





Southeast U.S. Climate

Leveraging Land Cover and Aboveground Biomass Products to Evaluate Carbon Emission Trends in the Talladega National Forest

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Pop-Up Project | Fall 2022

Outline

- Tech and Innovation Project
- ► SERVIR
- Background
- Study Area & Period
- Satellites/Sensors
- Objectives
- Methodology
- Results
- Conclusions
- Errors & Uncertainties
- Future Work
- Acknowledgements



Image Credit: Center for International Forestry Research (CIFOR)



Tech and Innovation Project

- Tool development
- Highly technical methods
- Coding heavy analysis
- Varied set of deliverables
 - Internal scripts
 - Tutorial
- AGILE framework



SERVIR



SERVIR-CArbon Pilot Program (S-CAP)

NASA, US Agency for International Development, and other geospatial organizations Uses remote sensing to report carbon emissions from deforestation in developing countries

Development, resource management, community resilience

Background

- Effective carbon management mitigates greenhouse gases
- Living trees are carbon sinks
 - Aboveground Biomass (AGB)
- Deforestation emits carbon into atmosphere
- Climate change mitigation goals require understanding regional carbon emissions





Background

- Deforestation: Disturbances that result in sustained loss of forest
 - Logging
 - Fire
 - Agriculture
 - Infrastructure expansion
- Carbon stock: The amount of carbon stored in a forest
- AGB and extent of deforested area needed to estimate carbon emissions
 - Difficult and costly to measure by foot



Study Area and Period

- Study Period: 2016-2021
- Study Area: Talladega National Forest, Alabama





- Over 300,000-hectare forest
- Comprised of oak, hickory, and pines
- Long history of logging
- Current management includes
 logging and prescribed fires

Satellites and Sensors



Satellites and Sensors

► Airborne LiDAR





Objectives



Methodology: Overview

을 Deforestation Carbon Emissions



Land Change Maps

Ground Biomass

National Land Cover Dataset (NLCD)

LandTrendr

Global Forest Watch (GFW) Landscape Change Monitoring System (LCMS)

ISS GEDI

ICESat-2 Atlas

Methodology: Land Change Maps (2016-2021)



Results: Land Change Maps (2016-2021)

Change Map Method	Area Classified (ha)*	Area Deforested (ha)*	%Area Deforested
LandTrendr	43,716	8,405	2.75%
NLCD	296,227	5,830	1.91%
GFW	63,998	3,586	1.18%
LCMS	297,114	1,032	0.034%

Results vary depending on the change map method and the land classification technique.

*Rounded to the nearest whole number.

- LandTrendr
 - Calculated most deforestation
 - Classified least ROI
- NLCD
 - Classified the 2nd most ROI
 - Specific land use classification made forest detection easy
- GFW
 - Year of loss method risks missing deforestation outside of 2016-2021
- LCMS
 - Classified the most ROI
 - Less specific land classification make change detection difficult

Methodology: Above Ground Biomass

ISS GEDI:

- Data obtained 2019-2021
- Provides AGB data
 - Uses statistical models
 - Accessible in GEE
 - Produces 1 km grid of mean AGB
- Overlap GEDI with non-deforested map
 Calculate a global AGB average for TN



Basemap: Google Earth Engine

Methodology: Above Ground Biomass

ICESat-2 ATLAS:

- Data acquired for 2021
- Provides canopy height
 - Processed in python and ArcMap
 - Moved into GEE
 - Produced point data
- Transformed data to AGB using Allometric Equations
- Calculate a global AGB average for forested areas



Basemap: Google Earth Engine

Methodology: Allometric Equations

- Saatchi et al. 2011
 - AGB = $0.314 * hmax^{2.0608}$
- Nelson et al. 2017
 - $AGB = -10.533 + hmax^{10.949}$
- Lefsky et al. 2005
 - $AGB = 20.7 * (0.098 * hmax^2)$

hmax= max tree height (m) AGB= Above Ground Biomass (Mg/ha)



Methodology: Carbon Emissions

Carbon stock =

Mean AGB * Carbon Fraction

- AGB = Mg/ha
- Carbon Fraction = .48 (IPCC, 2019)

Carbon emissions =

Carbon stock * area deforested



Results: LandTrendr Carbon Emissions

Change map	Data source	Height Transformation	AGB mean (Mg/ha)	Carbon Emissions (Mg)
LandTrendr	GEDI		202	814,971
	ICESat-2	Lefsky	122	495,091
		Nelson	331	1,338,357
		Saatchi	401	1,616,467

Full results available in presentation appendix.

Highlighting Land
 Trendr results

- Highest deforestation estimation
- Median emissions: 1,076,663.76
 - Equivalent to driving an average car around the Earth ~100,000 times

Results: Validation



- Airborne LiDAR data used to validate ICESat-2 data
 - Overlap
 - Clip
 - Calculate



Results: Validation

 Airborne LiDAR height data used to validate ATLAS height data

Sample region

▶ n=33

 ICESat-2 Atlas consistently overestimates height



Errors and Uncertainties



Causes of deforestation



Validation and accuracy



Dates



Land change methods



Regrowth



Method choice

Conclusions

- Deforestation estimates vary depending on the change map used
 - NLCD and LandTrendr
- AGB estimates depend on the sensor used
- Carbon emissions estimates will vary depending on AGB and forest change methods implemented
- More validation needed
- Reproducible coding scripts and tutorial developed for future teams



Future Work

Apply

Utilize tested methods on other regions and study areas.
Run simple accuracy analysis like random sampling test.

Introduce

- Teach methods to partners/end users, collaborating to inform policy decisionmaking and practices on determining carbon emissions.
- > Feedback from the partners could further refine capabilities.

Explore

- Investigate potential interactions of forest cover and carbon emissions in Indigenous communities and other areas.
- Examine specific types of disturbances (e.g., fires).
- Incorporate belowground biomass into measurements.

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Appendix 1: All Carbon Emissions Results

Change map	Total Hectares in Calculation	Area deforested (ha)	Data Source	Height Transformation	AGB mean (Mg/ha)	Carbon Emissions (Mg)
LandTrendr	43,715.6	8404.61	GEDI		202	814,970.94
			ICESat-2	Lefsky:	122	495,090.59
				Nelson:	331	1,338,356.58
				Saatchi:	401	1,616,467.44
NLCD	296226.9	5829.88	GEDI		175	489,770.53
			ICESat-2	Lefsky:	110	307,946.52
				Nelson:	308	860,948.83
				Saatchi:	350	978,532.59
GFW	63997.7	3586.23	GEDI		161	276,555.41
			ICESat-2	Lefsky:	160	182,732.81
				Nelson:	300	516,394.23
				Saatchi:	334	75,037.26
LCMS	297113.8	1032.47	GEDI		174	86,385.07
			ICESat-2	Lefsky:	110	54,734.61
				Nelson:	309	153,143.58
				Saatchi:	351	174,063.84

Appendix 2: Acronym Glossary

- AGB Aboveground Biomass
- ATLAS Advanced Topographic Laser
 Altimeter System
- ETM+ Enhanced Thematic Mapper Plus
- GEDI Global Ecosystem Dynamics
 Investigation
- GEE Google Earth Engine
- GFW Global Forest Watch
- ICESat Ice, Cloud, and Land Elevation
 Satellite

- ► **ISS -** International Space Station
- LiDAR Light detection and ranging remote sensing method
- LCMS Landscape Change Monitoring System
- LT LandTrendr
- NLCD National Land Cover Dataset
- OLI Operational Land Imager
- **S-CAP –** SERVIR-CArbon Pilot program