Measuring and monitoring aboveground woody biomass from the stand to the landscape

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Background to our work in Tanzania

Collaboration with the **Mpingo Conservation and Development Initiative (MCDI)** – Tanzanian NGO

Mpingo Conservation & Development Initiative

REDD+ pilot project 2010 – 2013; focus on fire management

Sustainable Mpingo (Dalbergia melanoxylon) harvest, Kikole Village, Kilwa district

Controlled fire experiment, Nhambita Village, Sofala Province, Mozambique. Photo credit: Casey Ryan

Talk outline

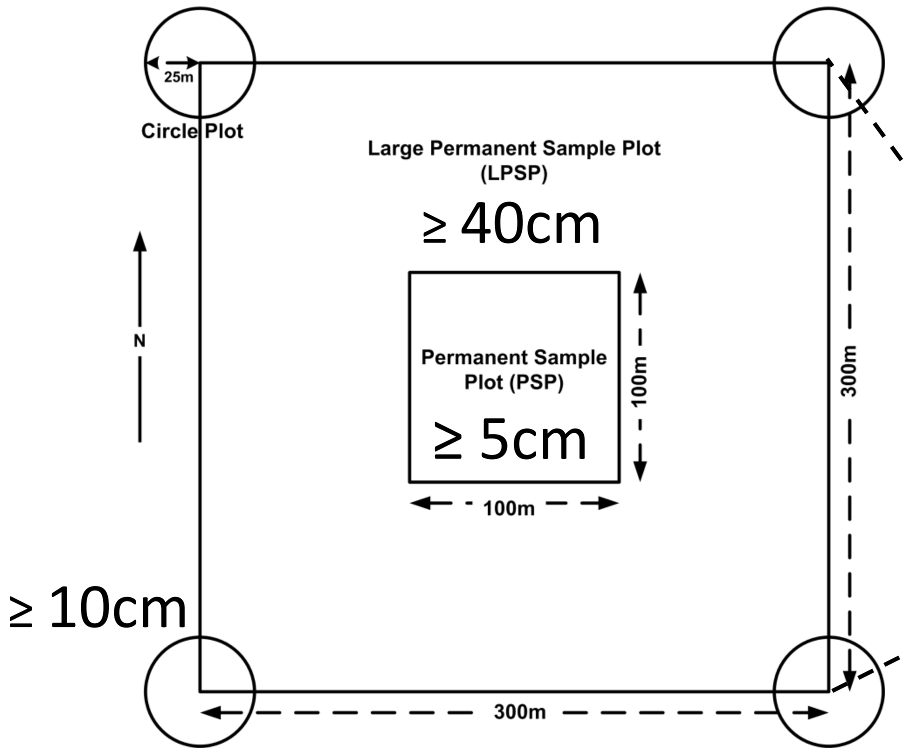
1. Ground based measurement of biomass: *How is biomass distributed at small (hectare) scales?*

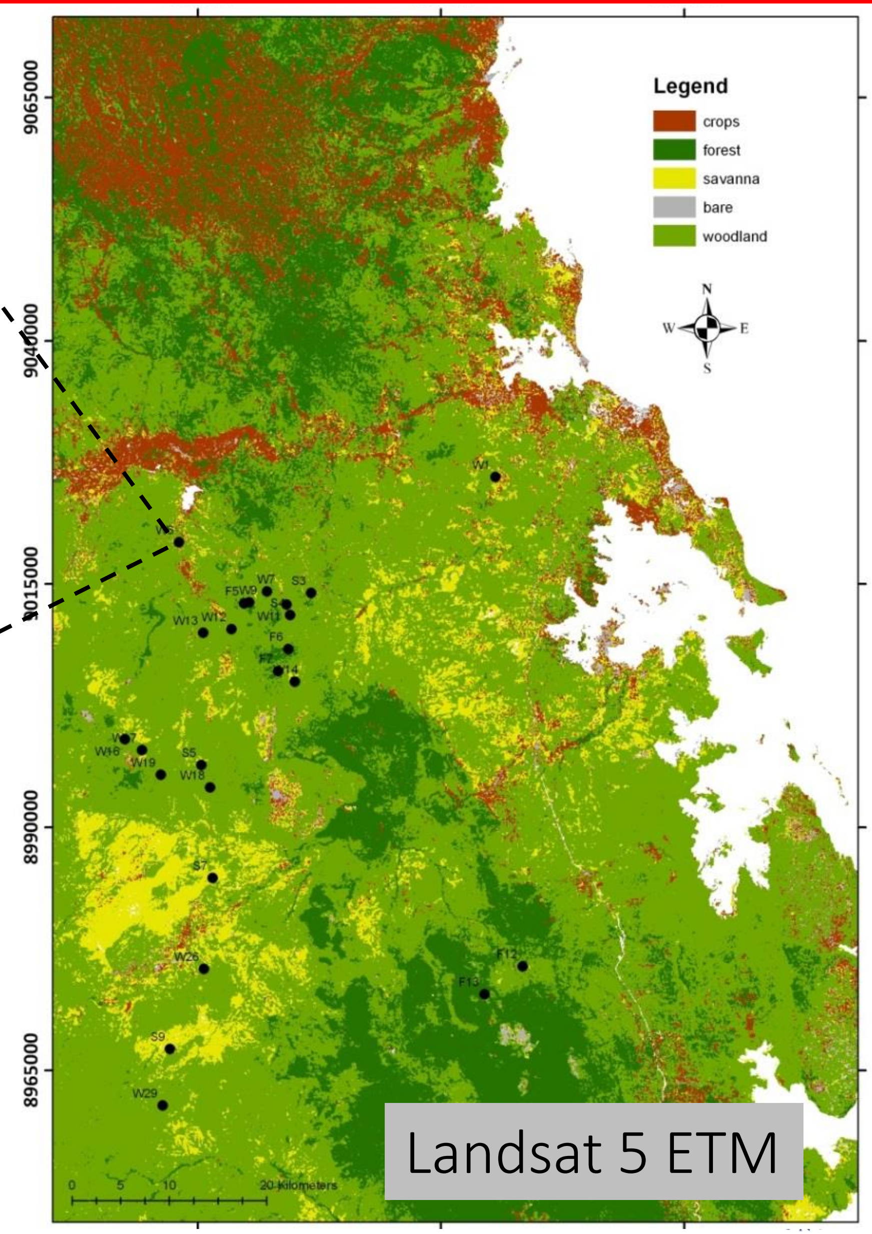
2. Remote mapping of forest biomass: *What is the spatial distribution and dynamics of biomass at regional scales?*

3. Key take home messages

Field based measurement of woody biomass

Permanent Sample Plots (PSPs)





Stratified according to broad vegetation type **(Savanna, Woodland, Forest)**

Nested plot design implemented at 25 sample locations (Savanna = 7, Woodland = 12, Forest = 6)

Aboveground woody carbon stocks (1 ha plots)

Questions:

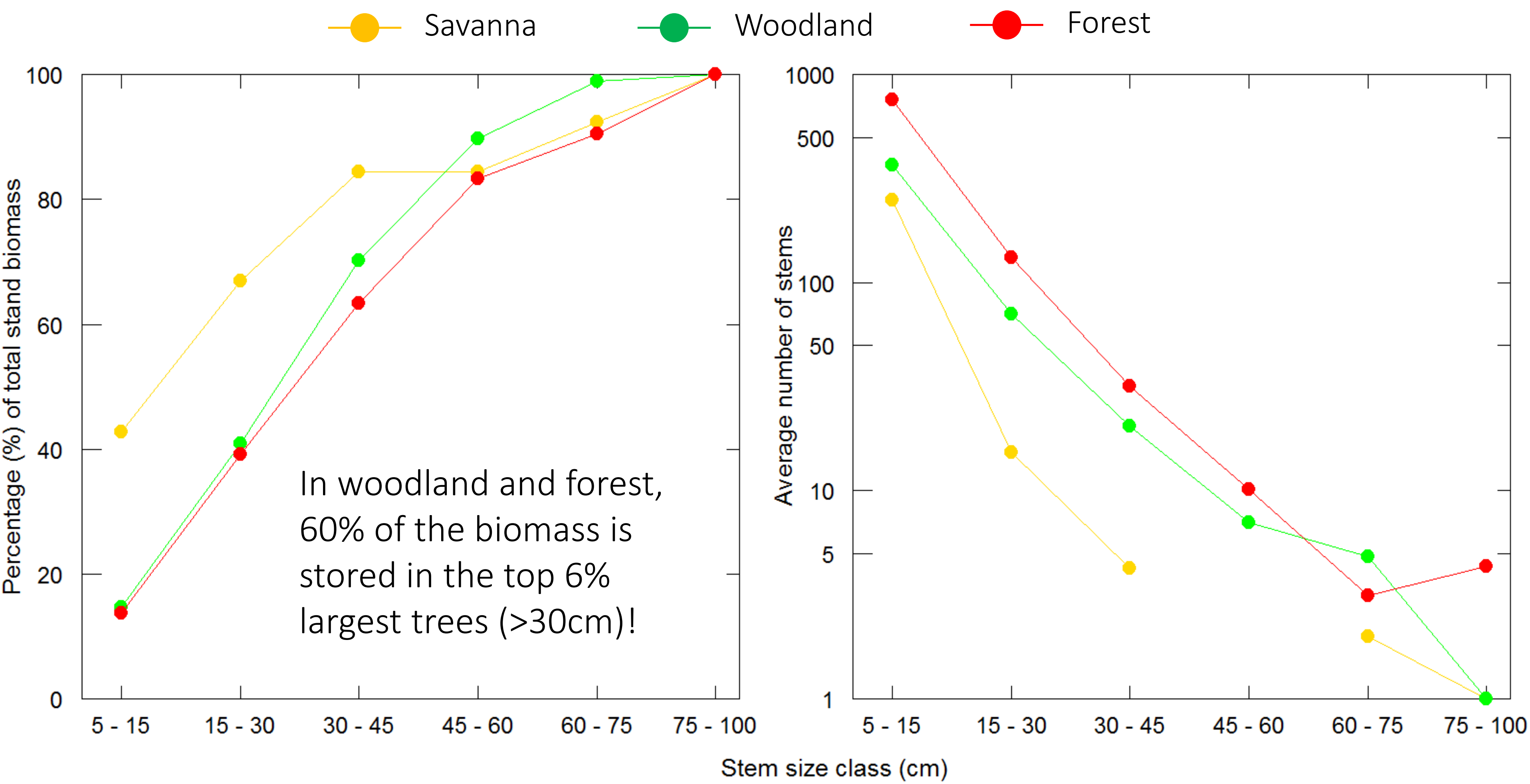
1. How are between plot differences in biomass linked to differences in forest structure and stem sizes?

2. How is biomass linked to tree diversity?

3. How variable is biomass over larger scales?

4. How can all of this information be used to design efficient ground based sampling strategies for biomass?

How does forest structure vary with AGB?



Average 1ha plot completion time (team of 6)

Savanna = 1 – 2 days
Woodland = 2 – 4 days
Forest = 5 – 10 days

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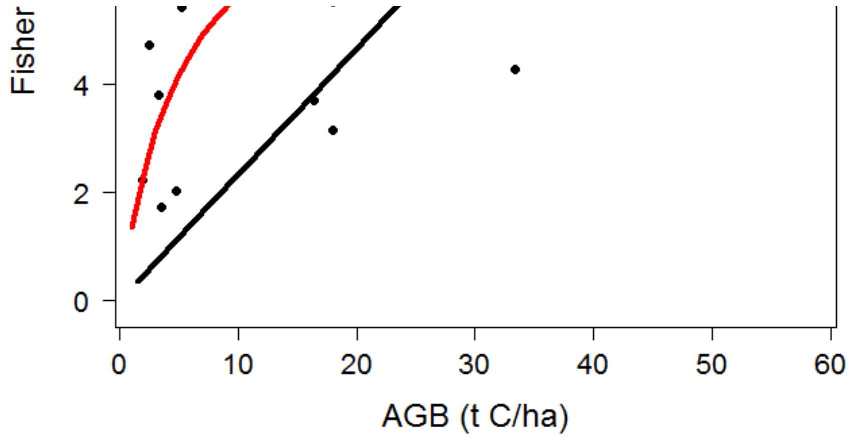
How is biomass related to tree diversity?

Management activities related to REDD+ should have the co-benefit of maintaining key Ecosystem Services inc. Biodiversity.

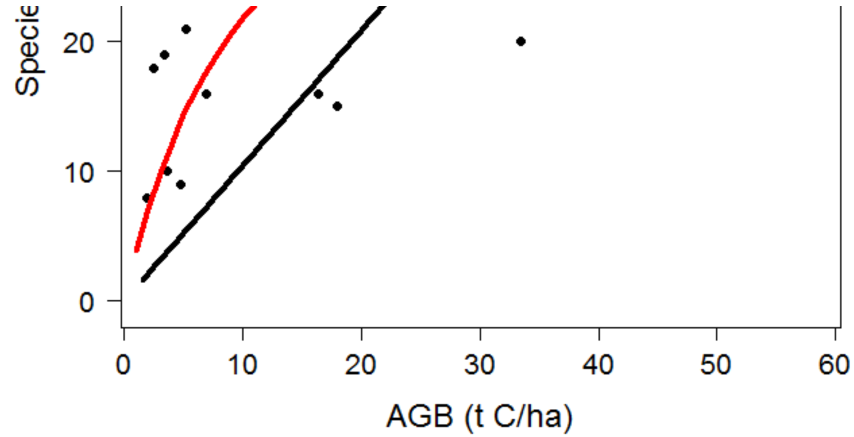
We need to remove our carbon-tinted glasses and focus on the ECOSYSTEMS as a whole….optimising land management for one aspect of the landscape is not a good idea!



Fisher's diversity index

Linear: *AIC* = 128.46

Saturation: *AIC* = **104.20**



Species richness

Linear: *AIC* = **179.68**

Saturation: *AIC* = **176.36**

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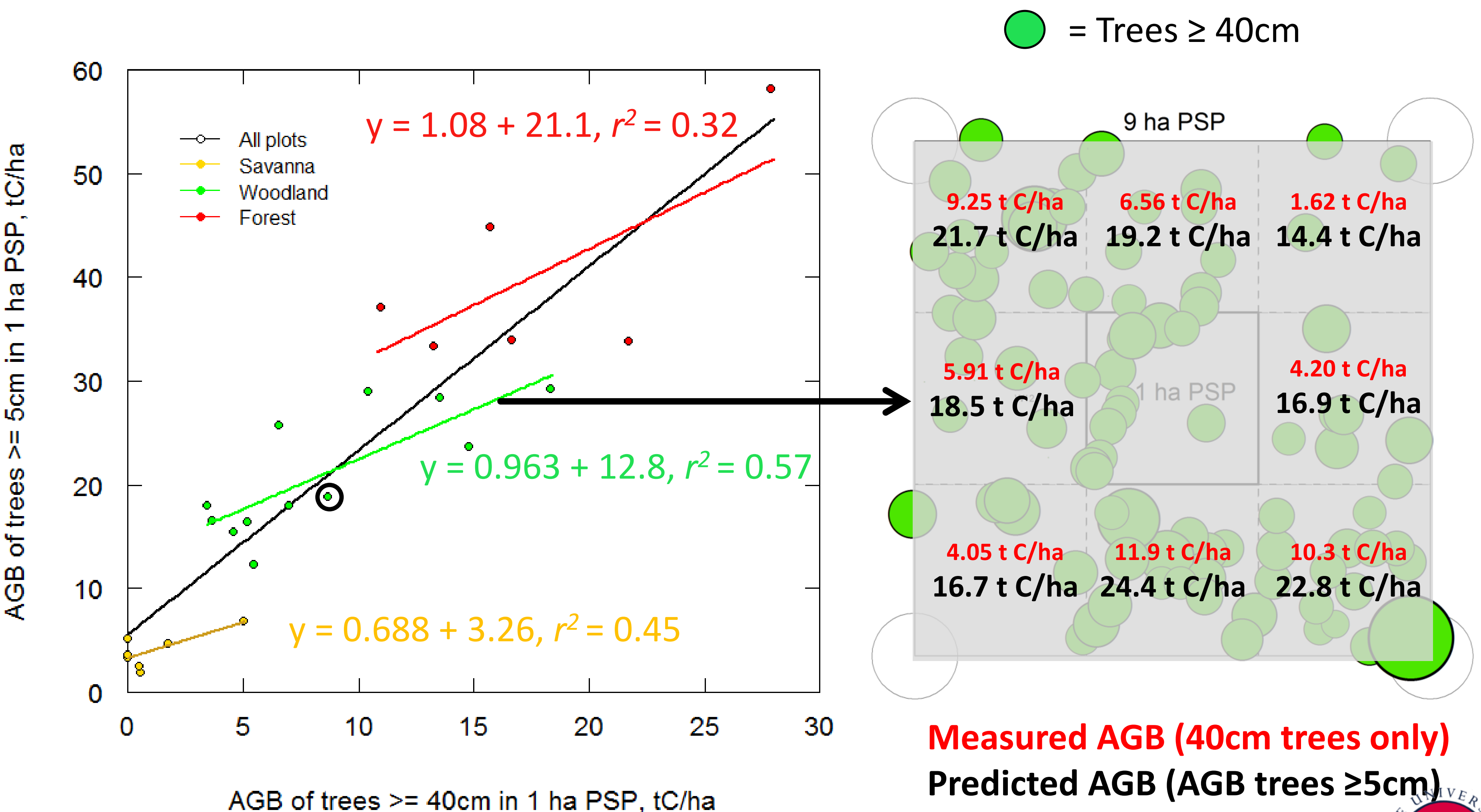
How spatially variable is biomass?



Measured AGB (40cm trees only)

Predicted AGB (AGB trees ≥5cm)

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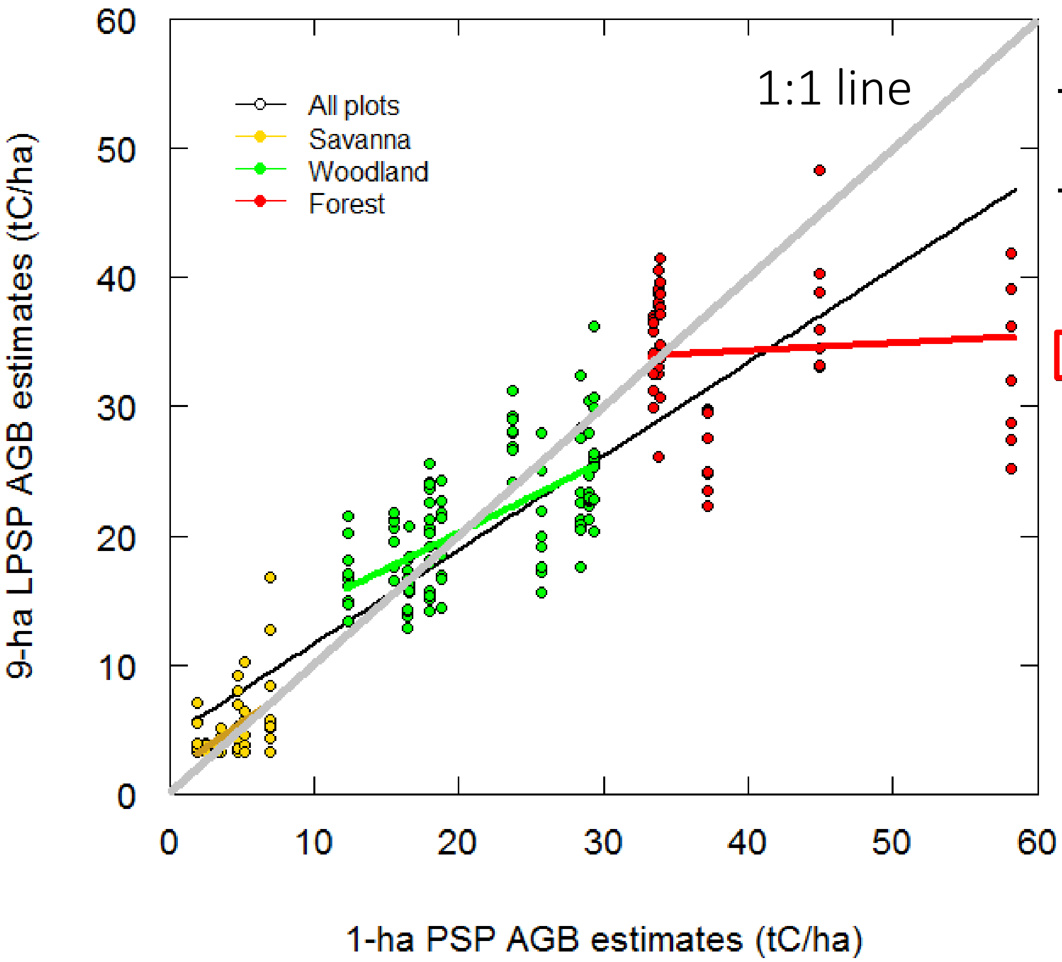
How representative are the 1ha plots?



	Slope	Intercept	adj R^2	p-value	Bias (tC ha^{-1})	RMSE (tC ha^{-1})
All plots	0.72	4.46	0.79	<0.001	1.29	6.74
Savanna	0.78	1.67	0.25	<0.001	-0.79	2.27
Woodland	0.56	9.14	0.4	<0.001	0.18	4.61
Forest	0.06	31.97	-0.01	0.53	5.92	11.87

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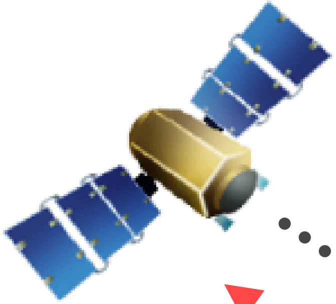
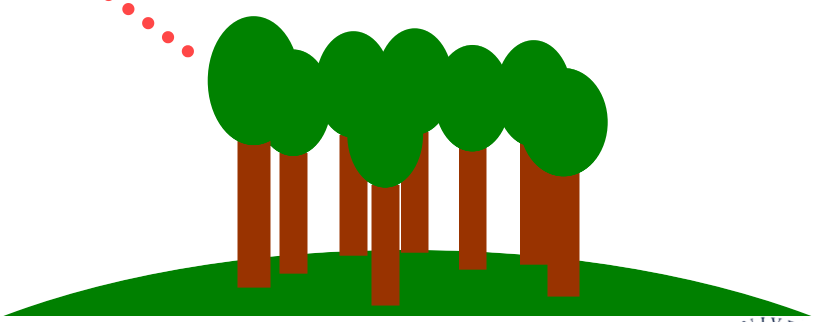
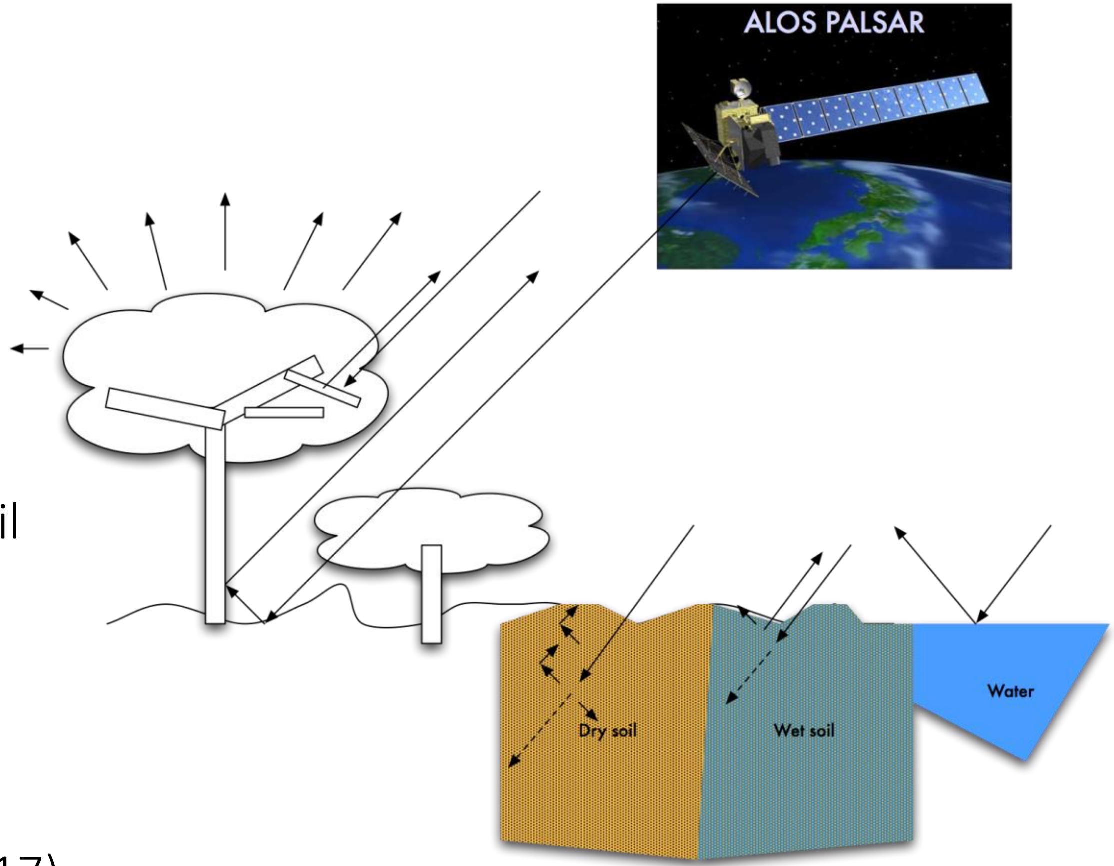


2 . Regional mapping and monitoring of aboveground woody biomass with implications for REDD+



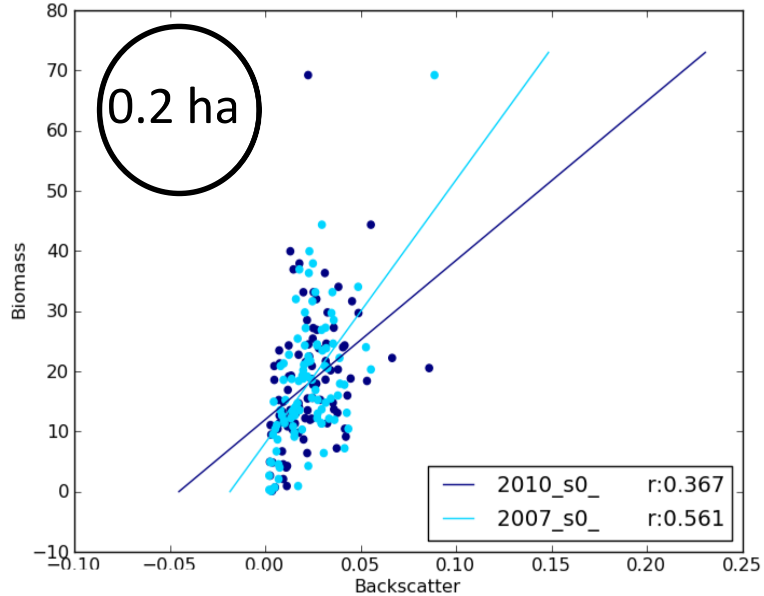
Radar remote sensing

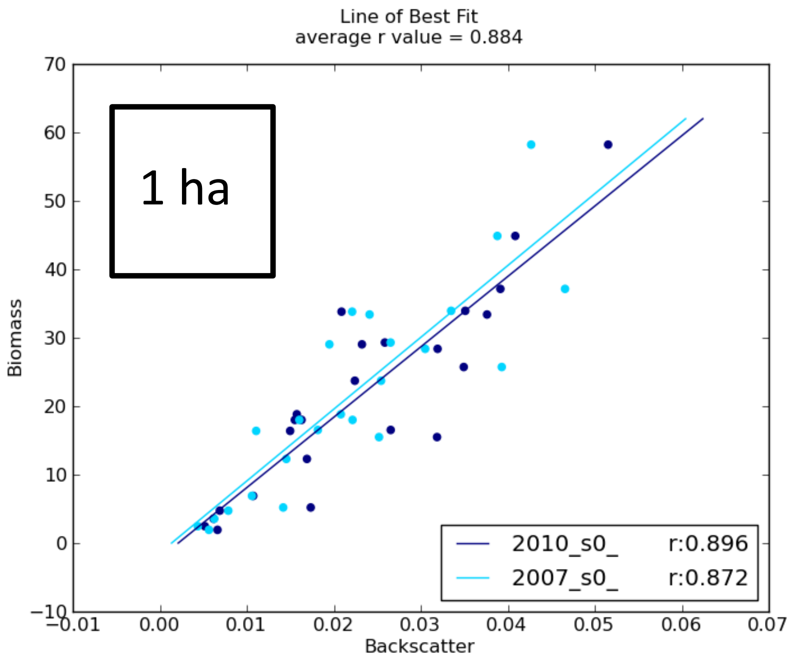
- ALOS PALSAR, L-band radar (23 cm wavelength)
- minimum 12.5m resolution
- no cloud or grass problems
- sensitive to woody structure
- instead, errors due to terrain, soil moisture and speckle
- operational from 2007 – 2010, ALOS-2 launching late 2013, ESA BIOMASS mission (90cm wavelength), planned launch 2017)

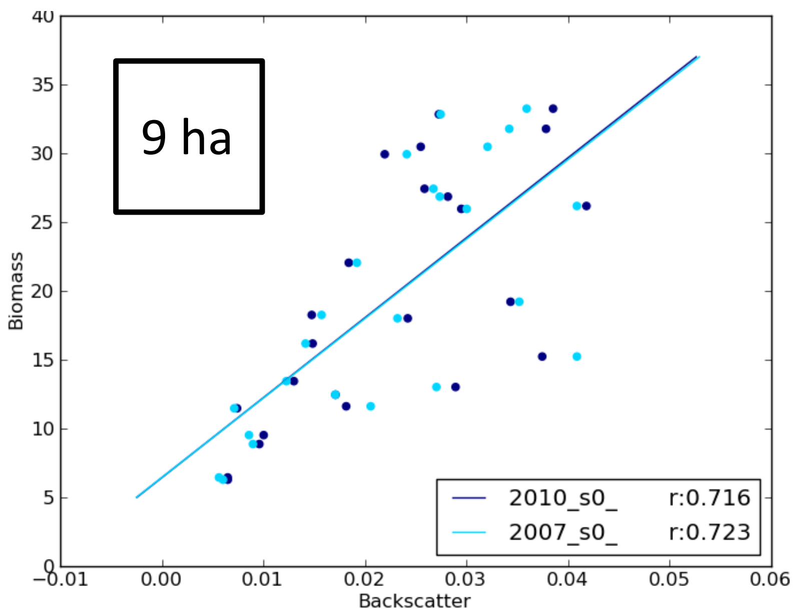


Slide courtesy of Casey Ryan

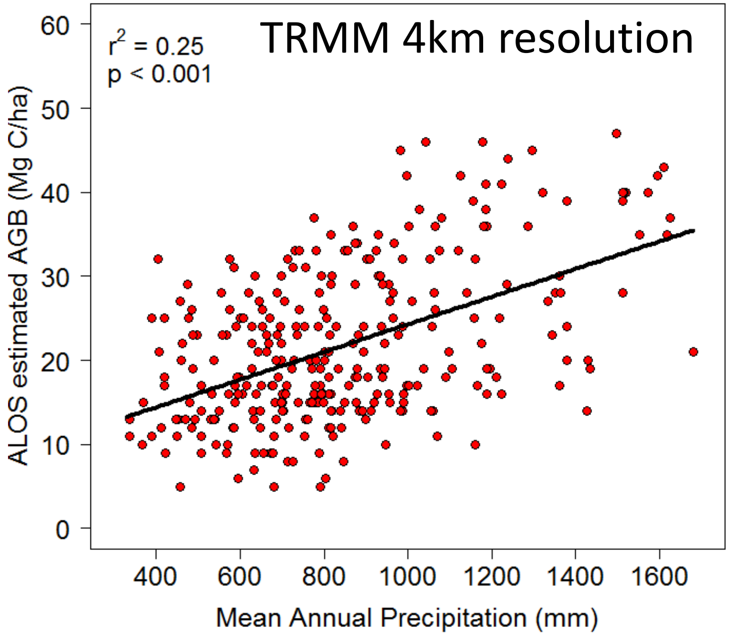
Field plots help to calibrate backscatter

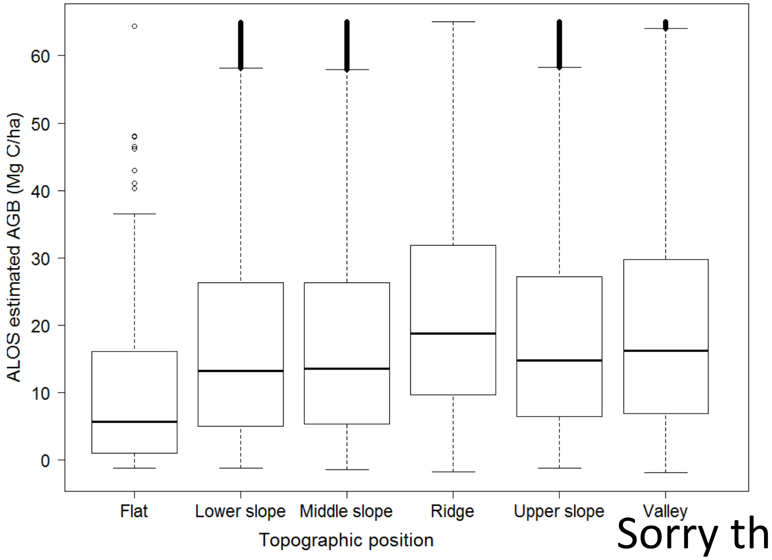




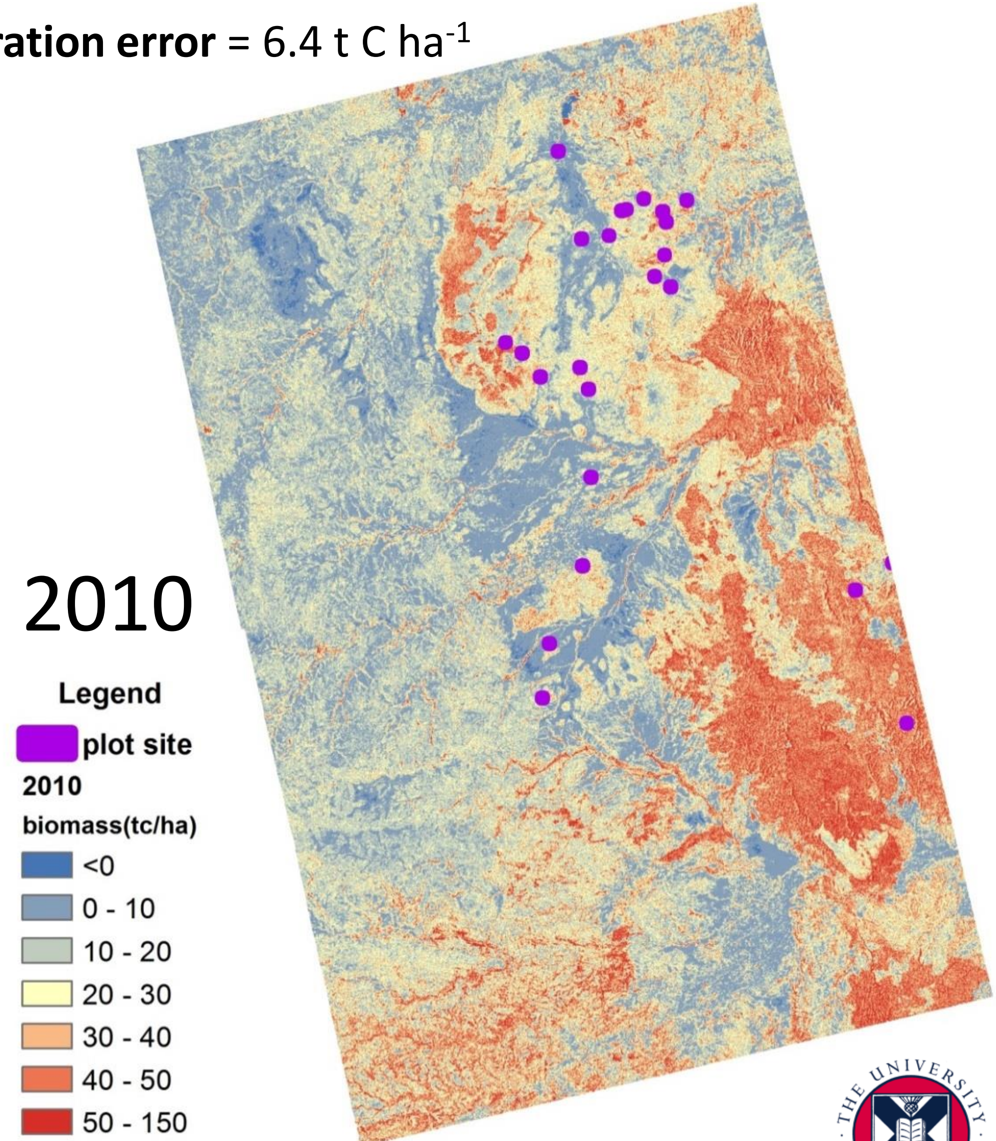


Aboveground biomass maps





Calibration error = 6.4 t C ha^{-1}



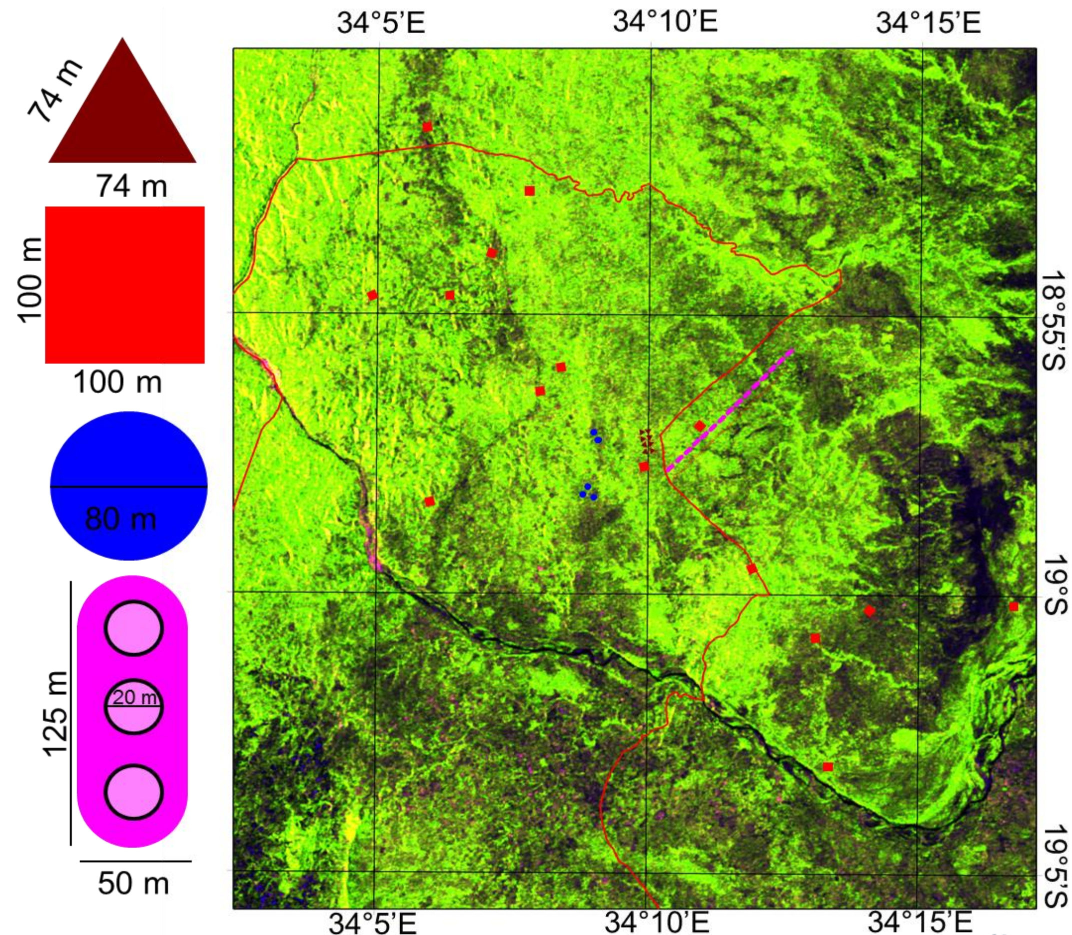
Sorry there is no scale bar…!

McNicol et al. *in prep*

Change detection using radar

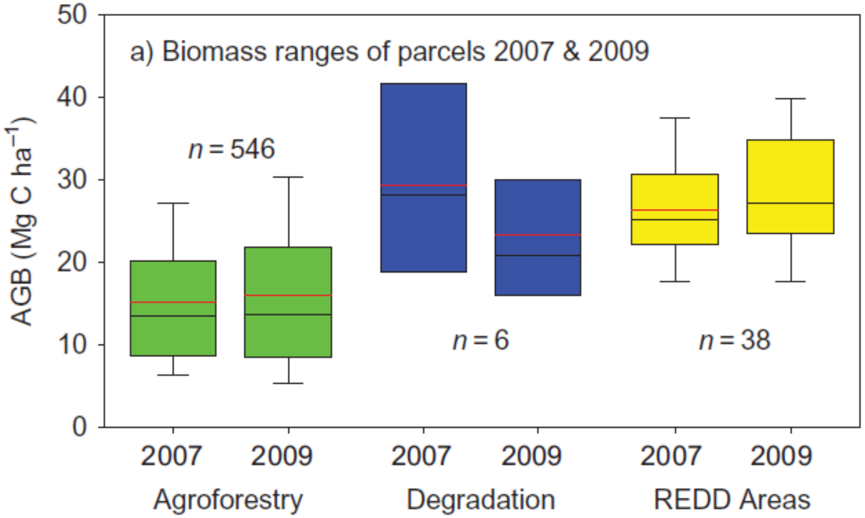
- Assumes that the 58 field calibration plots unchanged
- Calibration error of 3.1 t C ha^{-1}
- Assessed changes in areas of known land-use change between 2007 and 2009 (not shown on map)
  - 500 ha of agroforestry
  - 9500 ha of protected (REDD) areas
  - 25 ha (6 areas) of known degradation in 2008

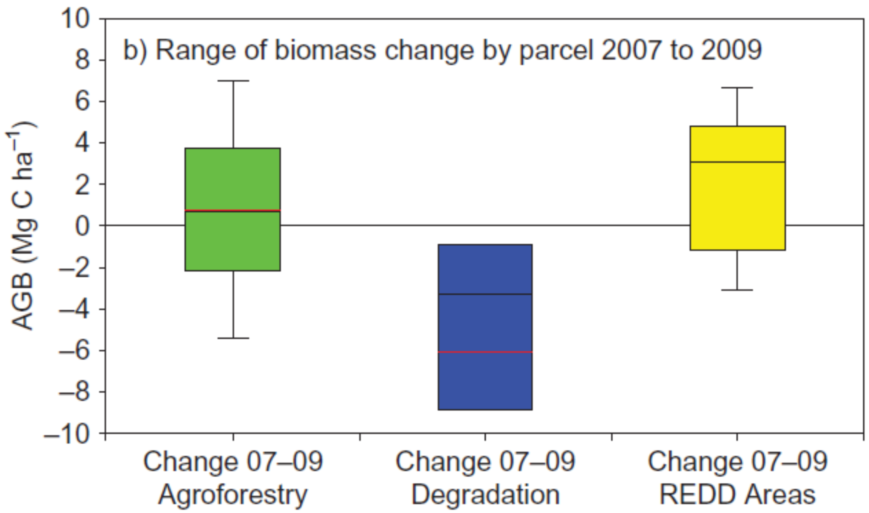
Nhambita Community Carbon Project



Mitchard et al. 2013

Is change visible?





Mitchard et al. (2013) - **A novel application of satellite radar data: measuring carbon sequestration and detecting degradation in a community forestry project in Mozambique**, *Plant Ecology & Diversity*

Other research

Above and belowground (soil) carbon dynamics following slash and burn agriculture across a 40-yr chronosequence
(Iain McNicol, Casey Ryan and Mathew Williams)

Spatial patterns of soil CO^2 efflux across a chronosequence of abandoned slash and burn agriculture
(Iain McNicol and Mathew Williams)

Rates of growth, recruitment and mortality in Permanent Sample Plots. Can we detect changes over broad scales using EO?
(Iain McNicol, Nicholas Berry, Casey Ryan and Mathew Williams)

Impacts of fire disturbance on forest structure and biomass
(Sam Bowers, Casey Ryan and Mathew Williams)

Summary of main points

Case study 1:

- 1 ha plots are sufficiently large to capture local patterns in AGB across savanna and woodland areas.

- A large proportion of biomass (60%) is stored in only 6% of the trees (>30cm). Higher DBH thresholds (10-15cm) may be used in higher AGB stands to maximise time, effort and resources

- Projects that focus on the enhancement of forest carbon stocks have the potential to result in an increase in tree species diversity which may increase the value of the credits sold from these areas BUT.....
  How do we quantify biodiversity benefits???

Summary of main points

Case study 2:

- Radar data is a novel method for mapping and monitoring AGB at high resolution, despite errors caused by i.e. topography

- **However it still requires ground data for calibration/validation, WE NEED MORE PERMANENT SAMPLE PLOTS!!**

- Simple automated processing chain has been developed to create AGB maps (in partnership with LTS international and Knowledge Transfer Partnership – Simone Vaccari)

- Detecting small changes (i.e. growth rates and minor degradation) remains uncertain at small scales (i.e. plot level), and we think that it can only be used reliably at the project level to calculate broad changes in the landscape carbon balance. NEEDS MORE RESEARCH!

Cheers!

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Andrew Mariki
Freddy Frederick

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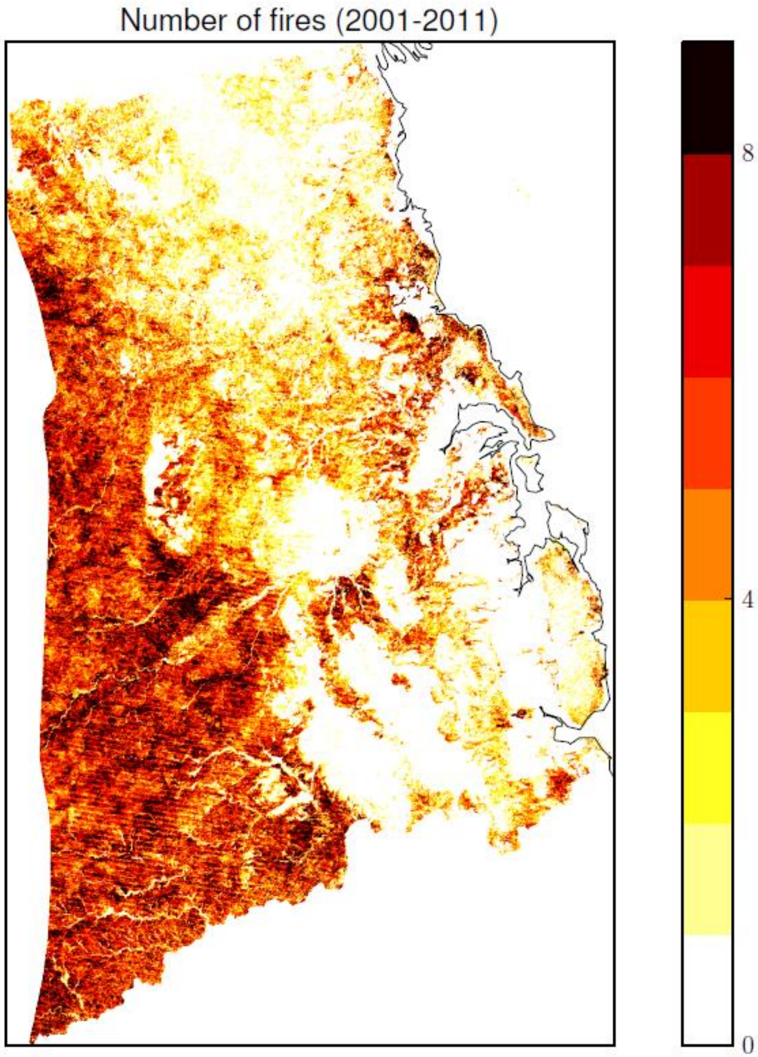
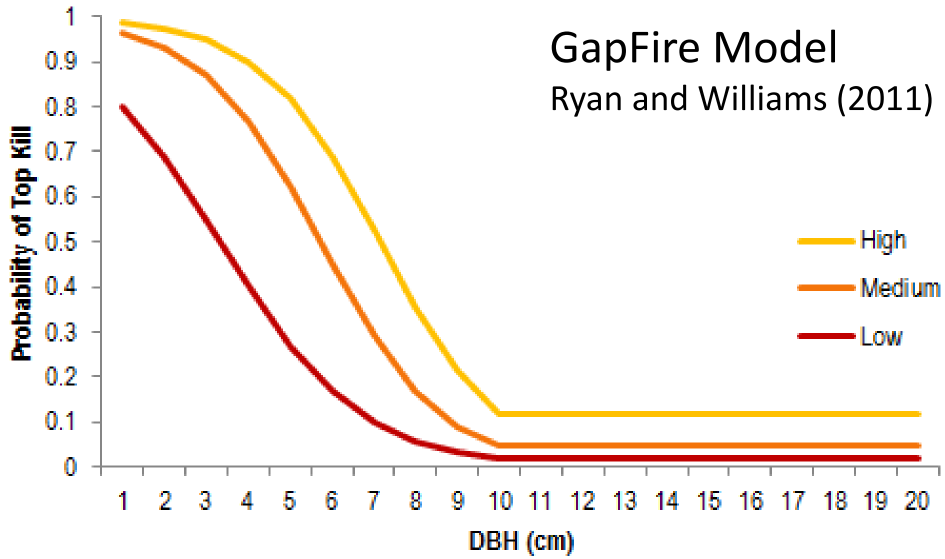
Fire management



Landsat 5 ETM + Landsat 7 (ETM+)



Late season burning (high intensity fires)

↓

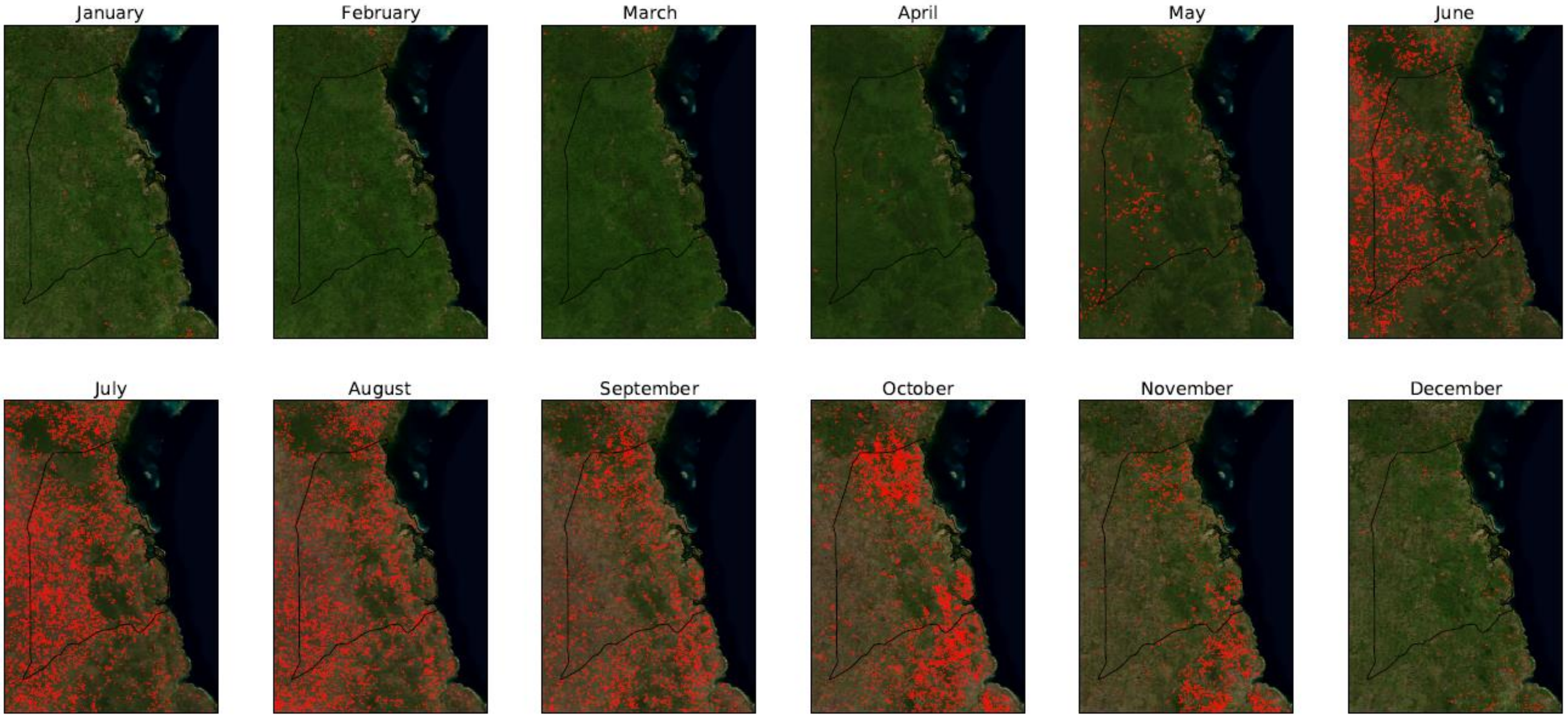
Early season burning (low intensity fires)

↓

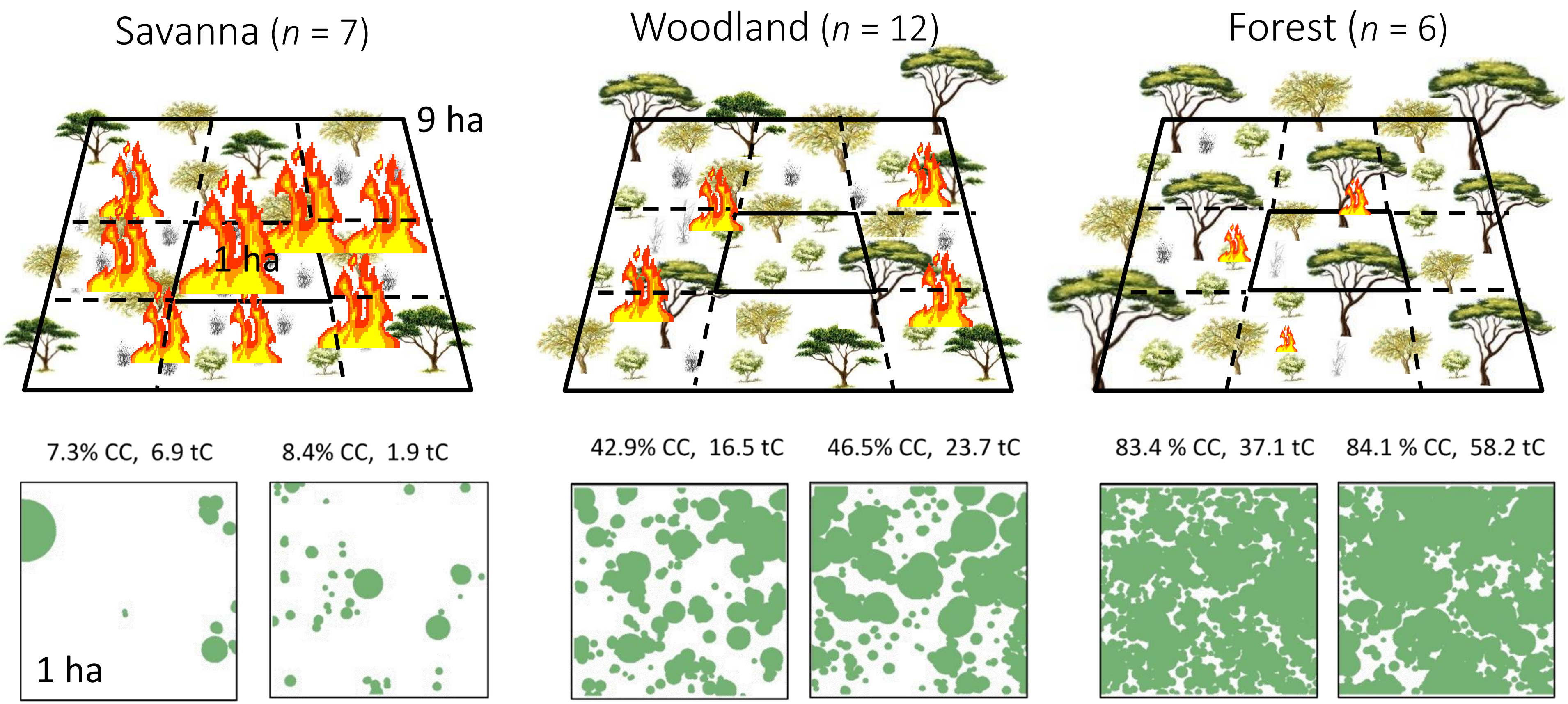
Accumulation of carbon over time

Data from Casey Ryan, Sam Bowers, Nicholas Berry and Jose Gomez Dans (UCL)

Time of burning as a proxy for fire intensity



Biomass dynamics between strata



Low tree cover, grasses dominant → Tending toward closed canopy

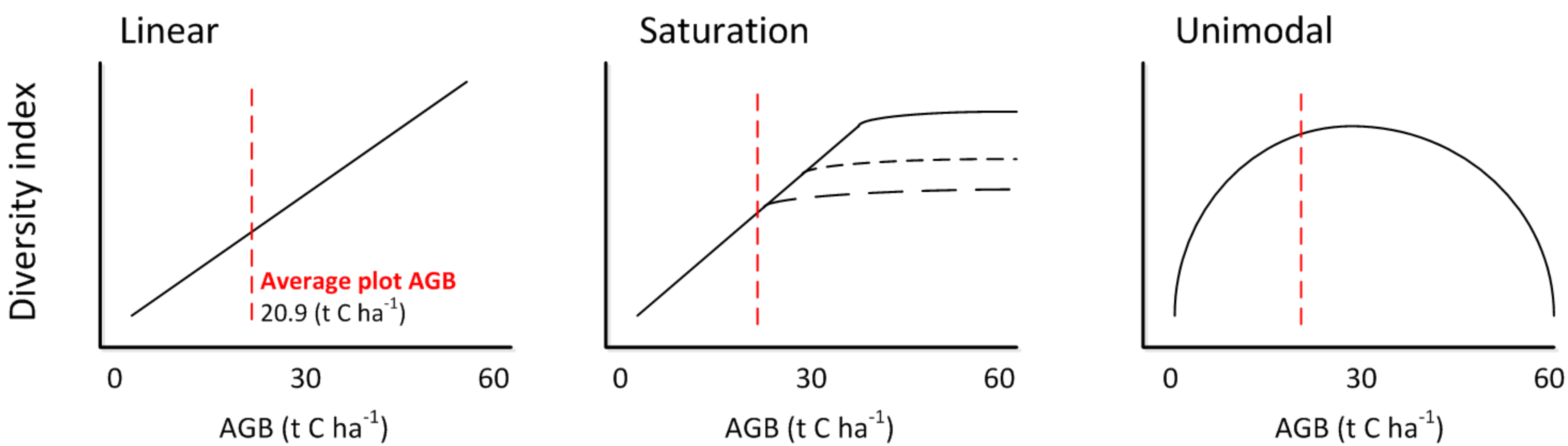
Frequent intense fires → Low grass biomass = less fuel

High rates of tree mortality → Low fire induced mortality

Seeing the forest for more than carbon

Management activities related to REDD+ should have the co-benefit of maintaining key Ecosystem Services inc. Biodiversity. Optimising for one aspect of the landscape is not a good idea!

By shifting from late to early season burning, what might happen to tree diversity…?



Theoretical predictions

More Individuals Hypothesis / Habitat Heterogeneity Hypothesis	Niche Complementarity Hypothesis	Intermediate Disturbance Hypothesis / Habitat Heterogeneity Hypothesis

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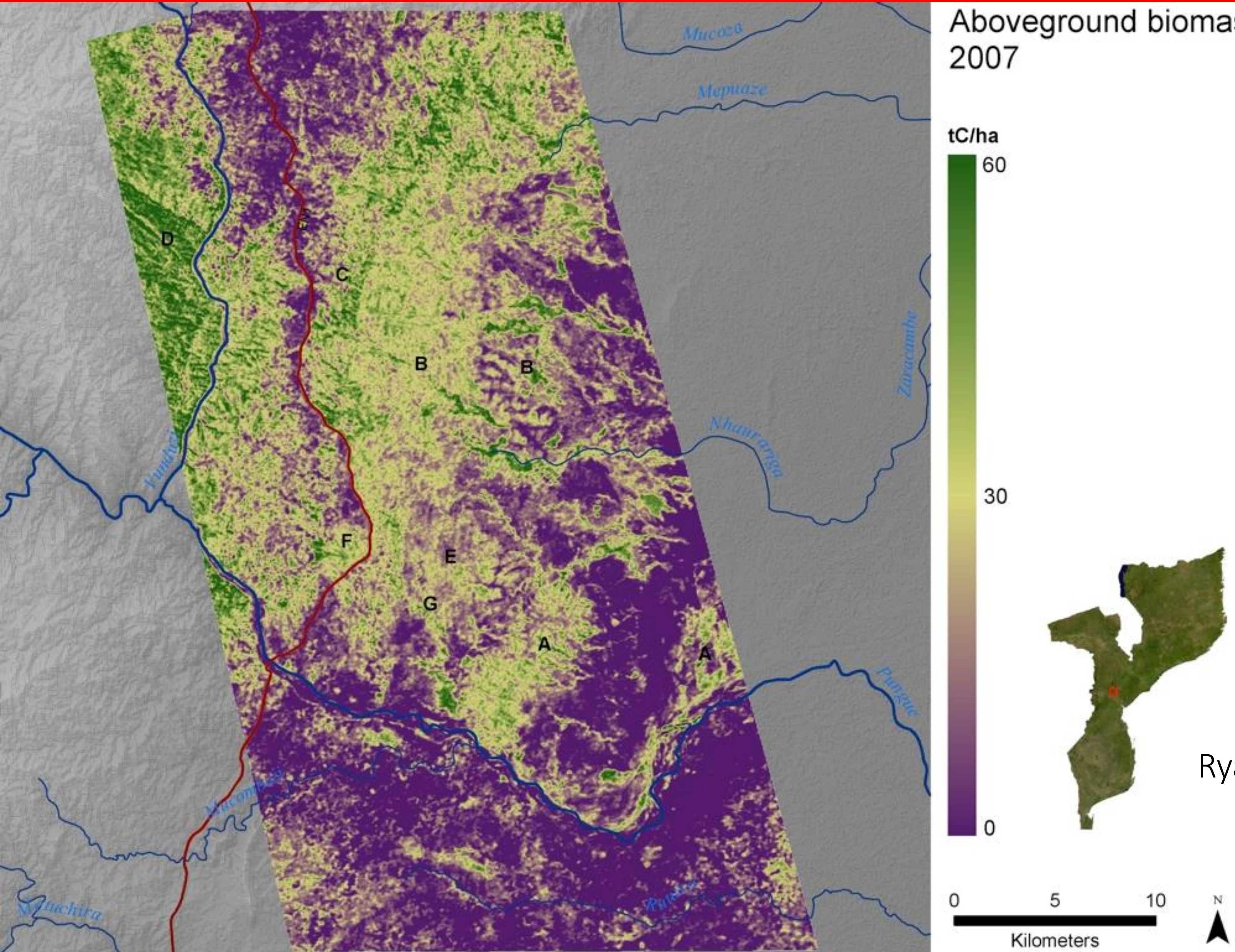
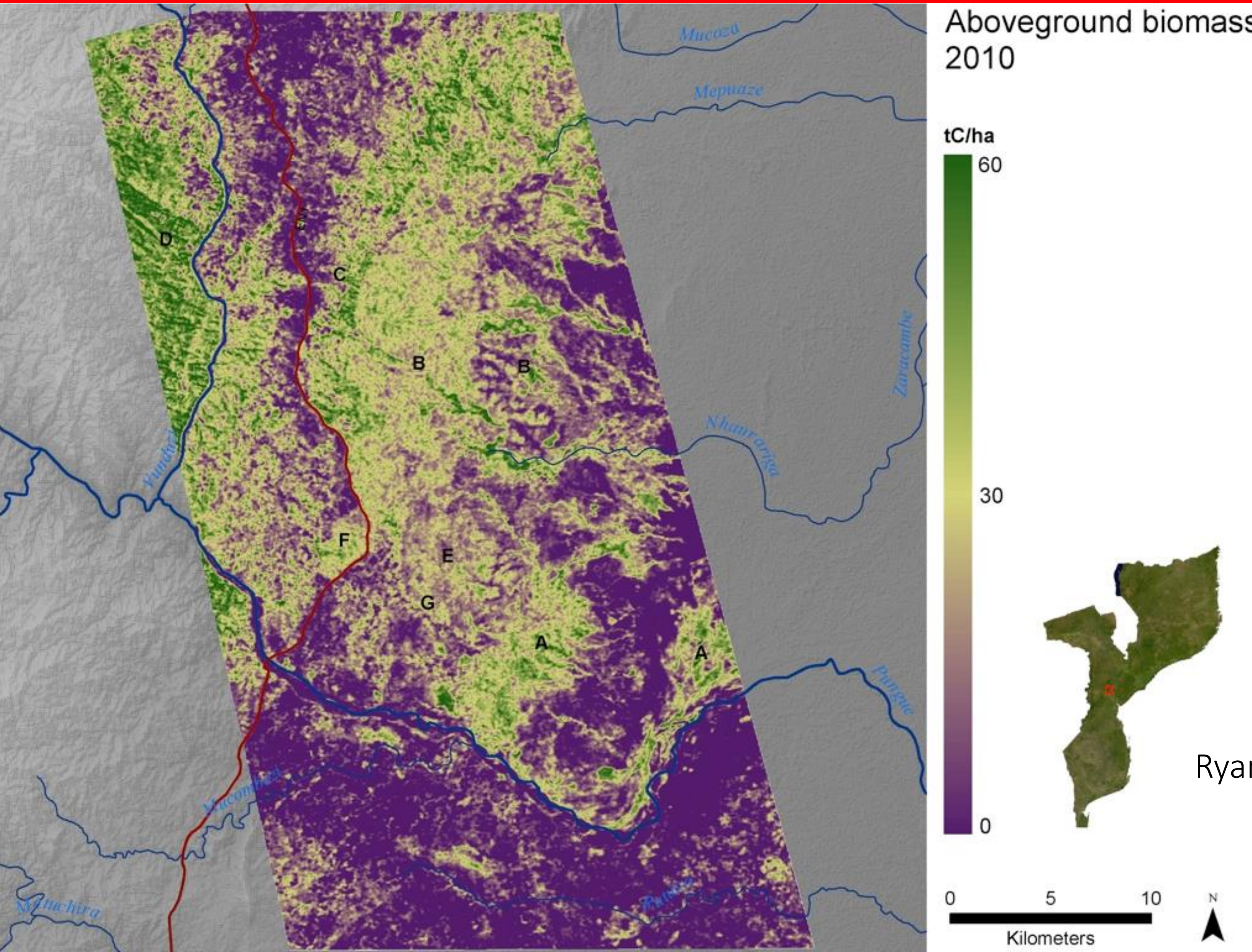
Monitoring land cover change



Ryan et al. (2012)

Monitoring land cover change



Ryan et al. (2012)

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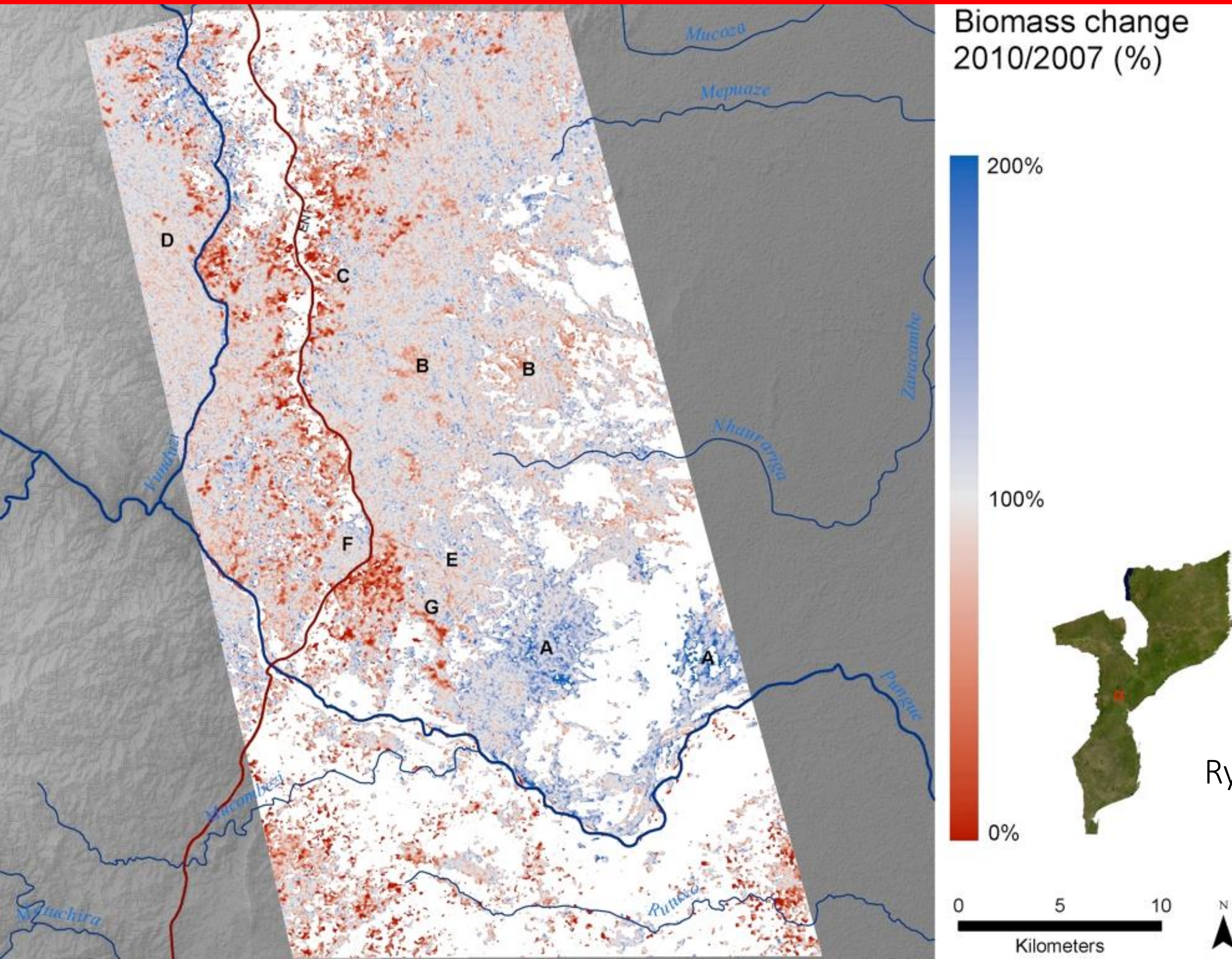
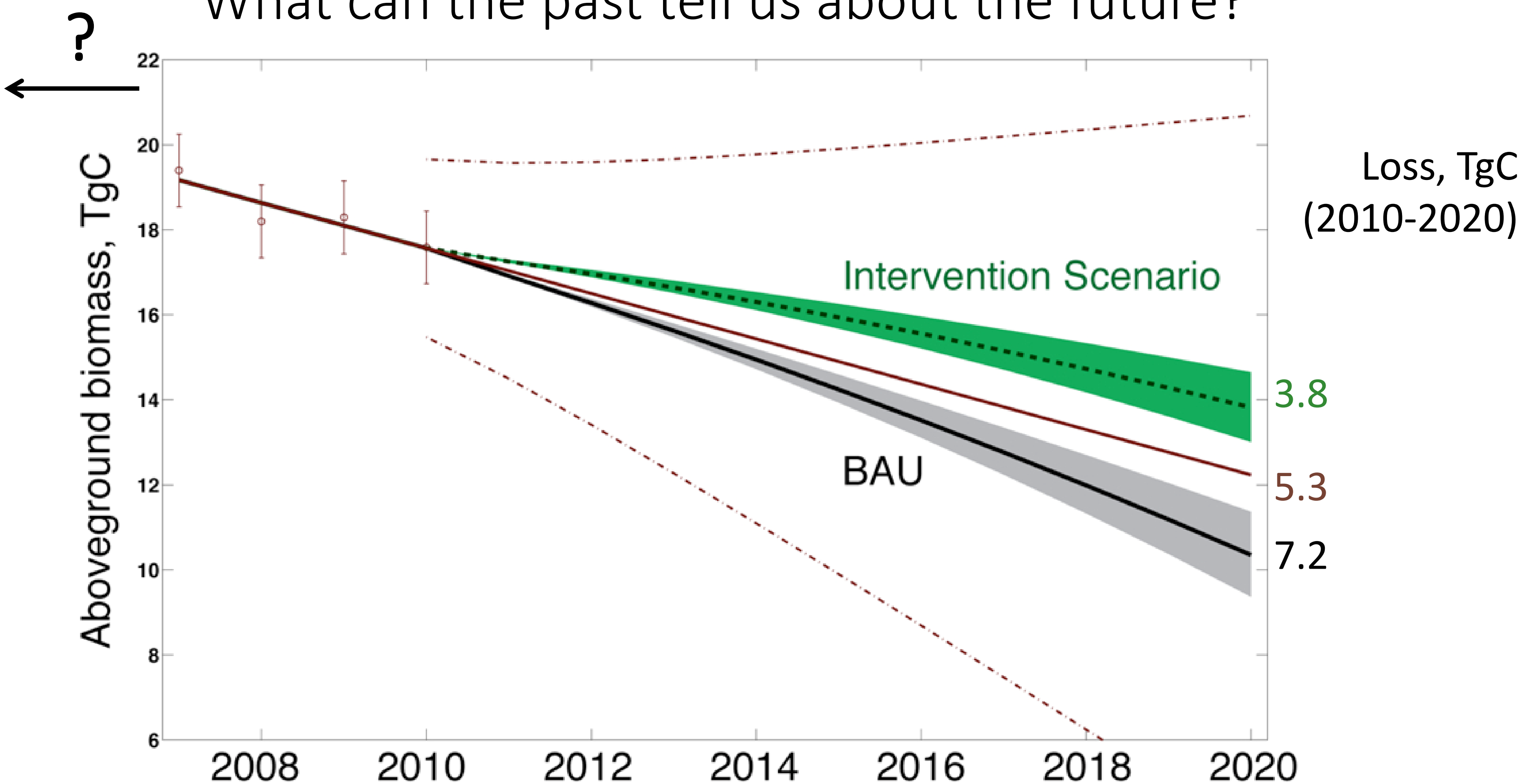


Ryan et al. (2012)

Setting baselines with radar data

What can the past tell us about the future?



data available from 2007 - 2010; creates issues setting baselines for REDD+; more data from 2014+

Ryan et al. *in prep*