Use of Sentinel-2 Imagery in Forest Health Monitoring



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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, MSS	30m (15m) 30m (15m) 30m (15m)	8 to 16 day (with both)	2013 - 1999 1984-2012	US NASA
Terra/Aqua, MODIS	500m (250m)	2 passes/day	2000 -	US NASA

What does a 10m spatial resolution tell us?

Plantation pine and hardwoods – Oconee National Forest, GA



Typically-used spatial resolutions of Sentinel-2 (10m) compared to Landsat (30m)





Key monitoring questions

- Can we capture and map progressive mortality as it unfolds?
 - Southern pine beetles, Oconee NF



Sentinel-2 true color Oct. 20, 2015

Scale in km

0

Sentinel-2 true color Dec. 23, 2016



Sentinel-2 true color May 2, 2017

Scale in km

0

Sentinel-2 true color Sep. 19, 2017

Scale in km

0

Sentinel-2 true color Sep. 19, 2017



Sentinel-2 true color Jan. 2, 2018



Mean change in reflectance during 2017 for a beetle-infested forest west of Eatonton, GA



1-year change in winter NDVI Dec. 23, 2016 vs. Jan. 2, 2018

Scale in km



Pine beetle mortality and logging during 2017

Smar Crock State

Eatonton

Existing evergreen 1/2018 Loss of evergreen in 2017

Scale in km



Key monitoring questions

• Can we capture and map progressive mortality as it unfolds?

Yes.

- Can we track understory change?
 - 2016 Appalachian wildfires, NC

Invasive Paulownia tomentosa establishing after moderate fire severity in NC

Evergreen shrubs under deciduous or dead hemlock canopy

Hypothetical seasonal detectability of humid temperate forest components as viewed from above from phenology



Complex structural-compositional effects from wildland fire



Photo credits: Steve Norman

First-winter fire effects to evergreen/understory



First-summer fire effects to overstory canopy





Key monitoring questions

- Can we capture and map progressive mortality as it unfolds?
 - Yes.
- Can we track understory change? Conditionally, yes.
- Can we map ephemeral effects during tricky times of year?
 - An extreme spring windstorm, TN

Status of the spring "green wave" May 02, 2017 (compared to the prior growing season maximum NDVI)

5 km

Gatlinburg

S 17

Great Smoky Mountains National Park

Nov. 28, 2016 ک Wildfire ک



18 m __Status of the spring "green wave"__ May 15, 2017

5 km

Clouds/Shadows

Gatlinbu

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Nov. 28, 2016 Wildfire



NC

Relative magnitude of the early May 2017 phenological reversal

Gatlinburg

ø

0

Nov. 28, 2016 Wildfire



km

ΤN

NC



Landscape extent of the May 04, 2017 wind event



Ephemeral vs. seasonal persistent disturbance effects from wind



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





Key monitoring questions

 Can we capture and map progressive mortality as it unfolds?

Yes.

- Can we track understory change? Conditionally, yes.
- Can we map ephemeral effects during tricky times of year?

With creativity and luck with clouds, yes.

 Can we get more accurate and efficient answers with multi-date compositing?

Hurricane Maria impacts in Puerto Rico

Multi-date compositing can be accomplished with or without cloud computing



What is a suitable seasonal baseline given phenology?

Google Earth Engine-generated 17-year average MODIS land surface phenology for Puerto Rico



16-day period for averaging

Hurricane Maria traversed Puerto Rico on Sep. 20, 2017 with 110-155 mph eye-winds



El Yunque National Forest



Sentinel-2 true color 10-20-2017



Sentinel-2 true color 10-25-2017



Sentinel-2 true color 11-04-2017



Sentinel-2 pre- H. Maria 3-yr. max. NDVI composite





Sentinel-2 post–H. Maria NDVI composite through early Nov. 2017



Sentinel-2 post H. Maria NDVI composite through late Dec. 2017



Change in forest NDVI after Hurricane Maria using Sentinel-2 composites and Google Earth Engine cloud computing

<u>Pre</u>: 3-year max. baseline <u>Post</u>: Sep 25-Dec. 31, 2017





Arecibo Radio Telescope

> Lago dos Bocas

Sentinel-2 true color for 10-20-17 showing H. Maria disturbance



Sentinel-2 true color for 12-14-17 showing rapid recovery response





1 km

Sentinel-2 composite NDVI <u>Pre</u>-Hurricane Maria



1 km

Sentinel-2 composite NDVI <u>Post</u>-Hurricane Maria



km 🕻

Pre-vs-Post Hurricane change in NDVI from Sentinel-2 composites

Summary



- With frequent 10m Sentinel-2, we can often capture and map tree <u>mortality as it unfolds</u>, then generate <u>annual summaries</u> of change (but causal attribution will remain more difficult).
- We can often track <u>understory evergreen change</u> in deciduous forests during winter more confidently at 10m.
- We can map <u>ephemeral disturbance impacts</u> during phenologically-tricky spring.
- We can <u>efficiently process</u> lots of data (now more than ever with cloud computing) to monitor broad scales with sophisticated compositing techniques.