Recognizing gradual loss of forest resilience using continuous satellite-based monitoring
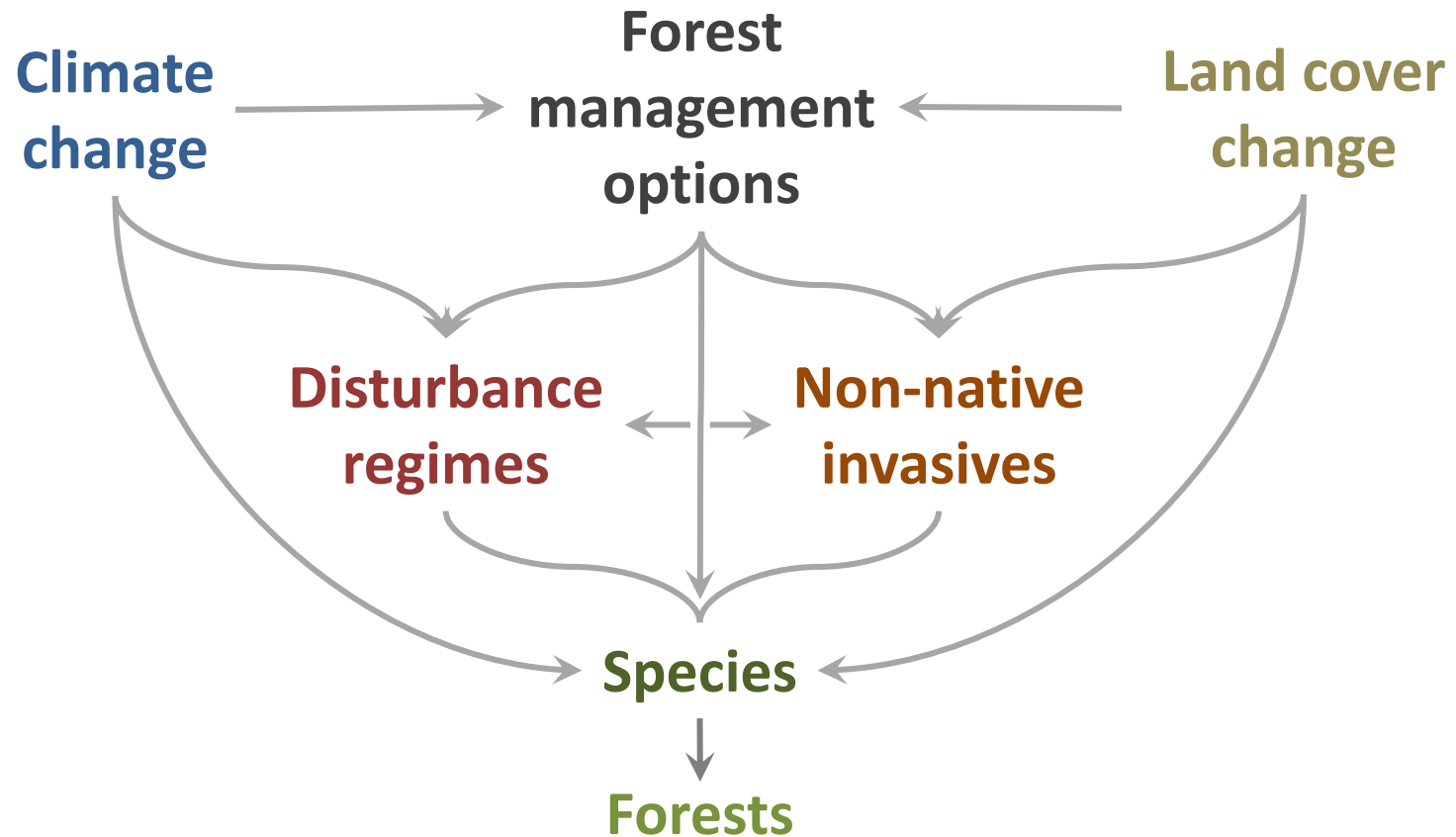
Steven P. Norman
William W. Hargrove
Joseph P. Spruce
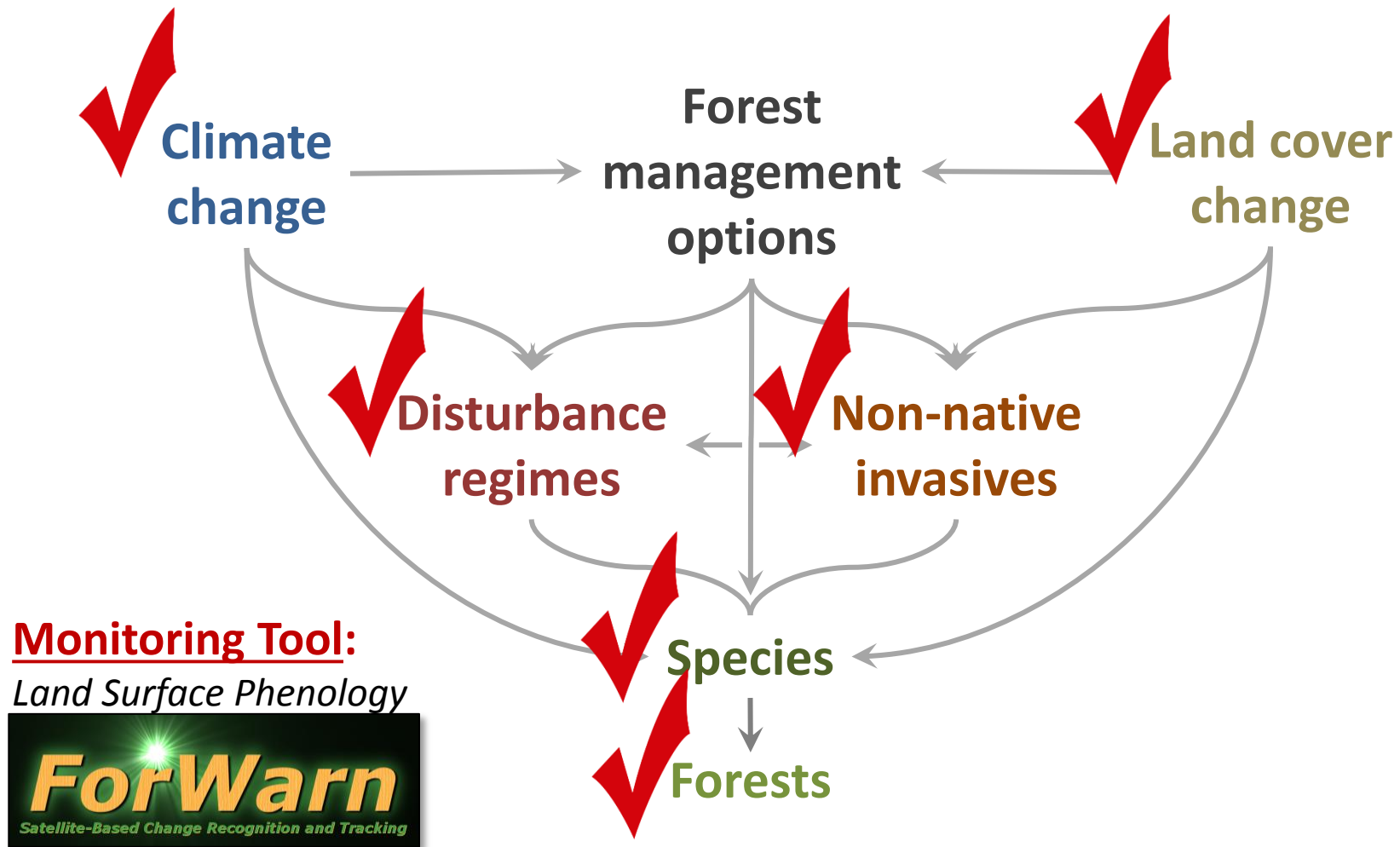**William C. Christie**

Appalachian Society of American Foresters
94th Annual Winter Meeting
Columbia, South Carolina, Jan. 21-23, 2015

Natural Disasters – How Managers Prepare, Foresters Respond, and Forests Recover"

# Gradual change in these factors can erode landscape resilience

Gradual change in these factors can erode landscape resilience

✓ **Climate change** → **Forest management options** ← **Land cover change** ✓

✓ **Disturbance regimes** — **Non-native invasives** ✓

✓ **Species**

Monitoring Tool:
Land Surface Phenology

ForWarn
Satellite-Based Change Recognition and Tracking

✓ **Forests**

The *ForWarn* system

- Normalized Difference Vegetation Index (NDVI) from daily eMODIS and MODIS
- 232 meter resolution
- 46 periods per year (8-day intervals)
- Max value of 24-day moving window
- 2000 to present historical database
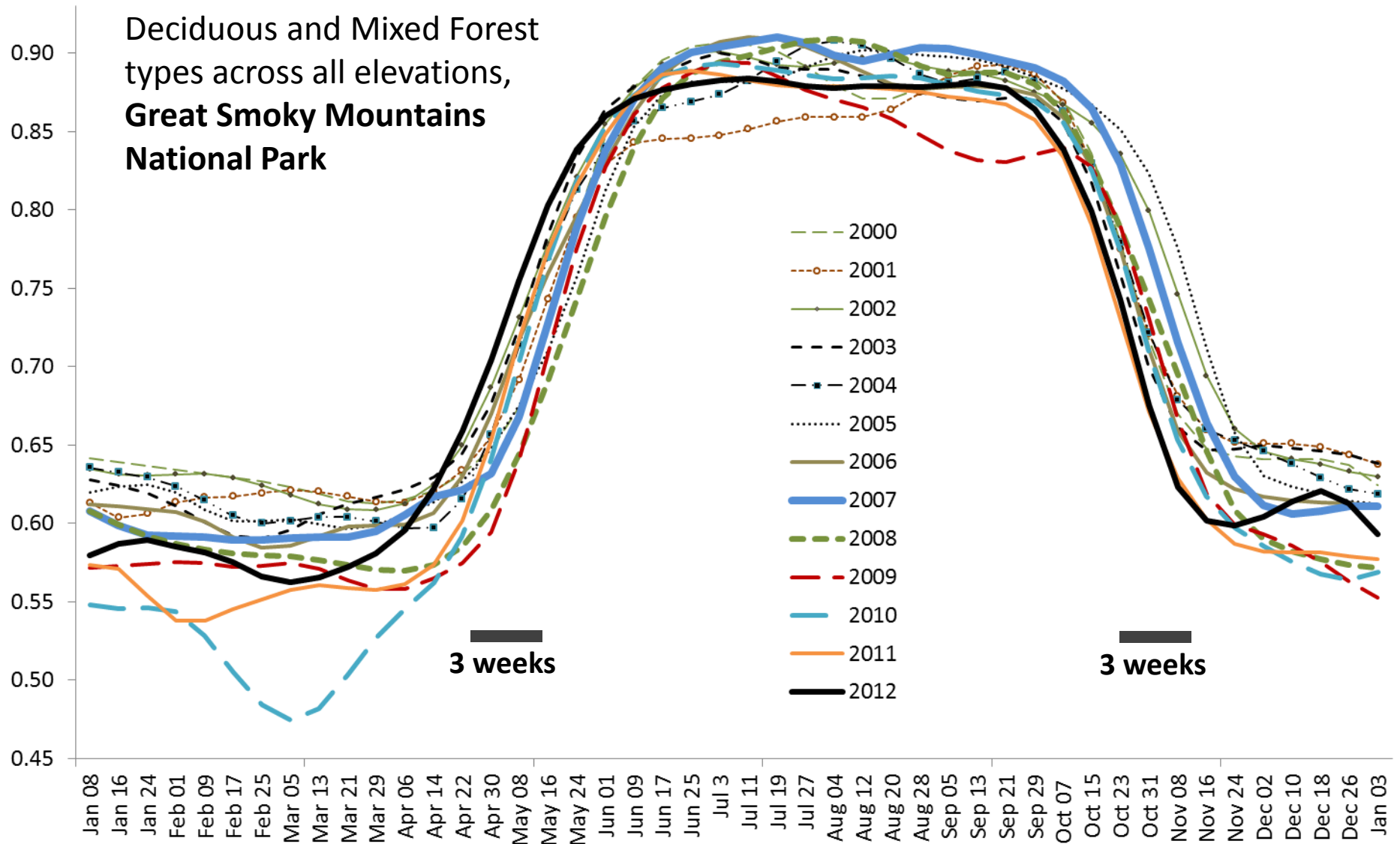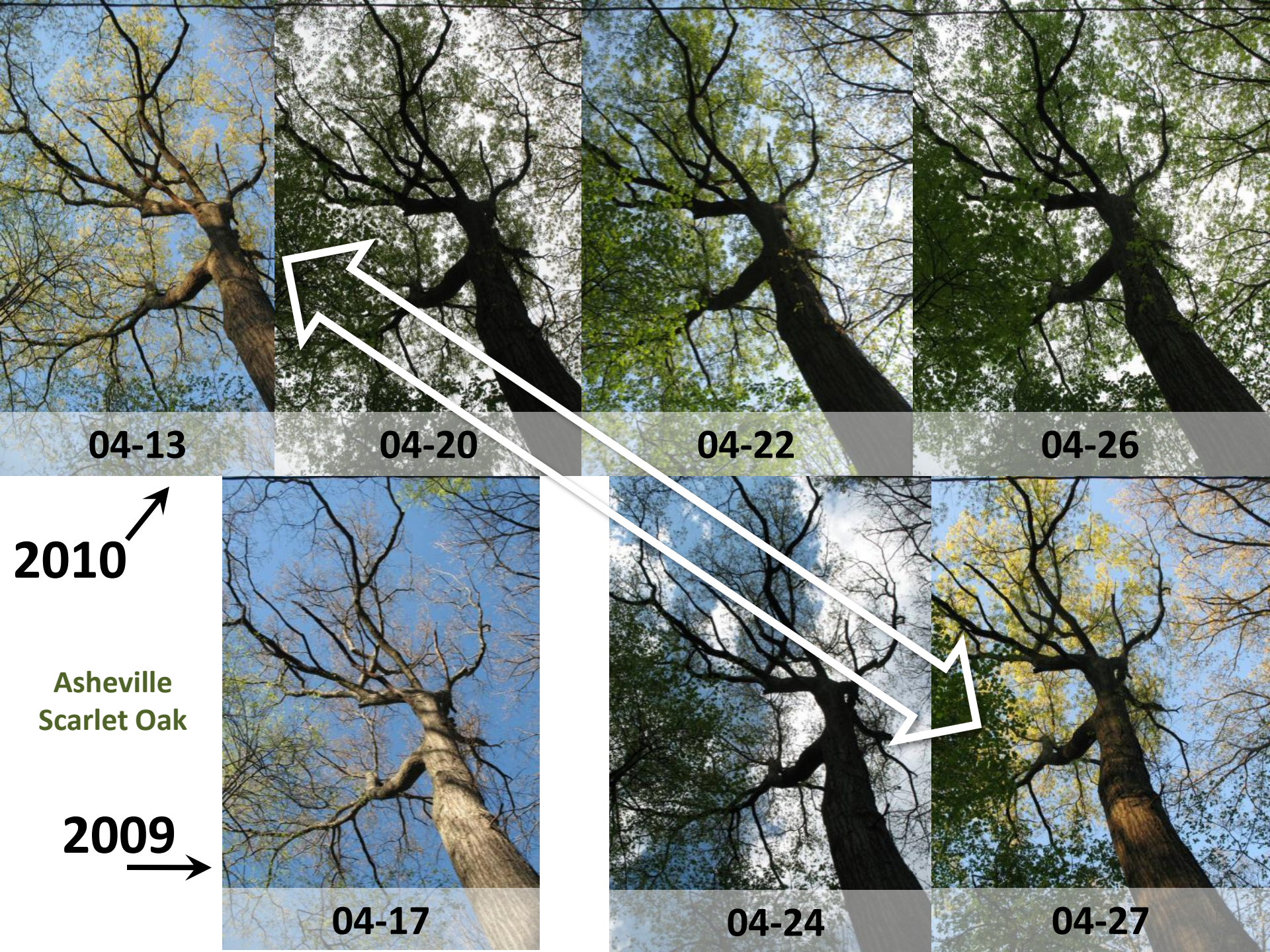- Includes NDVI time series and change maps
- Online: http://forwarn.forestthreats.org
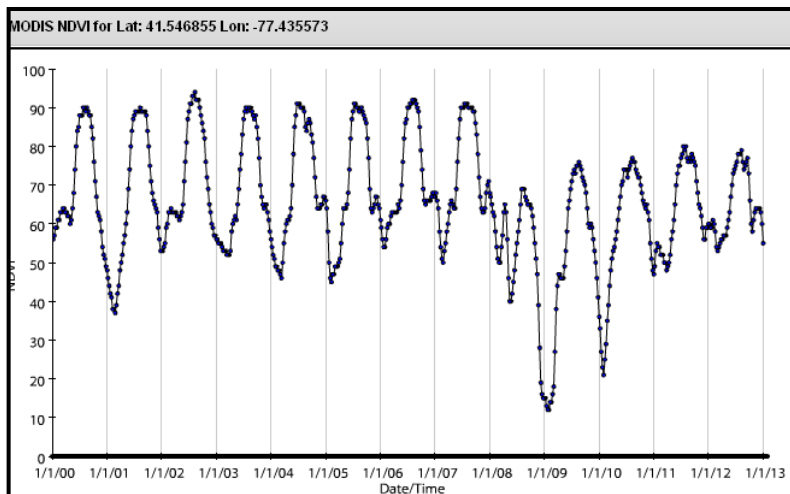
Baselines
- 1 year Early Detect
- 1 year value
- 3 year maximum
- All year maximum
- All year mean
- All year type mean
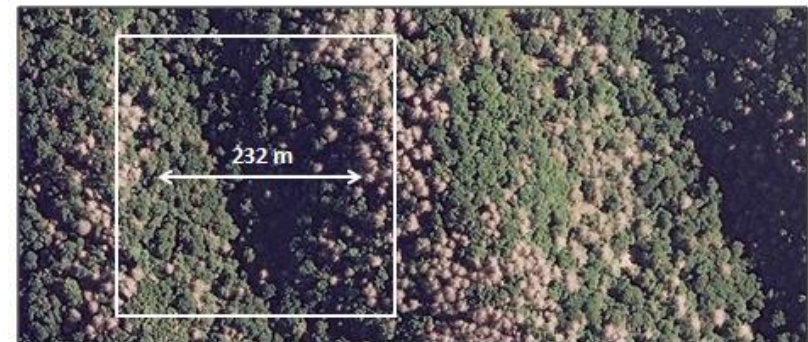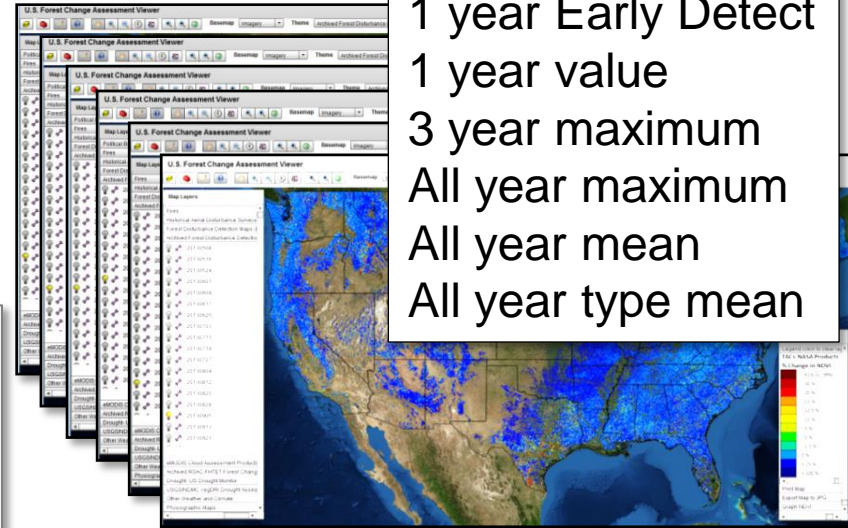
MODIS NDVI for Lat: 41.546855 Lon: -77.435573

Monitoring within-season to inter-year variation in weather- and climate-sensitive vegetational phenology

Deciduous and Mixed Forest types across all elevations, **Great Smoky Mountains National Park**

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

Effects of a warm March and April Frost along the Snowball Trail (4,950ft.), Pisgah National Forest, NC
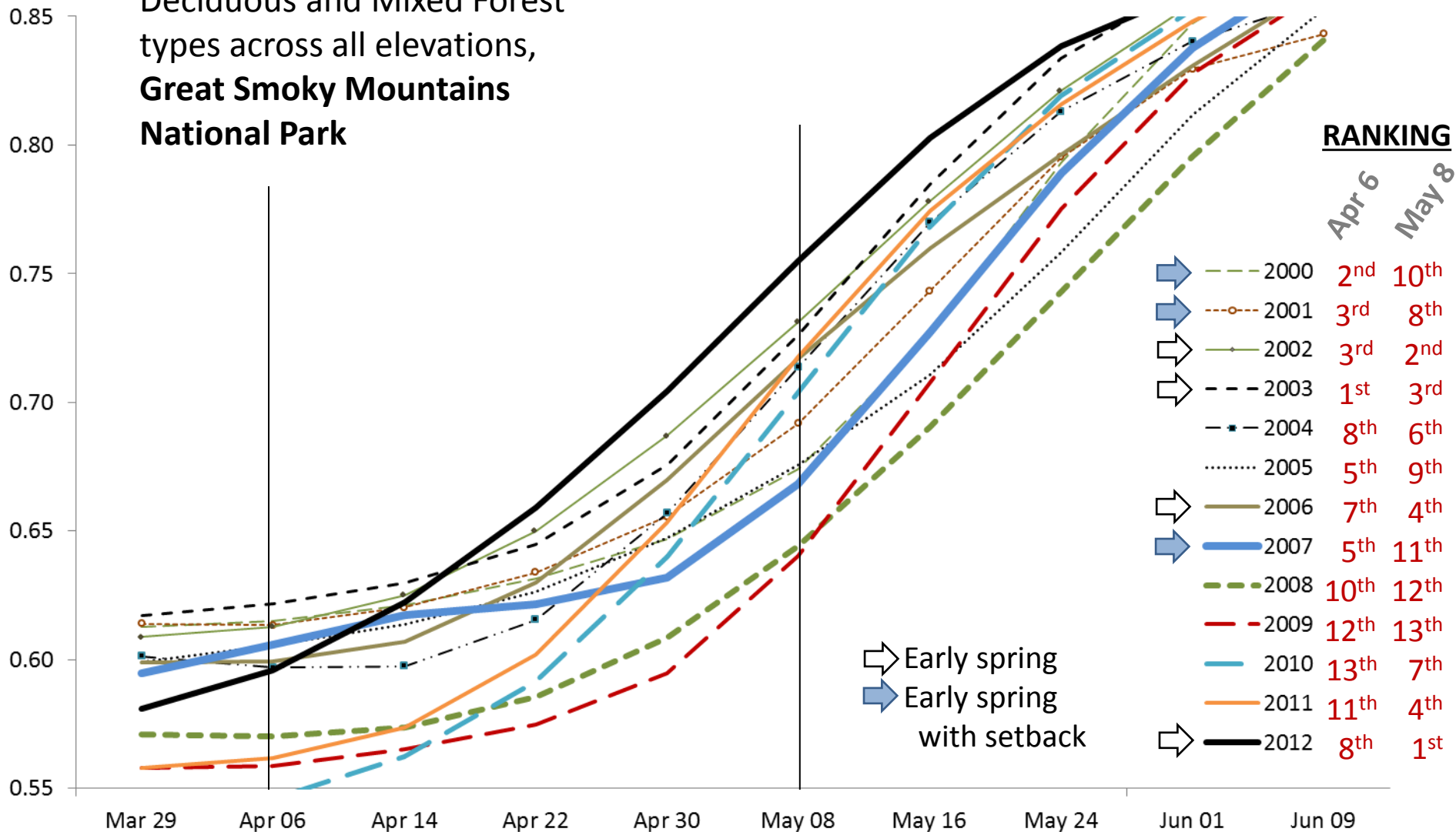(photos taken 4/27/2012 by SPN)

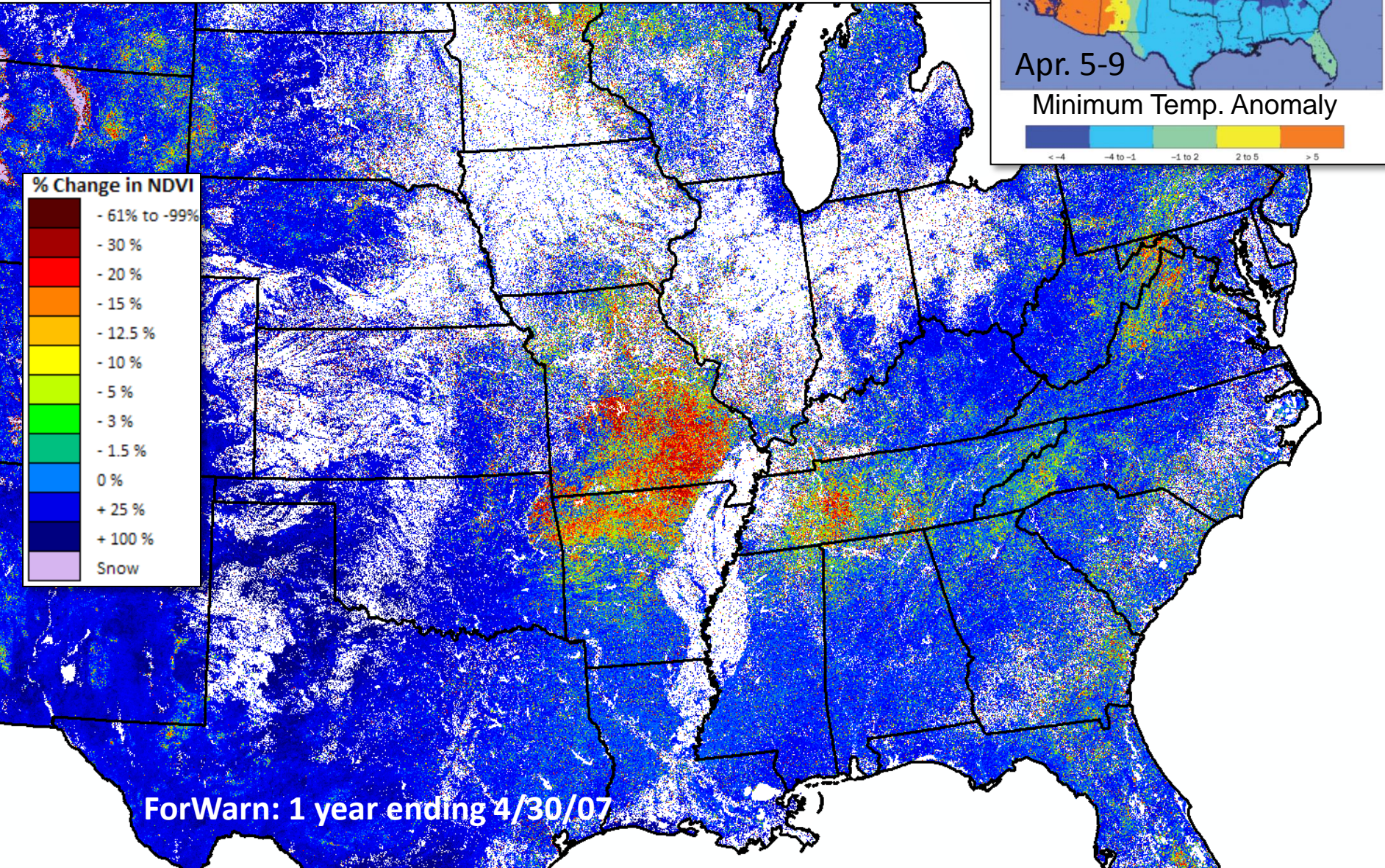Hobblebush Viburnum

Turk's Cap Lily

Yellow Buckeye

Monitoring within-season to inter-year variation in weather- and climate-sensitive vegetational phenology

Deciduous and Mixed Forest types across all elevations, **Great Smoky Mountains National Park**
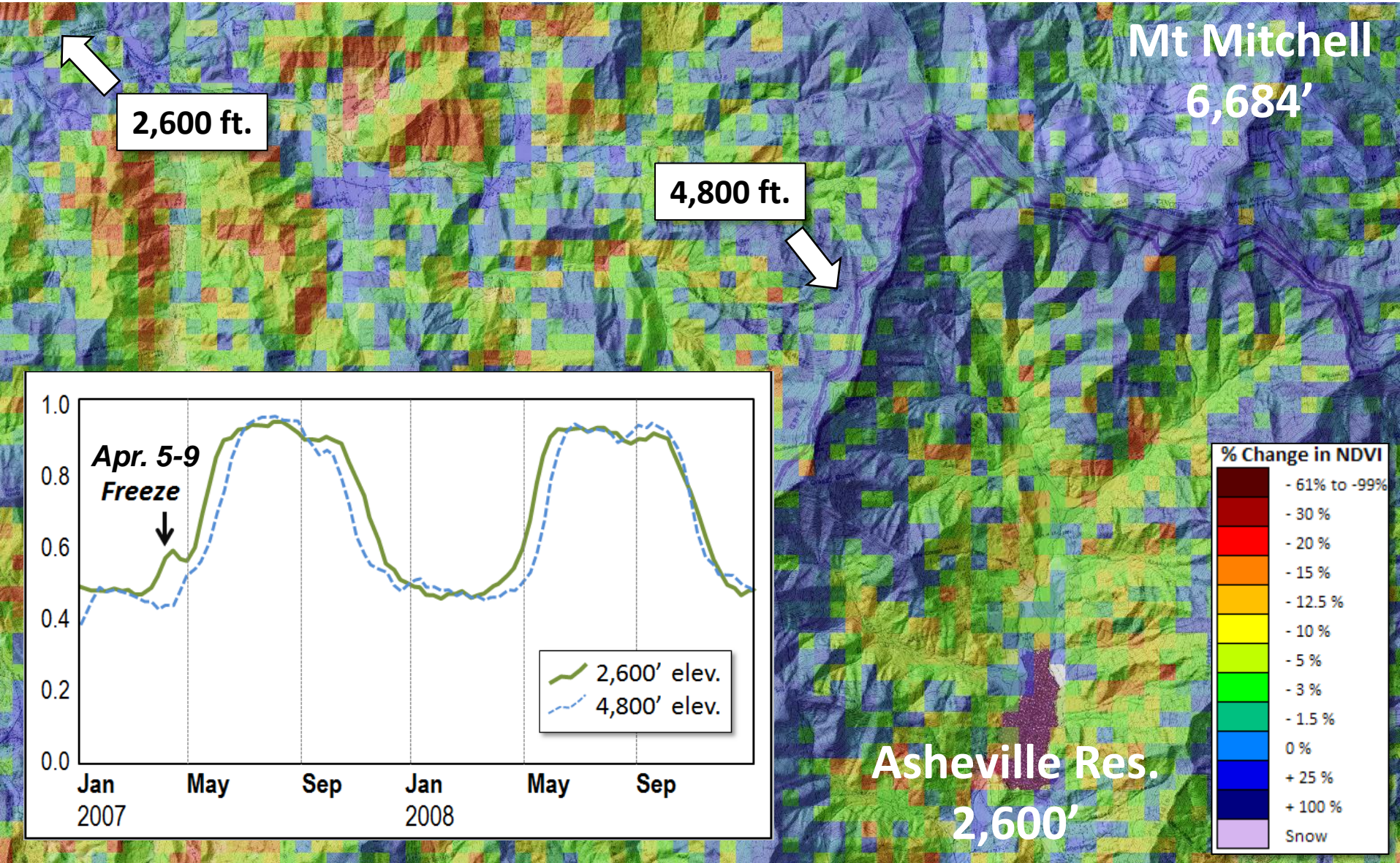
RANKING

	Apr 6	May 8
2000	2nd	10th
2001	3rd	8th
2002	3rd	2nd
2003	1st	3rd
2004	8th	6th
2005	5th	9th
2006	7th	4th
2007	5th	11th
2008	10th	12th
2009	12th	13th
2010	13th	7th
2011	11th	4th
2012	8th	1st

⇨ Early spring
⇨ Early spring with setback

Mean of 38,318 MODIS cells

Monitoring disturbances linked to gradual change: The 2007 "Big Freeze"

Apr. 5-9
Minimum Temp. Anomaly

| < -4 | -4 to -1 | -1 to 2 | 2 to 5 | > 5 |

% Change in NDVI

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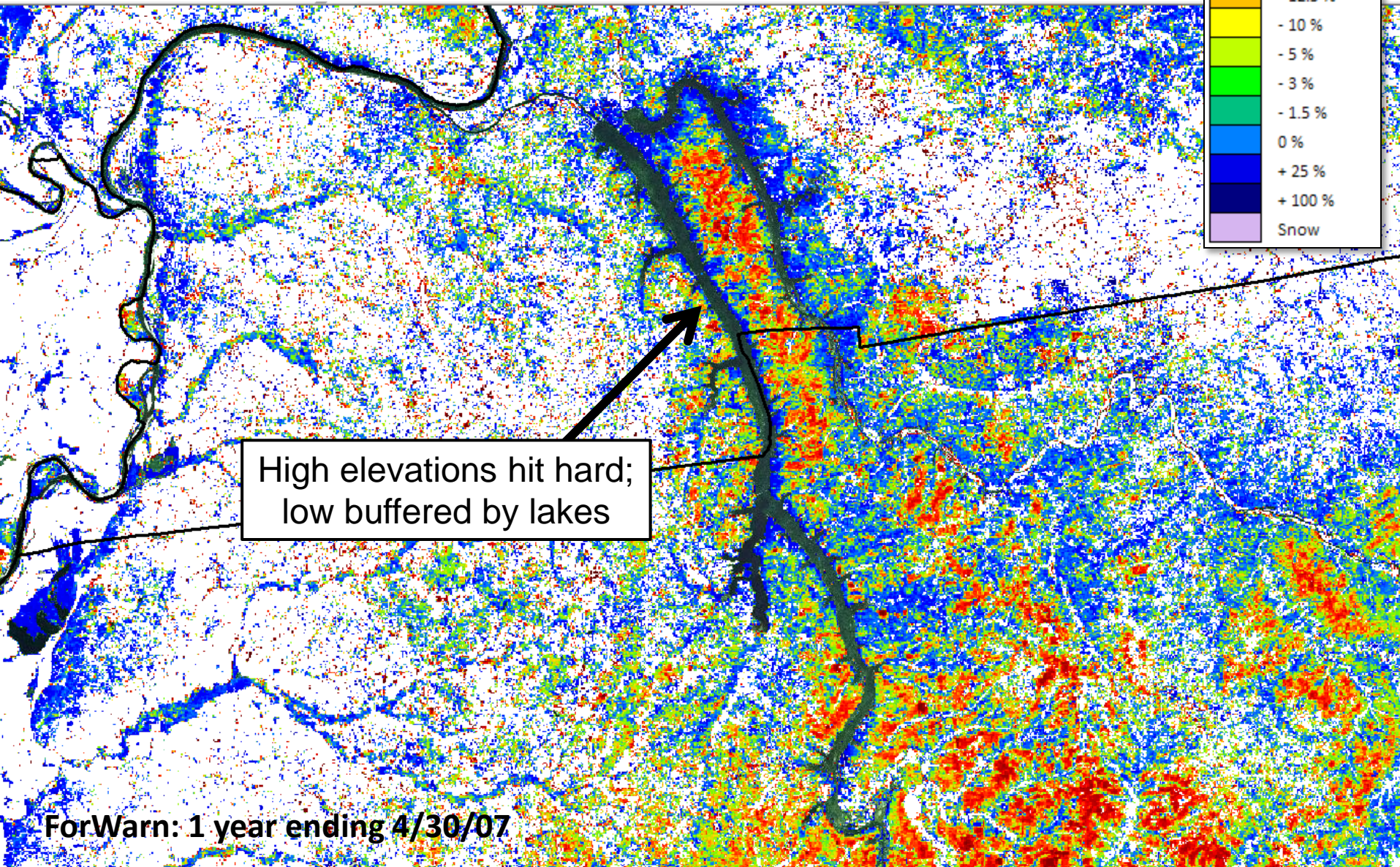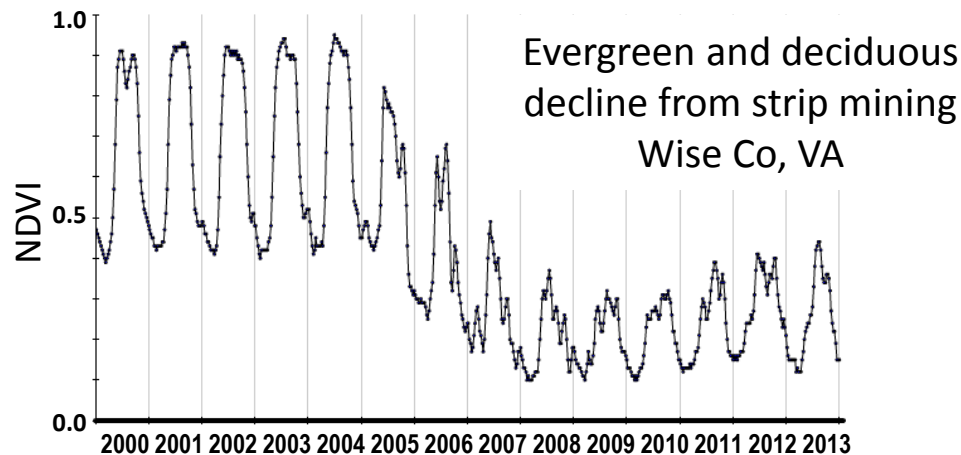- 1.5 %
- 0 %
+ 25 %
+ 100 %
- Snow

ForWarn: 1 year ending 4/30/07

Monitoring disturbances linked to gradual change: The 2007 "Big Freeze"—Topographic nuances

Monitoring disturbances linked to gradual change: The 2007 "Big Freeze"
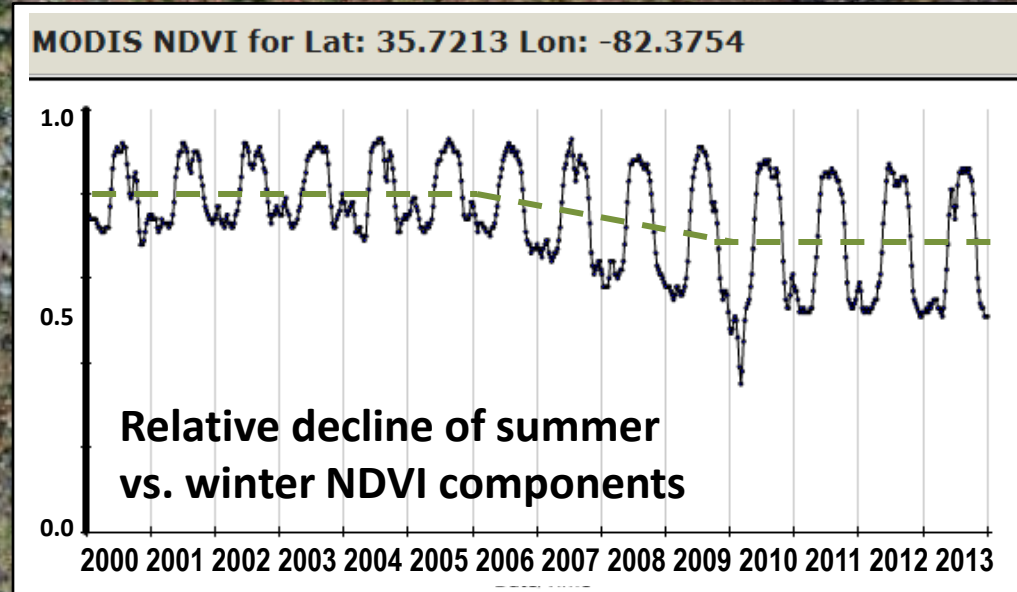

% Change in NDVI

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

High elevations hit hard; low buffered by lakes

ForWarn: 1 year ending 4/30/07

Monitoring change in vegetational type using insights from high frequency MODIS time series

DECIDUOUS FRACTION — **Low** winter NDVI; **high** inter-seasonal amplitude

EVERGREEN FRACTION — **High** winter NDVI; **low** inter-seasonal amplitude

Evergreen and deciduous decline from strip mining Wise Co, VA
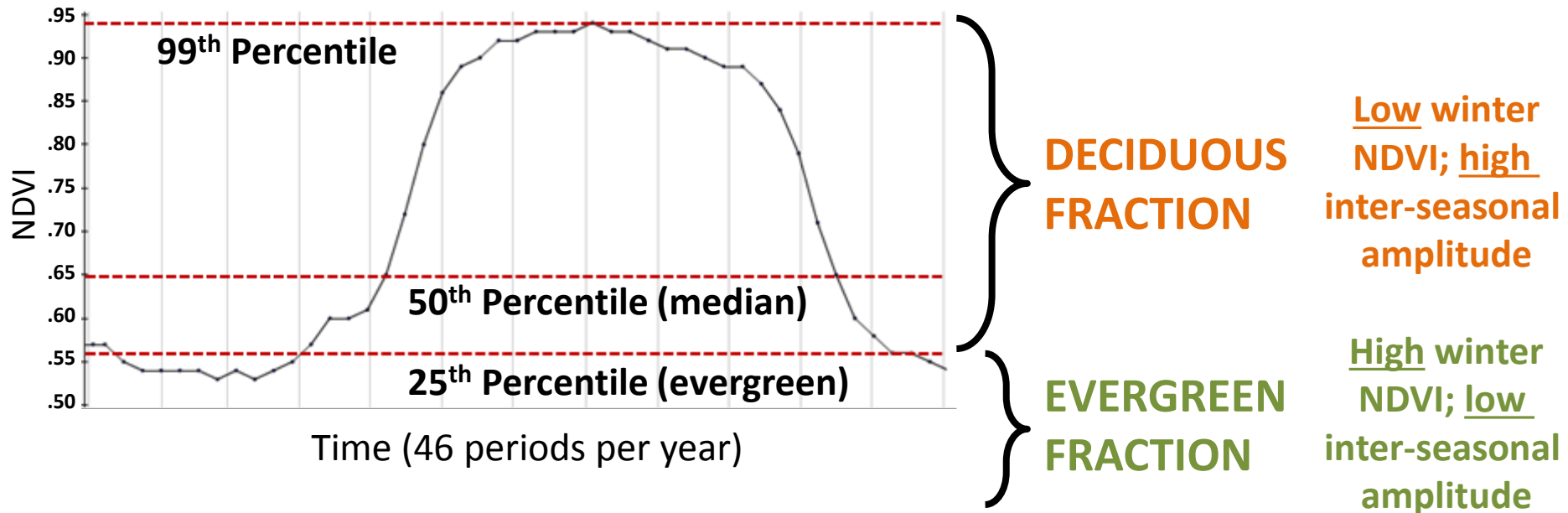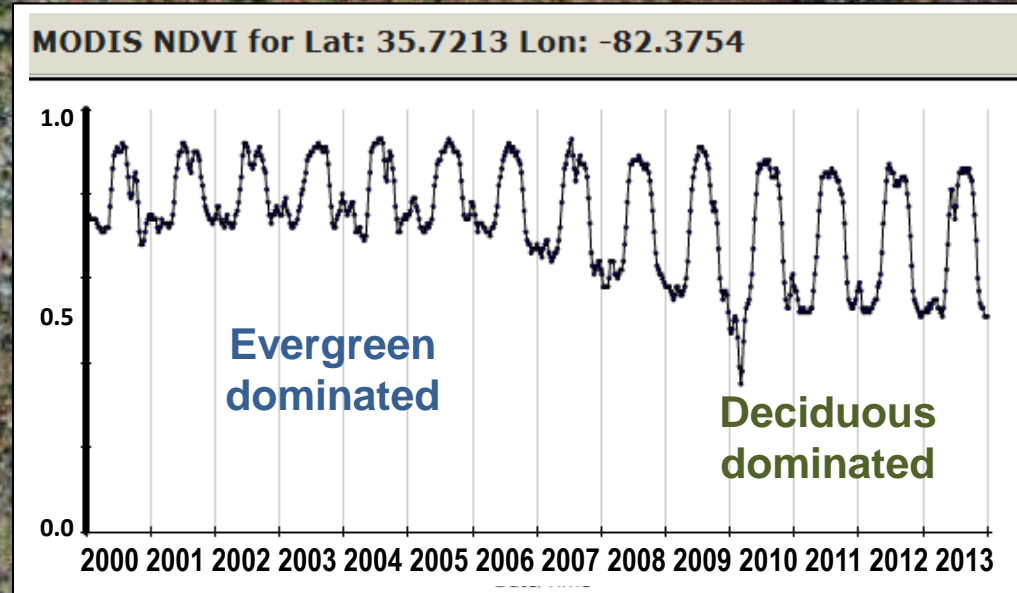
Monitoring gradual loss of evergreen (hemlock)

Monitoring gradual loss of evergreen (hemlock)
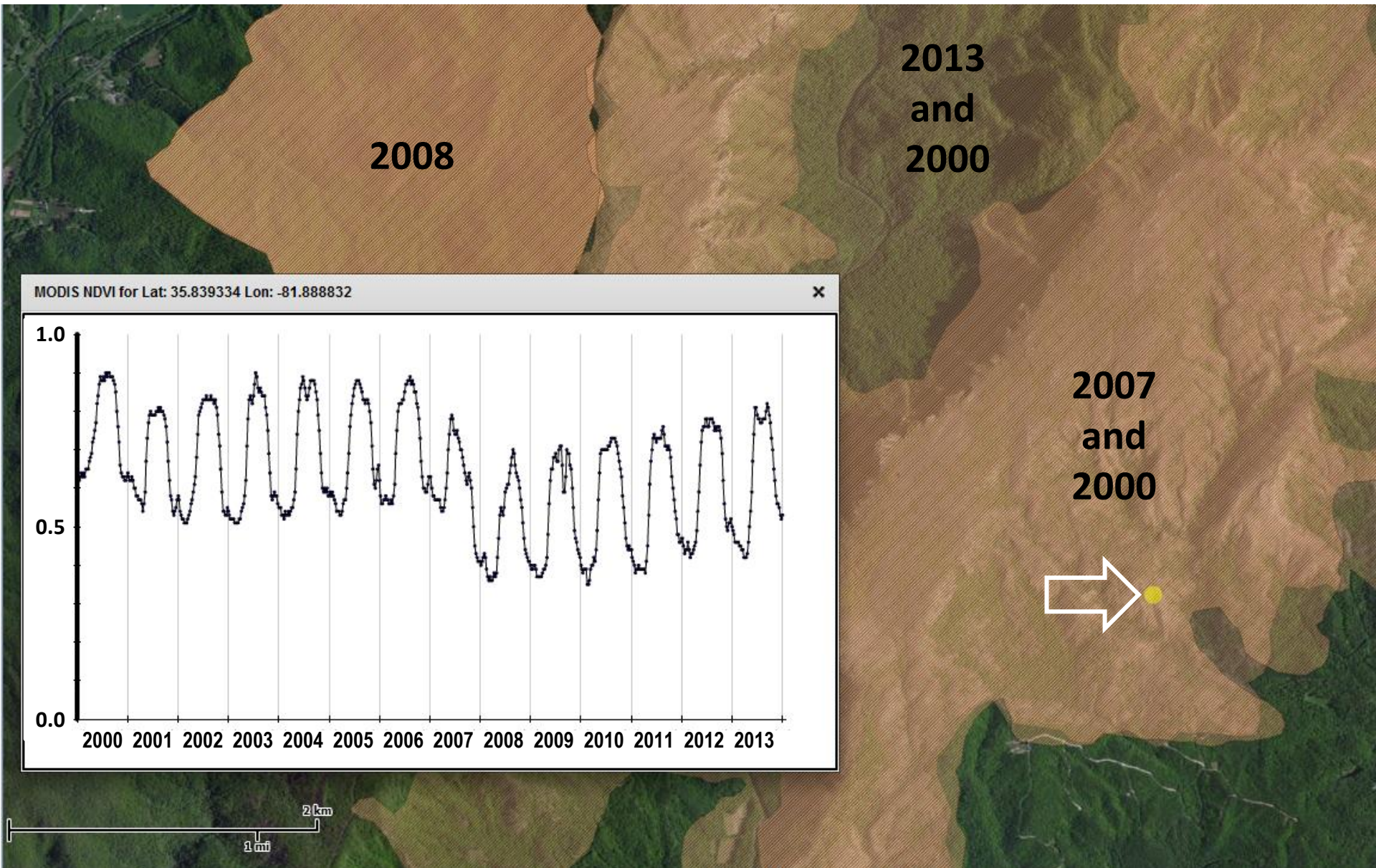
MODIS NDVI for Lat: 35.7213 Lon: -82.3754

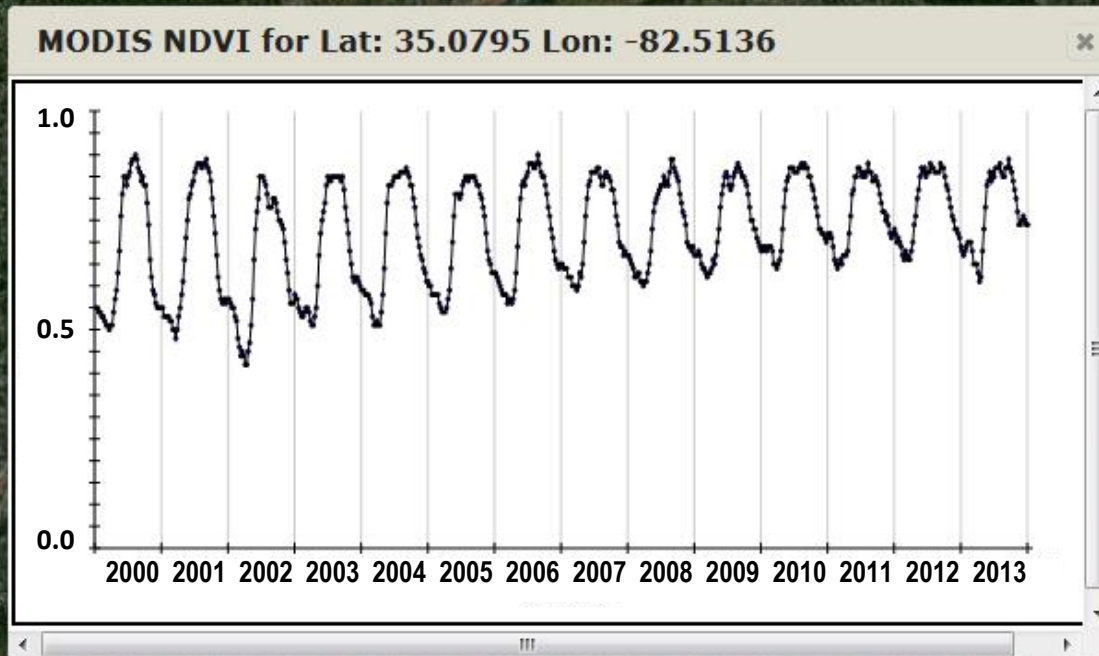Relative decline of summer vs. winter NDVI components
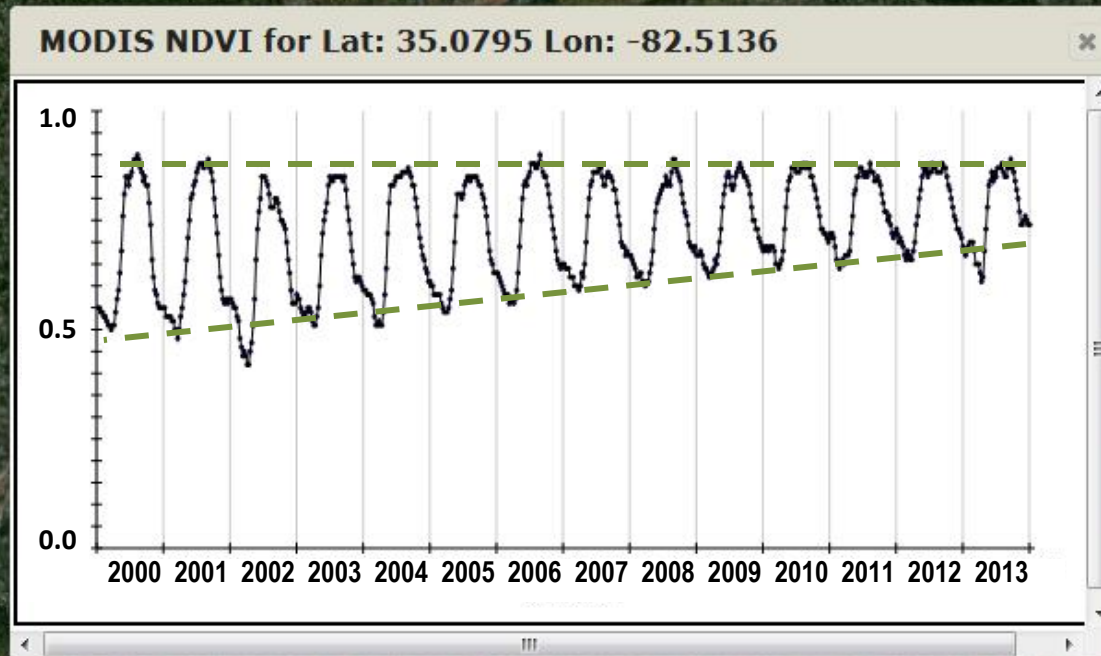
Monitoring multiple fire responses and recovery, Linville Gorge, NC

Monitoring multiple fire responses and recovery, Linville Gorge, NC

Monitoring logging recovery, Greenville County SC

MODIS NDVI for Lat: 35.0795 Lon: -82.5136

Monitoring logging recovery, Greenville County SC

MODIS NDVI for Lat: 35.0795 Lon: -82.5136

Monitoring Land Cover Change
Mountaintop development near Grandfather Mtn., NC

MODIS NDVI for Lat: 36.1217 Lon: -81.8781

Monitoring Land Cover Change
Mountaintop development near Grandfather Mtn., NC

MODIS NDVI for Lat: 36.1217 Lon: -81.8781
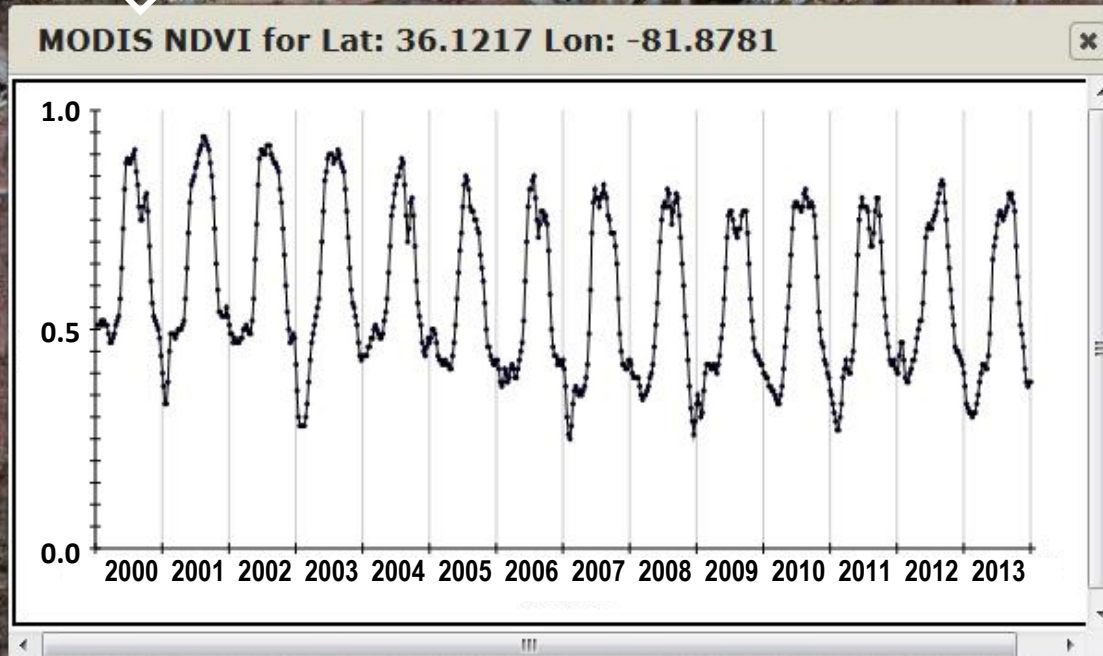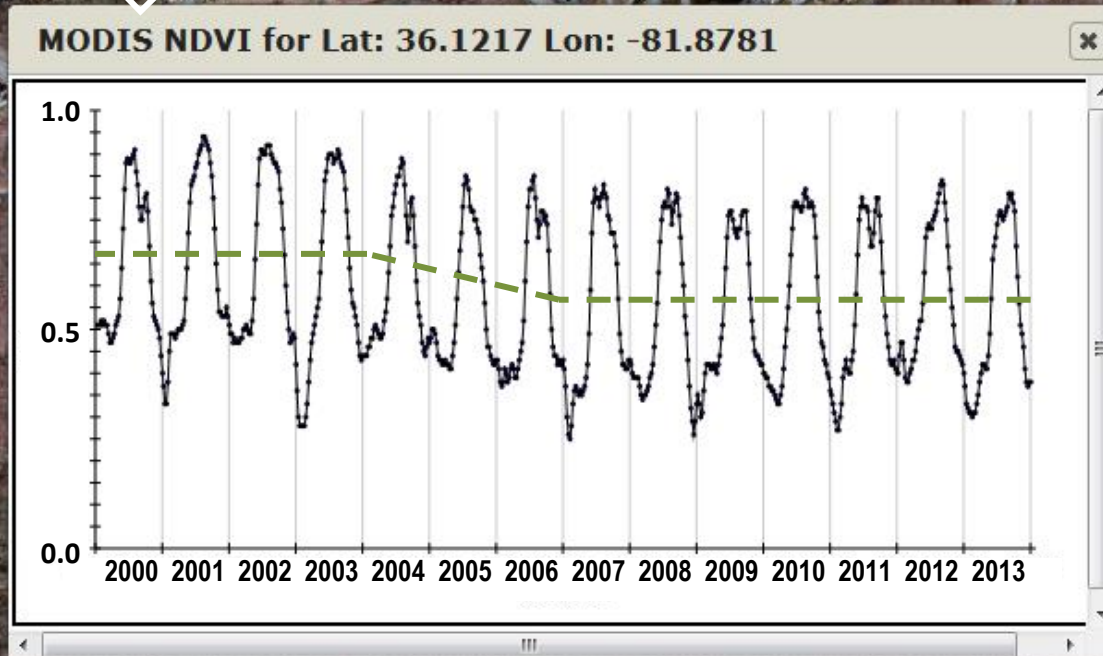
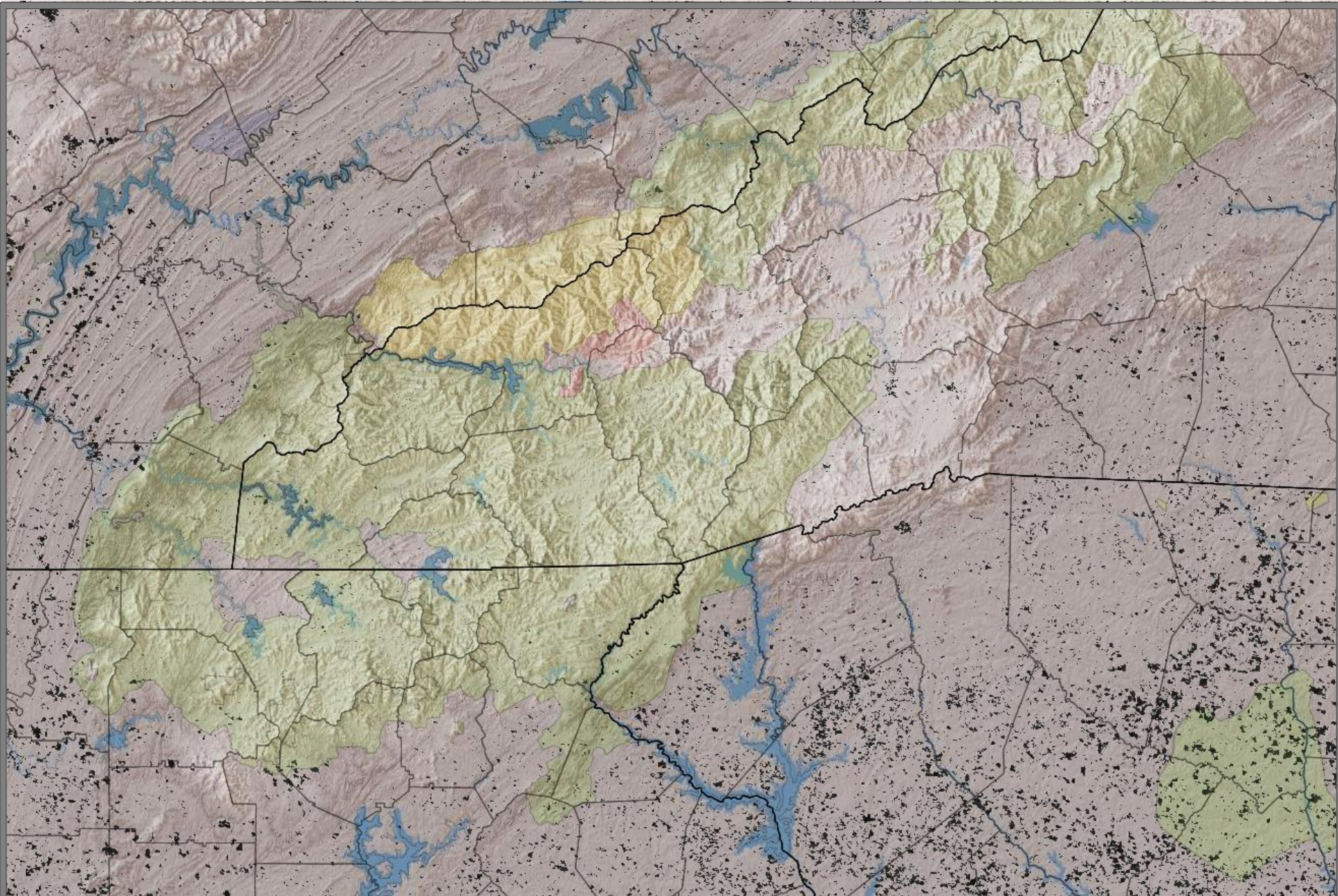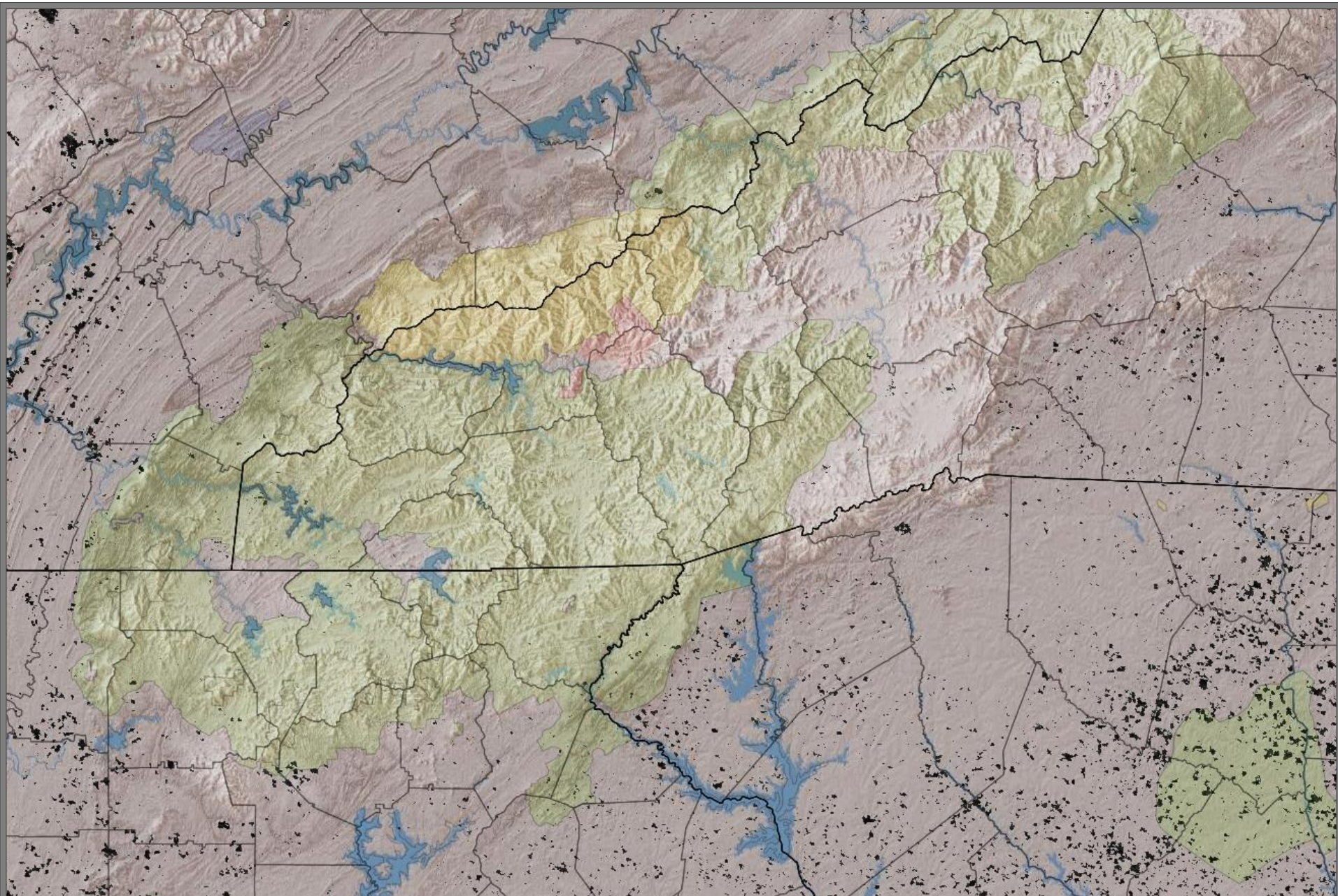# Tracking **Evergreen Decline** of Landscapes, 2000-2010
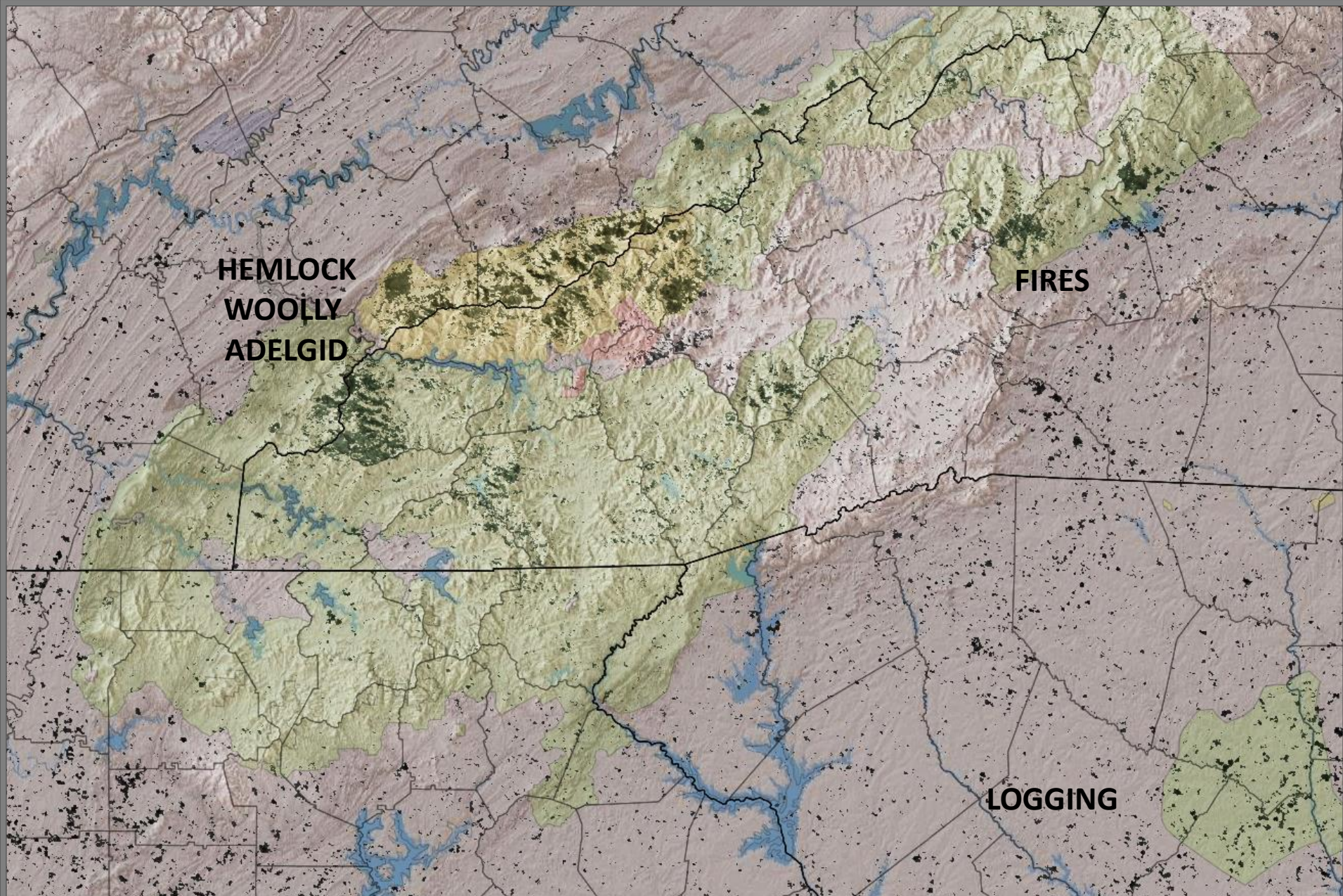
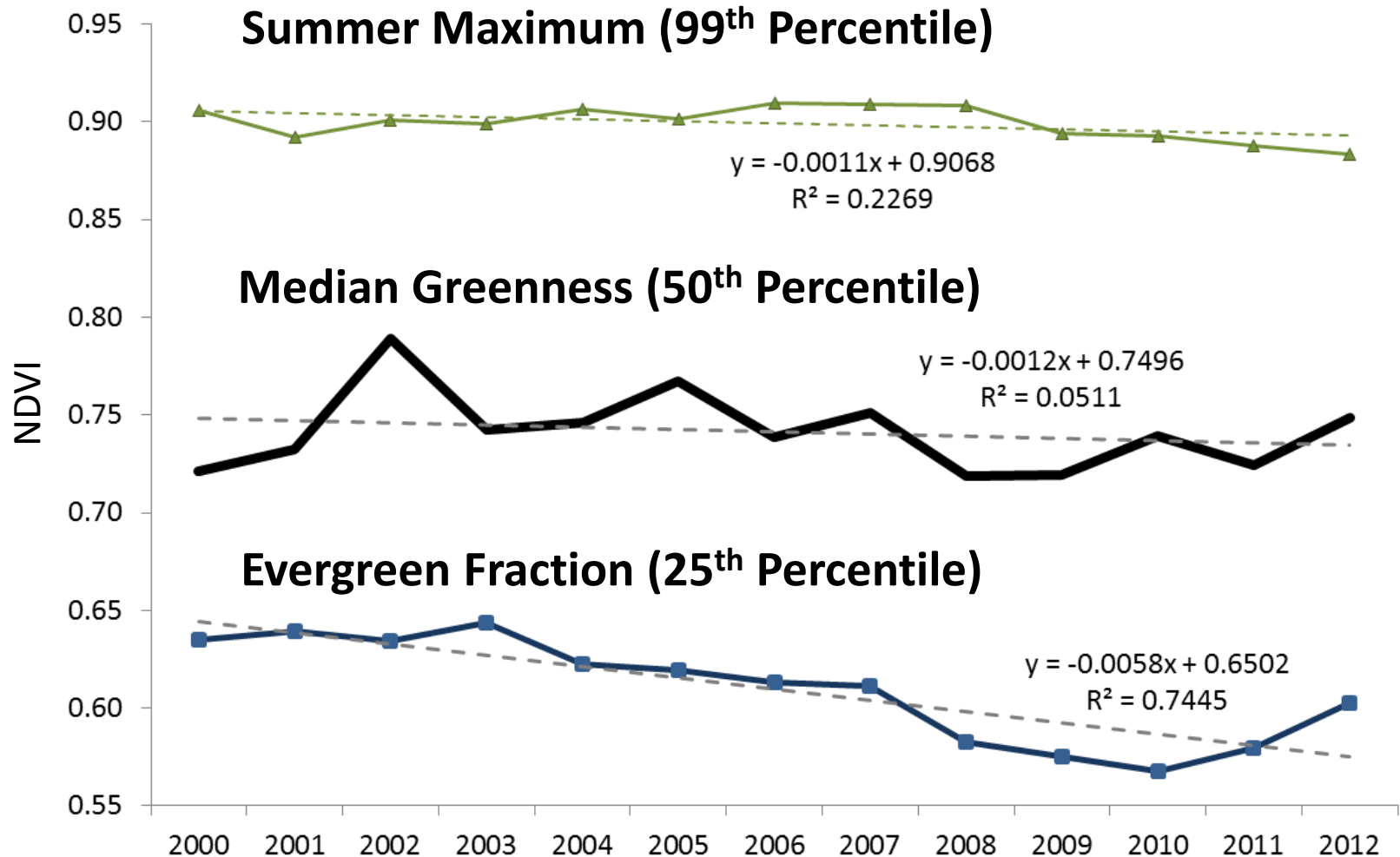# Tracking Deciduous Increase of Landscapes, 2000-2010
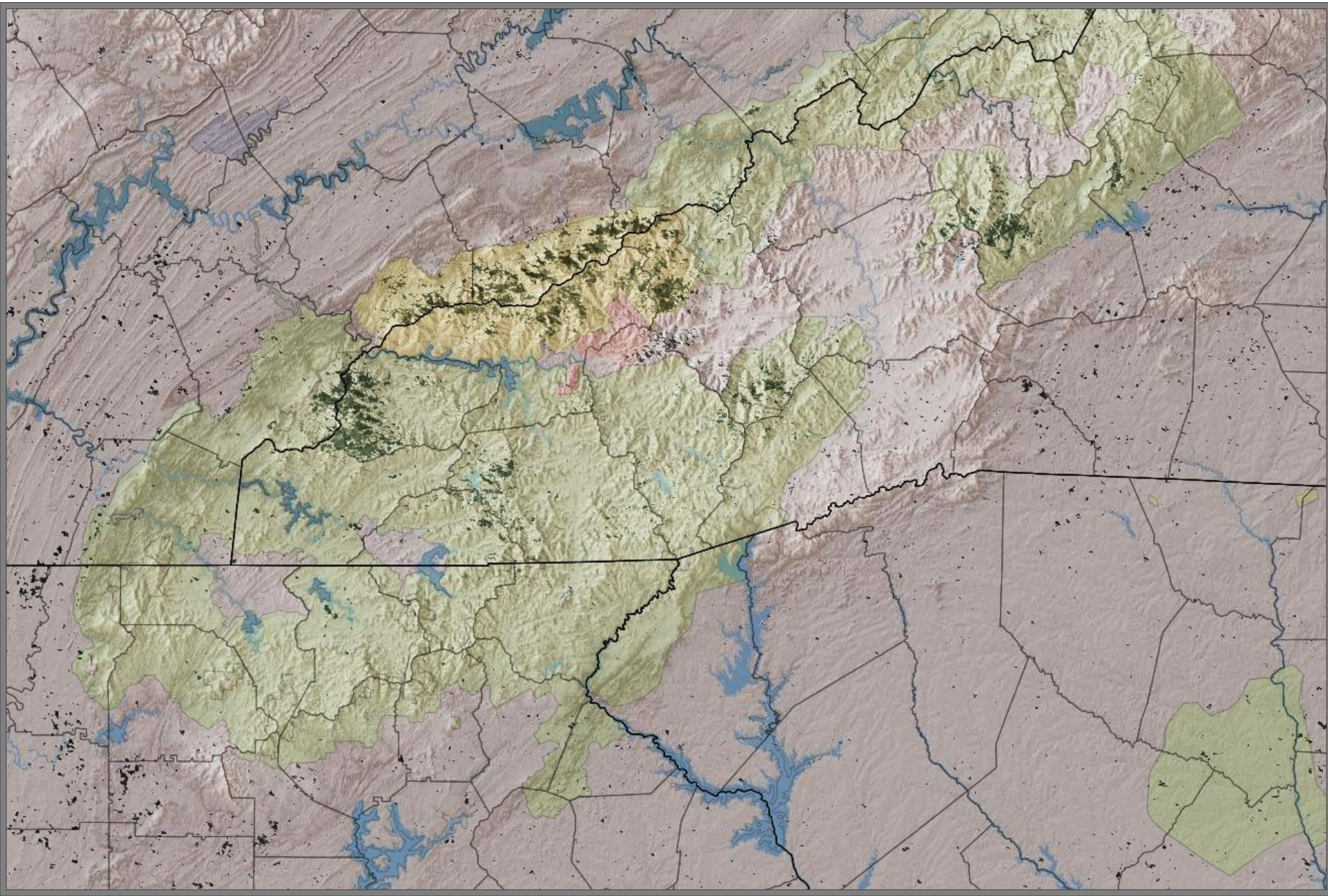
Tracking <u>Deciduous Decline</u> of Landscapes, 2000-2010

Tracking <u>Evergreen Increase</u> of Landscapes, 2000-2010

Monitoring trends in deciduous and mixed forests across all of Great Smoky Mountains National Park

Summary

- High-frequency monitoring of canopy greenness provides a broad suite of measures for monitoring both sudden and gradual forest change.

- For local areas, disturbance and recovery can be monitored directly: this relates to local resilience.

- More broadly, net change relates to landscape resilience which can be mapped for contextualizing threats, identifying specific forests at risk and for prioritizing active management solutions.