# Mangrove Inventory Methods, Multi-Agency Collaborative Studies in Florida

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Interim data reported for this active mangrove project is preliminary and under continued analysis until completion.

# Basic Challenges to Inventorying Mangroves

- Accessibility – Field crews can occasionally get to sample plots on foot or by small watercraft (e.g. hike/kayak); however, many plots require third party boat transportation.
- Timing – Since many mangrove sites are situated on or accessed across tidal flats, field crews are restricted by the amount of time spent on the plot based around the high tides.
- Density - Red mangrove (*Rhizophora mangle*) prop roots can be quite thick and dense, impeding mobility and making travel between subplots difficult. Plot damage can also occur from traverse to the subplots of the standard plot design.

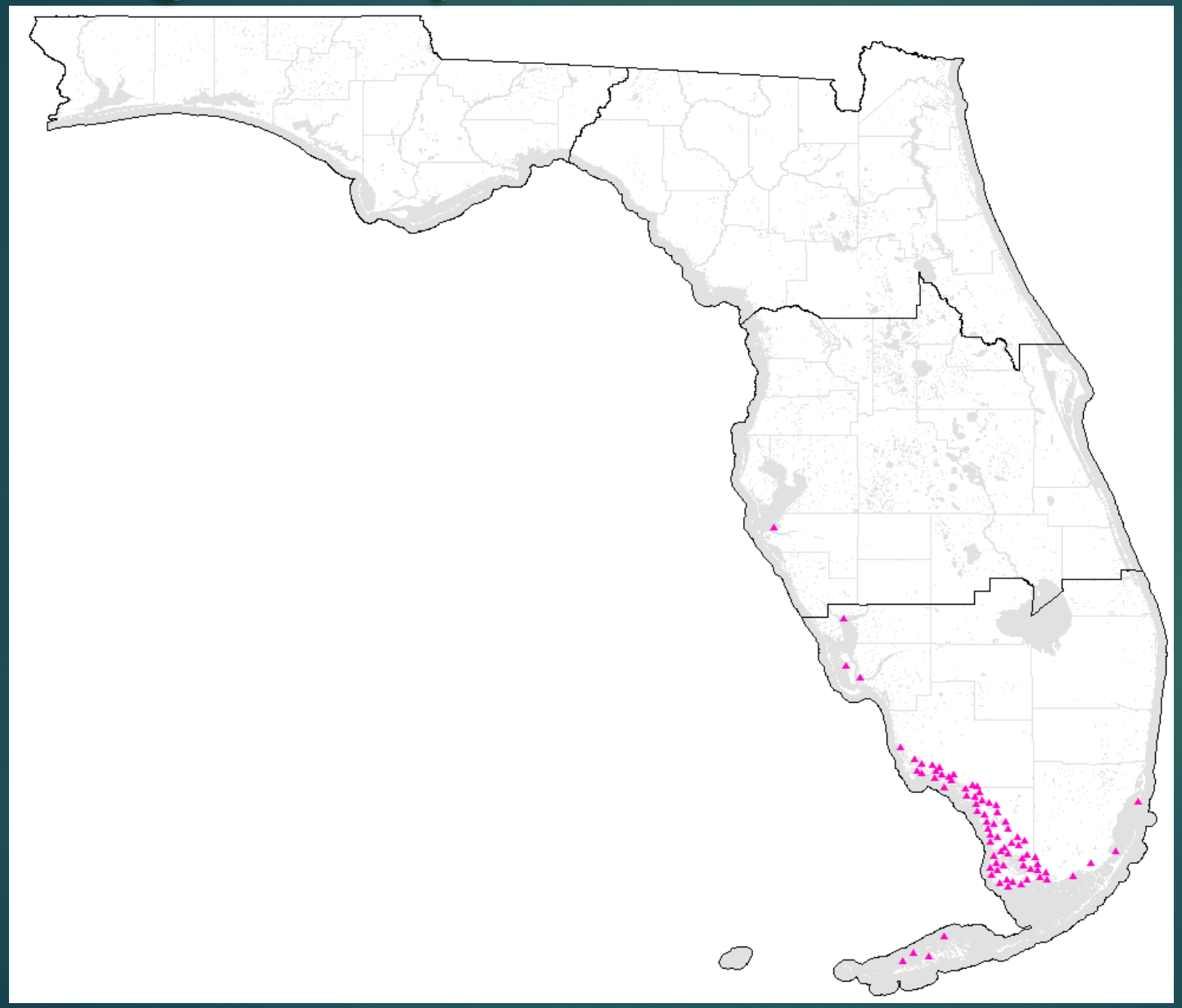
# 2016-2017
# Pilot Mangrove Project

Investigate mitigation of challenges to mangrove inventory

Augment sample plot acquisition

The U.S. Forest Service (USFS) Southern Research Station (SRS) Forest Inventory and Analysis (FIA) program and the Florida Forest Service (FFS) designed and began ground based inventory enhancement trials on FIA sample plots located in mangrove forests of SW Florida. The study was designed to test methods aimed at reducing the number of previously inaccessible plot locations. The National Aeronautic and Space Administration (NASA) performed remote sensing flyovers of project's plot locations for comparison. The Mexican Forest Service (CONAFOR) demonstrated alternative diameter measurement methods for trial.

# Mangrove Project 2016-2018 FIA Plots



## Mangrove Project

- FIA Plots
- County Line
- Unit Line

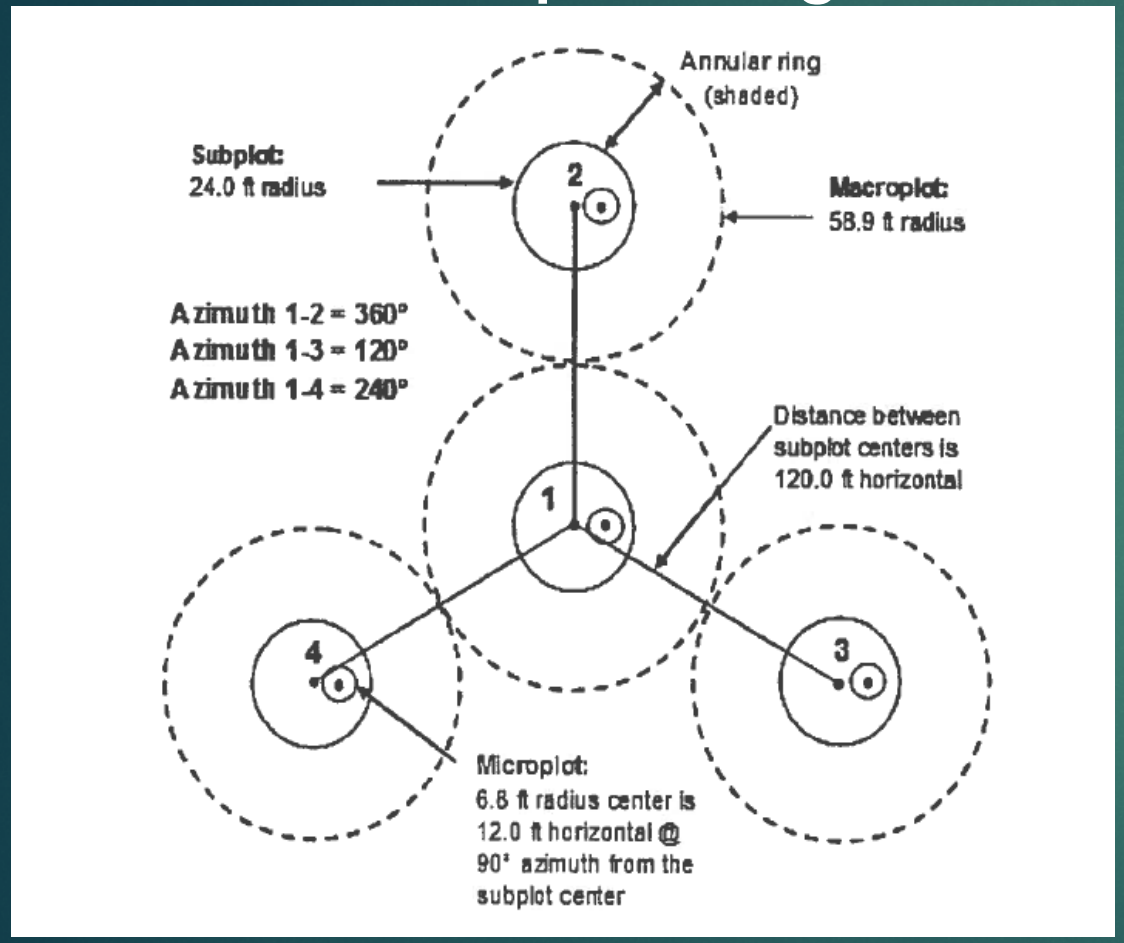
USDA FOREST SERVICE
SOUTHERN RESEARCH STATION
Forest Inventory and Analysis
Sources: USDA Forest Service,2016 FIA Plots
Visit: http://www.ncrs2.fs.fed.us/4801/fiadb/
Produced: October 3, 2017, Author: Mark Brown and Sam Lambert

# Project Objectives:

- Compare USFS FIA mangrove measurement details with Mexican forest inventory (CONAFOR) manual .
- Modify USFS FIA measurement methods for mangroves to develop common core variables between Mexico and the United States as part of an agreement for collaboration through the North American Forestry Commission.
- Use the modified USFS FIA mangrove methods to measure up to 40 plots.
- Test Alternate one point plot design against Standard four sub-plot design.
- Test USFS FIA diameter method against CONAFOR method.
- Compare data obtained through this pilot study to traditionally collected FIA mangrove information.
- Compare NASA remotely sensed flyover data to FIA ground measurements.

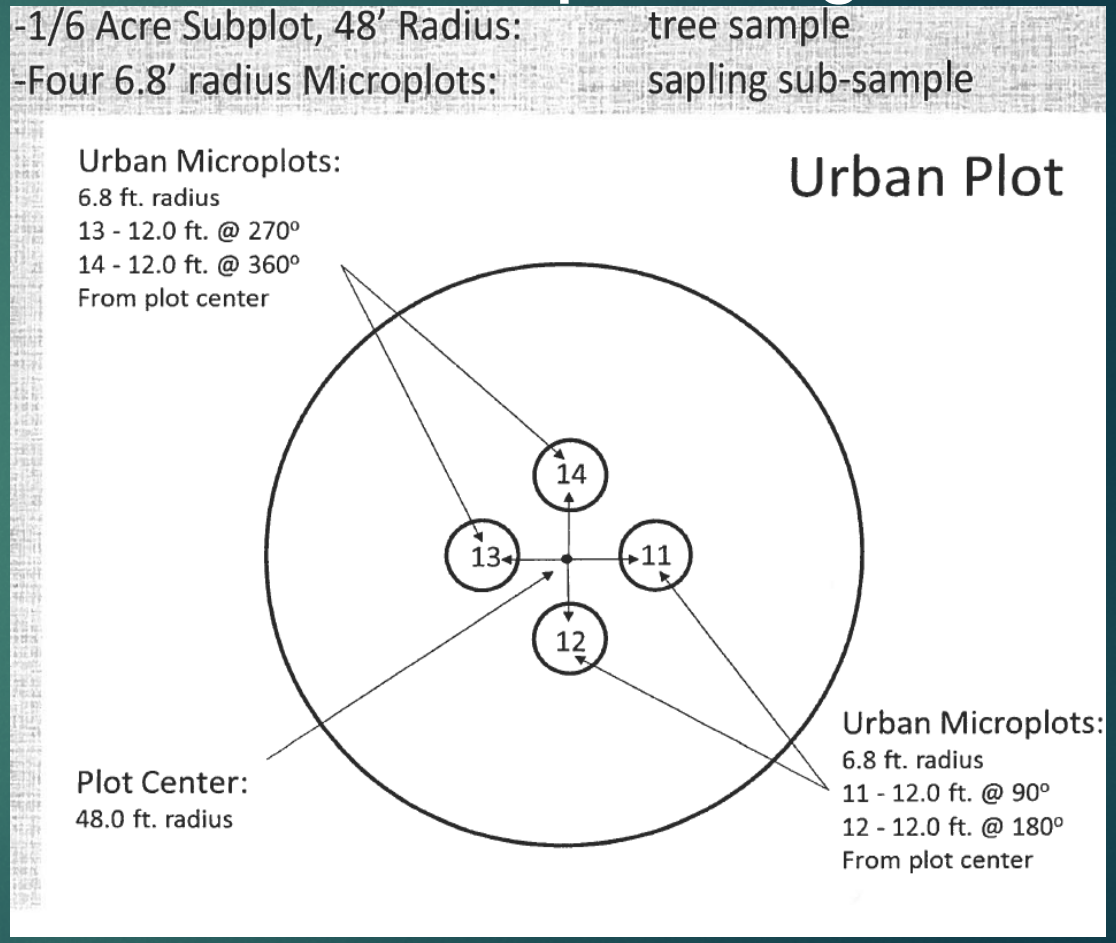
# More efficient to use a FIA Urban Plot design rather than the traditional FIA plot used for industrial timber.

## Standard plot design



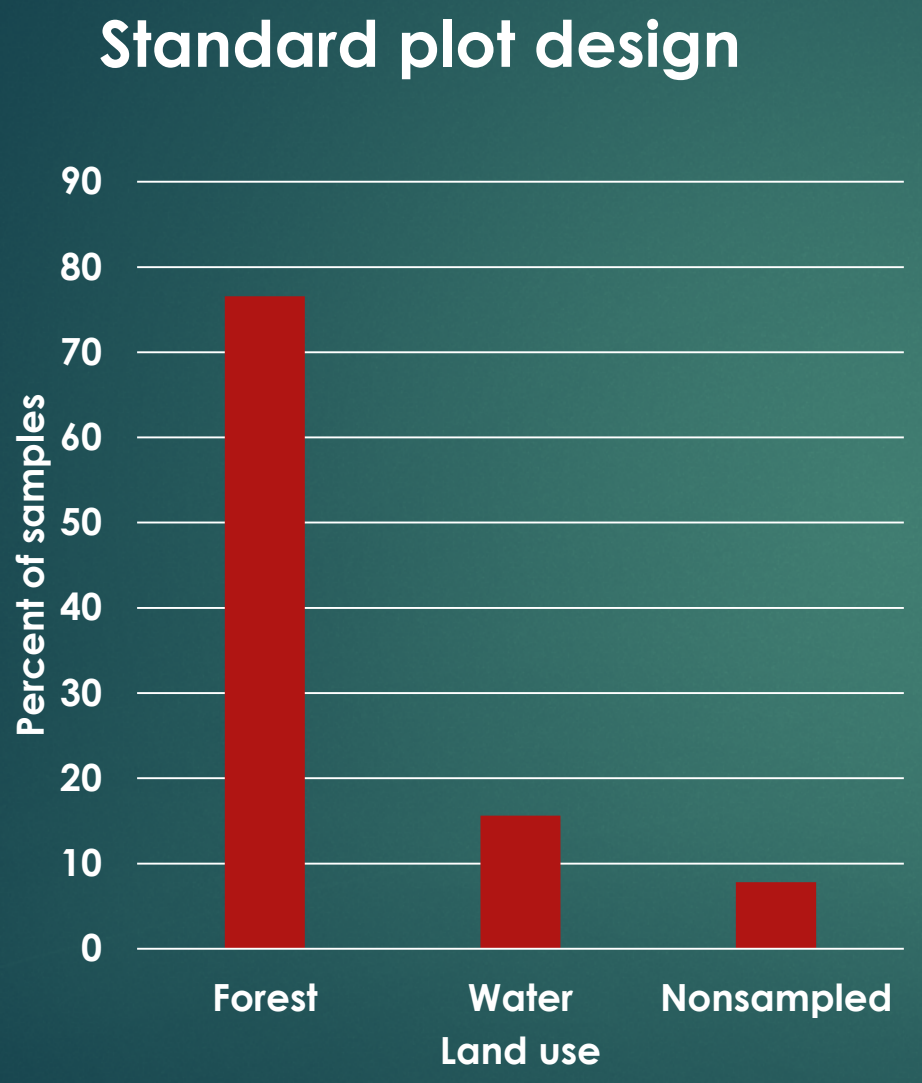

Four 24-foot radius subplots with one microplot each.

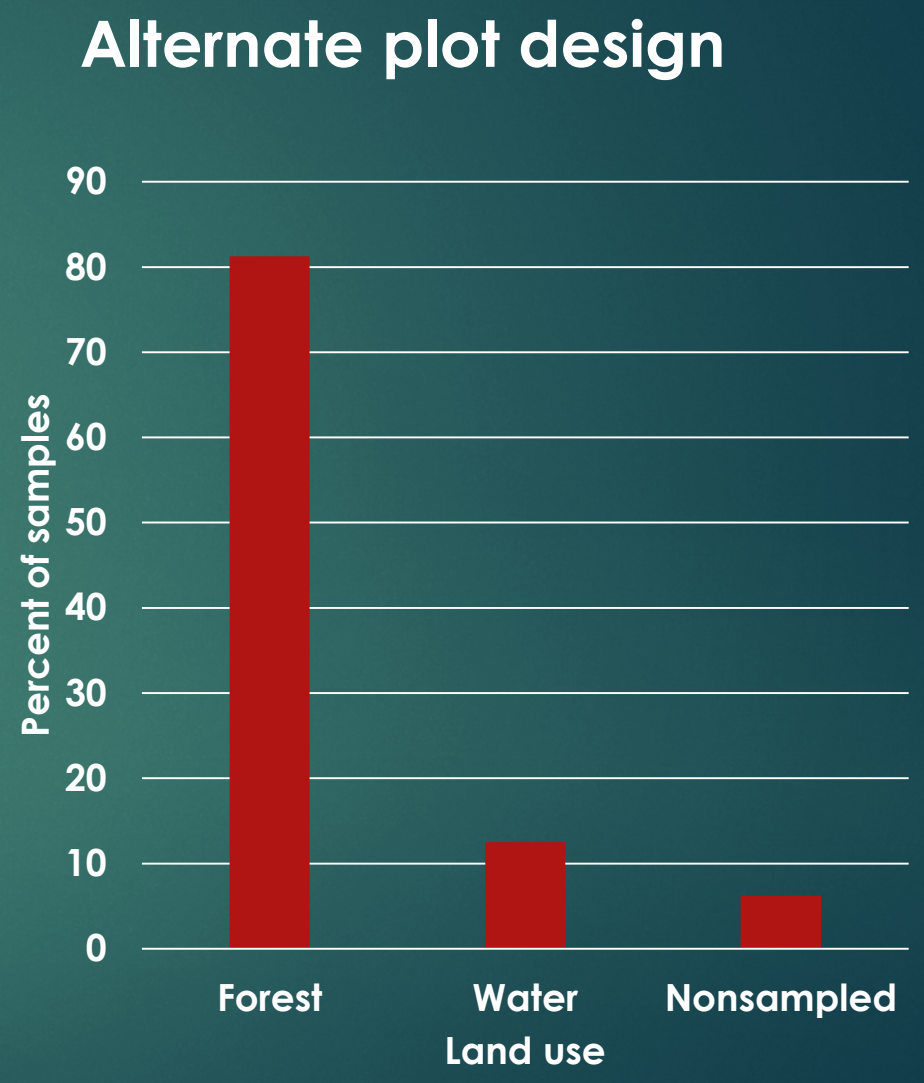
## Alternate plot design




One 48-foot radius plot with four 6.8-foot radius microplots

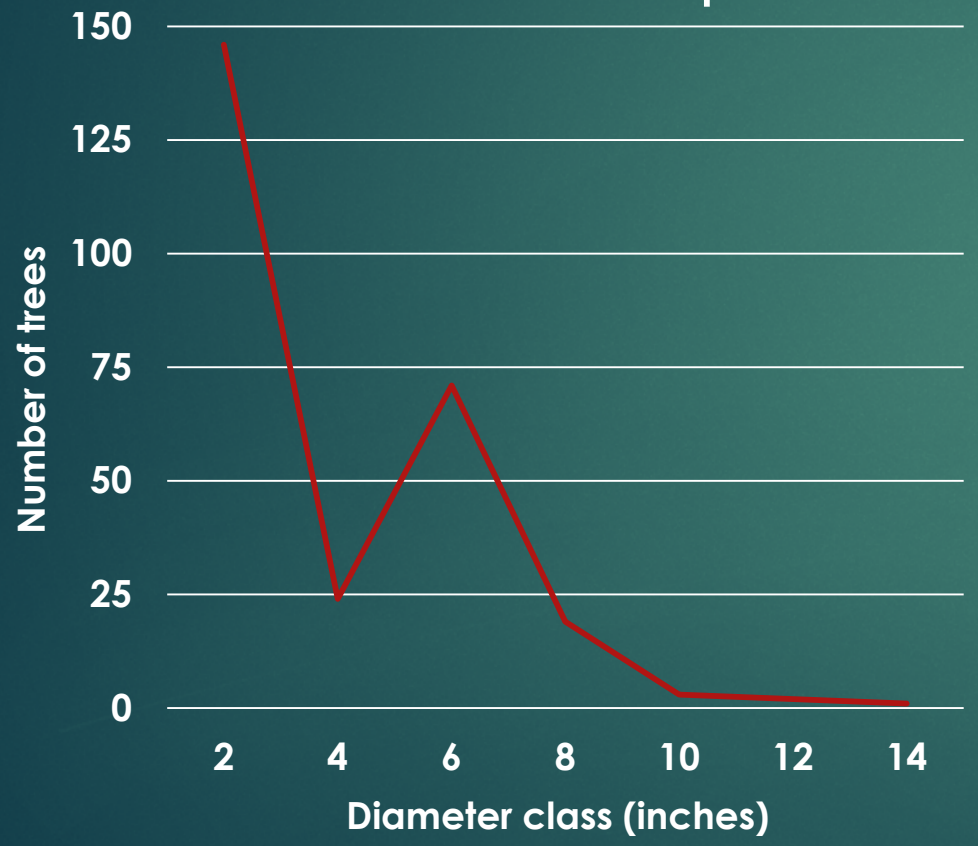
# Area Estimators – Standard versus Alternate



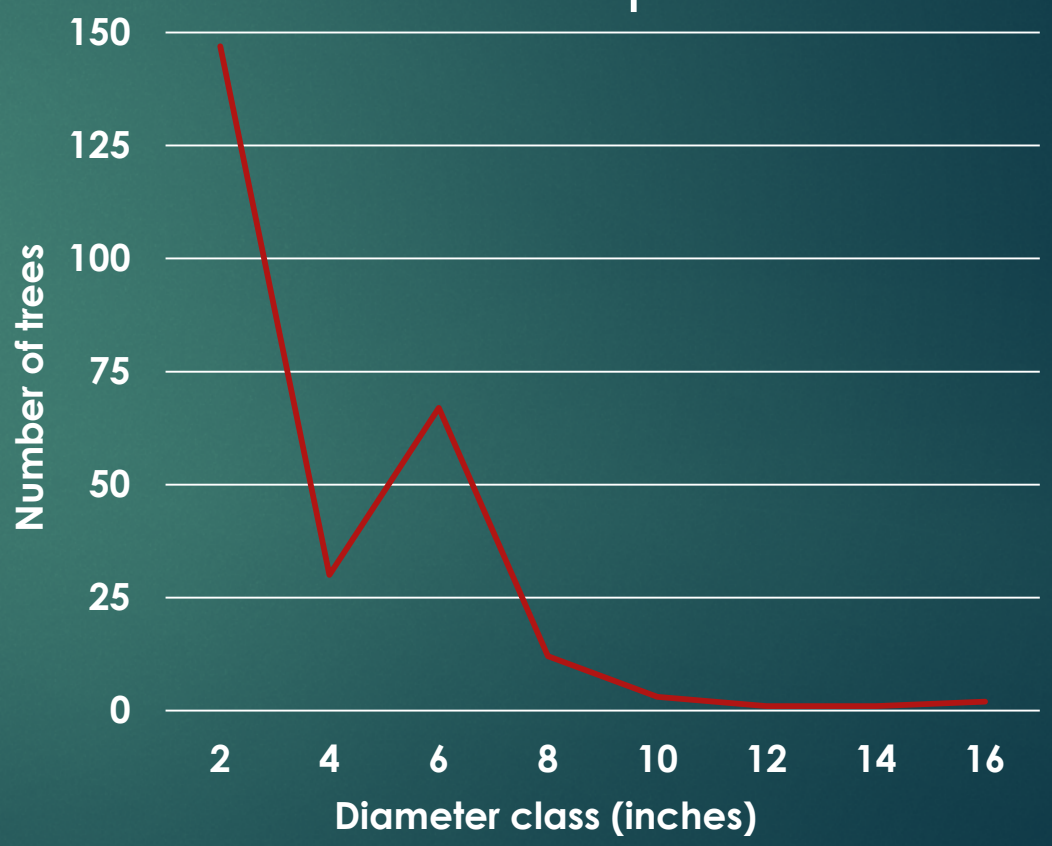



# Mangrove Tree Population by Diameter Class (all trees)

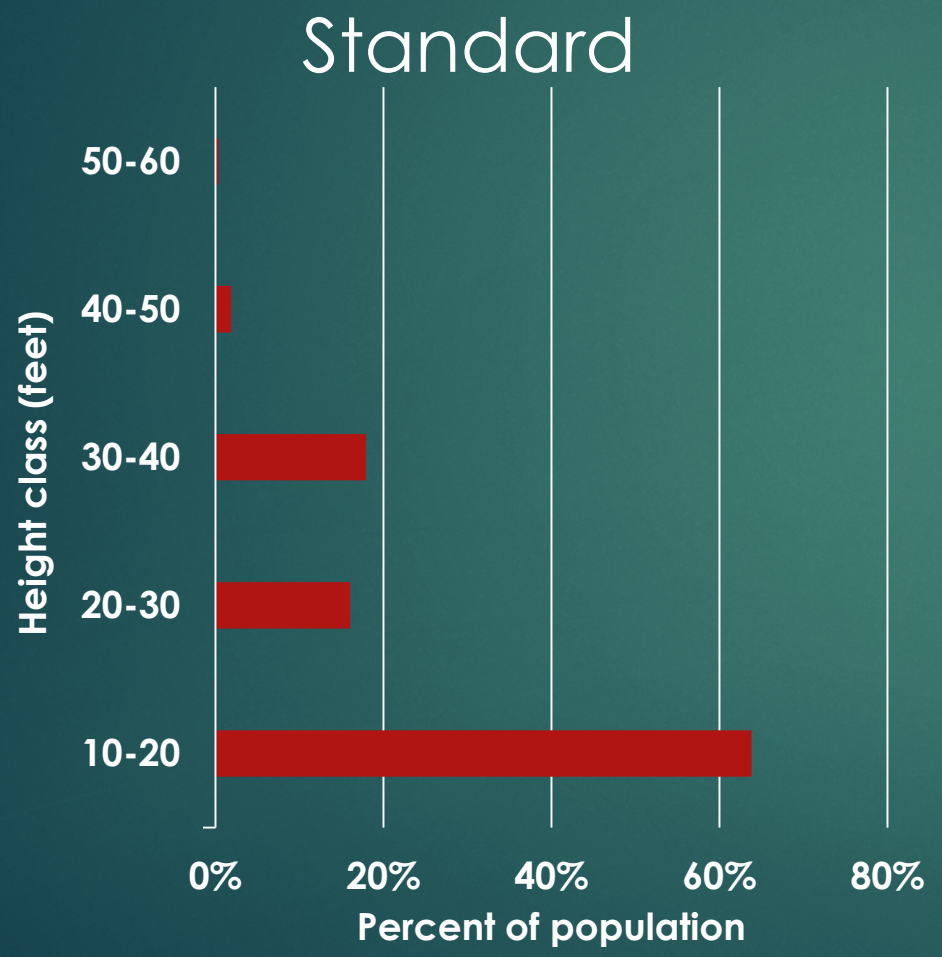
## Standard plot

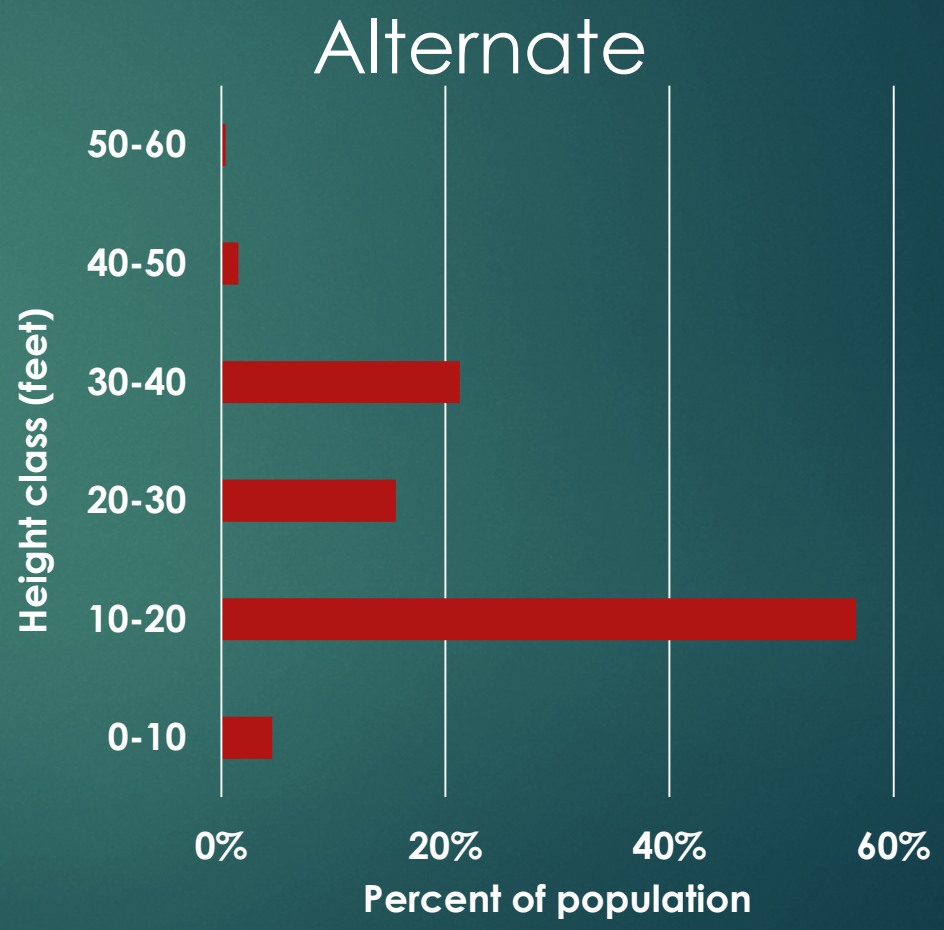



## Alternate plot



# Population by Height Class

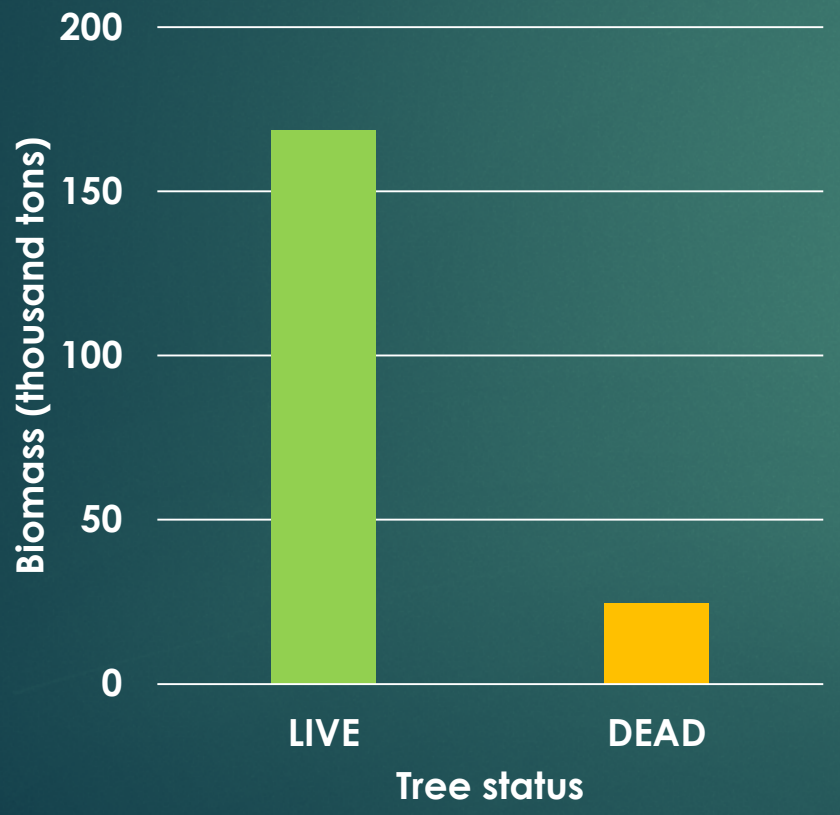


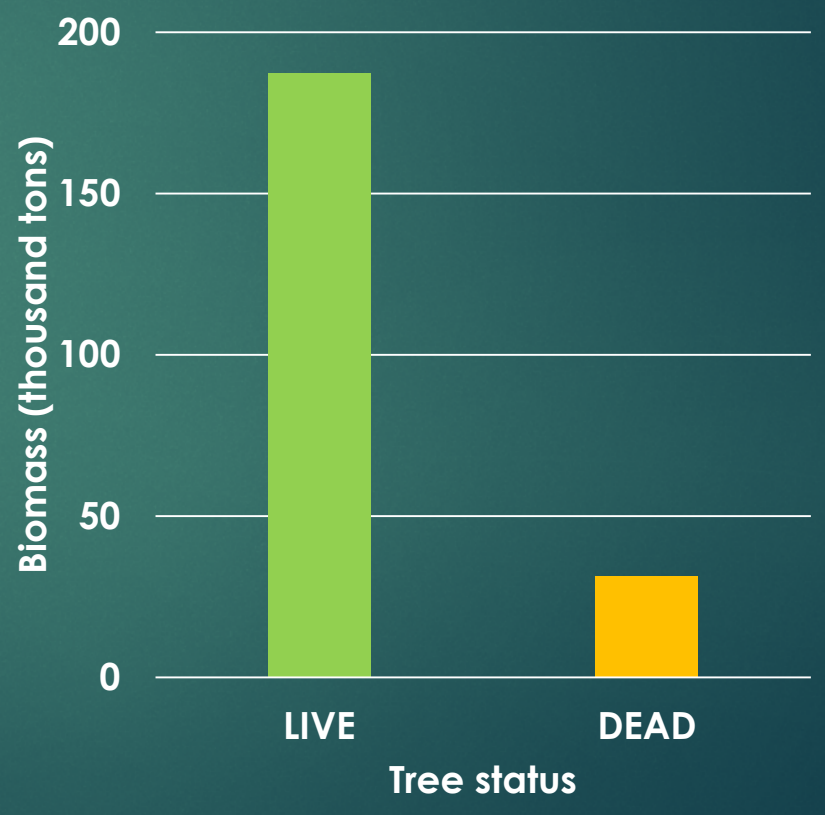
# Biomass Estimates

(thousand tons per acre)

## Standard plot




## Alternate plot

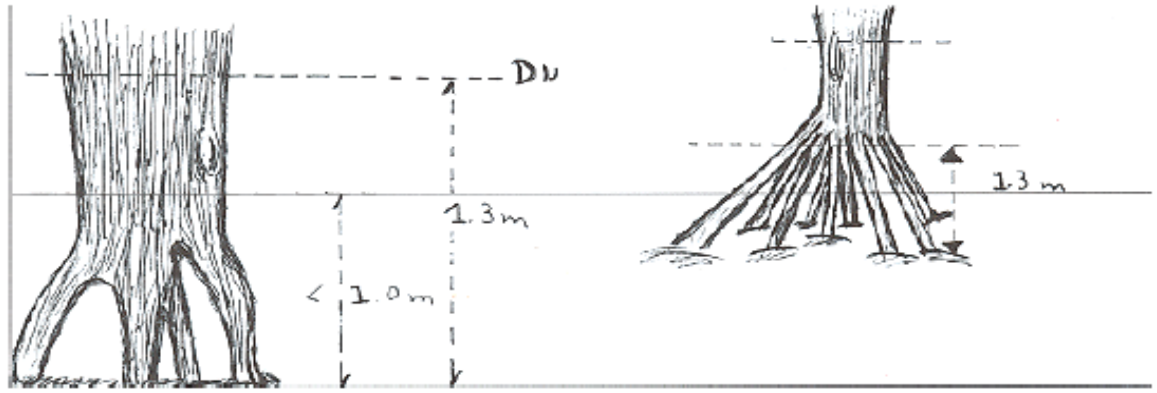


# Test Diameter Measurement of Mangroves USFS FIA method and CONAFOR method

- Historically, FIA crews take the DBH at 4.5ft above the highest prop root. This method was in some cases ineffective because of the growth patterns of mangroves, particularly red mangroves.
- CONAFOR (Mexican Forest Service) document on sampling procedures includes some discussion about special DBH situations, "trees with aerial or buttress roots over 1.3 m, it is indicated that the diameter will be measured 30 cm above the end of aerial/buttress roots.

**Árboles que presenten raíces aéreas o tablares mayores de 1.30 metros.**

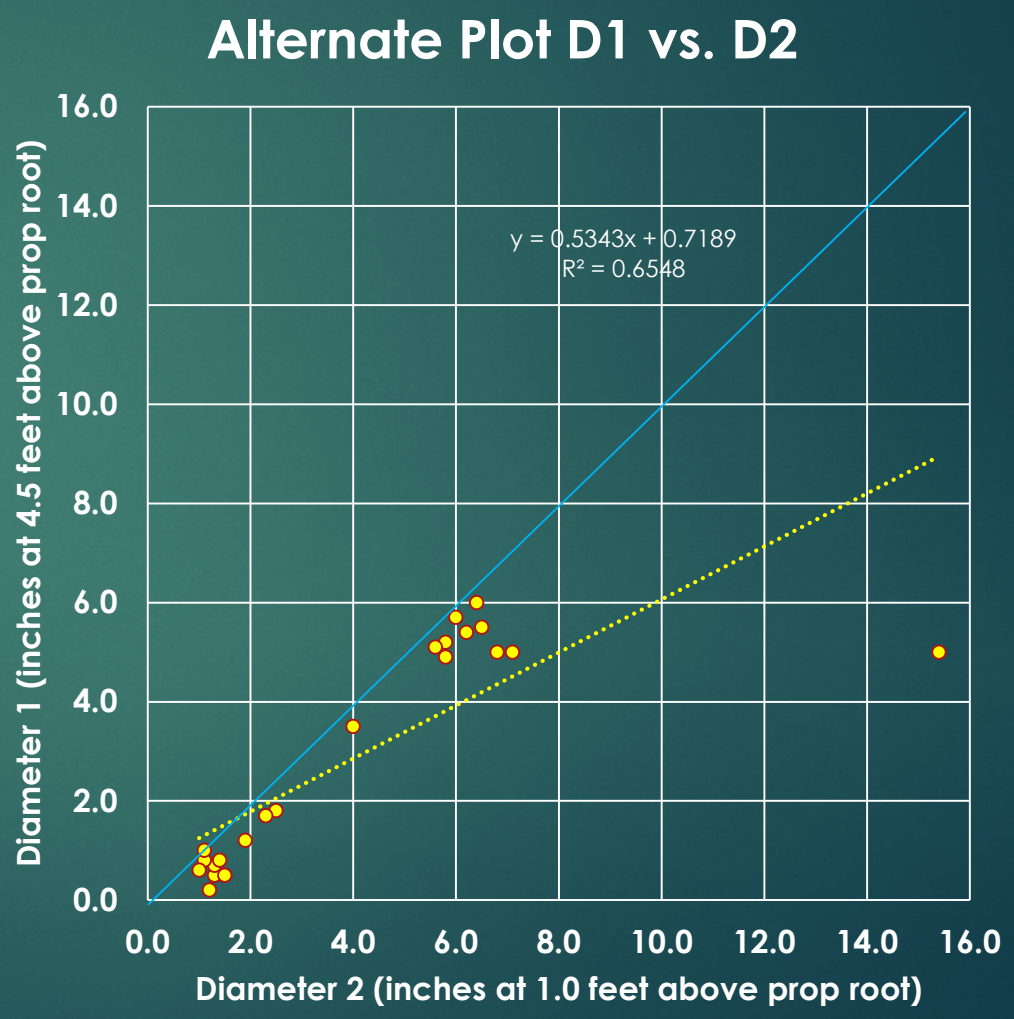
La medición del diámetro se realizará a 30 centímetros partiendo del límite entre el tronco y las raíces, justo donde se normalice el diámetro del árbol (FAO, 2009).



# Diameter Method Comparison

- Prop root issue confined to red mangrove (*Rhizophora mangle*)
- < 12 % of red mangroves tallied by CONAFOR method due to roots
- 22 % of those CONAFOR method tallied, not on tally by USFS method
- D1 = USFS method and D2 = CONAFOR method (used in next graph)

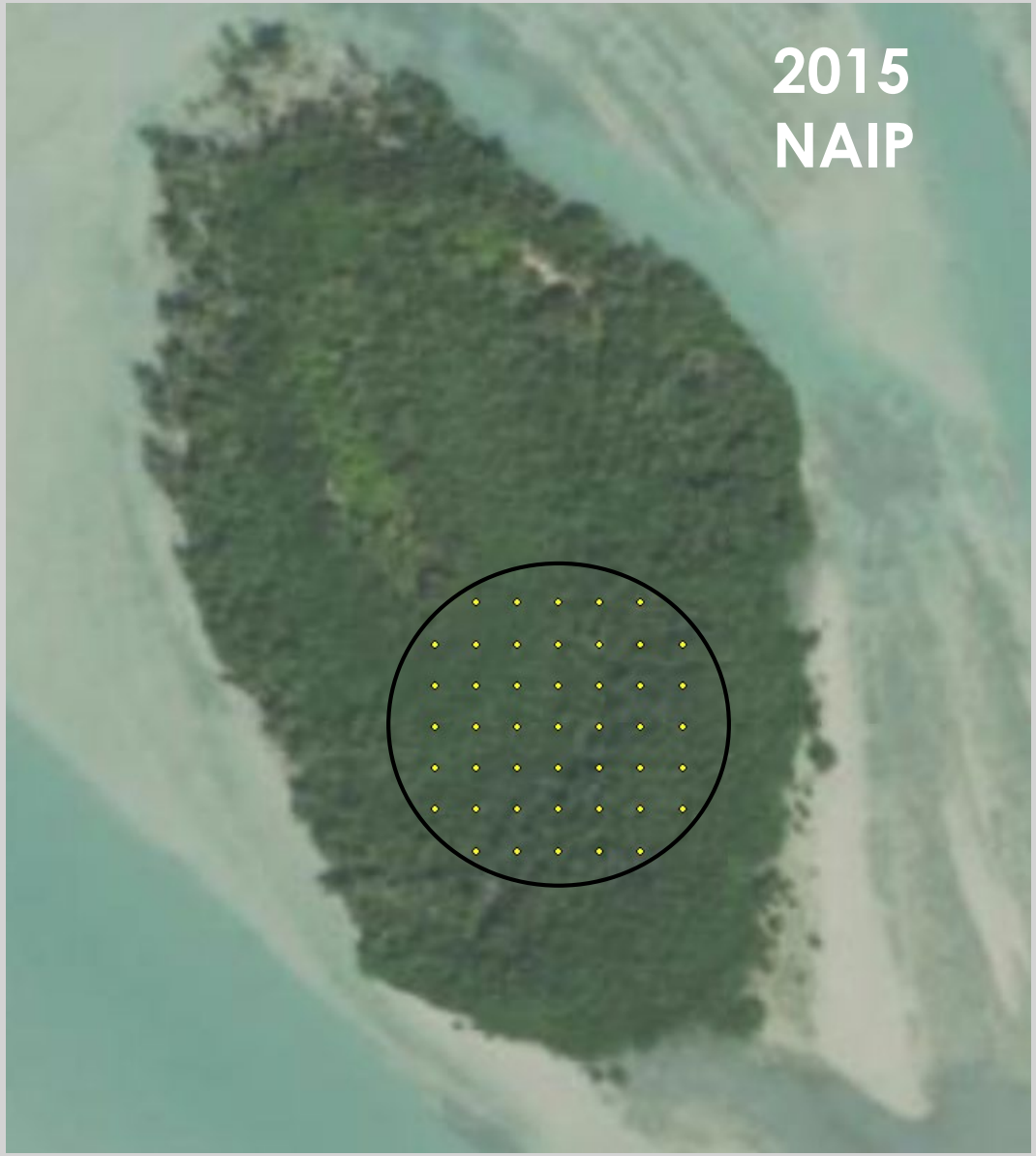
# Diameter 1 versus Diameter 2 for trees on tally under both methods

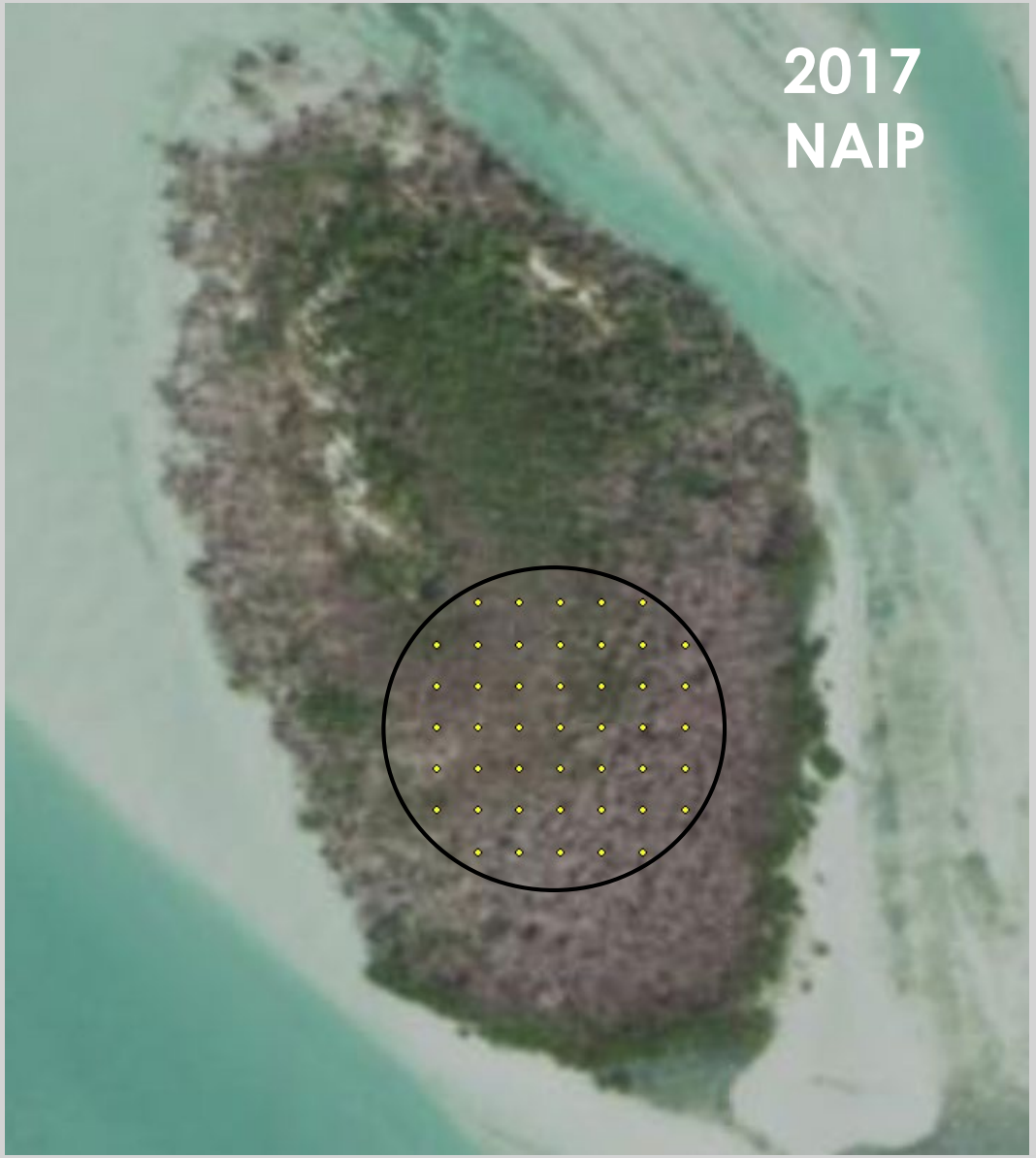


# What is ICE?

- ICE stands for Image-based Change Estimation.
- An inventory.
- A sampling approach using image-based interpretations to quickly estimate land cover, land use and change.
- A method for using high-resolution imagery for collecting LULC information more frequently than field collected data.
- Takes advantage of FS resources such as enterprise software, and investment into the National Agriculture Imagery Program (NAIP)

# Example FIA ICE Plot



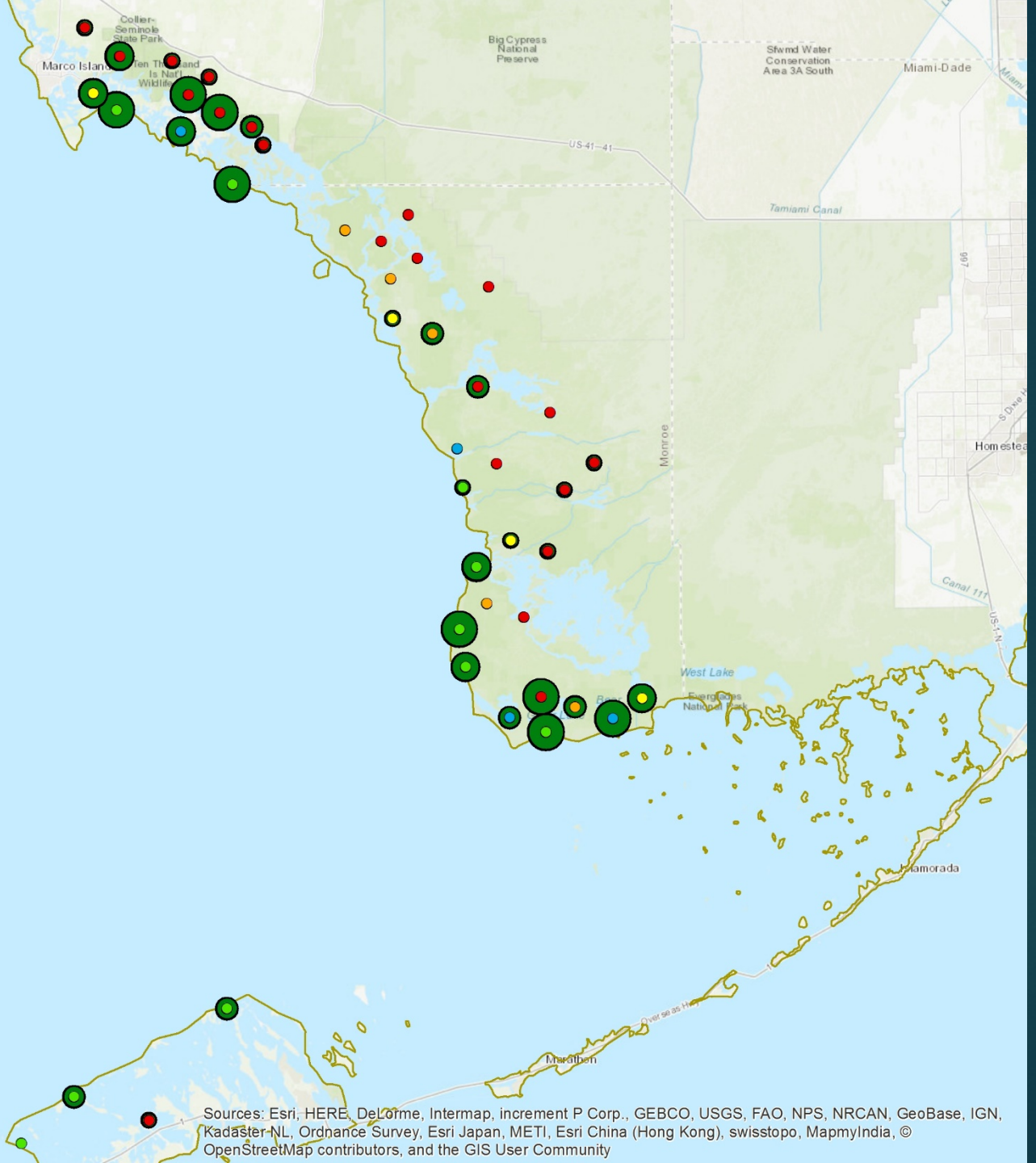
# Mangrove Plots

## Distance to Shore

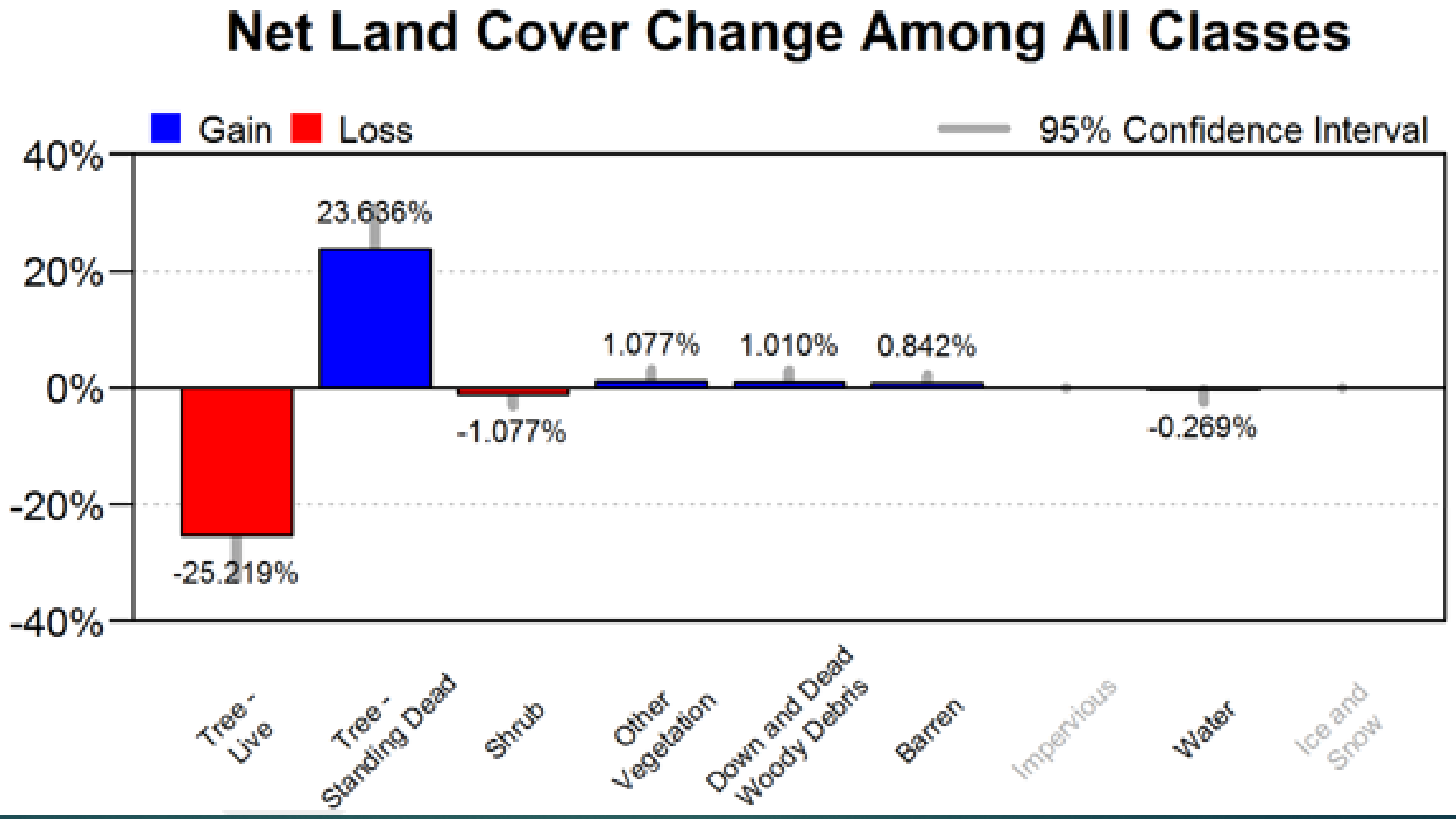
- 1km
- 2km
- 3km
- 5km
- 20km

## Amount of Change

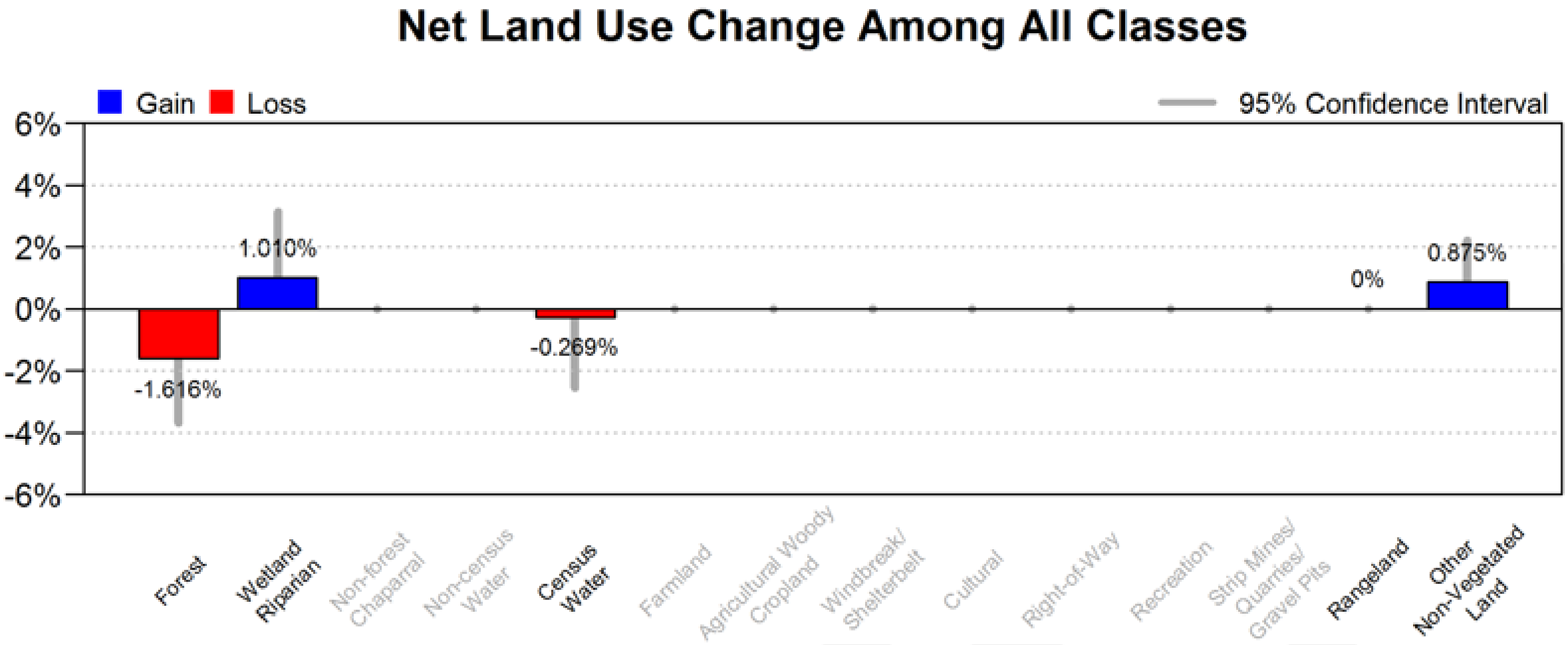
- < 15%
- 16% to 35%
- 36% to 60%
- 61% to 80%
- 81% to 100%



# Land Cover for FLmangrove (2015 to 2017)



# Land Use for FLmangrove (2015 to 2017)

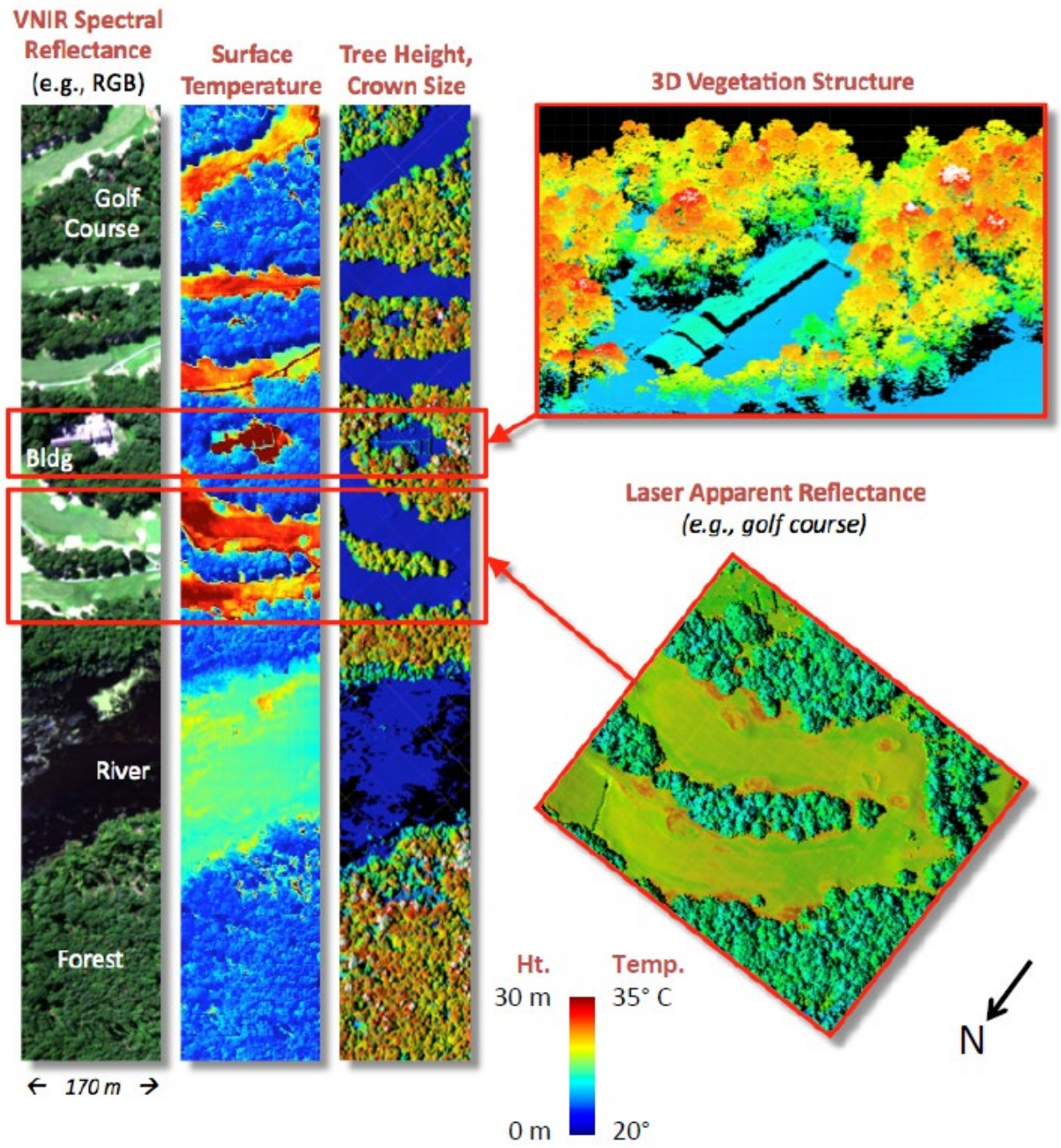


# NASA G-LIHT

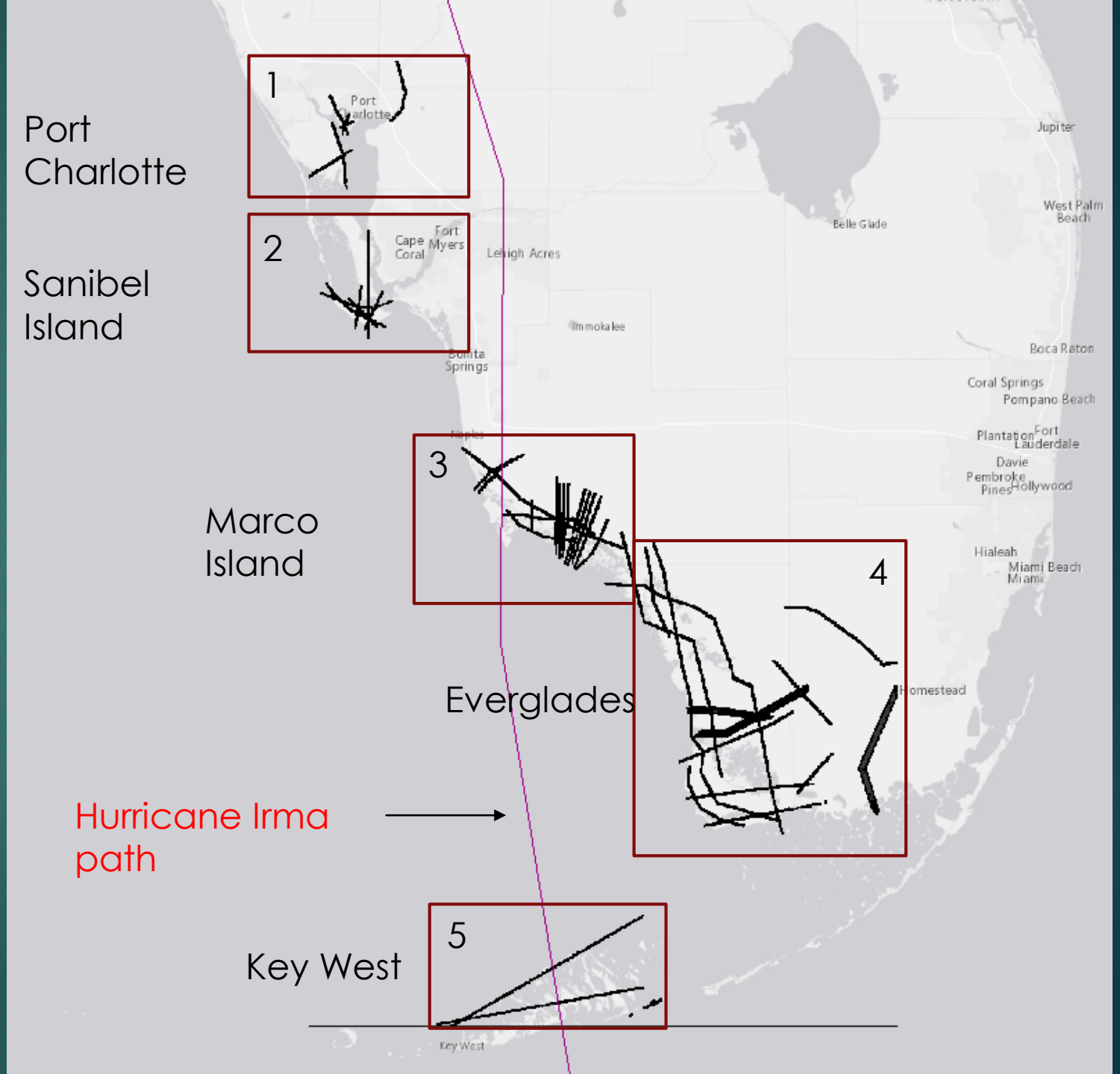
## (GODDARD LIDAR HYPERSPECTRAL THERMAL)

# What information can G-LiHT provide?

- State-of-the-art airborne remote sensing instrument that simultaneously maps the composition, structure, and condition of vegetation.
- LiDAR to provide 3D information about the spatial distribution of canopy elements.
- Imaging spectroscopy to discern species composition and variations in biophysical variables (e.g., photosynthetic pigments, nutrient and water content).
- Thermal measurements to quantify surface temperatures and detect heat and moisture stress.

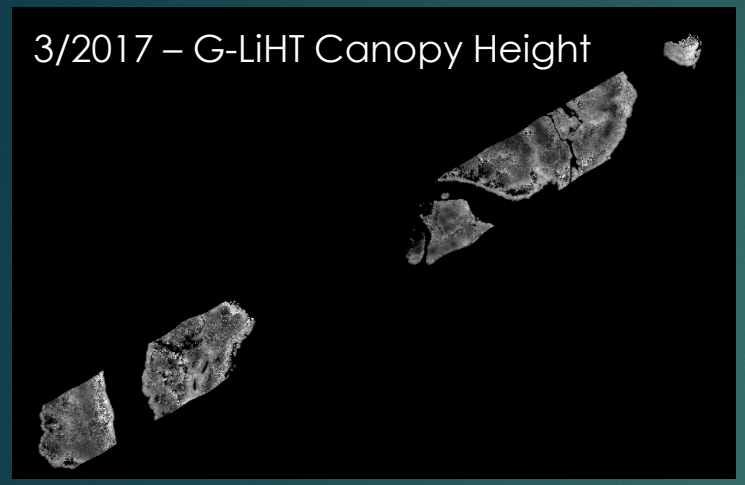


# Gliht LiDAR strips before/after hurricane Irma



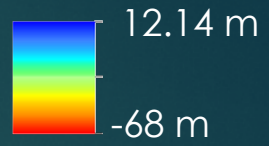
# Post-hurricane Lidar Assessment

**Pre-Irma**

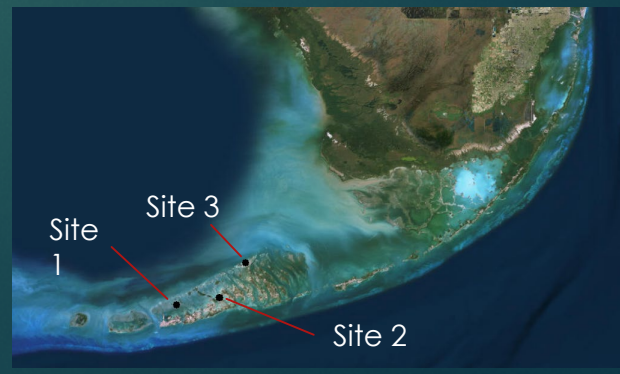



**Post-Irma**

**Lidar Canopy Height Difference**



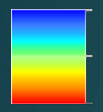

- **G-LiHT Canopy Height Model: Lidar-derived maximum canopy height (m AGL) and canopy rugosity (i.e. , standard deviation of heights within an area equivalent to one 1/24 acre USFS-FIA subplot) at nominal 1 m spatial resolution**
- **Areas shaded in blue experienced canopy height loss from T1 to T2**
- **NAIP (National Agriculture Imagery Program) acquired near T2 Lidar date**
- **G-LiHT optical data was collected but hasn't been processed yet**
- **The three sites contain FIA plots which may be re-measured post-hurricane**



Site 1

# G-LiHT Canopy Height Difference (m AGL)

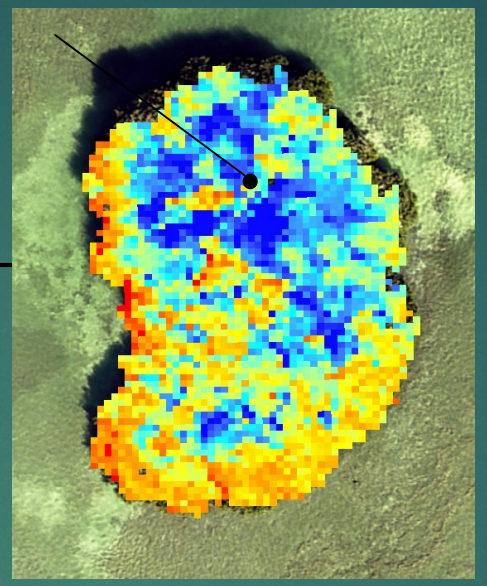
3/2017 – 12/2017



60.95 m

-65.96 m

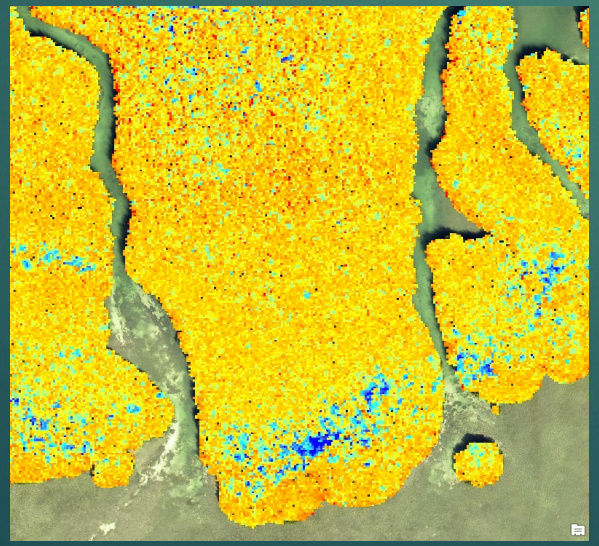
Mar – 8.35 m (27.40 ft)
Dec - 0.39 m (1.28 ft)



NAIP
12/27/2010

NAIP
12/30/2017

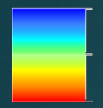
National Agriculture Imagery Program (NAIP) scenes for comparison



NAIP
12/30/2017

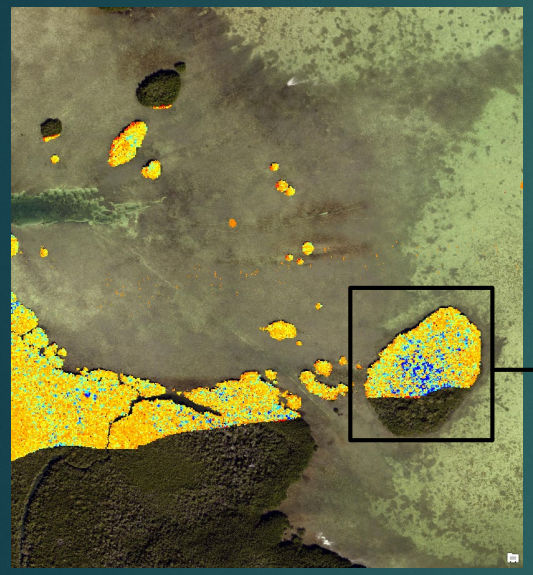
# G-LiHT Canopy Height Difference (m AGL)

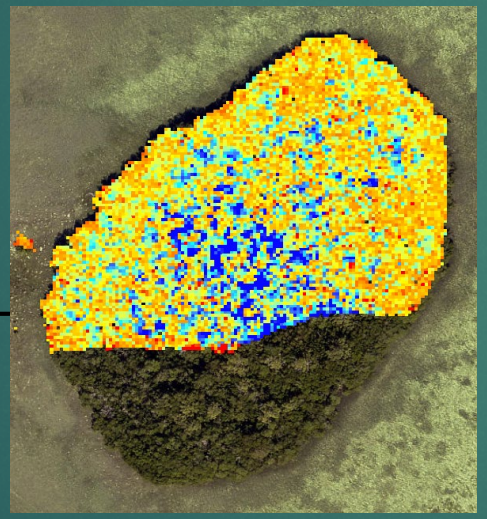
3/2017 – 12/2017



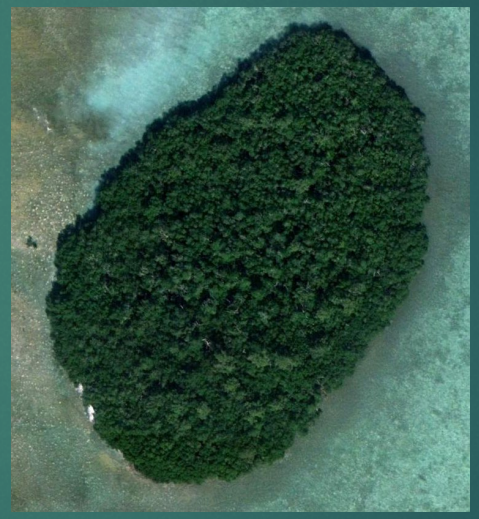
40.62 m

-11.15 m

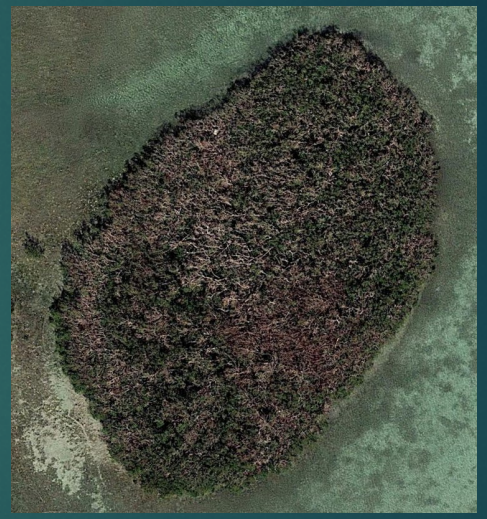




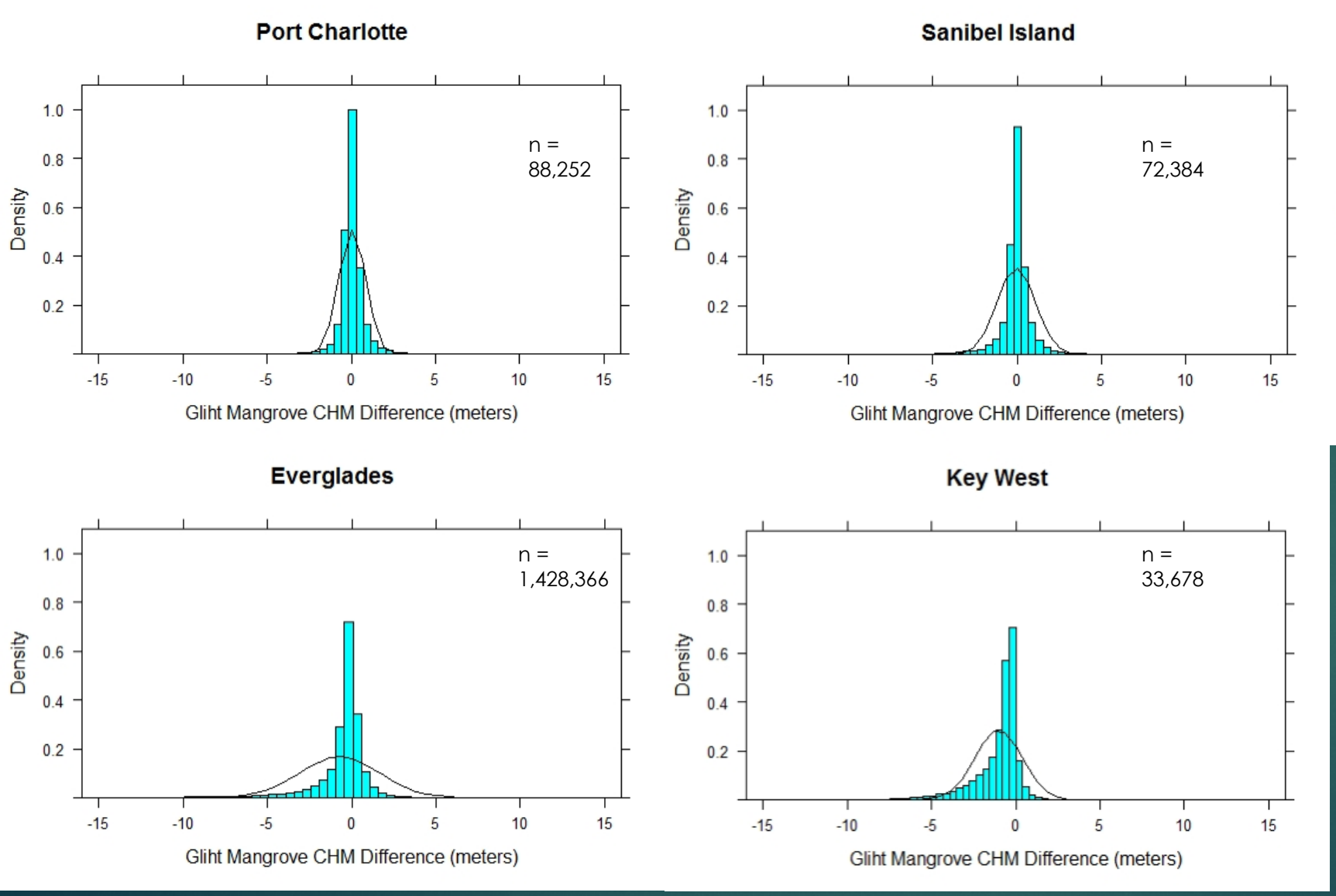
NAIP
12/27/2010



NAIP
12/30/2017



# Post-Irma Gliht Canopy Height Change

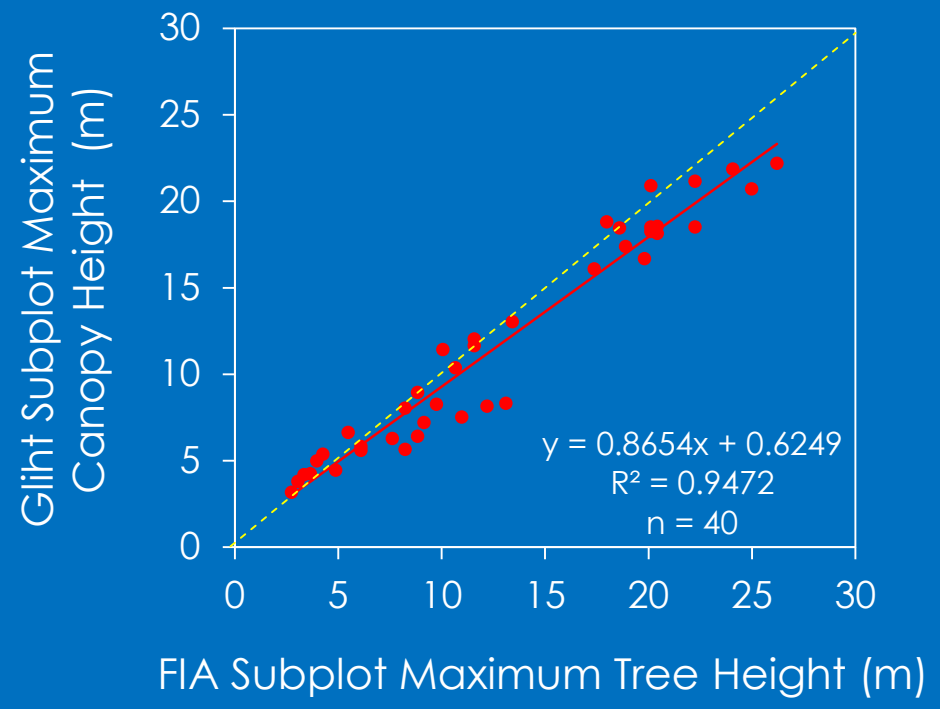



*Distributions based on random selection of 1% of pixels per region

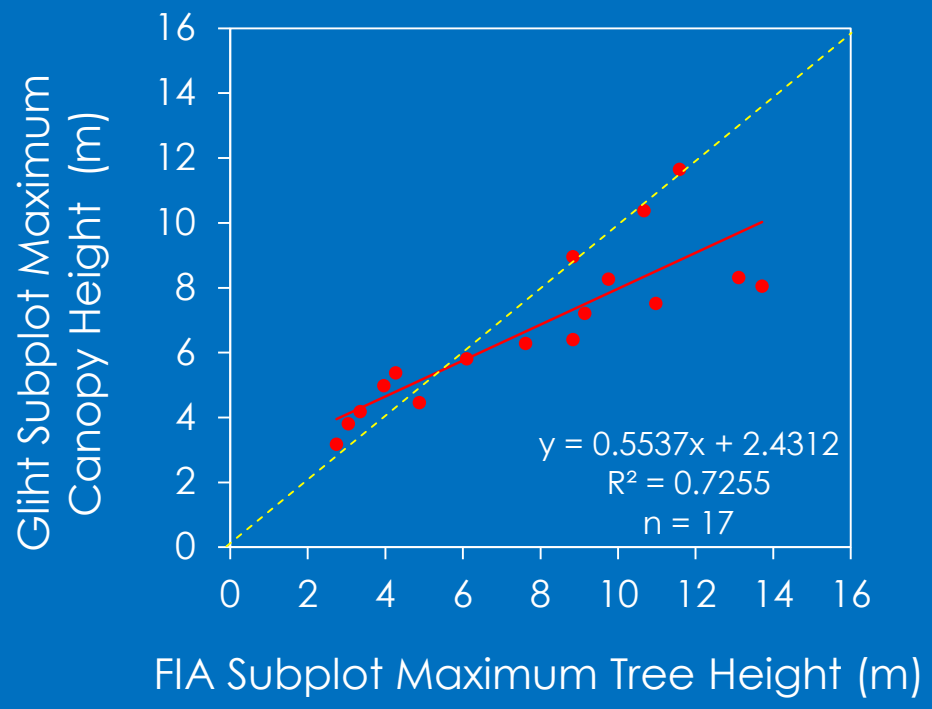
*Note since wind is the primary disturbance agent canopy height both decreases and increases

# NASA Gliht Canopy Height Model (CHM) vs. FIA Tree Height

## All Trees




## Mangrove Trees




*Note these are pre-hurricane relationships
*FIA trees were measured between 2004-2016
*FIA heights represent ACTUALHT (not HT)
*FIA and Gliht measurements represent the maximum height found on each FIA subplot
*Gliht LiDAR data was flown March 2017

# INTERIM SUMMARY of Mangrove Inventory Trials in Florida

1 – Area estimates of forest are slightly higher (81 % vs. 77 %) from the Alternate plot design

2 – Tree Population estimates are comparable for the Alternate and Standard plot designs

3 – Tree Height measurements are comparable for both designs

4 – Tree Diameter distribution pattern is similar, slightly more 6” & 8” standard, 4” alternate

5 – Biomass estimates are 10 percent higher for Alternate plot design than Standard design

6 – Time spent on the plot is shorter for the Alternate design than the Standard design

7 – Diameter test method at 1 foot above highest prop root is faster and safer

8 – Test Diameter (CONAFOR) accounted for <3 percent additional tally trees

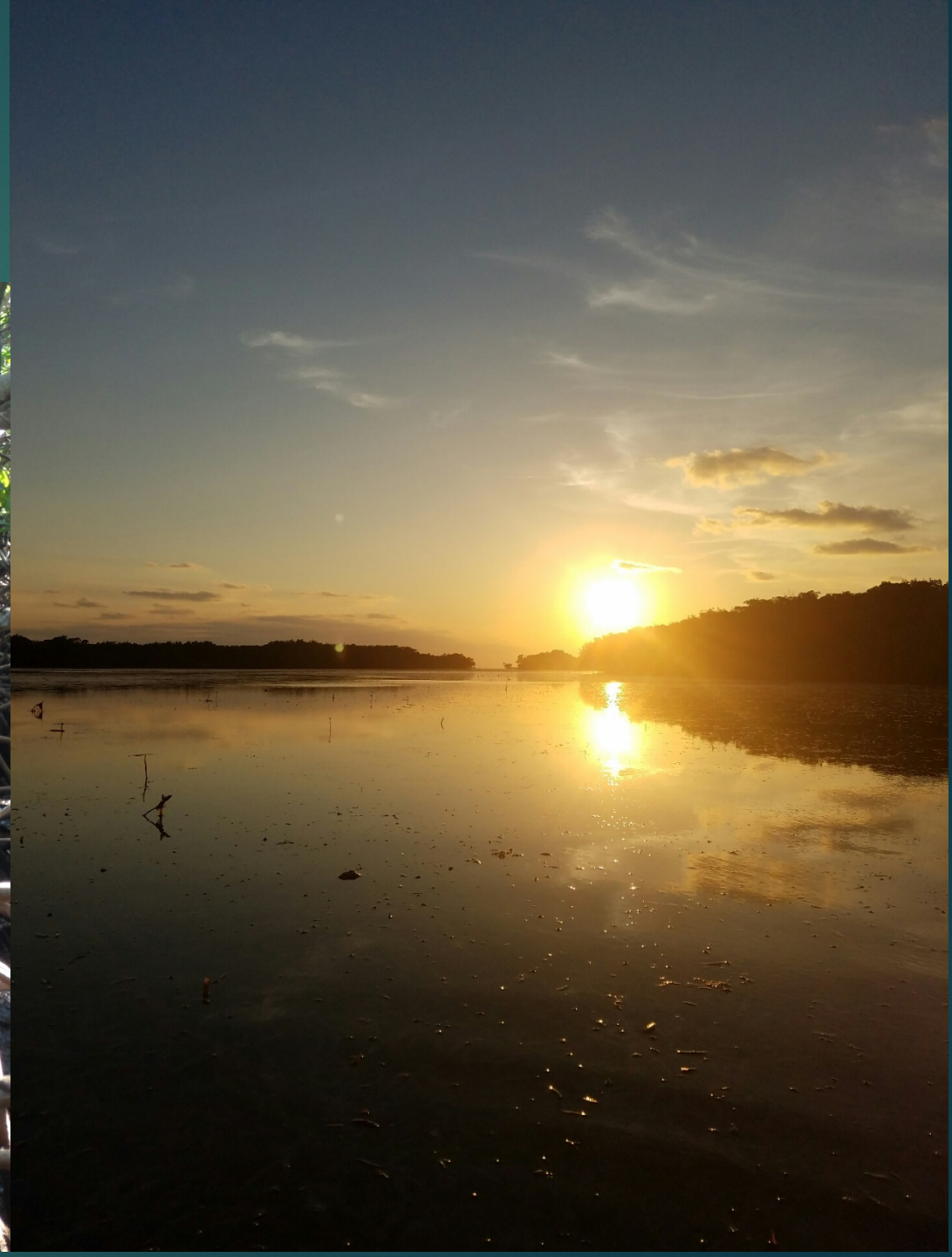
9 – Test Diameter raised individual diameter on <12 % of red mangrove trees

10 – G-LiHT mangrove heights less than FIA ground based heights; comparable for other species

11 – ICE estimates 25 % tree cover loss for the study plots

12 – ICE estimates < 2 % change from forest to nonforest land use for the study plots

# Exiting a Mangrove Plot



# Questions ?

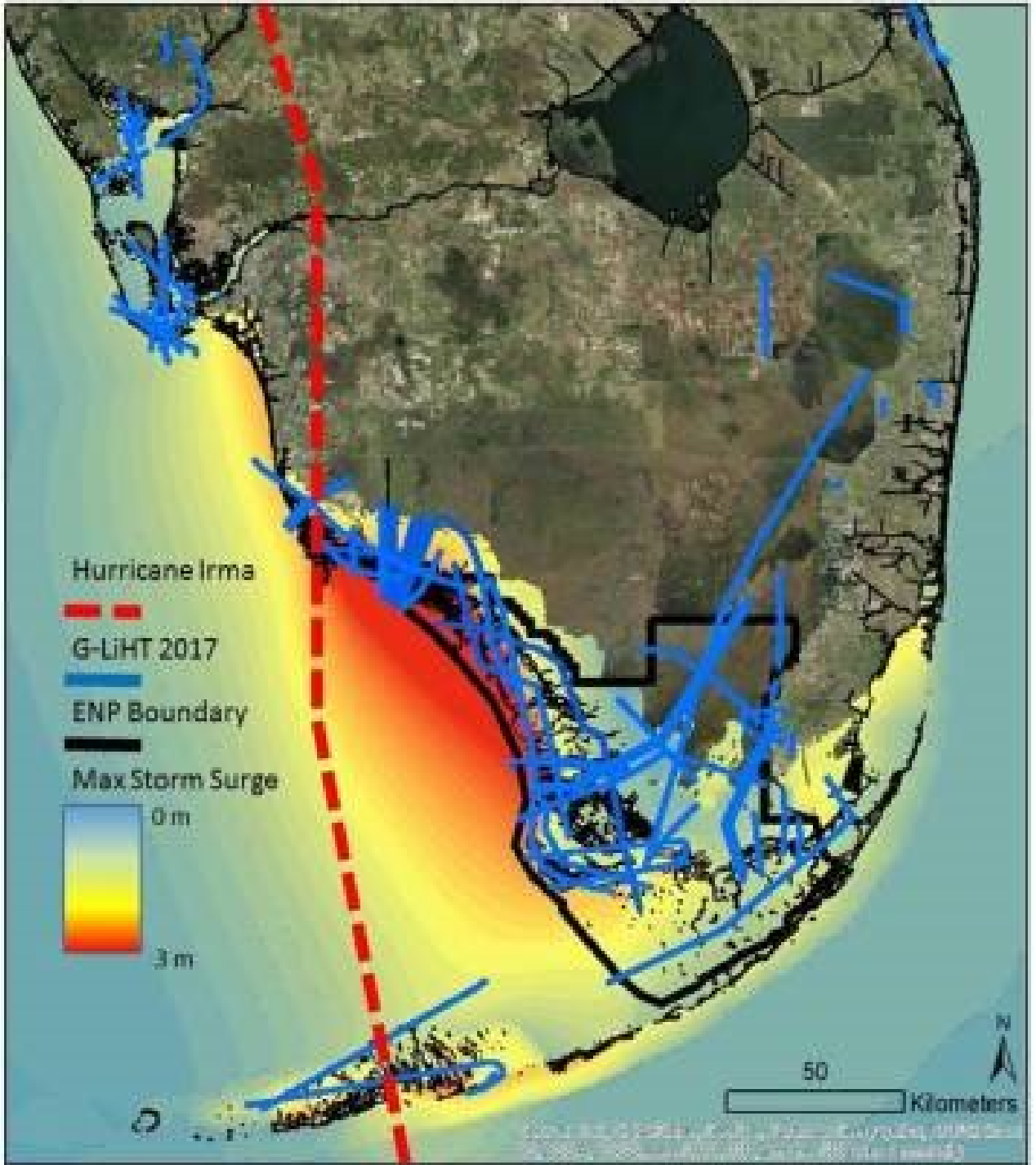
# …Hurricane IRMA !!!

September 10, 2017:

Hit Florida Keys as Cat 4 storm with winds 130-156 MPH

Hit Florida Mainland as Cat 3 with winds 111-129 MPH

With storm surge up to 10 feet of water



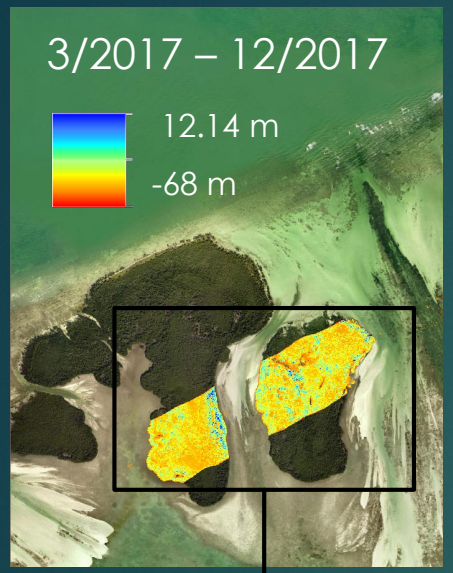
# November 2017 maximum damage

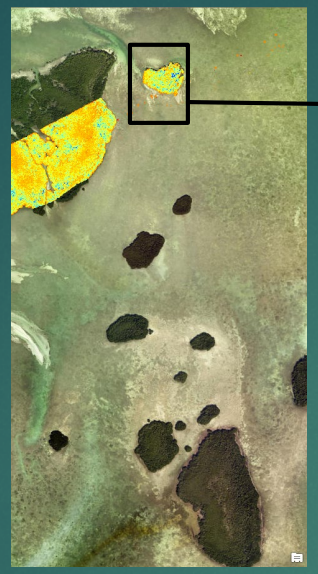
# November 2017 medium damage

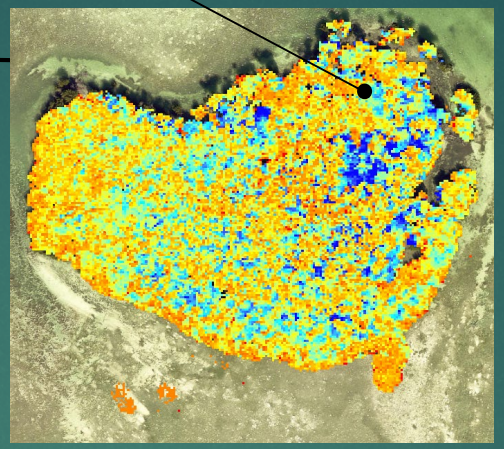
# November 2017
# no damage

# G-LiHT Canopy Height Difference (m AGL)

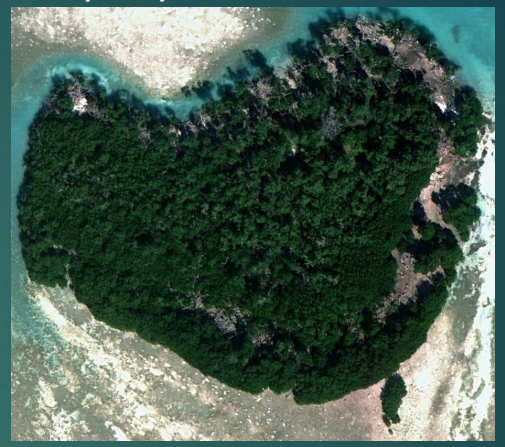
Site 3






NAIP
12/27/2010



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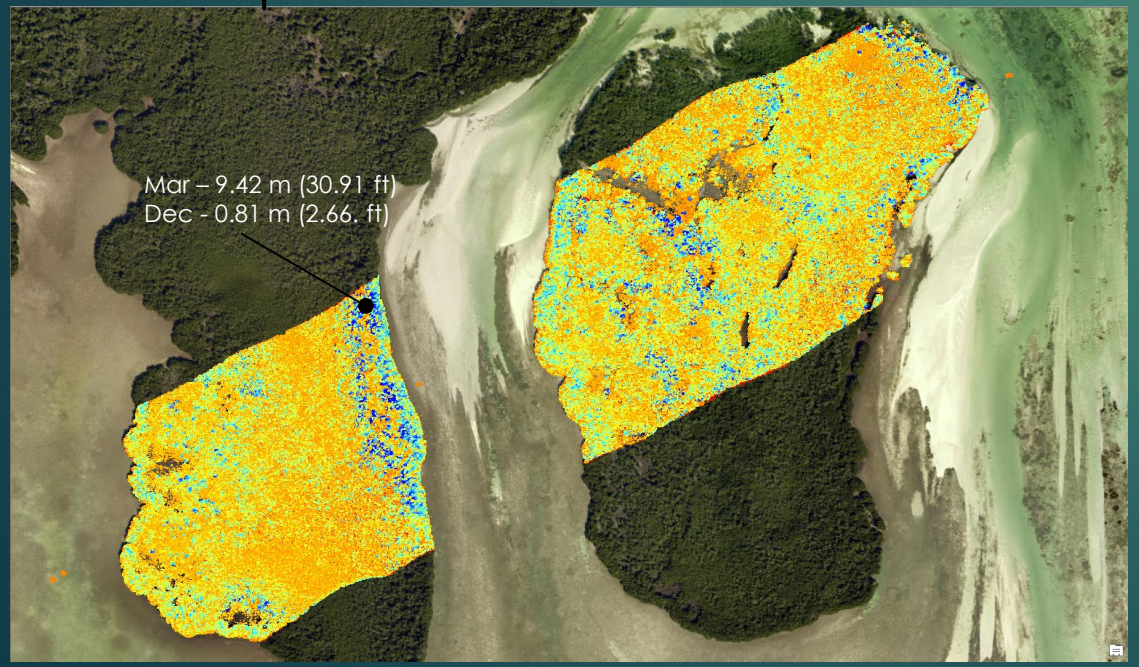

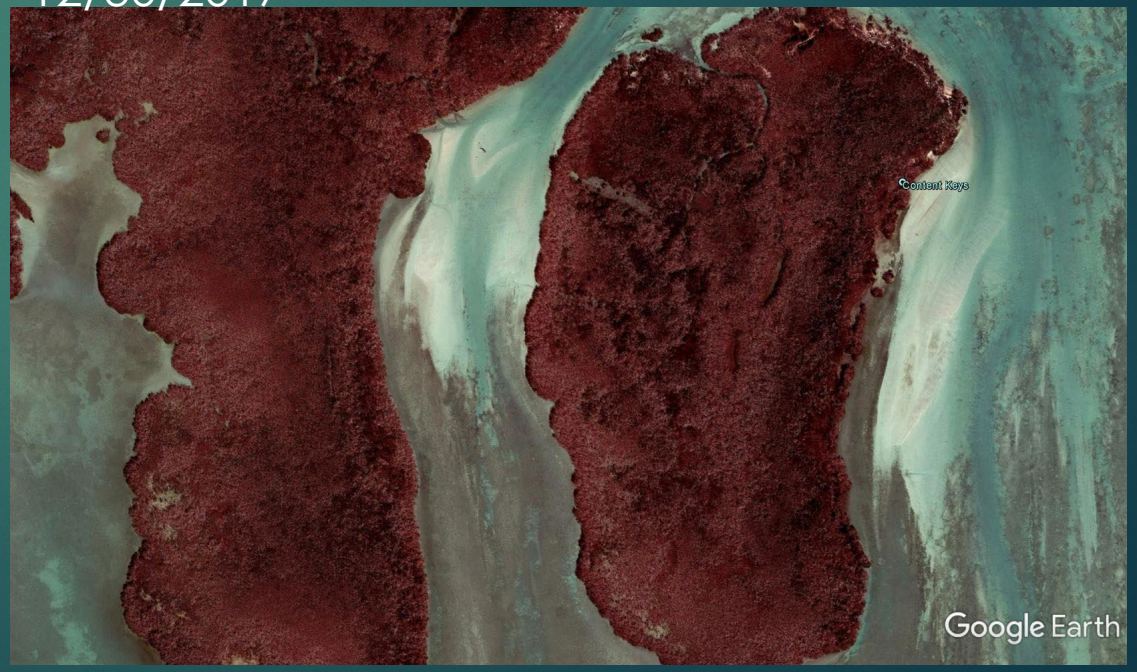
NAIP
12/30/2017