



Measuring Forest Carbon Stock and Stock Change

Belize

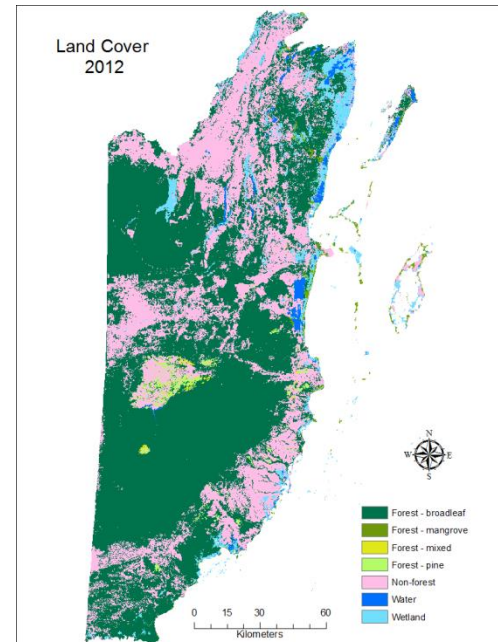


Experiences with linking data from National Forest Inventory to satellite derived metrics

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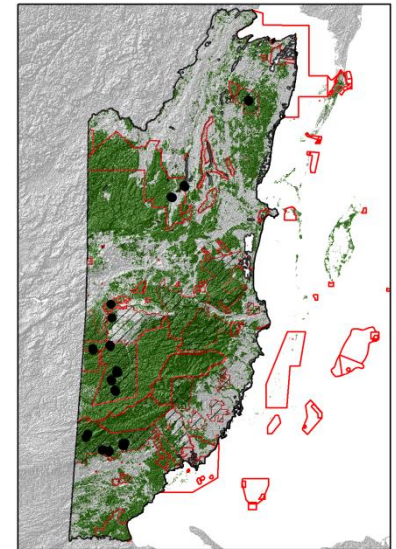
The Belizean Context

- 1.3 Million ha of forest spanning three climatic zones: dry, moist, wet
- Coarsely mapped 1980 to present
- 0.6 % annual deforestation rate
- Forests frequently disturbed by hurricanes and logging
- Wealth of mapping and field data
- Sparsity of human resources



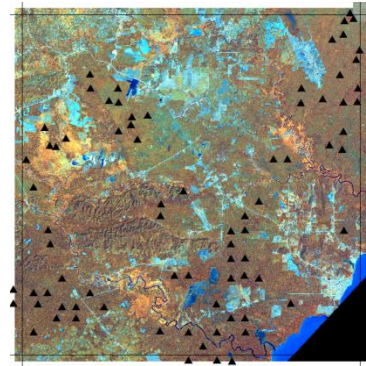
The Belizean REDD+ Context

- In the process of generating national land use/cover map 2011/2012 using Rapid Eye
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- Currently piloting our national forest inventory
- Expanding PSP network
- Recently accepted into FCPF



How to make a biomass map?

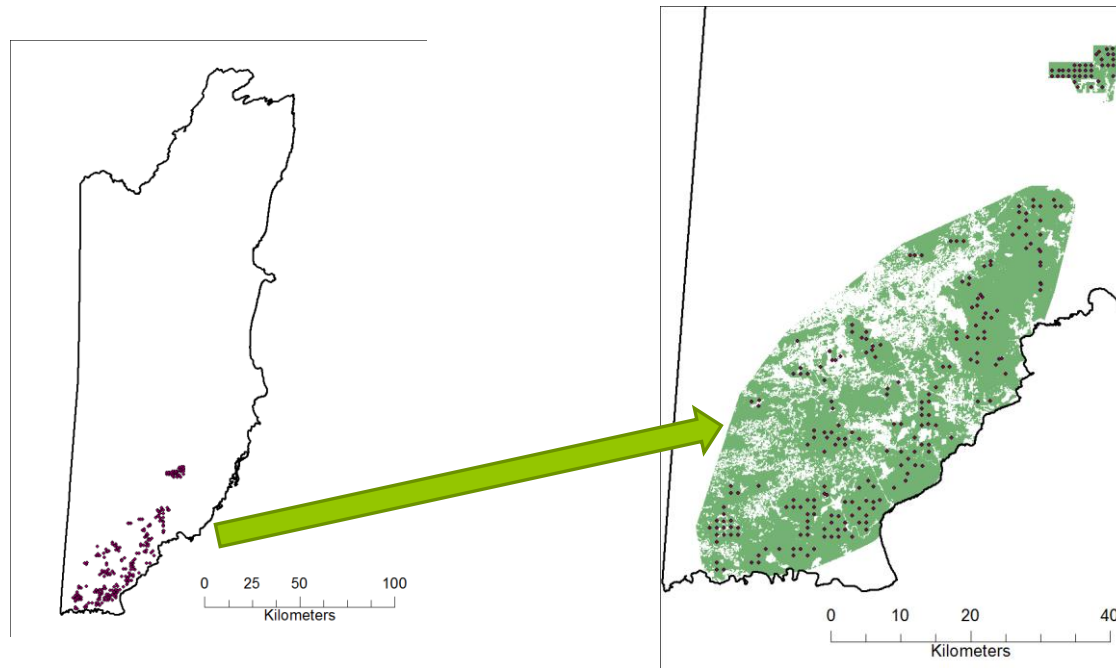
- To date no sensors directly measure AGB
- Method 1 – Regress field data from sparse surveys against satellite data over large areas to predict biomass distribution



- Method 2 – explain later

Linking field and Satellite data

- Country-wide Rapid Eye coverage
- Extensive dataset of standardized field measurements
- Eg.



The field biomass dataset

- 248 plots 0.5 ha each, part of NFI dataset
- Estimate biomass using local allometric model

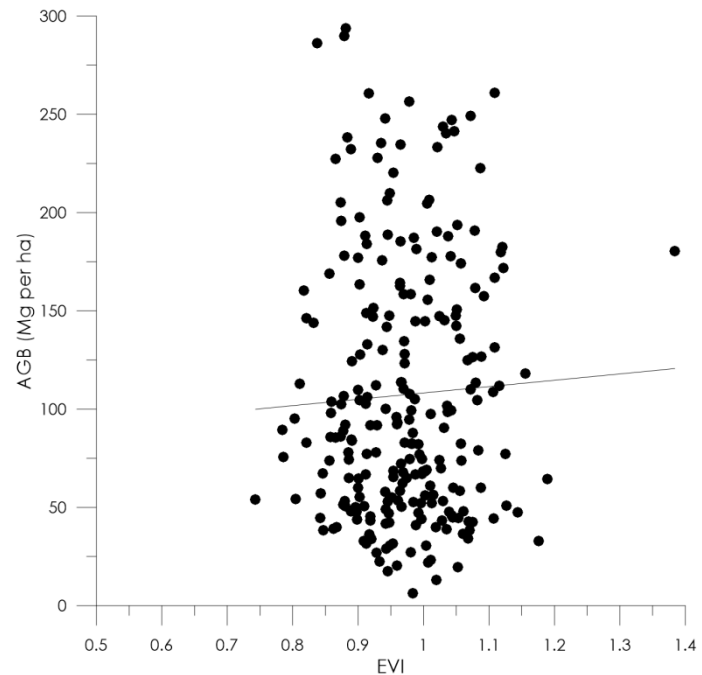
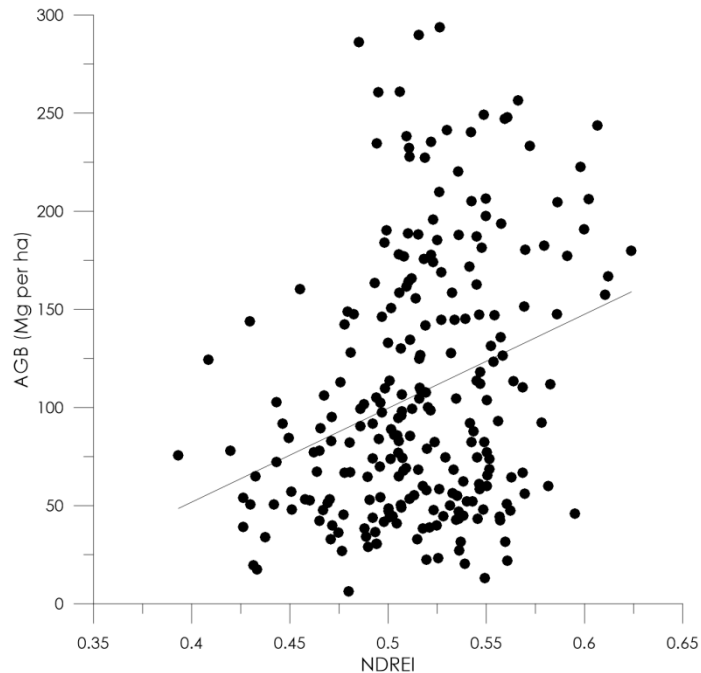
$$AGB_T = \frac{\rho \times \exp(-9.480 + 0.975 \ln DBH^2 H_S)}{1 - (0.723 CFI - 0.091)}$$

- Developed using >300 trees
- Stepwise model calculates stem and crown separate
- Crown AGB based on form
- Sensitive to tree damage
- >40% improved precision



Linking with satellite metrics

- From Rapid Eye
- Test two band indices: NDREI and EVI

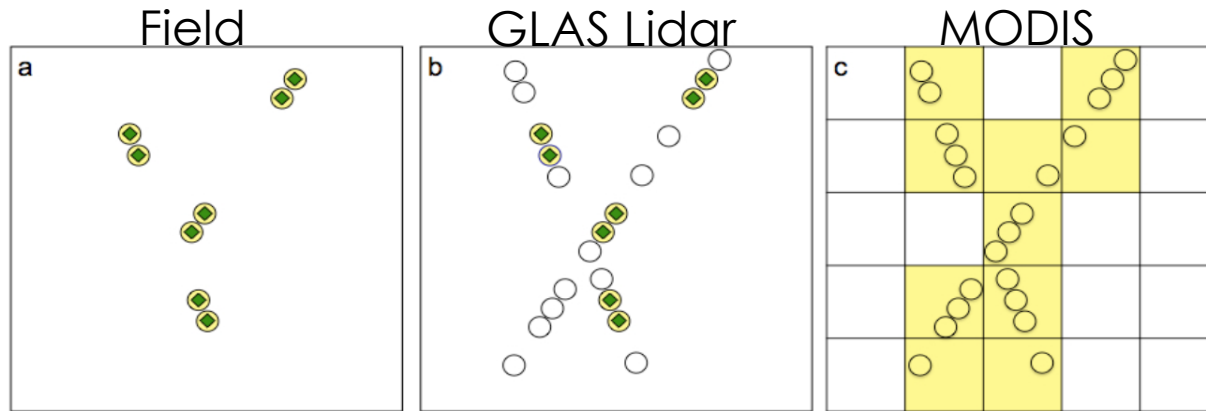


Linking with satellite metrics

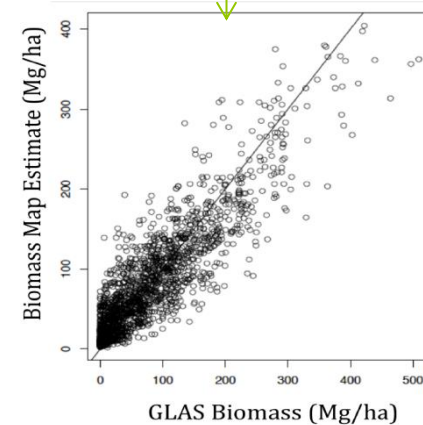
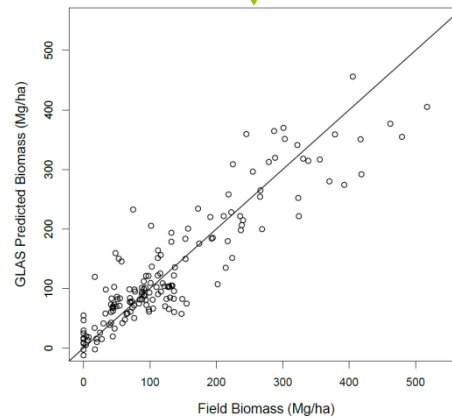
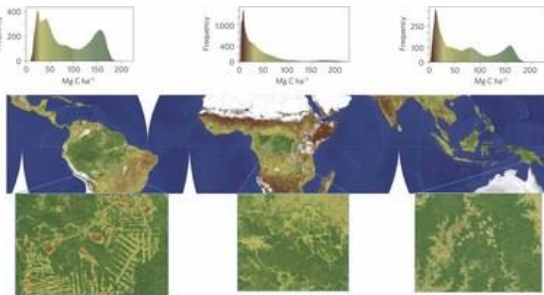
- Less than encouraging results
- Why? Maybe subtle canopy differences detected by satellites do not accurately reflect sub-canopy differences?
- Can try other band ratios and ancillary satellite-derived data and more complex predictive multiple-regression models
- But is it worth the effort?
- How well do published 'robust' satellite-derived biomass maps fare off?

Baccini et al. 2012

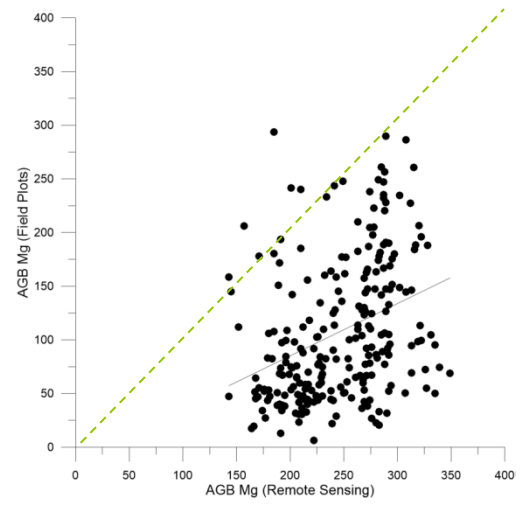
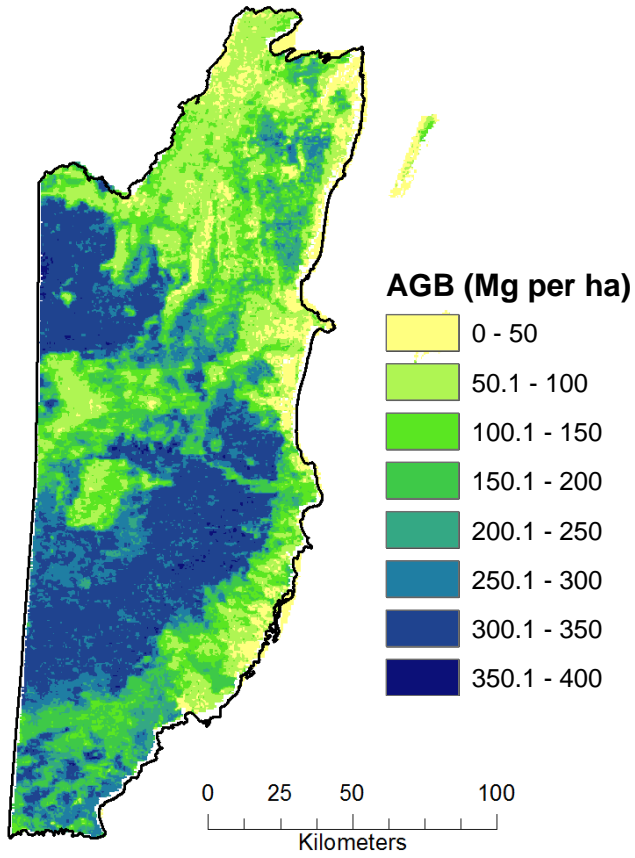
Method:



Benchmark Biomass
Map of the World

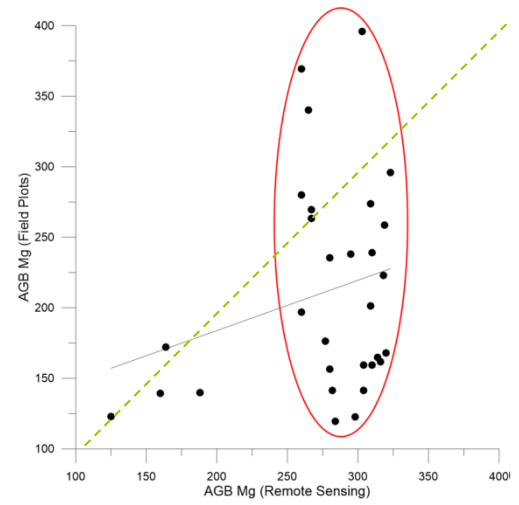


Baccini et al. 2012



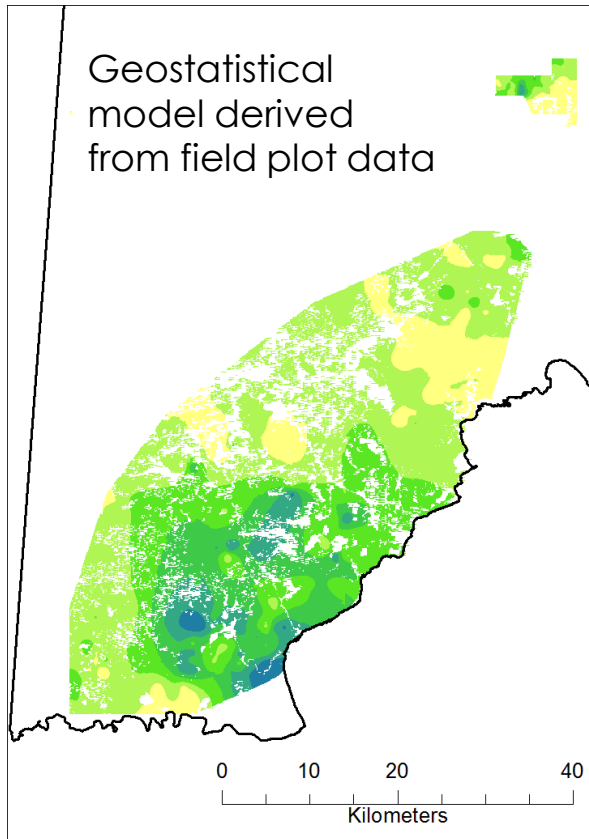
vs. 248
Inventory
Plots

vs. 30
PSPs



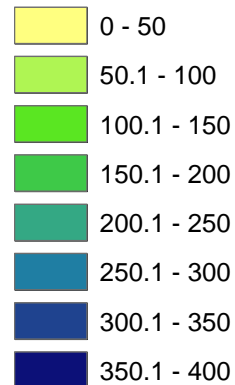
Field Plots vs Remote Sensing

Forest Inventory
Mean $104 \pm 0.1 \text{ Mg ha}^{-1}$
Total: 13.3 million Mg

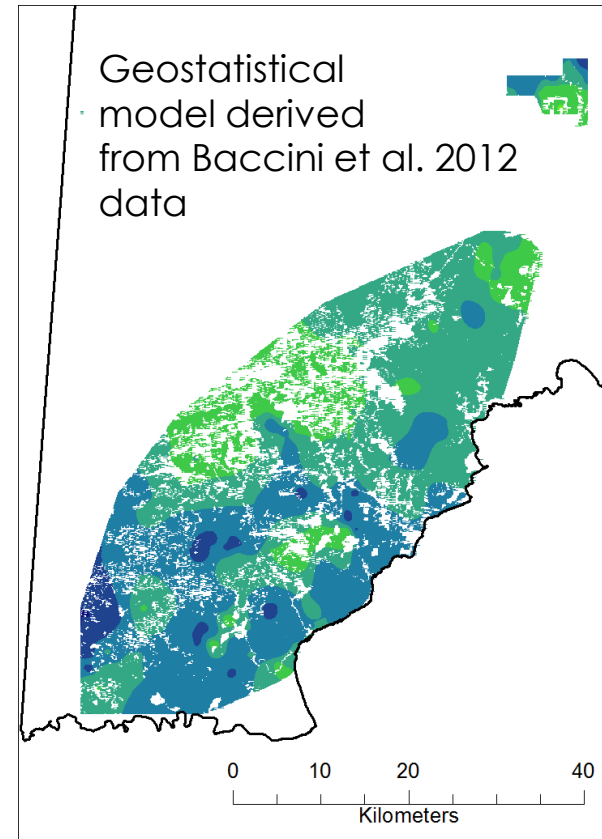


Study Area
129,514 ha

AGB (Mg per ha)

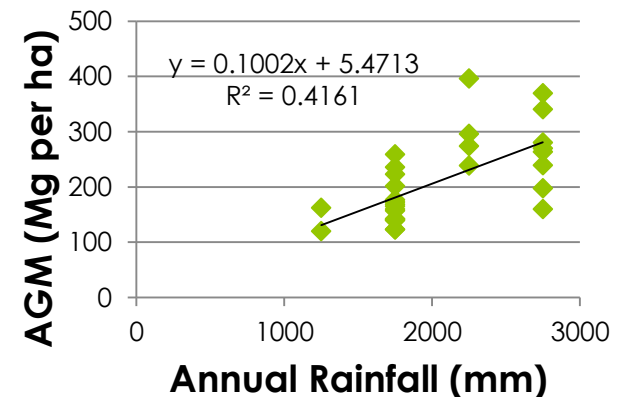


Remote Sensing
Mean $239 \pm 0.1 \text{ Mg ha}^{-1}$
Total: 30.9 million Mg



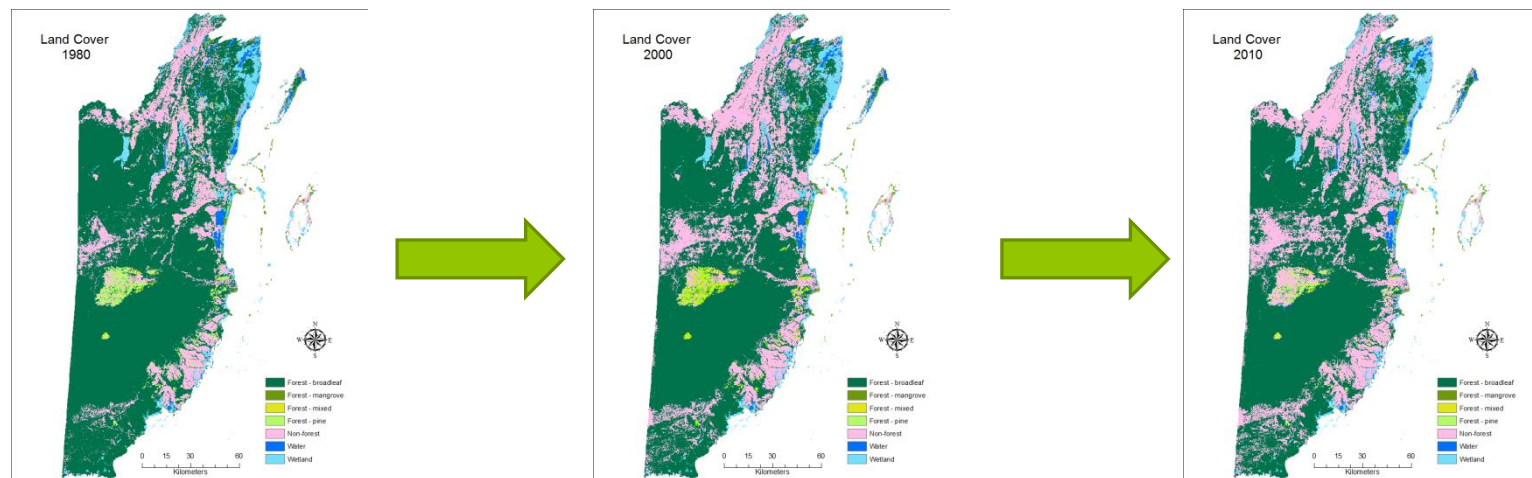
Back to the drawing board

- How to make a biomass map?
- Method 2 – classify land cover types, estimate mean AGB from surveys for each cover type, multiply by area of cover type
- Method 3 – regression against environmental variables eg. temperature and rainfall
- Or both



How to measure change?

- Land cover change informs biomass change using book keeping model



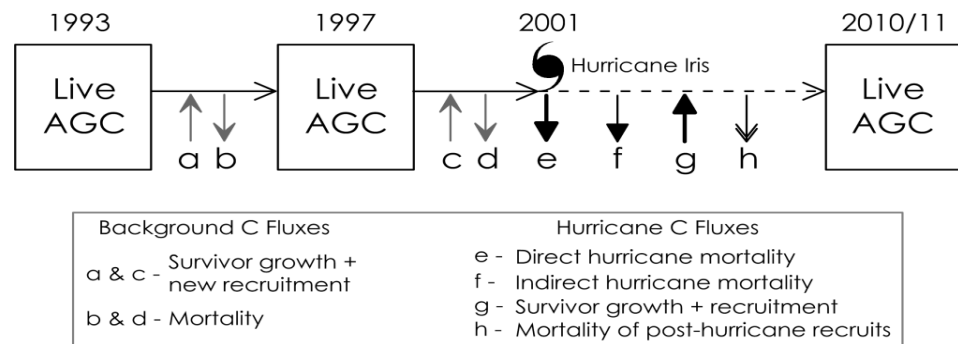
- But what about within-class changes? (i.e. degradation)

How to measure change?

- PSPs provide repeat measurements of forest biomass and can detect the degrading effects of logging, hurricanes, fire, etc.
- Determine mean annual per ha change in biomass caused by a given degradation agent and apply mean change values to all areas undergoing that type of disturbance or enhancement

How to measure change?

- eg. Seven PSPs were affected by a category 4 hurricane in 2001
- Were increasing in AGB by 2.6 Mg per ha per year on average before the hurricane
- Fell from 254 to 150 Mg per ha (by 40%) almost uniform reduction across plots
- Now recovering at a rate of 6.4 Mg per ha per year



Estimating emissions

- Apply mean change values to entire area affected by the disturbance in a book keeping model
- So how do we know the extent of areas undergoing a given type of land use change or degradation?
- Refer to previous two days...



Thank you.

Working Definitions

- In the context of REDD+

Forest – landscape definition

- *Any natural or planted tree assemblage, used for the production of wood and/or conservation of biodiversity, having minimum canopy height of 5 metres at maturity, minimum crown cover of 10% and minimum unit area of 1 hectare, including areas of regenerating natural or young planted tree assemblages therein or outside capable of reaching these thresholds in situ, and including roads, tracks and other small openings less than one linear hectare therein; but excluding agroforestry areas, urban parks and tree assemblages not planted primarily for wood production or biodiversity conservation.*

Deforestation

- *A change in cover and use from forest (as defined in its entirety above) to some other cover and use.*

Forest Degradation

- *A measurable instantaneous or gradual reduction in one or more components of above and/or below-ground forest biomass, but not below forest thresholds, and taking into account any re-growth;*