



Fire into the Future: Utilizing Geospatial Technology to Identify and Categorize Fire in the Southeast

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Fires are prevalent in the Southeast US

Southeast US contains half of fire area of the contiguous US

Florida burns 10% of US fire area

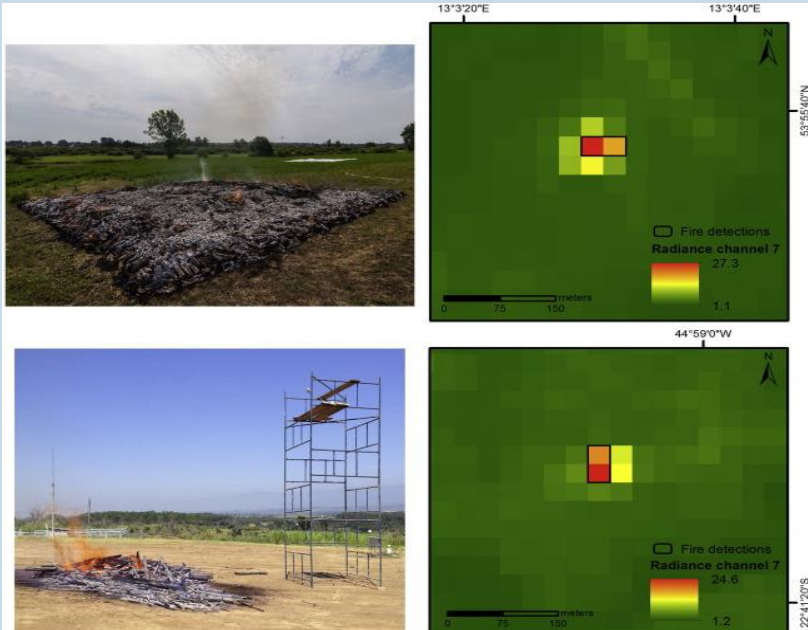
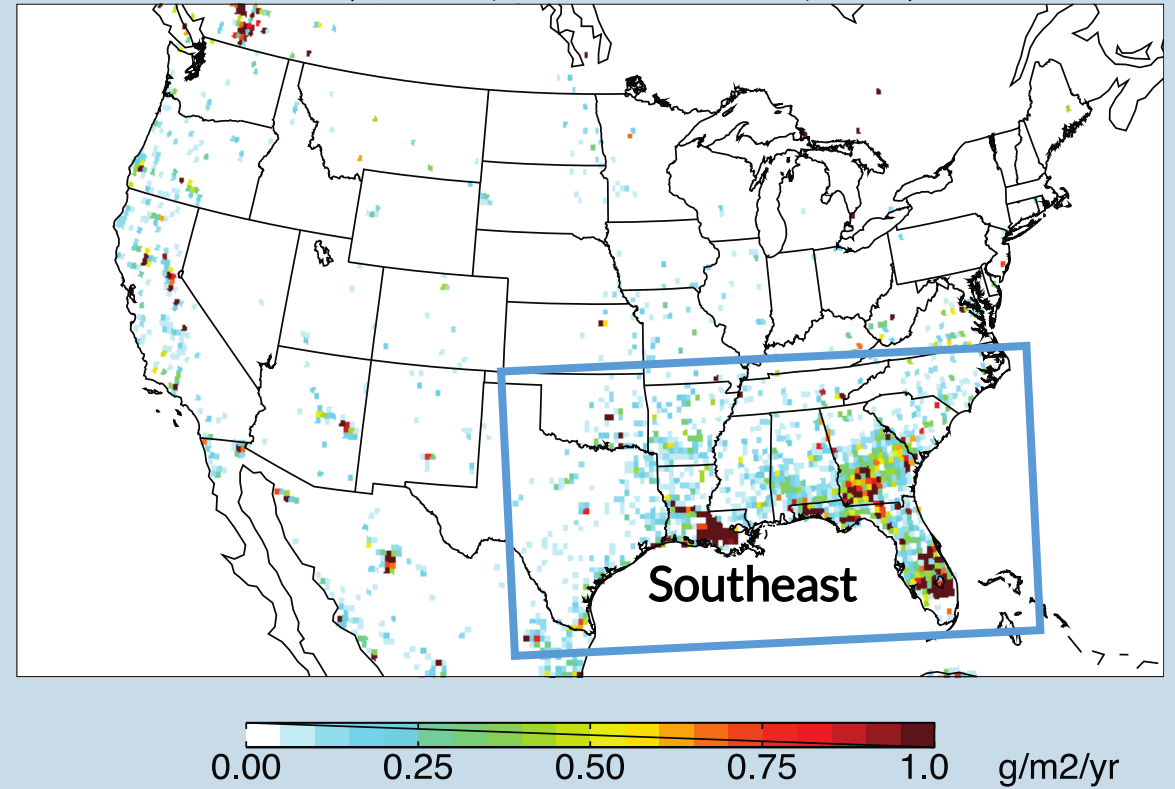
(Melvin, 2015; Short, 2014)

Satellites are critical for quantifying fire

Active fire detections

Burned area/scar detections

Fuel consumption in fires, 1997-2020 mean
(GFED4s, van der Werf et al., 2017)



Schroeder et al., 2015

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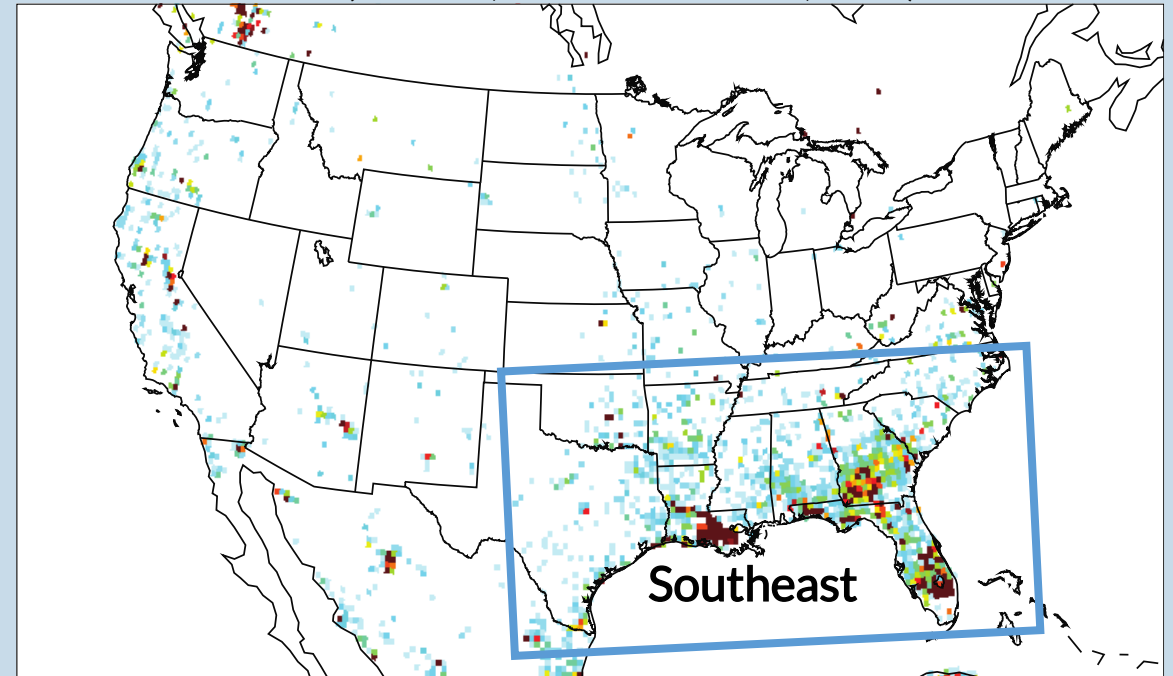
Burned area/scar detections

Regionally specific challenges:

- Prescribed fires are common – typically smaller, less severe relative to wildfires
- Clouds and canopy – block satellite views
- Wet and warm climate – limited clear-sky observations and rapid post-fire recovery

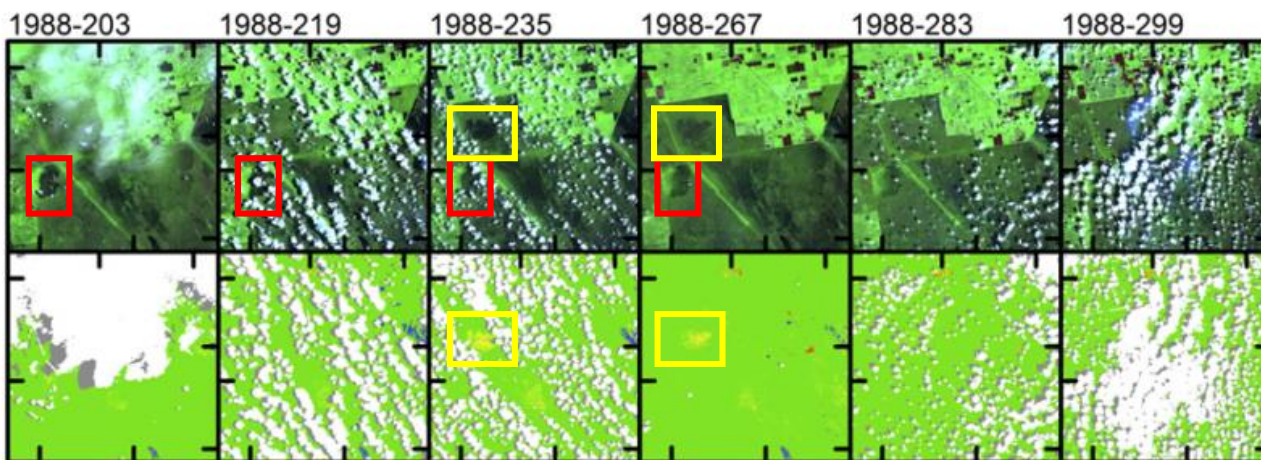
Fuel consumption in fires, 1997-2020 mean

(GFED4s, van der Werf et al., 2017)



0.00 0.25 0.50 0.75 1.0 g/m²/yr

How can we measure fire across the Southeast US?



Hawbaker et al., 2017

Atlas of Florida fires, 2004-2015

We combined government reports...

- Prescribed fire permits (Florida Forest Service)
- Wildfire FPA FOD (Short et al., 2014, 2017)

Annual fire activity:

25,000 fires

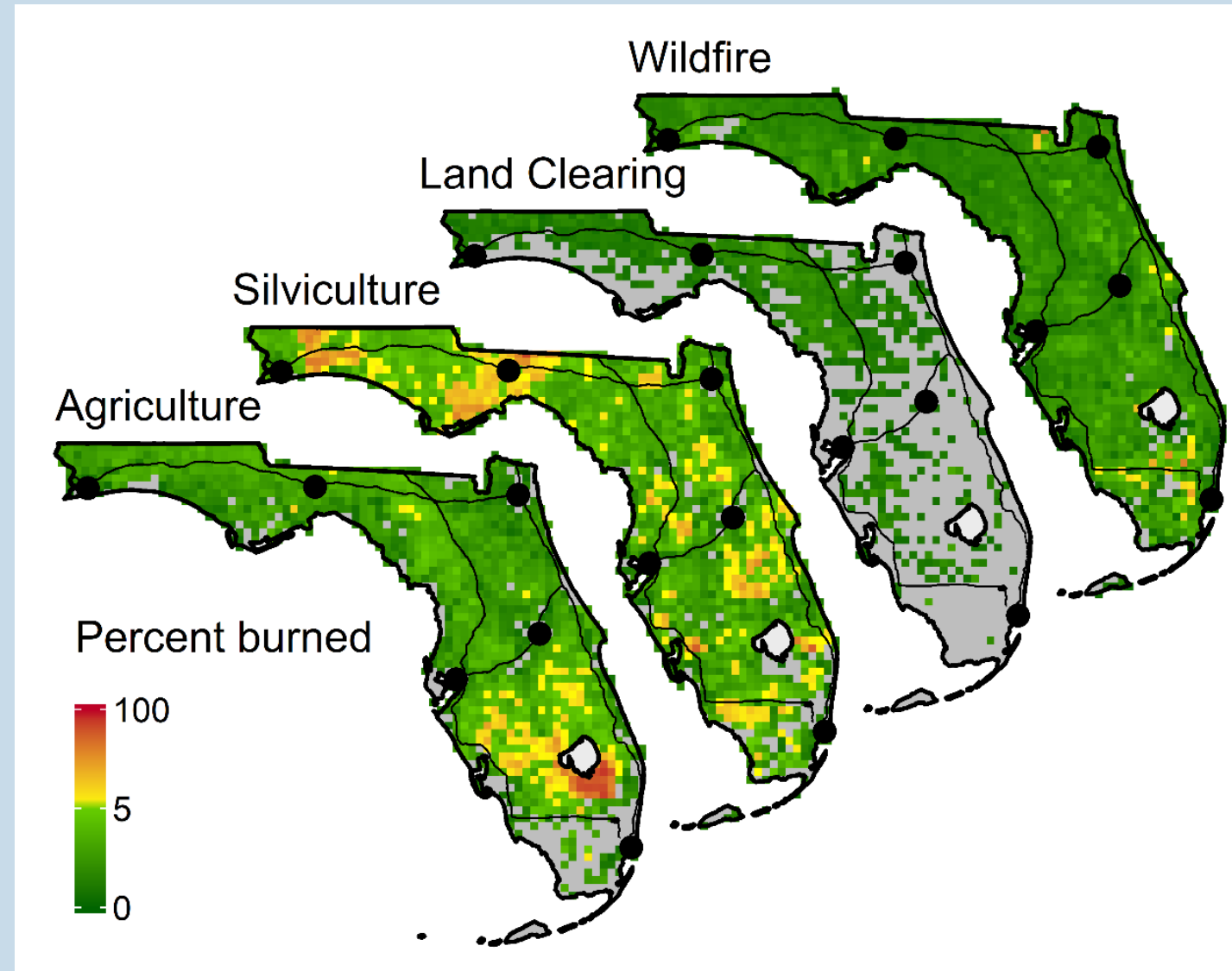
987,000 ha (7% of land area)

56% silviculture + land clearing

36% agriculture

8% wildfire

Prescribed fires dominate



Evaluation of satellite fire products

Known limitations

- Small size (most under 20 ha)
- Short duration (hours or less)
- Low intensity
- Hidden by frequent clouds, tree canopy
- Rapid vegetation regrowth in humid climate

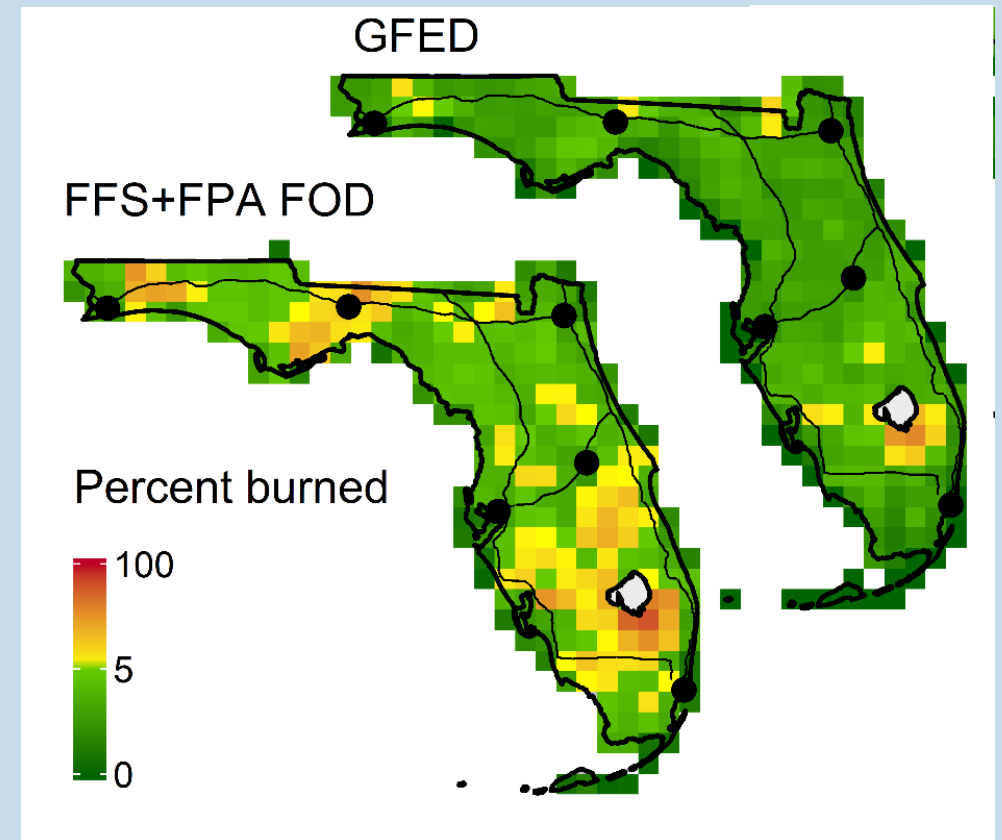
Overall, 70-80% of Florida fire area is undetected in four satellite products:

GFED4s/MODIS, BAECV1.1/Landsat, HMS, HMS/NEI Agriculture



Consistent with the high end of past literature (40-80% undetected; Hu et al., 2016; Huang et al., 2018)

Satellites vs. Government records



(van der Werf et al., 2017)

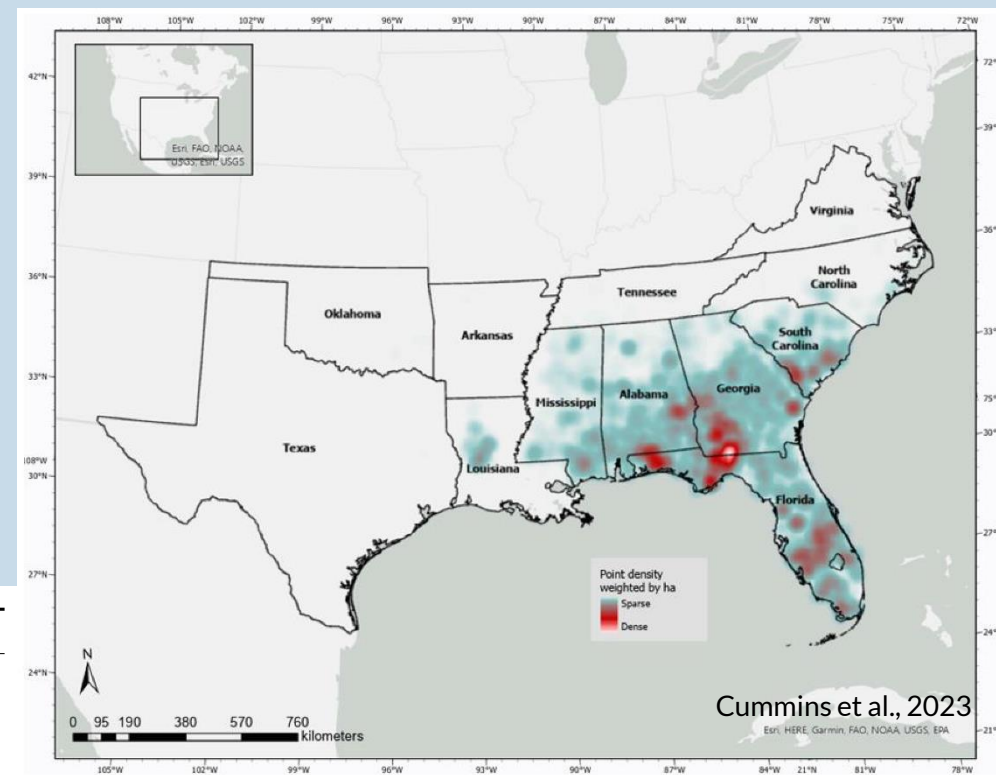
Ground-based fire products

Ground-based products across the Southeast US are not all the same

- Inconsistent rules between states
- Variable time series
- Point-based data
- Permit ≠ burned

State or Federal Agency	Years	Locational Data	Type of Burn System
Alabama Forestry Commission	2011–2021	X,Y	permit (required)
Arkansas Forestry Commission	2011–2021	X,Y	voluntary
Florida Forest Service	2010–2020	X,Y	permit (required)
Georgia Forestry Commission	2010–2020	X,Y; geocoding; county centroid	permit (required)
Fort Moore Military Base (GA)	2010–2020	X,Y	collected internally
Louisiana Department of Agriculture and Forestry	2010–2020	X,Y	voluntary
Kisatchie National Forest (LA)	2010–2020	X,Y	collected internally
Mississippi Forestry Commission	2010–2020	X,Y	permit (required)
North Carolina Forest Service	2014–2021	X,Y	permit (required)
Oklahoma Forestry Services	2015–2021	X,Y	notification (required)
South Carolina Forestry Commission	2010–2020	X,Y	notification (required)
Tennessee Division of Forestry	2012–2020	geocoding	permit system (required October15–May 15)
Texas A&M Forest Service	2017–2019	X,Y	voluntary
Virginia Department of Forestry	2010–2020	X,Y	voluntary

(Cummins et al., 2023)



Critical Need: Improved data and tools for tracking fire trends and patterns across public and private lands to help landowners prioritize landscapes for restoration and conservation through the use of prescribed fire

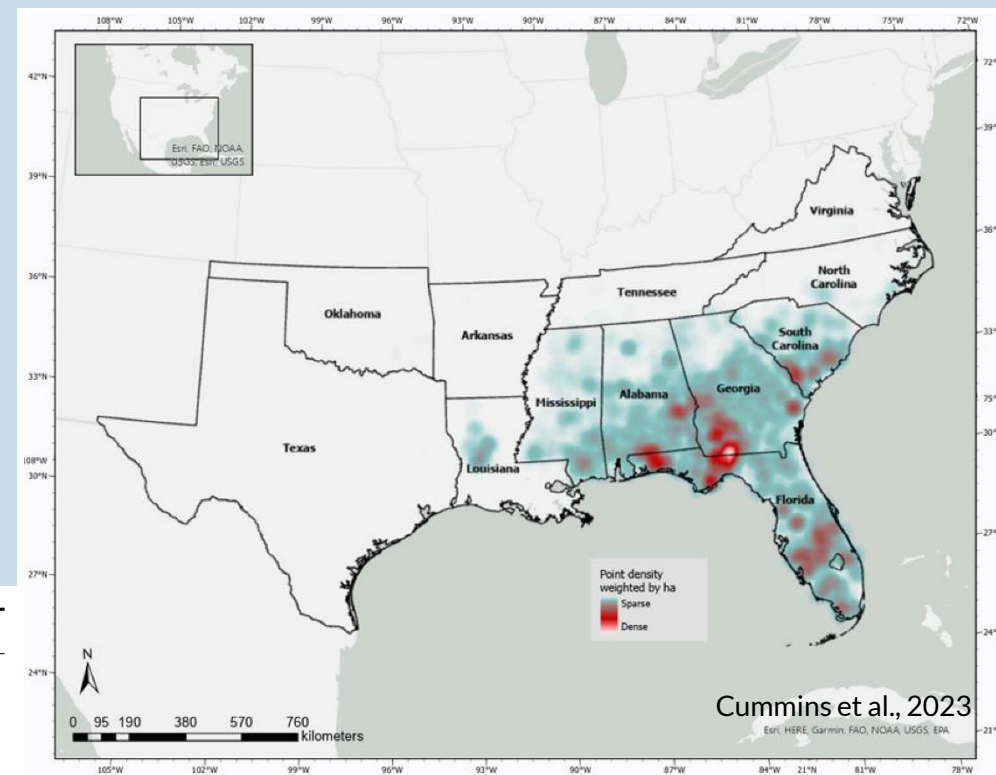
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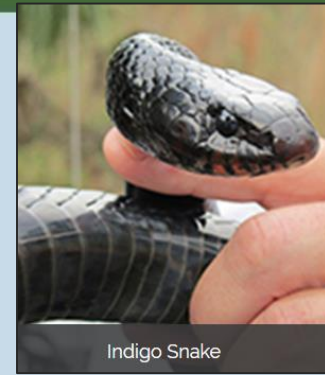
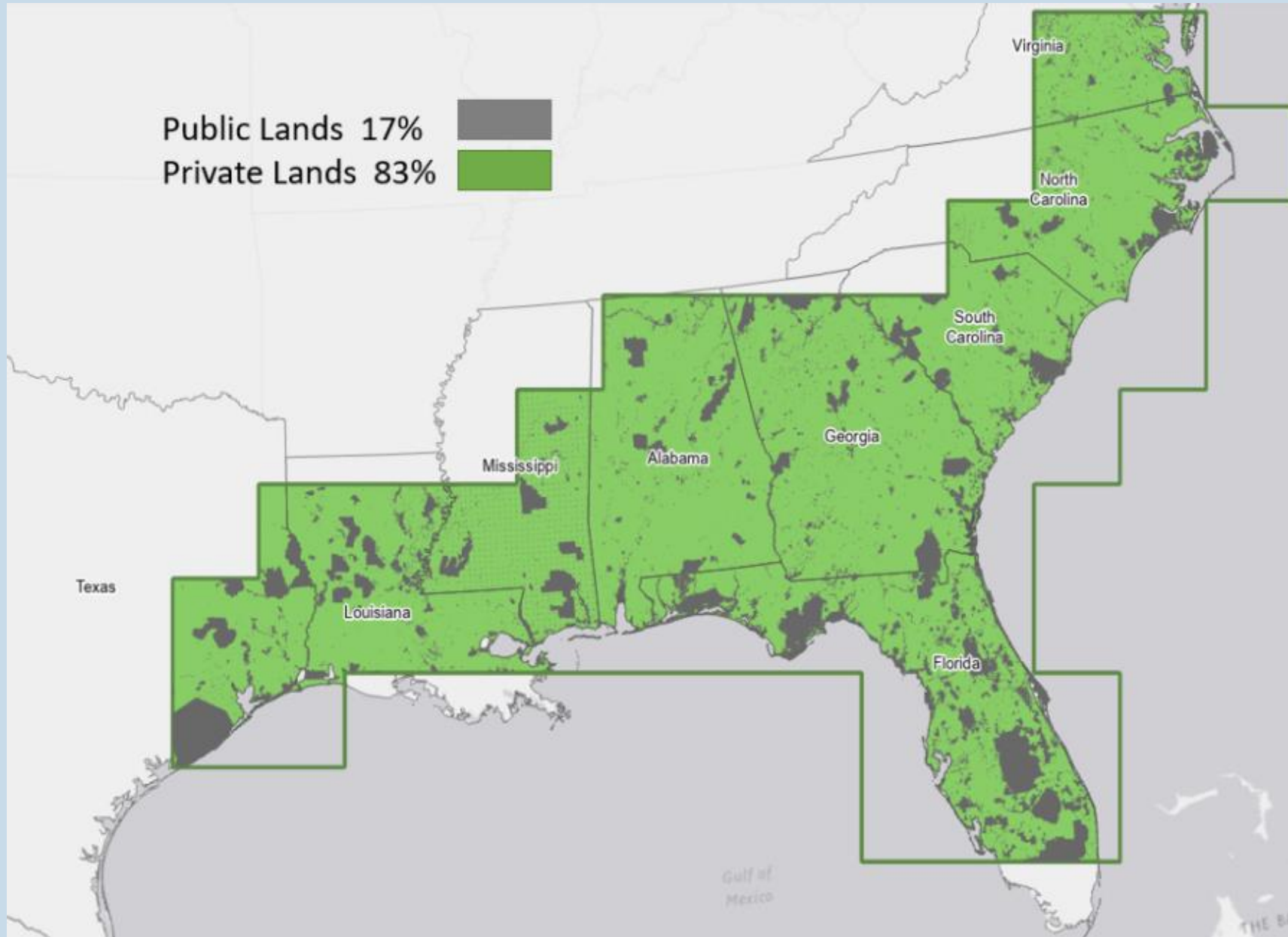
Northern Bobwhite



Wild Turkey



Gopher Tortoise



Indigo Snake



Red-cockaded woodpecker



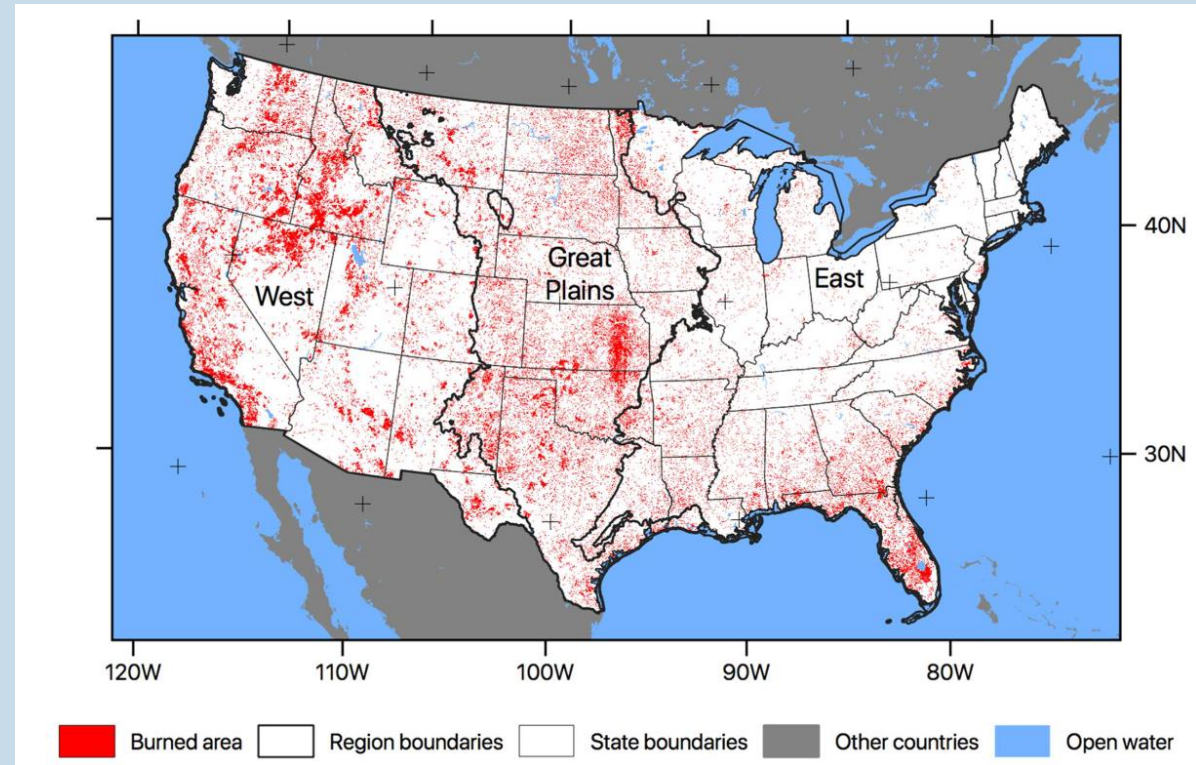
Fox Squirrel



© Mark Conlin

Creation of the Southeast FireMap

1. ***Meetings, workshops, webinars*** to convene partners and experts to discuss the current data collection, technologies and/or mapping being conducted in the Southeast and elsewhere
2. ***A report describing existing relevant mapping efforts***, current data collection methods and technologies, including a brief assessment of their strengths and weaknesses
3. ***Clear, detailed recommendations*** for building a scalable Southeast FireMap, a database that depicts fire occurrences in the southeastern U.S. through a web interface that supports simple queries, reports and downloads

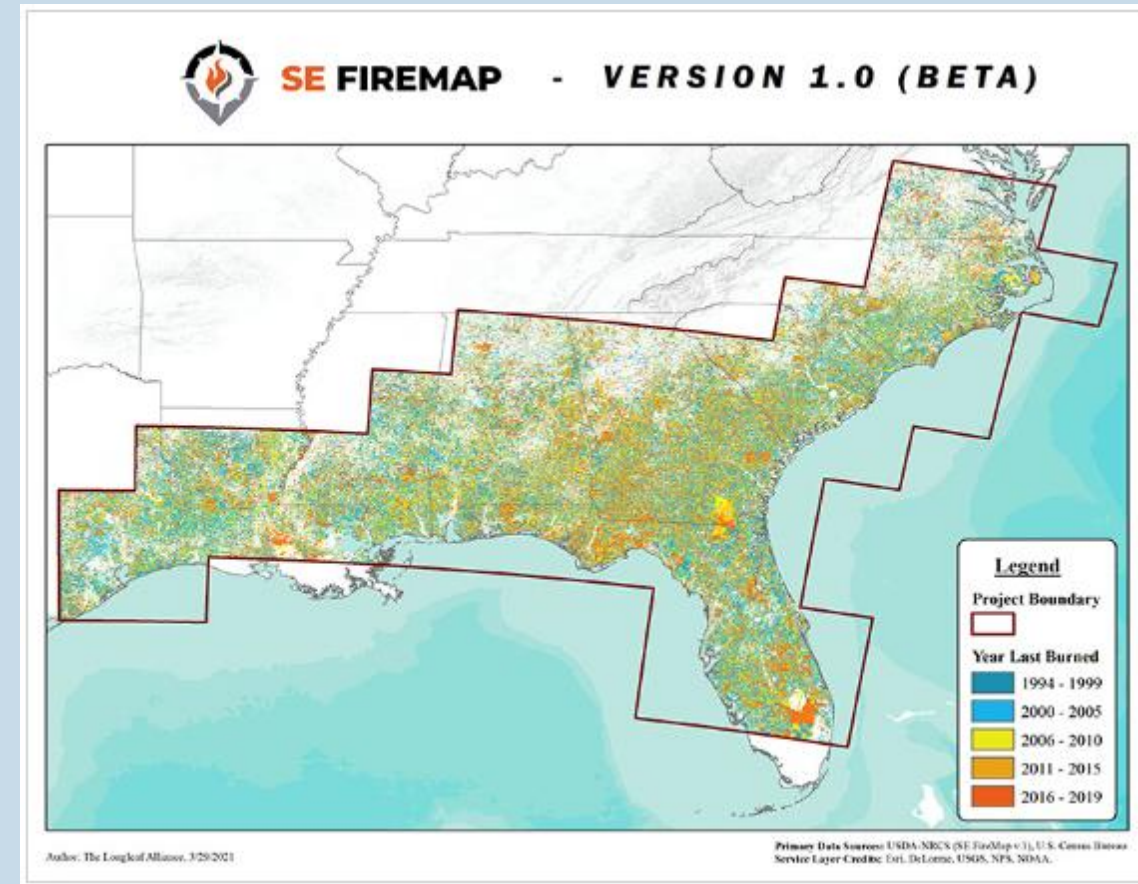


Hawbaker et al, 2019

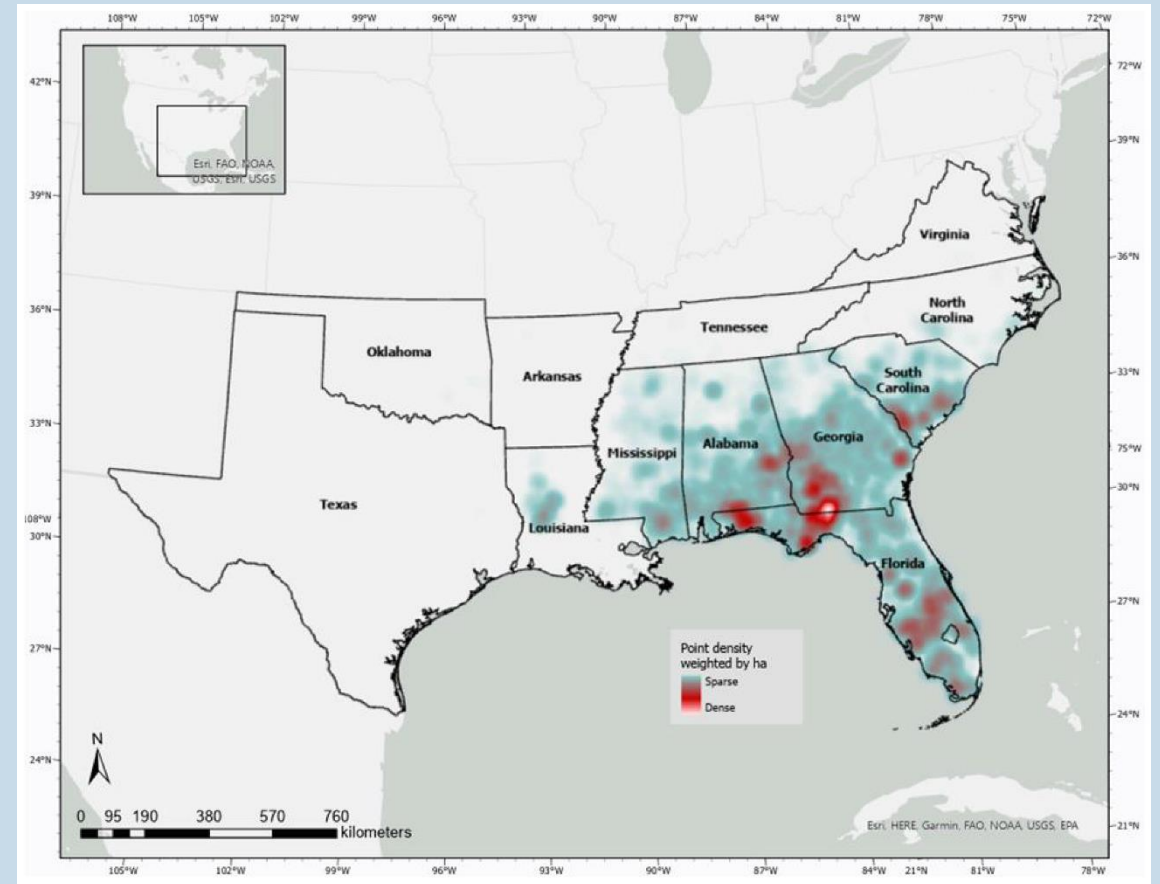
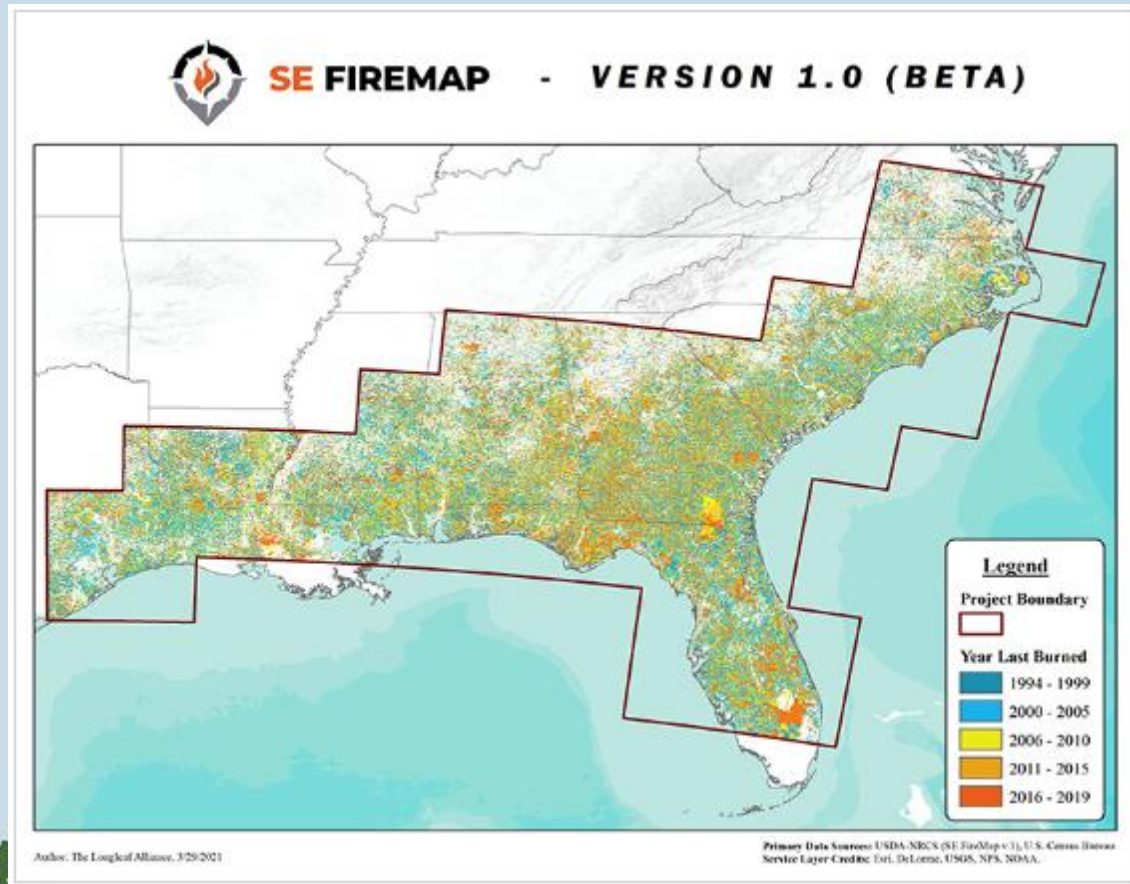


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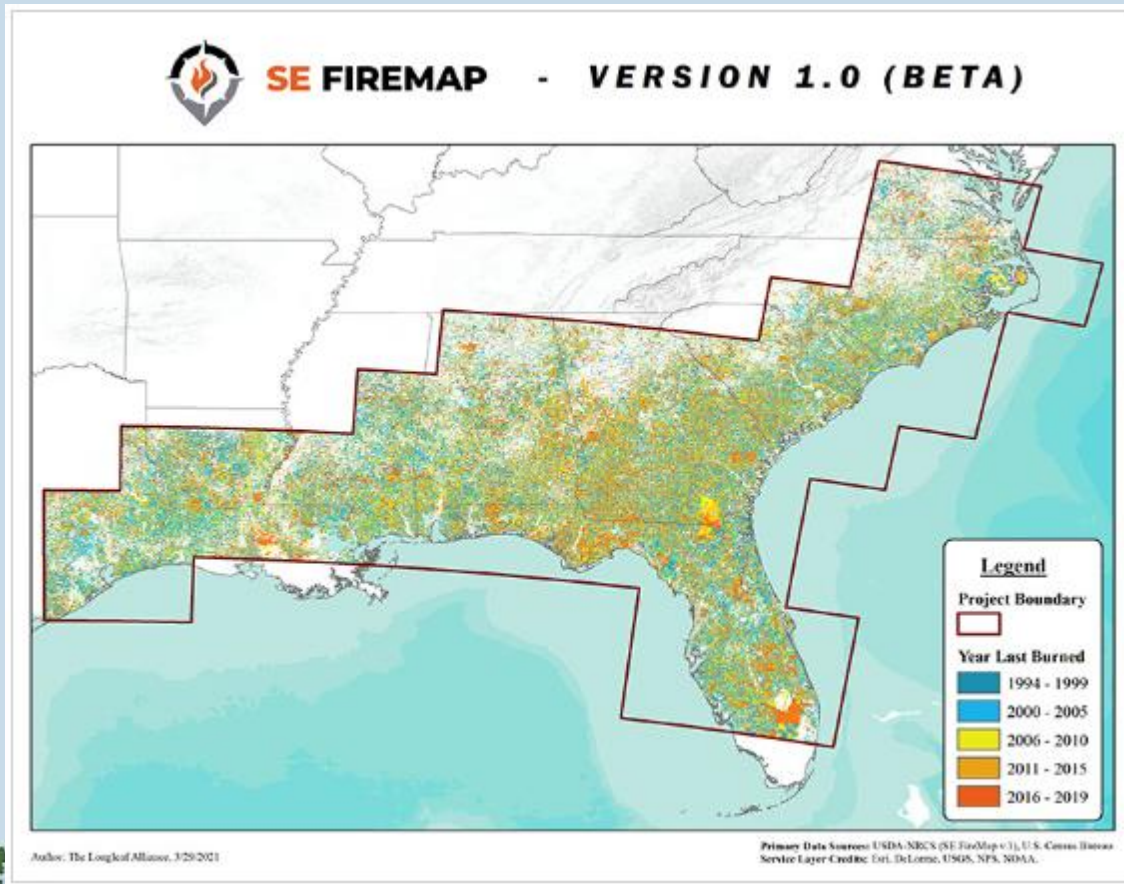


Southeast FireMap project

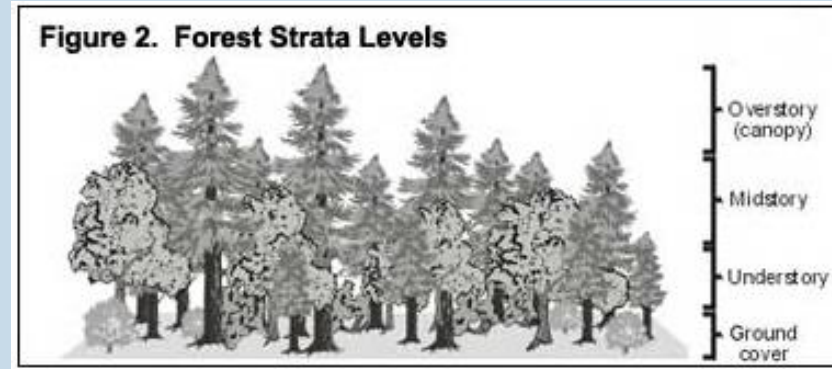
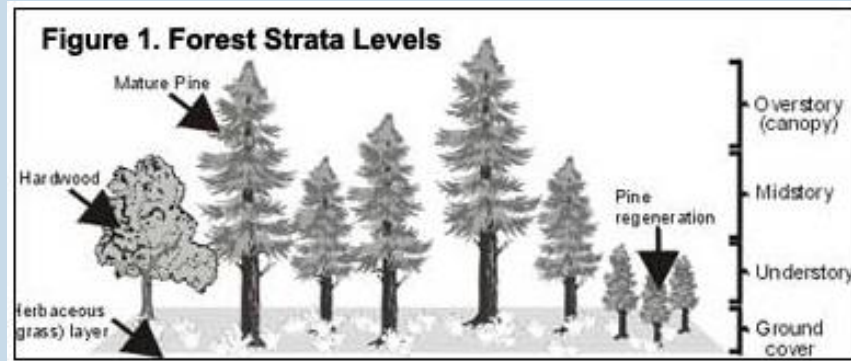


Fire history metrics

- **Fire Frequency** refers to the number of times a specific location has burned in the period of record (or for a given period of interest if a subset of total fire record)
- **Time Since Previous Fire** is the measure of time from a specific date back in time to the last date of a detected or known fire. Units can be months, days, or years. In the database, it is reported as the number of years from “present” to the last identifiable burn
- **Year Last Burned** is the year of the last detected fire in a location
- **Longest Fire Free Interval** is the period between two consecutive fires in a given location. In places where more than two fires have burned throughout time



Ability to “visualize” the landscape using FHM



Phase II: Southeast FireMap Project Components

1. Southeast FireMap – data delivery and platform analysis
2. Landsat BA product support
3. Research
 - Assessing regional patterns and impacts of burning
 - Incorporating harmonized Landsat Sentinel-2 data into BA product
 - Improving the characterization of uncertainty in the BA product
 - Adding burn severity as an attribute to the Landsat BA product

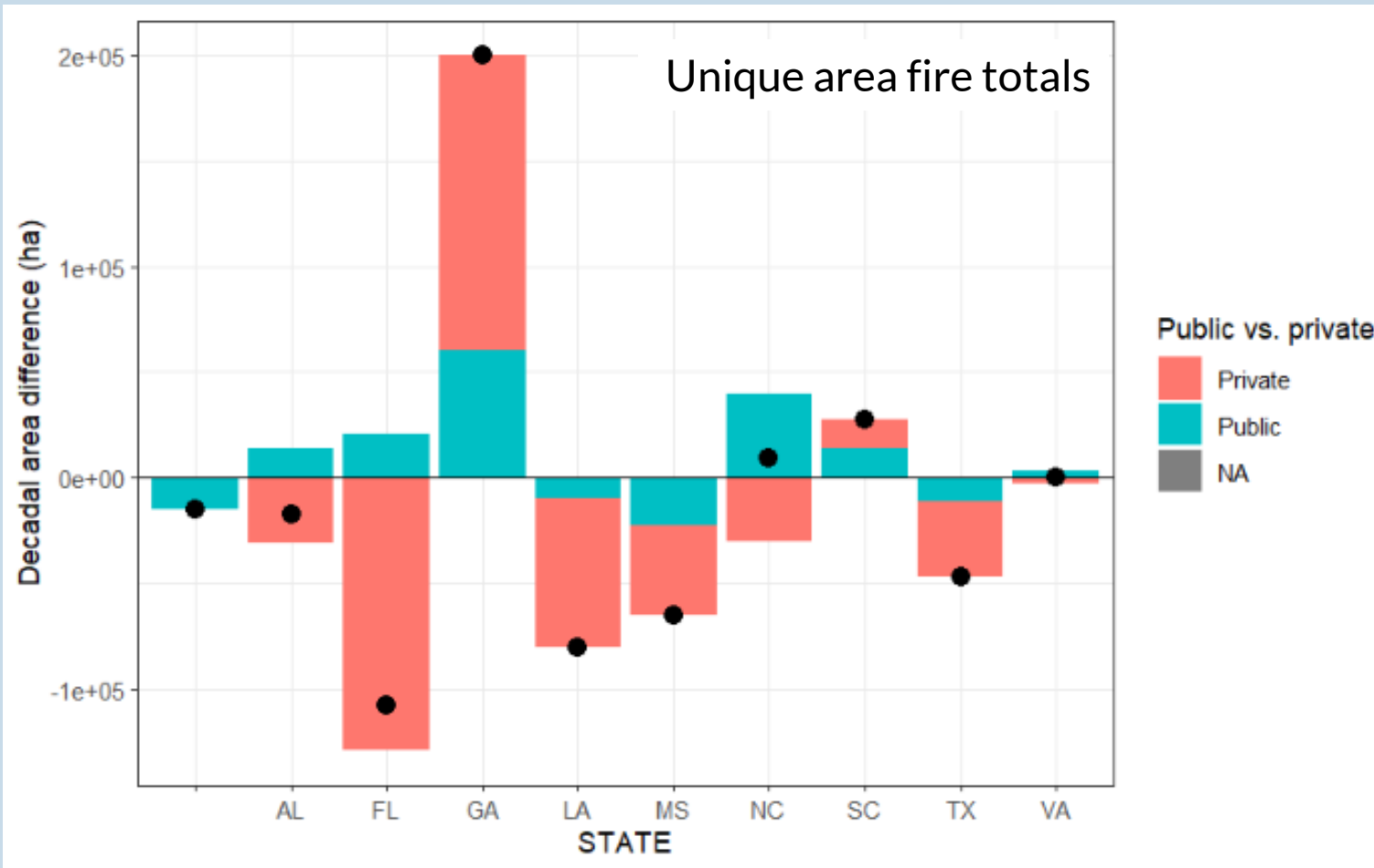


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Regional patterns of burning by decade



- Over the Southeast FireMap extent, burning of unique areas decreased slightly by 2% (-96,000 ha)
- Total burning (black dot) decreased overall for most states
- Most saw increase in unique public land burning and a decrease in private land burning



Harmonized Landsat – Sentinel 2 data



About Copernicus Sentinel-2...

WHAT?

A constellation of **two identical satellites in the same orbit**, Copernicus Sentinel-2 images land and coastal areas at high spatial resolution in the optical domain



WHERE?

Designed and built by a group of around **60 companies** led by **Airbus Defence** and Space for the space segment and **Thales Alenia Space** for the ground segment



WHICH?

Main applications include agriculture; land ecosystems monitoring; forests management; inland and coastal water quality monitoring; disasters mapping and civil security



WHO?

Services include **CLMS** (Copernicus Land Monitoring Service); **CMEMS** (Copernicus Marine Environment Monitoring Service); **CEMS** (Copernicus Emergency Management Service) and Copernicus Security Service; among others



WHEN?

Sentinel-2A was launched on 23 June 2015; Sentinel-2B on 7 March 2017, both on a Vega rocket from Kourou, French Guiana



DATA AND USERS

As of July 2020, about **20 million products** have been generated and made available for download, culminating a total of 10 Petabytes



DATA ACCESS

<https://scihub.copernicus.eu>

WHATS NEXT?

Continuity over the coming years will be ensured by the **launch of additional satellites** (Sentinel-2C and Sentinel-2D). Furthermore, a new generation of Sentinel-2 satellites is being prepared, to take up the relay from the first generation

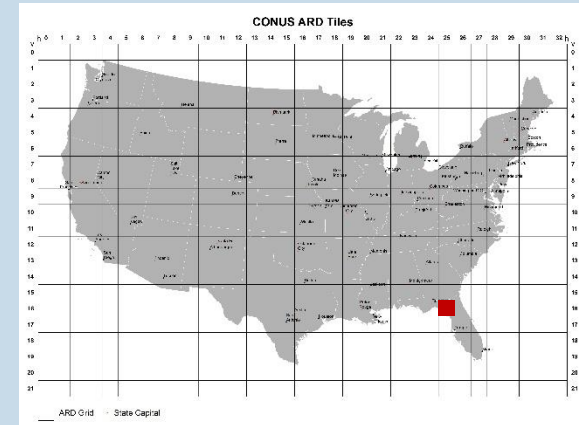


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Harmonized Landsat – Sentinel 2 data

Incorporating Sentinel-2 data increased observation counts from 43-300% depending on year



HLS image counts

Platform	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Landsat	12	27	20	29	34	25	23	30	26	34	260
Sentinel-2			1	15	24	53	57	45	59	30	284
Grand Total	12	27	21	44	58	78	80	75	85	64	544

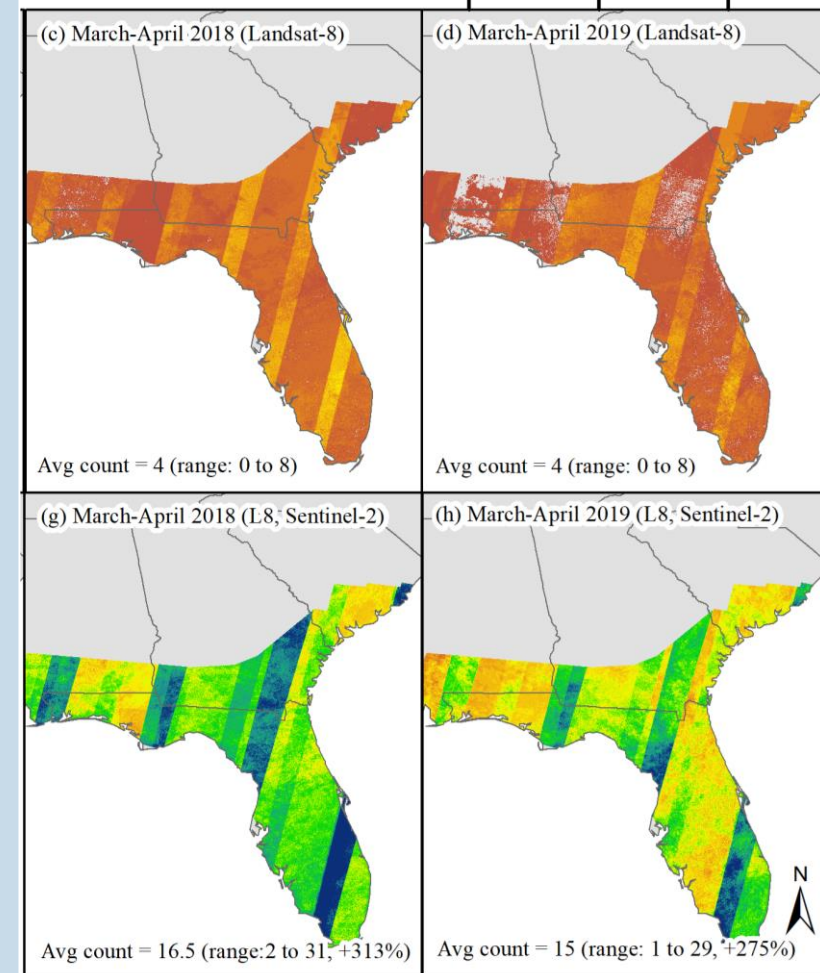
HLS sample counts (burned samples)

Platform	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Landsat					68	69	0	0	141		278
Sentinel-2					53	426	184	323	286		1272
Grand Total					121	495	184	323	427		



Known Limitations: Cloud Cover

- Southeast is cloudier than other areas
- Short detection window
- Addressing this by incorporating the European Space Agency's Sentinel Satellite data



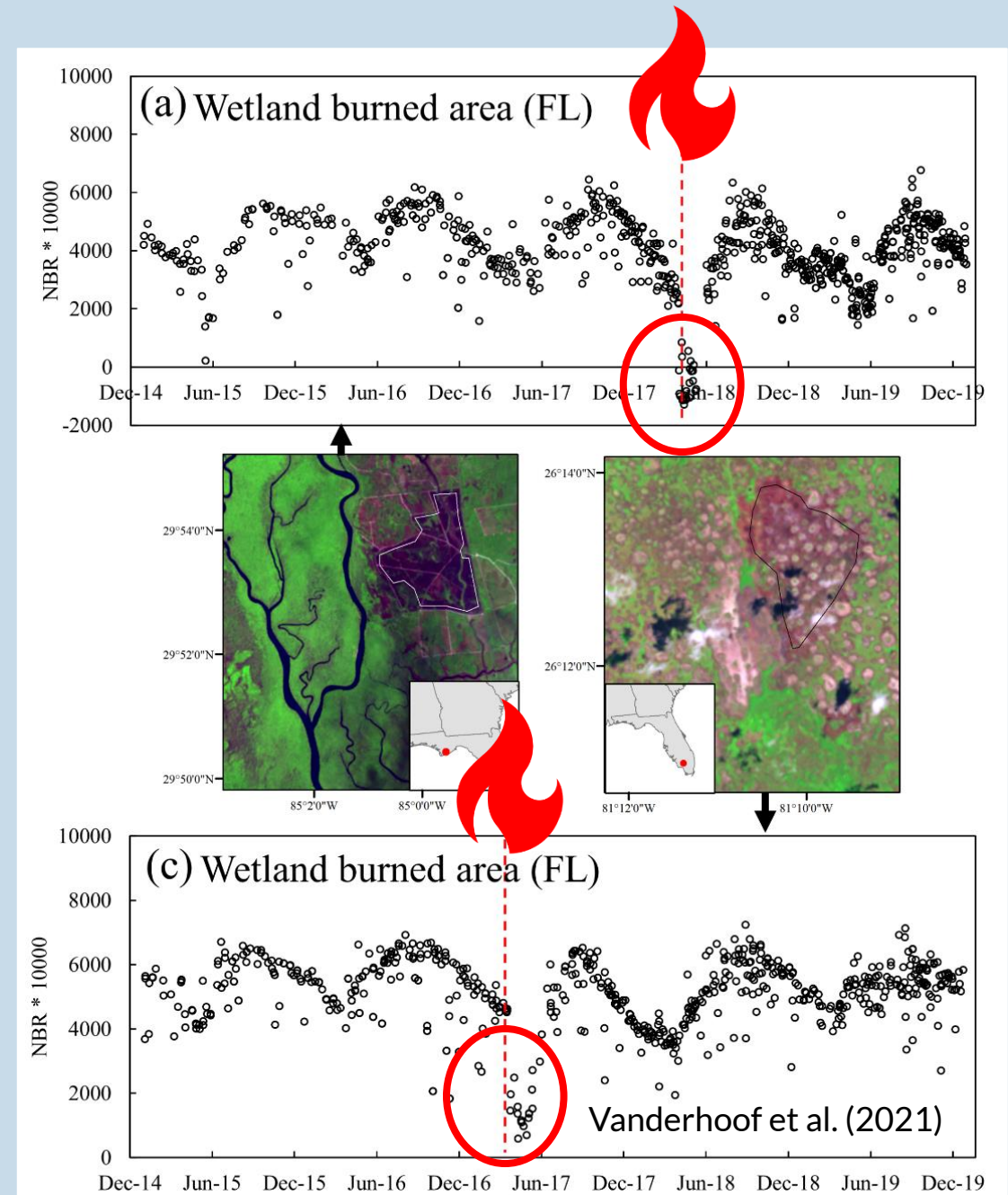
Landsat-8

Landsat-8
and
Sentinel-2

Vanderhoof et al. (2021)

Known Limitations: Rapid Green - Up

- Fire adapted species quickly re-vegetate
- There is a short window in which fires can be detected



Conclusions

- Fires can be difficult to detect in the Southeast US
- Southeast FireMap based off of Landsat BA provides best satellite solution for mapping fires across the Southeast US
 - Spatial footprint
 - Uniform across the entire area
 - Fire history metrics
- Allows for in-depth analysis of fire change across the landscape
- Inclusion of Sentinel-2 satellite will greatly increase detections
- Southeast FireMap Phase II is currently on-going and we are soliciting feedback



References

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