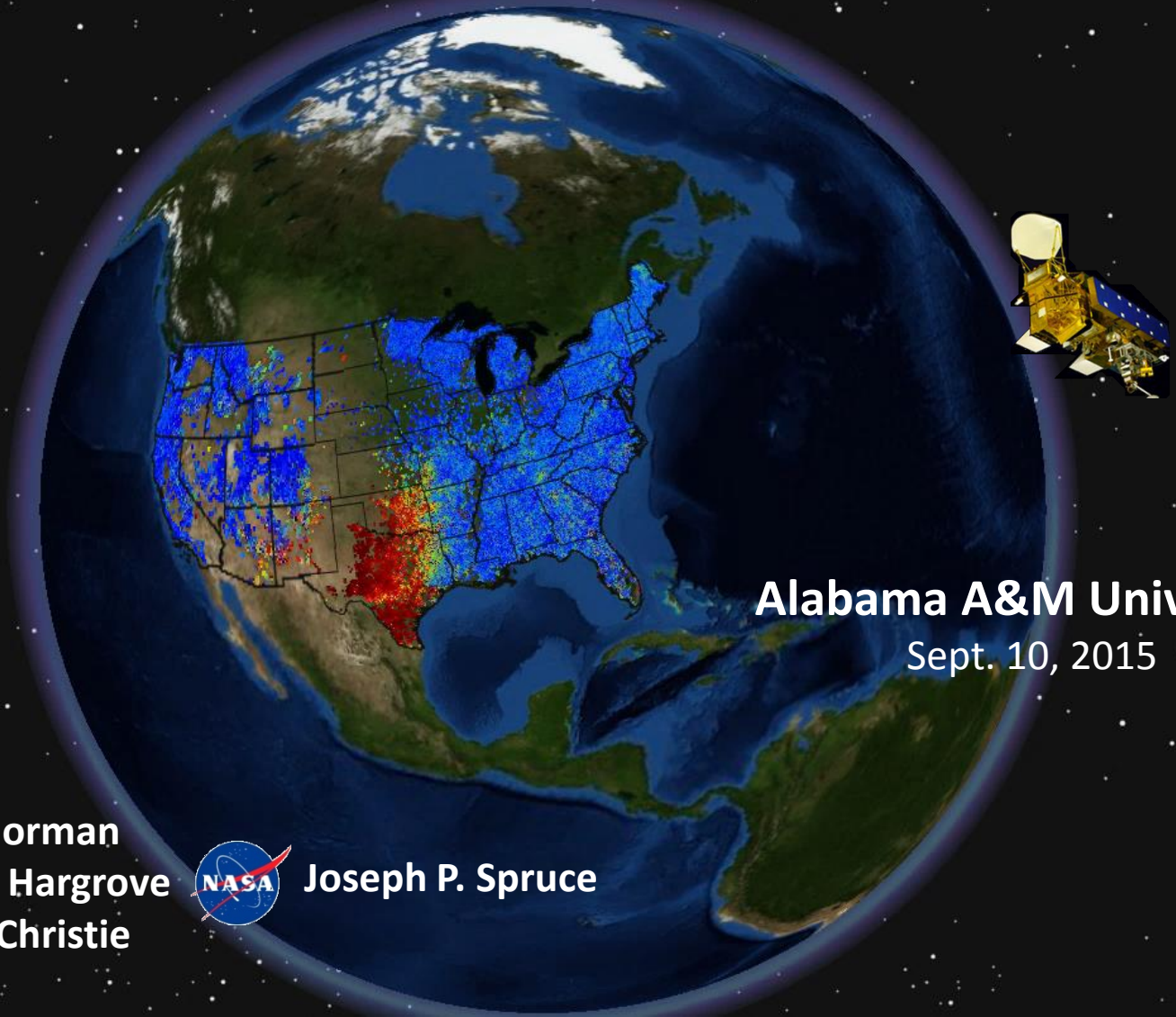
Tracking forest change from space:

How technology is transforming the way we think about disturbance



Alabama A&M University

Sept. 10, 2015

Steven P. Norman
William W. Hargrove
William C. Christie
Joseph P. Spruce

Q: Why do we care about forest disturbances?

A: Some are critical ecological processes

2015 Bald Knob Fire, NC

Q: Why do we care about forest disturbances?

A: Some are valuable tools for forest management

2015 Lafayette Fire, LA in Longleaf pine

Q: Why do we care about forest disturbances?

A: Some are inconsistent with values

Tornado damage in the South (SRS)

Q: Why do we care about forest disturbances?

A: Some indicate long-term environmental or cultural changes

Balsam Woolly Adelgid mortality, Great Smoky Mountains National Park

Disturbance

Hemlock Woolly Adelgid mortality, Pisgah National Forest

1. Disturbance defined

In ecology, a *disturbance* is a biotic or abiotic phenomenon that causes a *consequential* change in vegetation conditions, such as storms, fires, droughts, landslides, logging or insects or diseases.

- Effects may be temporary, followed by succession.
- Response may or may not be “recovery” (multiple pathways).

Technologies

1. Disturbance defined

2. New and evolving technologies

- Remote sensing
- Computational power

Perspectives

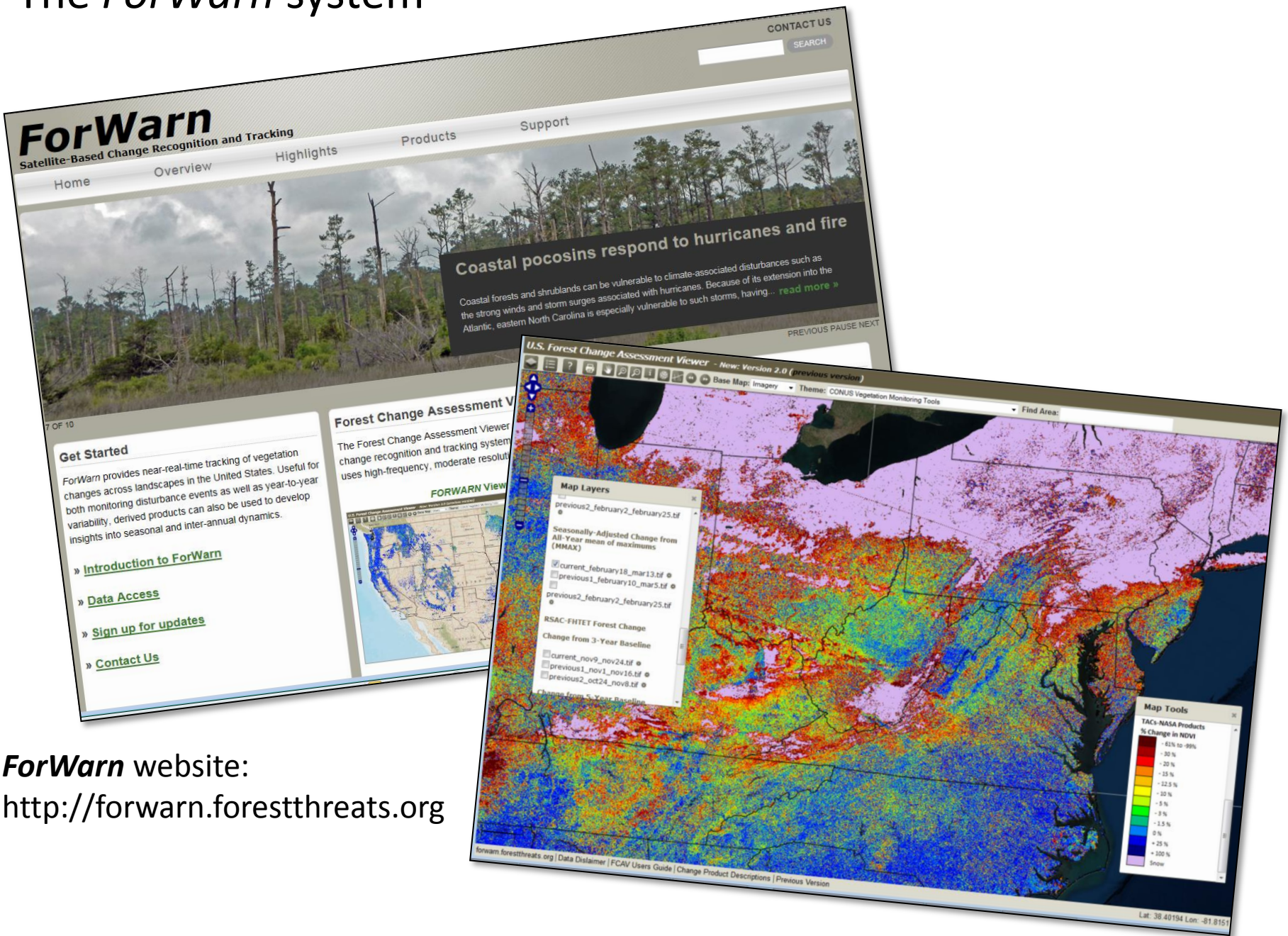
1. Disturbance defined

2. New and evolving technologies

3. Transforming science perspectives

- Deeper understanding of impacts
- Broadened spatial context
- Longer term insights

The *ForWarn* system



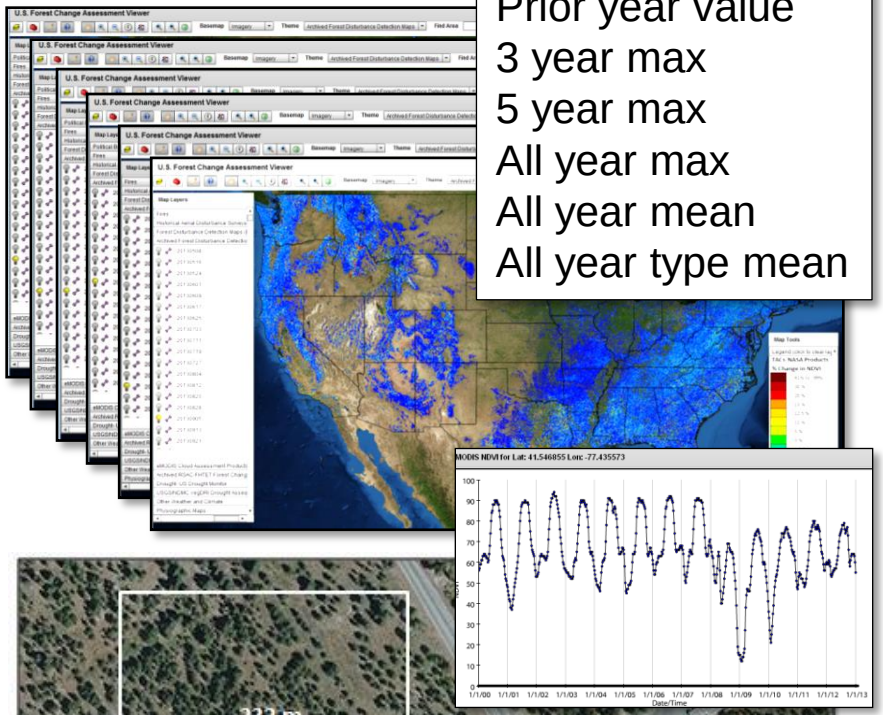
ForWarn website:
http://forwarn.forestthreats.org

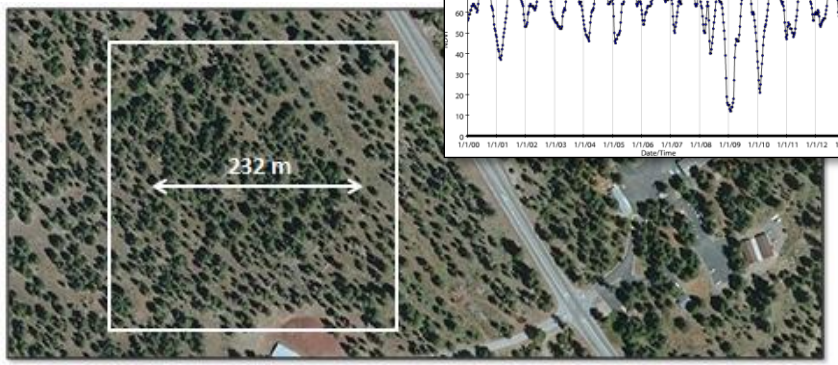
The *ForWarn* system

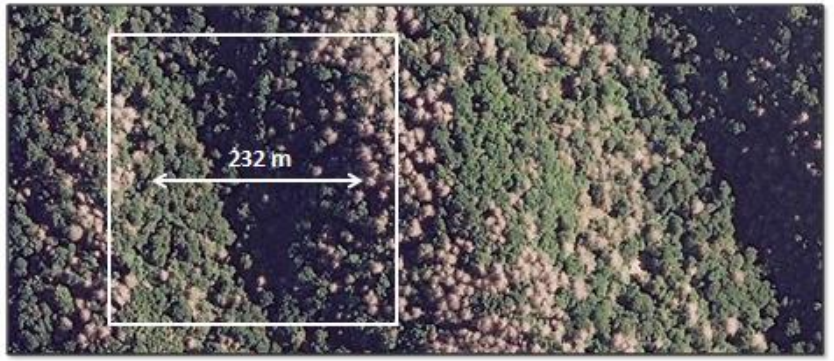
- Uses NDVI (the Normalized Difference Vegetation Index)
- From daily MODIS satellite streams
- Pixels are 232 m resolution (13.4 ac.)
- Uses the maximum value from a 24-day moving window, calculated at 8-day time steps (46 periods per year)
- Period data is available from 2000 to the present and viewable as a time series
- Includes various baseline “states” for comparing current conditions
- Accessible online at: http://forwarn.forestthreats.org

Baselines

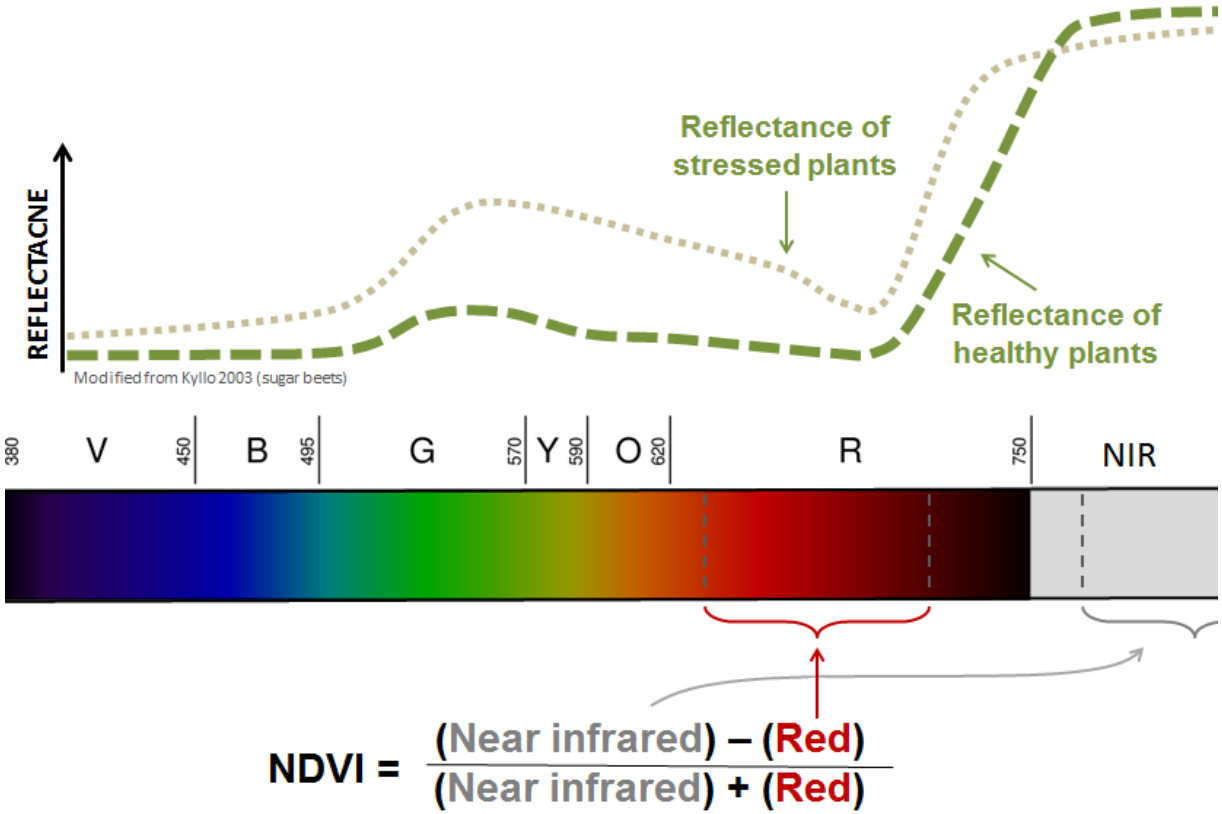
Prior year value
3 year max
5 year max
All year max
All year mean
All year type mean



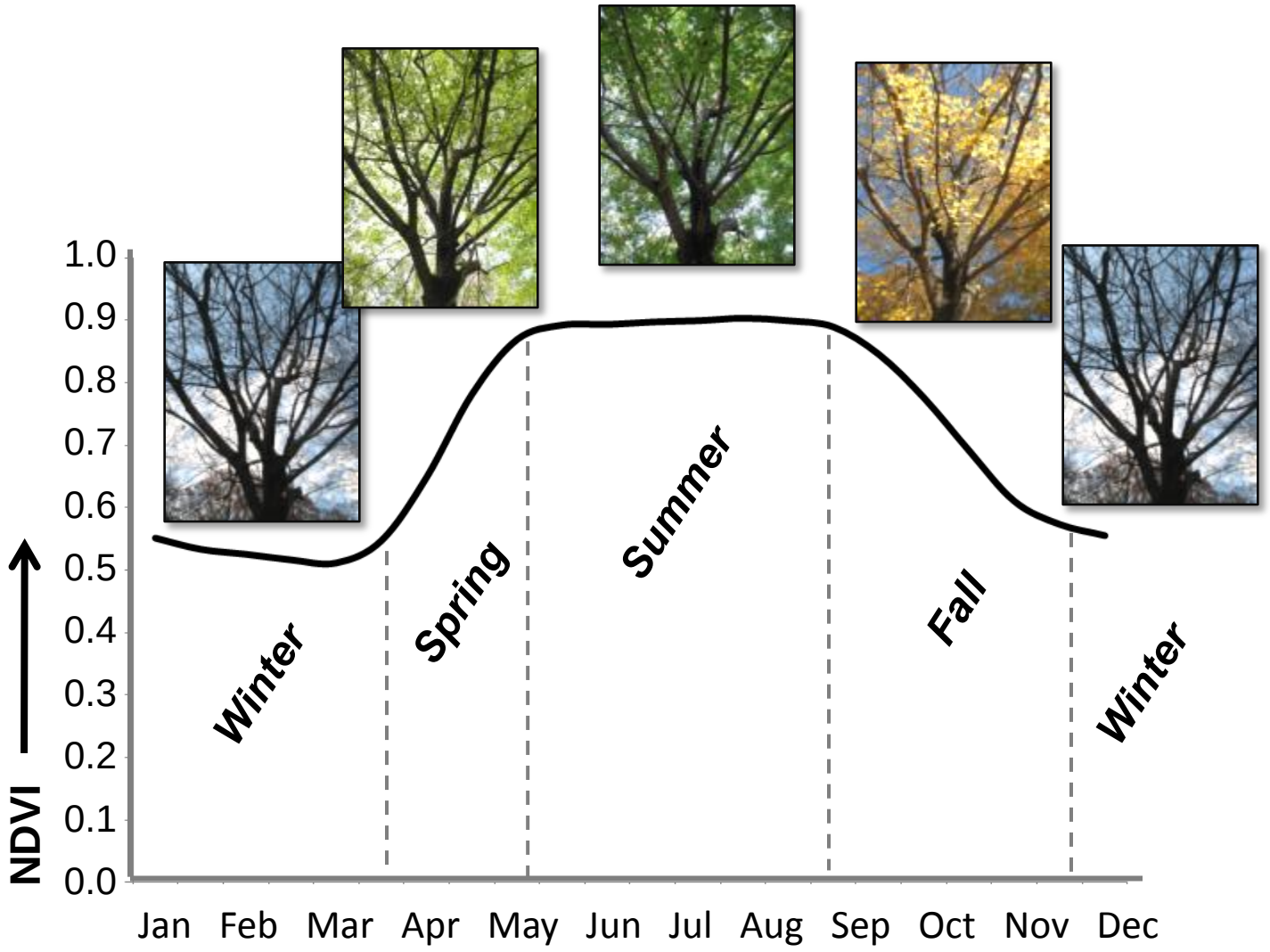




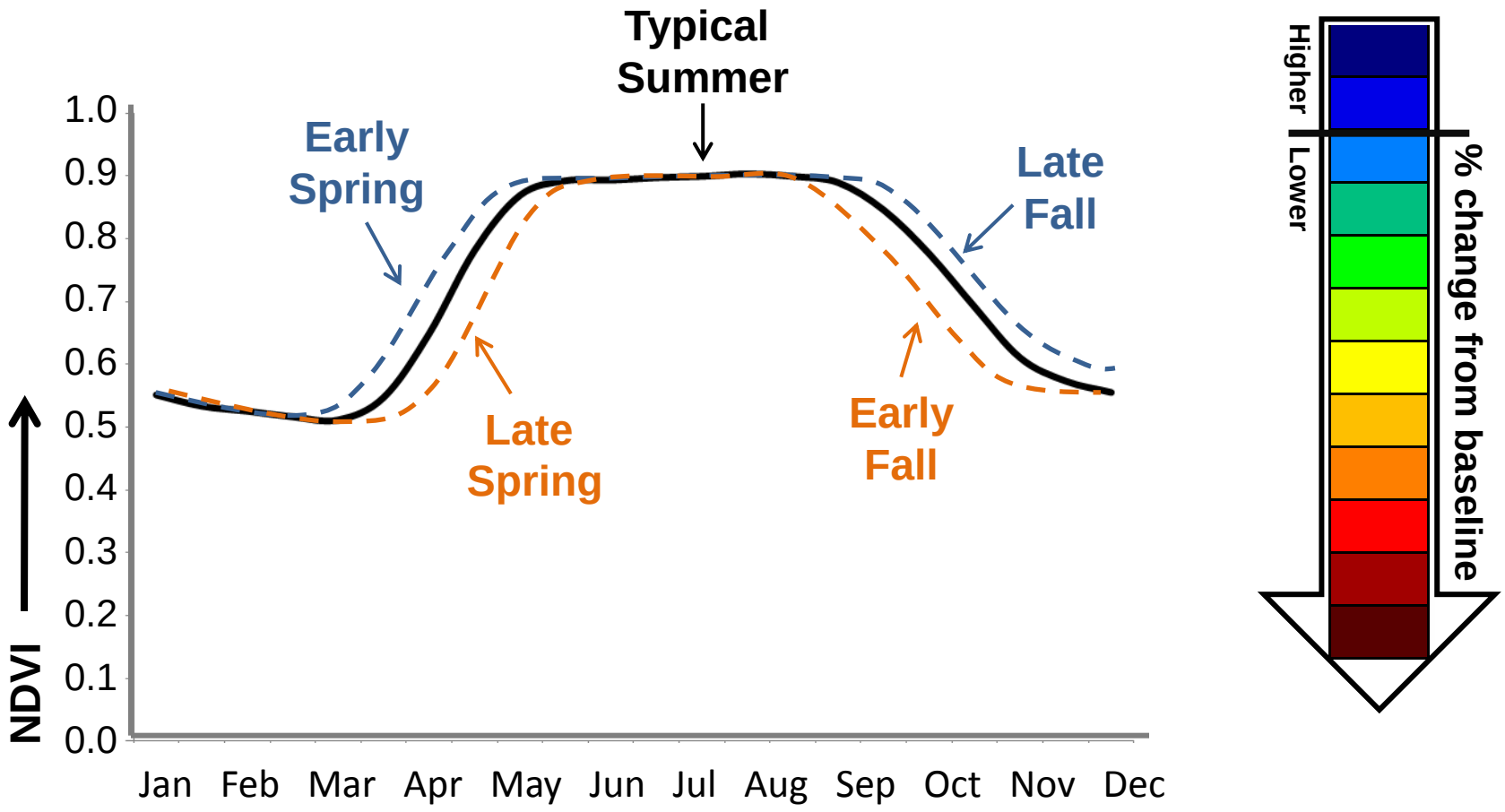
NDVI as a measure of disturbance stress



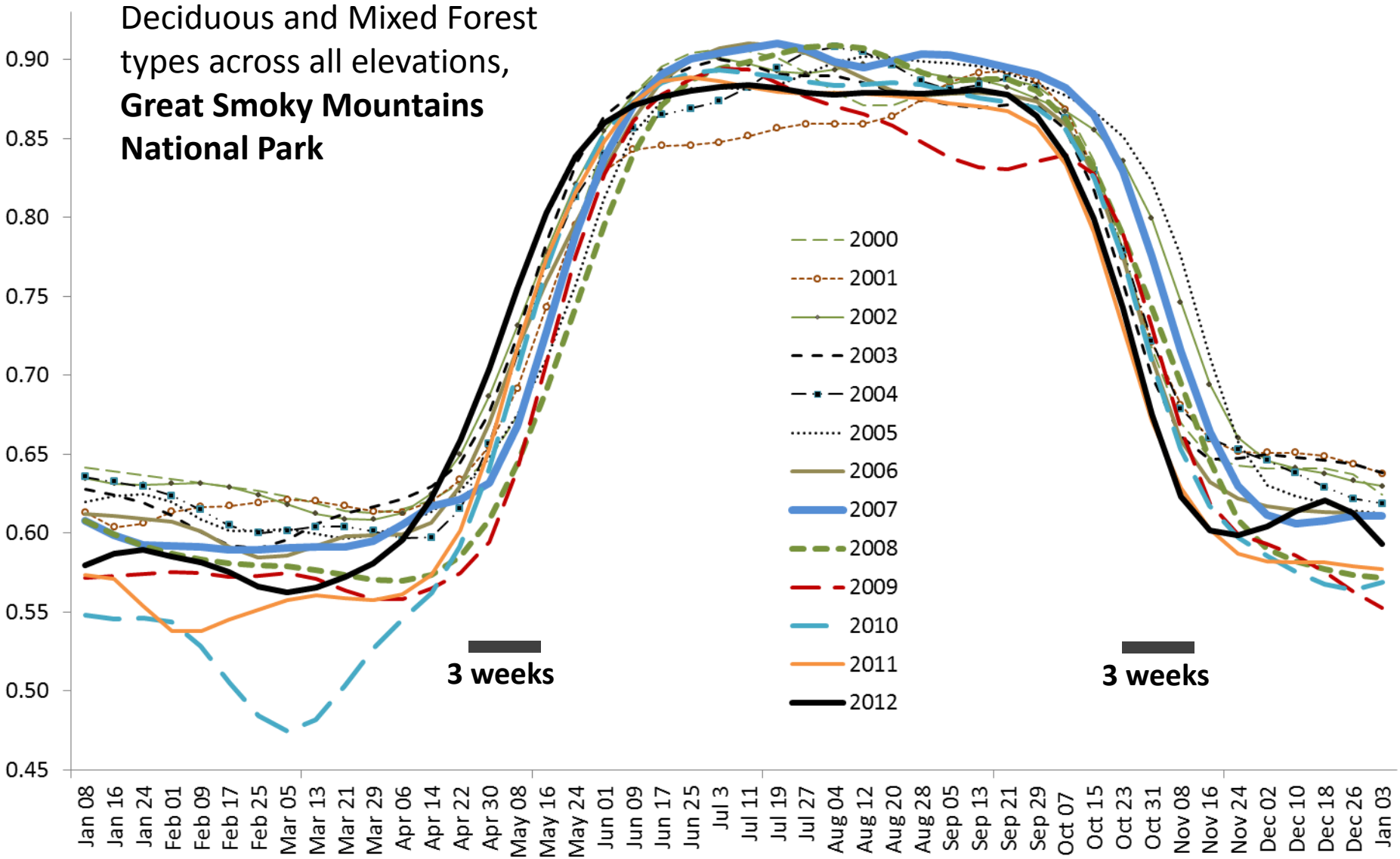
NDVI as a measure of Land Surface Phenology



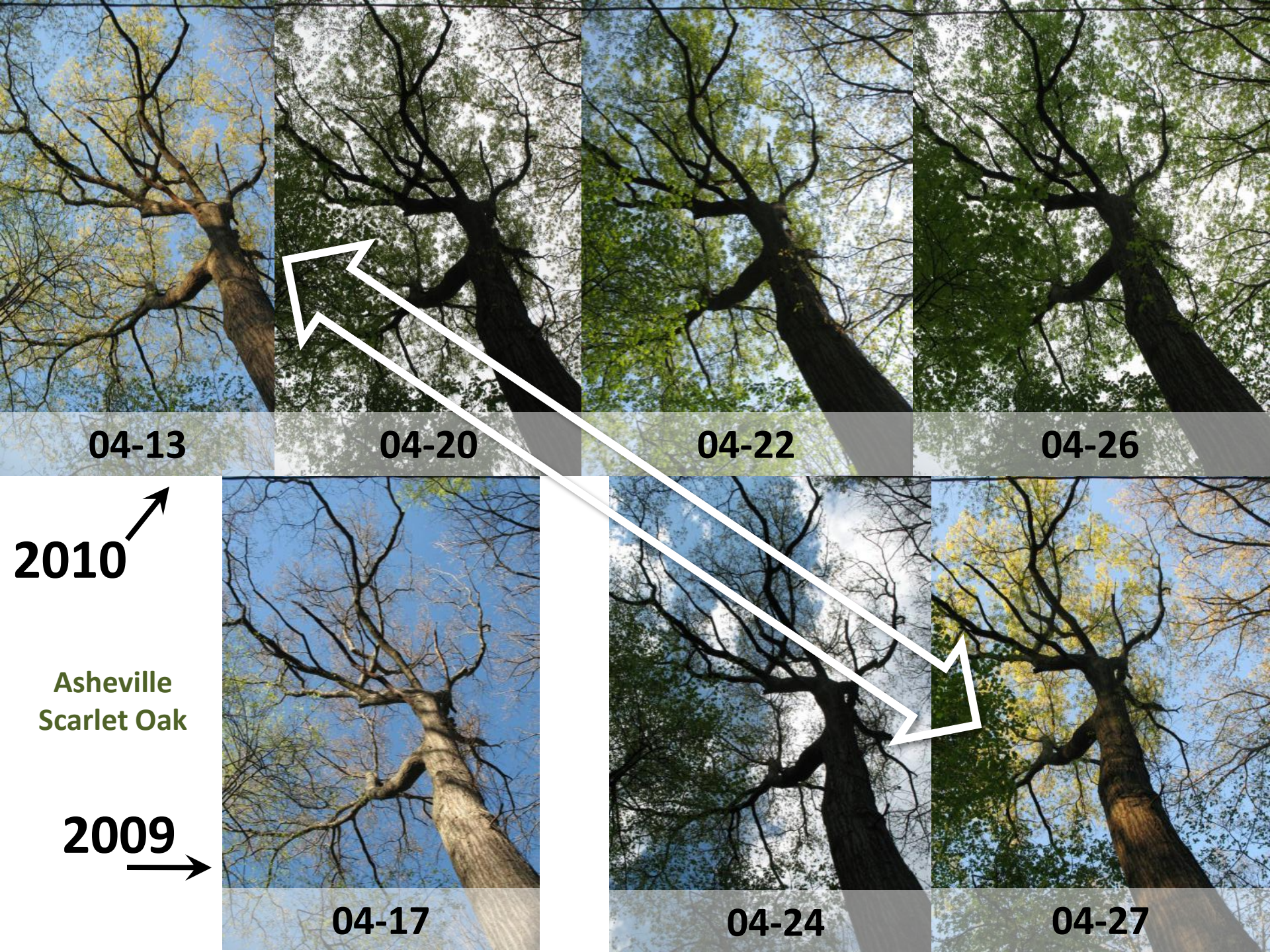
Baseline phenology compared to early and late Spring and Fall



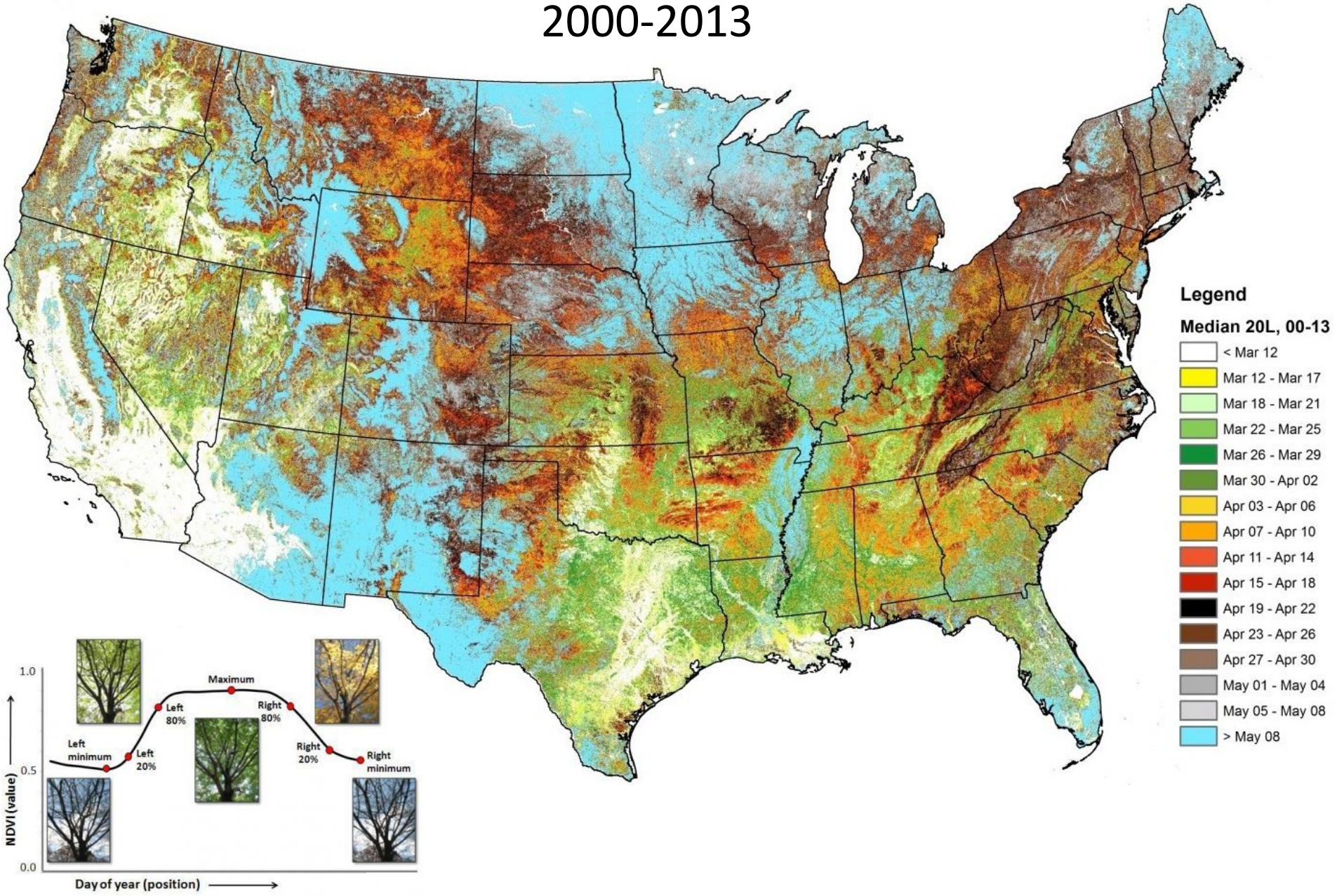
Variation in seasonal Land Surface Phenology over 13 years



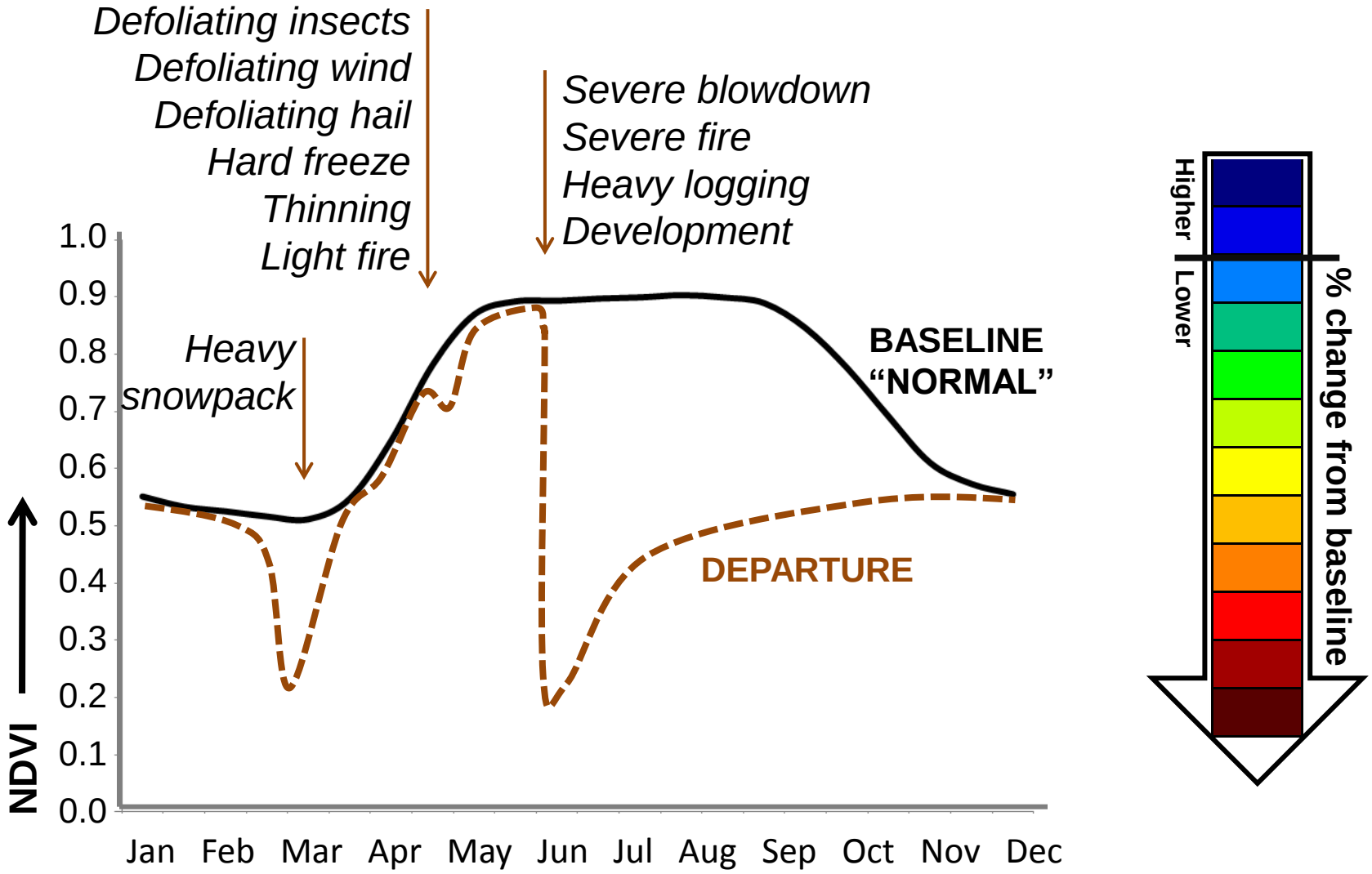
Mean of 38,318 MODIS cells


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

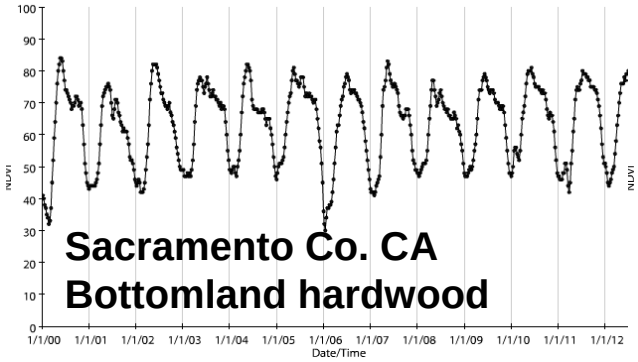
ForWarn's Median Start of Greenup Date 2000-2013

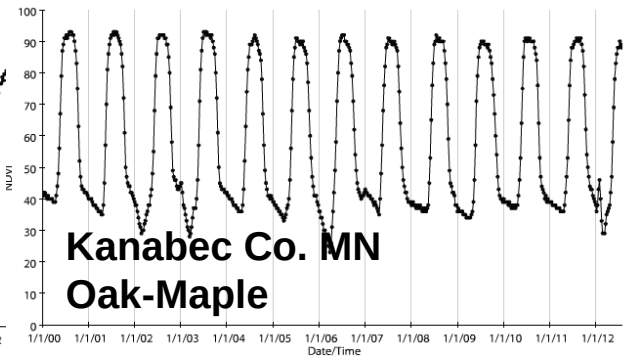


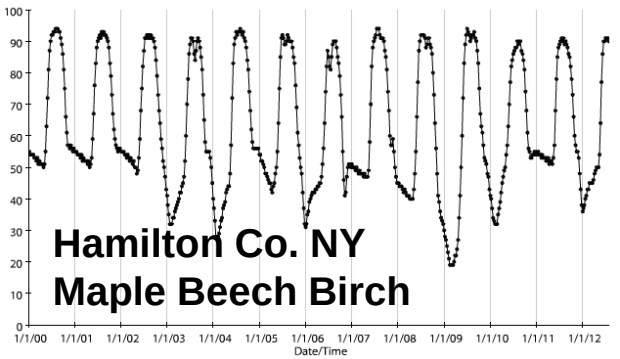
Baseline phenology compared to disturbance effects

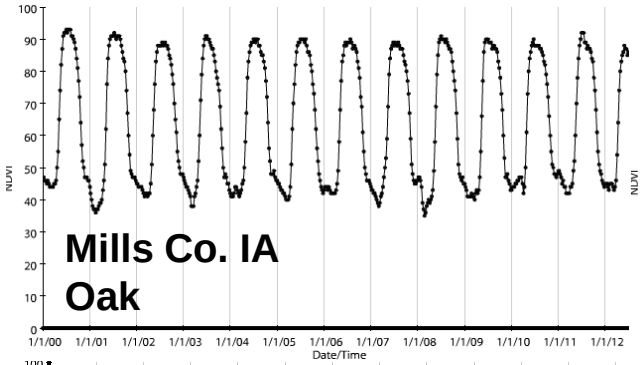


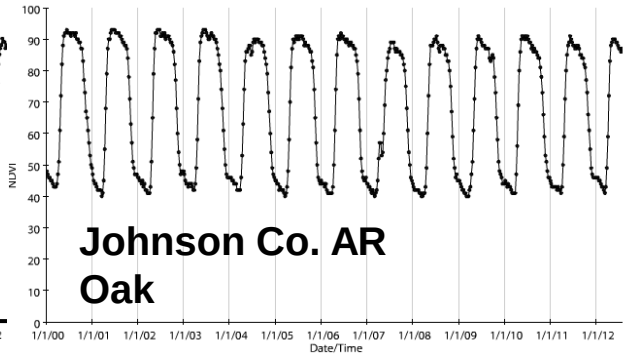
Seasonal “signatures” of hardwood forests over 13 years

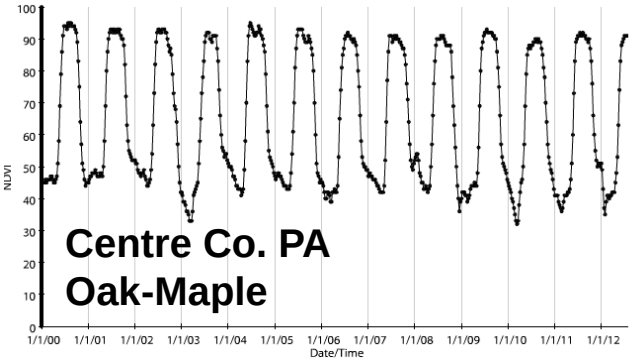


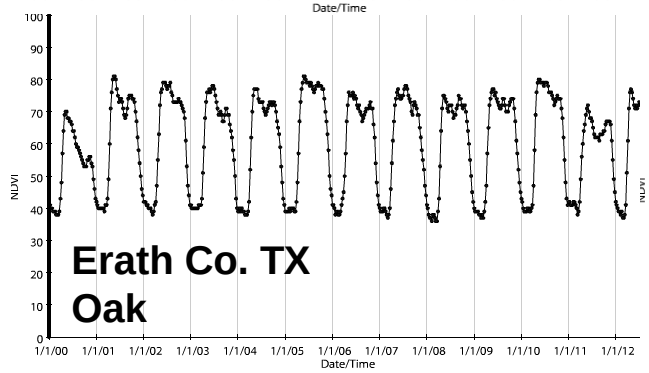


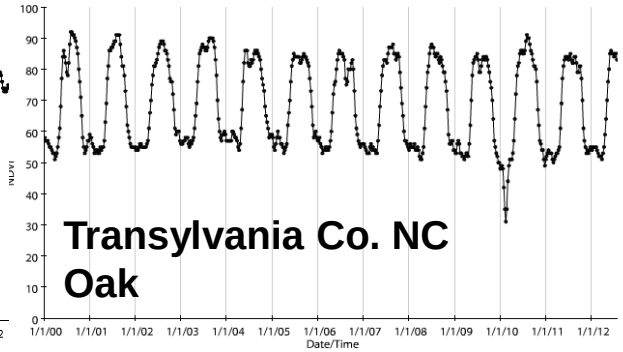


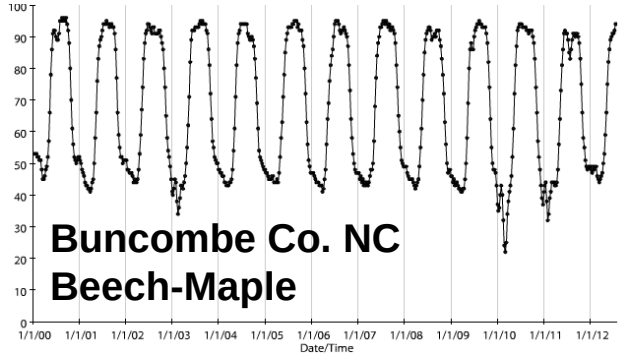




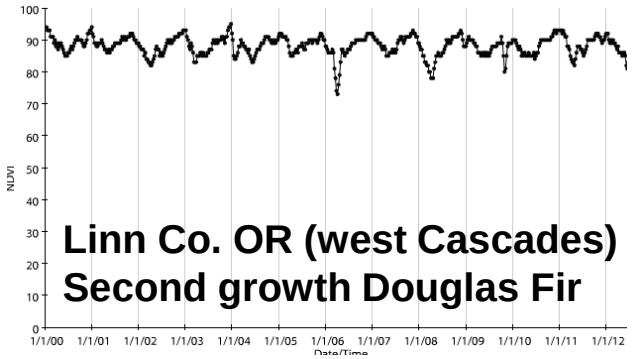




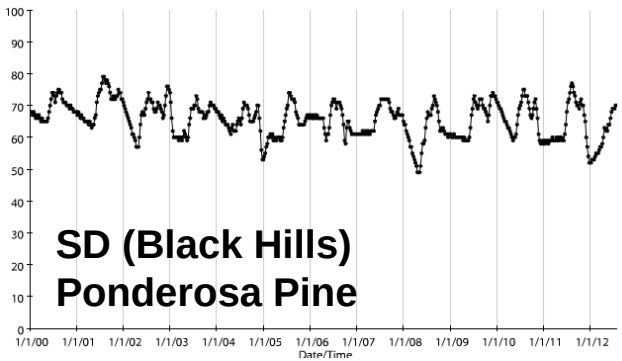




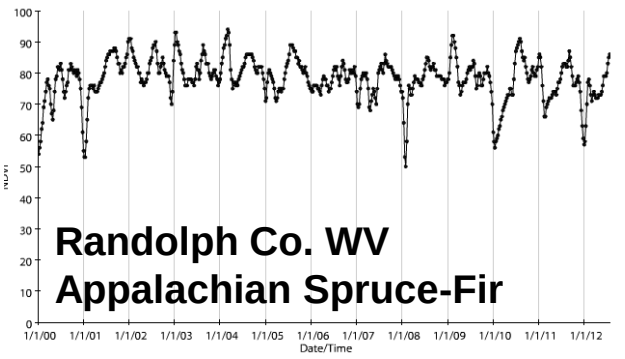
Seasonal “signatures” of evergreen forests over 13 years



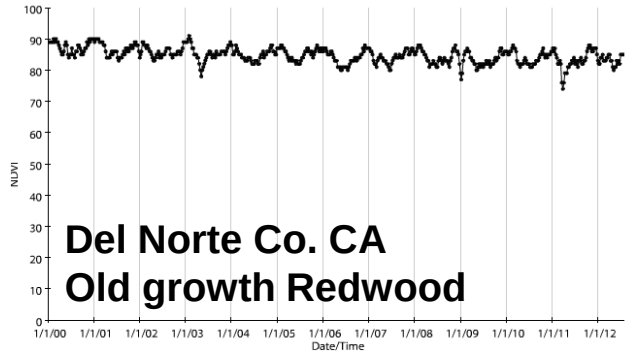
Linn Co. OR (west Cascades)
Second growth Douglas Fir



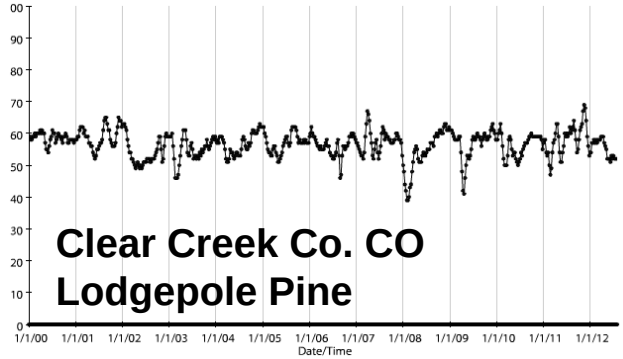
SD (Black Hills)
Ponderosa Pine



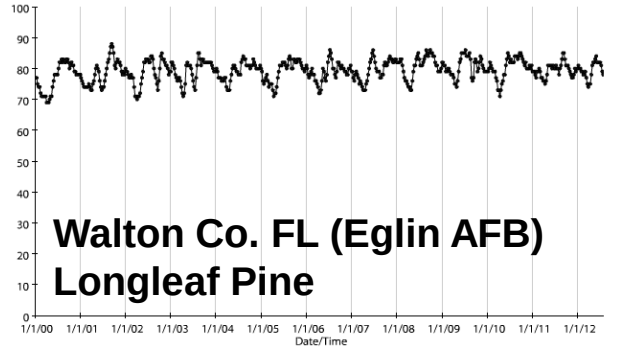
Randolph Co. WV
Appalachian Spruce-Fir



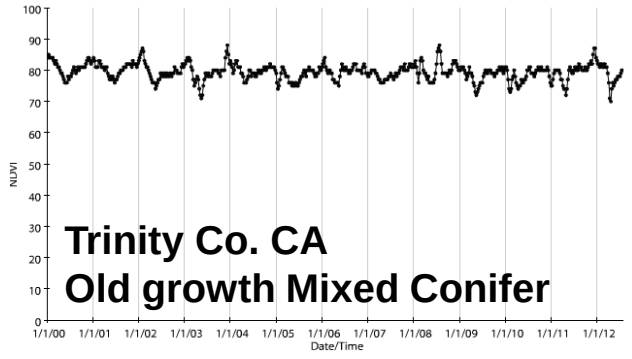
Del Norte Co. CA
Old growth Redwood



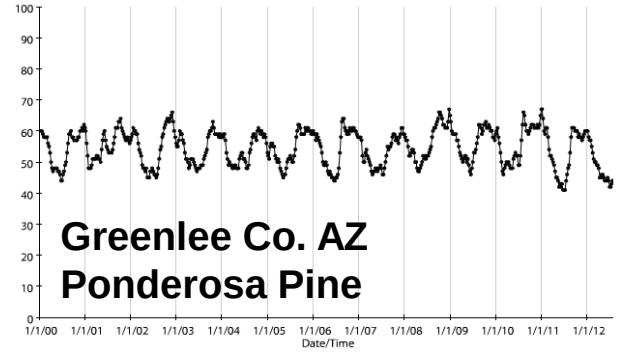
Clear Creek Co. CO
Lodgepole Pine



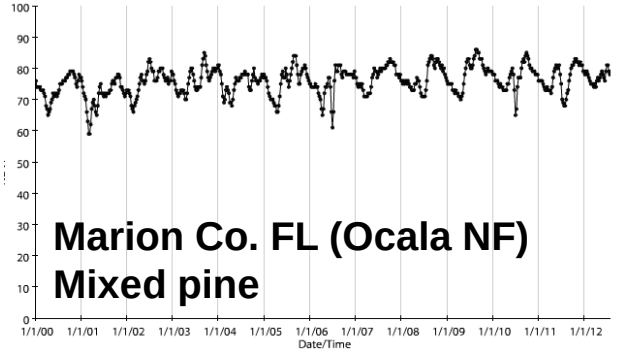
Walton Co. FL (Eglin AFB)
Longleaf Pine



Trinity Co. CA
Old growth Mixed Conifer

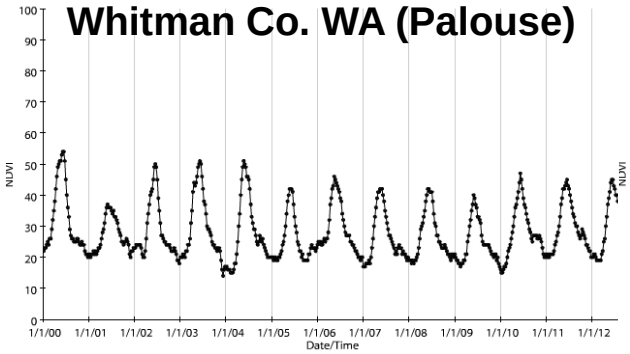


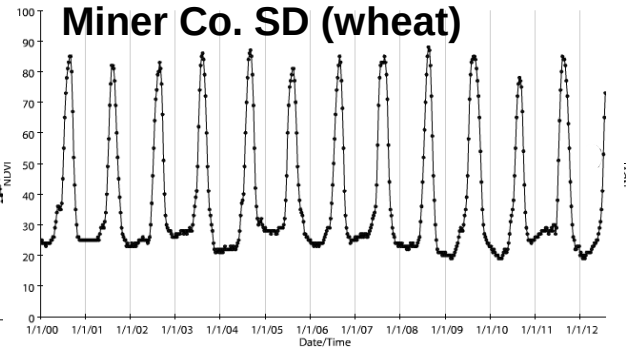
Greenlee Co. AZ
Ponderosa Pine

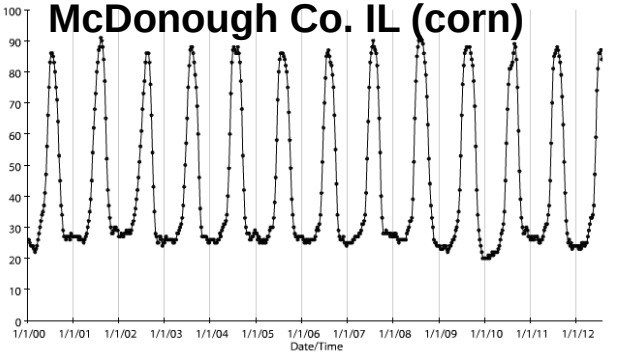


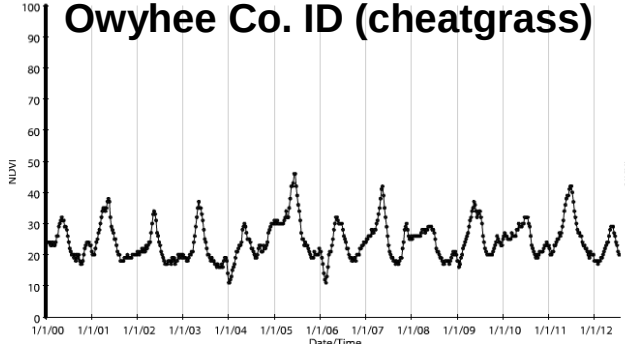
Marion Co. FL (Ocala NF)
Mixed pine

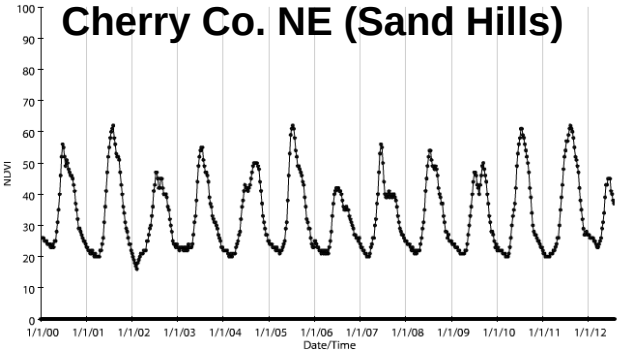
Seasonal “signatures” of grass and crops over 13 years

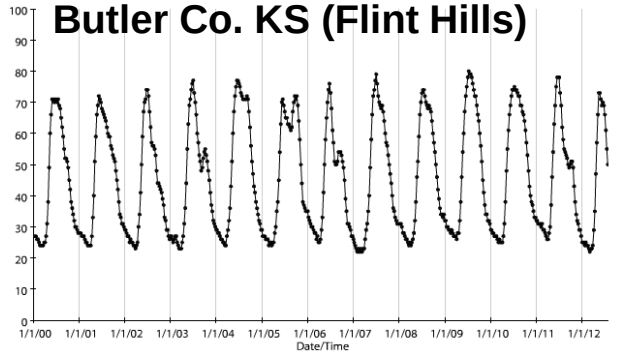


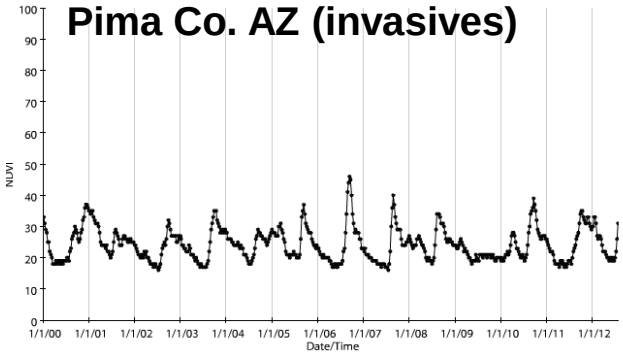


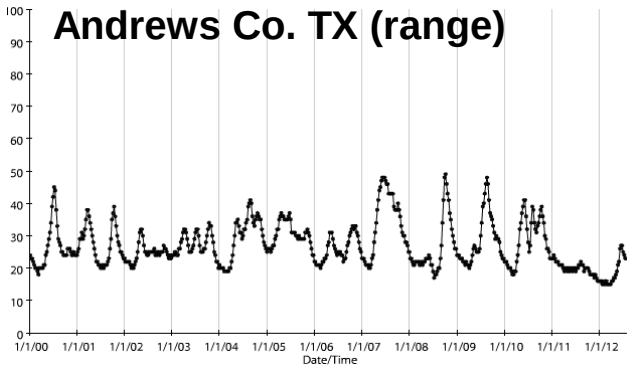


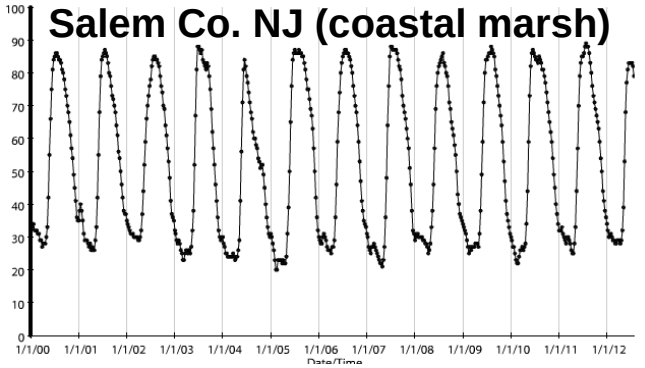












FROST

Effects of a warm March and April Frost along the Snowball Trail (4,950ft.), Pisgah National Forest, NC

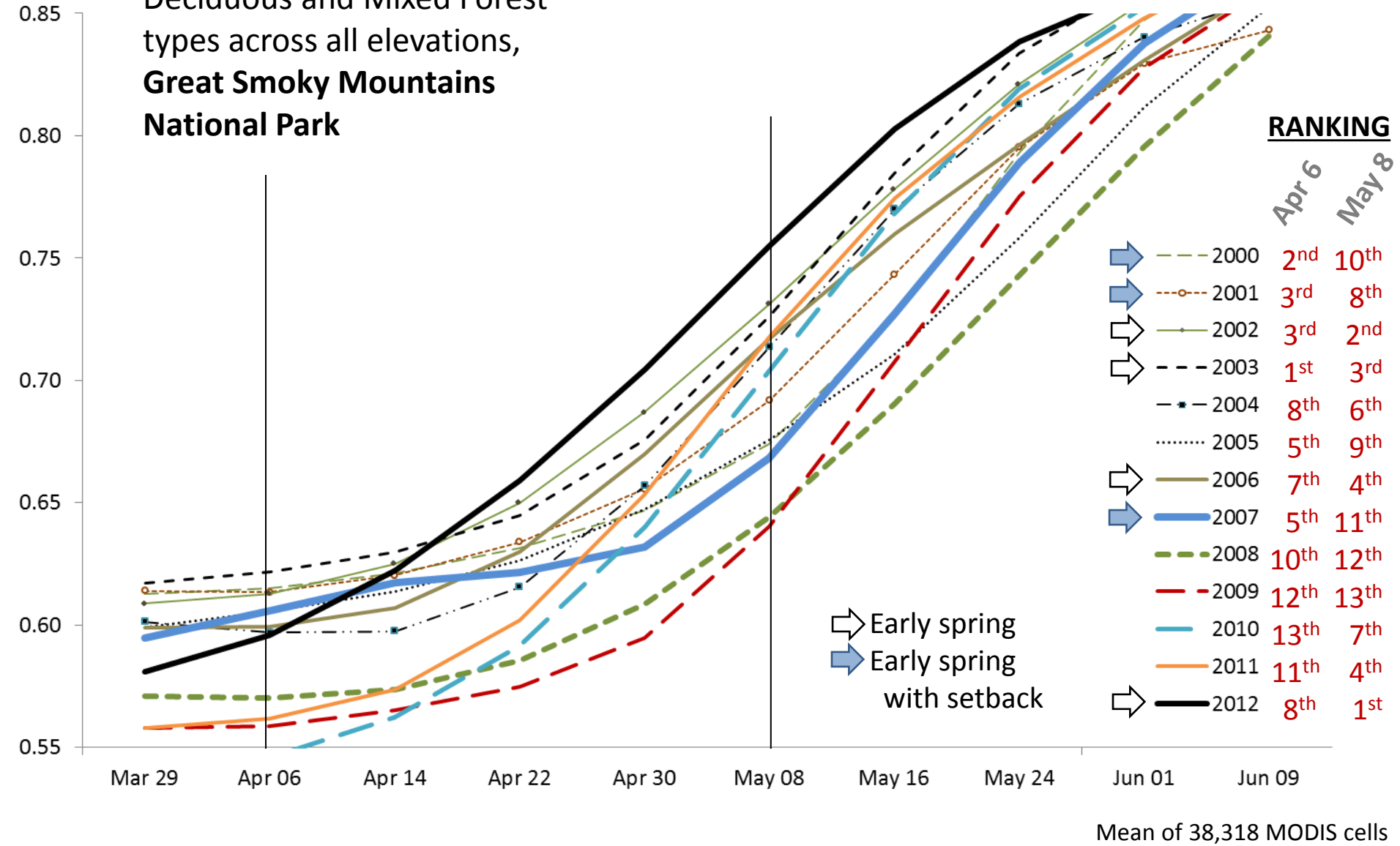
(photos taken 4/27/2012 by SPN)

Hobblebush Viburnum

Turk's Cap Lily

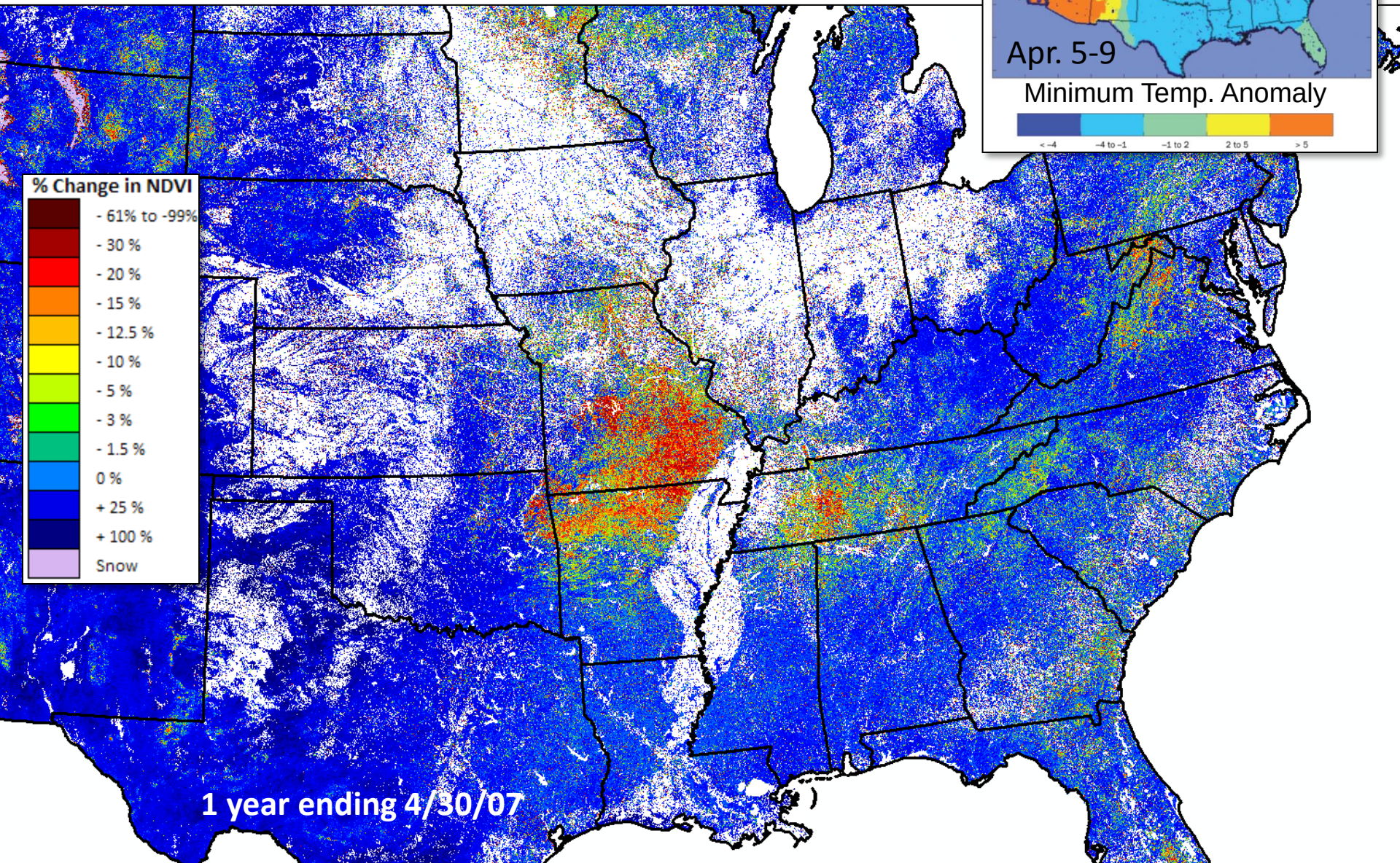
Yellow Buckeye

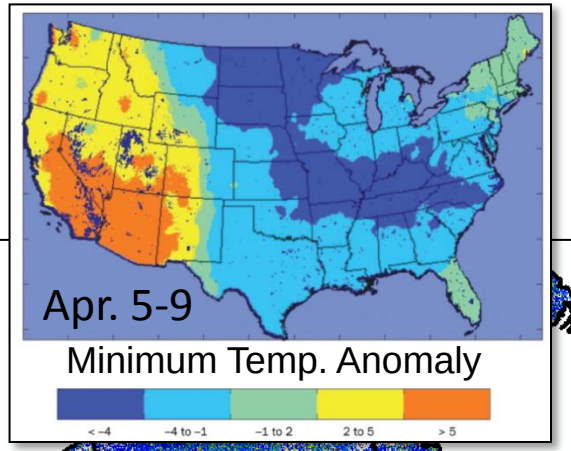
Variation in spring Land Surface Phenology from climate



Mean of 38,318 MODIS cells

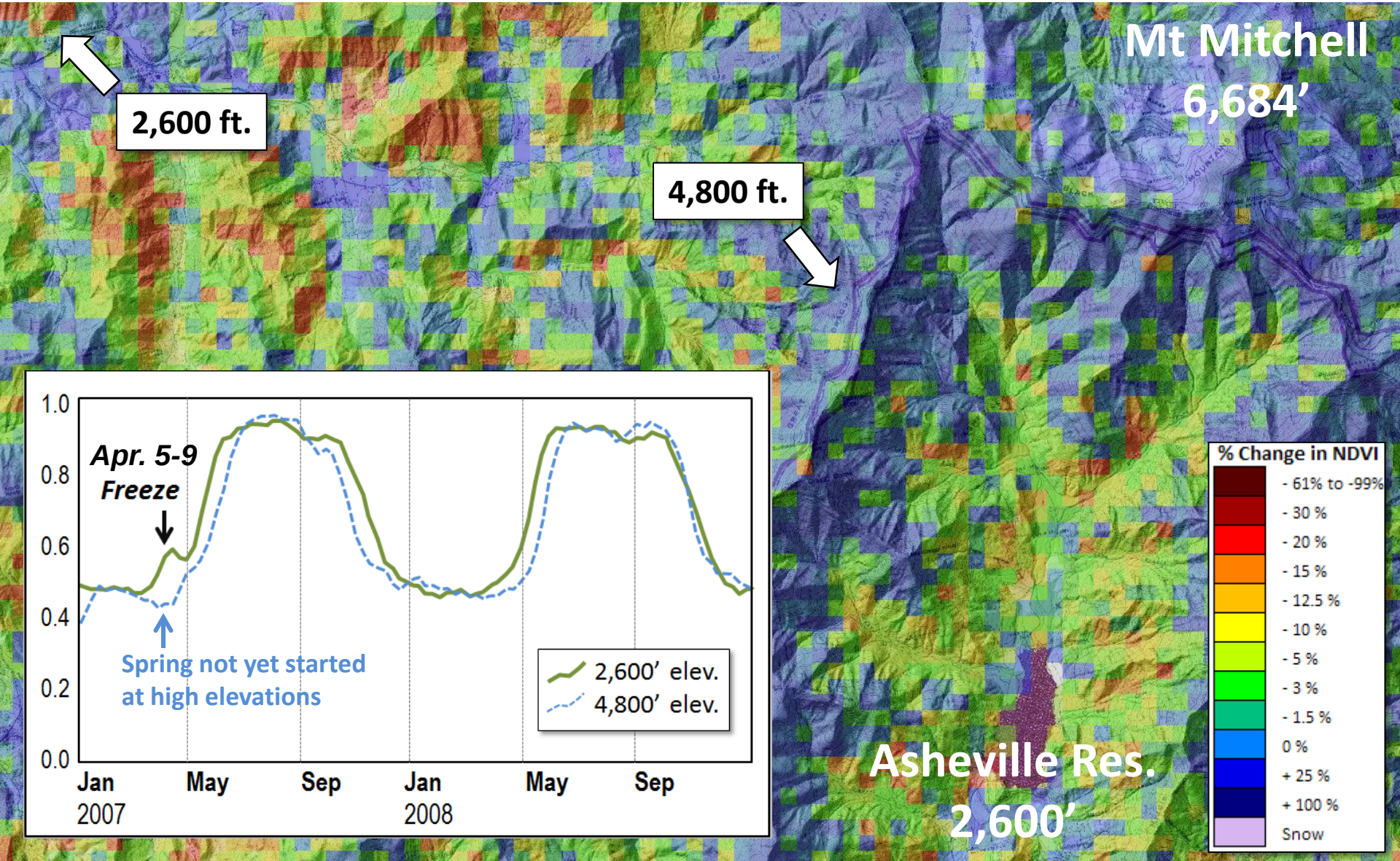
The 2007 “Big Freeze” effects as of Apr. 30



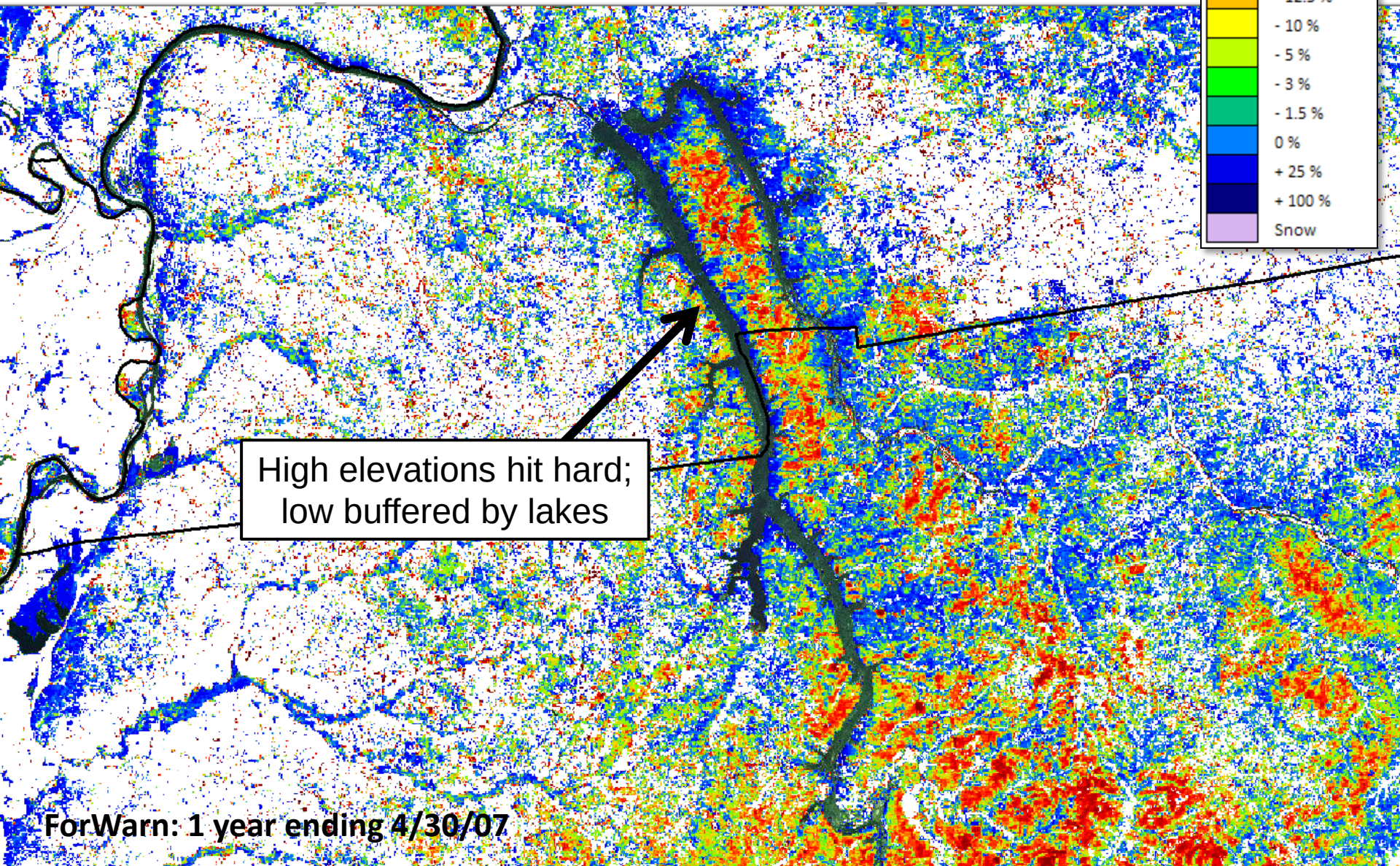


The 2007 “Big Freeze”—Topographic nuances

1 year ending 4/30/07



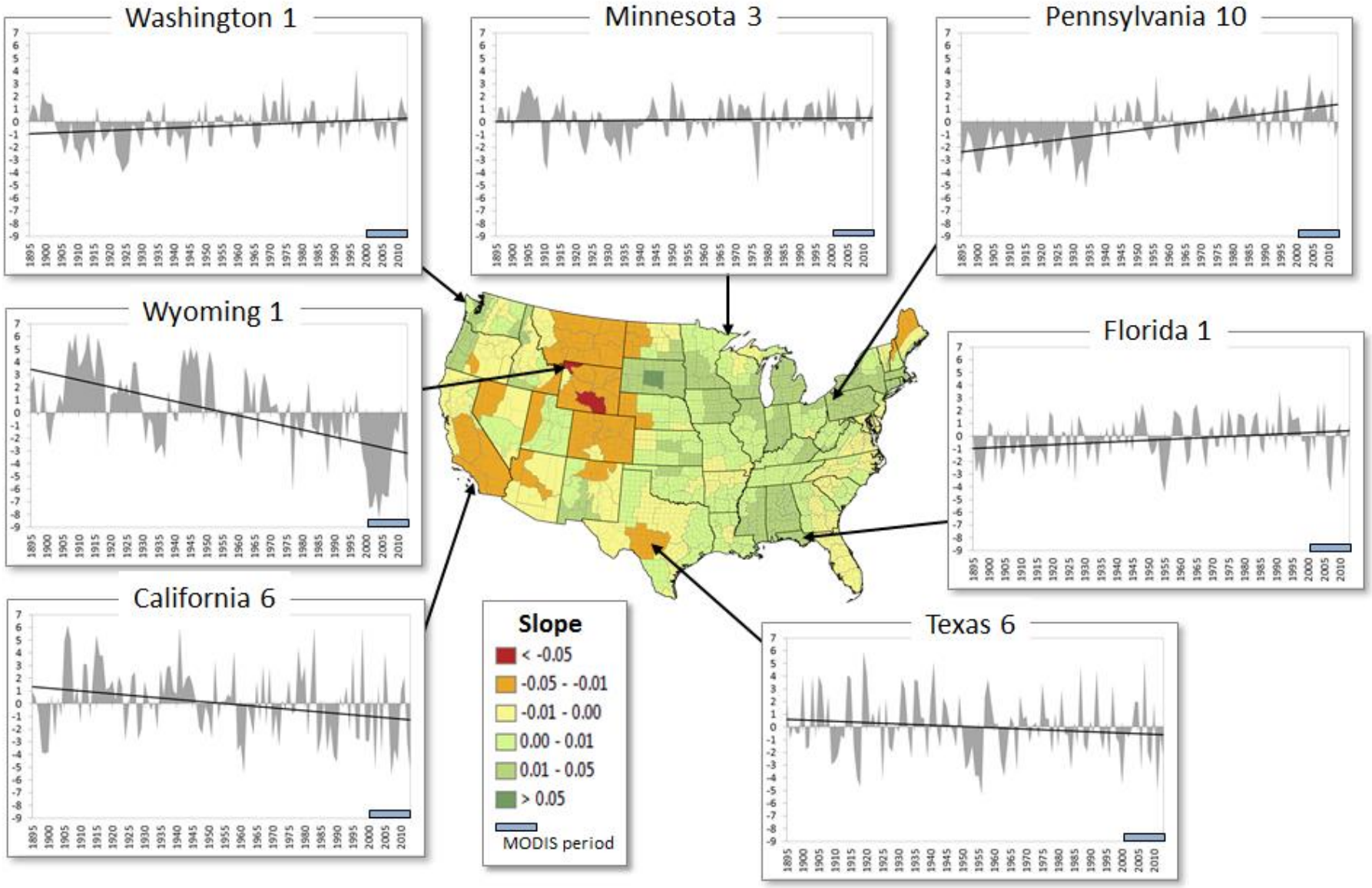
The 2007 “Big Freeze”—Topographic nuances



DROUGHT

Climate trends alone may suggest potential forest impacts

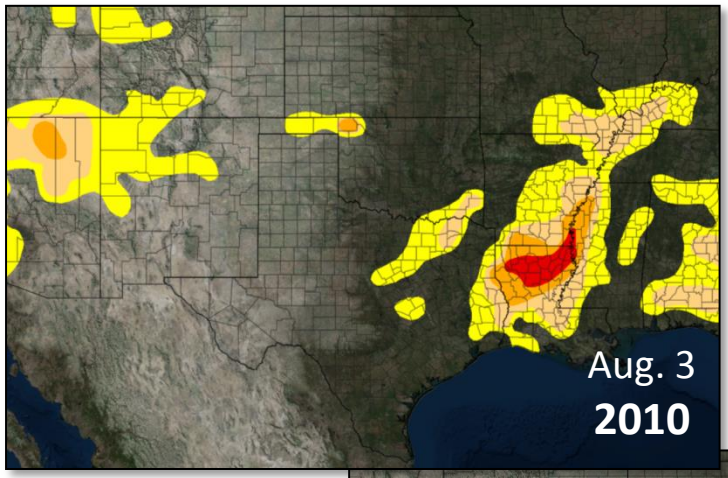
Mean Apr. to Sep. Palmer Modified Drought Index 1895-2013, by NCDC Climate Division

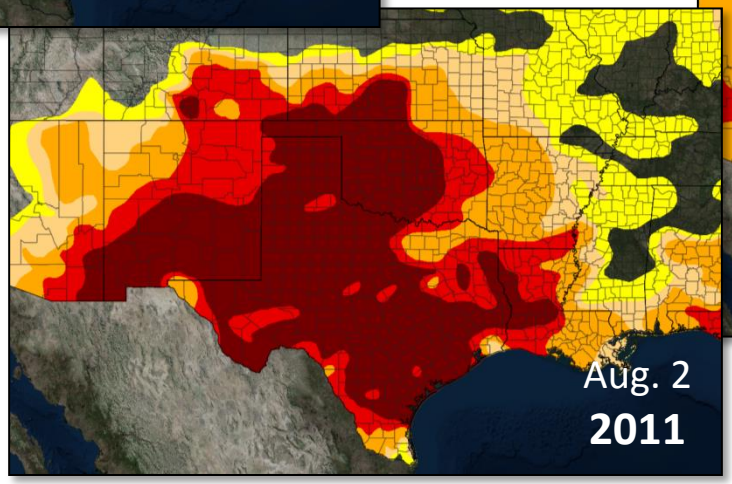


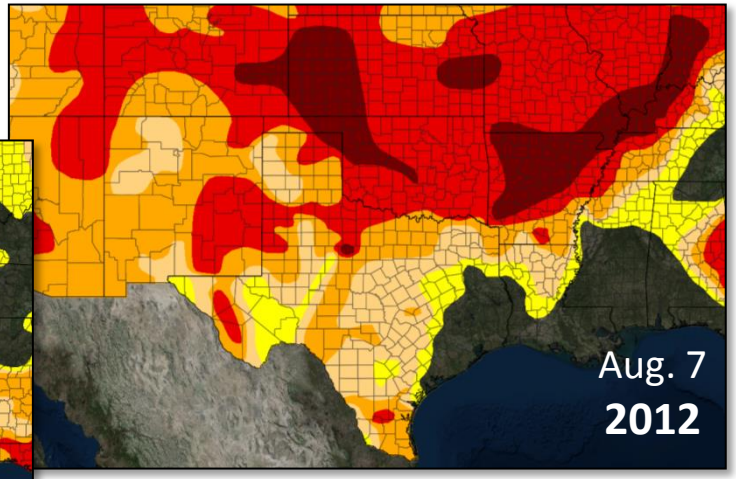
Source: Norman, Koch and Hargrove 2015

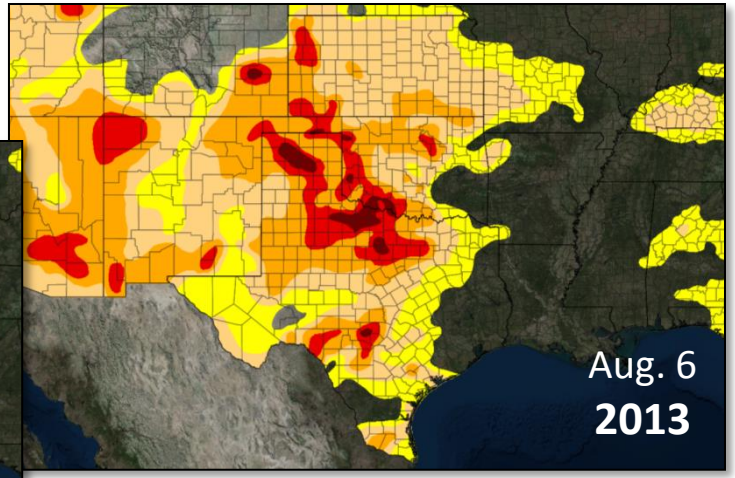
Drought Occurrence

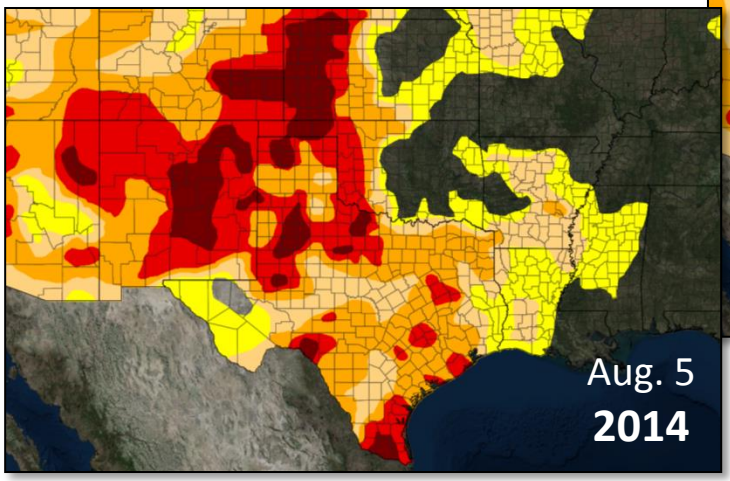
for Texas and the Southern Great Plains









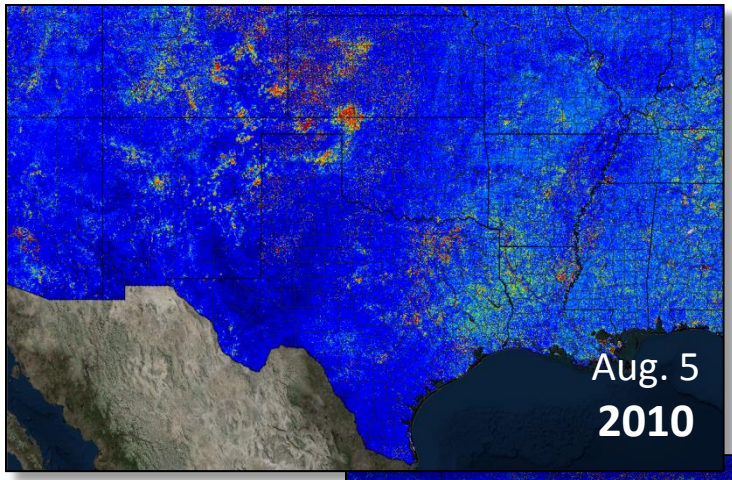


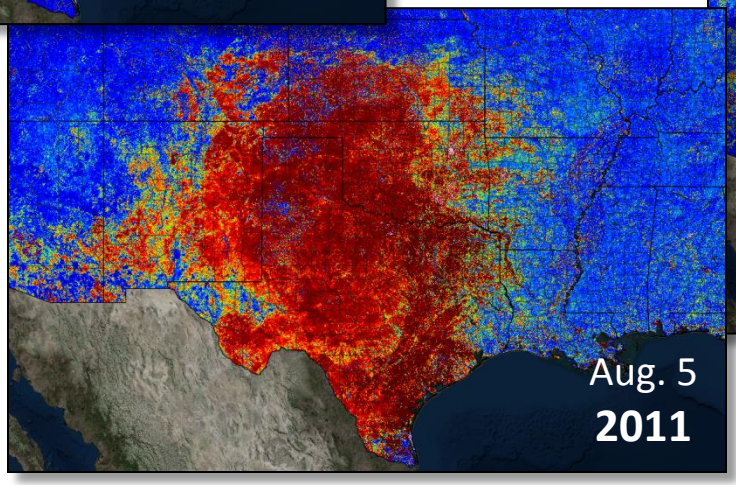
U.S. Drought Monitor

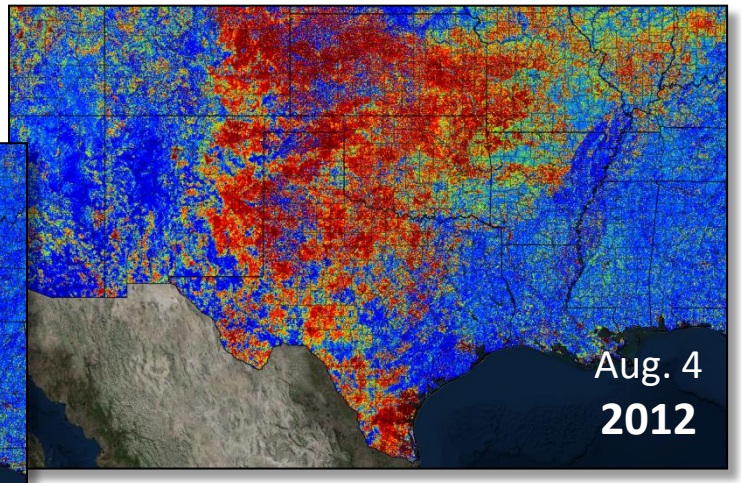
- Abnormally dry
- Moderate drought
- Severe
- Extreme
- Exceptional

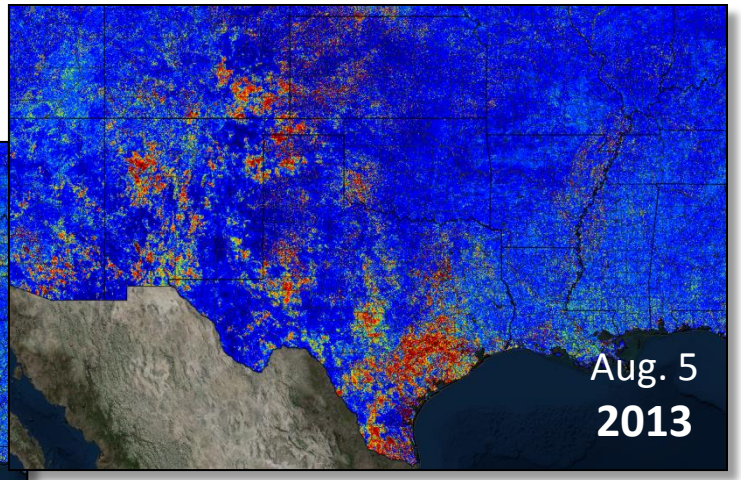
Drought (and Wildfire) Effects on NDVI

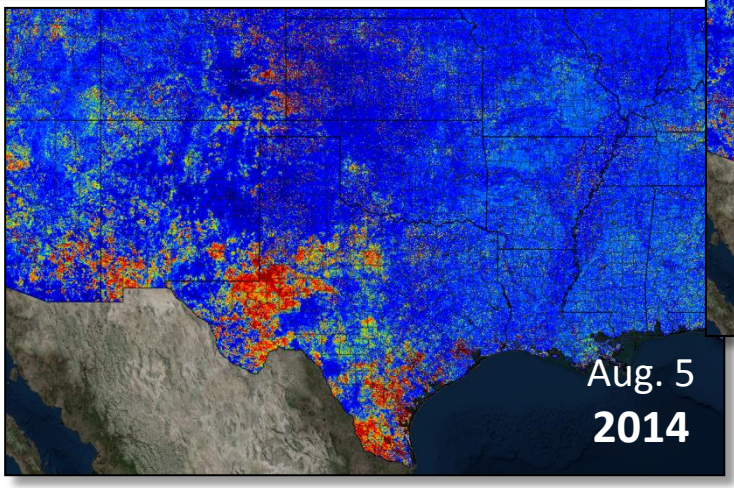
for Texas and the Southern Great Plains











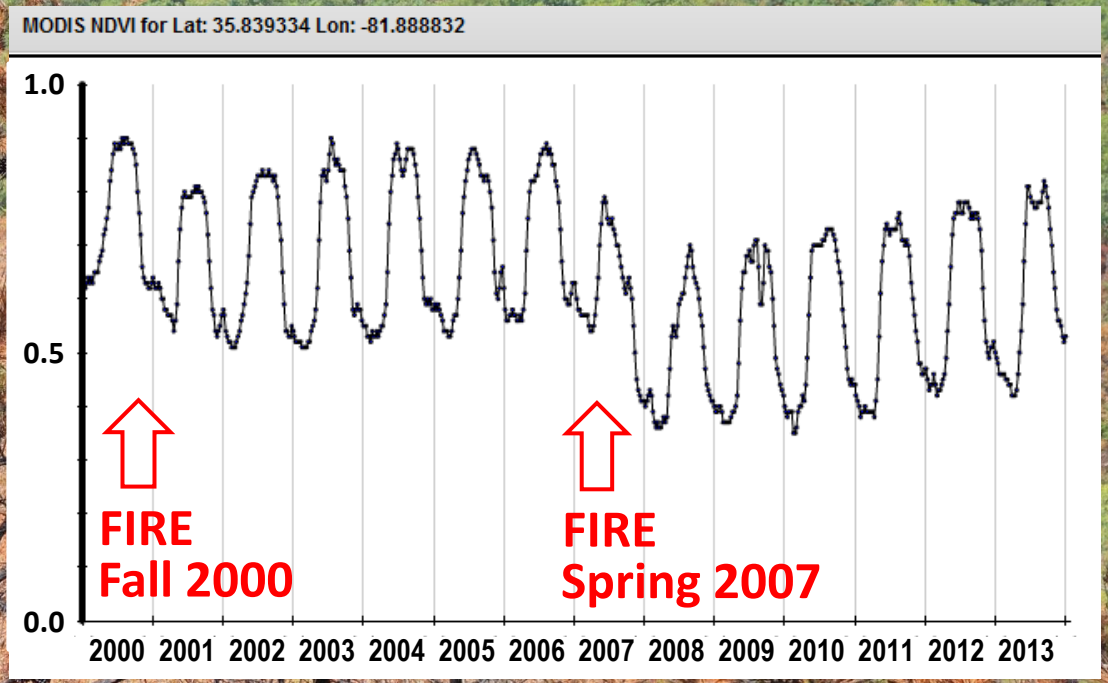
% Change in NDVI from All-Year Mean

- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
- 0 %
- + 25 %
- + 100 %

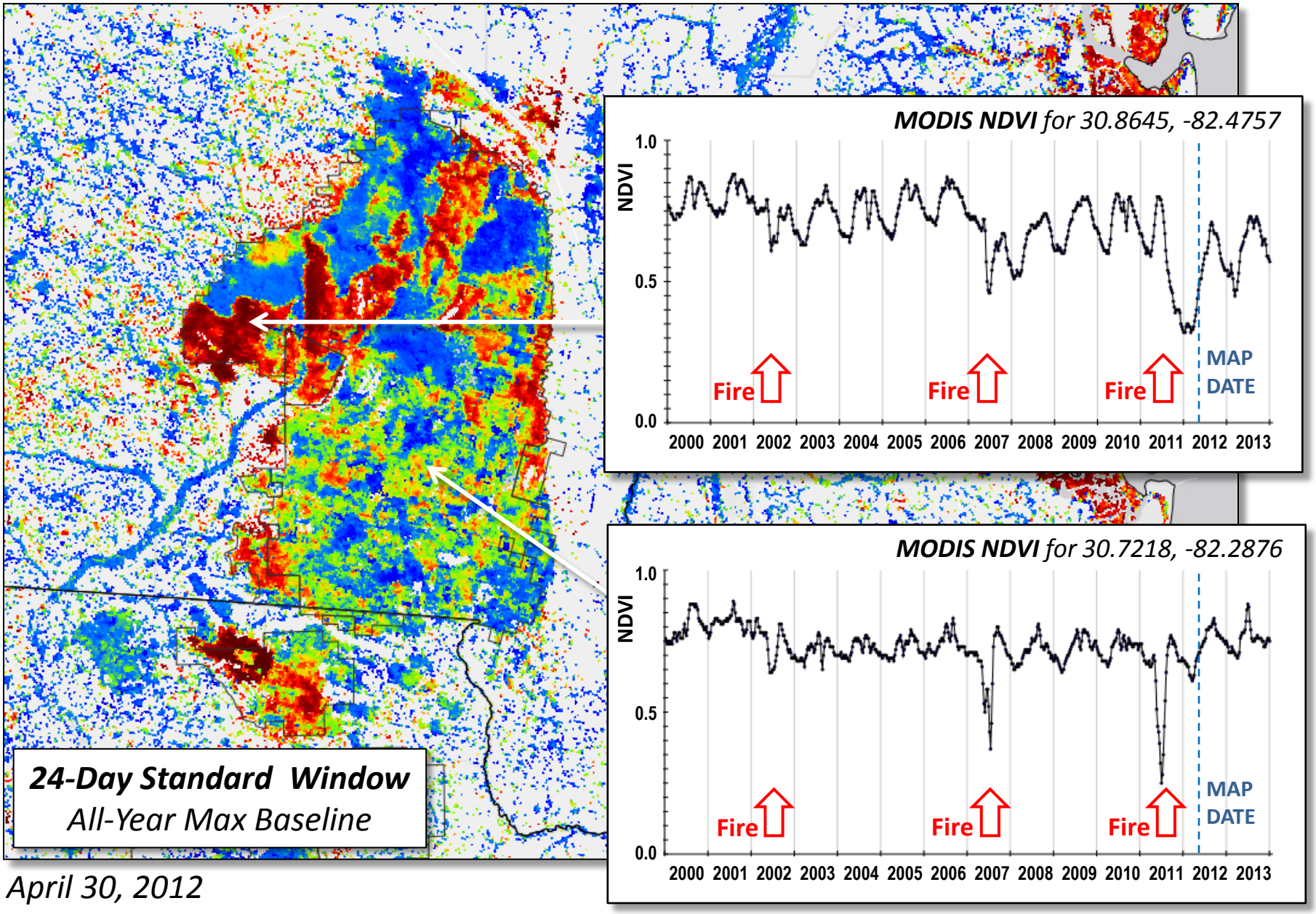
FIRE

Response to fire regime change

Pisgah National Forest, NC

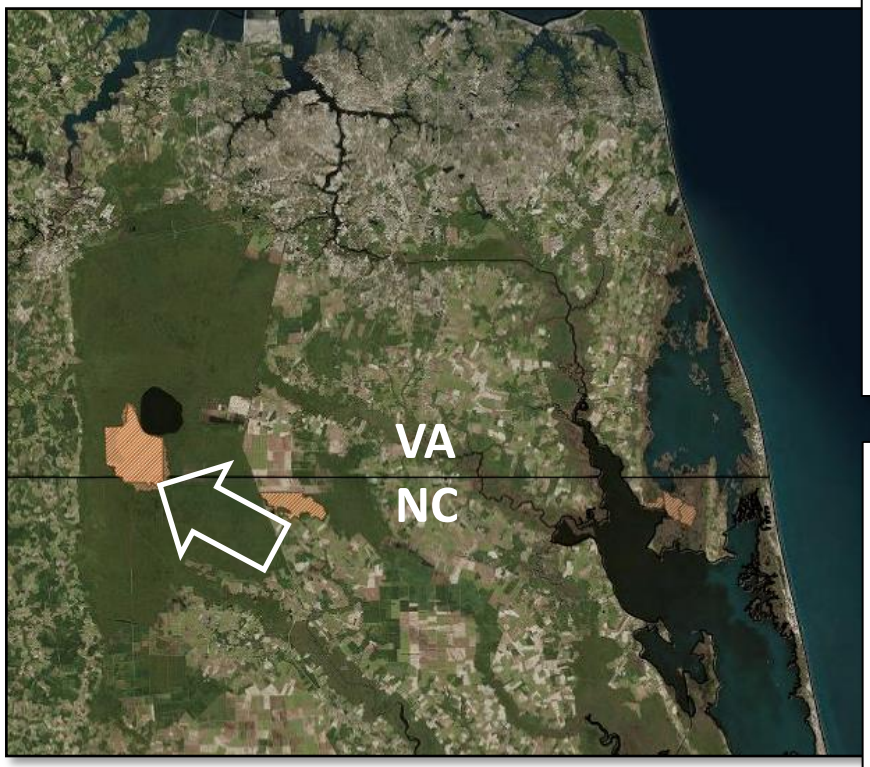


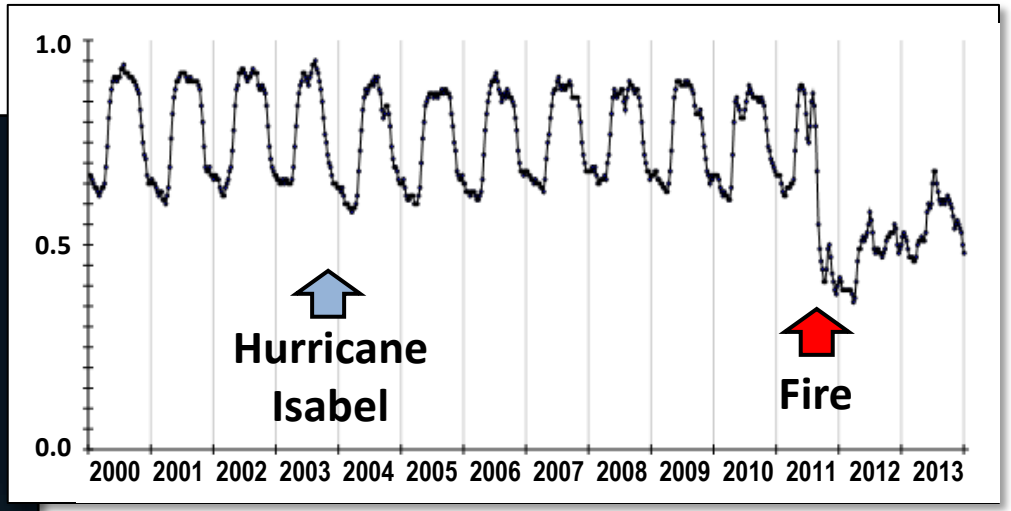
Response to fire regime change, Okefenokee wetlands, GA

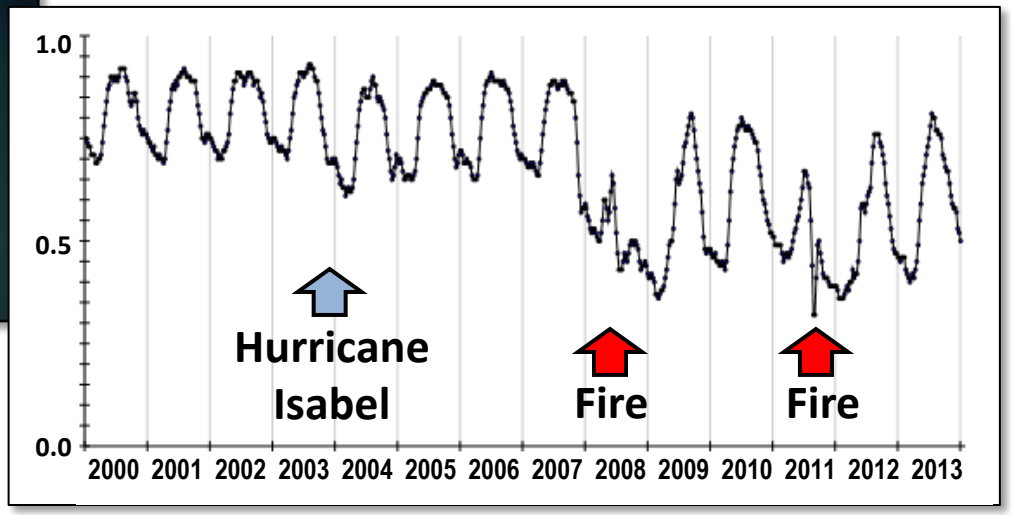


April 30, 2012

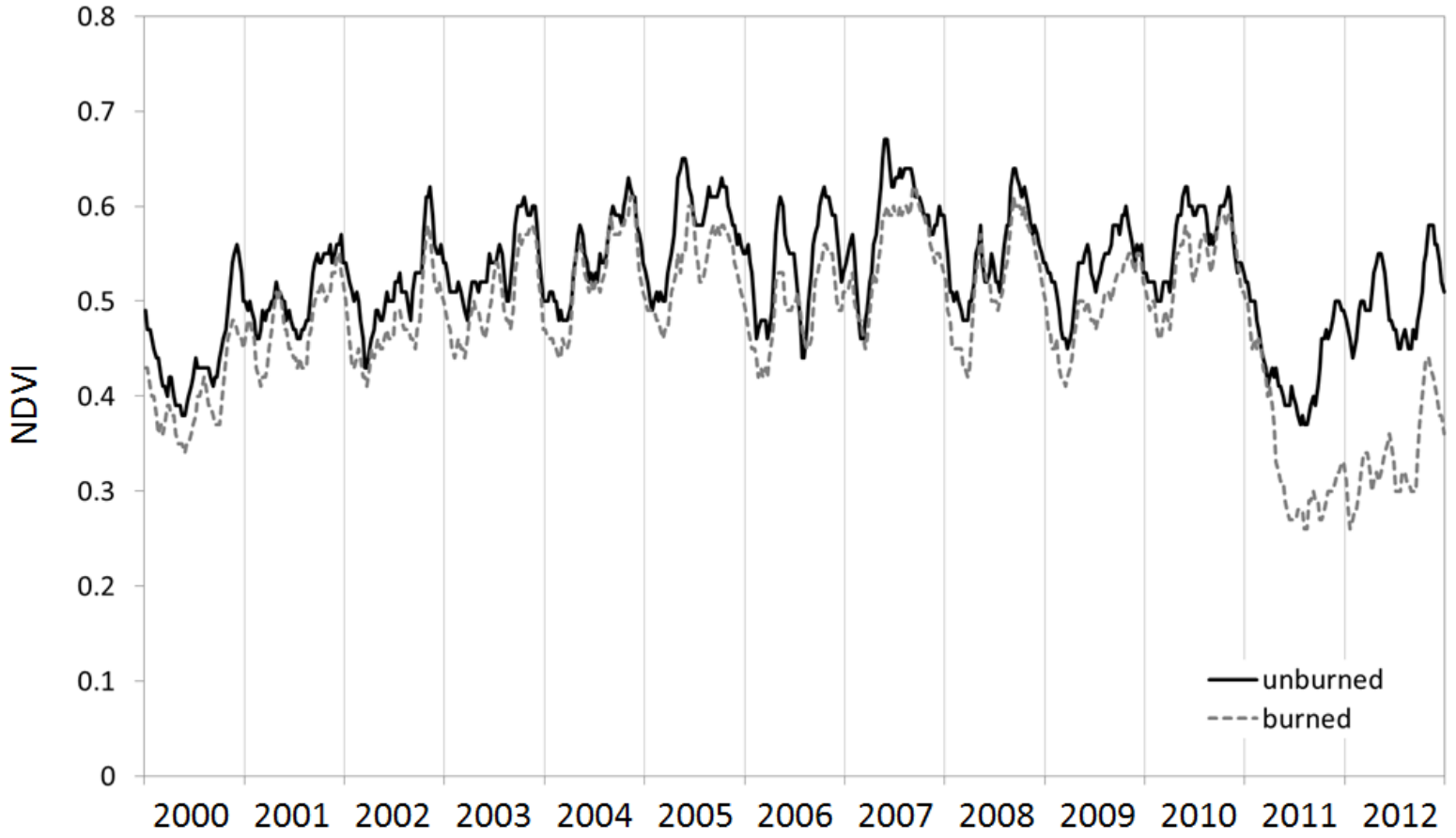
Impacts from sequential disturbances in forest wetlands of the Great Dismal Swamp, VA







Impacts from multiple concurrent disturbances: drought and fire in TX

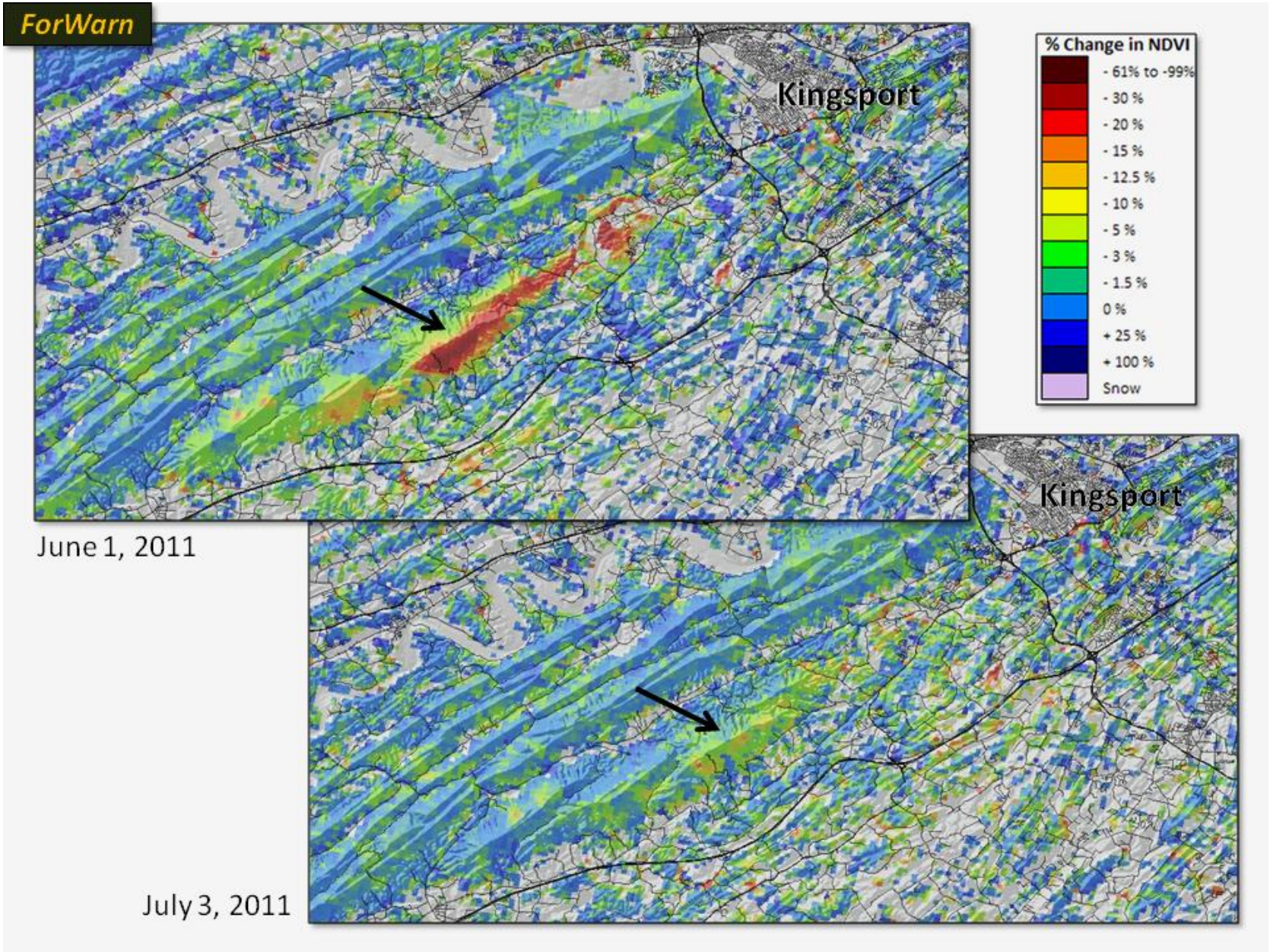


Two nearby woodland ***ForWarn*** pixels in west Texas on similar sites, one that burned and one that did not during 2011. Note that effects persisted through 2012 on both sites, but that the cumulative effects of drought and wildfire were more pronounced than drought alone.

STORMS

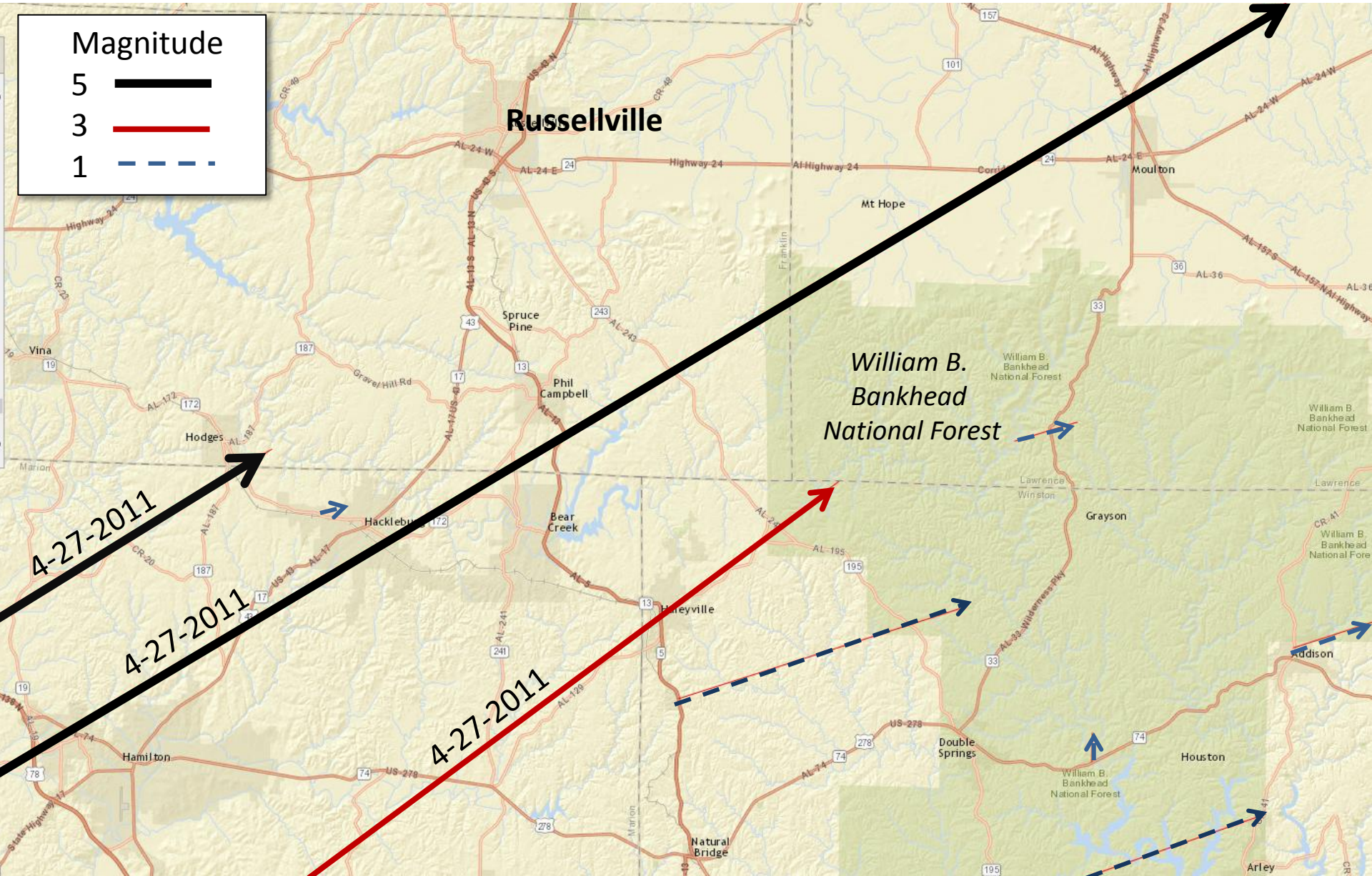
Eastern Tennessee Ice Storm

Ephemeral changes are readily captured by frequent observations



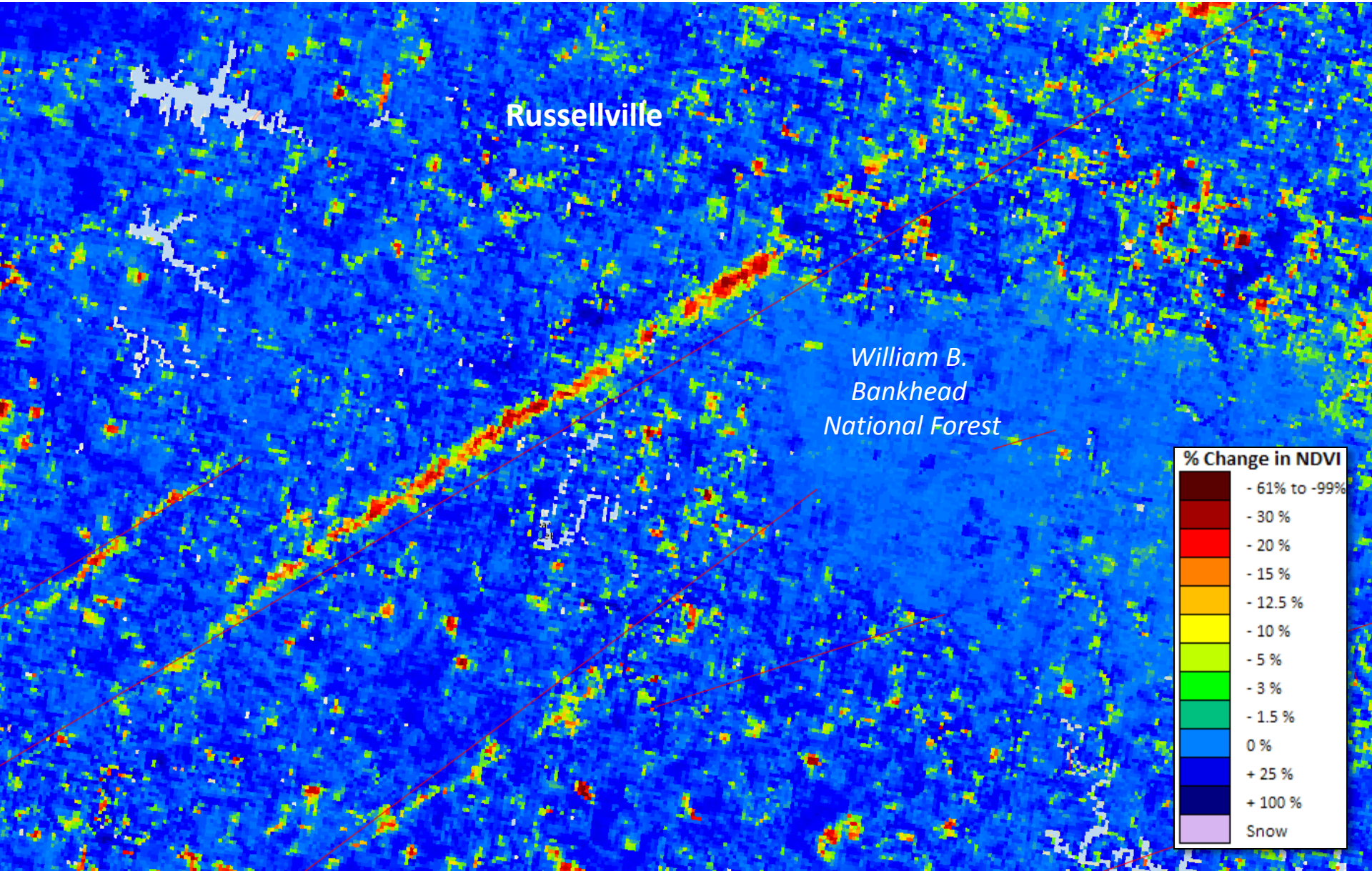
Northern Alabama Tornadoes

According to the National Weather Service (2010-2013)



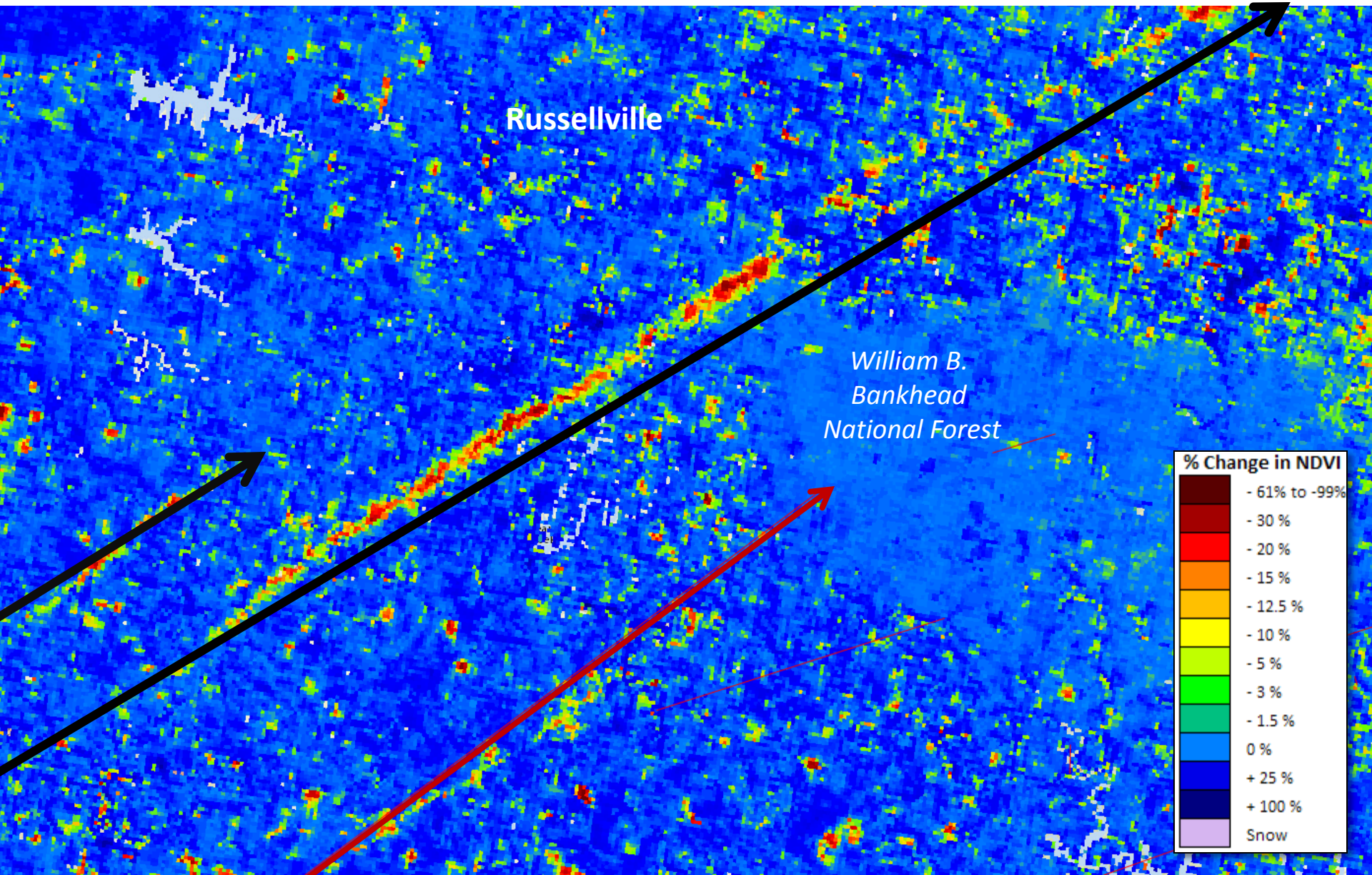
Northern Alabama Tornadoes

Location and variable severity as mapped by *ForWarn* Jun. 1, 2011 (vs. 1 yr.)



Northern Alabama Tornadoes

Location and variable severity as mapped by *ForWarn* Jun. 1, 2011 (vs. 1 yr.)

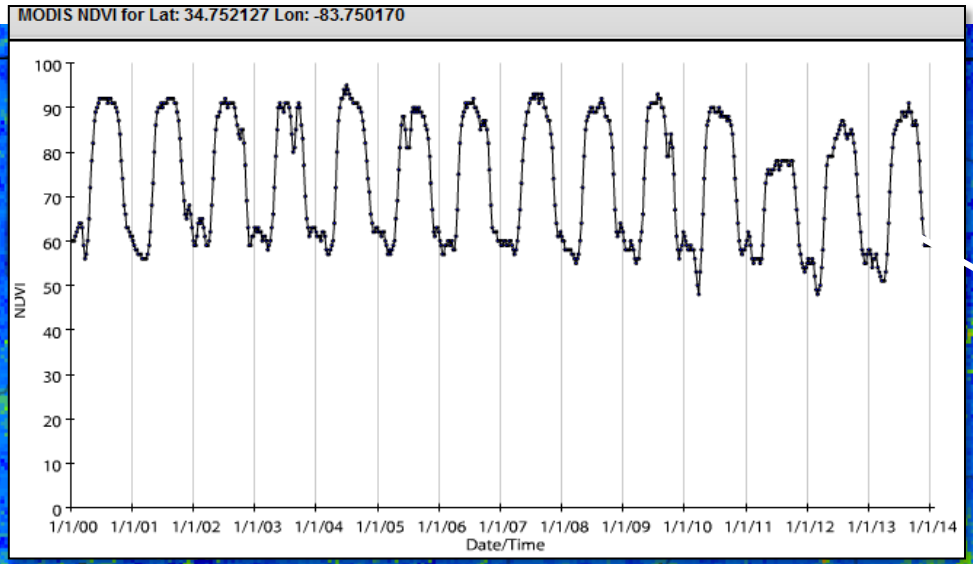


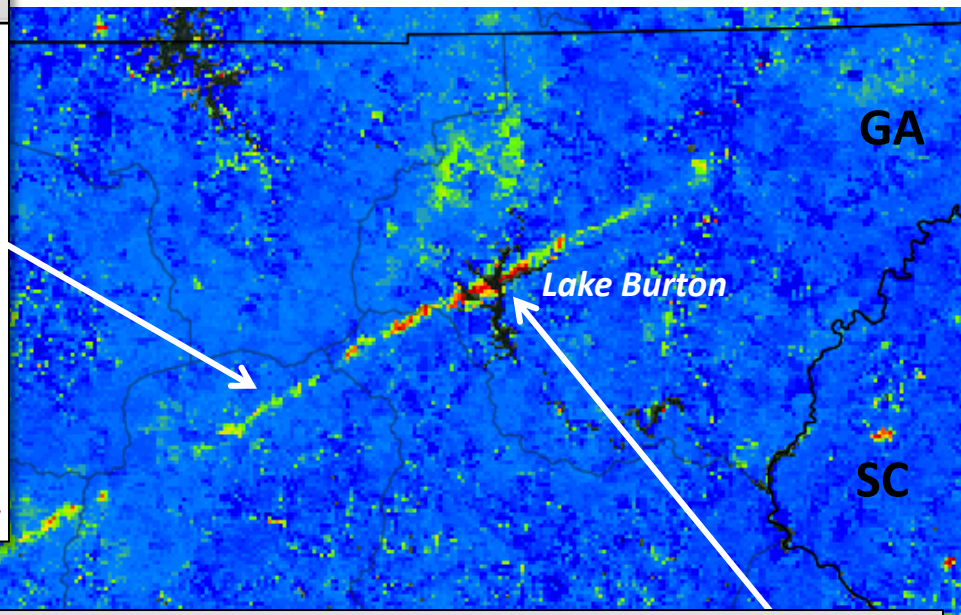
Northern Georgia Tornado in Chattahoochee National Forest

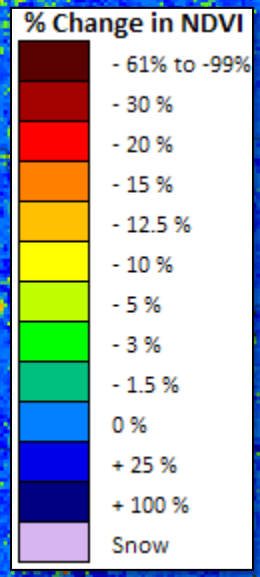
The view over Lake Burton after Apr. 27, 2011

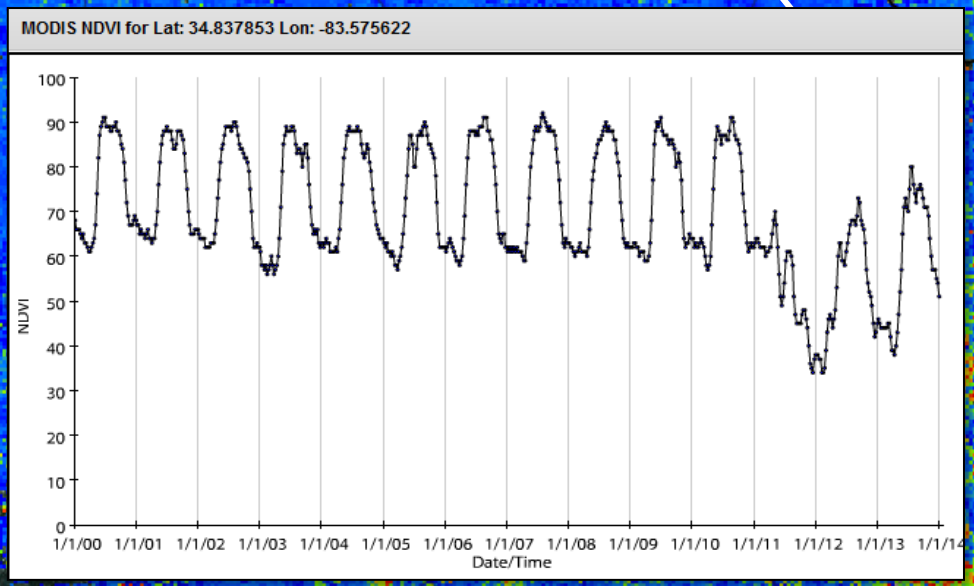
Northern Georgia Tornado in Chattahoochee National Forest

Location and variable severity as mapped by *ForWarn* Jul. 3, 2011 (vs. 1 yr.)



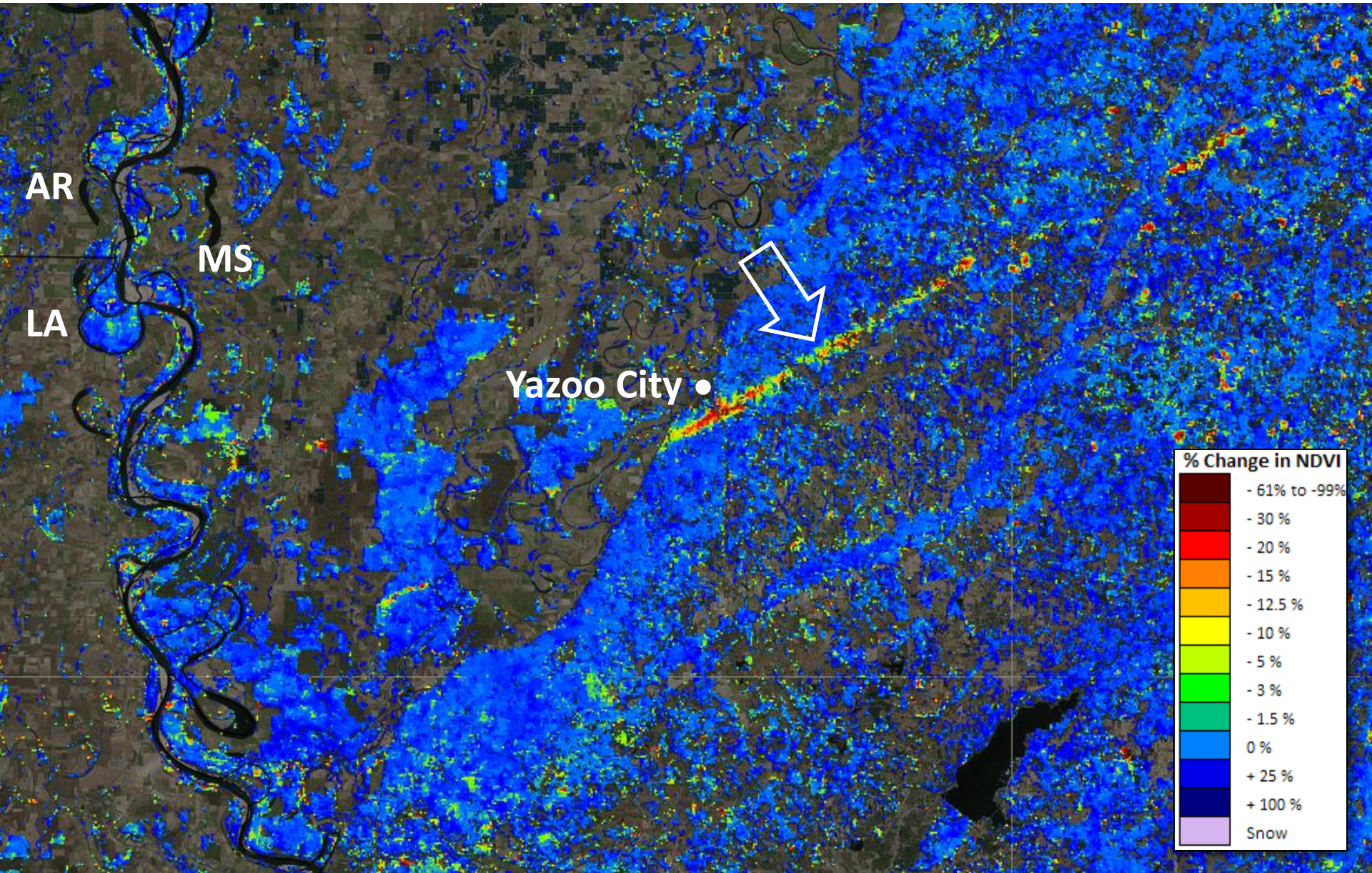






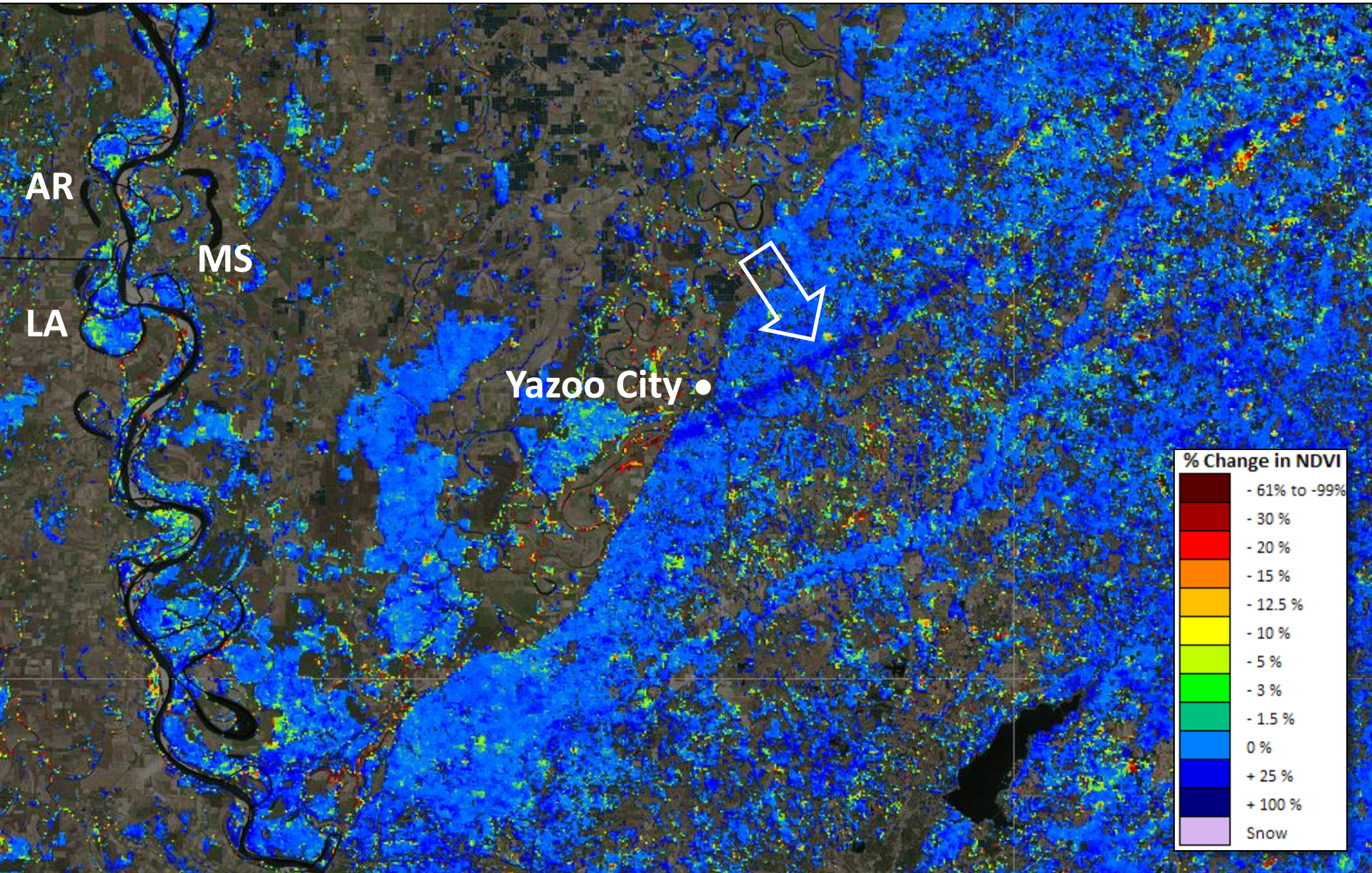
Western Mississippi Tornado near Yazoo City

Location and variable severity as mapped by *ForWarn* Jul. 19, 2008 (vs. 1 yr.)



Western Mississippi Tornado near Yazoo City

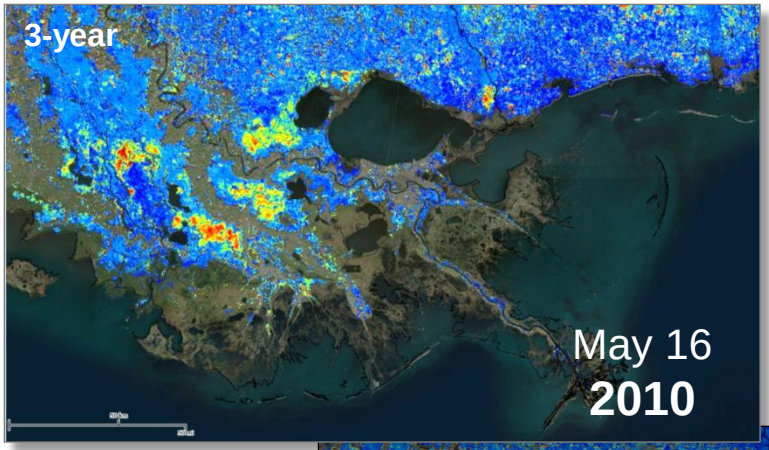
Location and recovery (dark blue) as mapped by *ForWarn* Jul. 19, 2009 (vs.1 yr.)

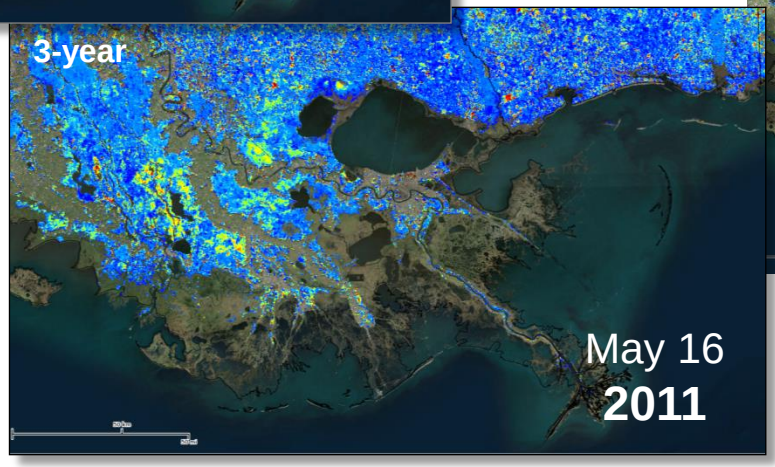


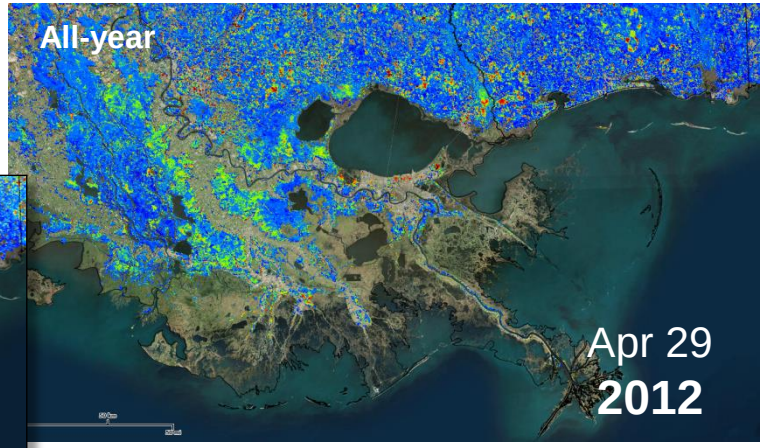
INSECTS & DISEASE

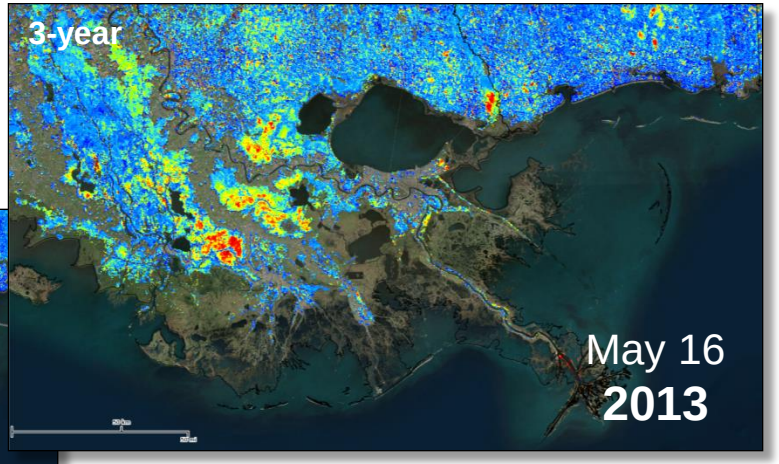
Defoliation of forested wetlands

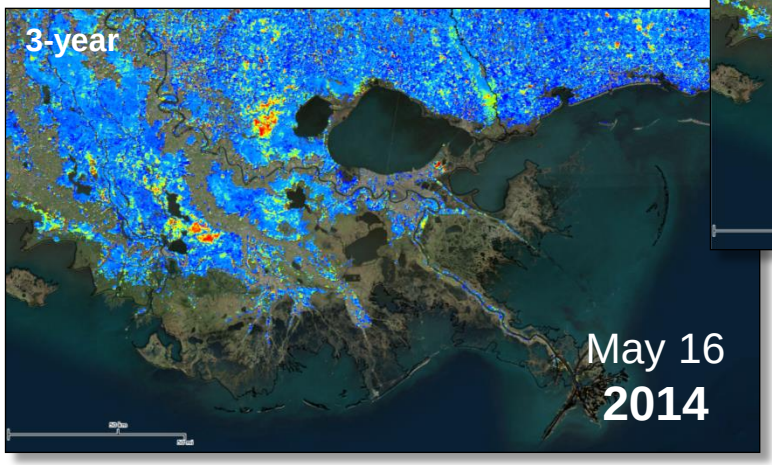
Forest Tent Caterpillar, Bald Cypress Leafroller











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- 5 %
- 3 %
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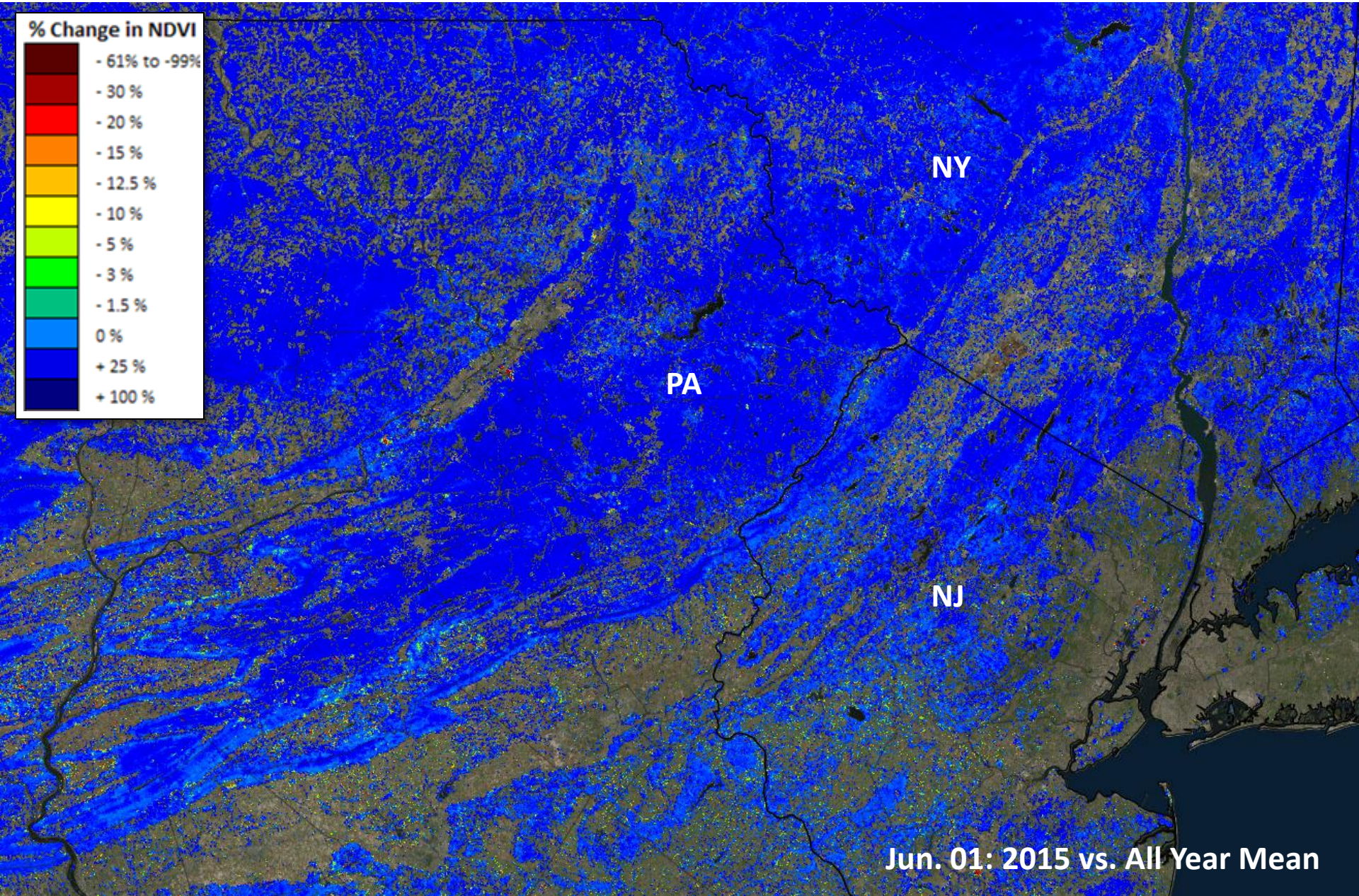
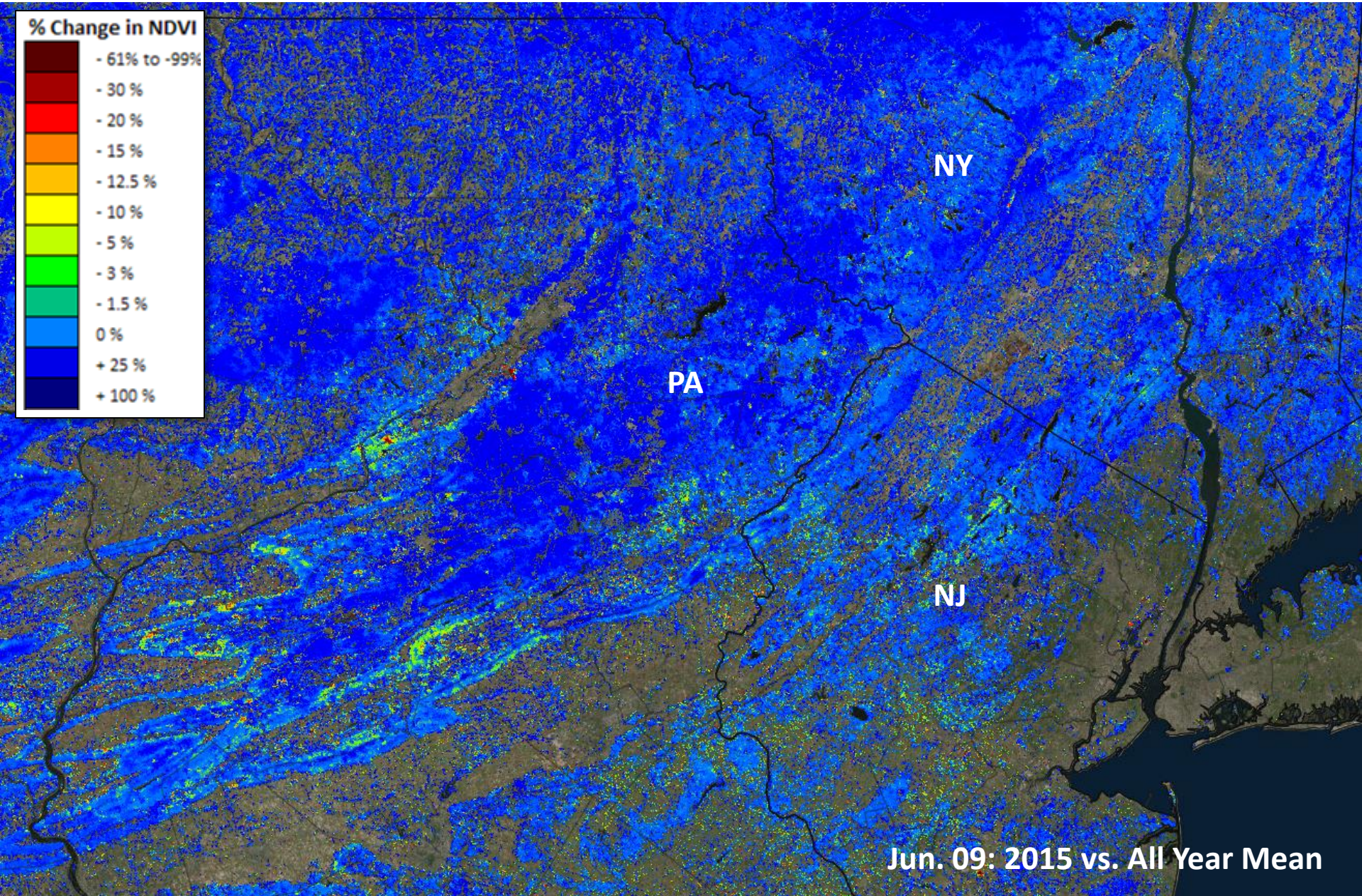
- + 25 %
- + 100 %

How frequent does native insect defoliation recur?

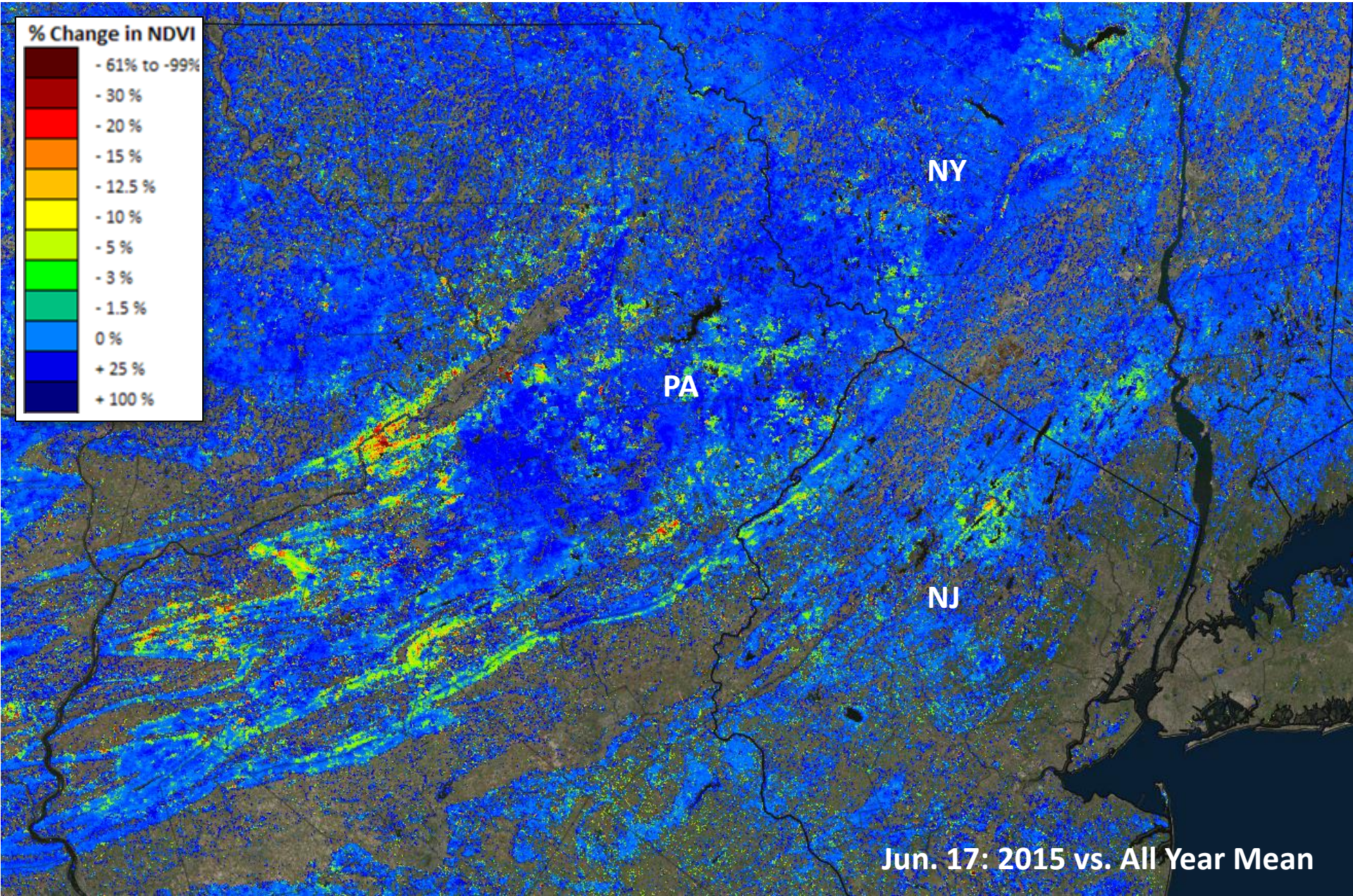
The 2015 Gypsy moth outbreak in the Northeast



The 2015 Gypsy moth outbreak in the Northeast



The 2015 Gypsy moth outbreak in the Northeast



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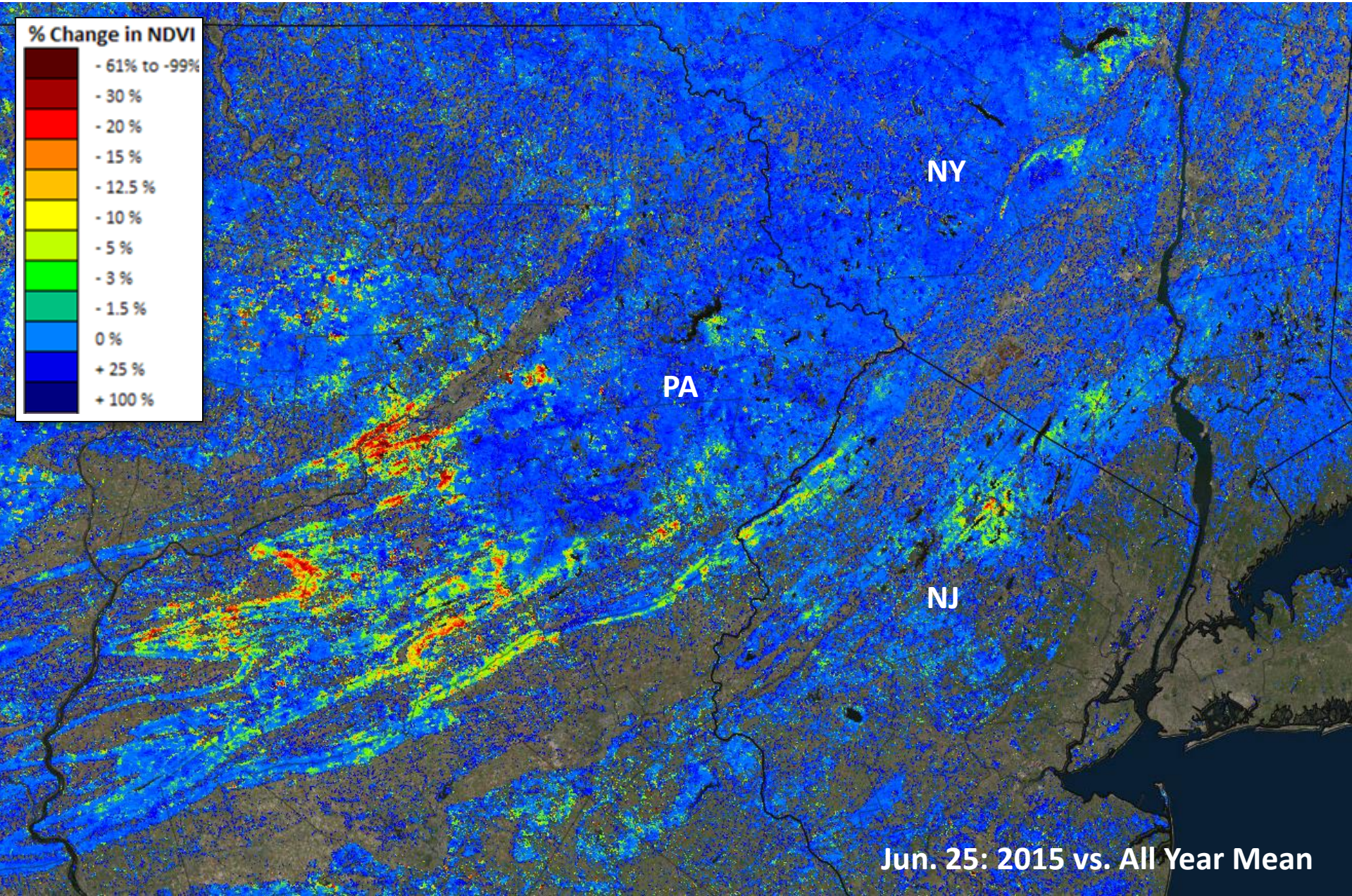

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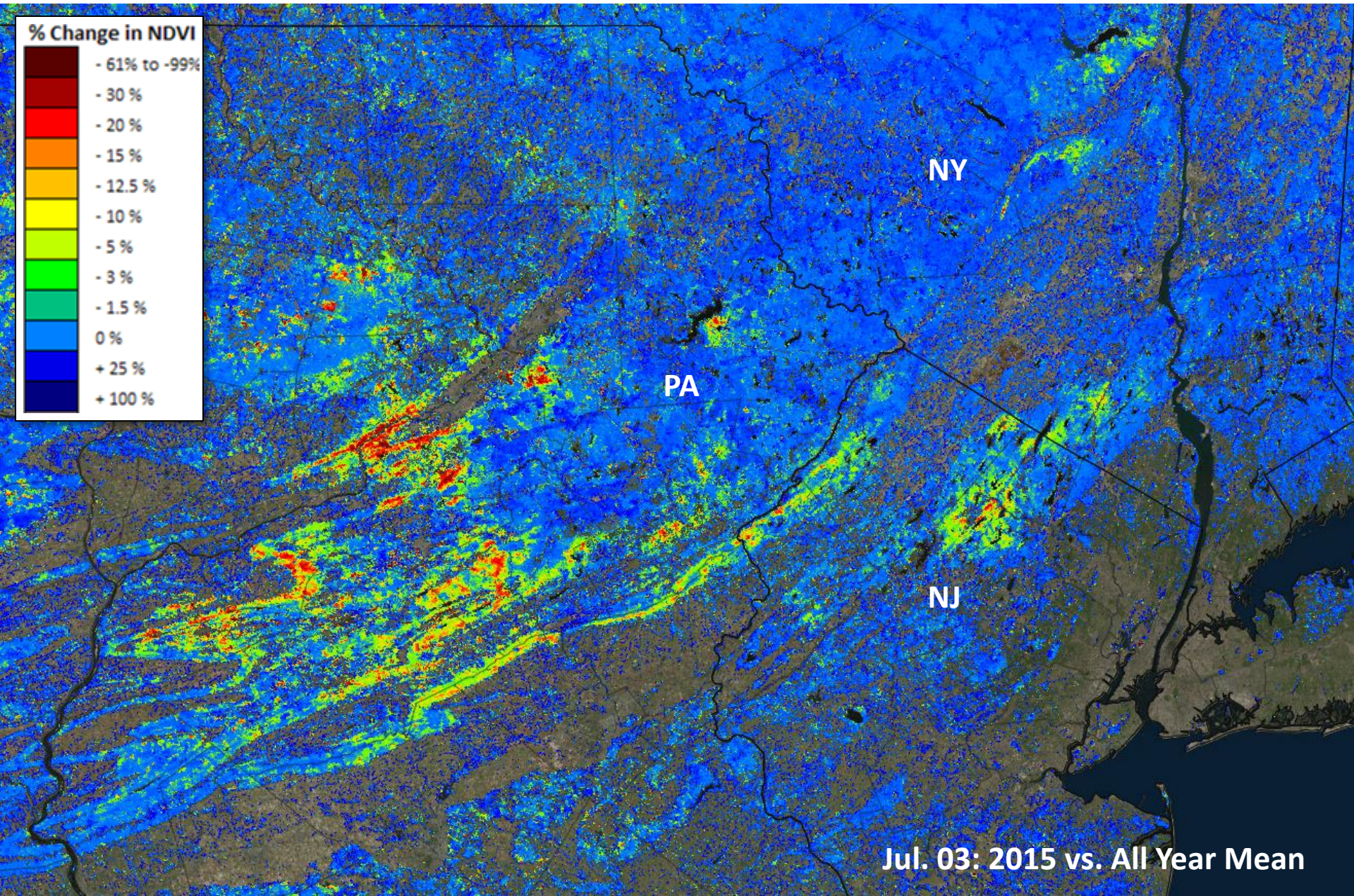
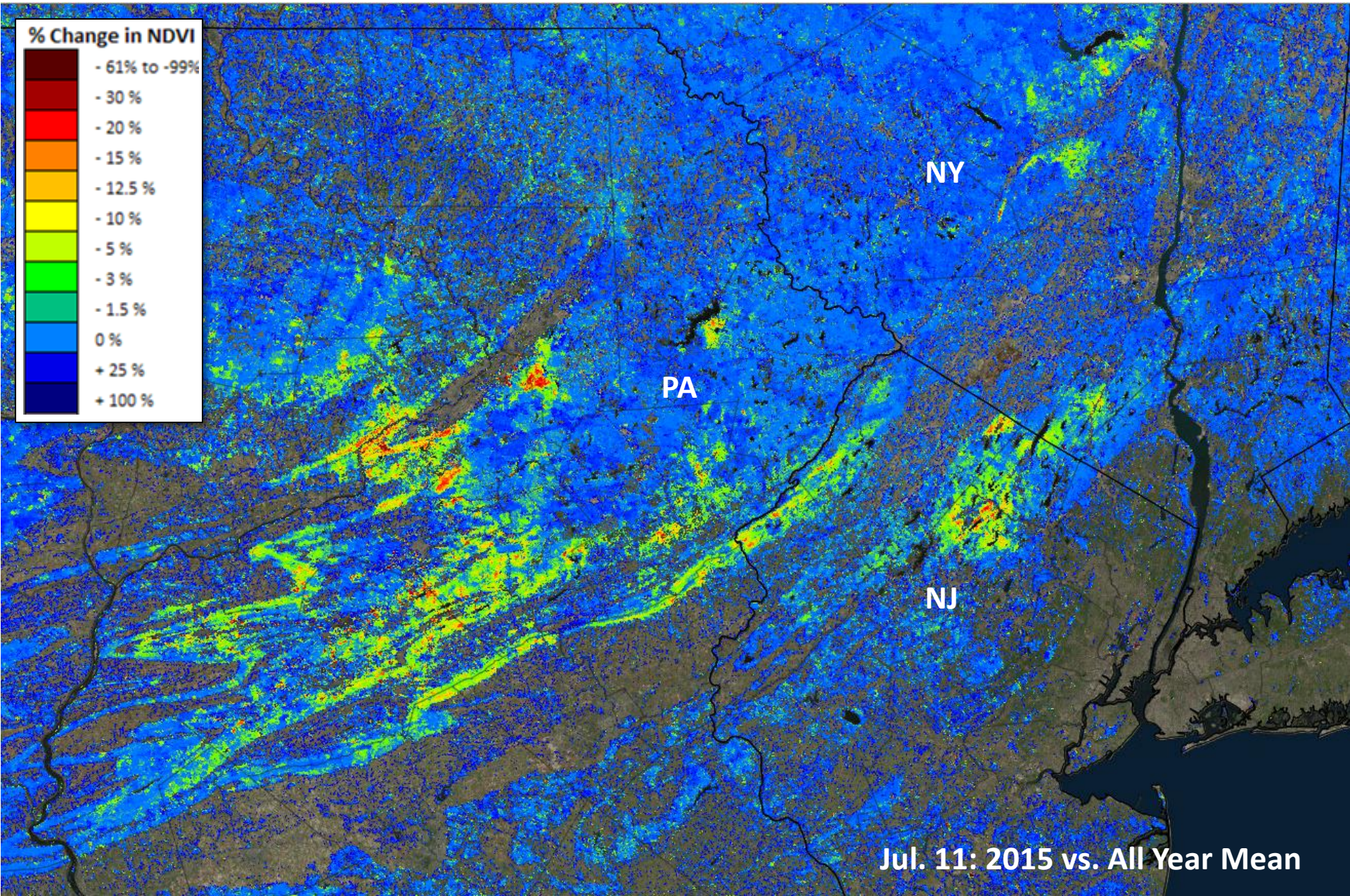
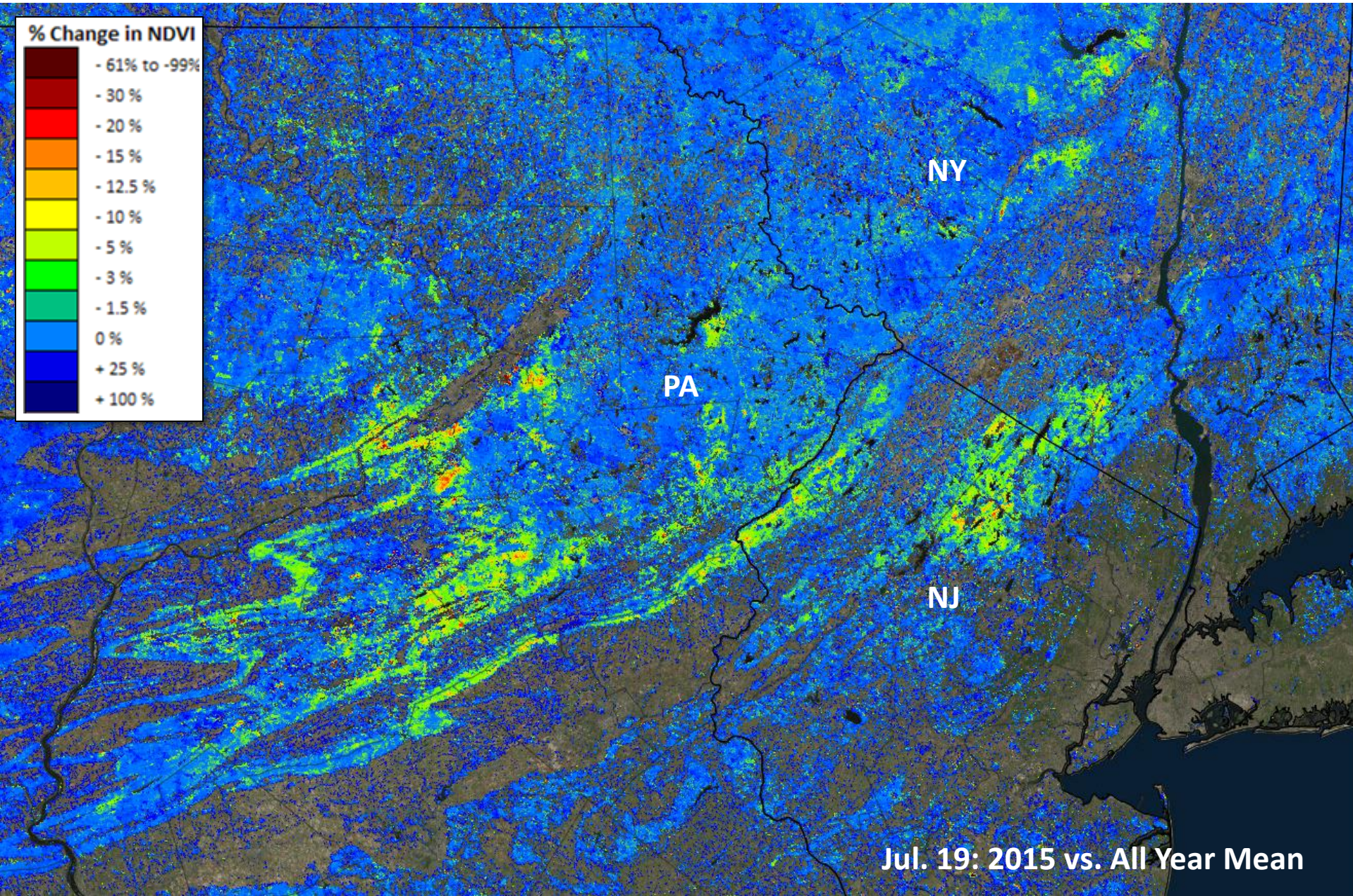


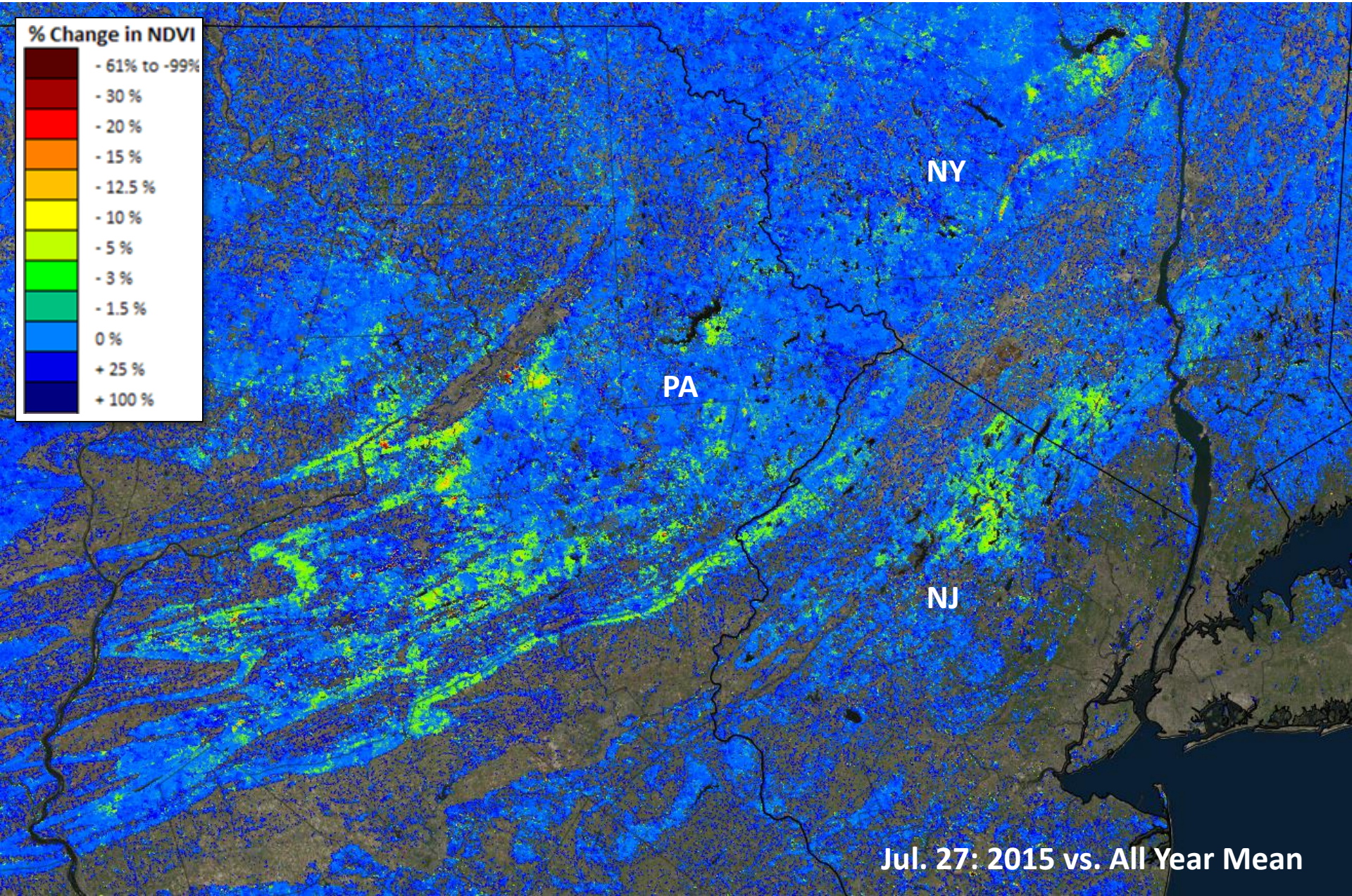
The 2015 Gypsy moth outbreak in the Northeast



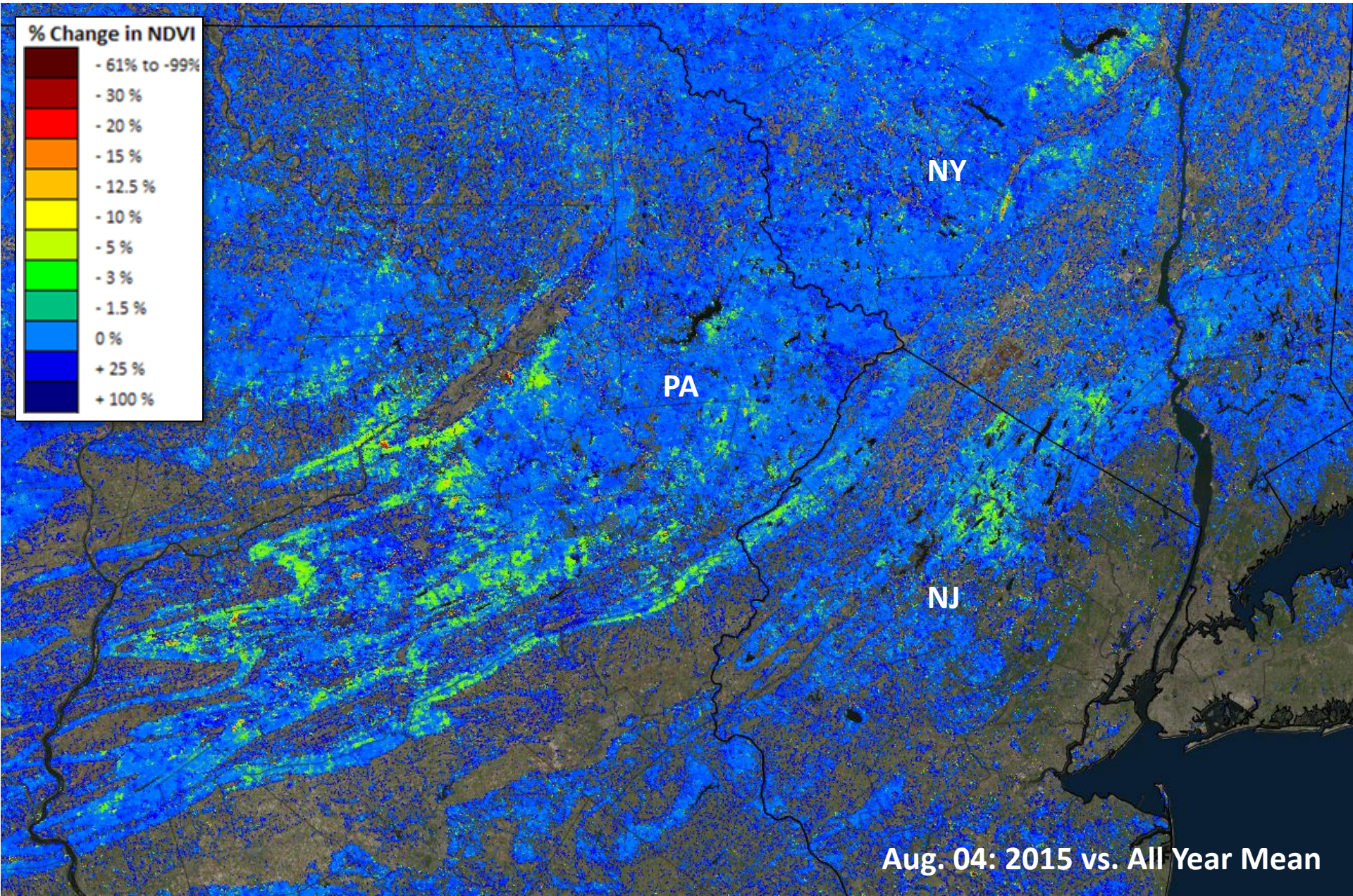
The 2015 Gypsy moth outbreak in the Northeast



The 2015 Gypsy moth outbreak in the Northeast



The 2015 Gypsy moth outbreak in the Northeast



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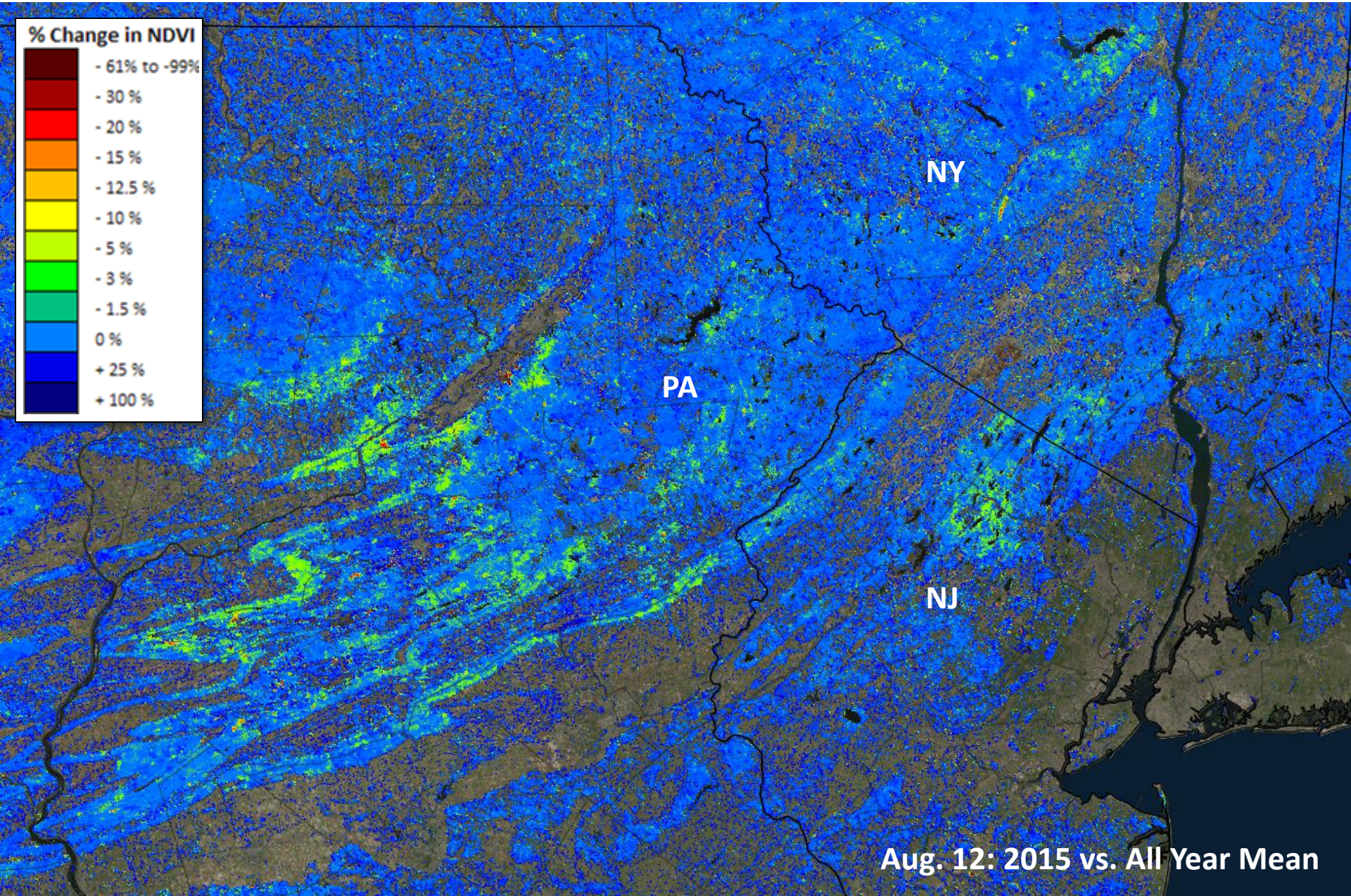

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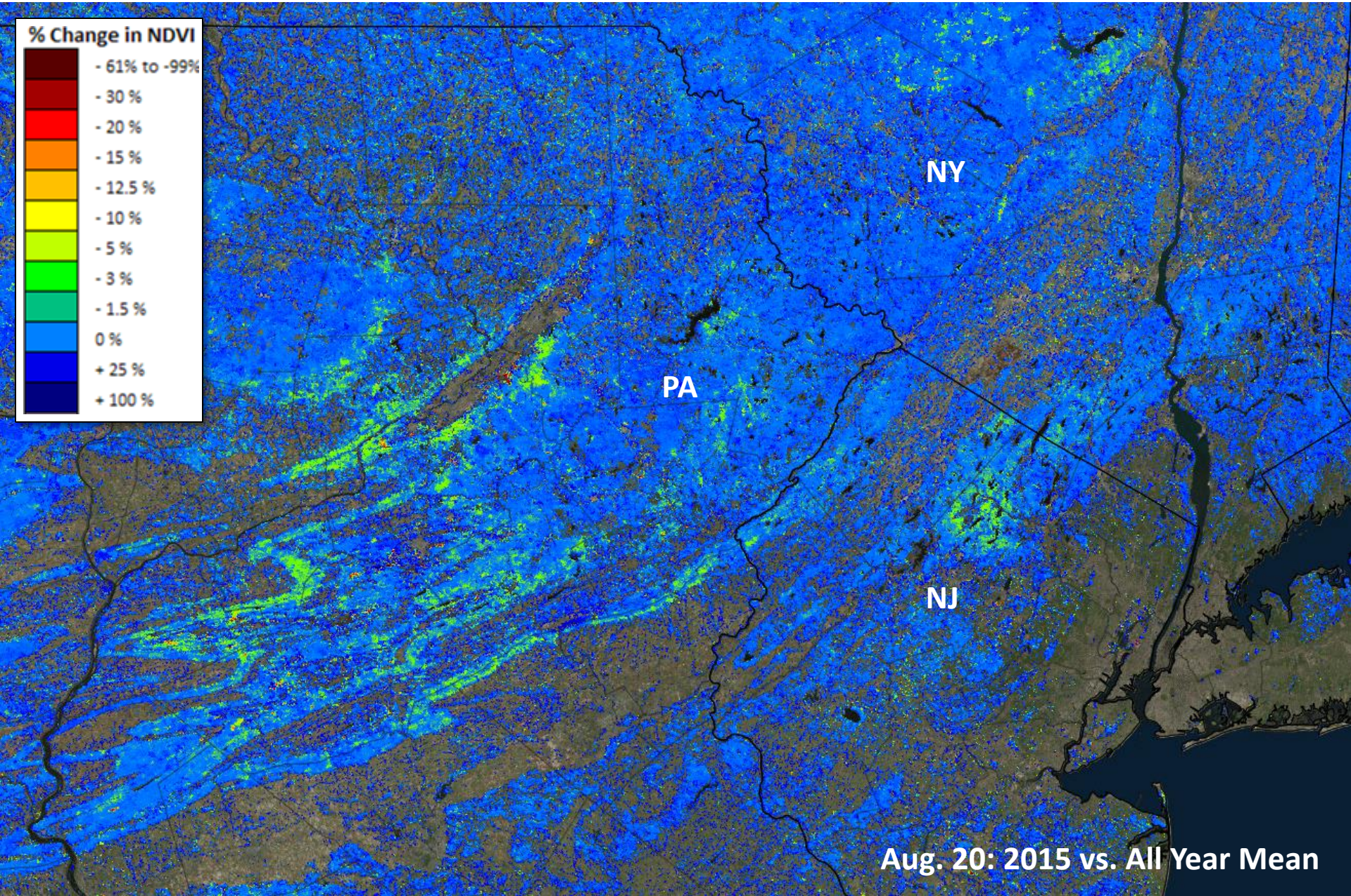

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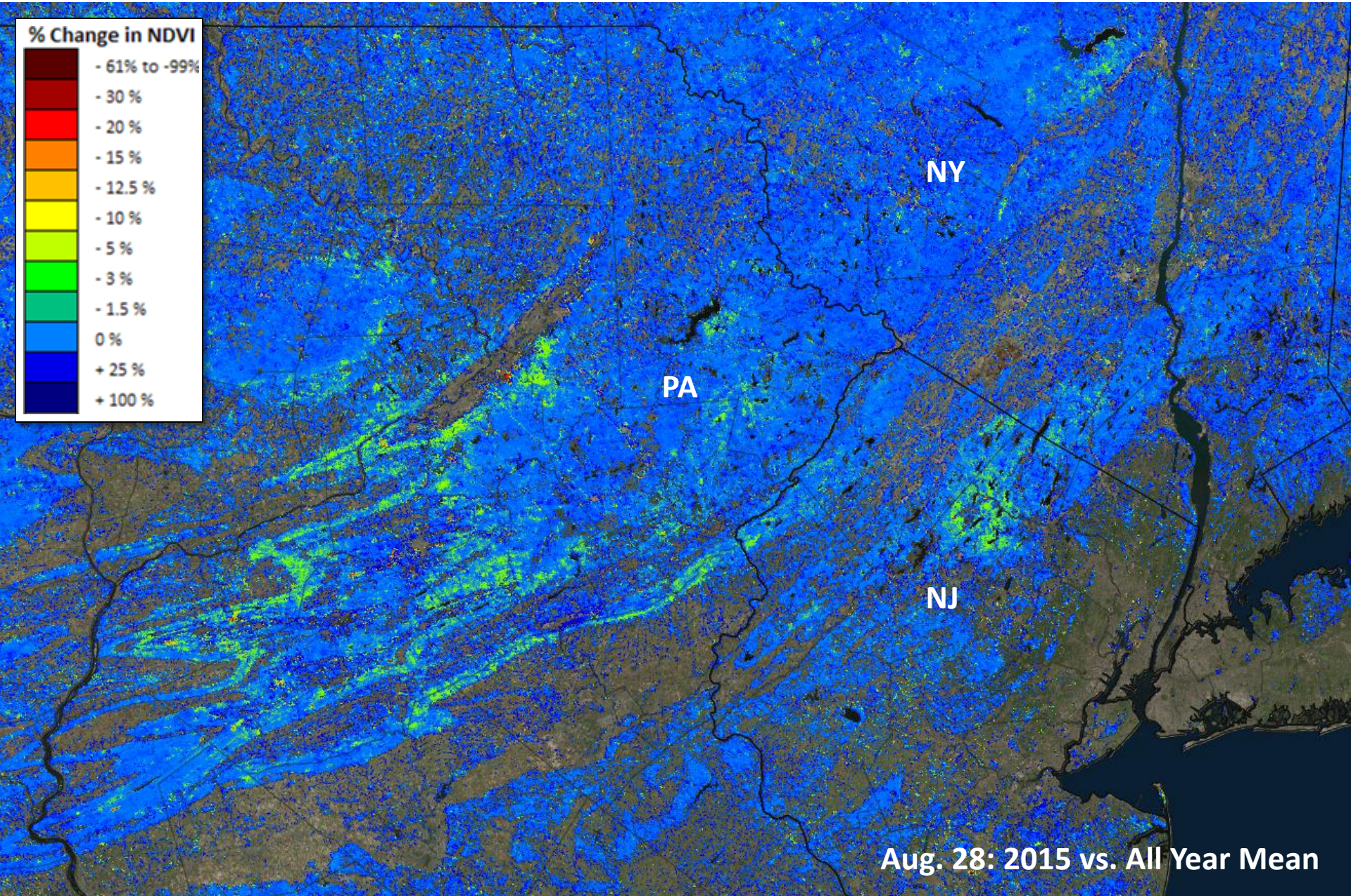

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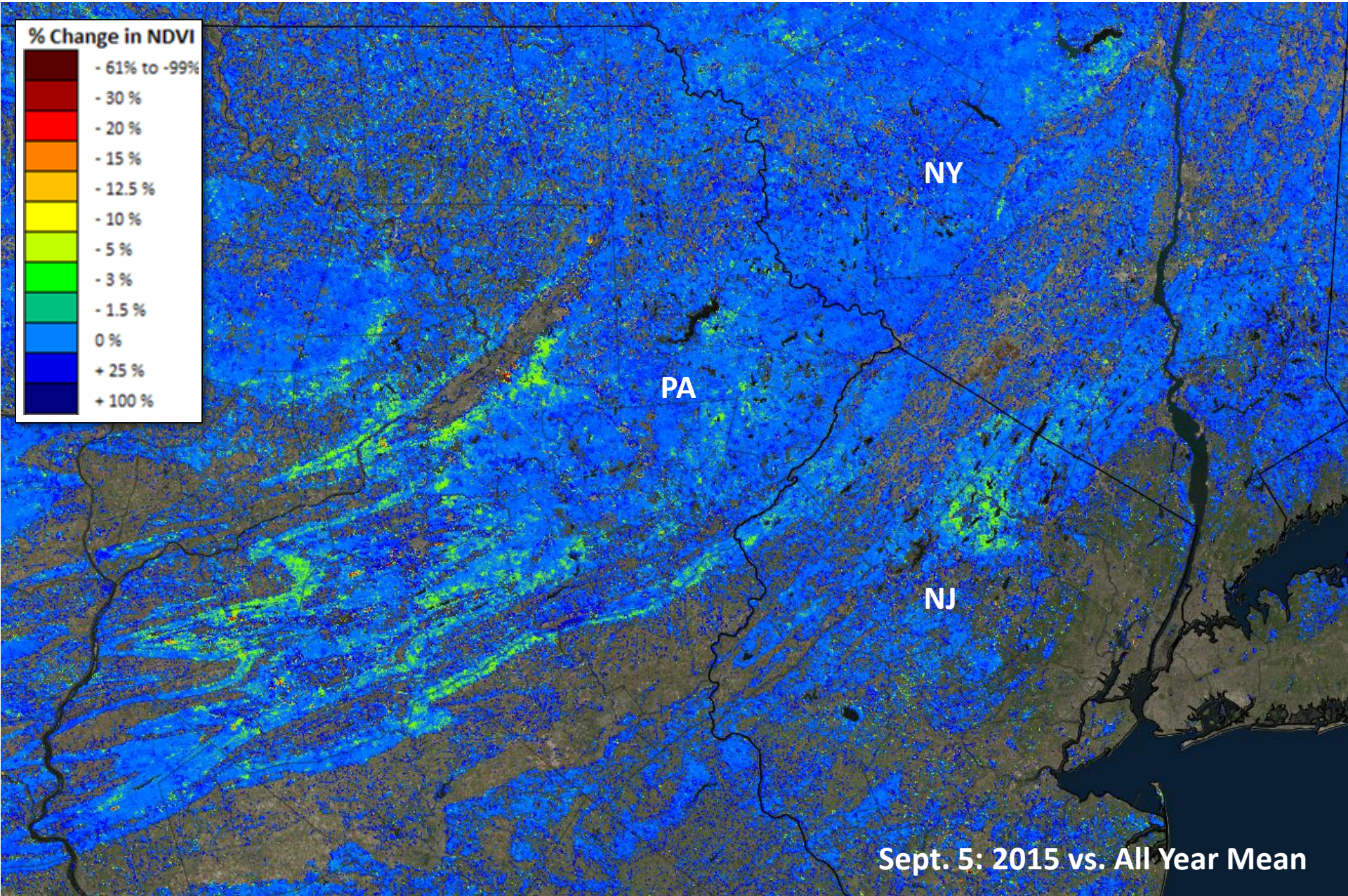
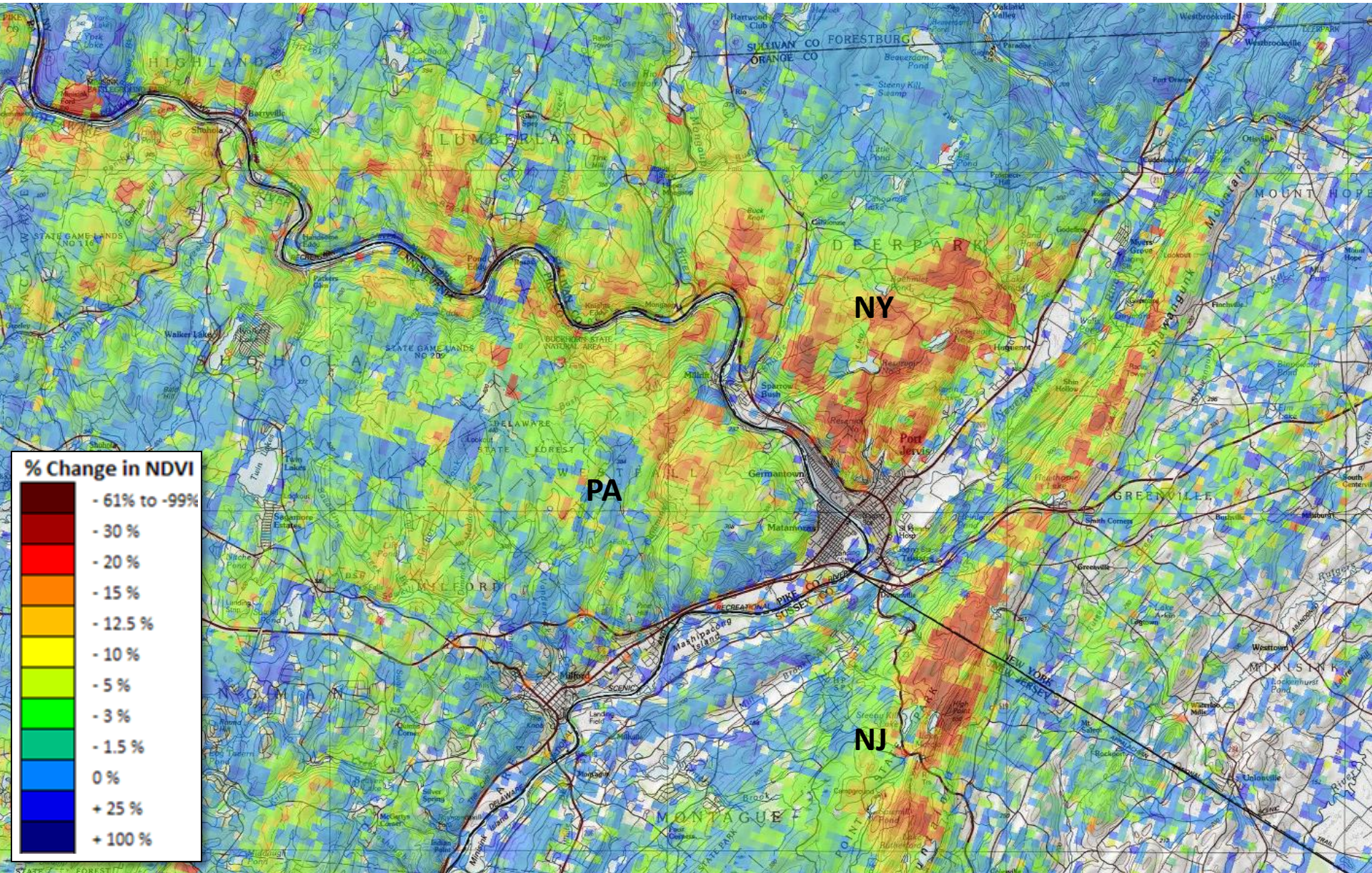


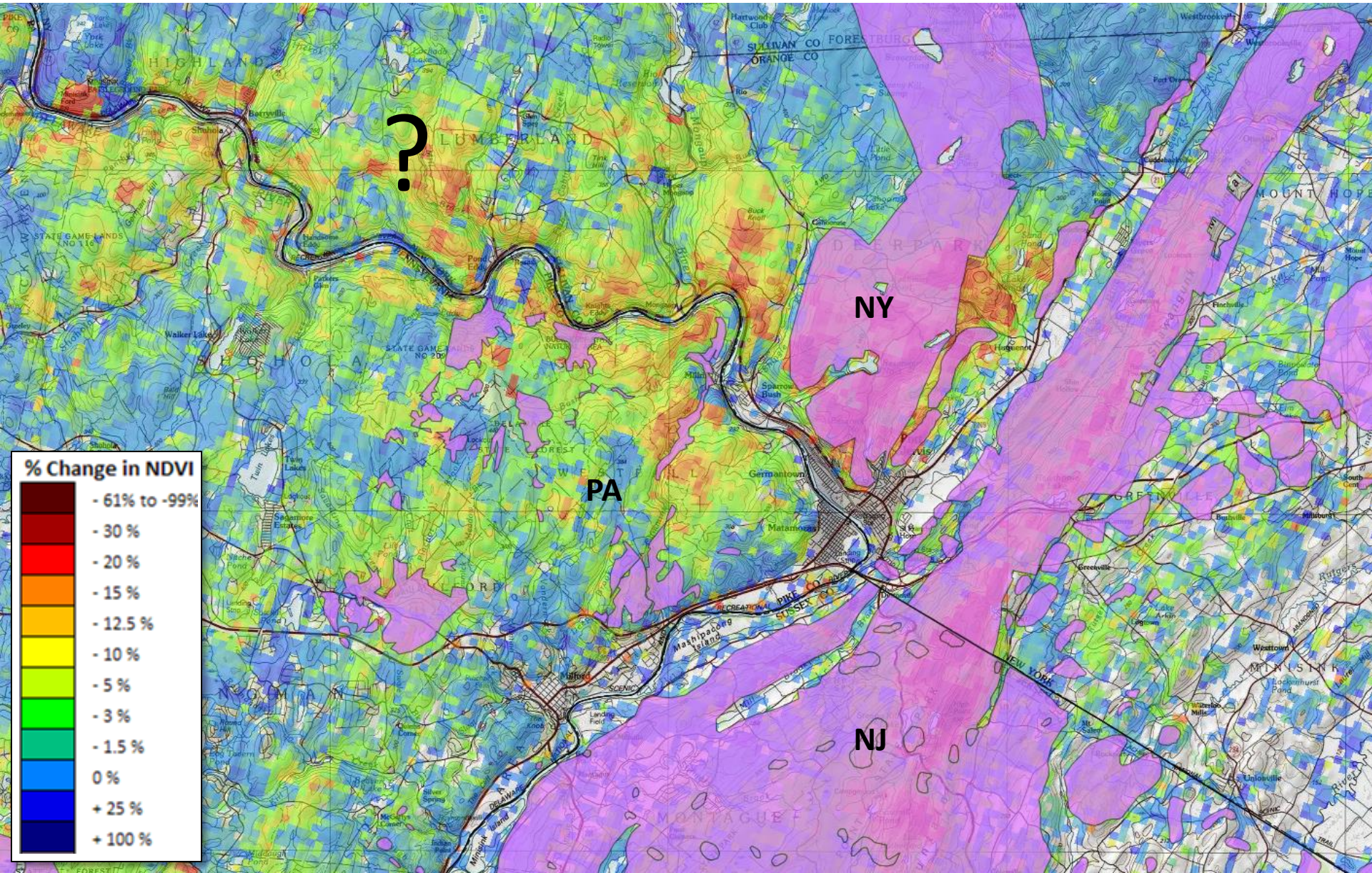
Comparing technologies that map Gypsy moth outbreaks

Jul. 10: 2008 vs. Prior 3-Year Max



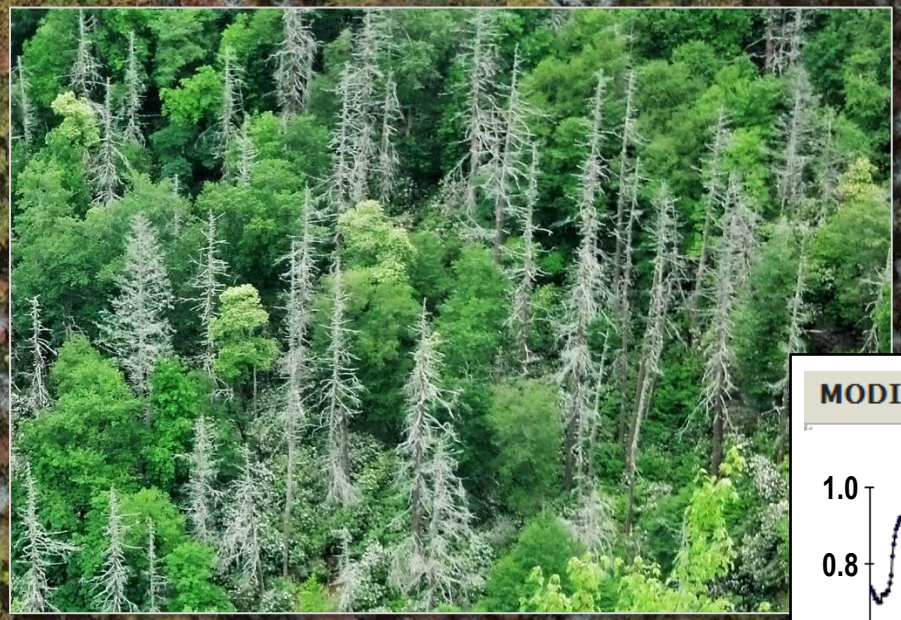
Comparing technologies that map Gypsy moth outbreaks

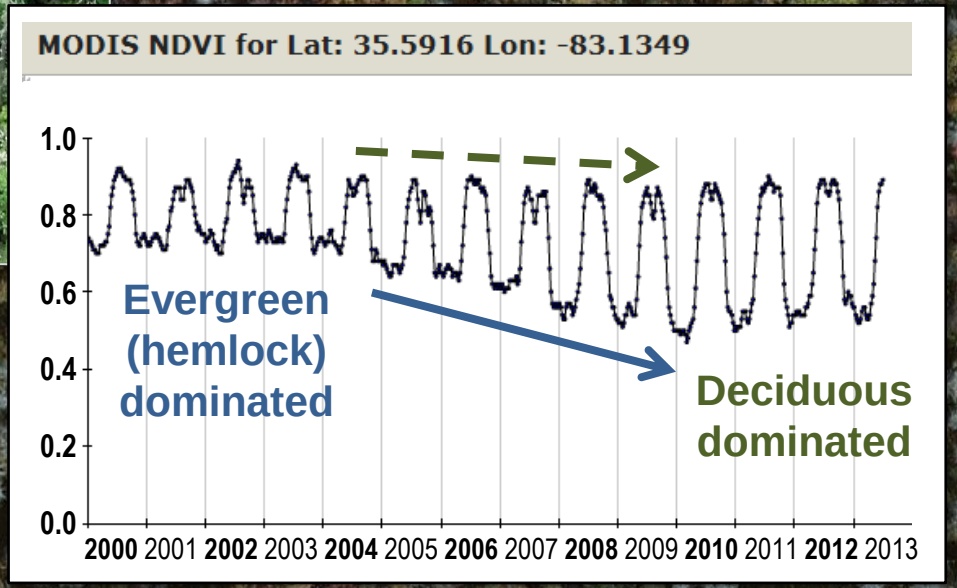
Jul. 10: 2008 vs. Prior 3-Year Max showing 2008 State Aerial Mapping Artifacts



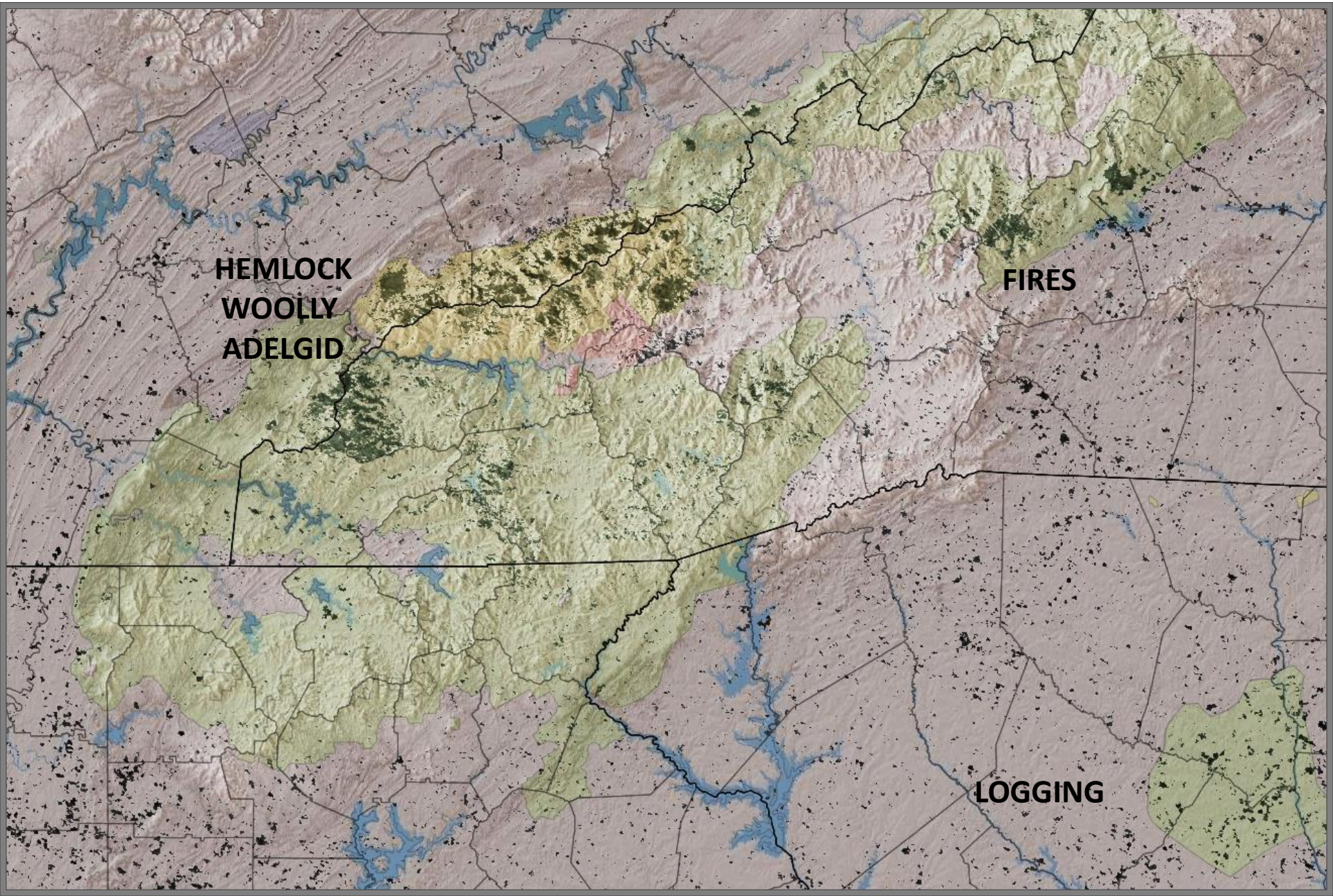
Gradual mortality from the non-native Hemlock Woolly Adelgid

Evergreen forests have a high winter NDVI and low inter-seasonal amplitude.

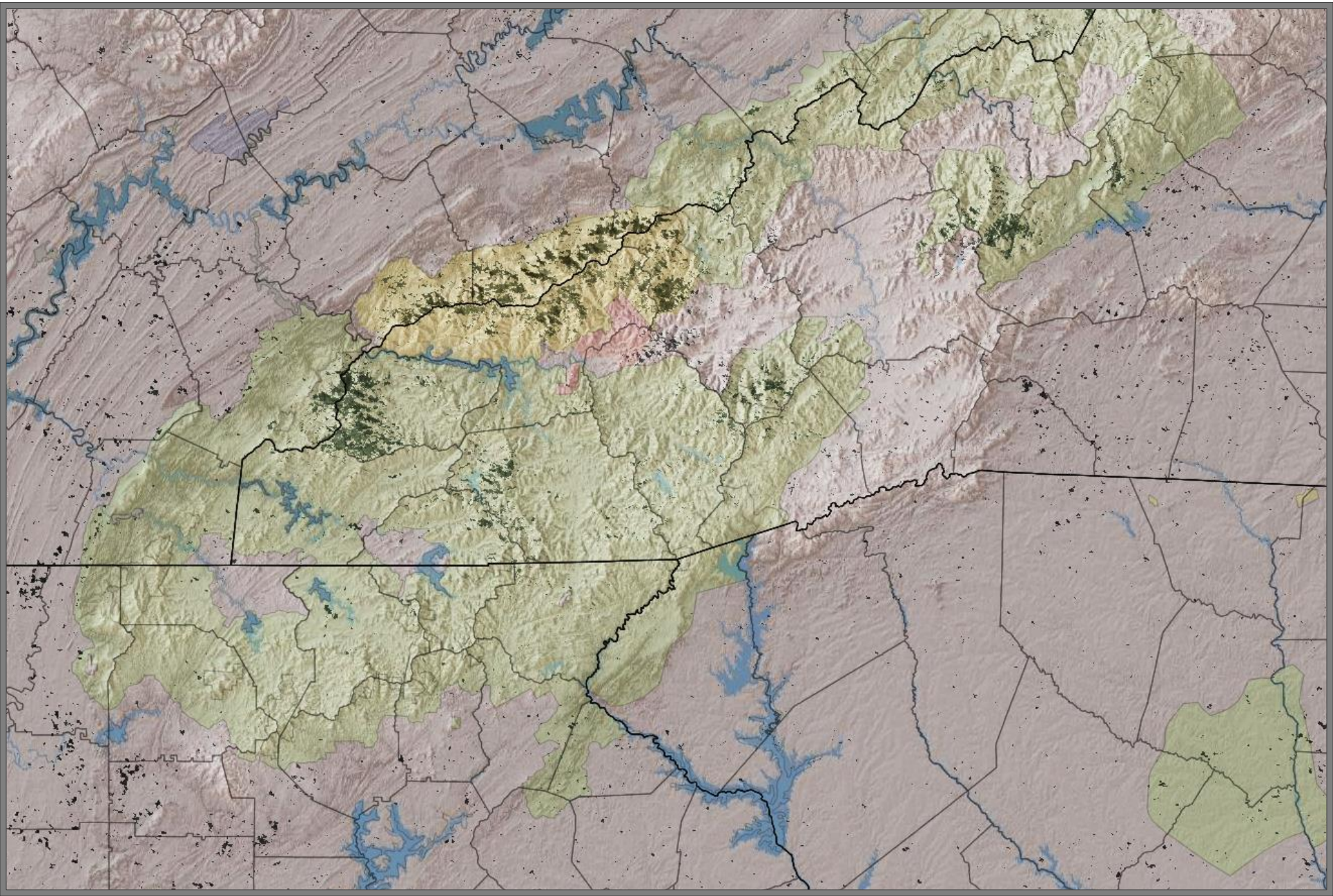




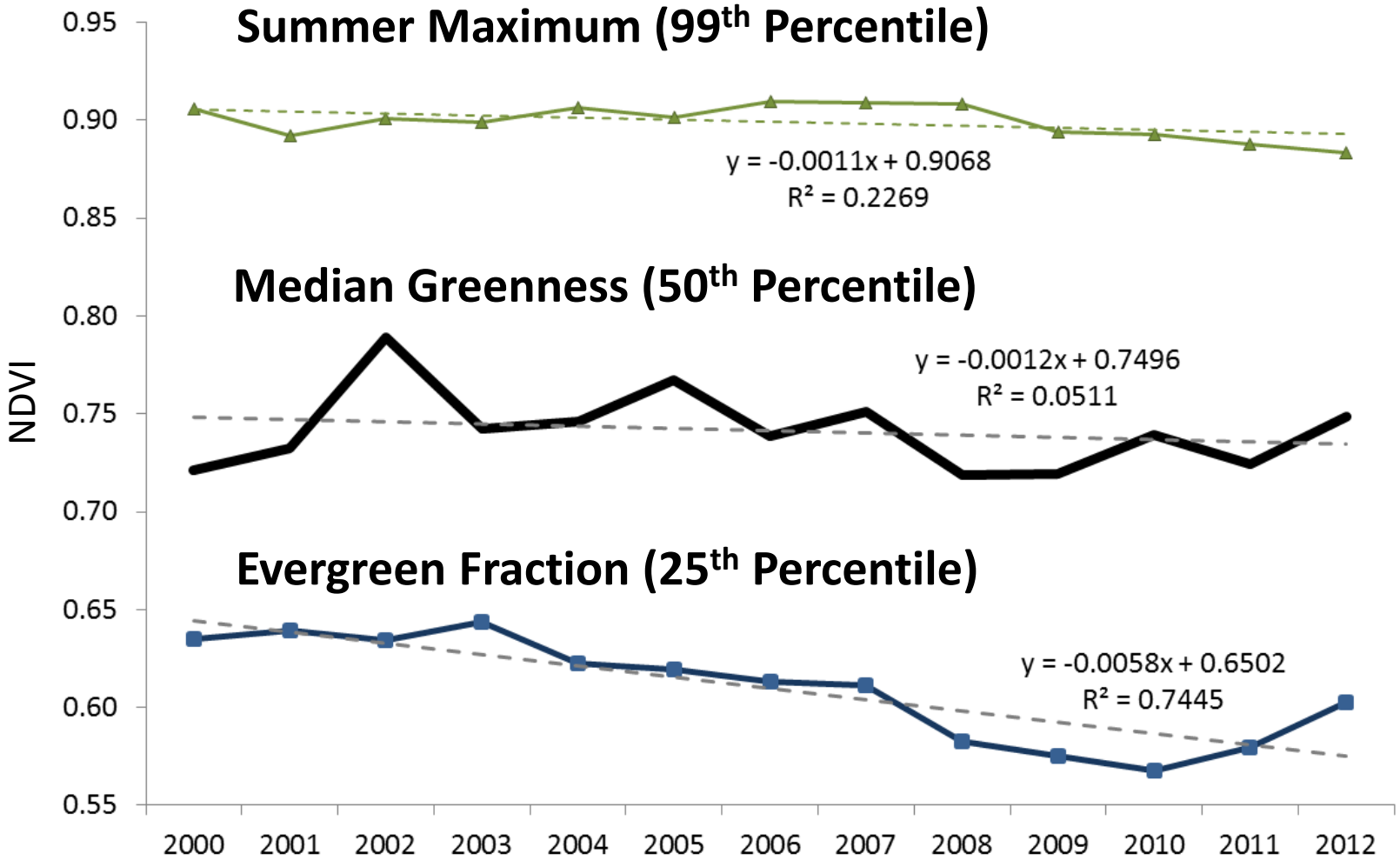
Tracking Evergreen Decline 2000-2010



Tracking Deciduous Increase 2000-2010

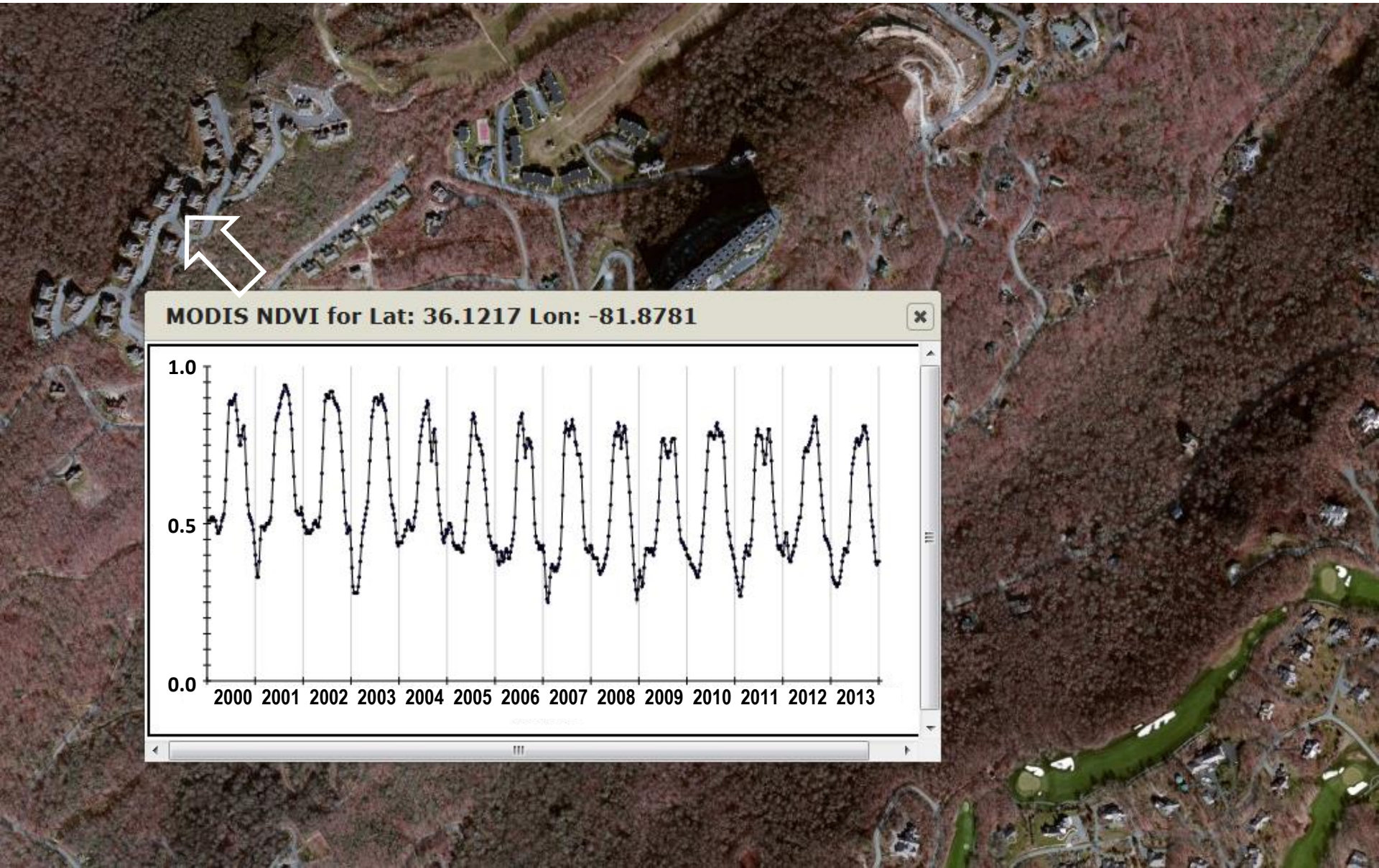


Monitoring multi-annual trends in Great Smoky Mountains National Park

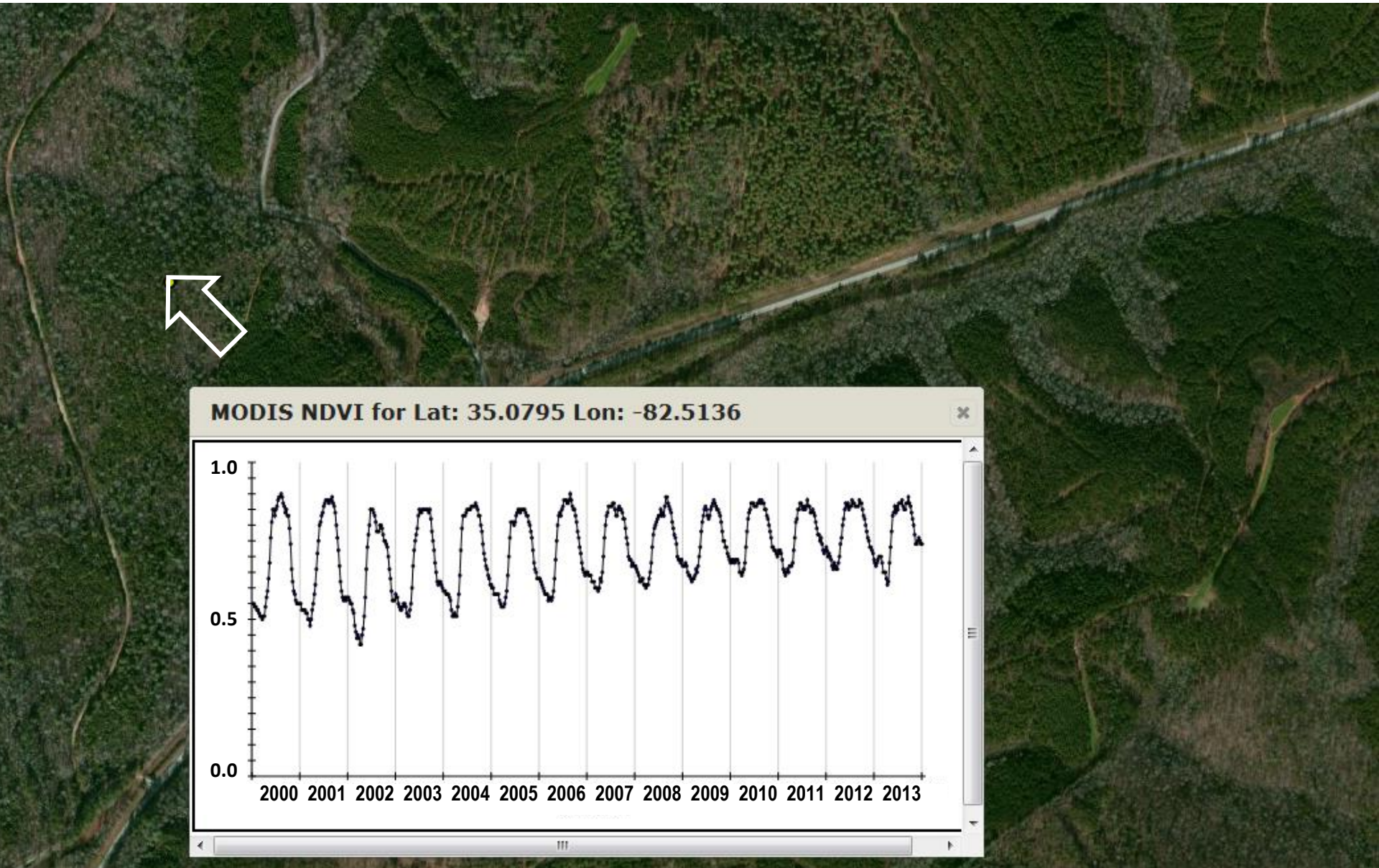


LAND COVER CHANGE

Mountaintop development in deciduous forests near Grandfather Mtn., NC



NDVI recovery after logging, Greenville County SC



Summary

- Forest disturbance is ubiquitous, and advances in remote sensing and computation let us see what's going on in new and exciting ways.

- These new science tools give us deeper insights into disturbances including:
  - the behavior of disturbances and recovery
  - disturbance geography across all lands
  - longer term perspectives, including the impacts of multiple disturbances and disturbance regimes

stevenorman@fs.fed.us