

Phenological unmixing of sequential wildfire and windstorm effects in the Southern Appalachians



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Programmatic objectives:

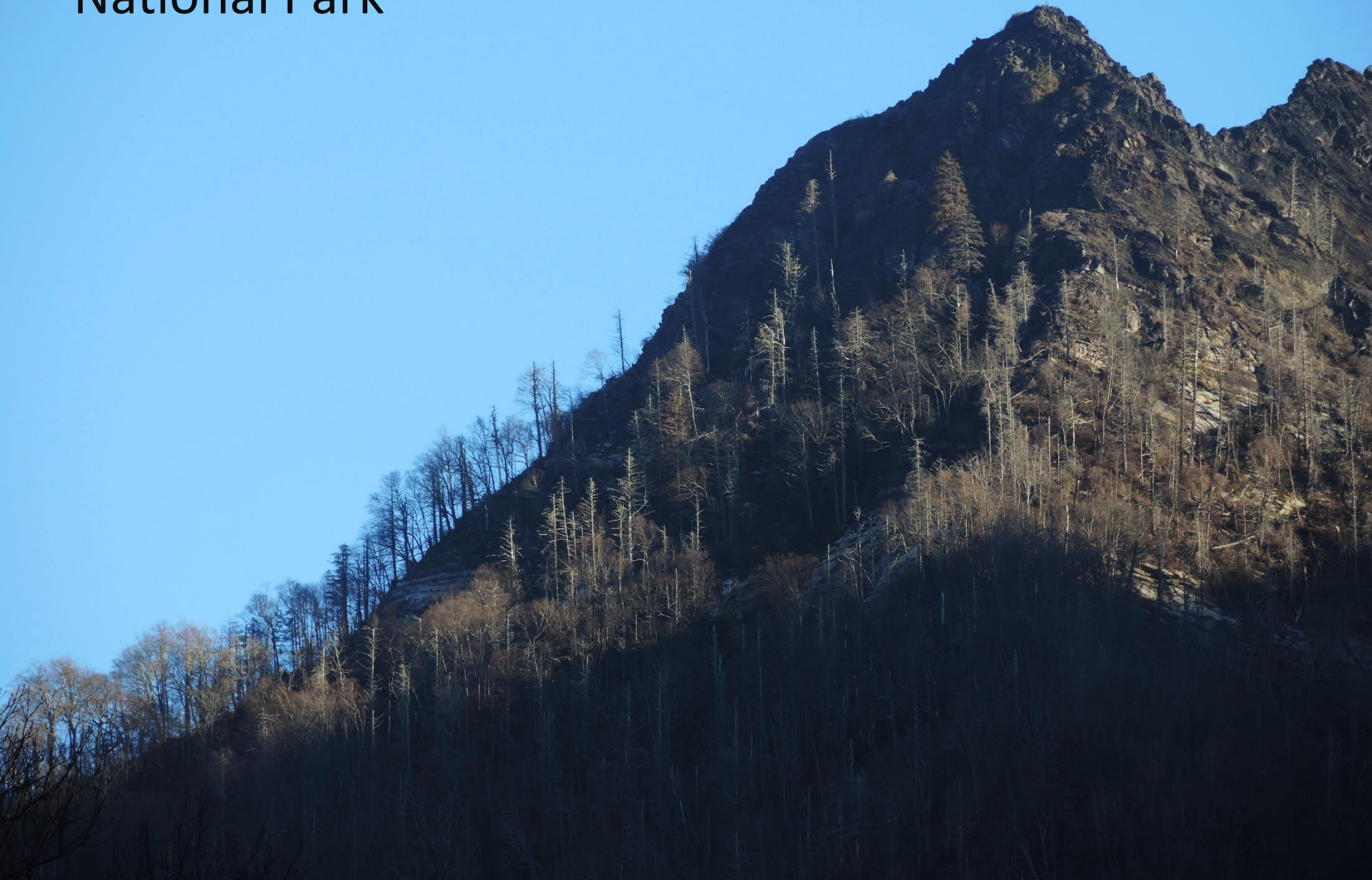
To use **Land Surface Phenology** as a **tool** to help understand and map disturbances in deciduous forests.

To demonstrate the value of “**cross-seasonal assessment**” for understanding wildfire’s structural effects.

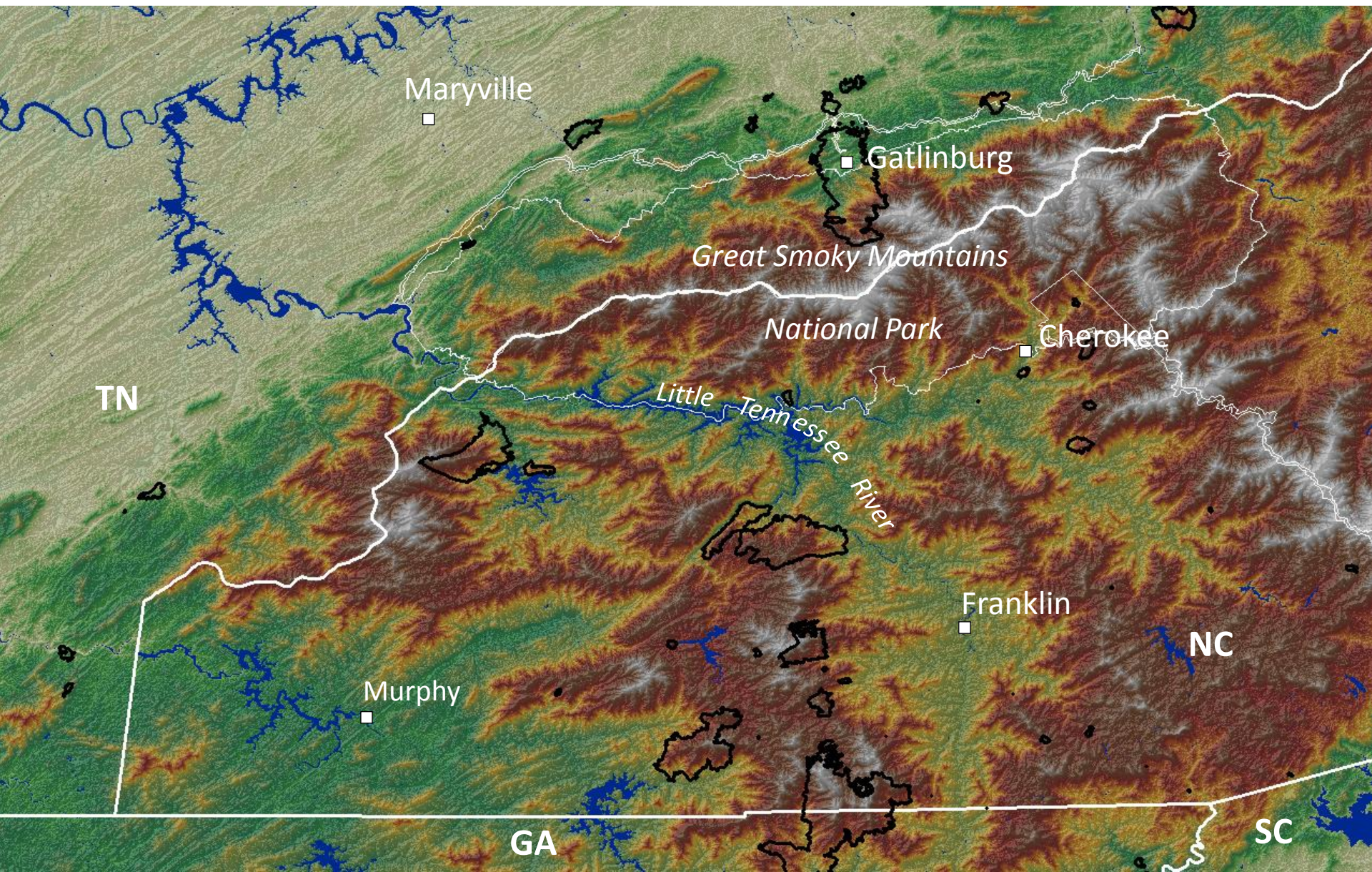
To demonstrate how “**greenup-reversal**” can capture ephemeral spring disturbance.

To illustrate these techniques with a recent high-profile example of **overlapping consecutive disturbances** of similar “Mountain Wave” origin.

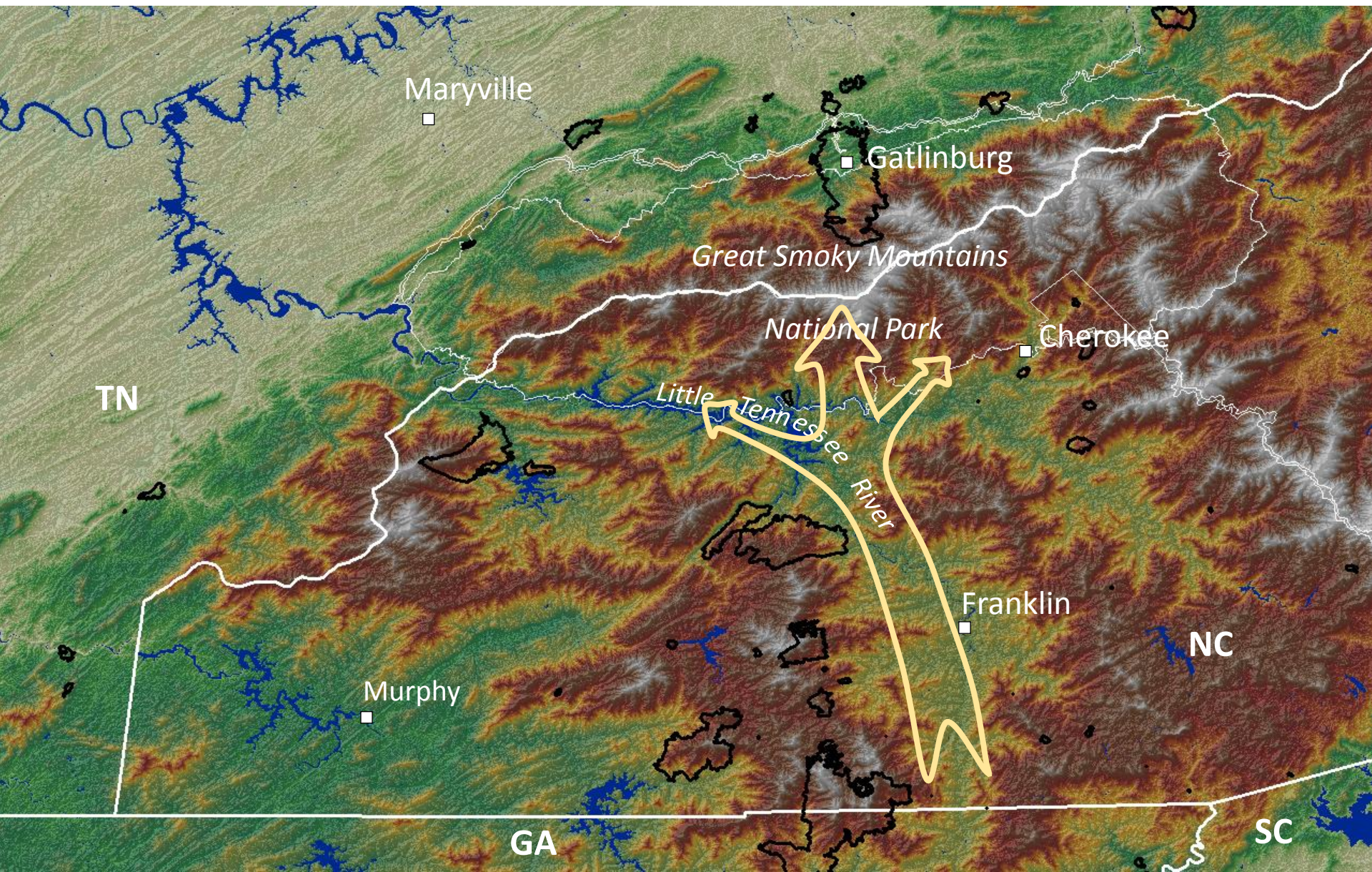
Great Smoky Mountains National Park



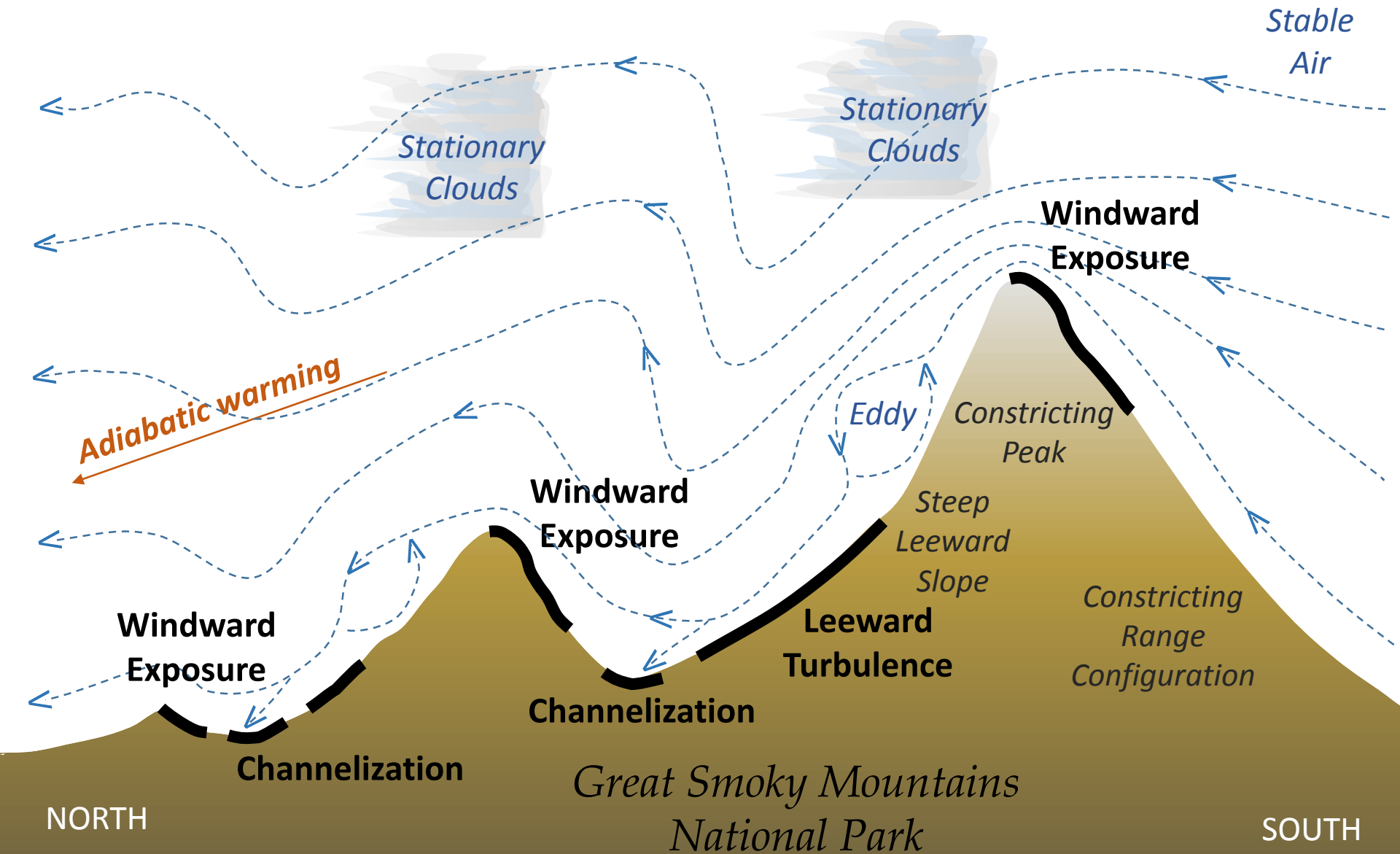
Research area showing large scale topographic features and 2016 wildfires



Research area showing large scale topographic features and 2016 wildfires



Generalized structure of a Mountain Wave over Great Smoky Mountains National Park

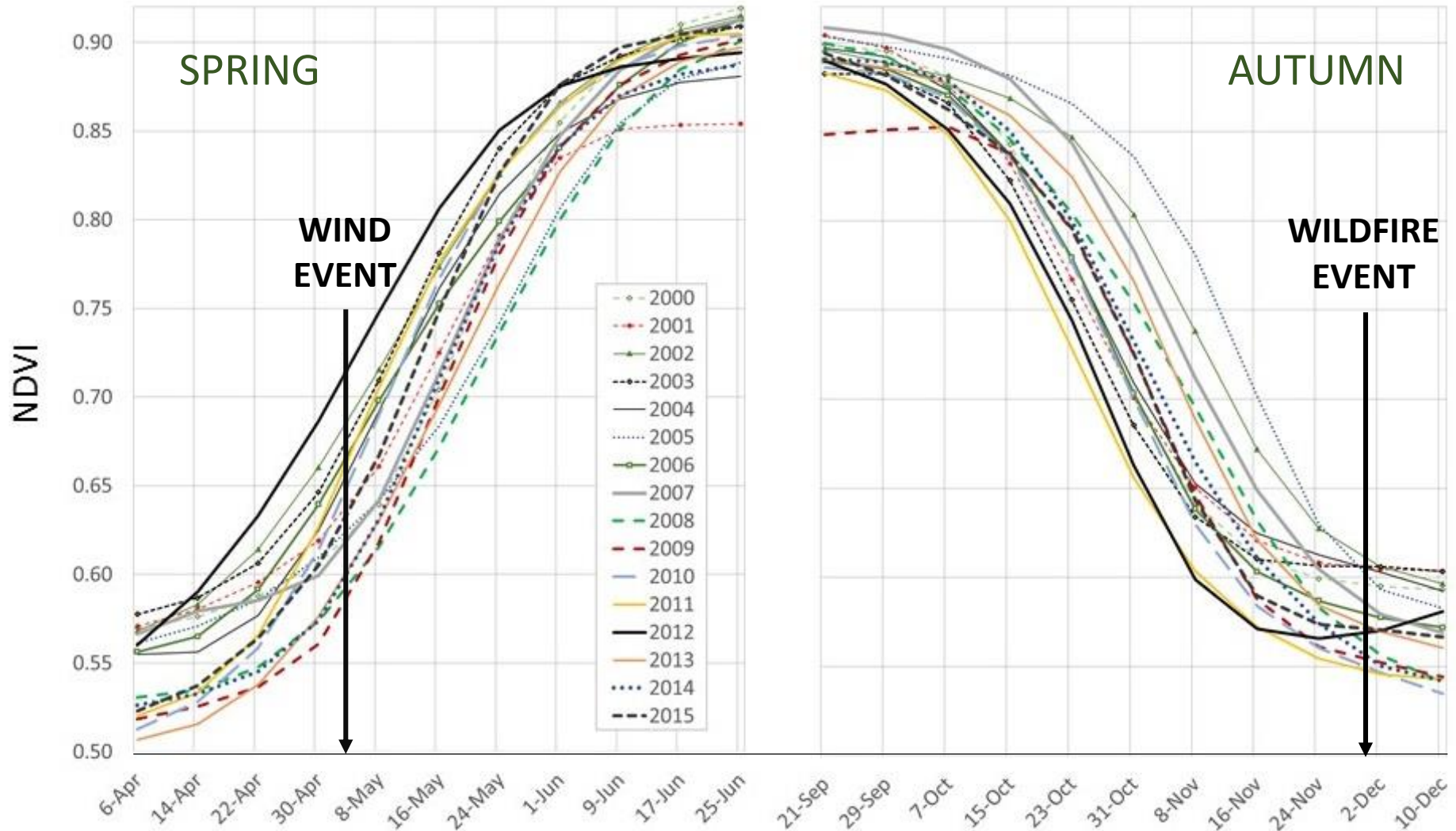




May 4, 2017

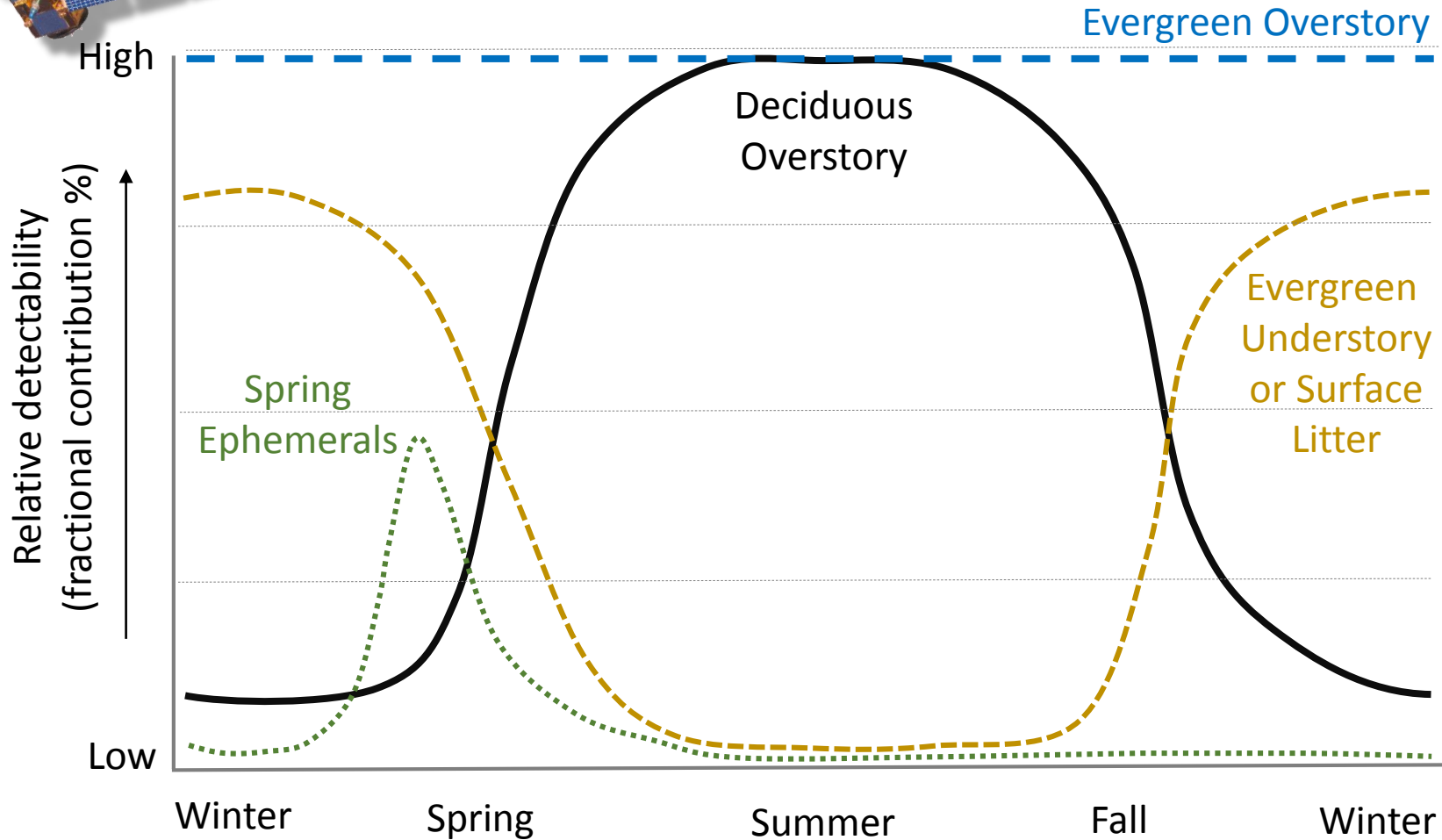
Courtesy of Jim Renfro, NPS

Variation in MODIS Land Surface Phenology for deciduous forests of Great Smoky Mountains National Park

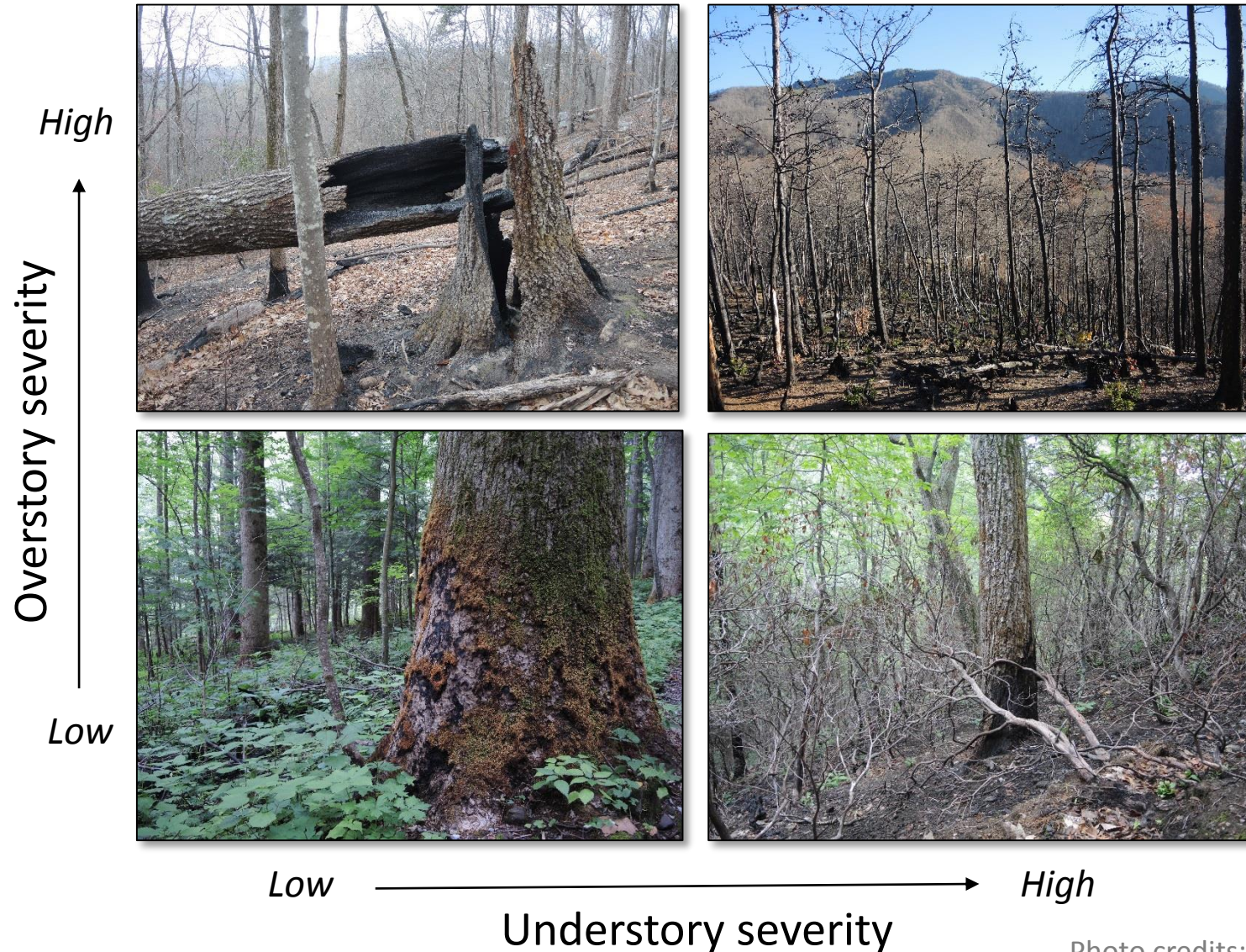


Source: Norman et al. 2017. Remote Sensing.

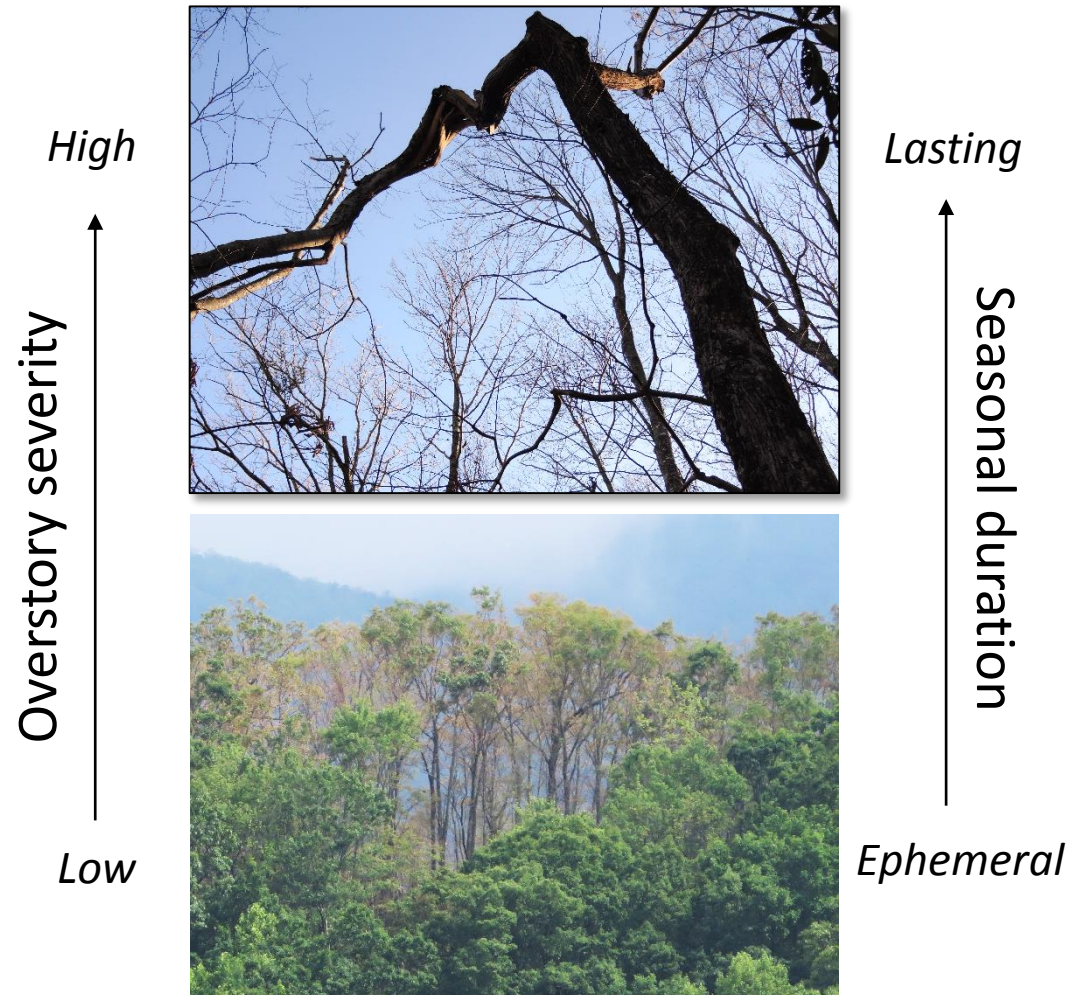
Hypothetical phenologically-mediated above-canopy detectability of forest components from reflectance



Wildfire structural and compositional impacts to resolve using Land Surface Phenology



Windstorm impacts to resolve using Land Surface Phenology



Lower image from May 4, 2017
courtesy of Jim Renfro, NPS



The Mountain Wave Wildfire

Date: Nov. 28, 2016

Phenological state: After a heat-delayed fall senescence, abscission varied with species and elevation; this contributed to extreme fire behavior at lower elevations.

Impacts: Highly variable severity to forests of the Park, but in nearby Gatlinburg, TN, 14 people were killed and 2,460 structures were lost with \$1 billion in damages!



The Mountain Wave Windstorm

Date: May 4, 2017

Phenological state: Spring progress varied by elevation. At lower elevations, greenup was mid-way+, but it was still early at higher elevations of the Park.

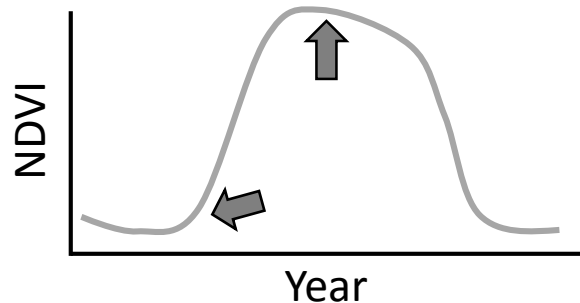
Impacts: Spotty crown damage and blowdowns with widespread (ephemeral) leaf stripping in the Park. Damages were \$1 million in Gatlinburg!



The Mountain Wave Wildfire

Date: Nov. 28, 2016

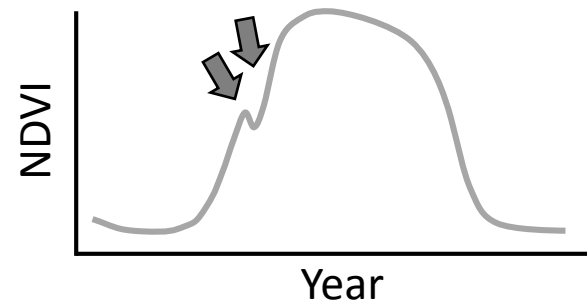
Methodology: Cross-seasonal assessment of (deciduous canopy's) leaf off vs. leaf on (growing season) impacts.



The Mountain Wave Windstorm

Date: May 4, 2017

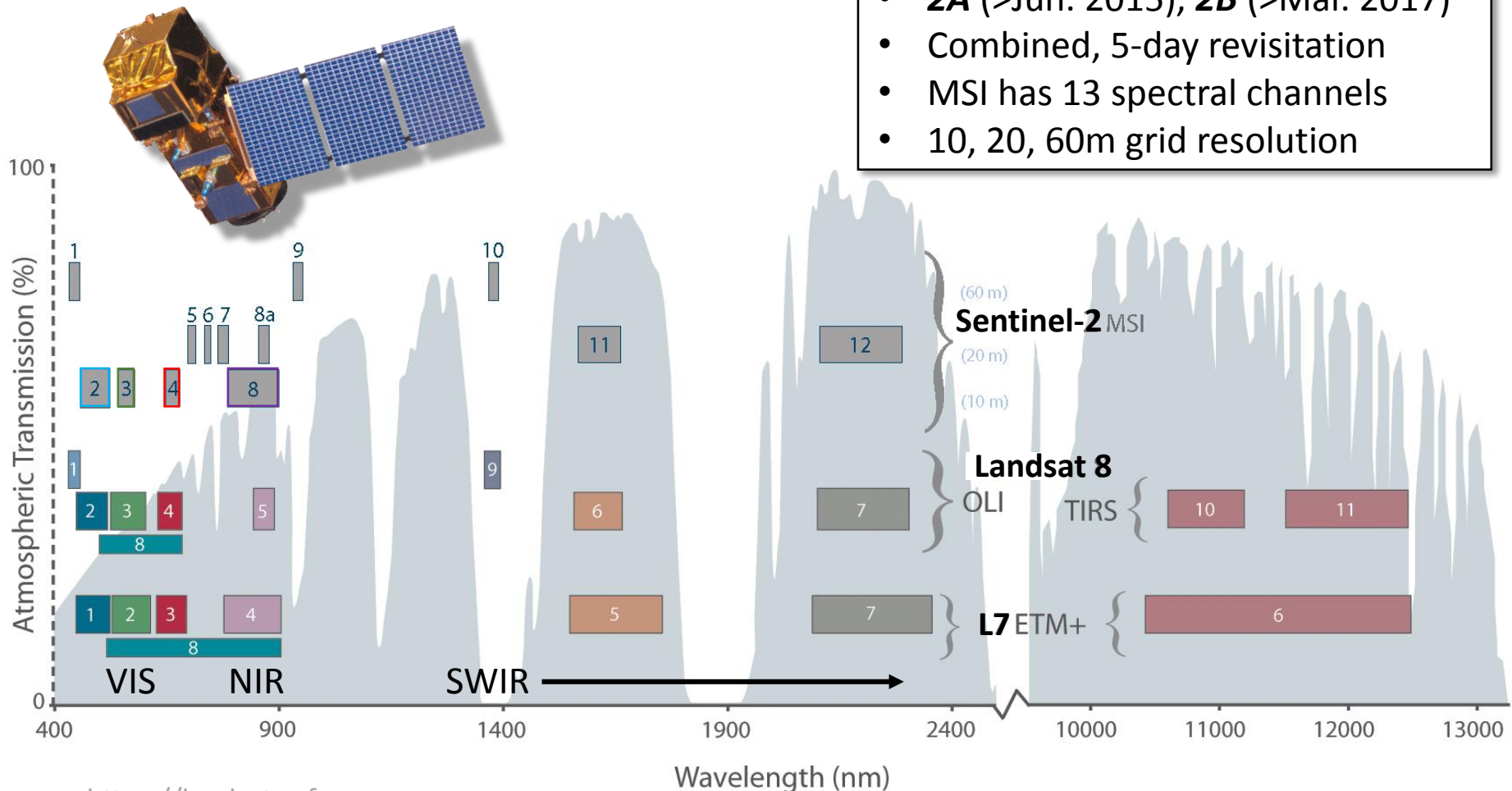
Methodology: Within-spring phenological greenup reversal.



Why Sentinel 2?

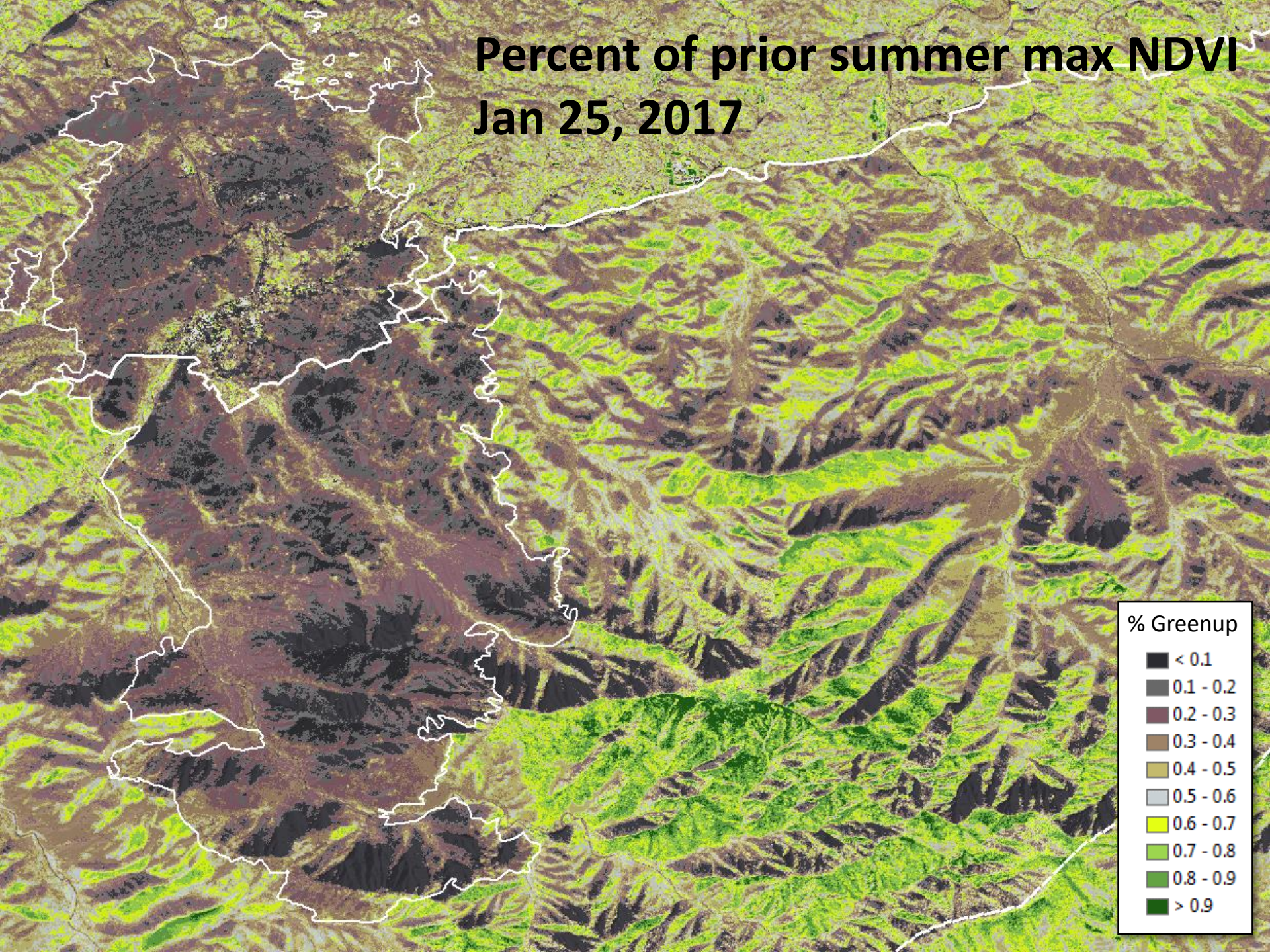
- Targeted features are near 10m resolution
- Has relatively high frequency
- Provides a standardized product for landscape analysis

- European Space Agency
- Global coverage
- Free and open data policy
- **2A** (>Jun. 2015), **2B** (>Mar. 2017)
- Combined, 5-day revisitation
- MSI has 13 spectral channels
- 10, 20, 60m grid resolution



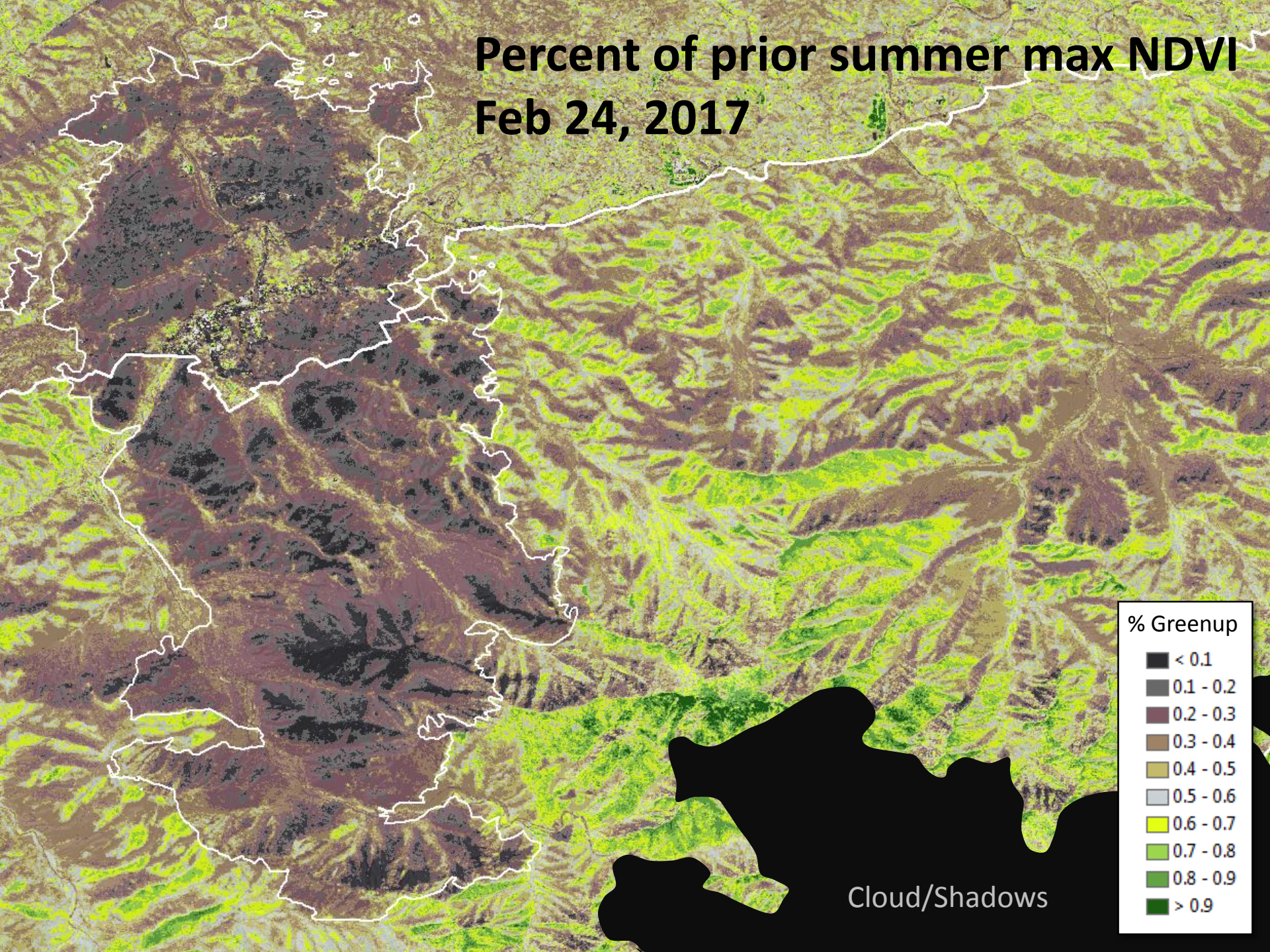
Percent of prior summer max NDVI

Jan 25, 2017



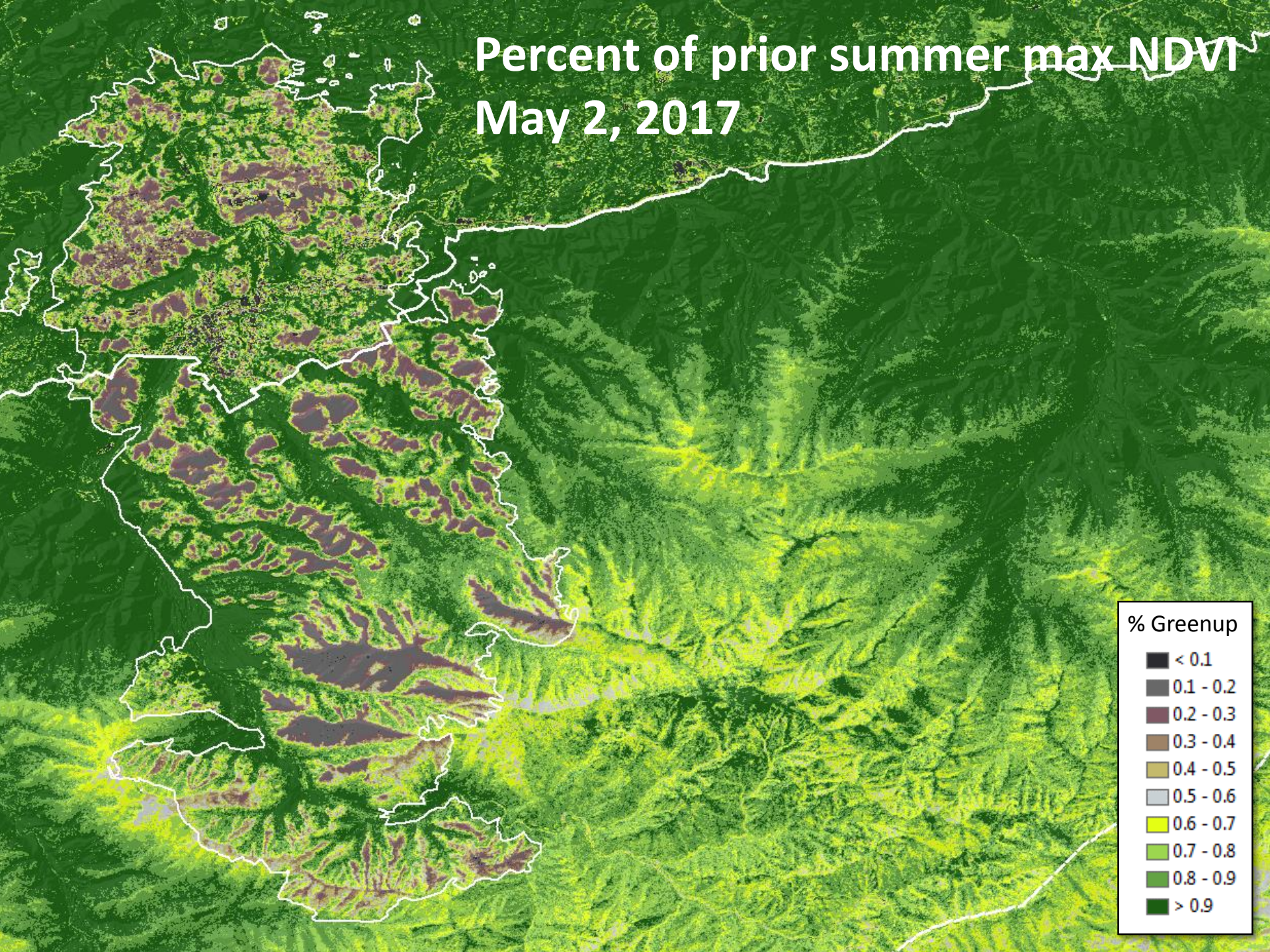
Percent of prior summer max NDVI

Feb 24, 2017

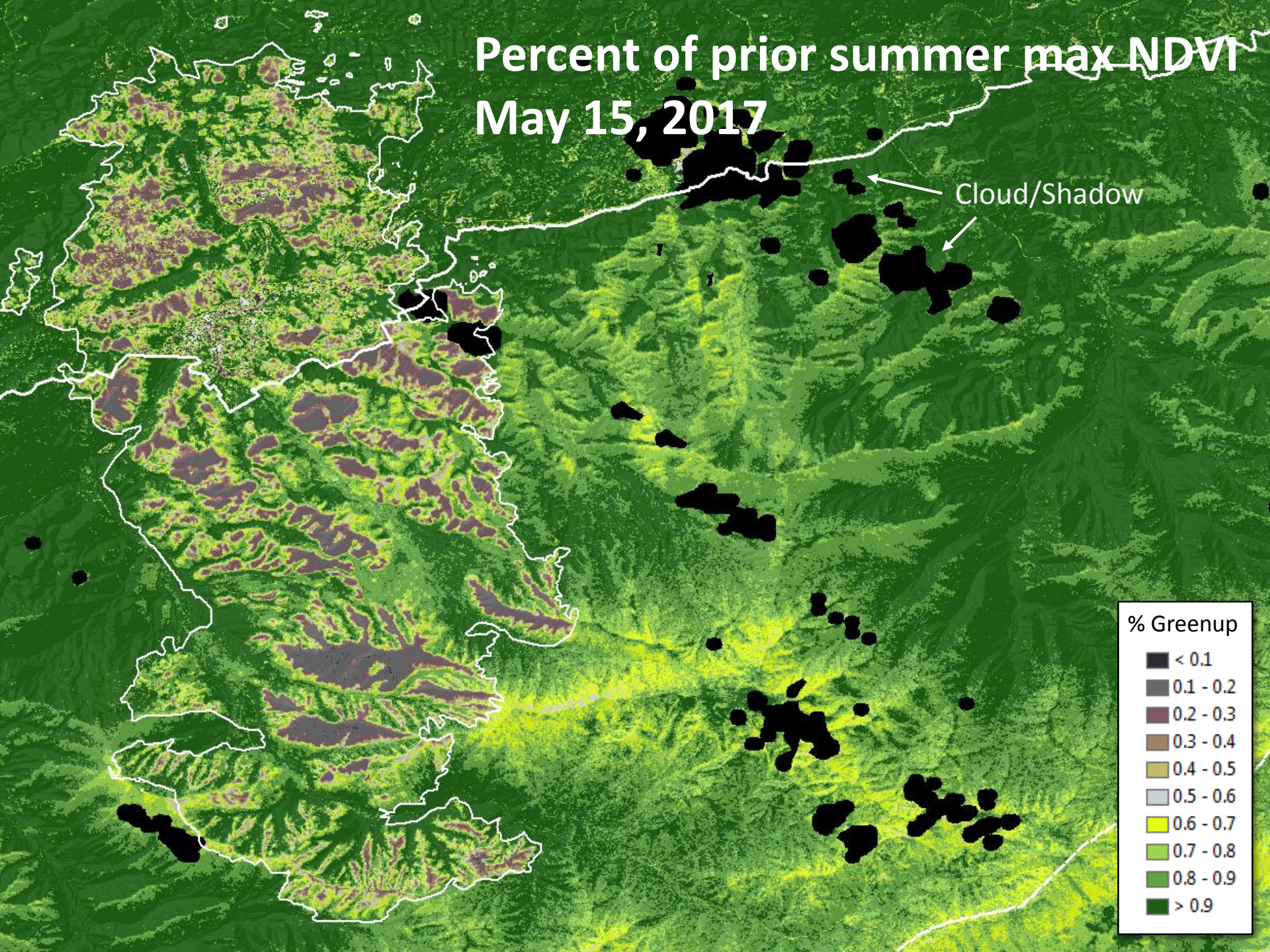


Percent of prior summer max NDVI

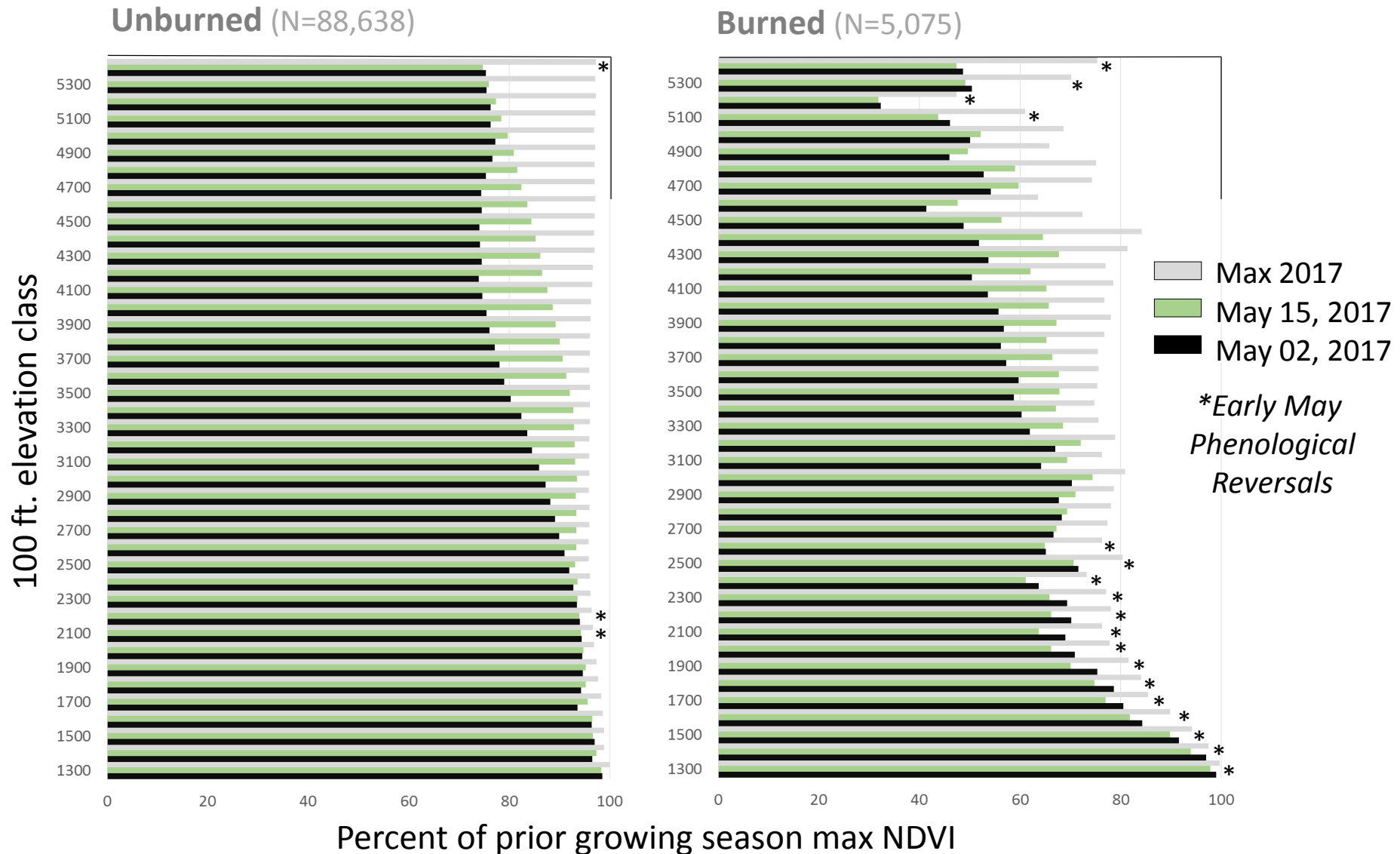
May 2, 2017



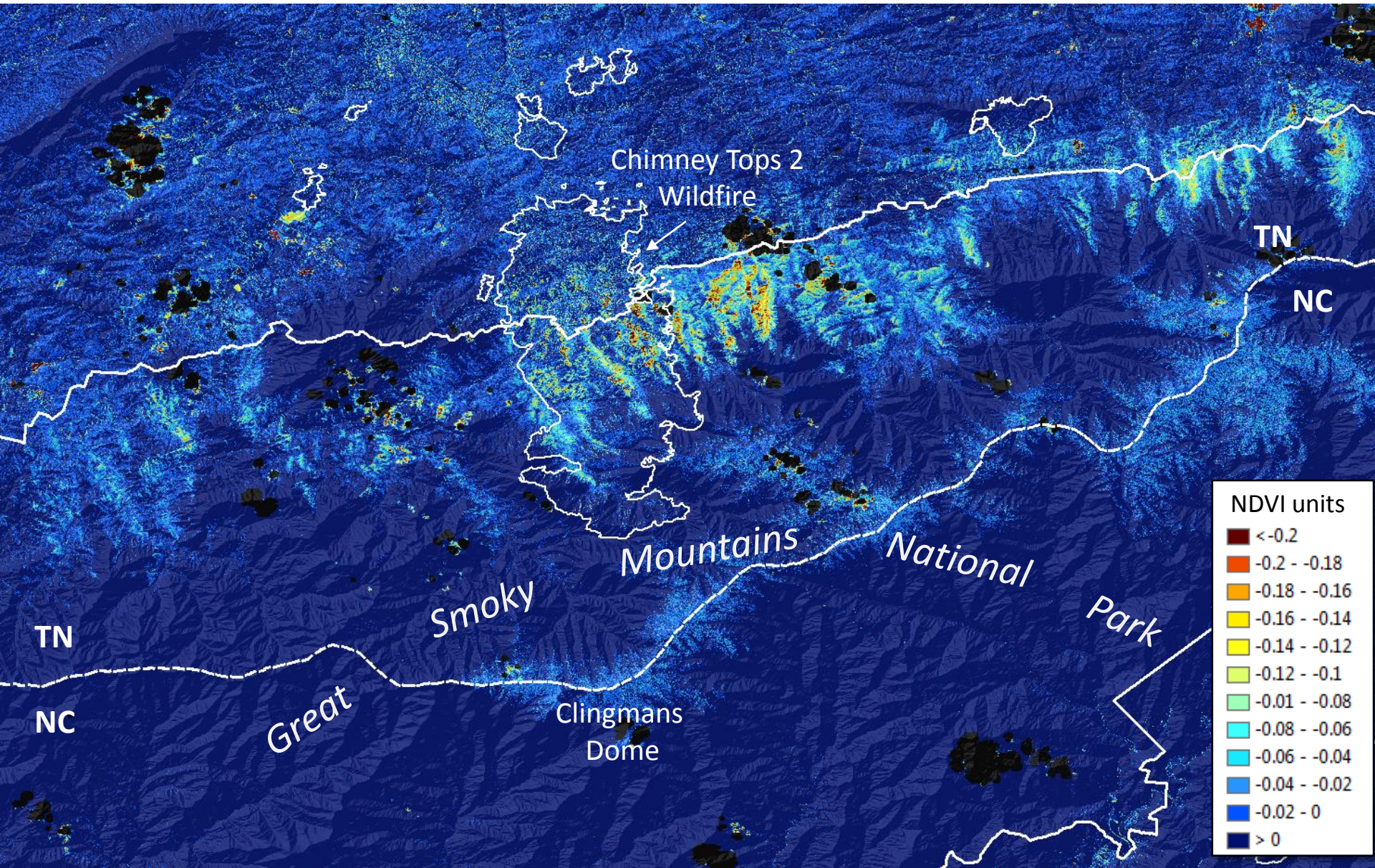
Percent of prior summer max NDVI May 15, 2017



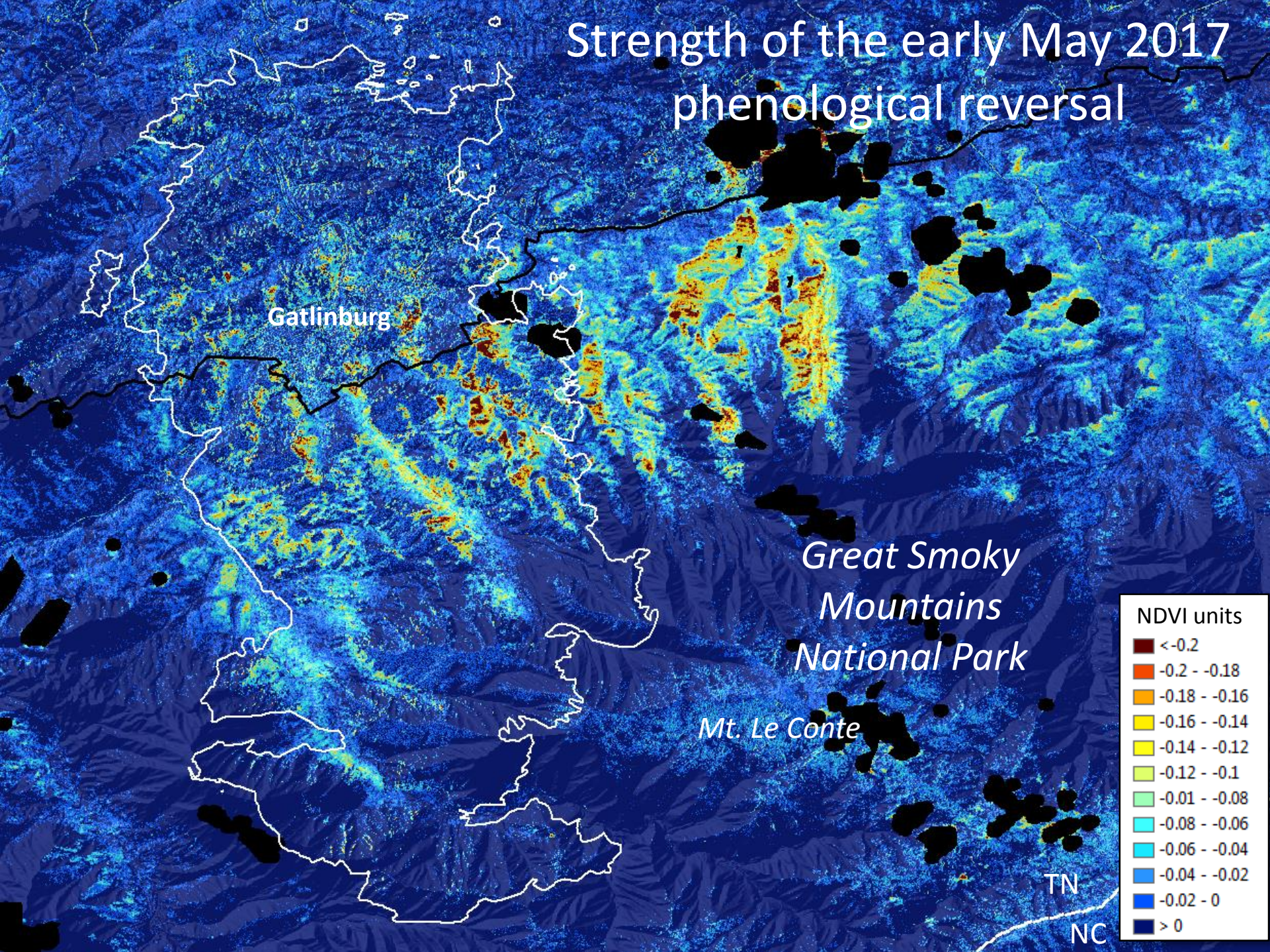
Progression of greenup for burned and unburned sites in Great Smoky Mountains National Park (TN)



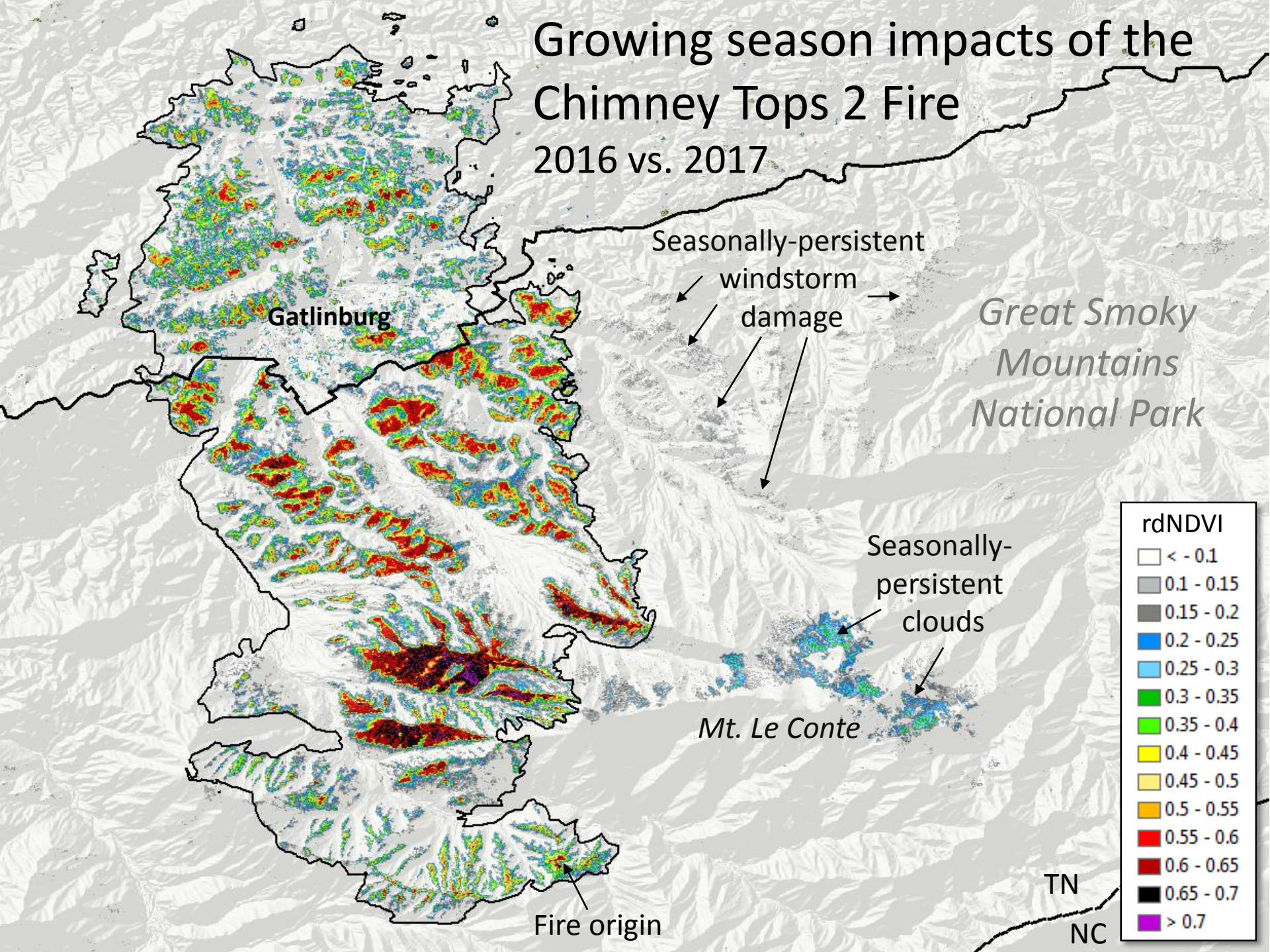
Strength of the early May 2017 phenological reversal for the Great Smoky Mountains National Park region



Strength of the early May 2017 phenological reversal



Growing season impacts of the Chimney Tops 2 Fire 2016 vs. 2017



Conclusions

- Use of new high spatial and temporal resolution imagery (such as Sentinel 2) can leverage Land Surface Phenology (LSP) for high spatial and temporal insights into disturbance impacts through:
 - (1) **cross seasonal assessments**, as shown after this wildfire, and
 - (2) **greenup reversal** from a subsequent spring windstorm, even though most impacts were ephemeral.
- In deciduous forests, LSP can mediate the **detectability** of disturbance impacts across forest structure, by elevation, or through **loss of sensitivity** after a prior disturbance.
- Nonetheless in this landscape, both disturbance impacts were mediated by **topography**, suggesting the existence of refugia that cross disturbance types.

