Cross-seasonal assessments of Appalachian forest compositional response after fire using Sentinel 2 imagery

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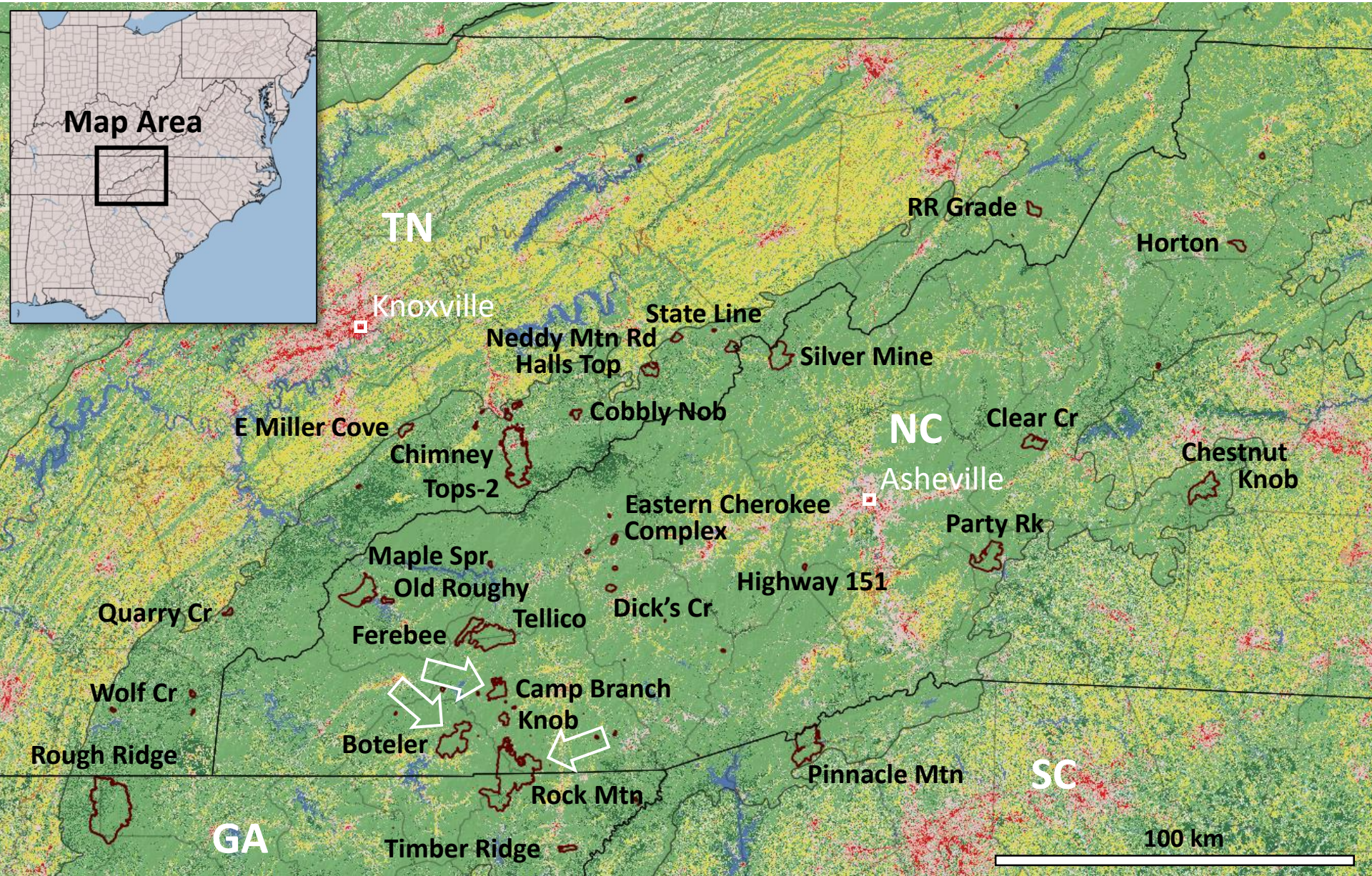
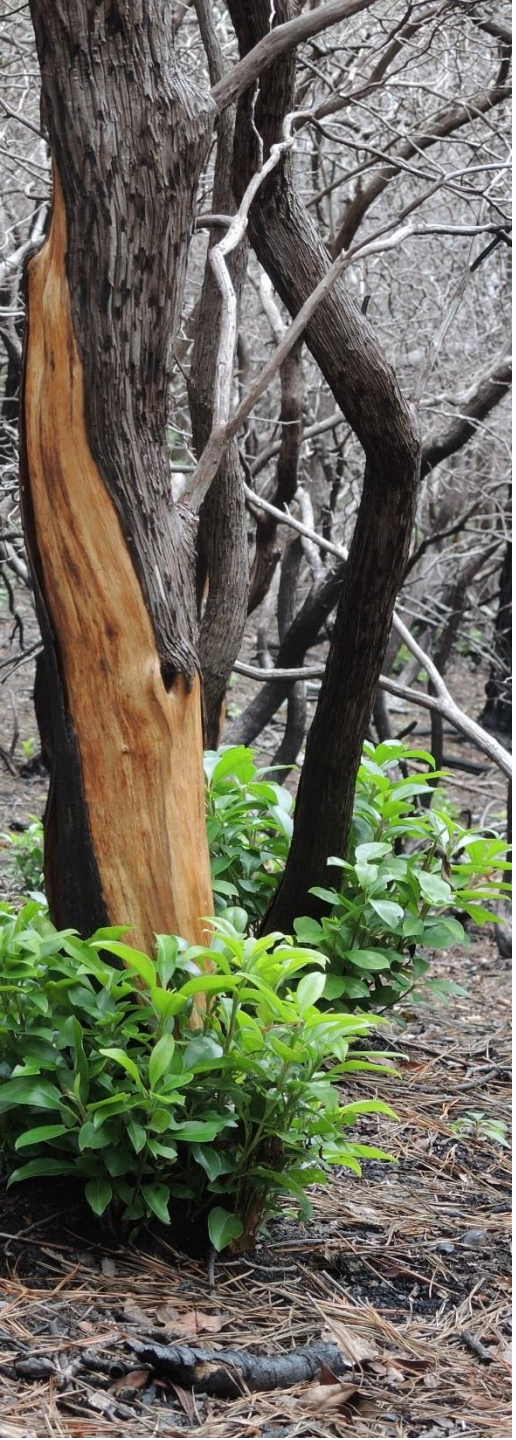
2016: The Year of the Fires

Large 2016 Southern Appalachian wildfires and land cover





Objectives

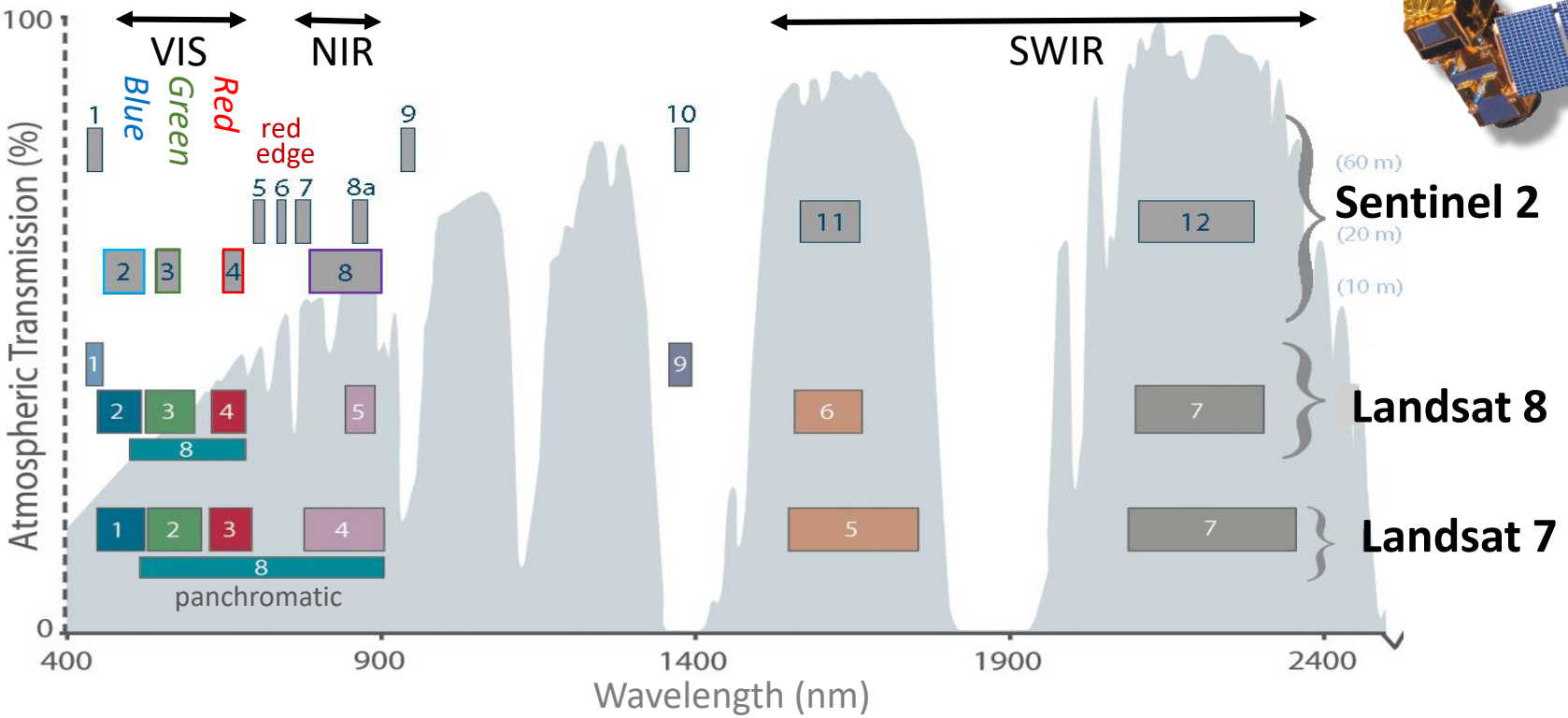
- Develop new, efficient monitoring approaches for forests, especially with respect to wildland fire hazards and effects.

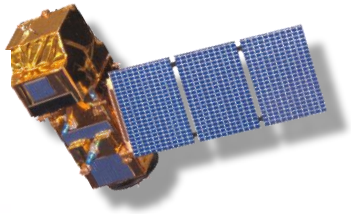
  …for understory shrub fuels after fire that is separate from overstory canopy severity.

  …for conifer canopy trees apart from the deciduous component.

- Explore new frequent, high resolution Sentinel 2 satellite technology.

Why Sentinel 2?

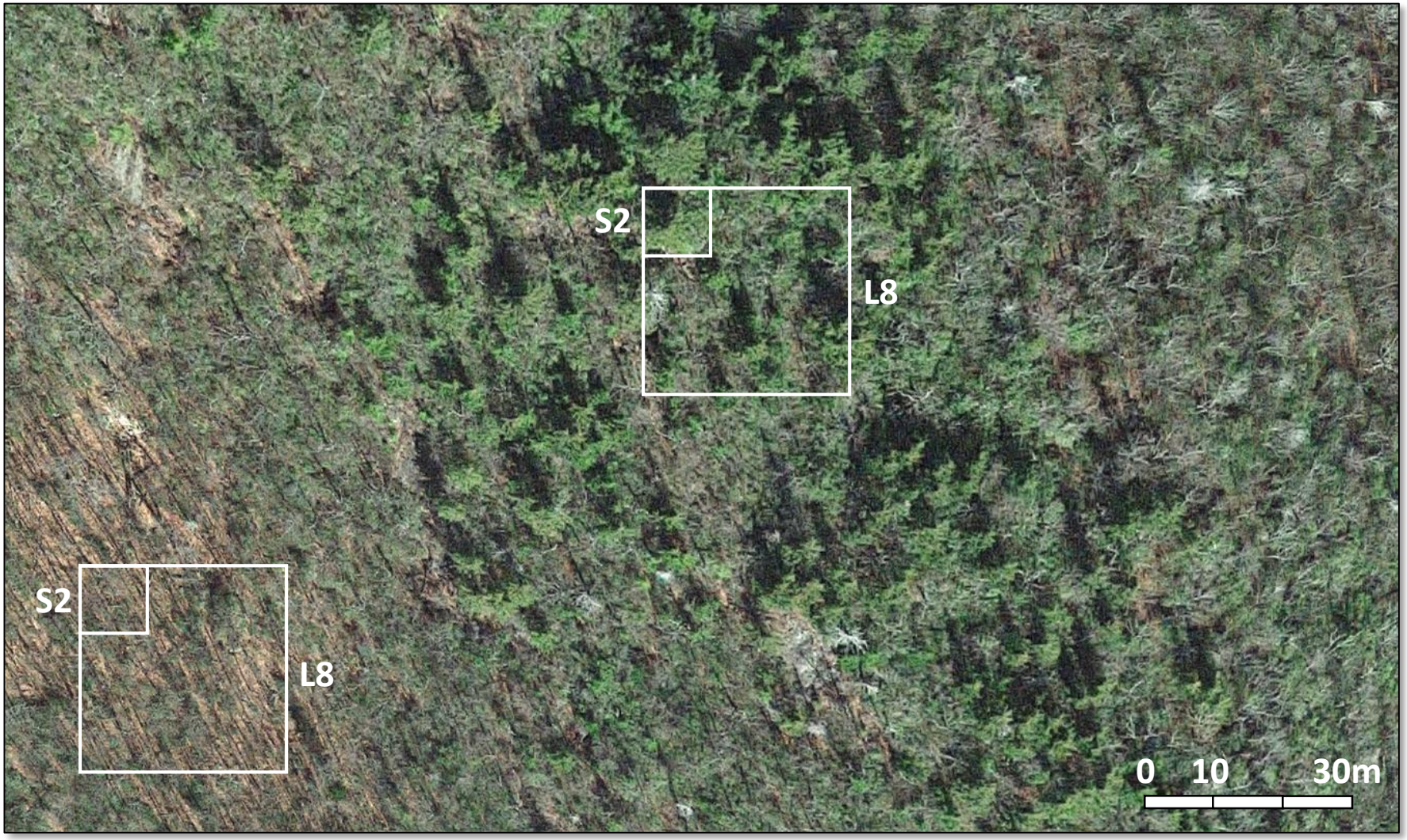




Satellite, Instrument	Spatial resolution	Temporal resolution	Historical Availability	Source
Sentinel-2a/b, MSI	**10m** (20m)	**5 day** (both)	Jun 2015 -	Euro. Space Agency
Landsat 8, OLI Landsat 7, ETM+ Landsat 5, TM	30m (15m) 30m (15m) 30m	8 to 16 day (with both)	2013 - 1999 - … 1984-2012	US NASA
Terra/Aqua, MODIS	250m (500m)	2 passes/day	2000 -	US NASA

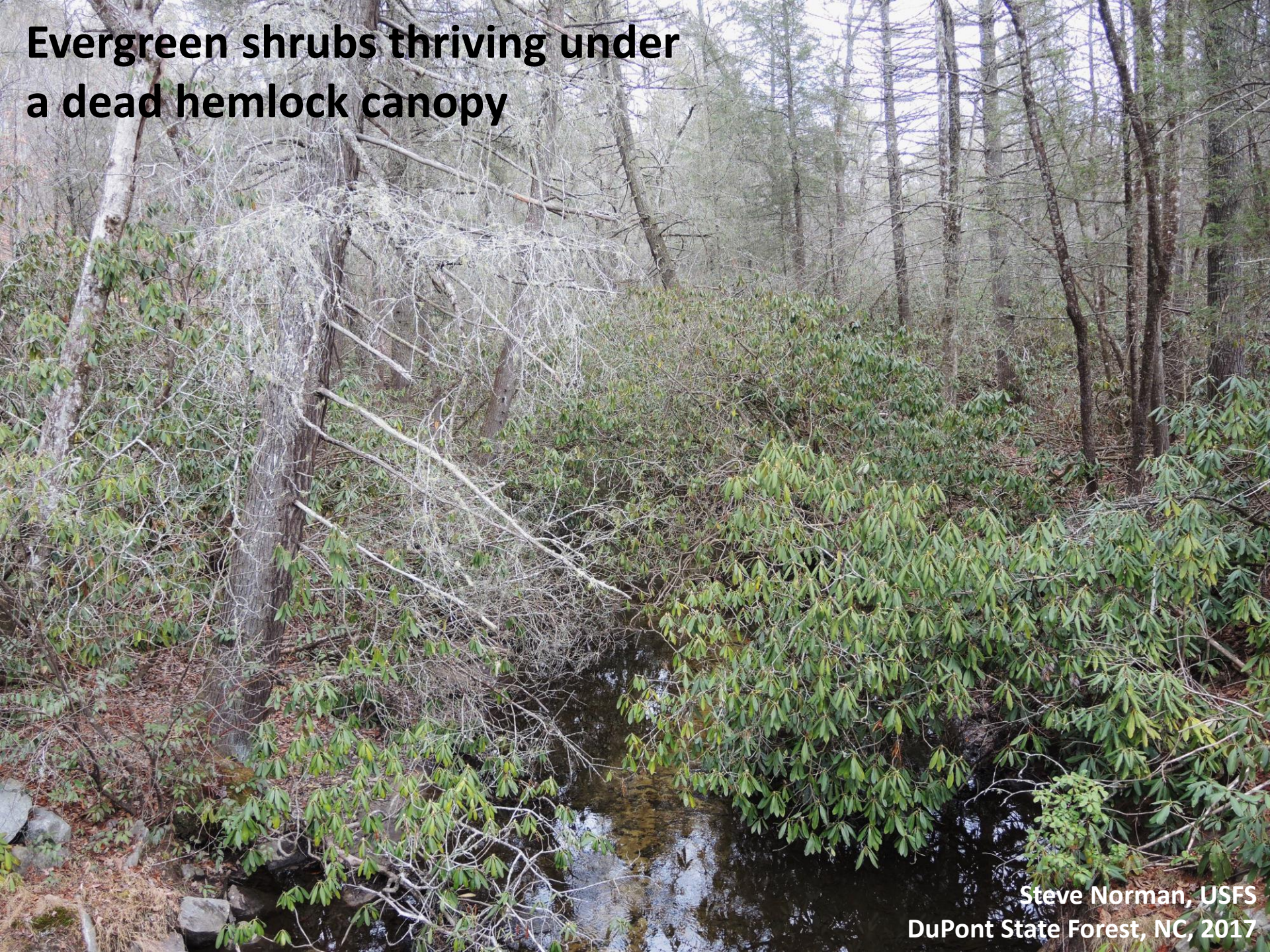
What can 10m spatial resolution tell us?

Sentinel 2 (10m) compared to Landsat 8 (30m)



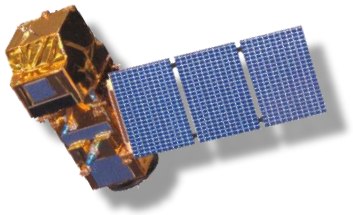
Overstory and understory evergreen off the Blue Ridge Parkway, NC

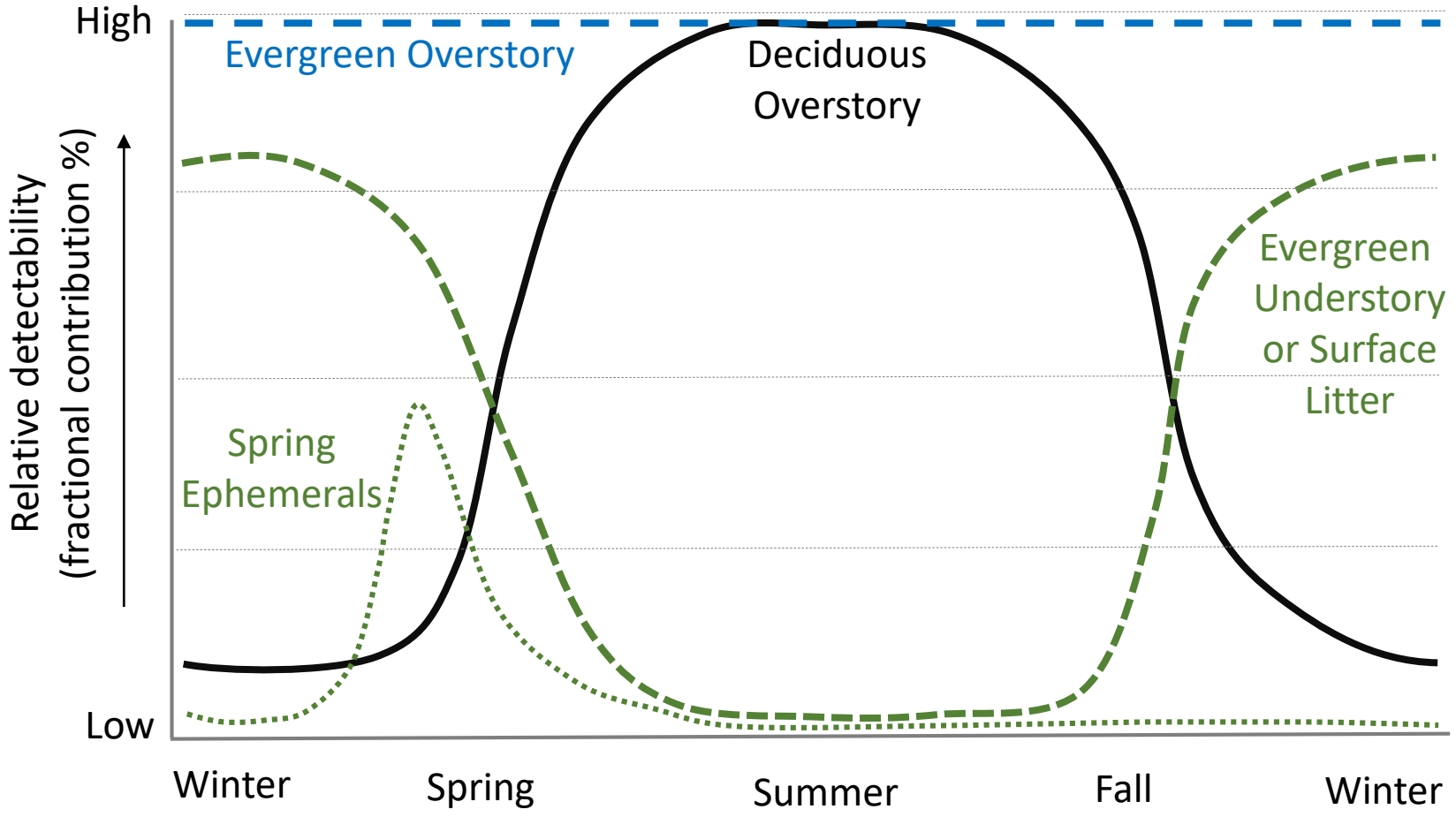
Evergreen shrubs thriving under a dead hemlock canopy



Steve Norman, USFS
DuPont State Forest, NC, 2017

Hypothetical detectability of humid temperate forest components, given seasonal phenologies and masking effects





We need to monitor overstory *and* understory vegetation and fuels

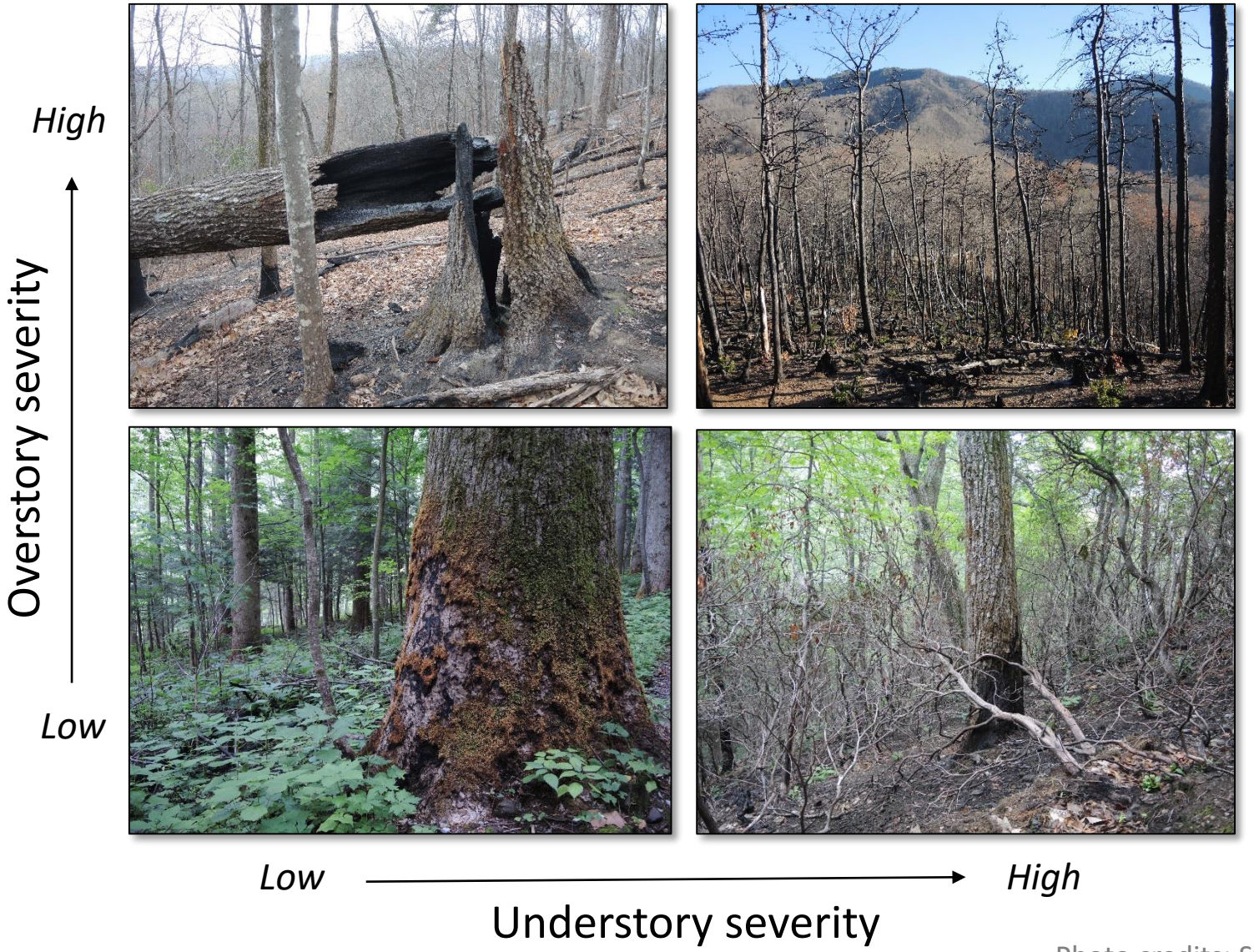
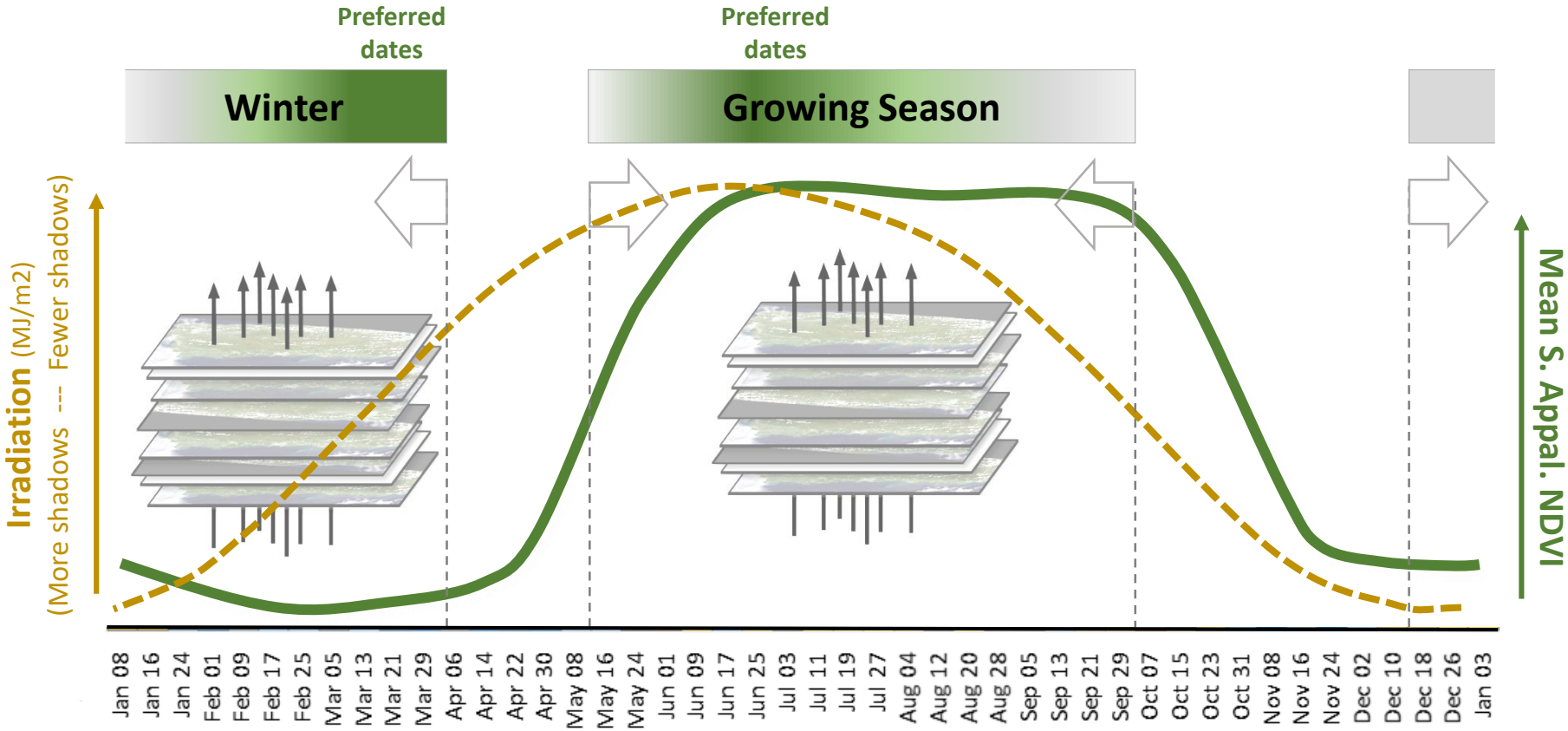


Photo credits: Steve Norman

Southern Appalachian leaf-on/leaf-off maximum value NDVI composite periods

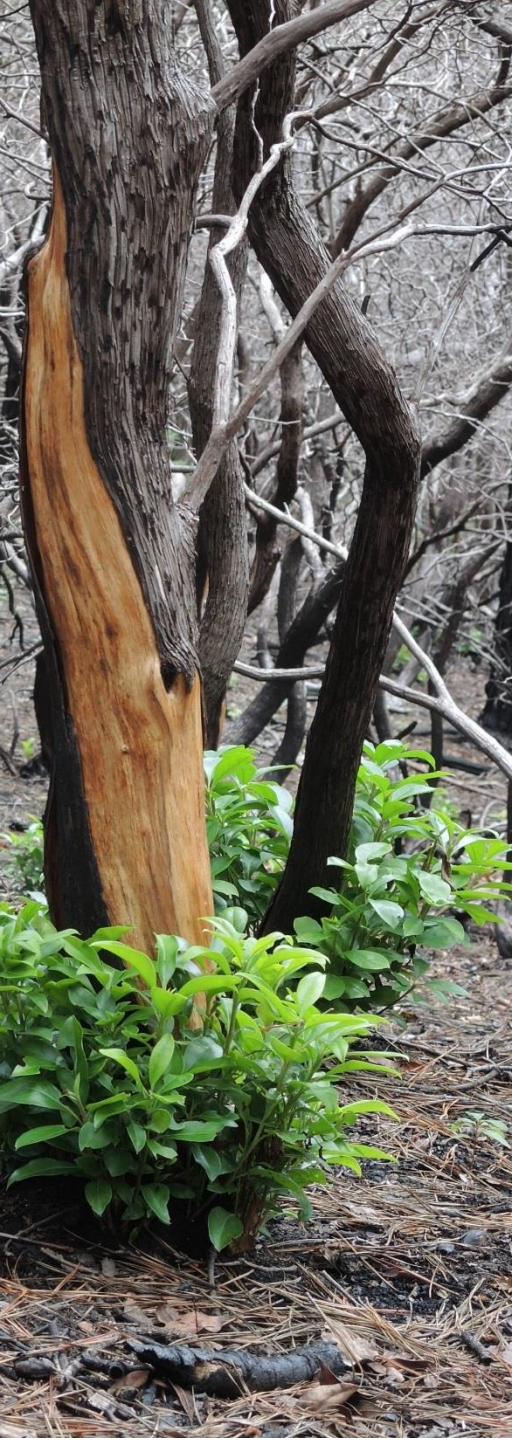


<u>Special winter concerns</u>:

Topographic shadows/slope aspect, pitch
Illumination (light quality)
Snowpack
Bole/canopy shadows and tree heights
Un-abscised canopy litter in Dec.
Precocious green-up in spring

<u>Special growing season concerns</u>:

Humidity
Within-summer decline in NDVI
Change in illumination through the summer
Elevational differences affect the growing season windows



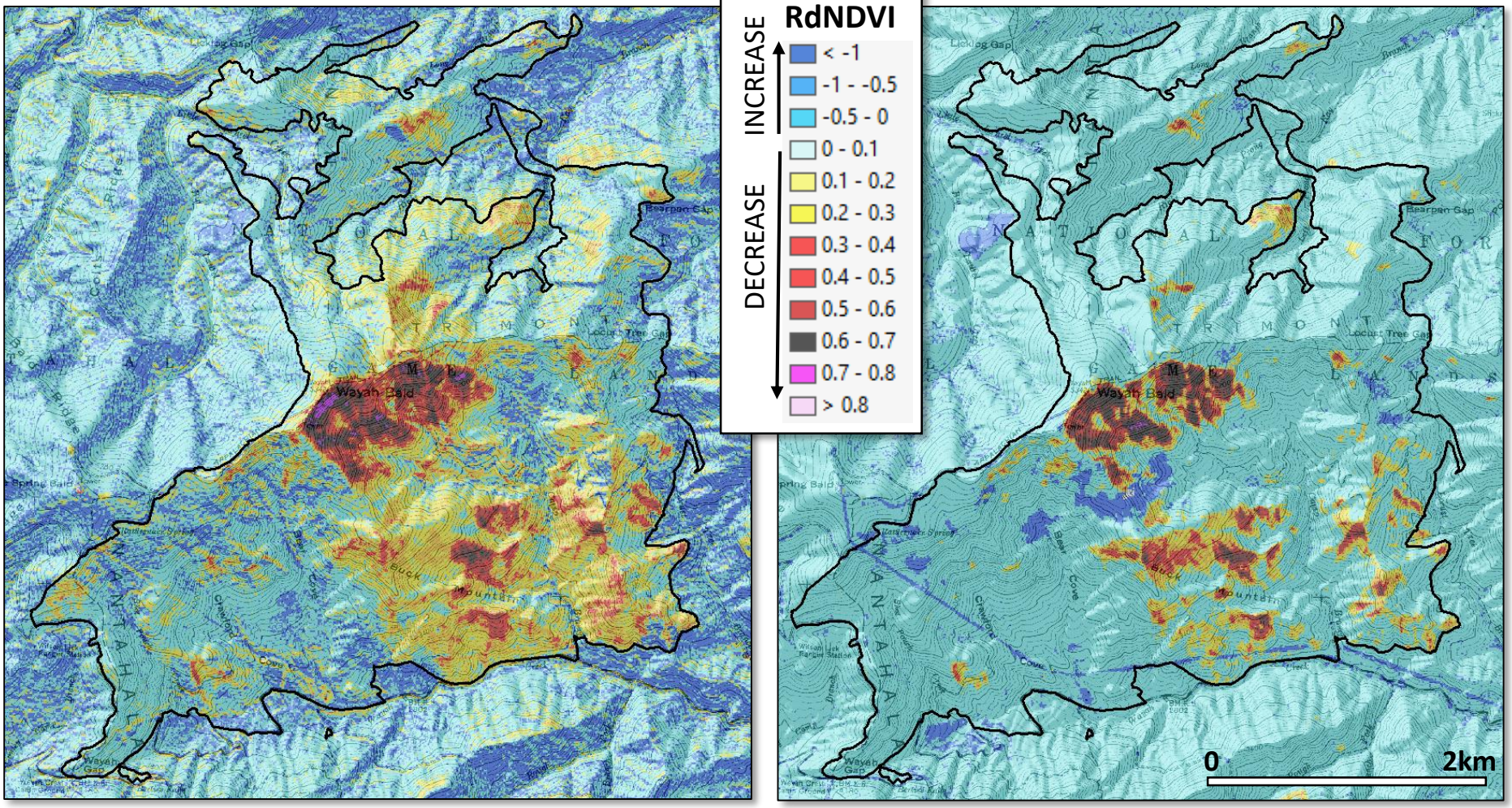
Comparing fire effects:
growing season
vs. late winter severity

Cross-seasonal fire effects

Camp Branch Fire NC (Nov. 2016)

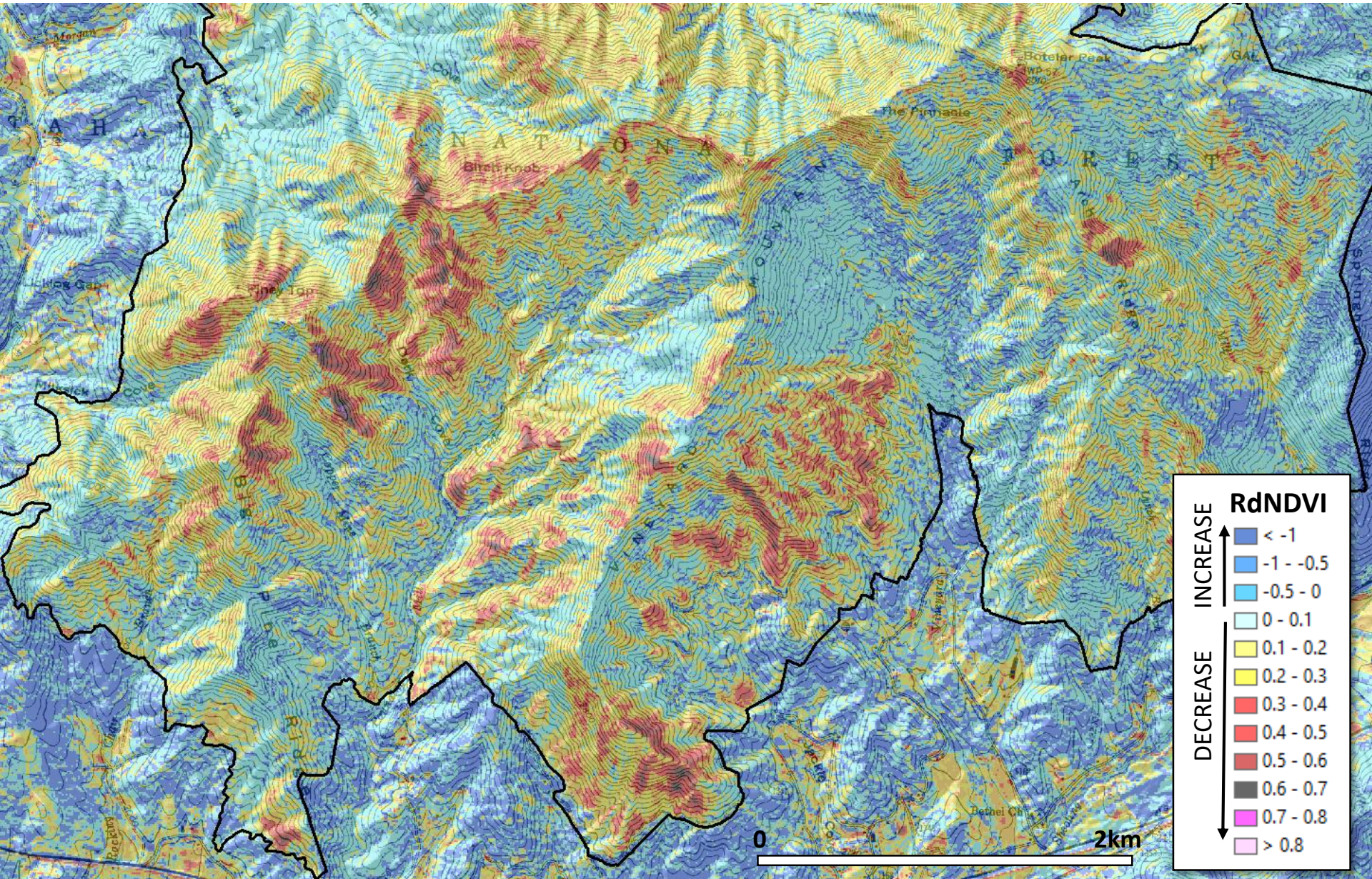
First winter effects to evergreen/understory

First growing season effects to overstory canopy



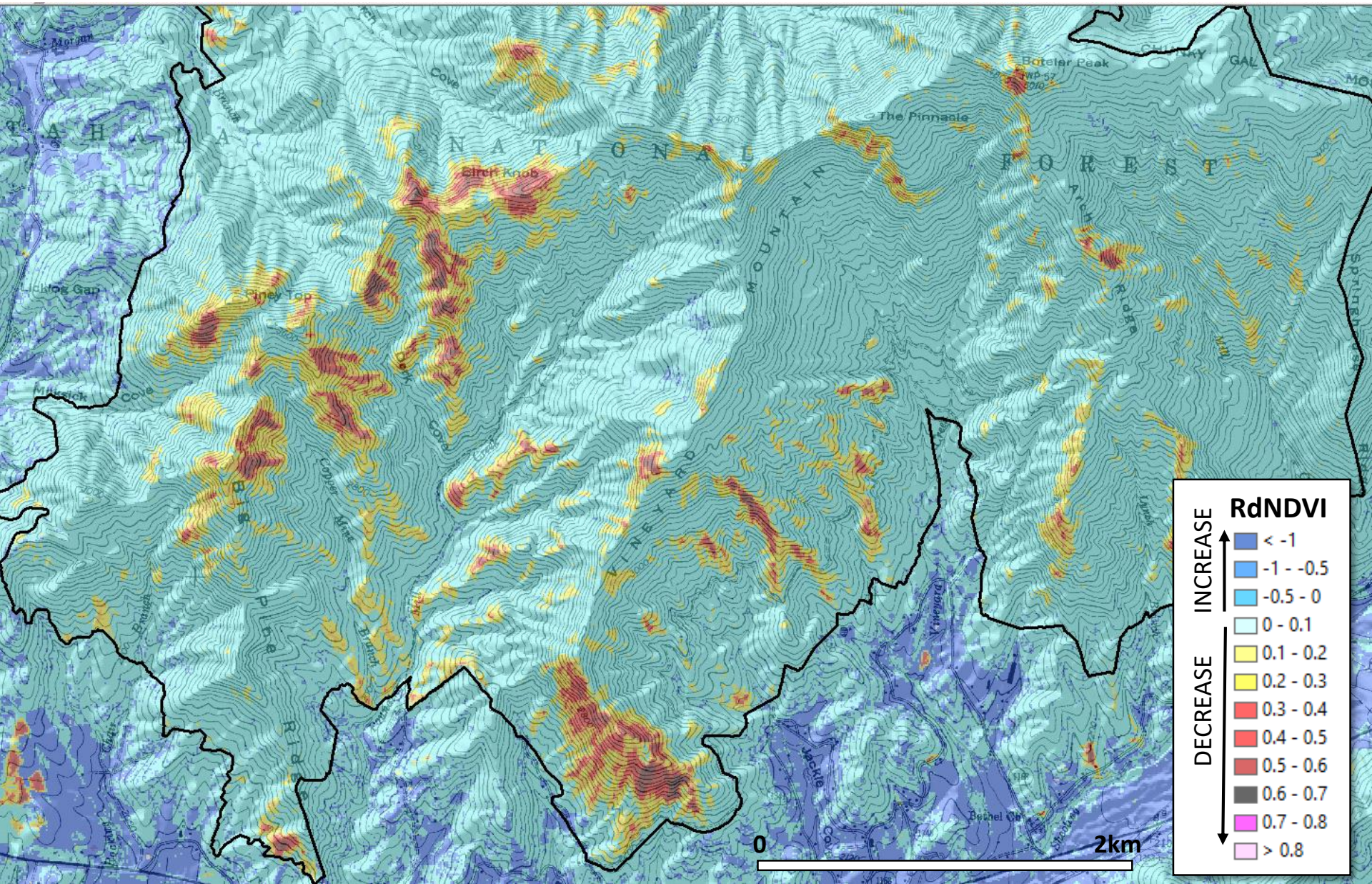
First winter fire effects to evergreen/understory

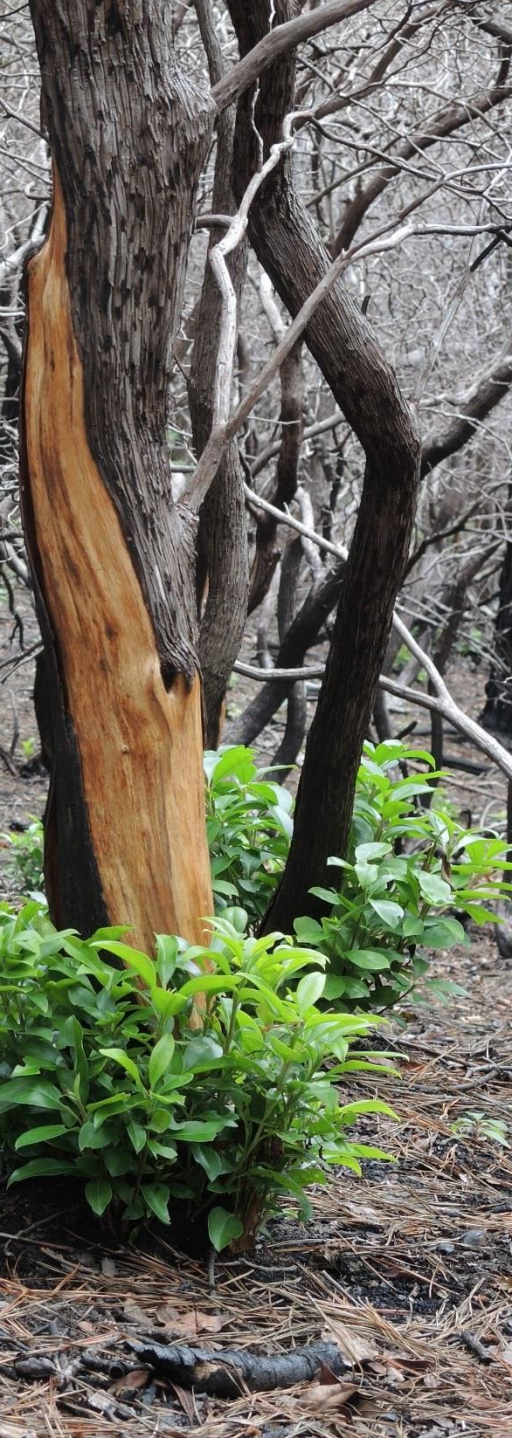
Boteler Fire NC (Oct.-Nov. 2016)



First growing season fire effects to overstory canopy

Boteler Fire NC (Oct.-Nov. 2016)



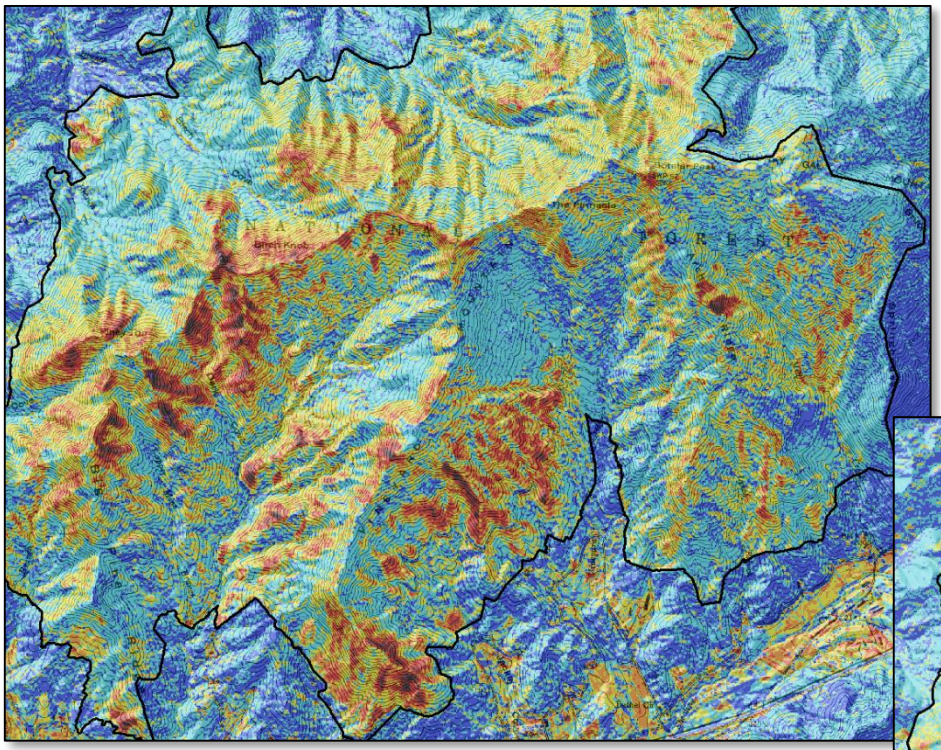


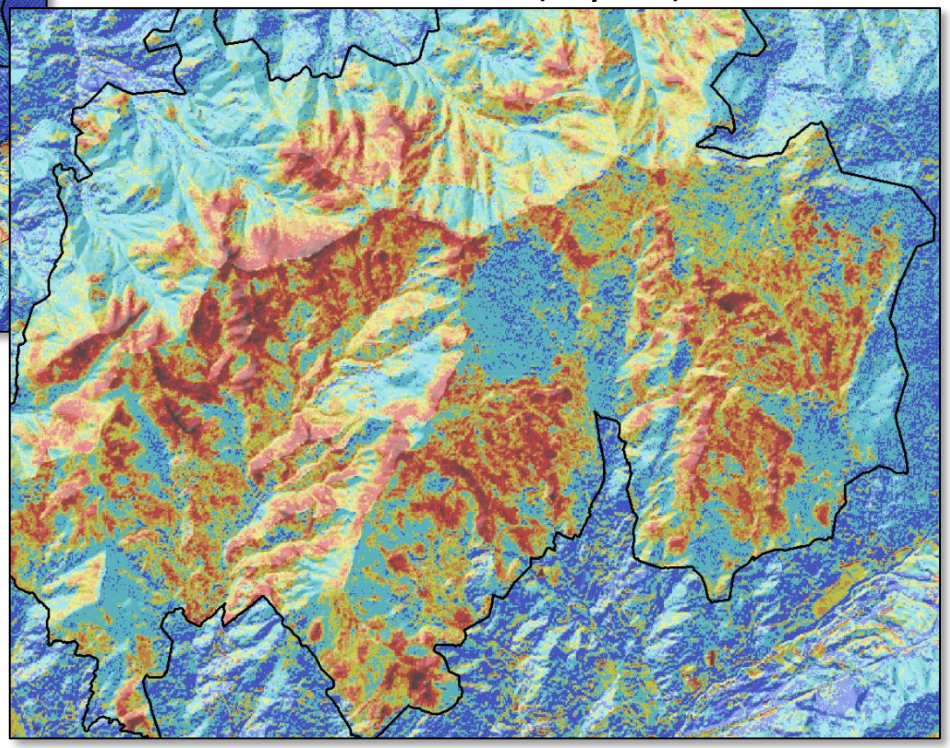
Comparing fire effects:
year 1 vs. year 2
late winter severity

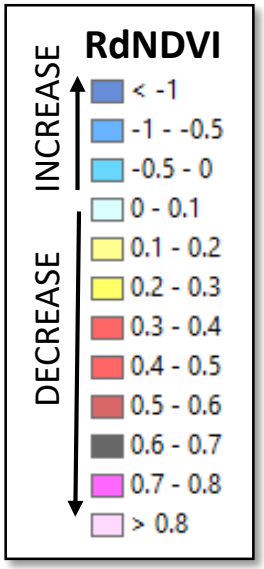
Initial and delayed late winter change

Boteler Fire

Pre fire vs. March 2017



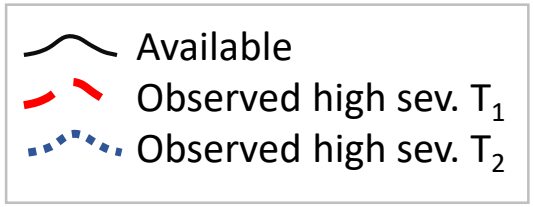




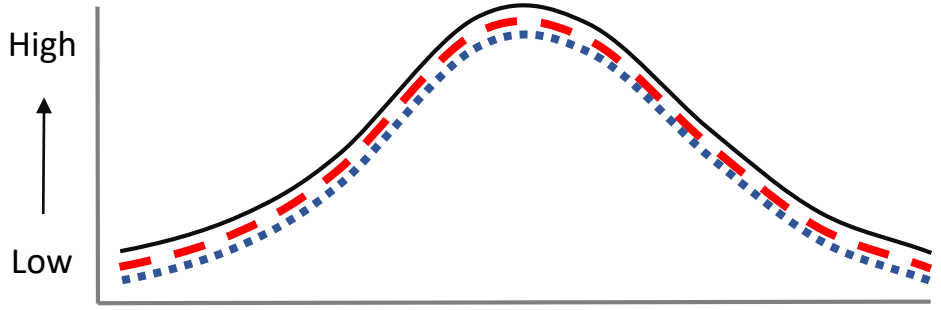
Pre fire vs. March 2018 (2-year)

0 **Scale in km** 5

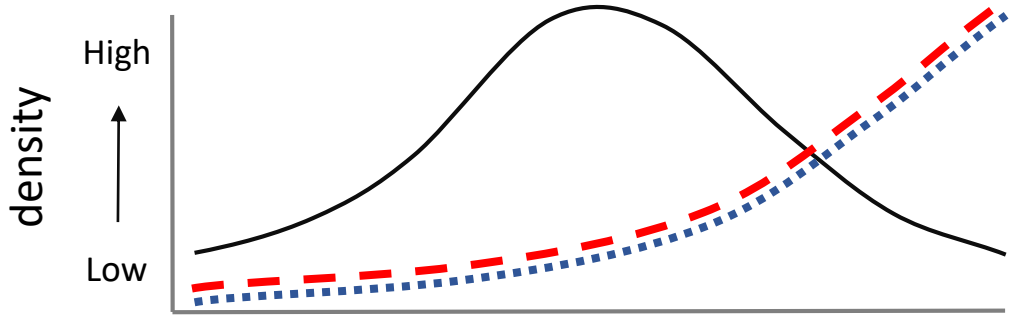
Hypothetical landscape patterns of first vs. second order fire-associated declines



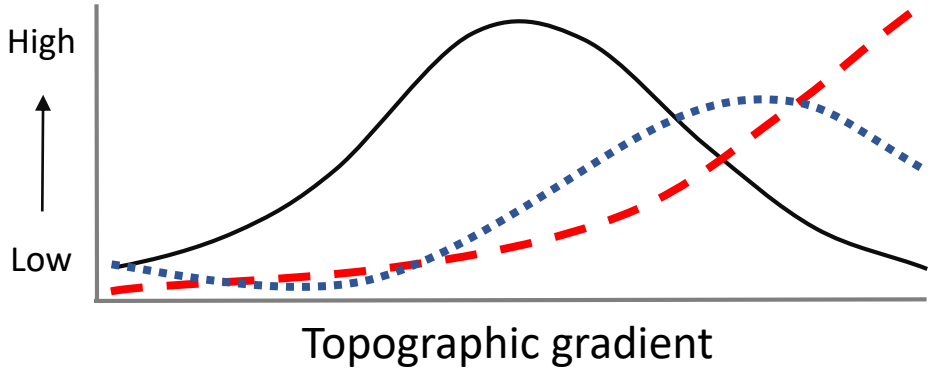
1. No preferred responses
(same as availability; random)

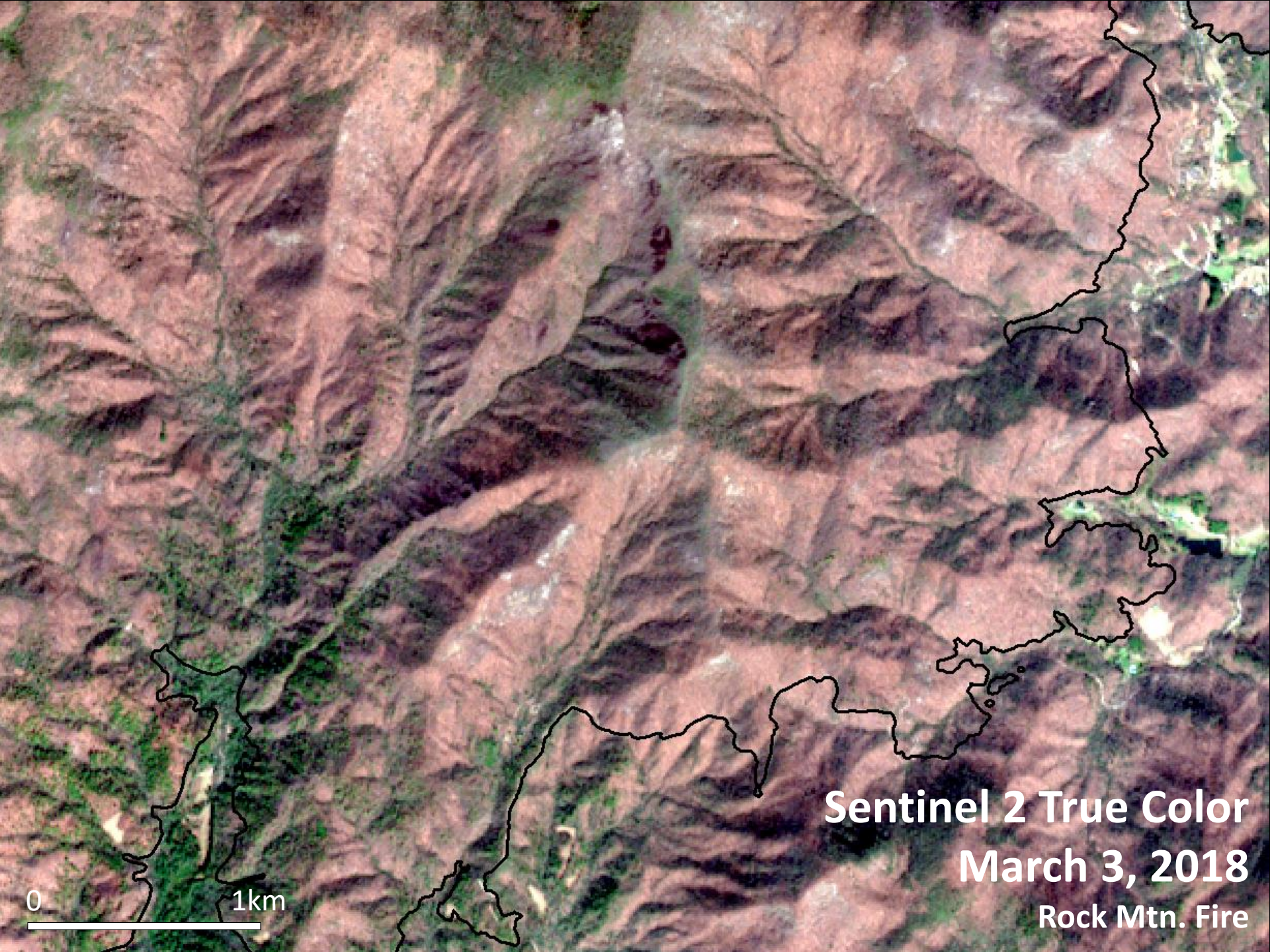


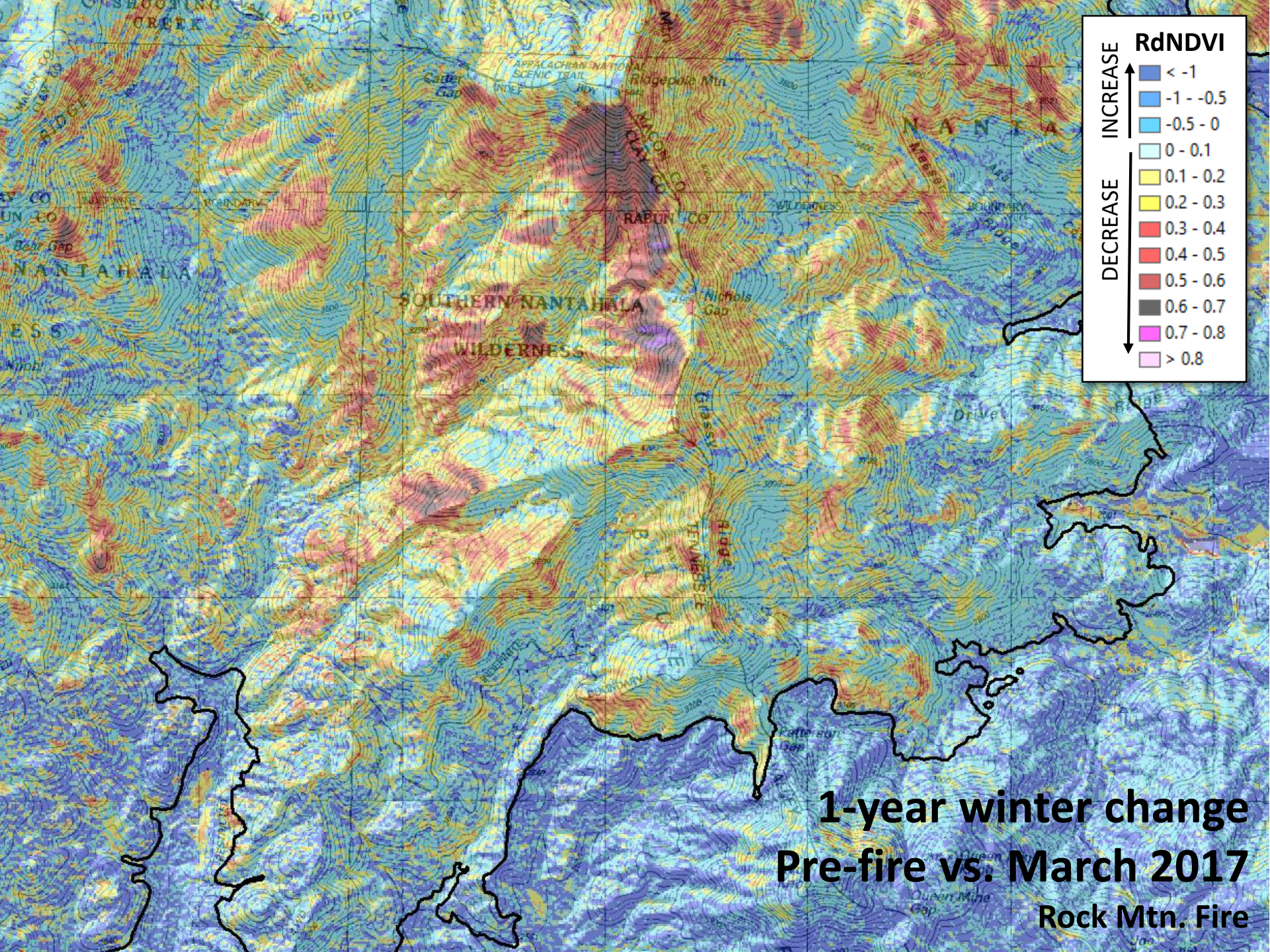
2. Consistent preferred responses

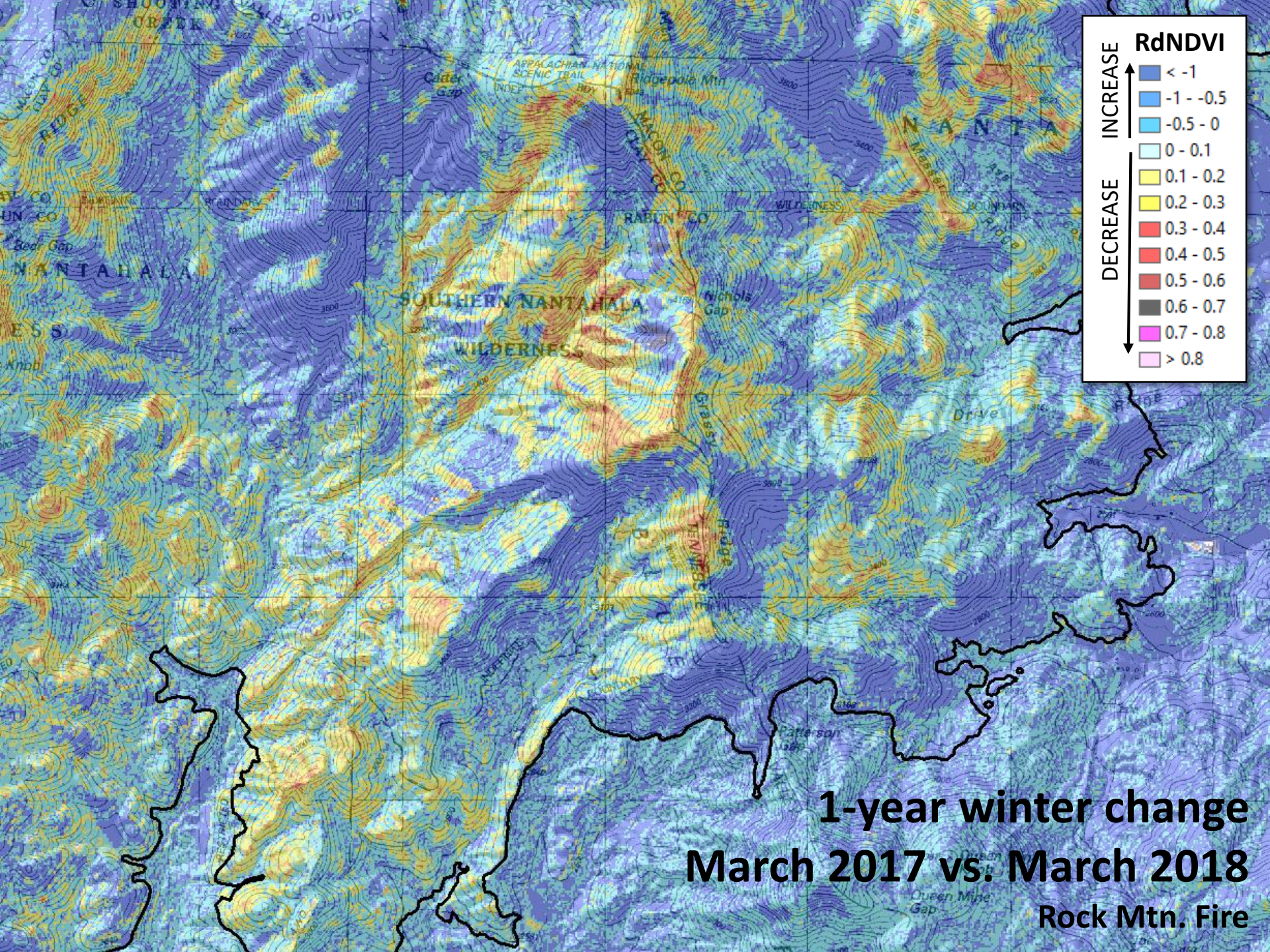


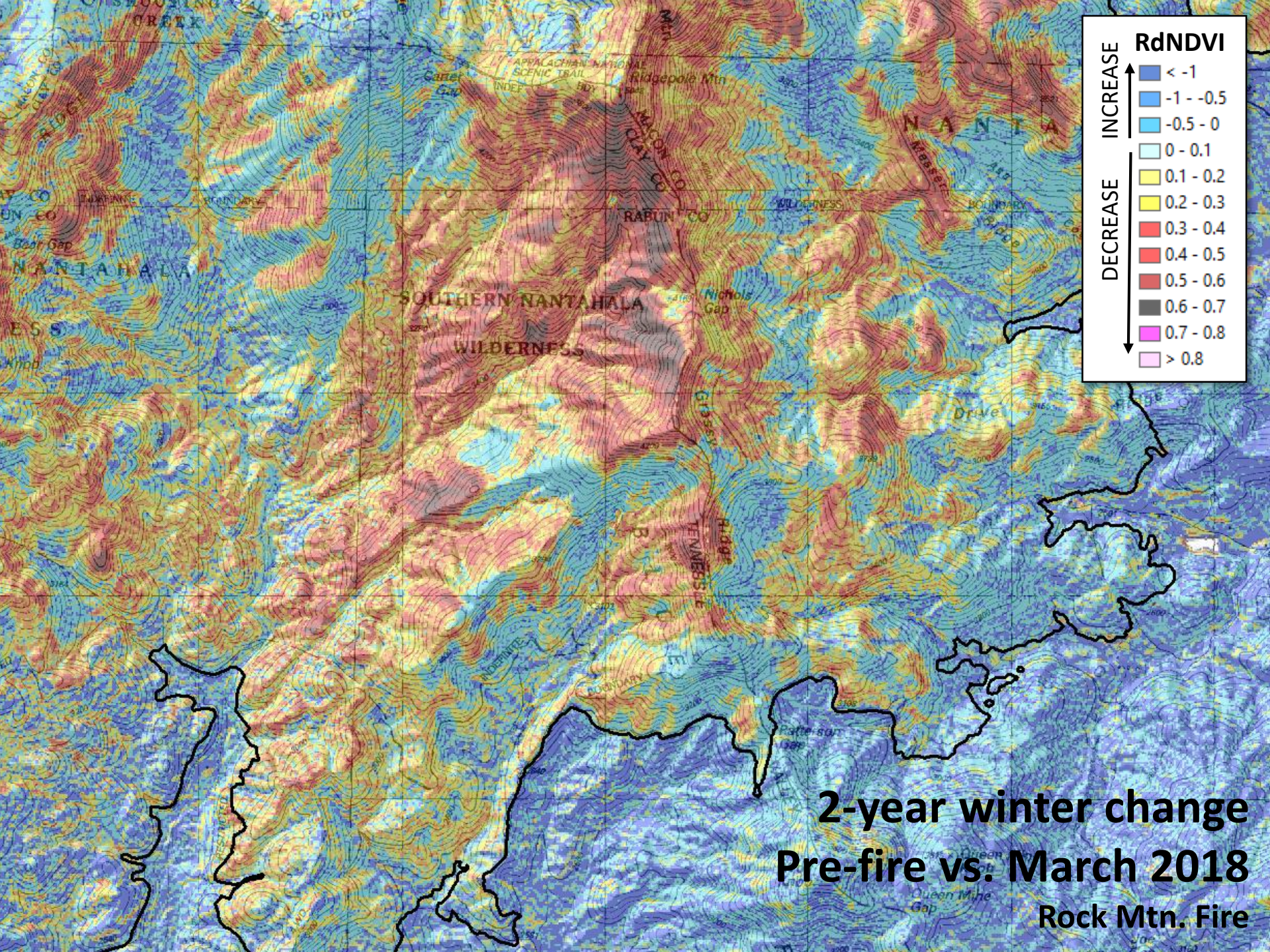
3. Distinct preferred responses (from altered opportunities for decline, given T_1 state or from a different post-fire process)

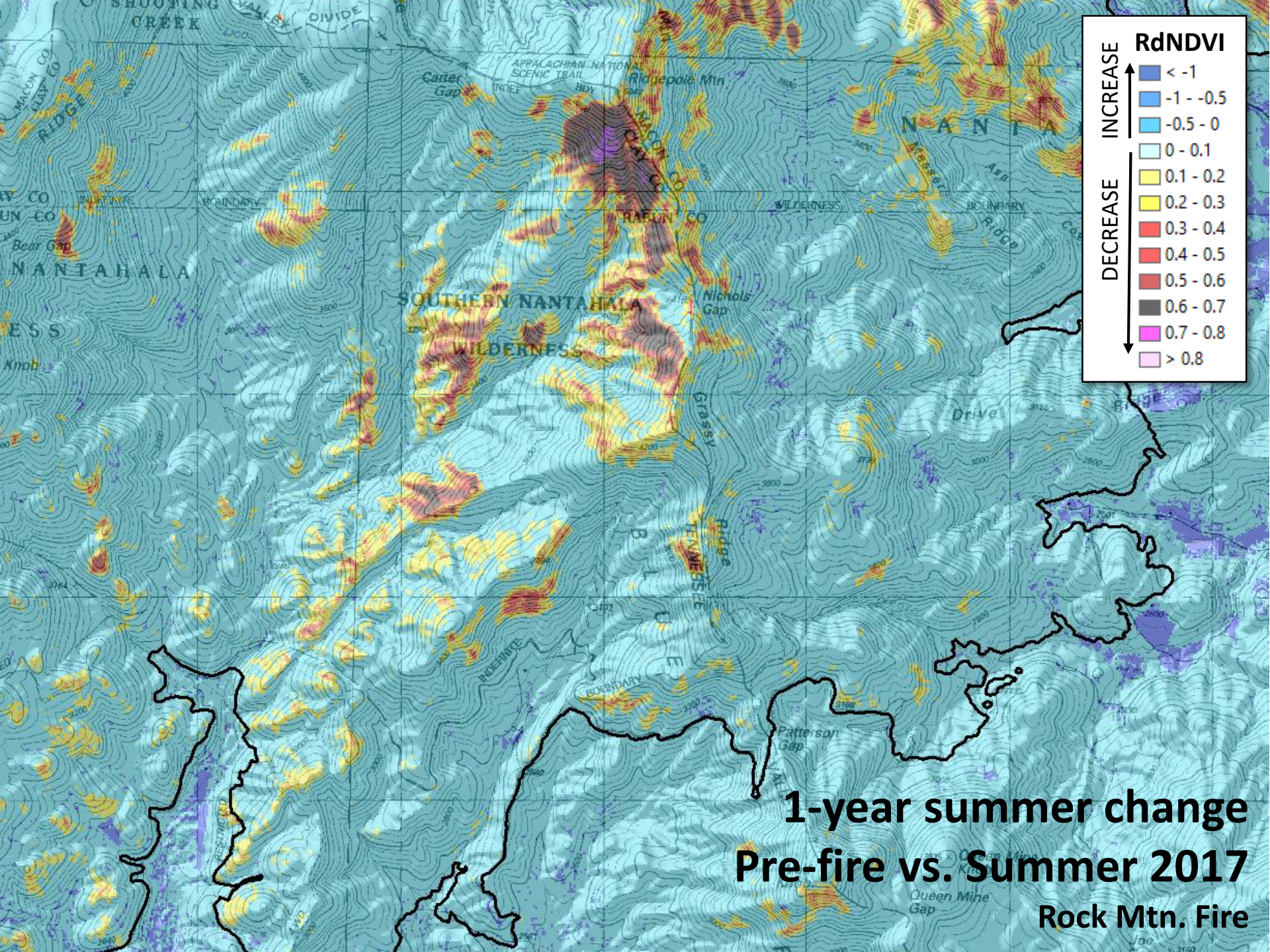


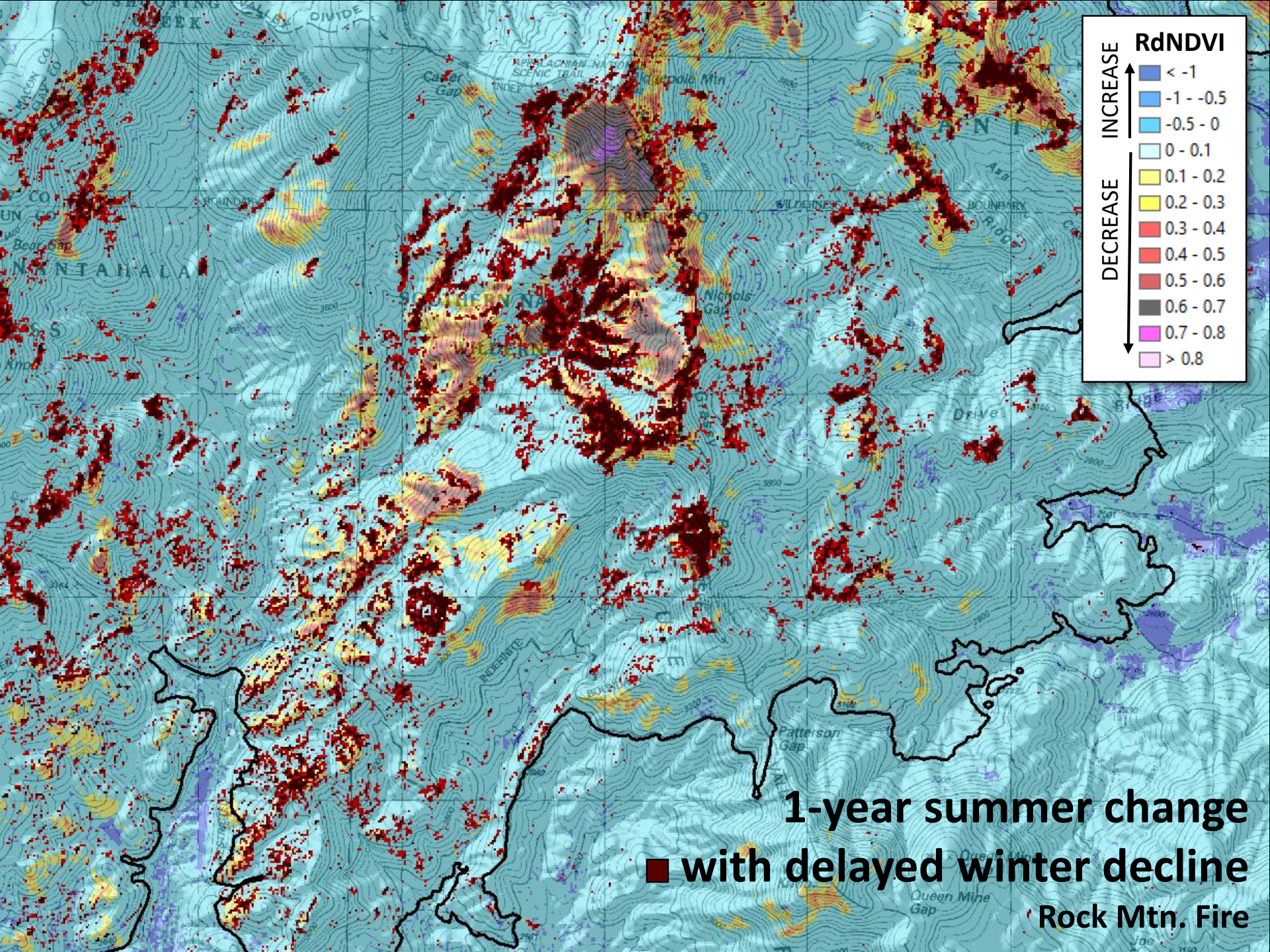

Sentinel 2 True Color
March 3, 2018
Rock Mtn. Fire
0
1km

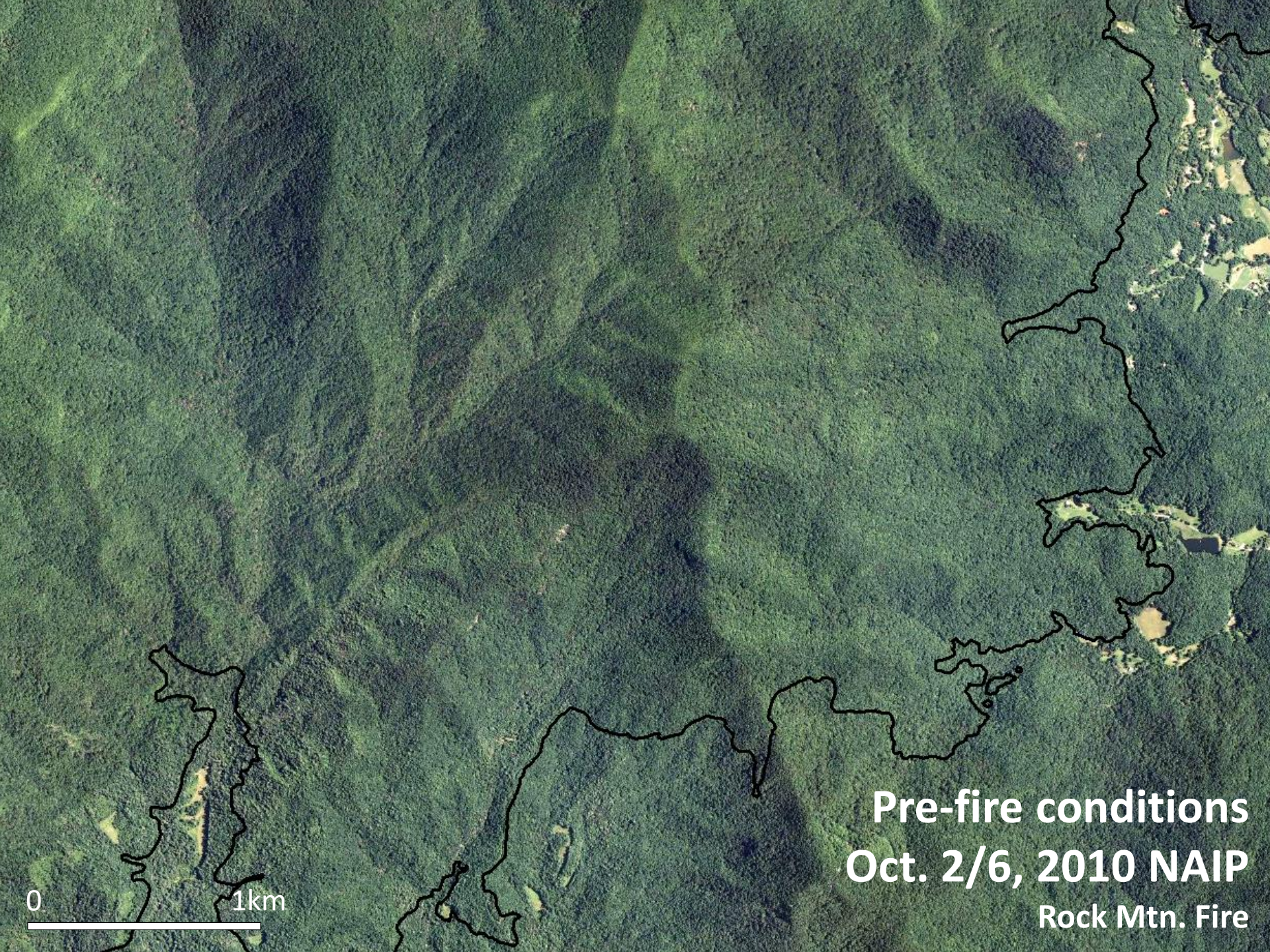

RdNDVI
INCREASE
DECREASE
< -1
-1 - -0.5
-0.5 - 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
SOUTHERN NANTAHALA WILDERNESS
RABUN CO
MACON CO
Ridgepole Mtn
Cader Gap
Bear Gap
Nichols Gap
Patterson Gap
Queen Mine Gap
1-year winter change
Pre-fire vs. March 2017
Rock Mtn. Fire

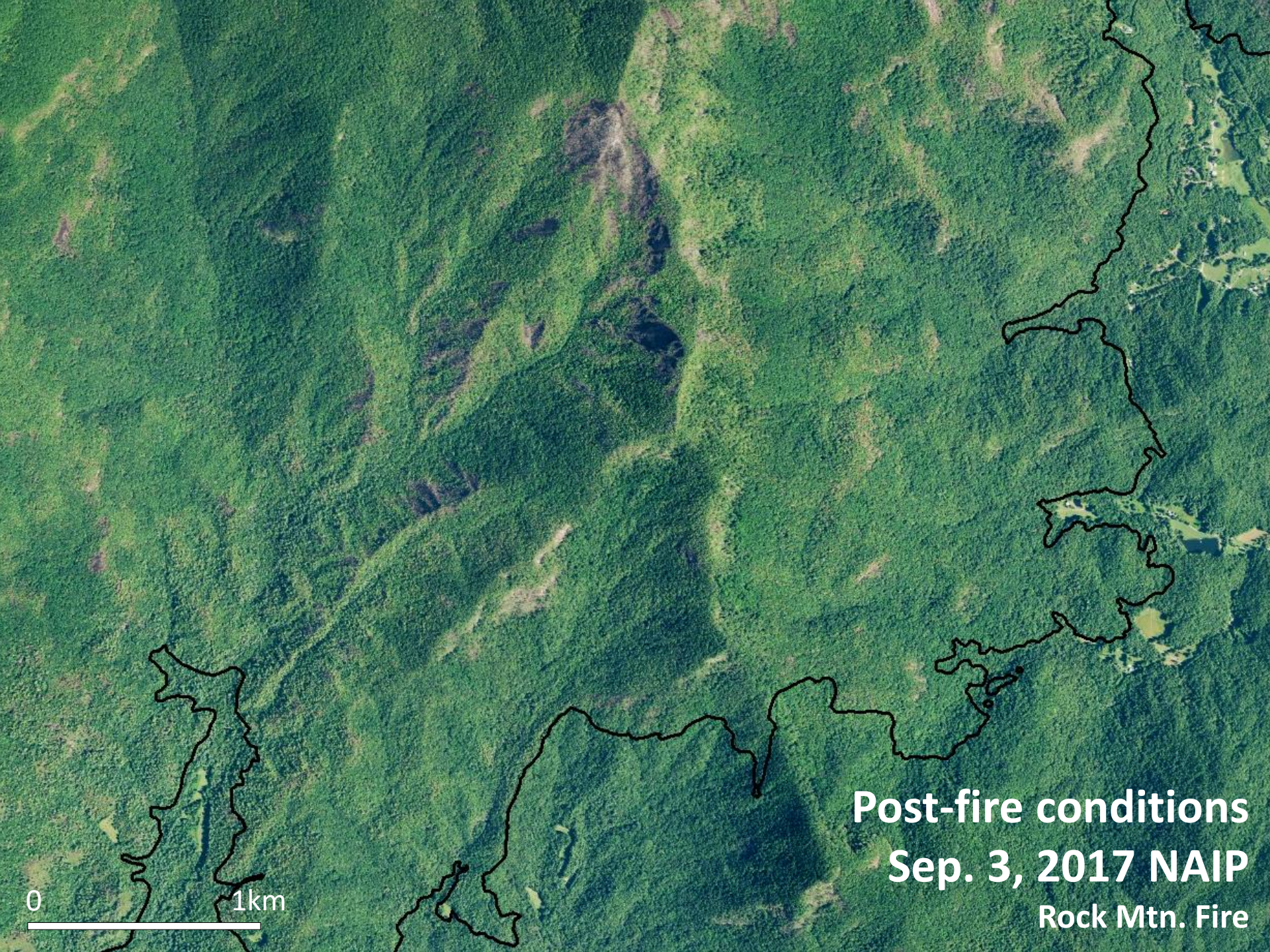

RdNDVI
INCREASE
DECREASE
< -1
-1 - -0.5
-0.5 - 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
1-year winter change
March 2017 vs. March 2018
Rock Mtn. Fire

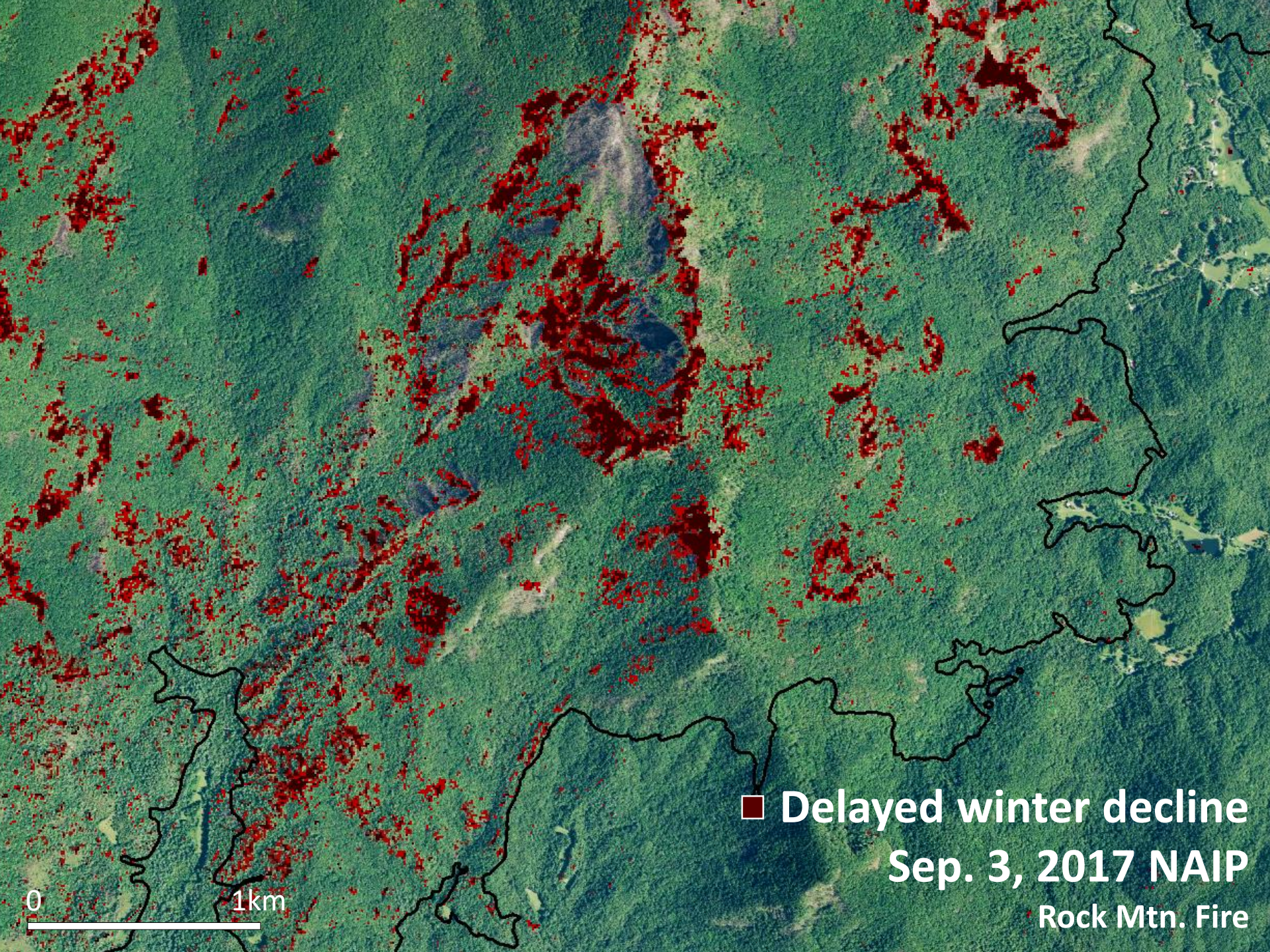

RdNDVI
INCREASE
DECREASE
< -1
-1 - -0.5
-0.5 - 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
SOUTHERN NANTAHALA WILDERNESS
RABUN CO
MACON CO
CLAY CO
Ridgepole Mtn
Nichols Gap
Bear Gap
Carter Gap
Glassy Ridge
TENNESSEE
Queen Mine Gap
2-year winter change
Pre-fire vs. March 2018
Rock Mtn. Fire

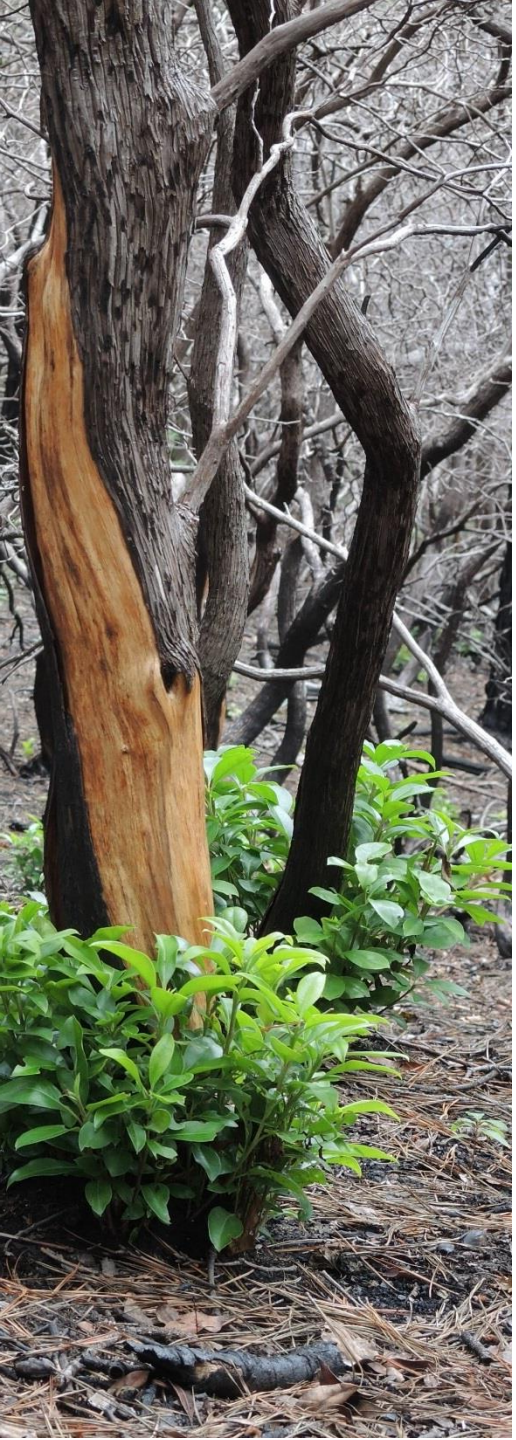

RdNDVI
INCREASE
DECREASE
< -1
-1 - -0.5
-0.5 - 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
1-year summer change
Pre-fire vs. Summer 2017
Rock Mtn. Fire


RdNDVI
INCREASE
DECREASE
< -1
-1 - -0.5
-0.5 - 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
1-year summer change
with delayed winter decline
Rock Mtn. Fire


Pre-fire conditions
Oct. 2/6, 2010 NAIP
Rock Mtn. Fire
0
1km


Post-fire conditions
Sep. 3, 2017 NAIP
Rock Mtn. Fire
0
1km


Delayed winter decline
Sep. 3, 2017 NAIP
Rock Mtn. Fire
0
1km



Post-Fall 2016 Wildfire Summary

- Use of rdNDVI with Sentinel 2 provides high resolution insights into fire severity: it captures observed changes to the overstory conifer and dense evergreen understory in late winter, conditional on canopy height and topographic factors

- Winter composites that use a clear March value are ideal in this mountain region for detecting change; this is prior to green-up and it minimizes shadows.

- Systematic multi-seasonal monitoring provides rich insights into overstory vs. understory/evergreen change as well as apparent delayed stress or mortality. While poorly understood, this secondary response may have implications for scheduling field validation efforts, predicting future fire hazards, successional pathways and landscape biodiversity.

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Cross-seasonal assessments of Appalachian forest compositional response after fire using Sentinel 2 imagery

AUTHORS: Steve Norman, William Hargrove – US Forest Service

ABSTRACT: In deciduous forests, remote sensing-based assessments of fire impacts are often confounded by the seasonal flux of land surface phenology (LSP). In the Southern Appalachians, USA, fires burn primarily in late winter/early spring and during or immediately after leaf abscission in the fall. This timing can make it challenging to recognize fire impacts apart from ongoing phenological transitions, particularly in cloudy regions where clear imagery is infrequent. More fundamentally, wildfire impacts, like those of low intensity prescribed fire, are often structurally isolated to just the understory, leaving overstories immeasurably affected. While such structurally selective impacts can have huge implications for wildlife and fuels management, the independent phenological detectability of these elements is routinely ignored. In this research, we use 10m seasonal maximum NDVI composites in both the growing season and winter to isolate deciduous and evergreen impacts separately for numerous fall 2016 wildfires that burned NC, SC, GA and TN. We then compare differences in season-specific impacts across topographic gradients. Results show greater winter than summer impacts, but spatial coherencies are consistent with fire behavior and impacts observed in the field. Insights suggest the value and need for formal incorporation of LSP into wildfire and forest monitoring and a reappraisal of how we conceptualize fire severity in this widespread forest type.