Tracking spring and fall phenology across Great Smoky gradients: A 16-year record of climate and vegetation change



Why monitor vegetational phenology?





Phenological values include spring flowering, wildlife, and fall foliage: these are sensitive to seasonal variation.

Climate-mediated phenology impacts disturbances dynamics and growing season productivity. **Research questions**

- What is the fundamental nature of the Park's land surface phenology (LSP) gradients?
- How and why does spring and autumn LSP vary from year to year?
- What do observations tell us about our ability to monitor LSP and its response to climate change?

Great Smoky Mountains National Park



The ForWarn dataset





- Uses NDVI (the Normalized Difference Vegetation Index)
- From daily MODIS satellite streams (Terra and Aqua satellites)
- Pixels are 232 m resolution (13.4 ac.)
- Calculated at 8-day time steps (46 periods per year)
- Highly processed to remove clouds and other image quality issues
- Starts in 2000; through a year ago
- Near-real-time change products are online at: <u>http://forwarn.forestthreats.org</u>



The seasonal timing of deciduous forest phenology (NDVI), daylength, temperature, precipitation across GRSM National Park



End day of 8-day period

Landsat 5 TM: Color Infrared 2010 April 2

Clingman's Dome

Landsat 5 TM: Color Infrared 2010 April 18

ΤN

NC

Cherokee

Clingman's Dome

Long-term mean phenological behavior of "pure deciduous" forests by elevation and aspect



pril 20, 2015

Tulip poplar

White oak

Phenological variation of "pure deciduous" forests of GRSM below 5000 ft. from MODIS NDVI, 2000-2015



B. Autumn



Comparison of MODIS NDVI with other data: The PhenoCam Network's green chromatic coordinate (gcc)

https://phenocam.sr.unh.edu/webcam/



Smokylook PhenoCam Elevation 801m (2628 ft.) 2003-8, 2010-15





Smokypurchase PhenoCam Elevation 1550m (5085 ft.) 2008-2015



Comparison of MODIS-NDVI (100m elev. bands) and PhenoCam green chromatic coordinate (gcc)



A. Spring

B. Autumn

------ Smokylook (801m, 2628 ft.)

---- Smokypurchase (1550m, 5085 ft.)





Deciduous distribution (left)
Conifer/Mixed distribution (right)



Deciduous correlation curve

Notable correlations



Deciduous distribution (left) Conifer/Mixed distribution (right)

The 1st, 25th, 50th, 75th and 99th percentiles are shown by each box plot

Effects of Cumulative Growing Degree Days and Precipitation (over 88 days) on Spring and Autumn NDVI

B. Autumn (Oct. 31 period) WARM DDD 2004-2015 2011 2006 2004 COOL 675 700 725 225 250 275 300 325 350 375 400 425 450 475 500 525 550 575 600 625 650 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500 525 550 575 600 625 DRY WET DRY WET Precipitation Precipitation

A. Spring (May 16 period)



Mapped correlations of Spring and Autumn NDVI with lagged weather



Areas of Disturbance within GRSM National Park, 2000-2015



Mapped correlations of Spring NDVI with antecedent growing degree days, 2000-2015





Summary of results

- <u>Elevation</u> is the primary driver of Land Surface Phenology (LSP) for the Park, with a secondary, though important influence of <u>aspect</u> and <u>vegetation</u> type.
- Satellite-based measures of LSP capture how spring timing can vary as it progresses, and that green-up and brown-down have varied by about <u>2.5 weeks</u> over these 16 years.
- Warm-wet spring weather <u>accelerates</u> green-up, while warm-dry or average fall weather <u>delays</u> senescence, with potential cross seasonal lags in both seasons.
- <u>Disturbances</u> can confound our ability to monitor LSP, but we can deal with this problem through aggressive use of ancillary data filtering.