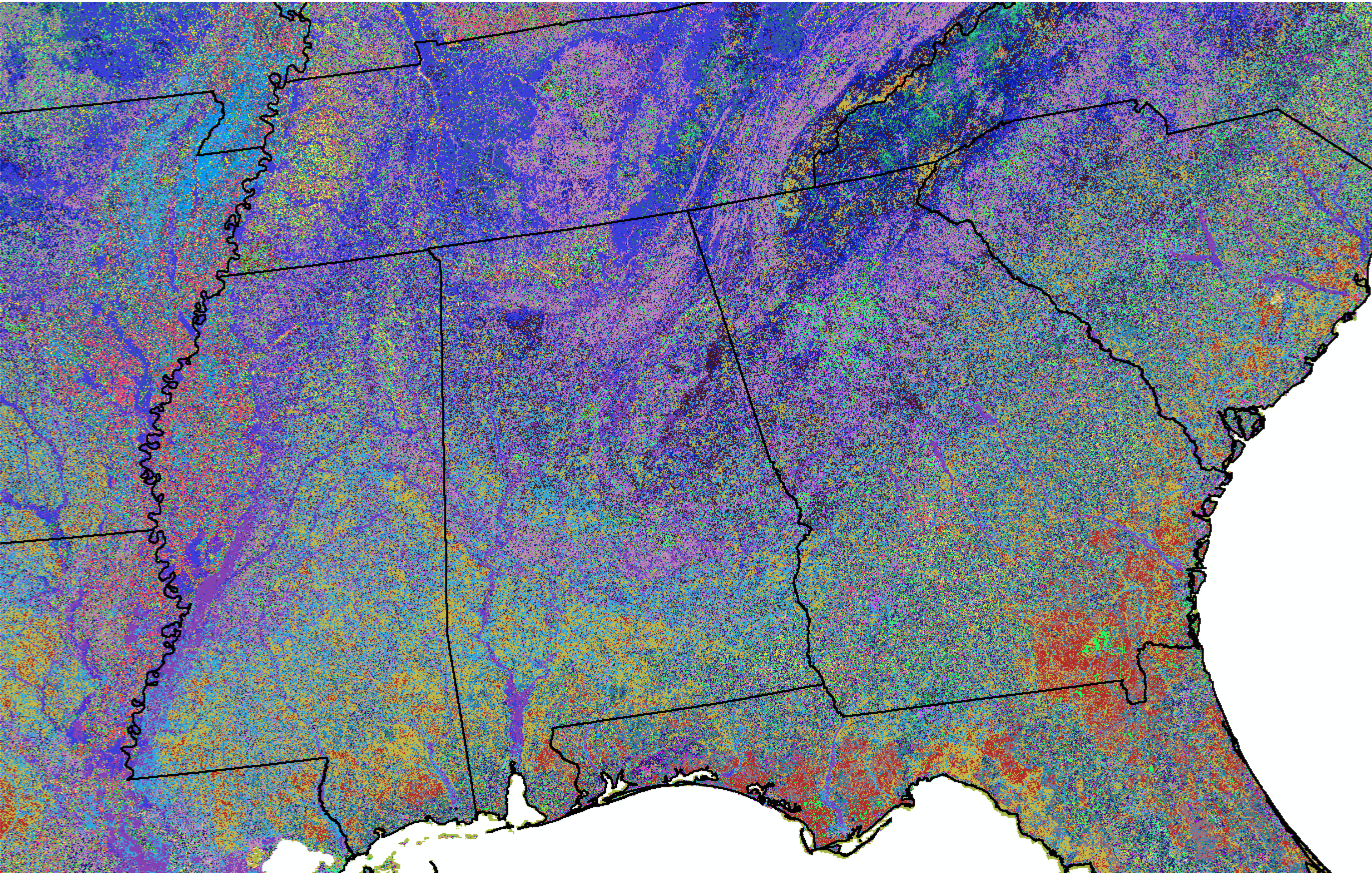



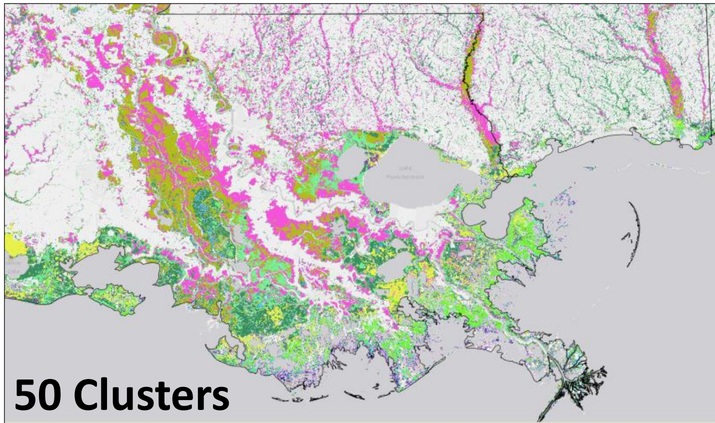
# Land Surface Phenology-based vegetation types

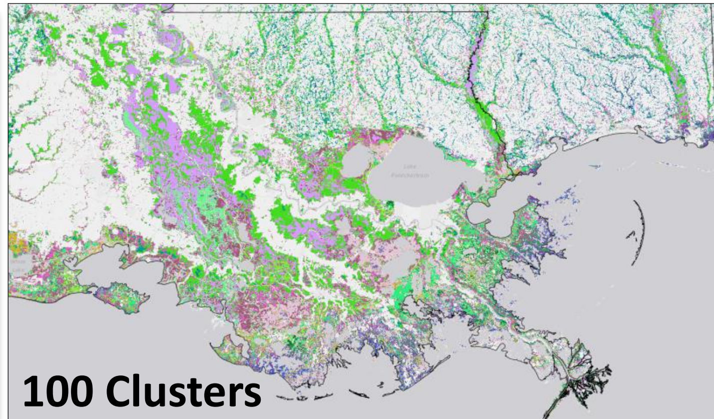
## 200 “Max-Under” phenoregions (random colors)

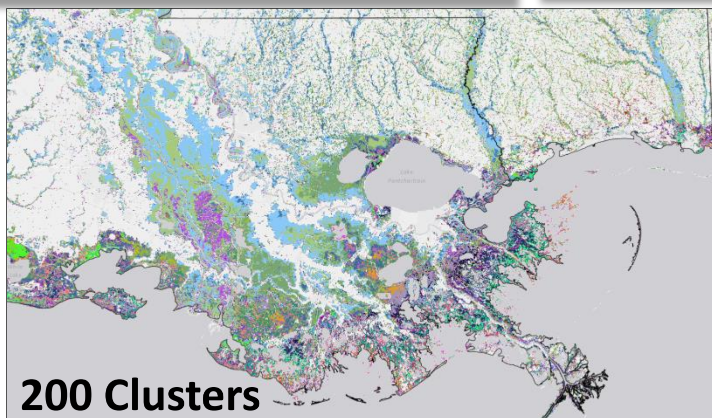


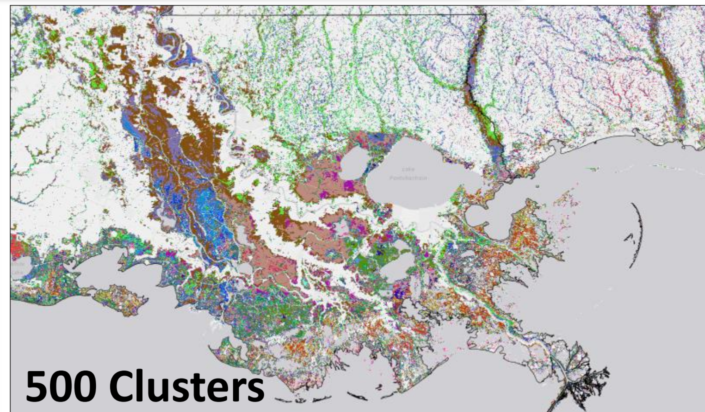
# Land Surface Phenology-based wetland types

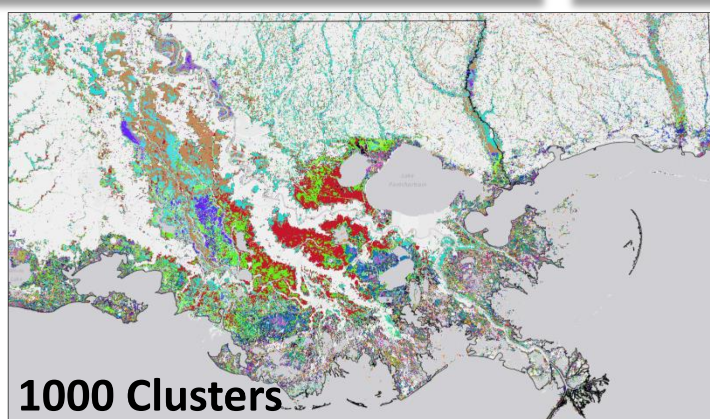
**2000-2012**
**Max Mode**
**Phenoregions**

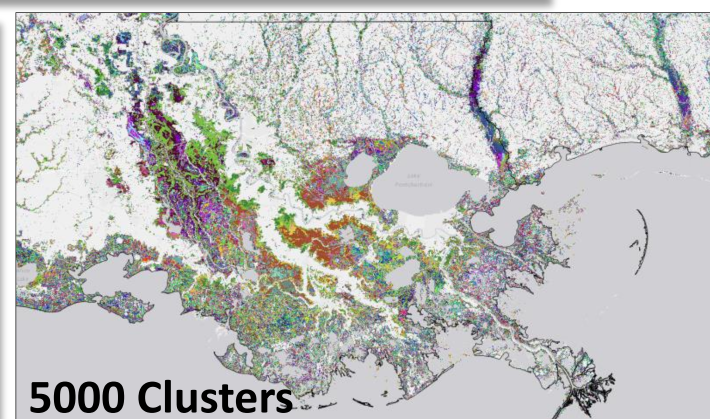


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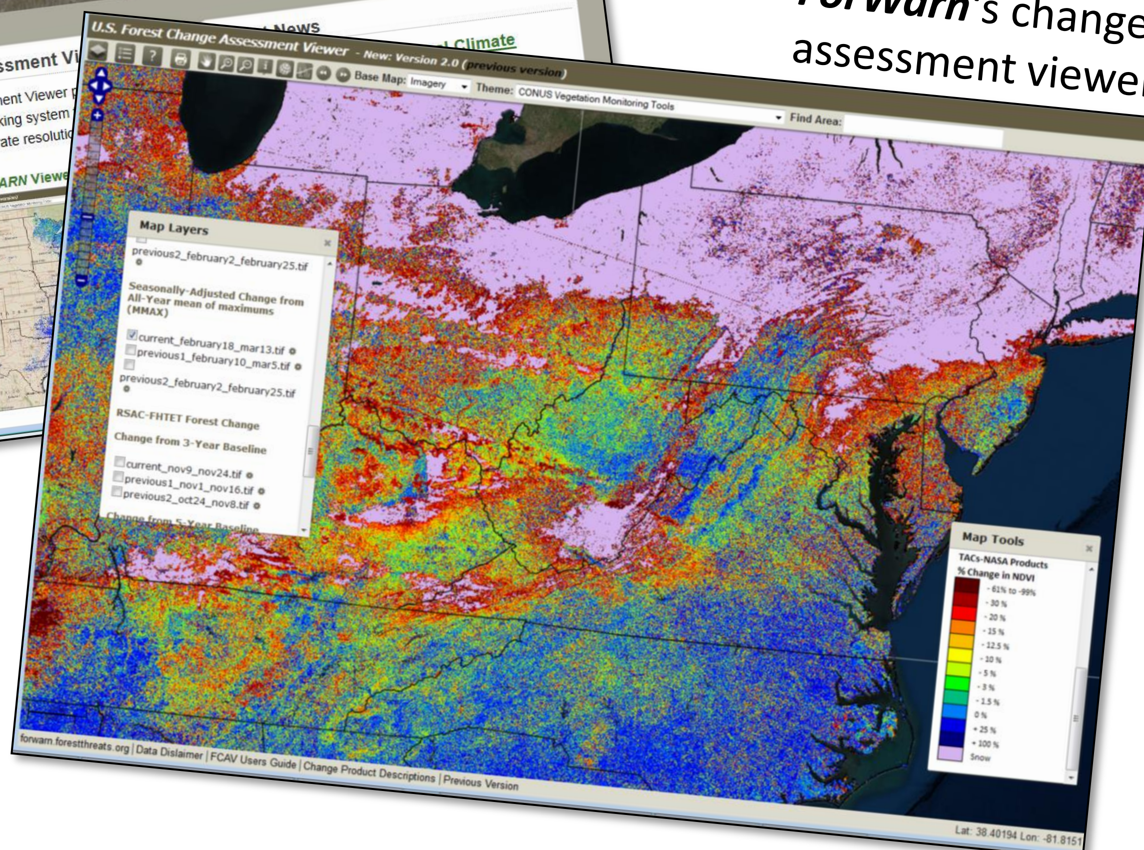
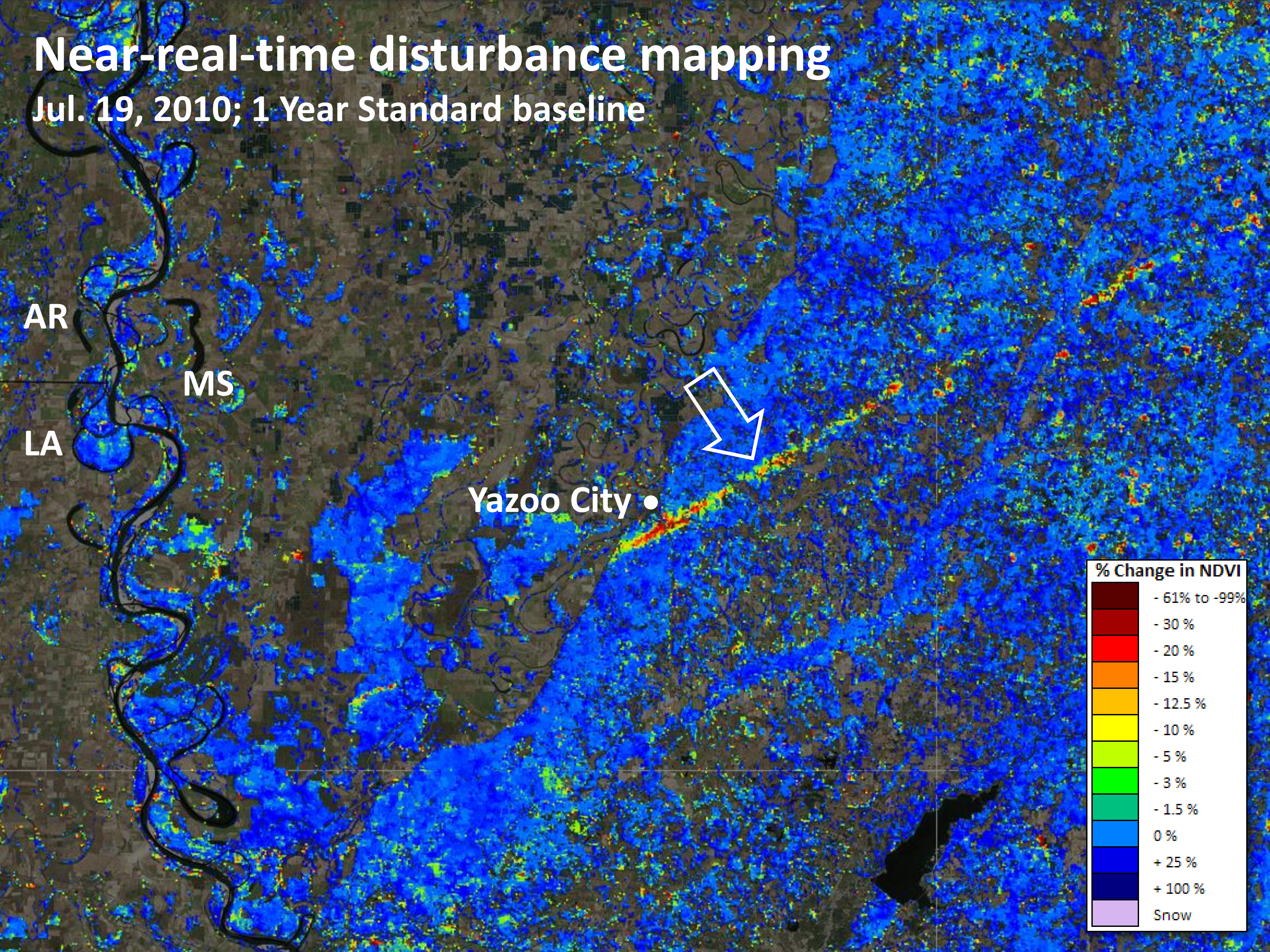
The ***ForWarn*** website: http://forwarn.forestthreats.org

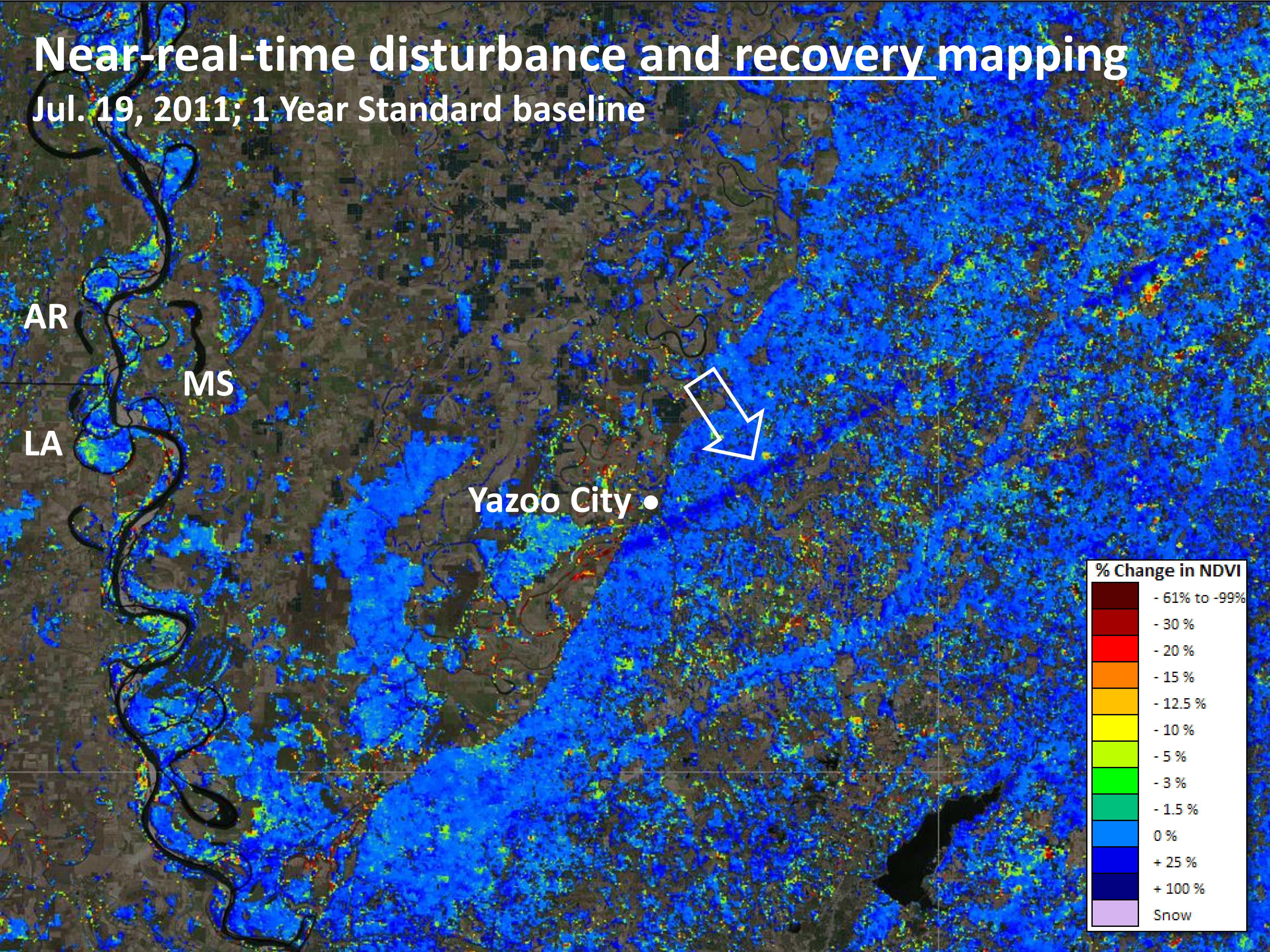

***ForWarn***'s change assessment viewer




Near-real-time disturbance mapping
Jul. 19, 2010; 1 Year Standard baseline
AR
MS
LA
Yazoo City
% Change in NDVI
- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow

# Near-real-time disturbance and recovery mapping

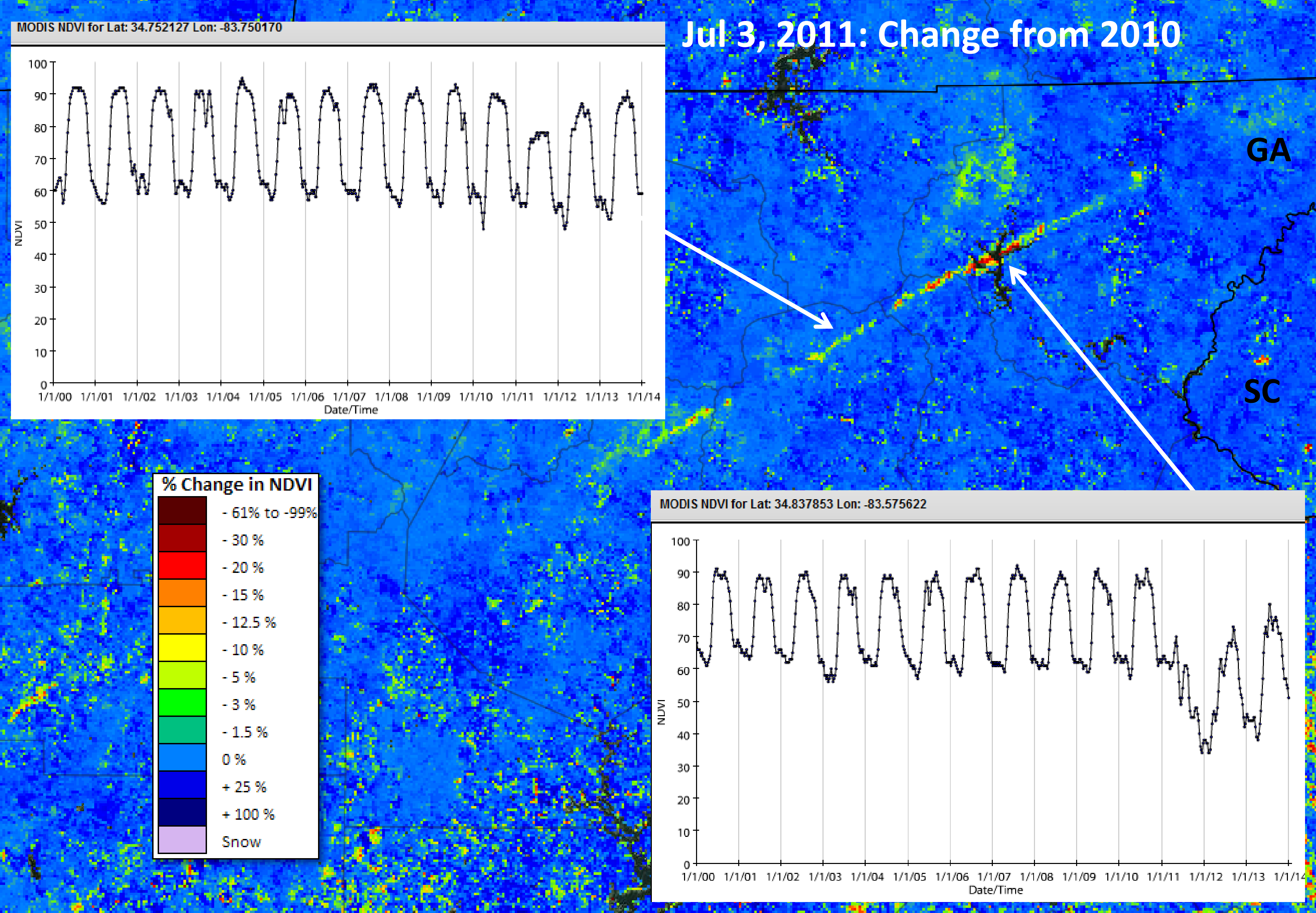
Jul. 19, 2011; 1 Year Standard baseline



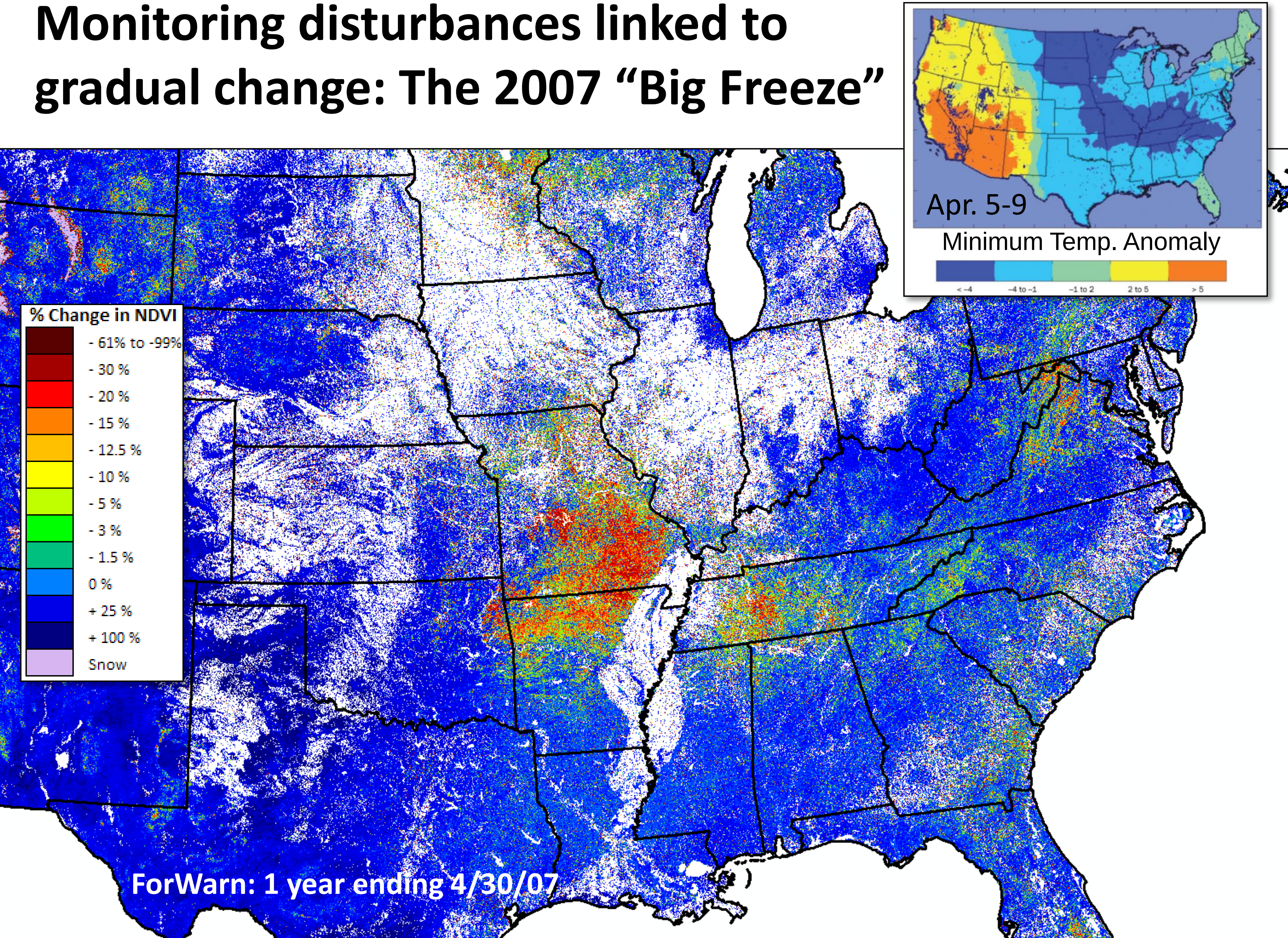
# Near-real-time disturbance mapping

## Chattahoochee National Forest tornado, Apr. 27, 2011

# Near-real-time Chattahoochee NF tornado severity



# Monitoring disturbances linked to gradual change: The 2007 “Big Freeze”



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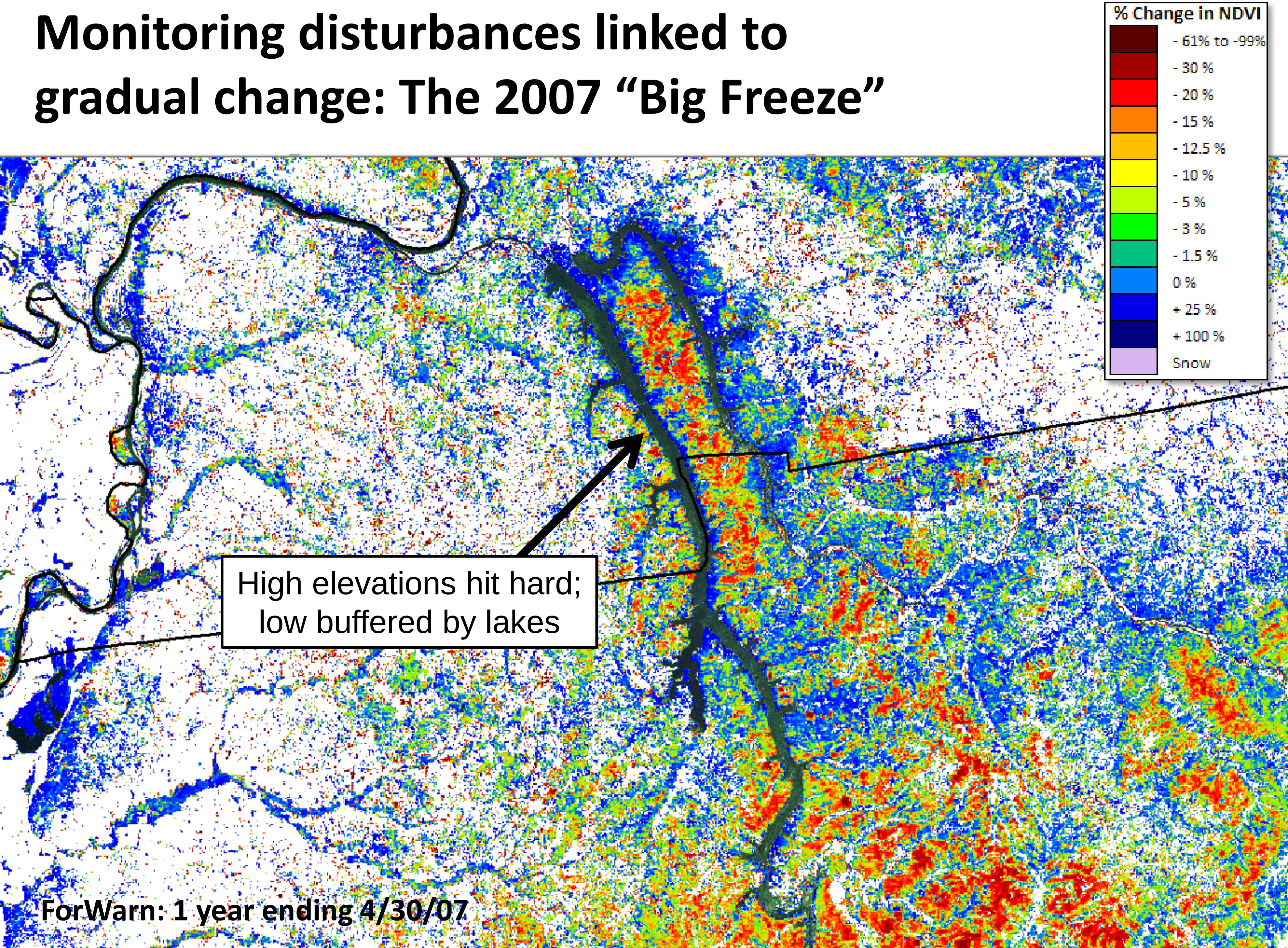
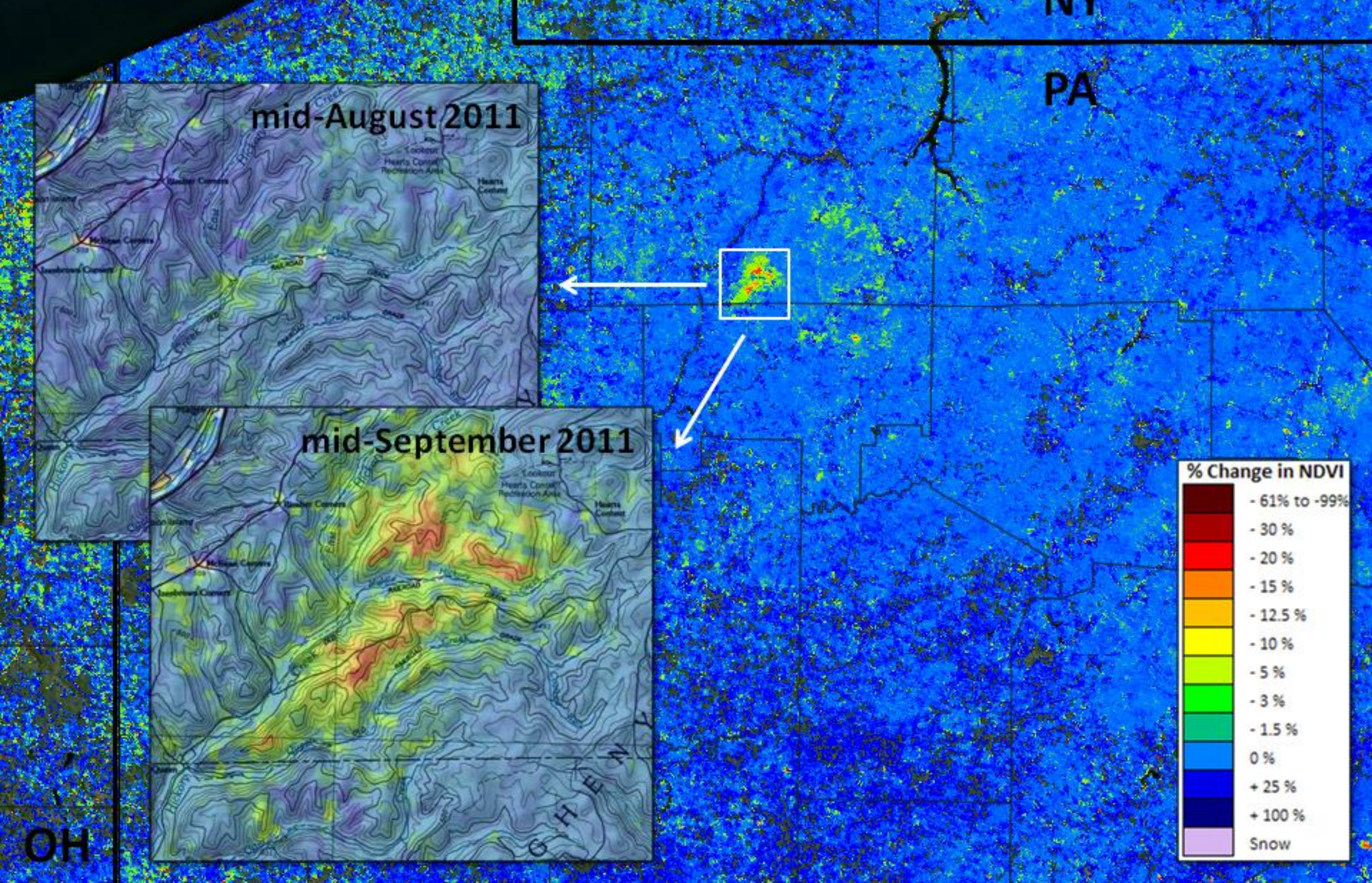
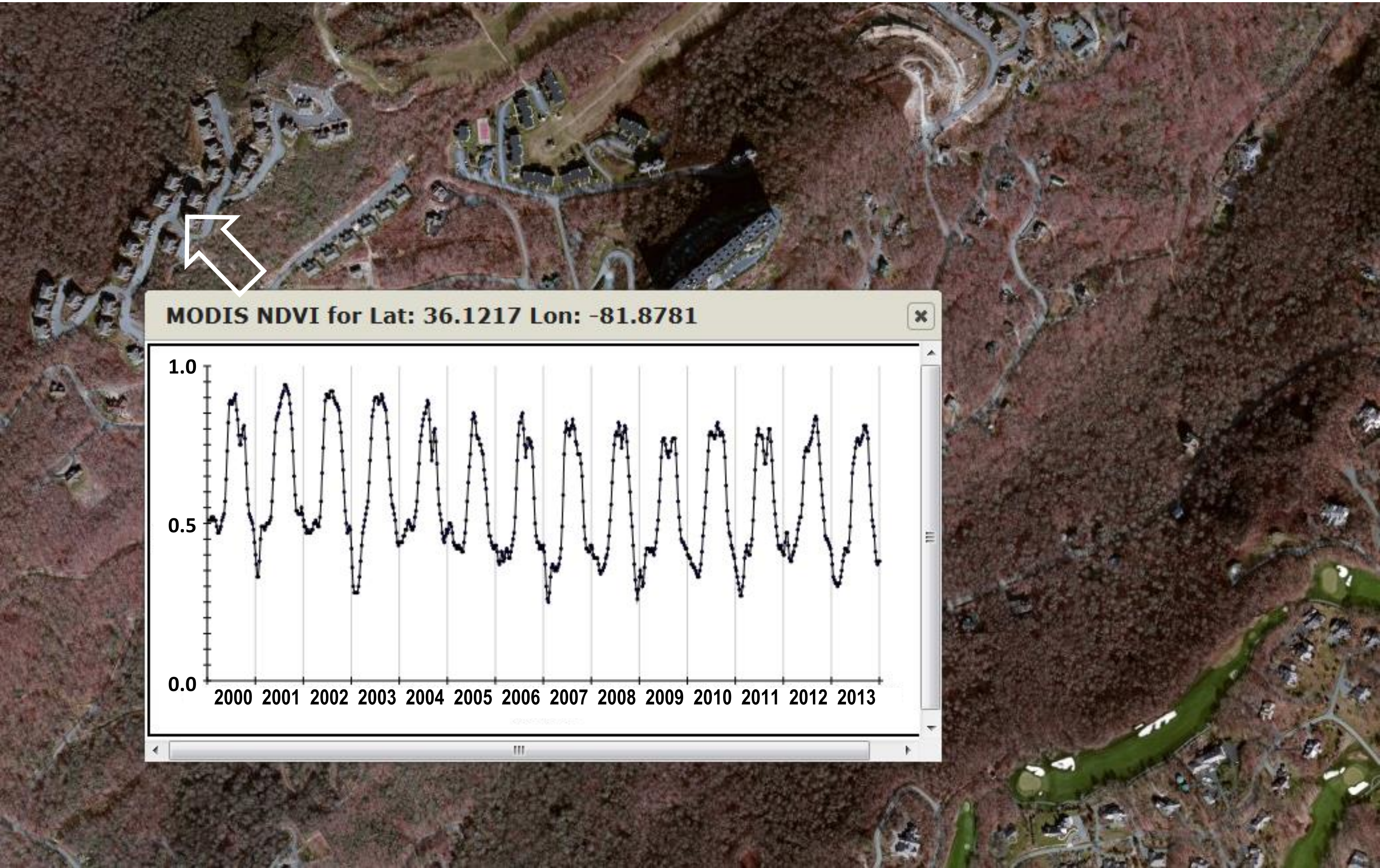


# Near-real-time late season Fall Webworm defoliation Allegheny National Forest



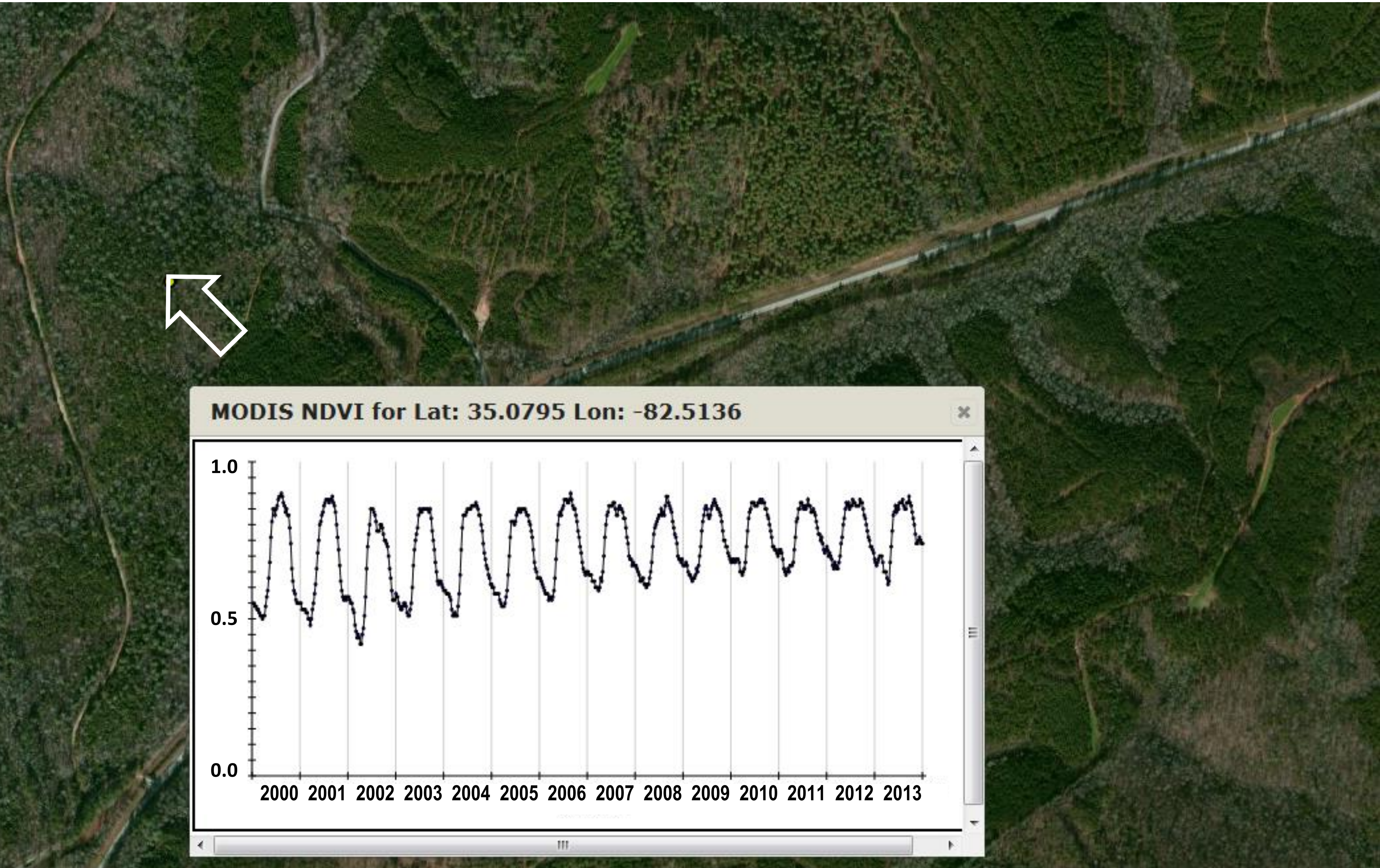
# Monitoring Land Cover Change

## Mountaintop development near Grandfather Mtn., NC



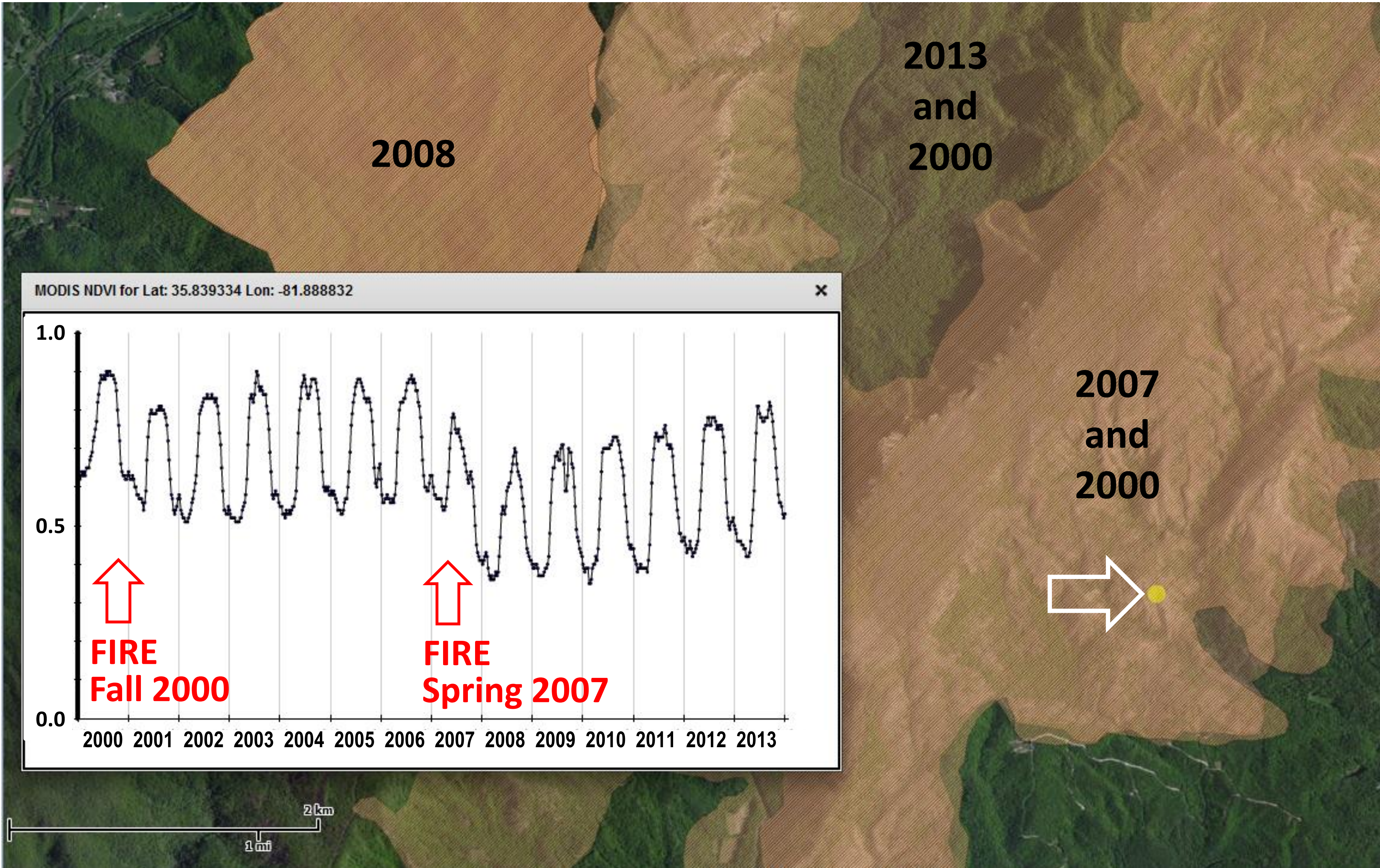
# Monitoring NDVI recovery after logging

## Greenville County SC



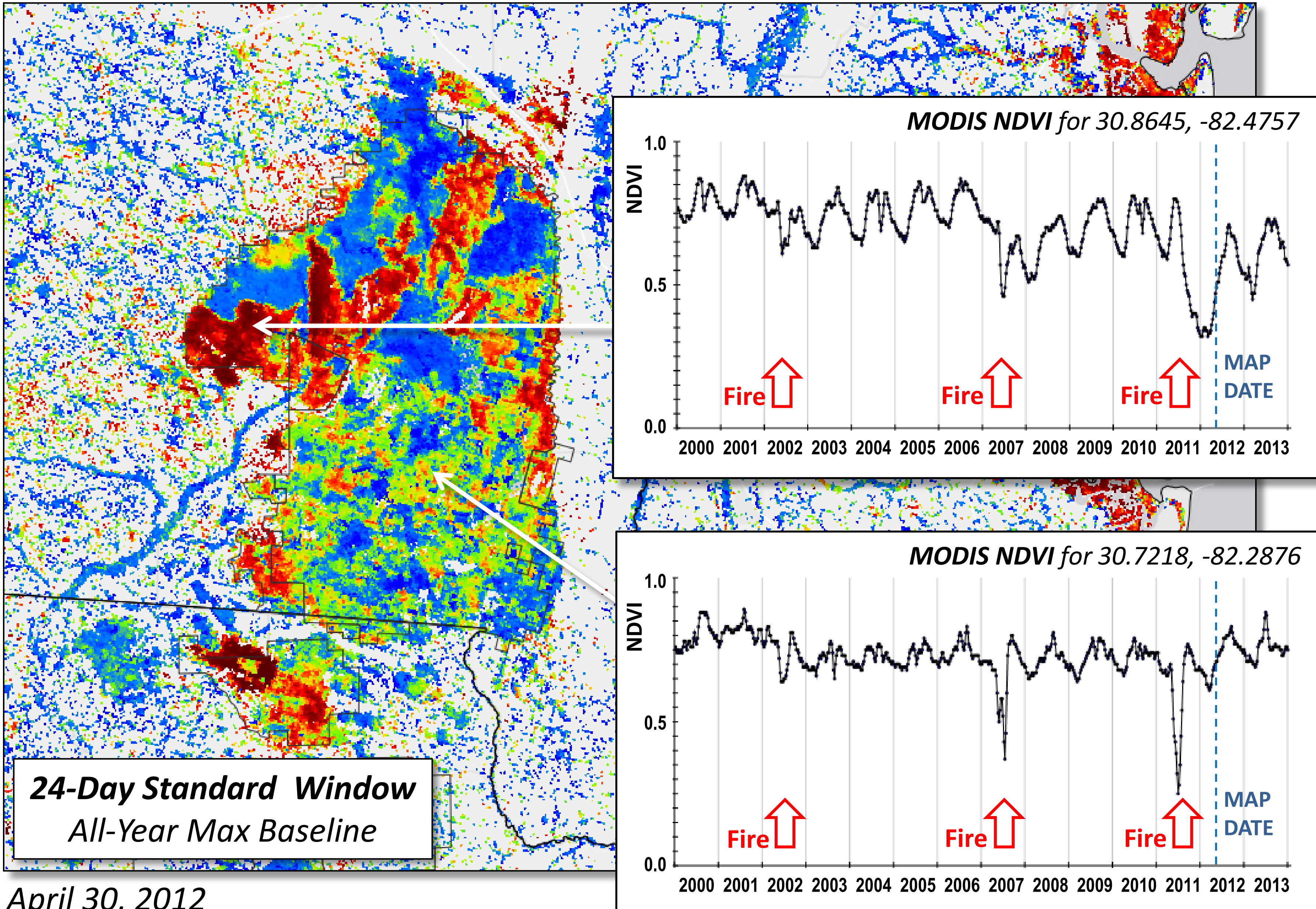
# Monitoring fire regime responses and NDVI recovery

## Linville Gorge, NC



# Response to fire regime change, Okefenokee wetlands

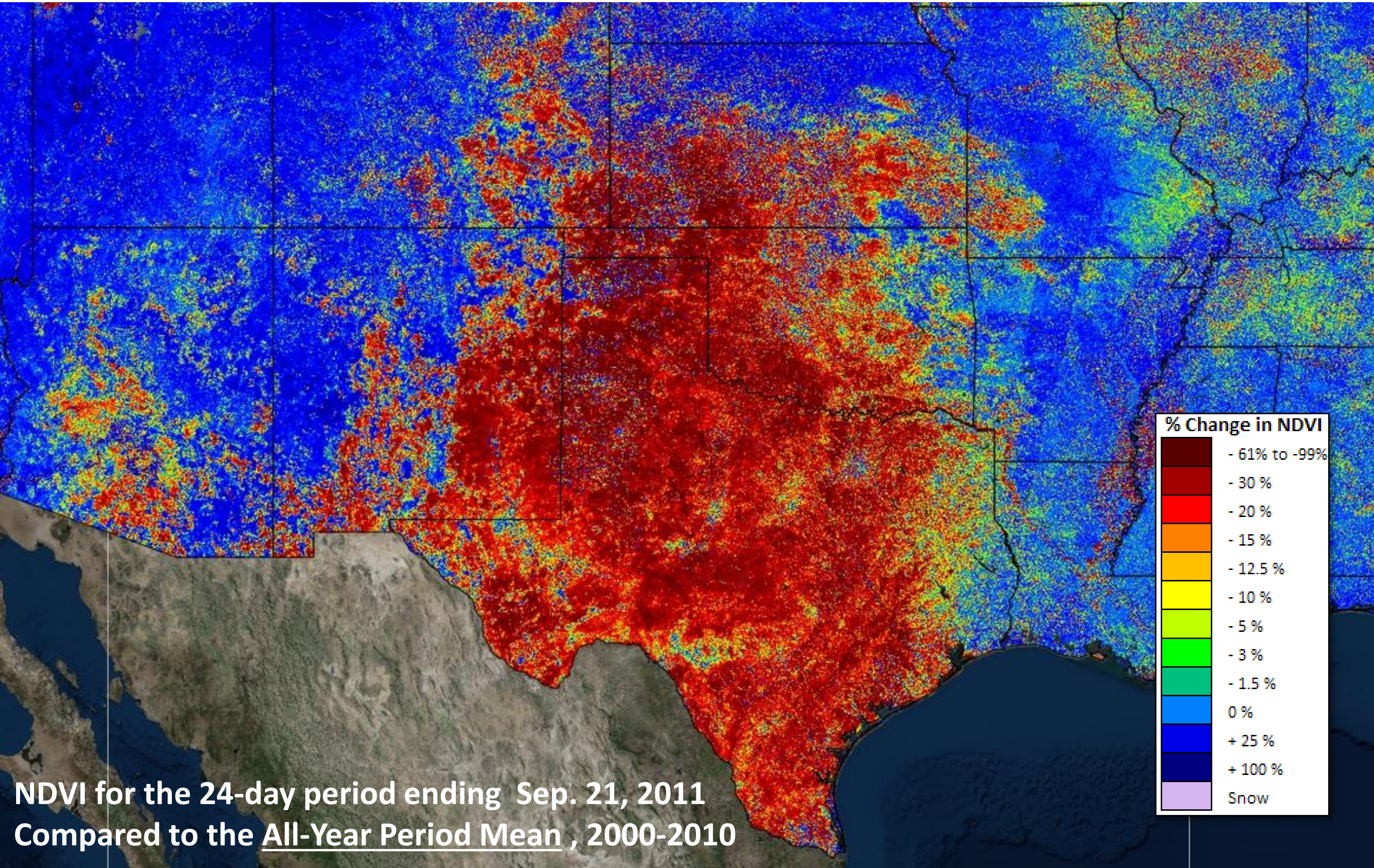
## Gradual erosion of resilience?




*April 30, 2012*

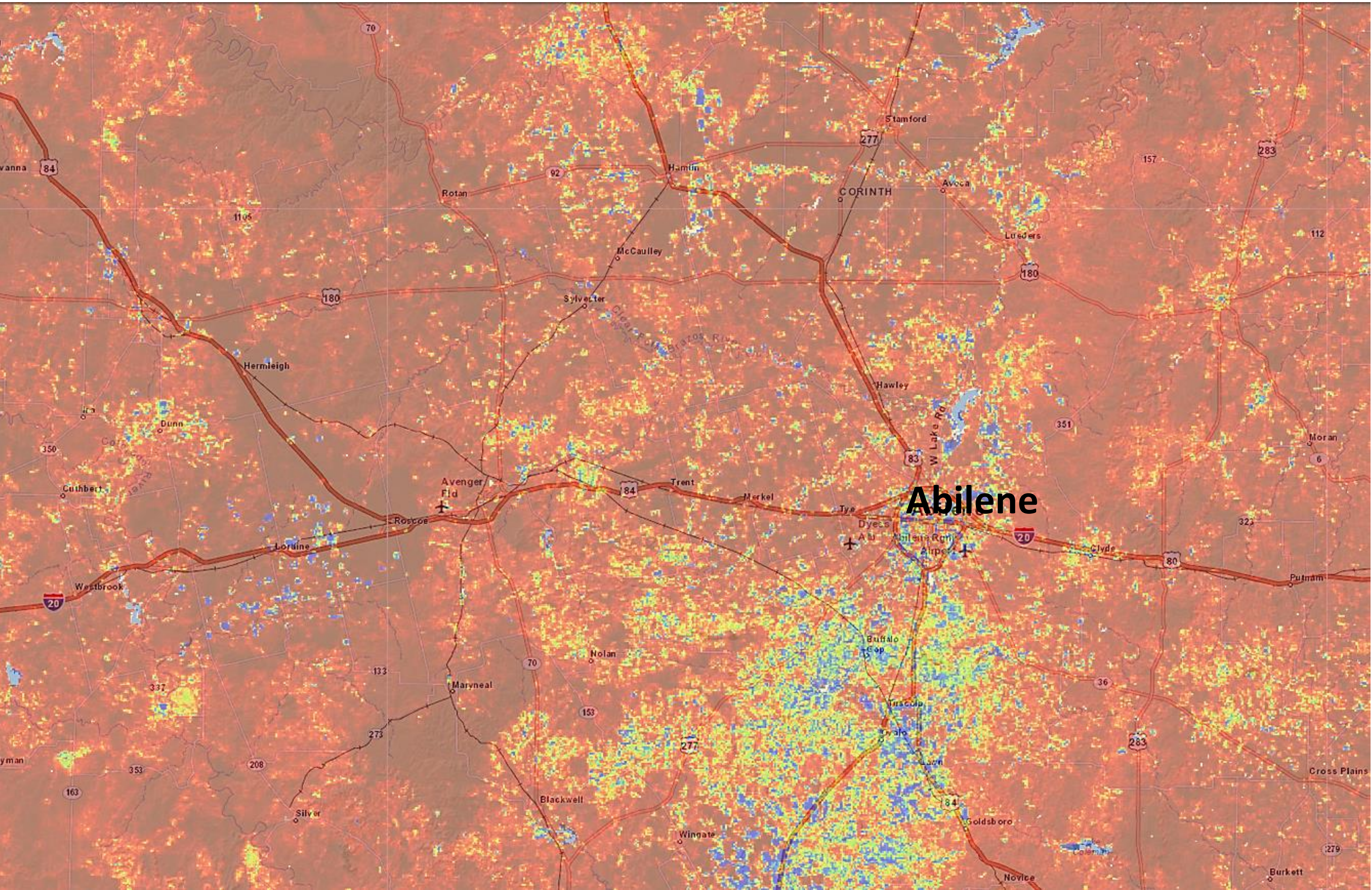
# Monitoring drought and fire

## Texas



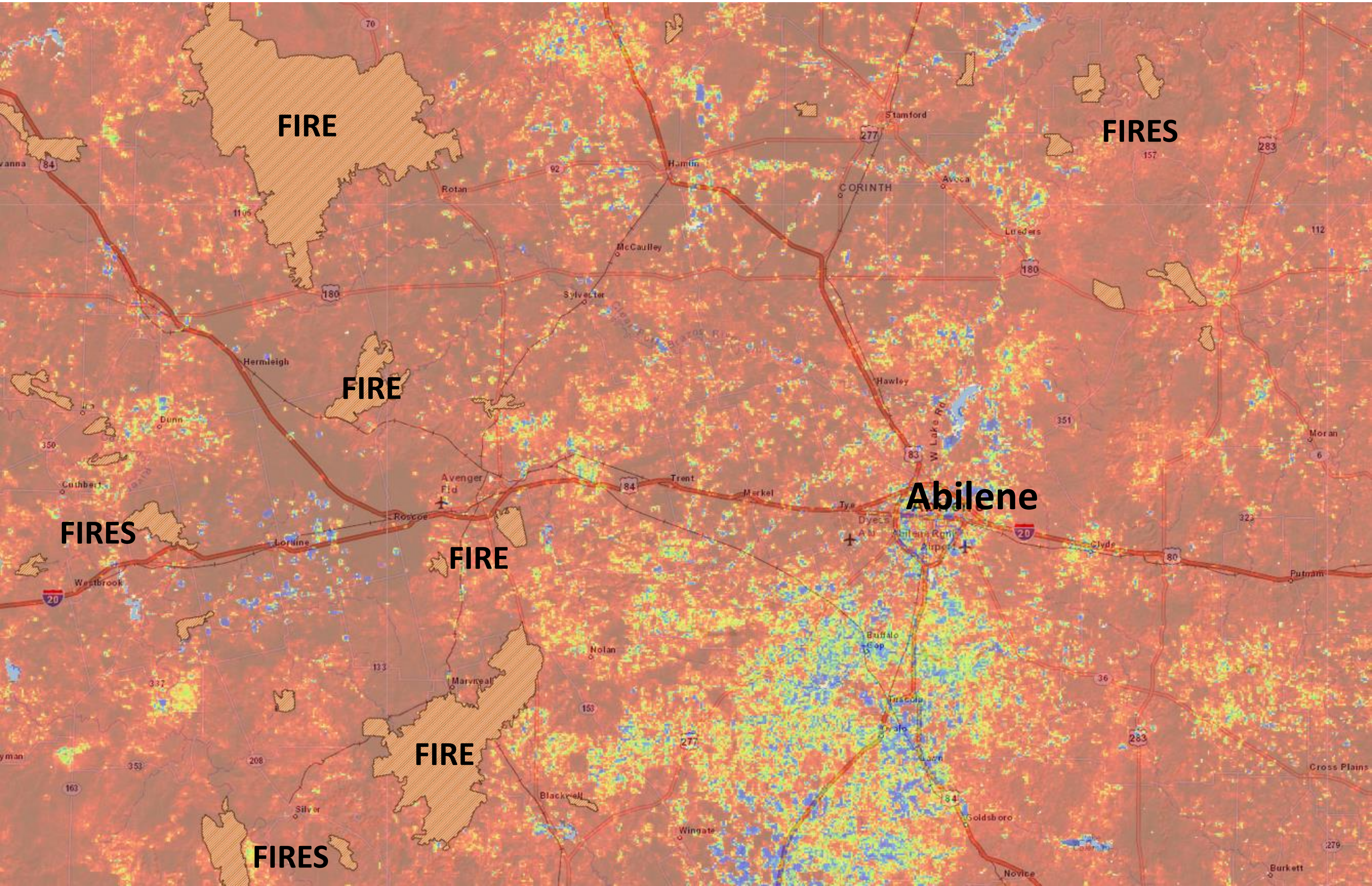
# Monitoring drought and fire

## Texas



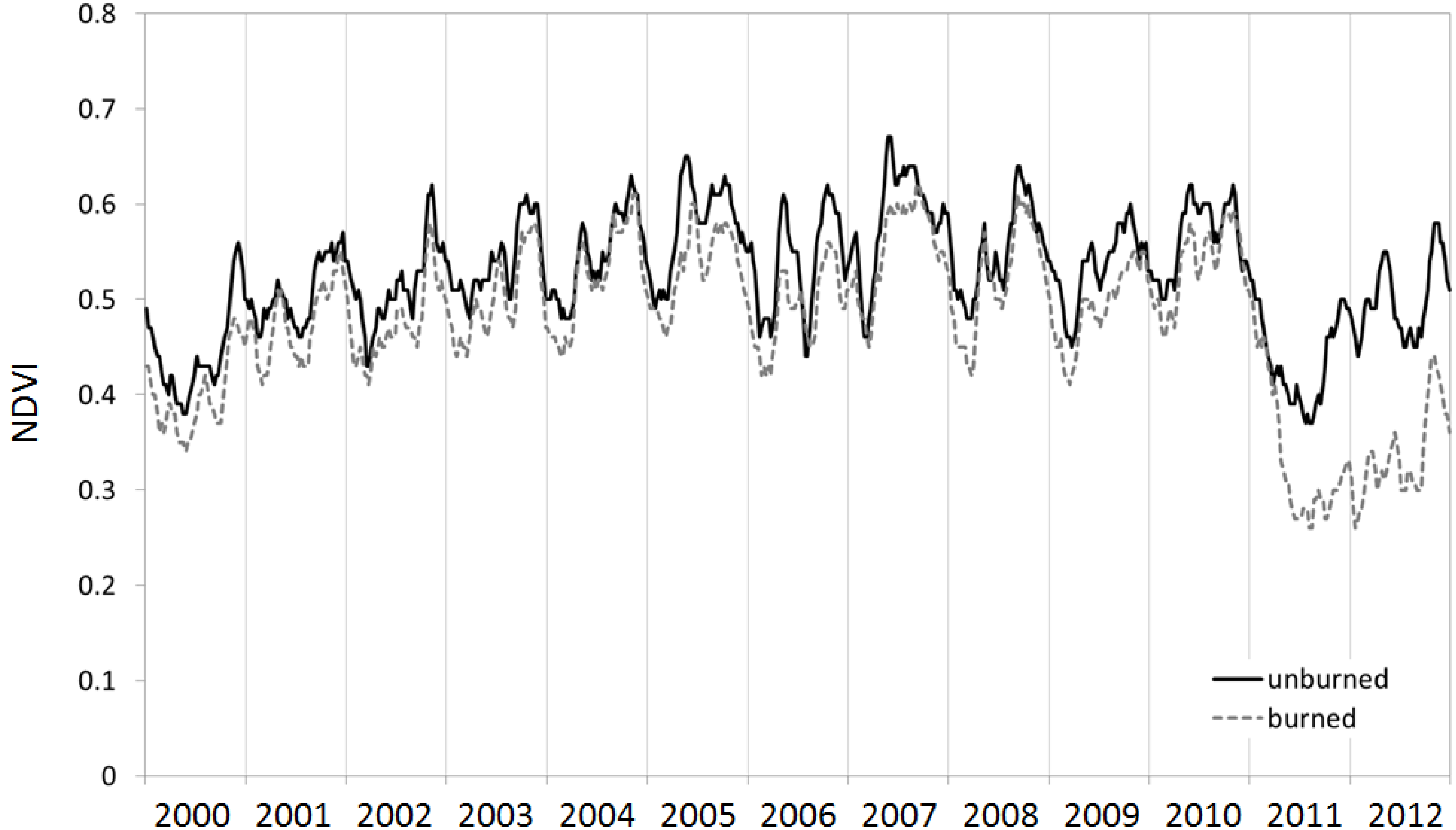
# Monitoring drought and fire

## Texas



# Monitoring drought and fire

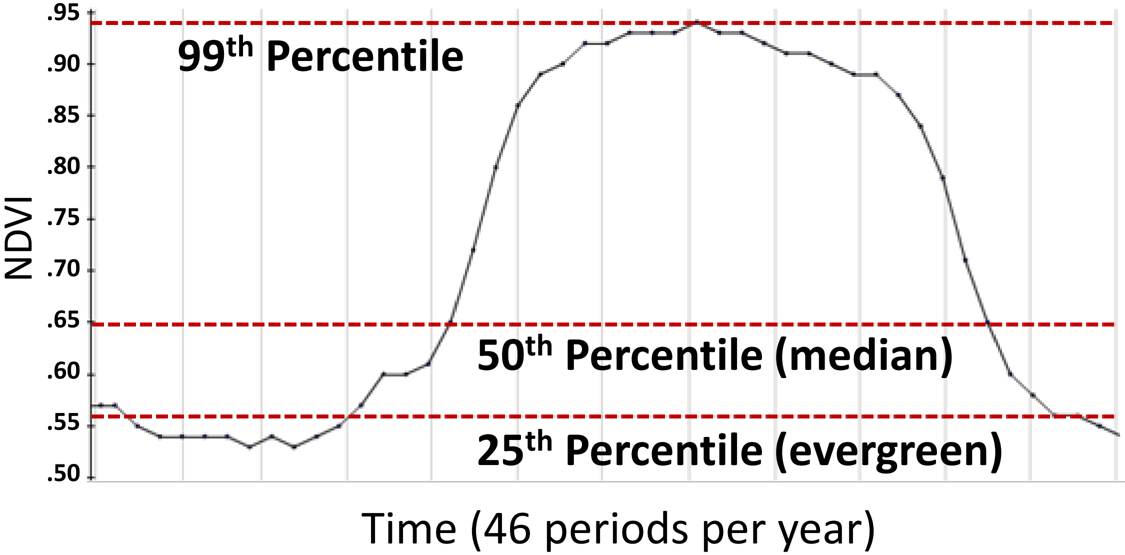
## Texas




Two nearby woodland ***ForWarn*** pixels in west Texas on similar sites, one that burned and one that did not during 2011. Note that effects persisted through 2012 on both sites, but that the cumulative effects of drought and wildfire were more pronounced than drought alone.

# Synthesis products

## *ForWarn*'s high precision from high frequency observations

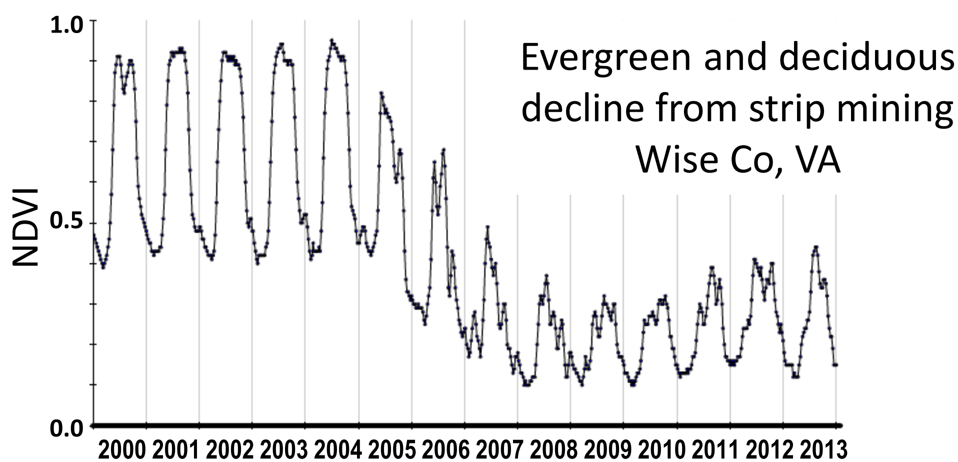



**DECIDUOUS FRACTION**

**Low winter NDVI; high inter-seasonal amplitude**

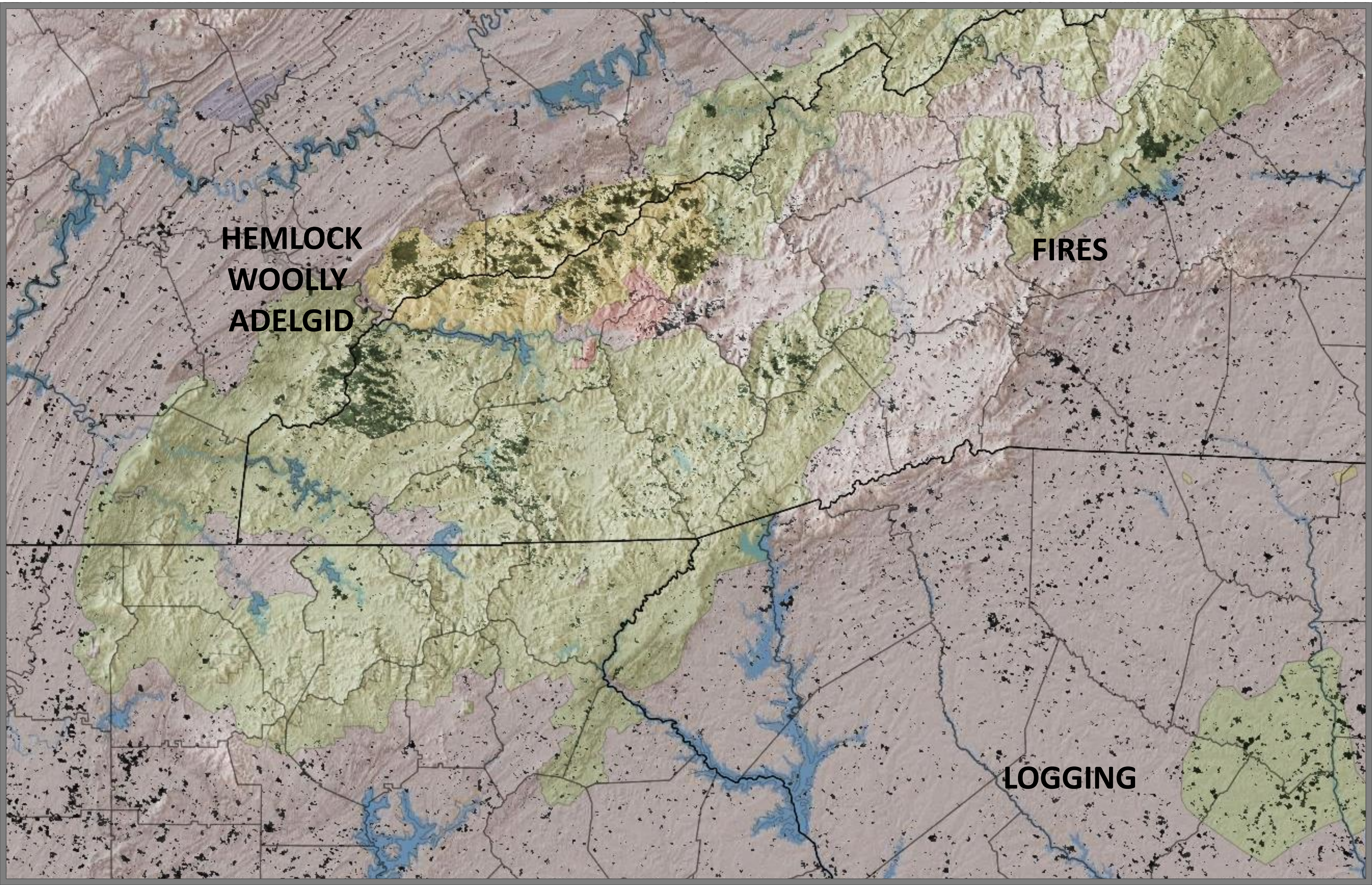
**EVERGREEN FRACTION**

**High winter NDVI; low inter-seasonal amplitude**



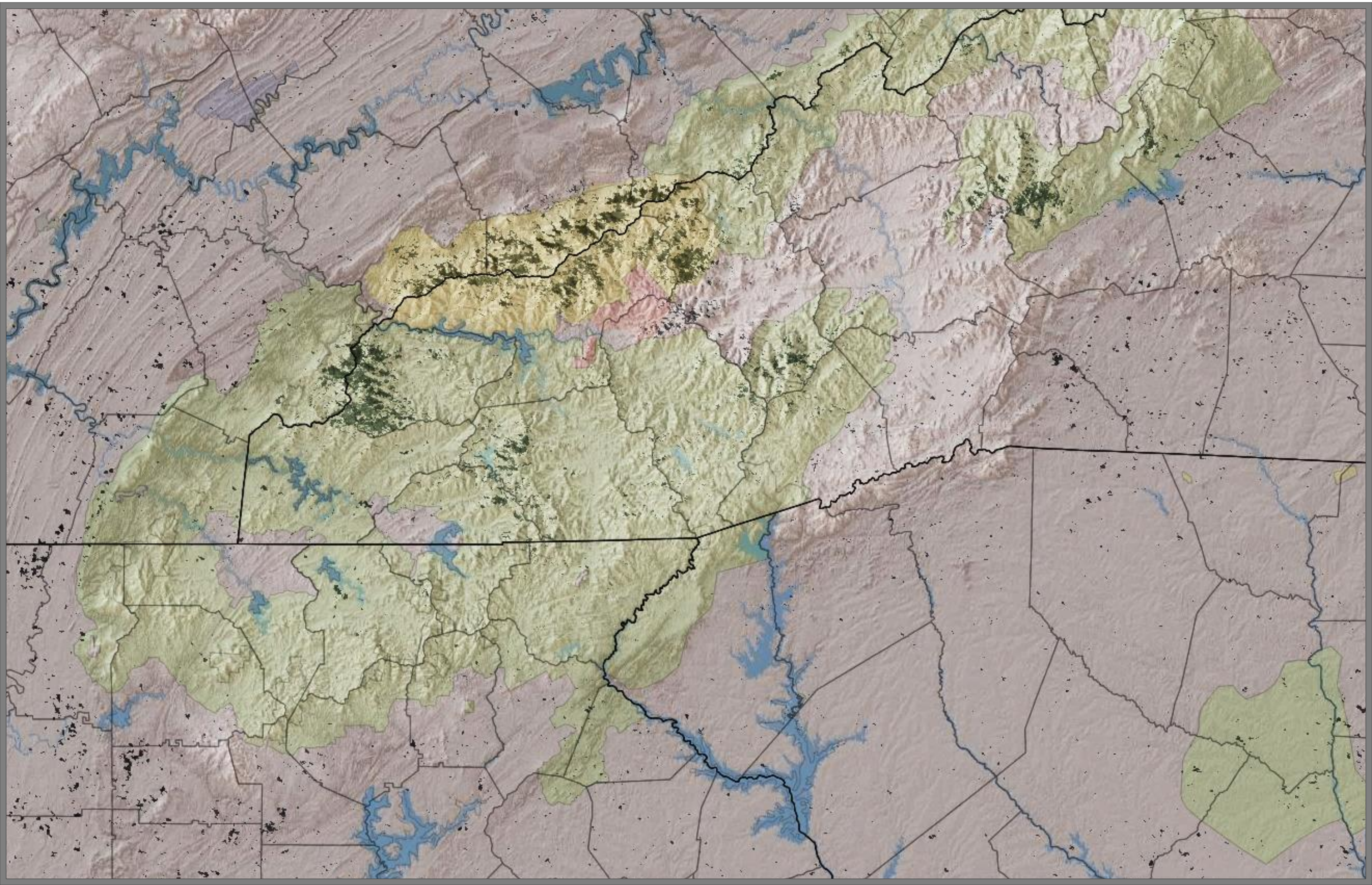
# Synthesis products

## Tracking Evergreen Decline of Landscapes, 2000-2010



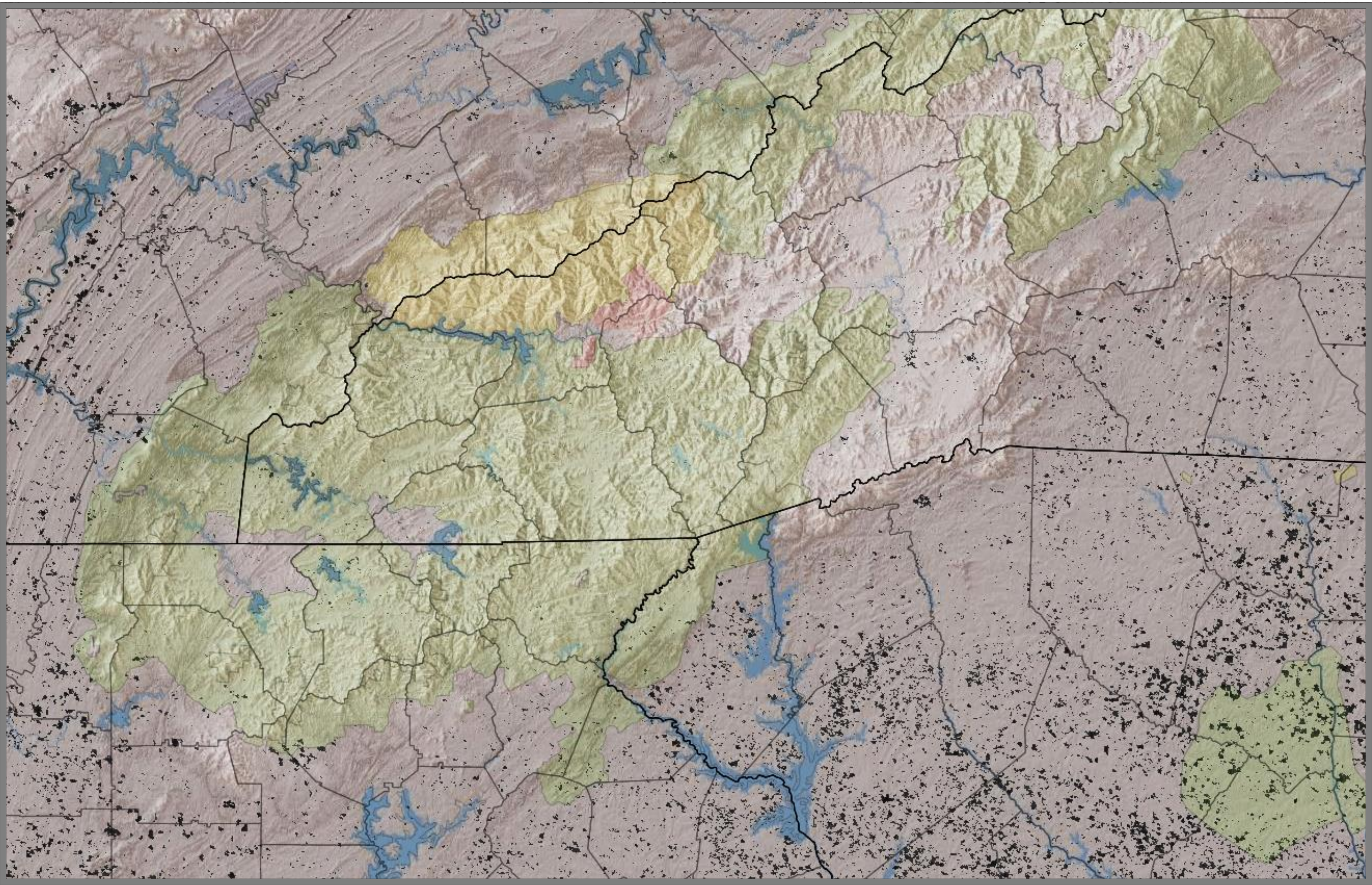
# Synthesis products

## Tracking Deciduous Increase of Landscapes, 2000-2010



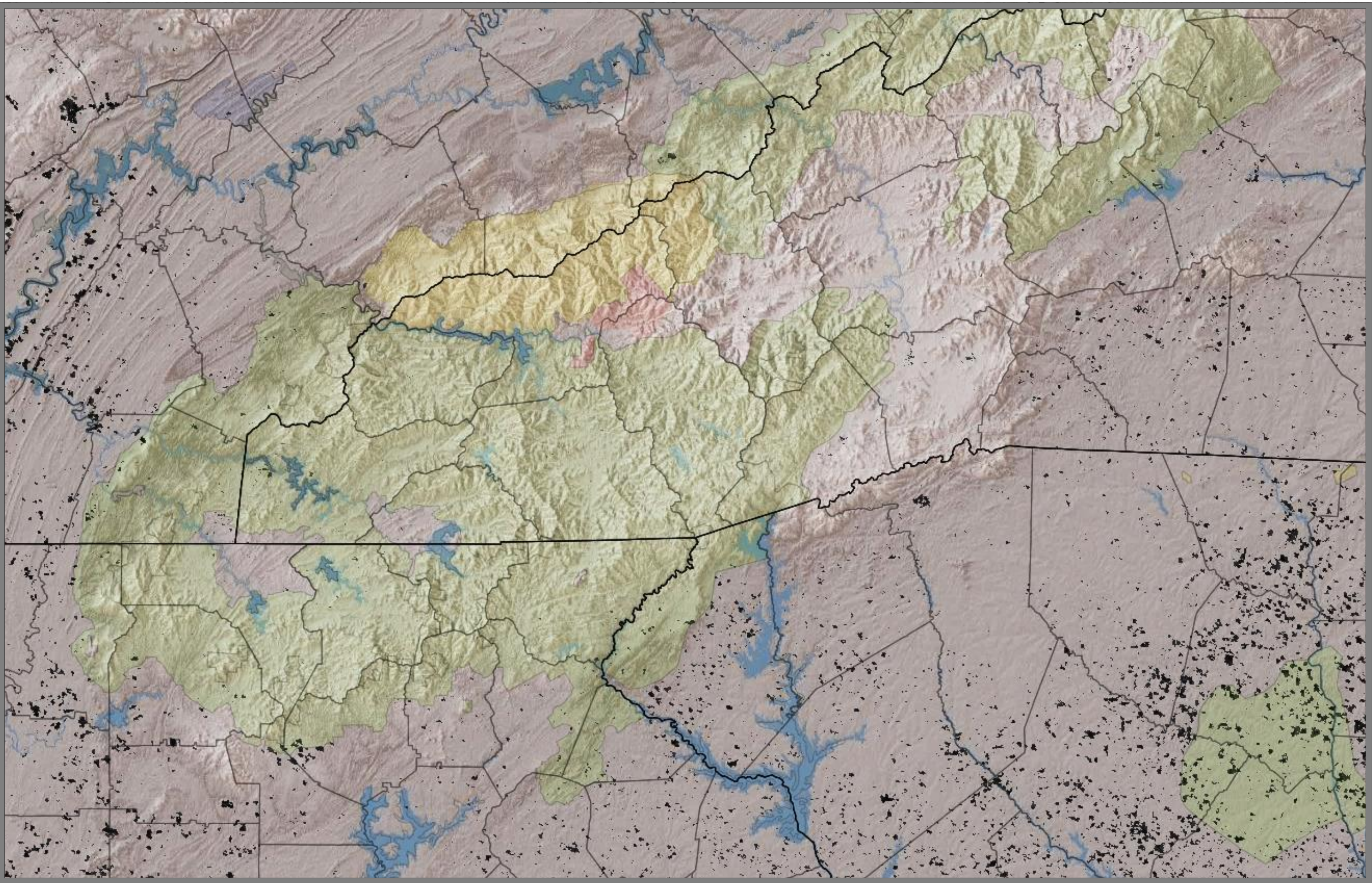
# Synthesis products

## Tracking Deciduous Decline of Landscapes, 2000-2010



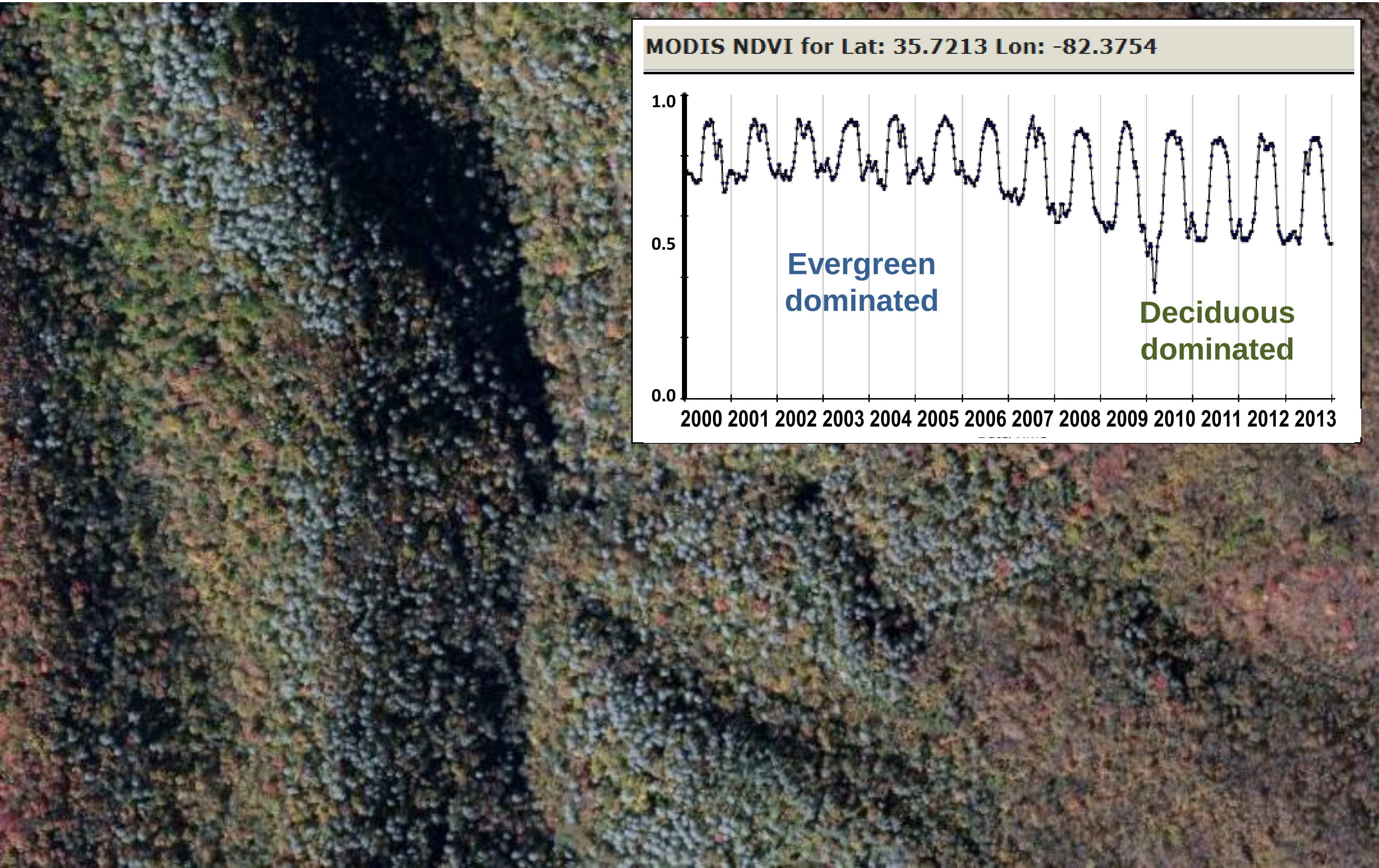
# Synthesis products

## Tracking Evergreen Increase of Landscapes, 2000-2010



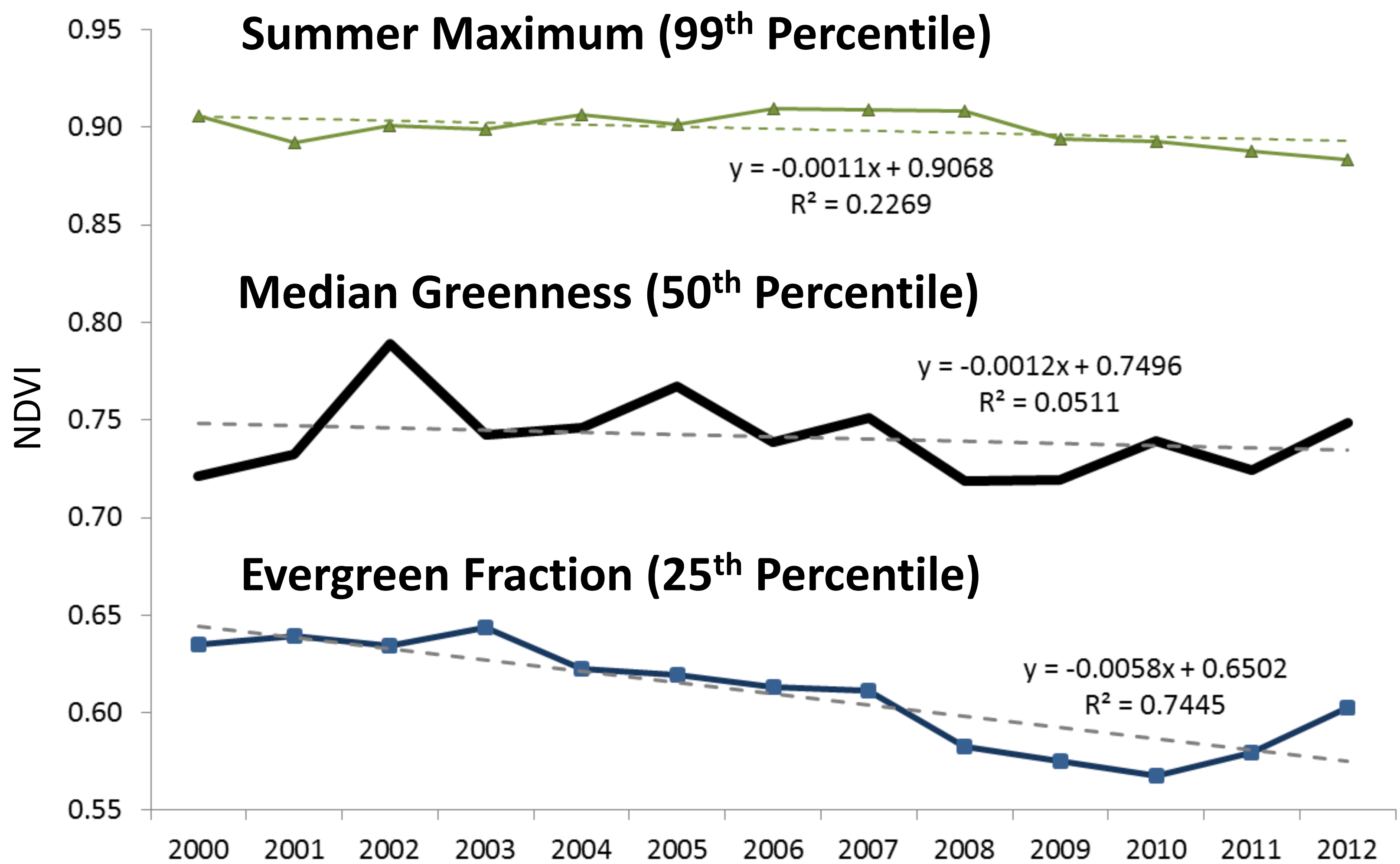
# Synthesis products

## Monitoring gradual loss of hemlock in the southern Appalachians



# Synthesis products

## Trends in seasonal NDVI across Great Smoky Mountains National Park



# Summary

- Great insights into forest disturbance and recovery can be had using coarse resolution, high frequency satellite data.
- Statistically robust classification or typing provides ways to make big data more manageable.
- Big data can be integrated and successfully exploited online in near-real-time for decision making.