Photo credit: Kevin Reese

Contextualizing Appalachian Fire with Sentinels of Seasonal Phenology

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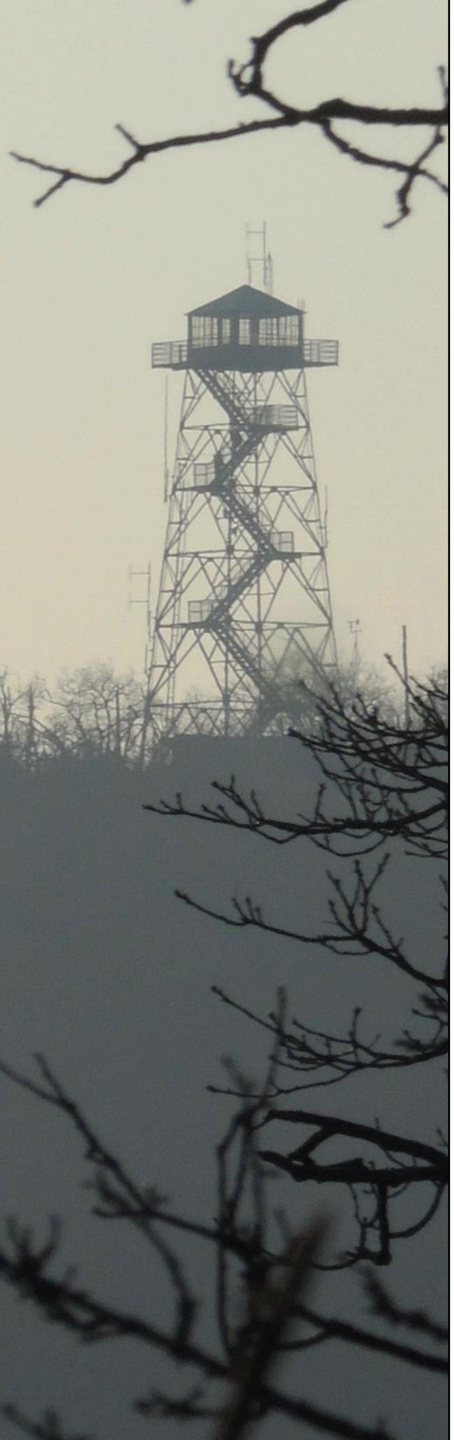
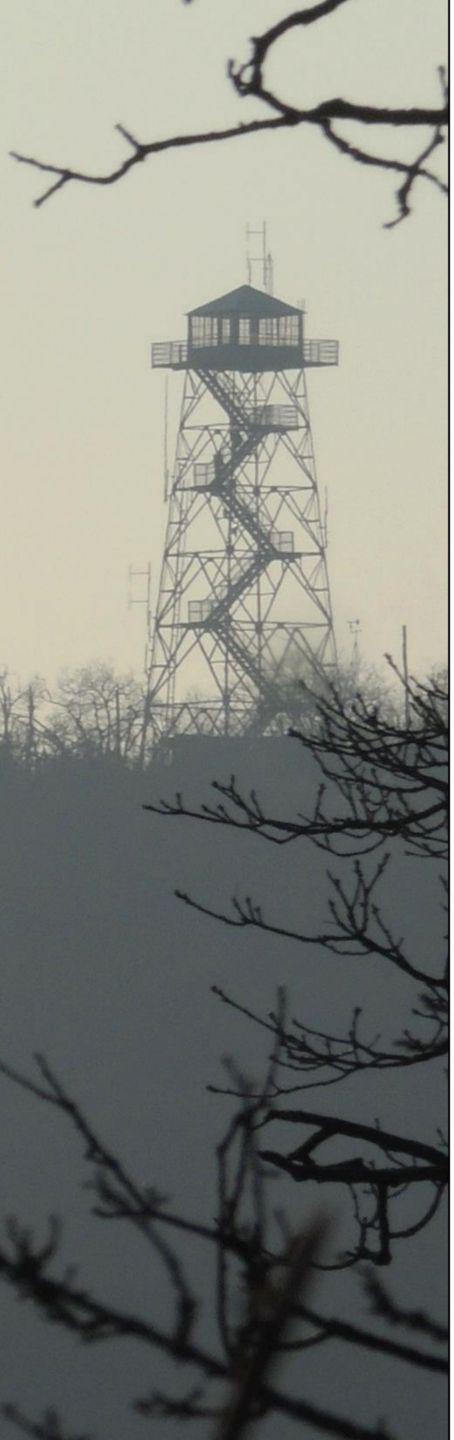


DRIVING MANAGEMENT CONCERNS

- Appalachian wildfire hazards are strongly seasonal, but responders seek greater precision and predictability.

- Prescribed fire burn windows are also seasonal, but there is a need to expand them.

- Ecological and fuels effects from fire often vary by season, and “growing season” or “dormant season” designations are vague and unstandardized concepts for monitoring.



OUTLINE

I: Ruminations on the variable timing of Appalachian spring and fall.

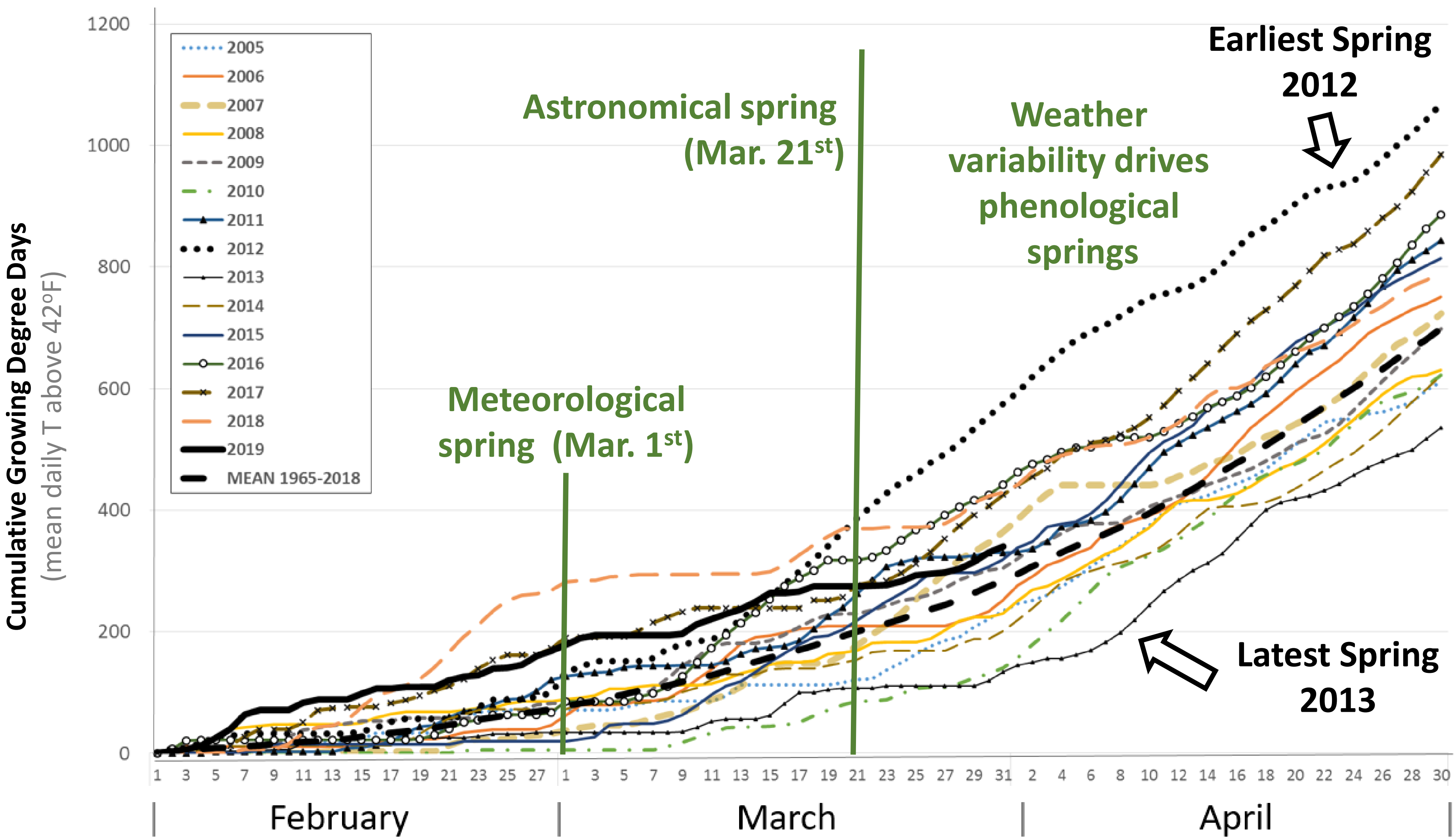
II. On the distinctive seasonal bimodality of Appalachian fire regimes.

III. On the spring/fall precision that is desirable and possible from existing remote sensing streaming datasets.

IV. "Percent Completion" illustrated with case studies.

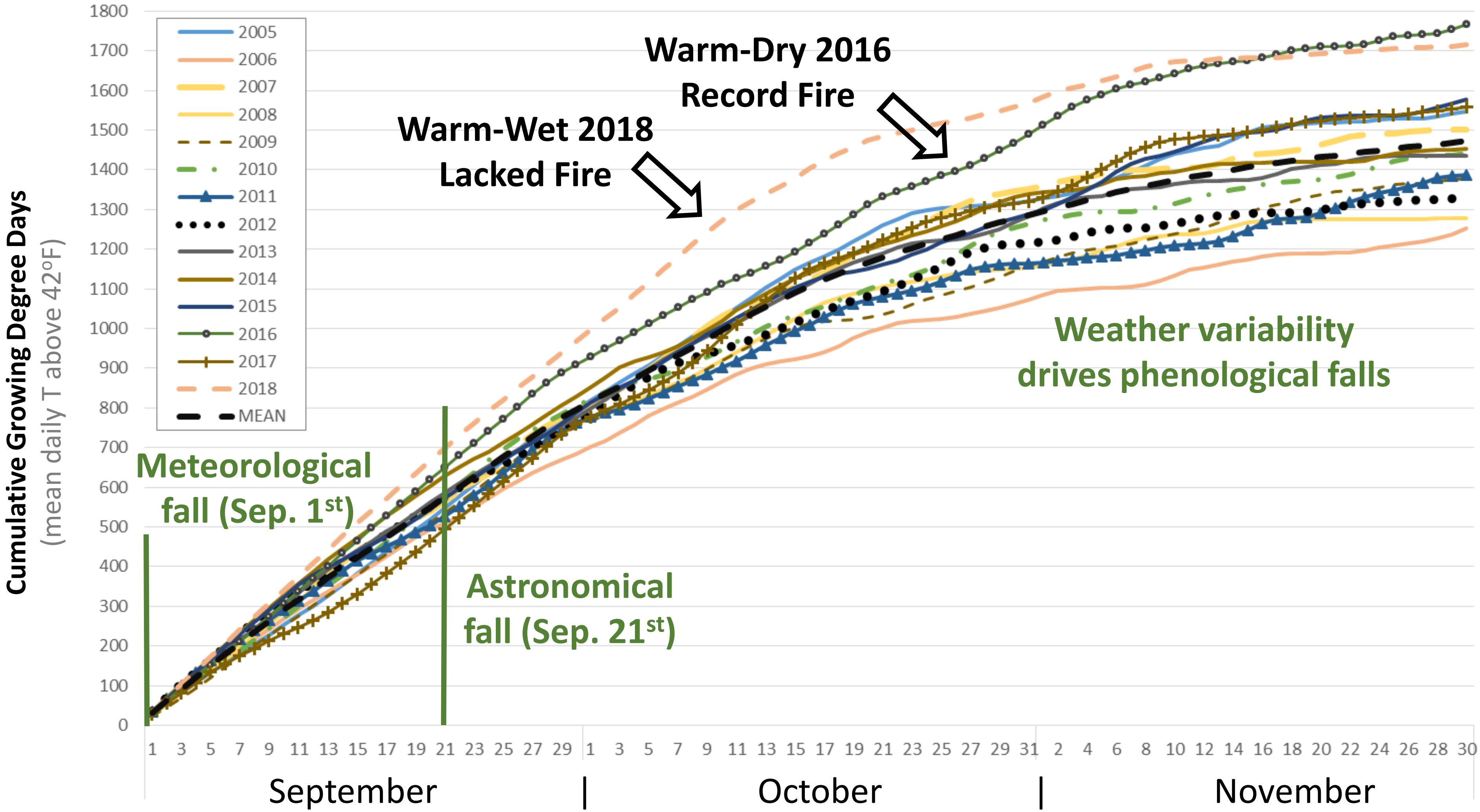
I. The variable timing of spring and fall

Spring Cumulative Growing Degree Days (CGDD) for Asheville, NC Airport



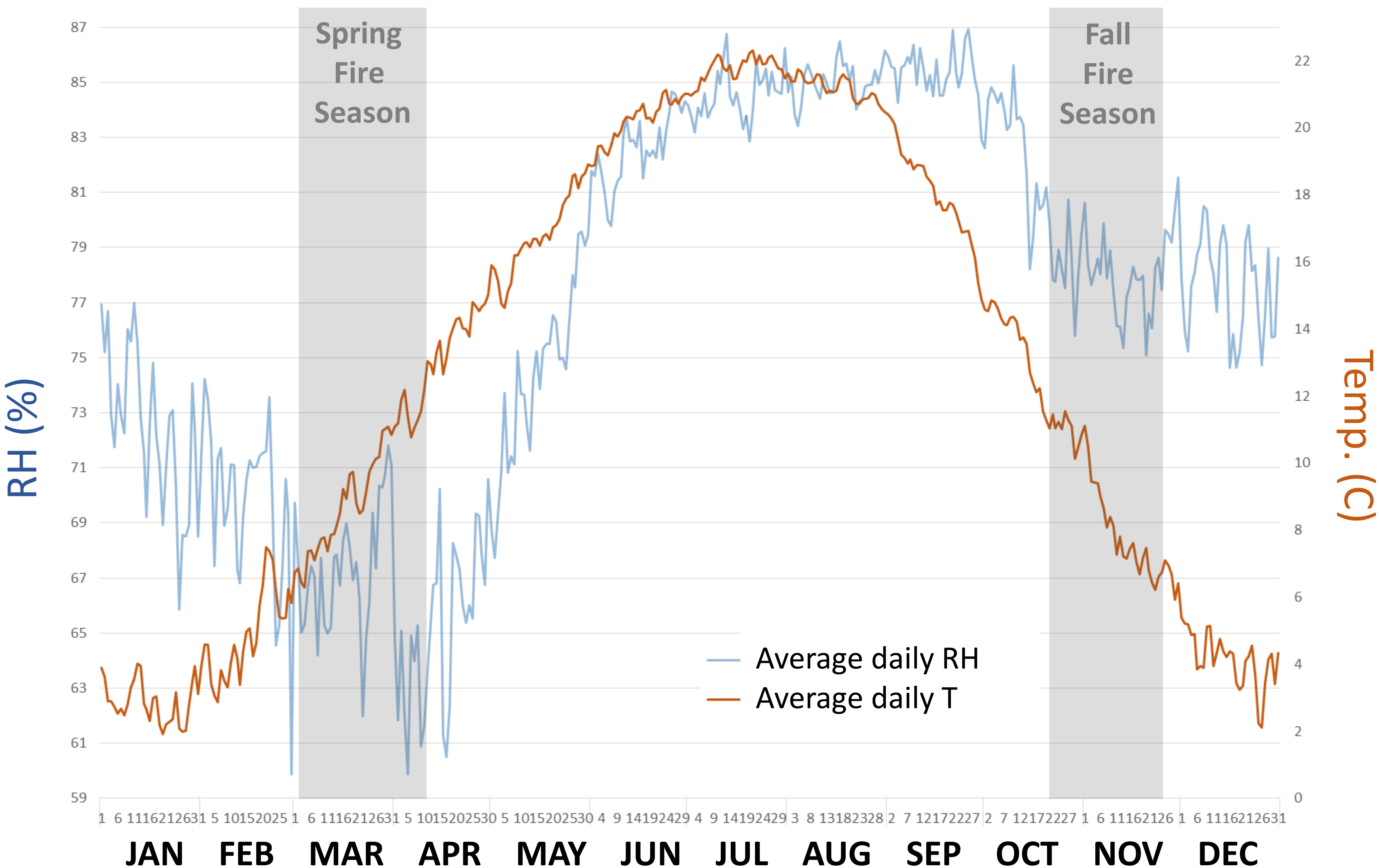
I. The variable timing of spring and fall

Fall Cumulative Growing Degree Days (CGDD) for Asheville, NC Airport



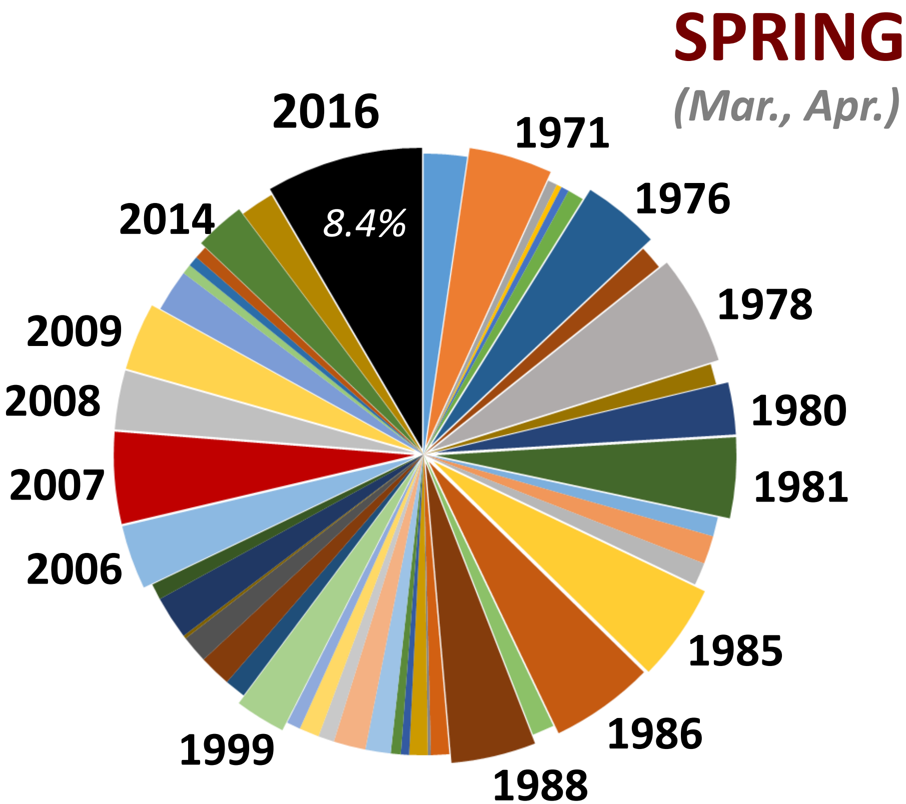
II. The seasonal bimodality of Appalachian fire regimes

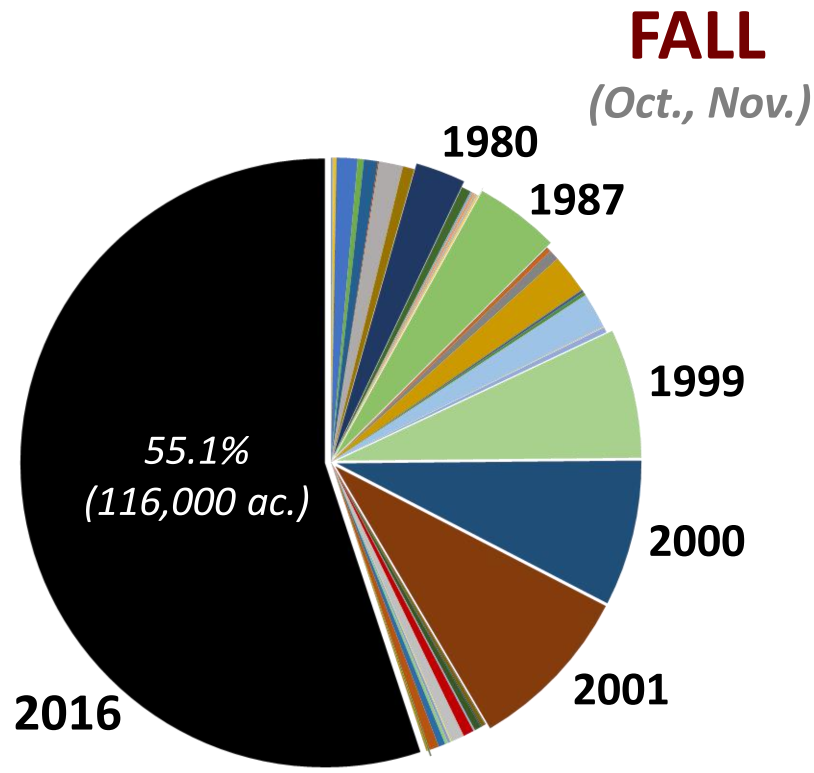
Average seasonal relative humidity and temperature at Coweeta Hydro. Lab.



II. The seasonal bimodality of Appalachian fire regimes

The yearly fraction of seasonal area burned by wildfire across Southern Appalachian federal lands, 1970-2016

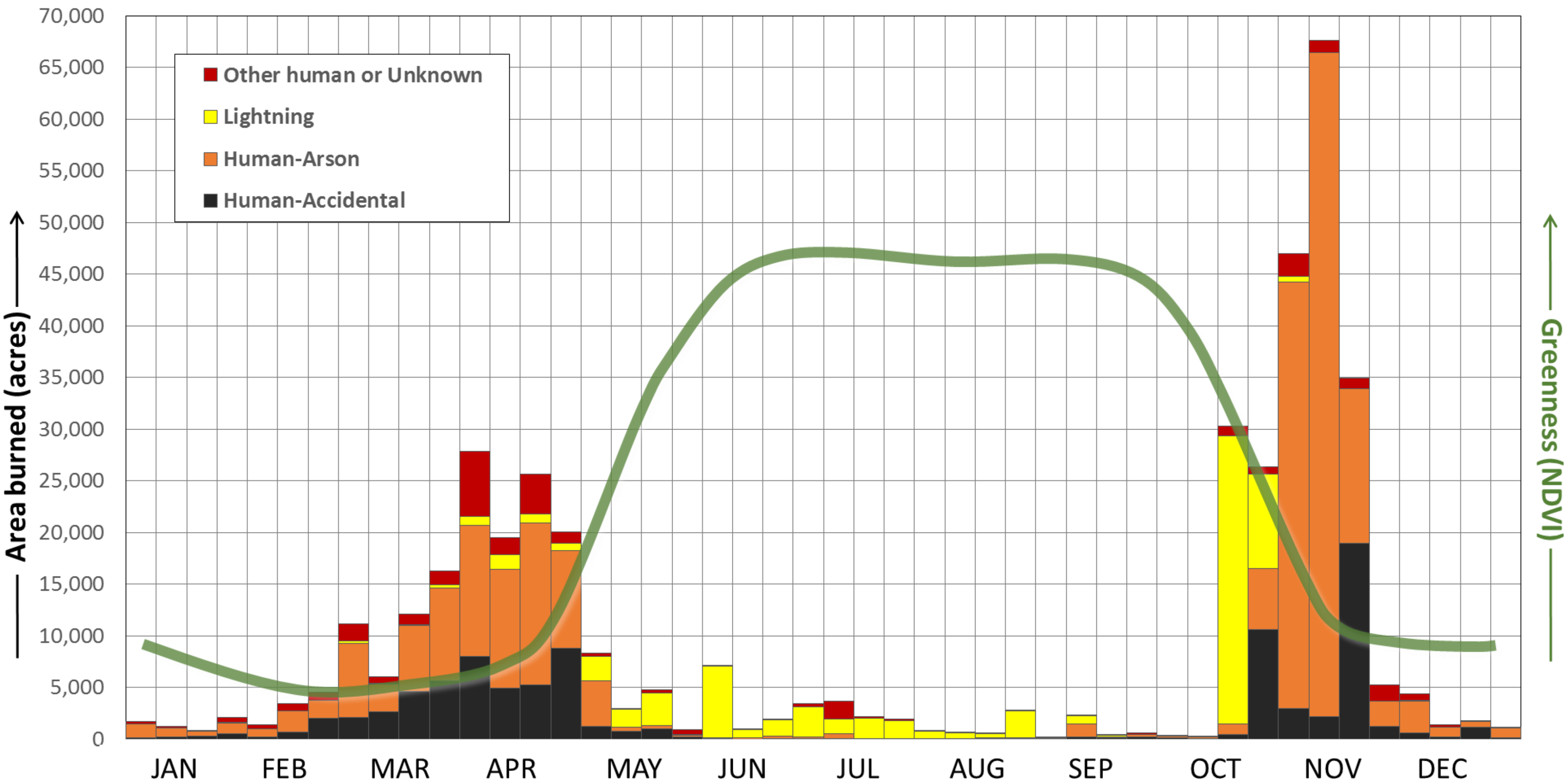




Labeled years exceed 2.5% of the 47-year season total.

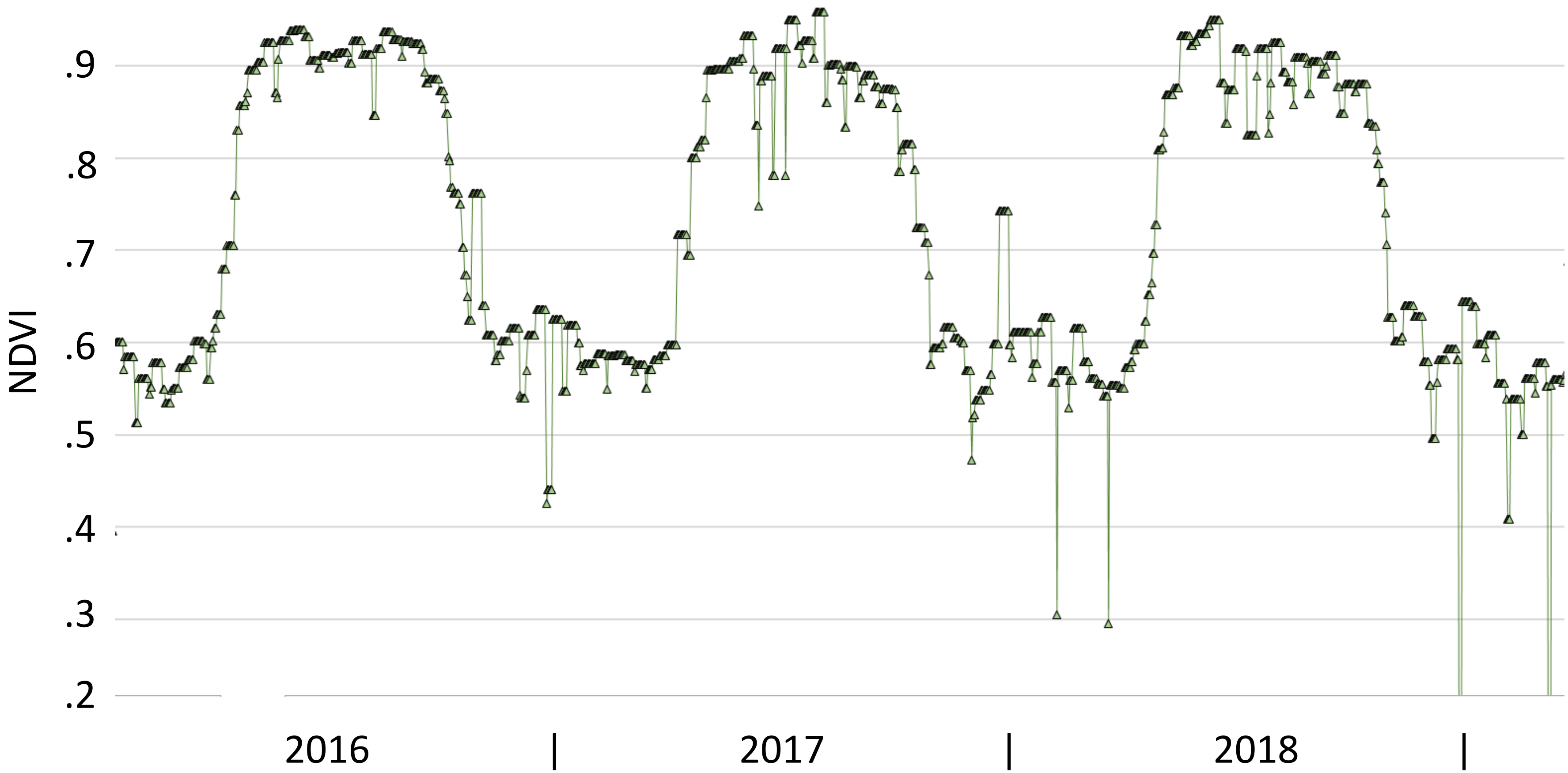
II. The seasonal bimodality of Appalachian fire regimes

Weekly area burned on Southern Appalachian federal lands by cause (1970-2016) compared to the mean MODIS vegetation phenology for Great Smoky Mountains National Park (2000-2015)



III. Needed and desirable precision from remote sensing

Running 8-day-maximum NDVI from Terra and Aqua 500m MODIS



Cloud-Filtered Frequency 2017-2018

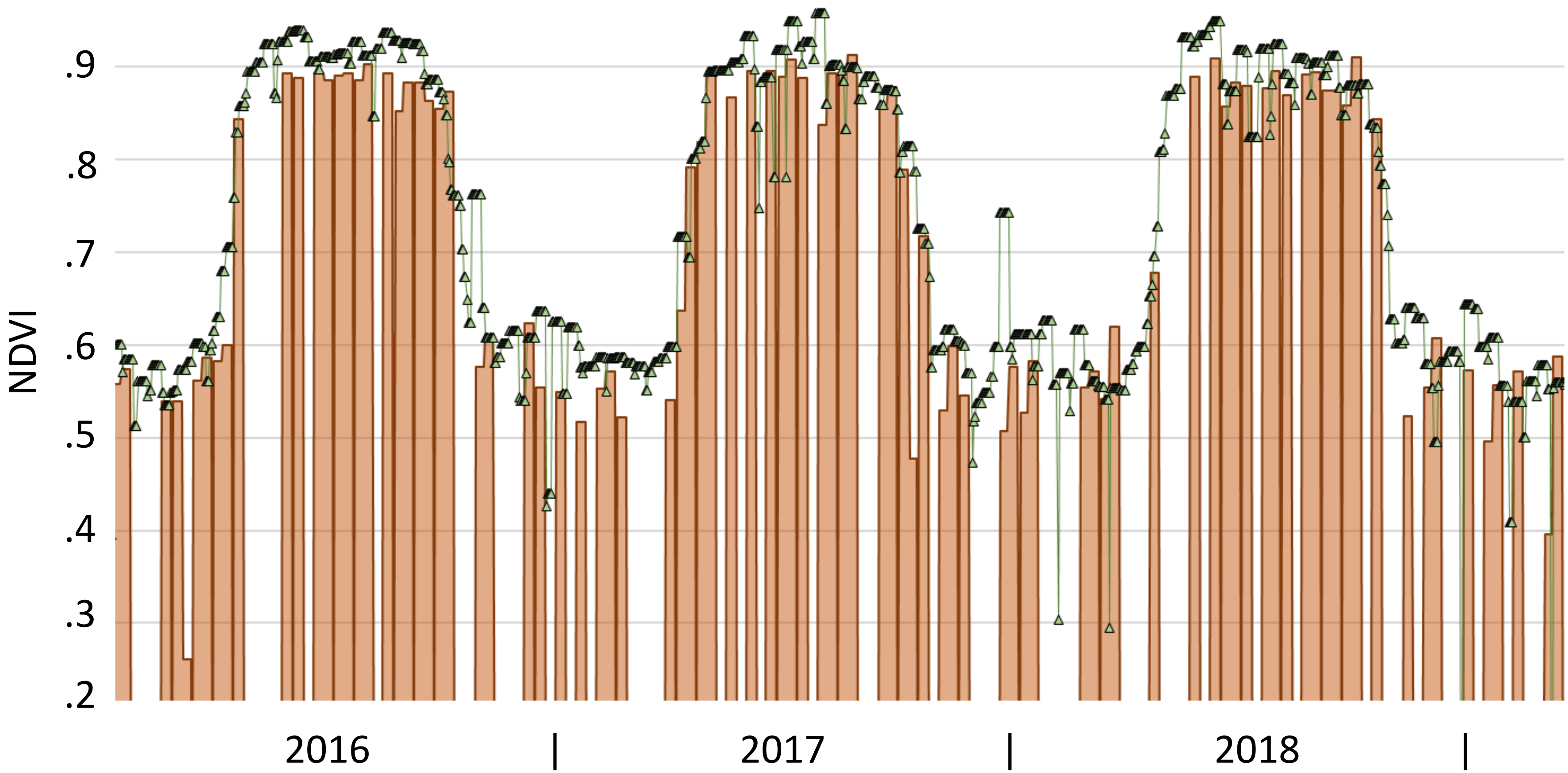
Satellite System	Mean	Median	St Dev
MODIS (A,T)	1.5	1.0	1.0

Source: Climate Engine

Location: Coweeta Watershed, NC

Running 8-day-maximum NDVI from Terra and Aqua 500m MODIS and Running 8-Day-Maximum NDVI from BOA 30m Landsat 8

(WITH L8 PATH OVERLAP)



White between bars are running 8-day data gaps!

Source: Climate Engine

Location: Coweeta Watershed, NC

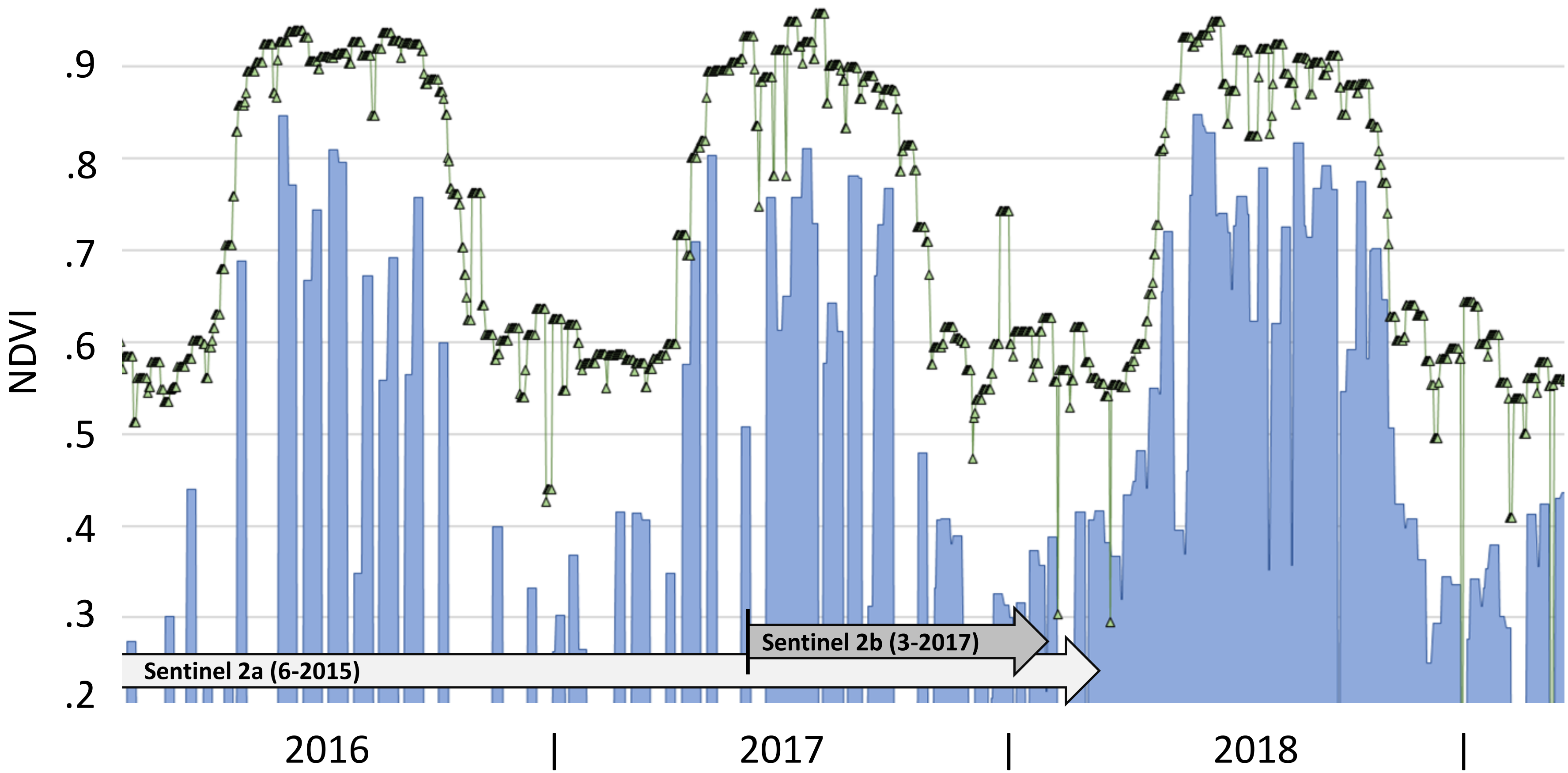
Cloud-Filtered Frequency 2017-2018

Satellite System	Mean	Median	St Dev
MODIS (A,T)	1.5	1.0	1.0
Landsat 8	13.5	9.0	8.8

III. Needed and desirable precision from remote sensing

Running 8-day-maximum NDVI from Terra and Aqua 500m MODIS and Running 8-Day-Maximum NDVI from TOA 10m Sentinel 2

(WITH S2 PATH OVERLAP)



White between bars are running 8-day data gaps!

Source: Climate Engine

Location: Coweeta Watershed, NC

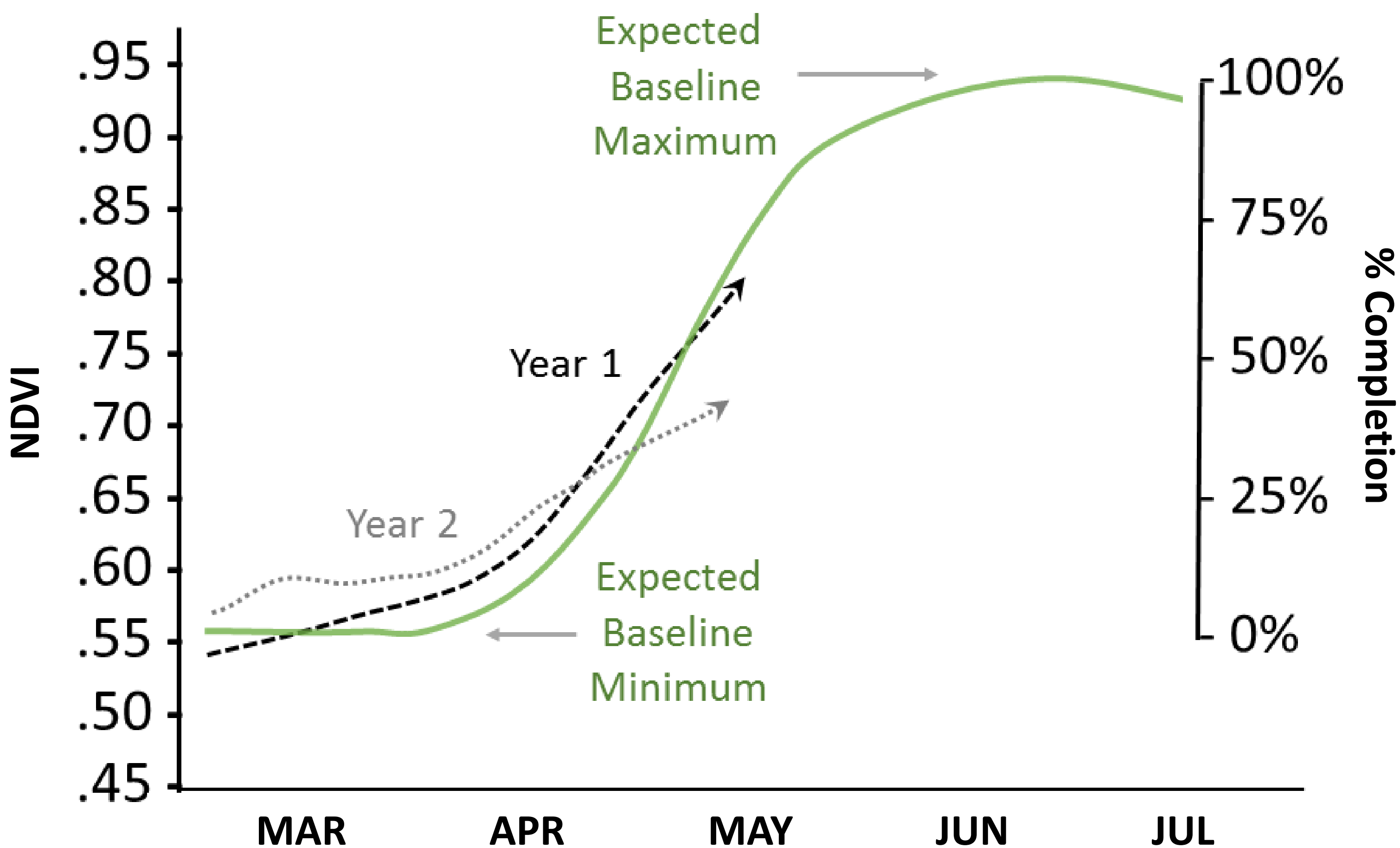
Cloud-Filtered Frequency 2017-2018

Satellite System	Mean	Median	St Dev
MODIS (A,T)	1.5	1.0	1.0
Landsat 8	13.5	9.0	8.8
Sentinel 2 (a/b)	5.5	5.0	4.6

IV. Seasonal completion

Graphical and mathematical explanation

$$\% = \frac{(\text{Current} - \text{Min})}{(\text{Max} - \text{Min})}$$



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Graphical and mathematical explanation

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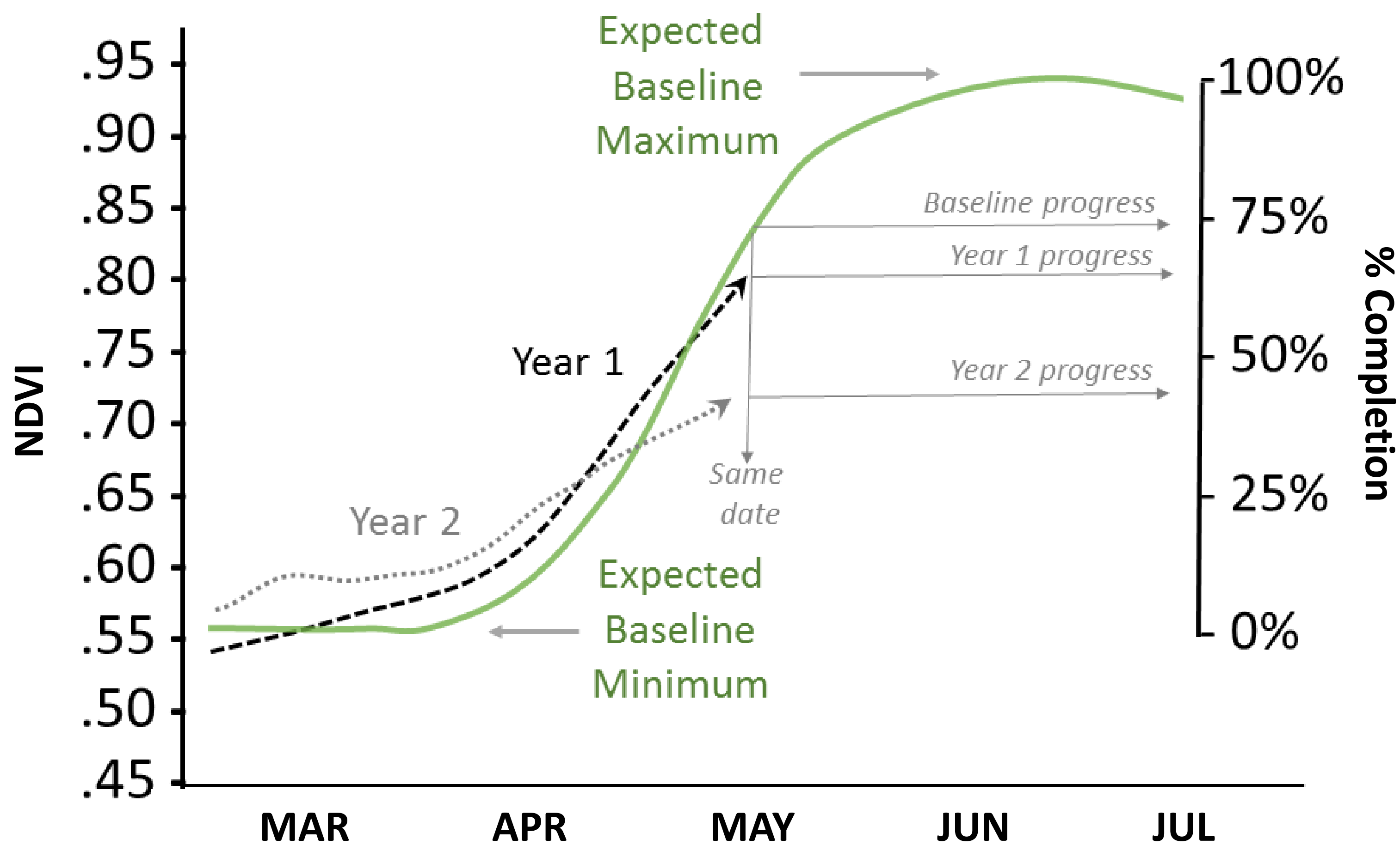
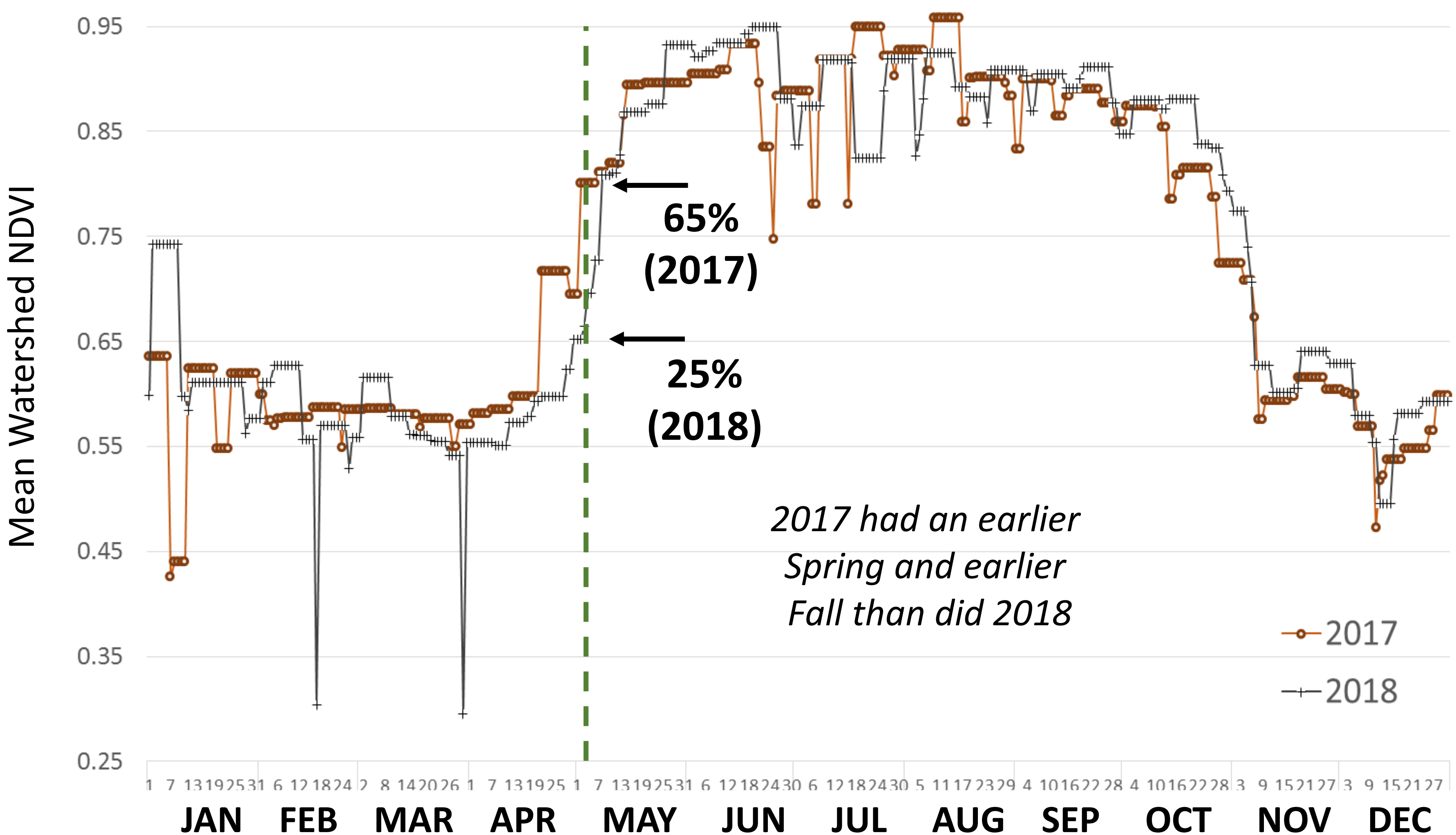


IV. Seasonal completion

A mid-scale example from running 8-day-maximum NDVI from Terra and Aqua 500m MODIS for Coweeta Watershed, NC **2017 vs. 2018**



IV. Seasonal completion

Coweeta tower "phenocam" view for **May 2, 2017**

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

IV. Seasonal completion

Coweeta tower "phenocam" view for **May 2, 2018**

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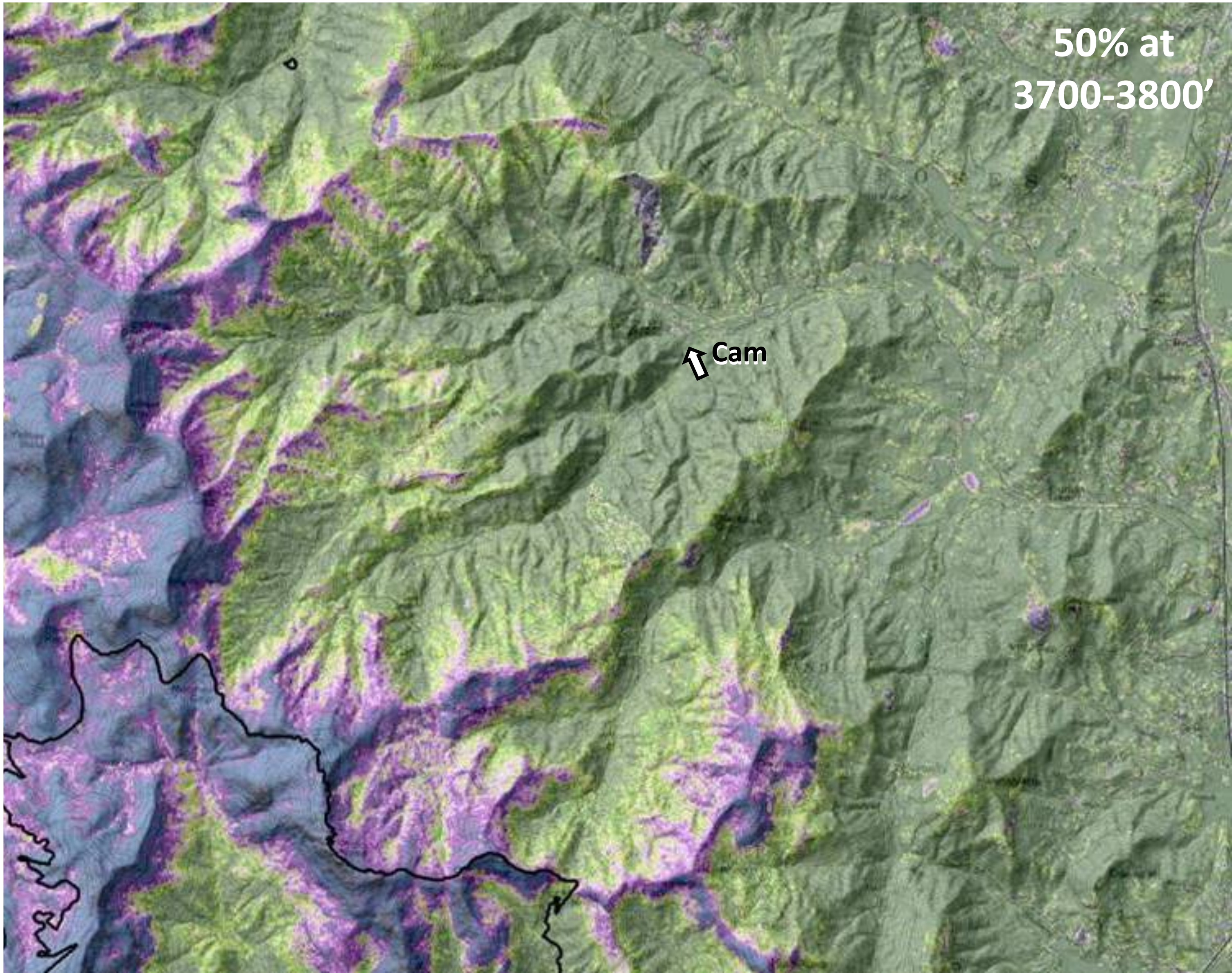
% Completion for Coweeta watershed for **May 2, 2017**

10m Sentinel 2

% Completion

- <0.00
- 0.00 - 0.10
- 0.10 - 0.20
- 0.20 - 0.25
- 0.25 - 0.30
- 0.30 - 0.35
- 0.35 - 0.40
- 0.40 - 0.45
- 0.45 - 0.50
- 0.50 - 0.55
- 0.55 - 0.60
- 0.60 - 0.65
- 0.65 - 0.70
- 0.70 - 0.75
- 0.75 - 0.80
- 0.80 – 0.85
- 0.85 - 0.90
- >0.90



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% Completion for Coweeta watershed for **May 2, 2018**

10m Sentinel 2

% Completion

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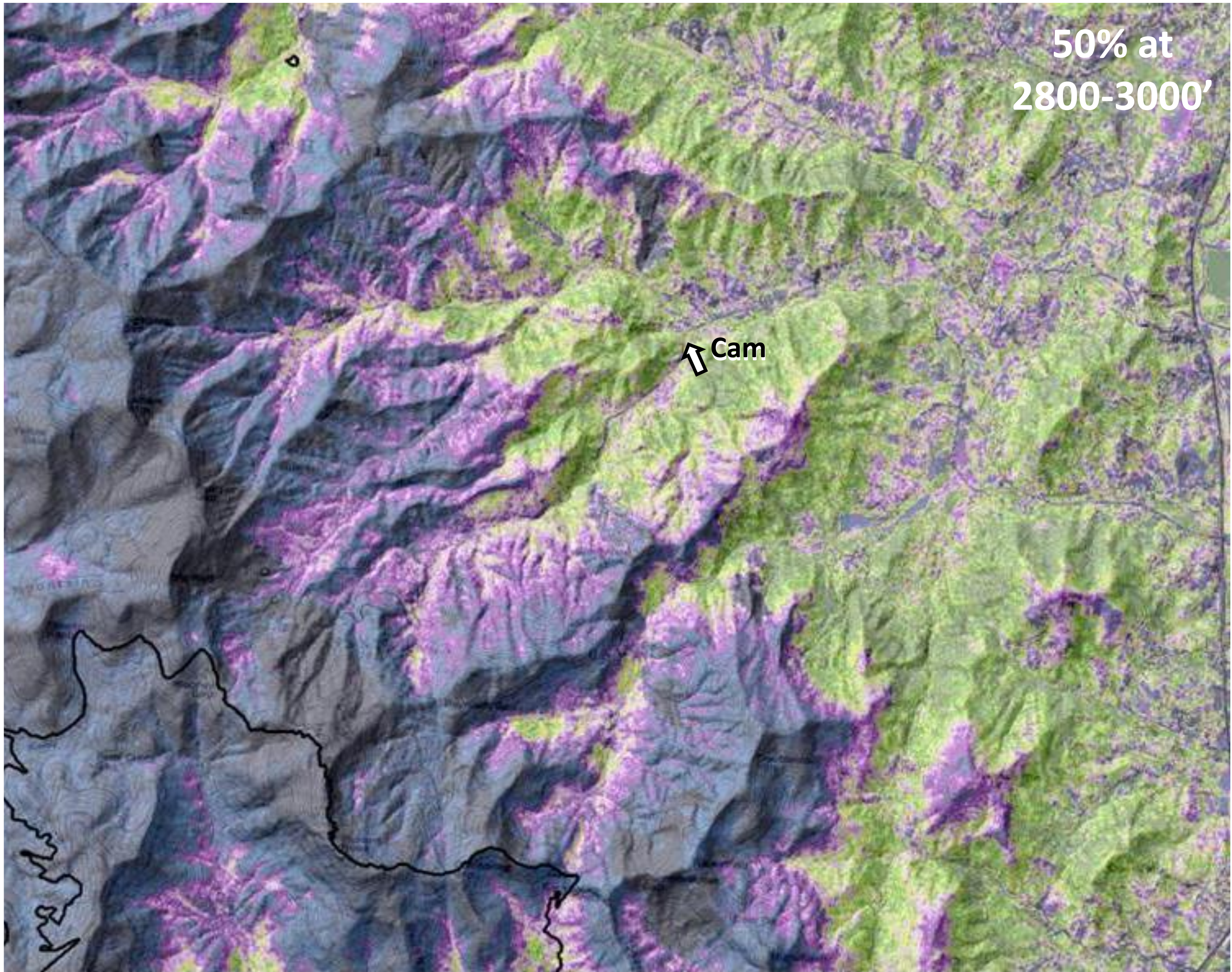
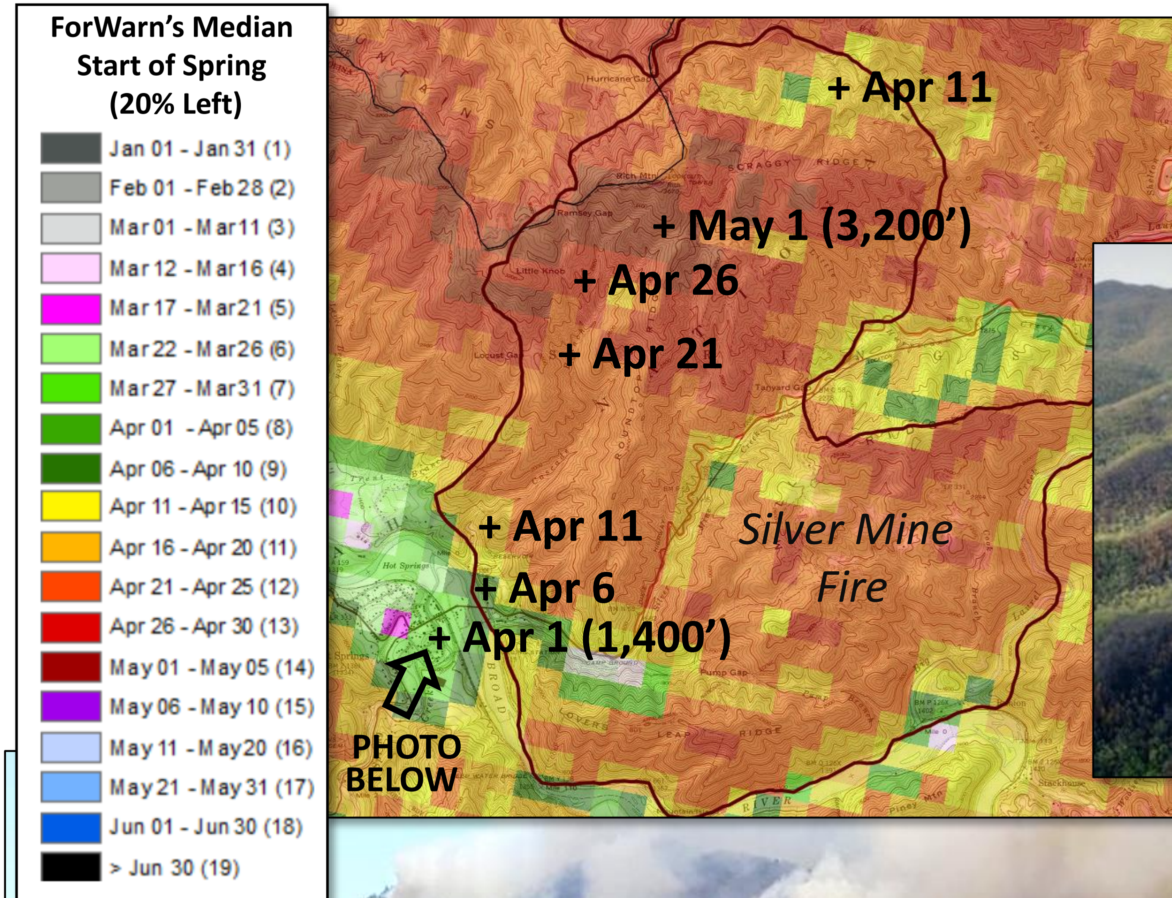
- 0.45 - 0.50
- 0.50 - 0.55
- 0.55 - 0.60
- 0.60 - 0.65
- 0.65 - 0.70
- 0.70 - 0.75
- 0.75 - 0.80
- 0.80 – 0.85
- 0.85 - 0.90
- >0.90

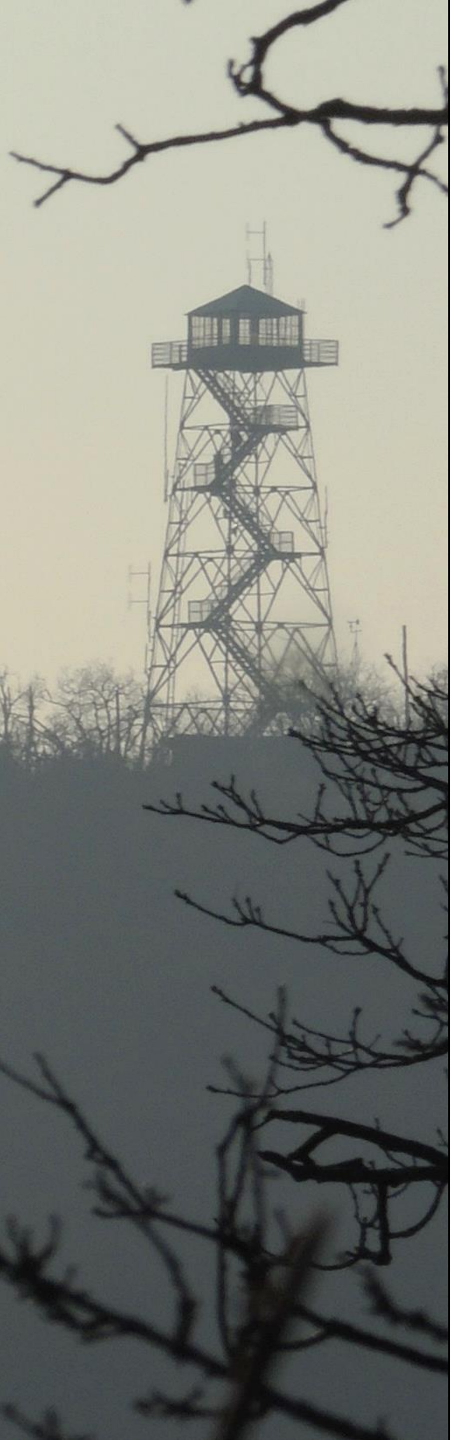


Silver Mine Fire

Appalachian District, Pisgah NF

April 21 – May 4, 2016





SUMMATION

- Quantifying phenological progress will allow managers to better anticipate and contextualize fire effects and time prescribed fire for its intended effects.
- The adaptable and scalable *Percent Completion* concept has practical value for categorizing burn windows and, ultimately, for tracking how they vary and change over years.
- High spatial resolution data can be too infrequent for continuously tracking phenological progress and may not be necessary for tracking vegetation. However, special high-resolution questions can be explored with 30m and 10m products when high-res. satellite data are available.

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ABSTRACT: Vegetation phenology is an important seasonal driver of Appalachian fire in the eastern US, yet its functional role has been overshadowed by meteorological data. As spring progresses, leaf emergence and canopy closure increase understory humidity while buffering temperature and wind speed. These factors combine to dampen fire ignition and spread, which may in turn affect manager's ability to achieve resource objectives, whether wildfire suppression or prescribed fire use. In fall, the timing of leaf senescence and abscission help determine the availability and flammability of the litter that affects fire intensity and spread. When combined with fall drought, the timing of leaf fall can have implications for fire operations and community safety. The importance of spring and fall seasonality is reflected by the bimodal fire season that is characteristic of many forests of the eastern US. In the Appalachians, satellite-observations suggest that the timing of spring and fall has varied by as much as three weeks from one year to the next. With twice-daily temporal frequency, but 250m spatial resolution, MODIS captures more cloud free views than either Landsat 8 (16 day/30m) or Sentinel 2 (5 day/10m), but MODIS lacks the spatial precision often desired in complex mountain landscapes. However, differences in deciduousness across high and low resolution datasets make cell-to-cell comparisons of timing difficult. We illustrate how a simple NDVI transformation to Percent Completion helps overcome this problem of degrees of deciduousness while providing a crosswalk for connecting satellite sensors with different temporal frequency. This approach provides a practical method for integrating remotely-sensed phenology with specific fire events and fire regimes across complex landscapes and broad gradients.