Mapping Forest Degradation with Alos Palsar: Case Studies from Ghana & Mexico

Charlotte Wheeler[1], Edward Mitchard[1], Mathew Williams[1], Hugo Nolasco Rayes[2], Yakubu Mohammed[3]

[1] University of Edinburgh
[2] FIPRODEFO, Trust for the administration of the Forest Development Program of the State of Jalisco
[3] RMSC, Resource management Support Centre, The Forestry Commission of Ghana

THE UNIVERSITY of EDINBURGH
School of GeoSciences

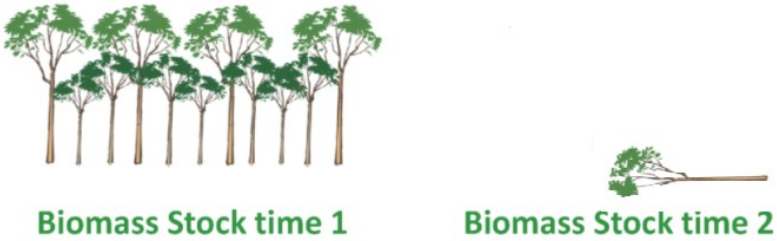
Forests 2020 UK

Overview

- Forest degradation – Why monitor it & why is it so challenging?
- Methodological approach – Combining ground data & radar data
- Case study 1 – Mexico, Jalisco State
  - Degradation issues
  - Case study results
- Case study 2 – Ghana, Brong Ahafo Region/Western Region
  - Degradation issues
  - Case study results
- Summary

What is forest degradation?

Deforestation – Total clearance of forest



Degradation – Reduction in aboveground biomass from an area that remains forest after disturbance

- Gradual process
- Canopy cover remains
- Changes can be subtle
- E.g. Removal of large trees for timber (selective logging)
  OR
  Sub-canopy – removal of understory trees and replaced with crops (shade grown coffee/cocoa)

Why monitor forest degradation?

- Covers huge area
  - Potentially 2-10 x greater area than tropical deforestation annually (de Andrade et al. 2017 *Car Bal manage*.)

- So emissions from degradation could be substantial
  - ~70% of tropical forest emissions from degradation (Baccini, 2017, *Science*)
  - Degradation emissions twice that of deforestation (Mitchard, 2018, *Nature*)

- Furthermore, degradation often precedes deforestation

- **BUT** estimated poorly constrained

- Need to quantify - extent +
  - rate +
  - magnitude of emissions

- Not a purely academic effort –
  - Countries must report degradation emissions to UNFCCC

Challenges & Opportunities

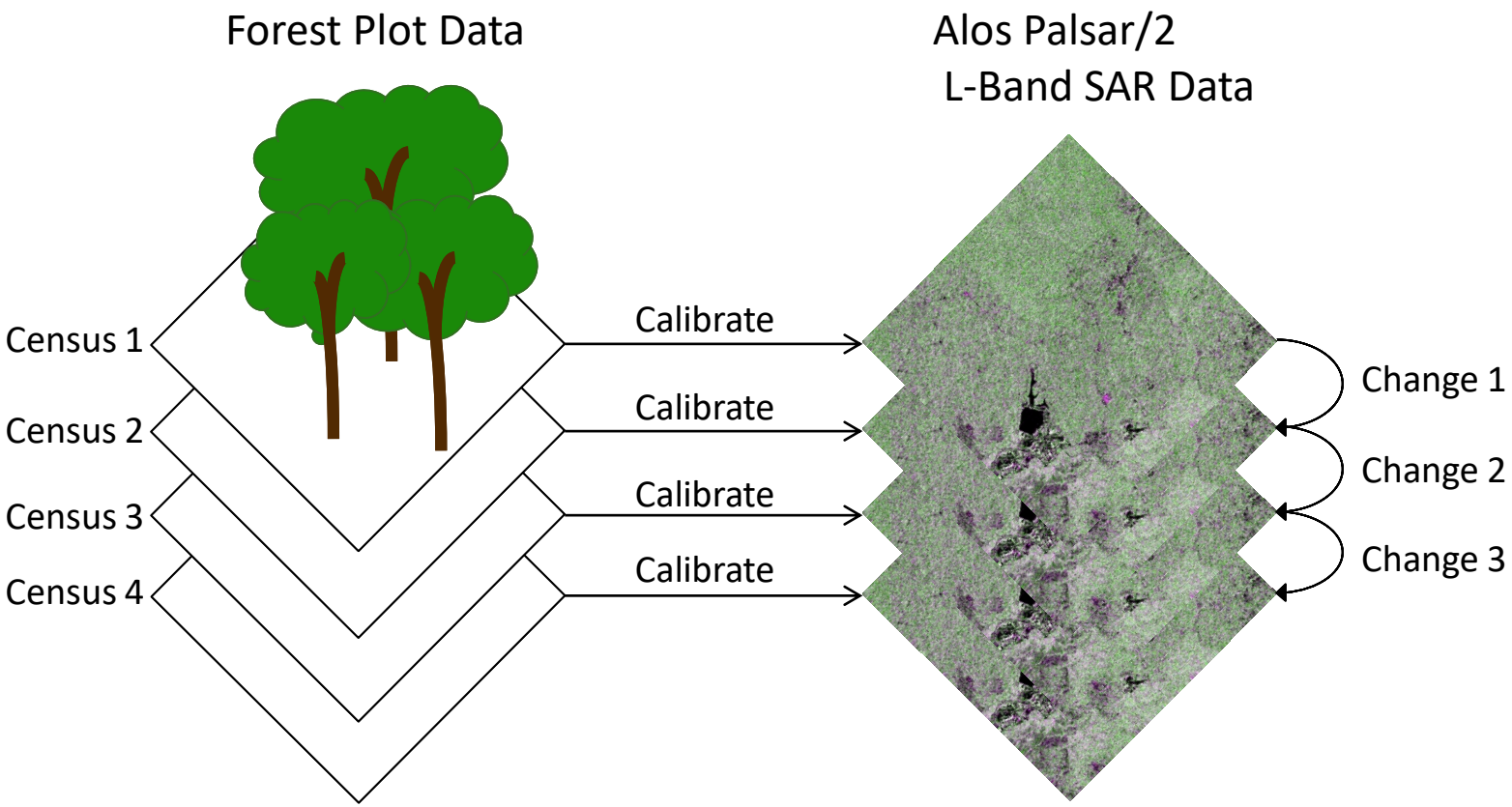
Challenges

- Degradation can occur below the forest canopy
- Often occurs in regions with persistent cloud cover
  - So traditional optical satellites (e.g. Landsat) not suitable as can't pass through cloud or forest canopy.
- Differentiating between intact forest canopy and degraded forest canopy challenging
- Degradation events are typically small (<1ha)
  - Optical satellites can detect changes in canopy cover, but big changes in canopy cover are related to heavy degradation

Opportunities

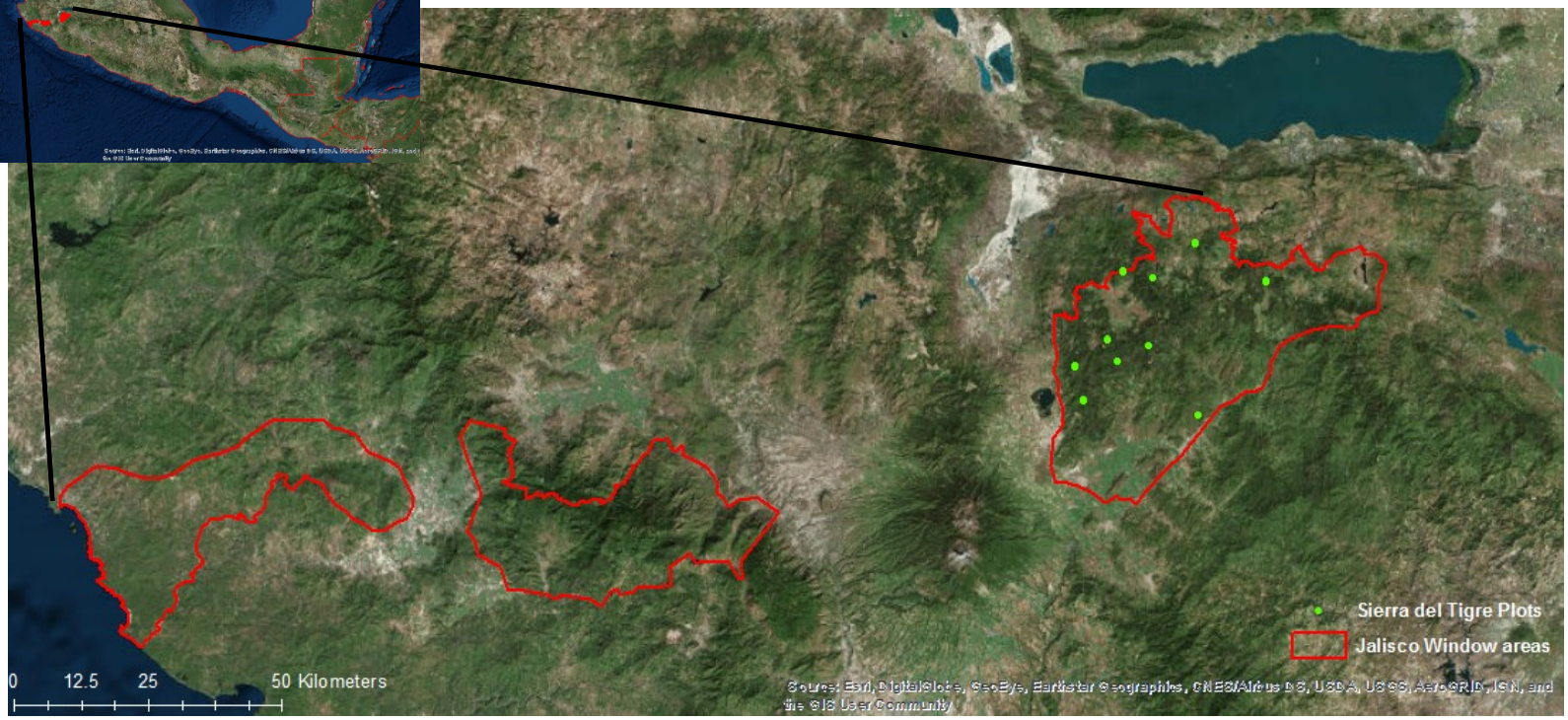
- Radar satellites can pass through forest canopy
  - Interacts with branches & stems - gives information about forest structure
- Radar backscatter signal correlated with biomass
  - Can be used to create biomass maps
  - BUT - Backscatter signal saturates at high biomass

Methodological Approach



Case Study 1 – Mexico, Jalisco

- Sierra Del Tigre
- 0.5ha
- Census 1 = 2017 (n = 10)
- Census 2 = 2018 (n = 10)



Degradation in Jalisco

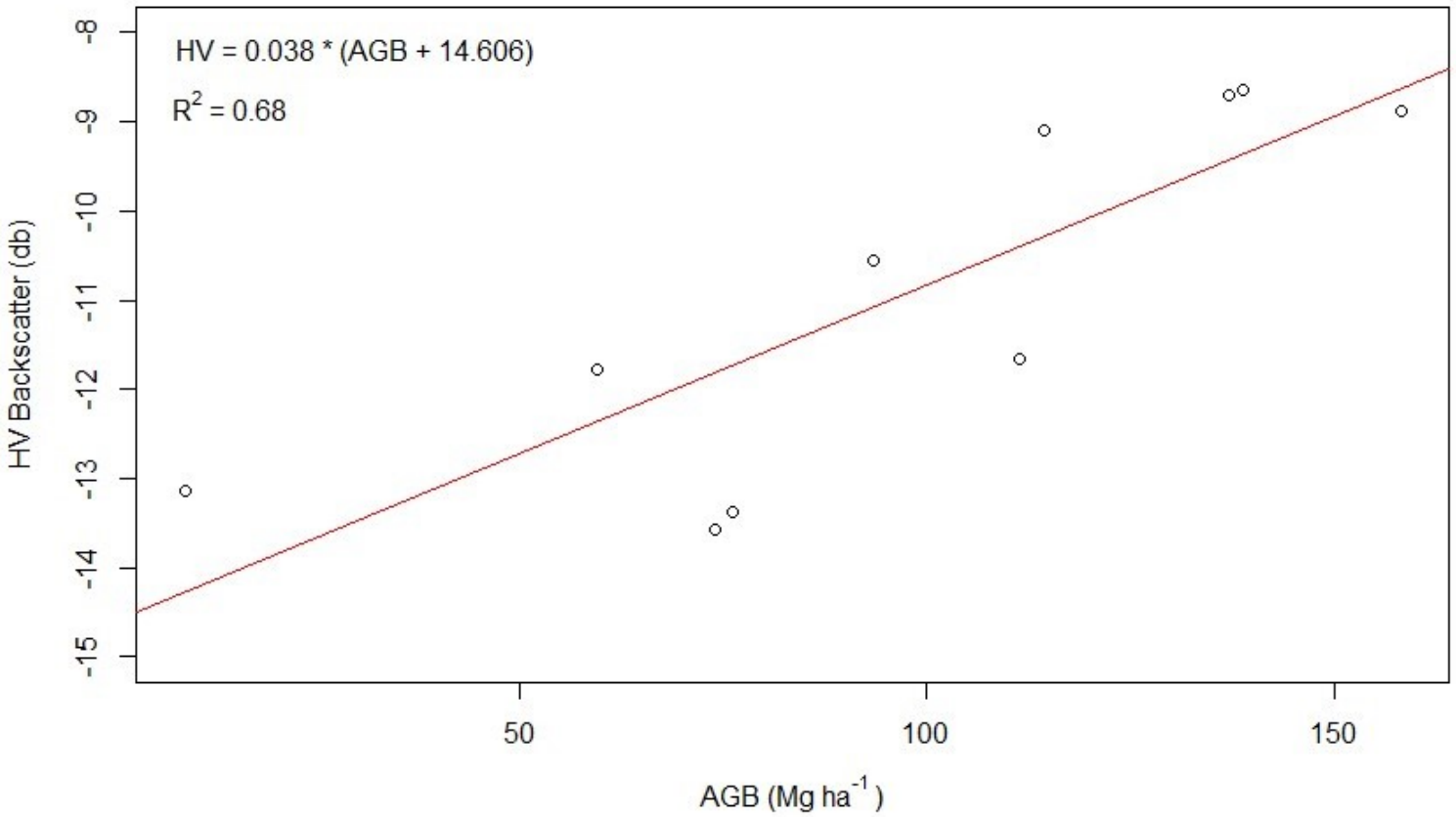
Forest affected by:

- Forest fires
- Pests – bark beetles
- Agro-industry (E.g. Avocado)

THE UNIVERSITY of EDINBURGH
School of GeoSciences

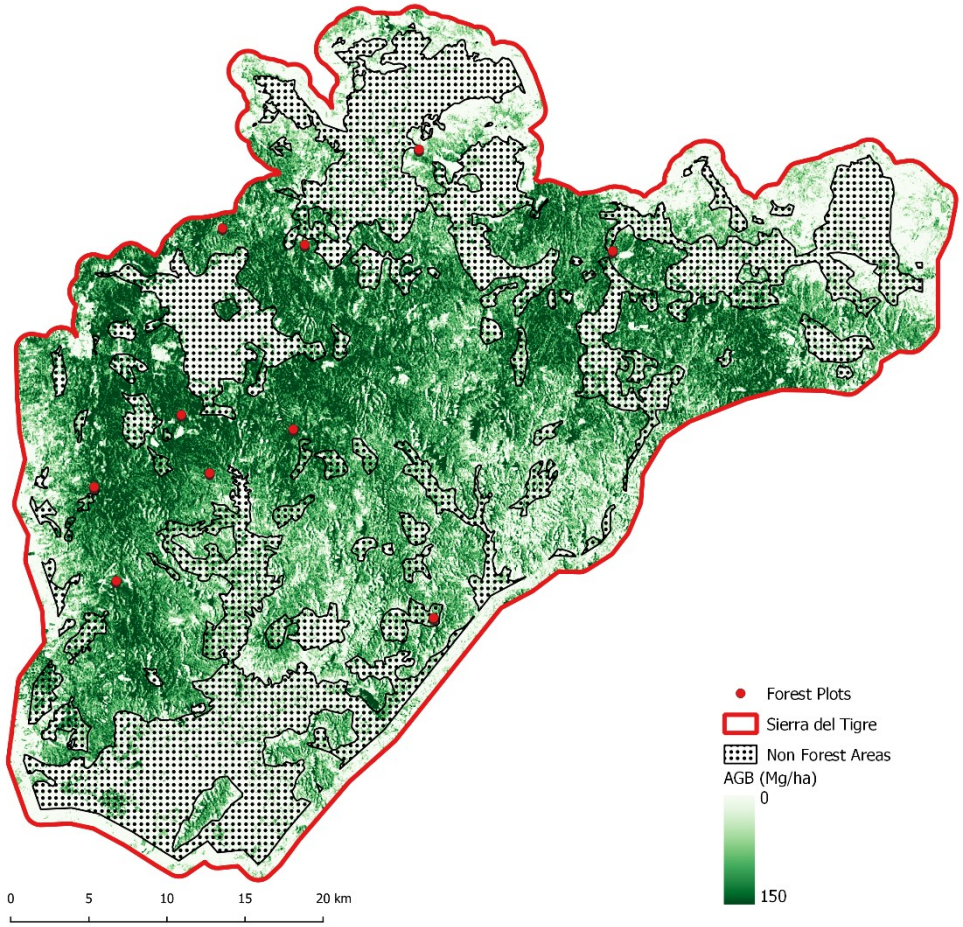
Mexico - Results

Census 1 (2017) – Linear model has best fit

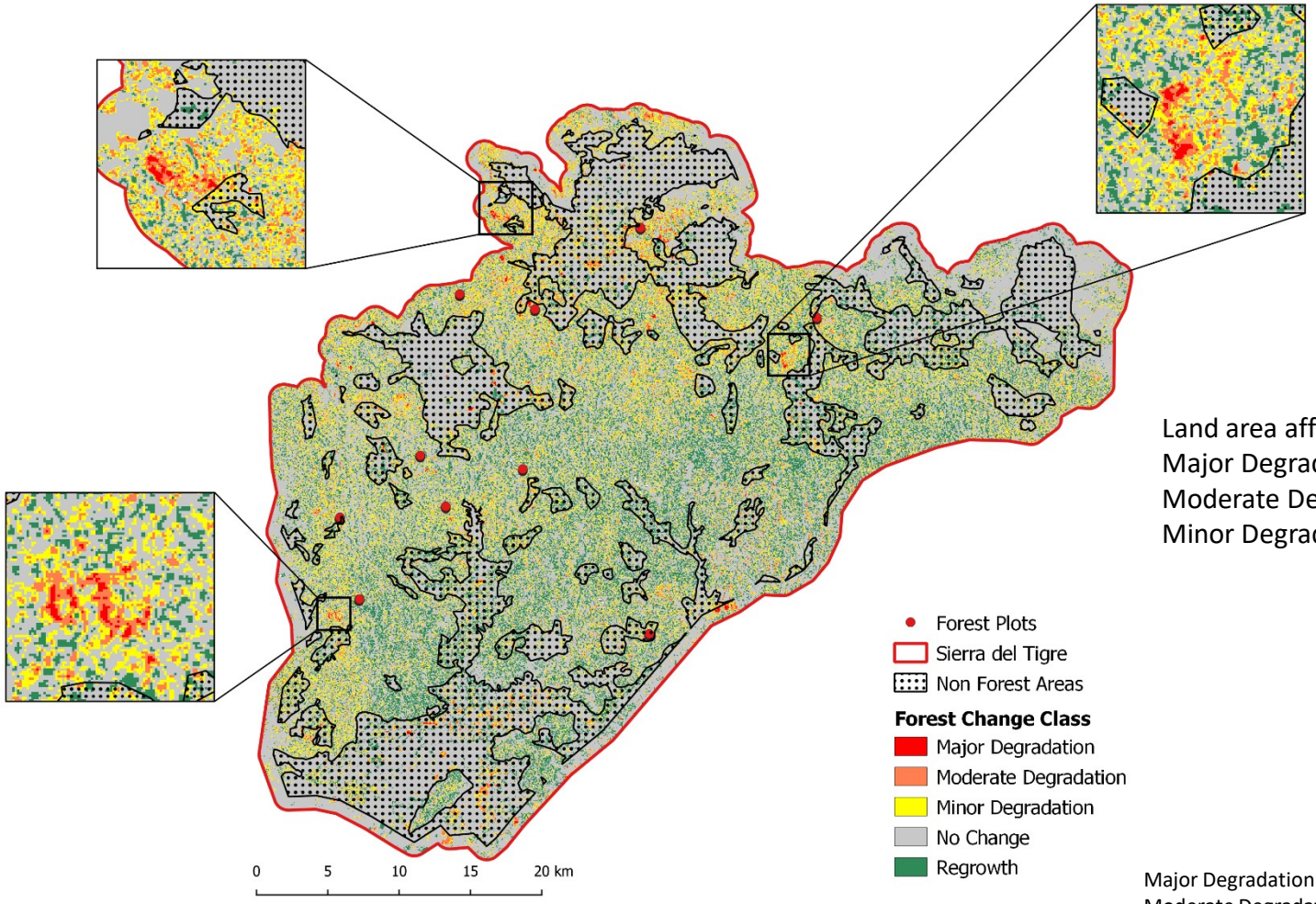


Mexico – AGB in 2016 & 2017

2016



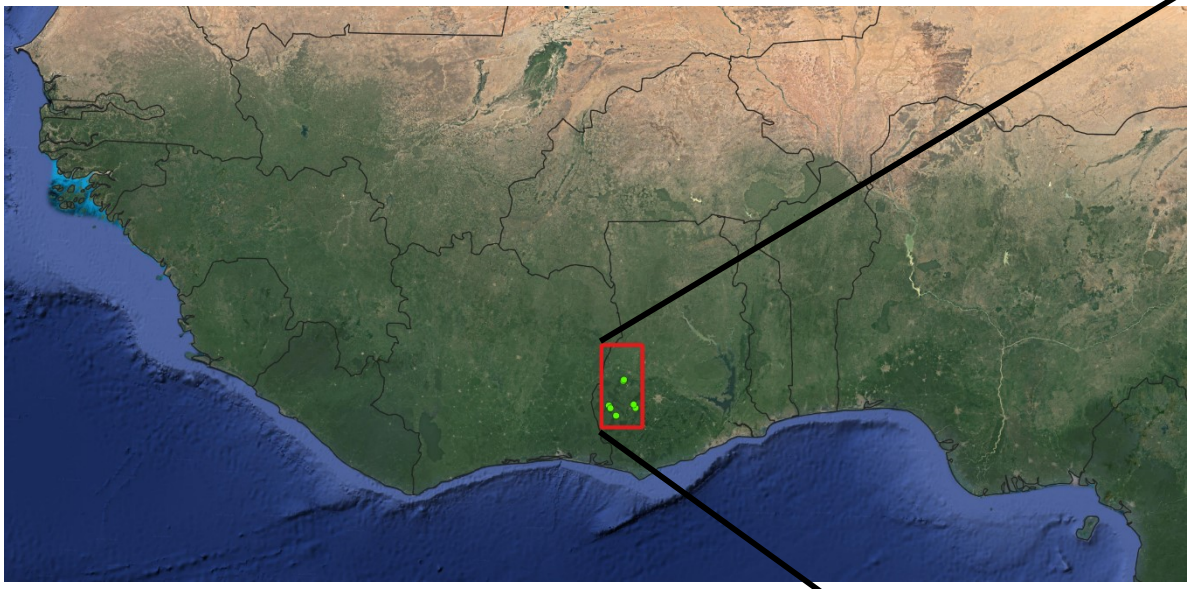
Mexico – AGB Change & Degradation

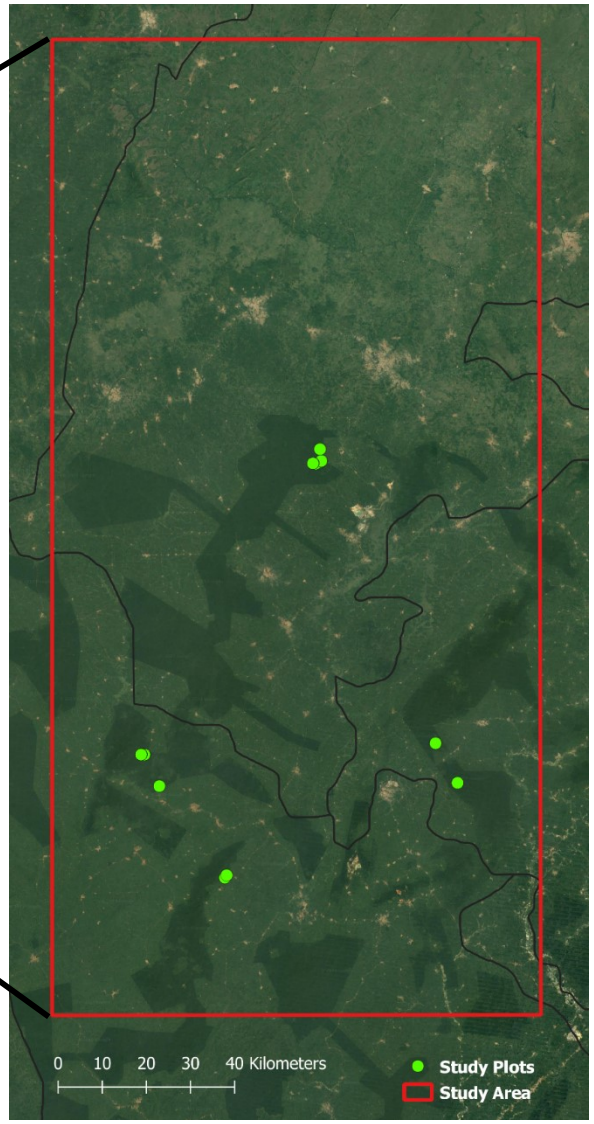


Land area affected by -
Major Degradation – 0.3%
Moderate Degradation – 3.9%
Minor Degradation – 12.8%

Major Degradation – loss>100 Mg ha^{-1}
Moderate Degradation – loss 50-100 Mg ha^{-1}
Minor Degradation – loss 10-50 Mg ha^{-1}

Case Study 2 - Ghana





- 11 plots in Sierra del Tigre
  - 1 ha
  - Census 1 = 1996 (n=11)
  - Census 2 = 2007 (n=4)
  - Census 3 = 2010 (n=5)
  - Census 4 = 2018 (n=11)

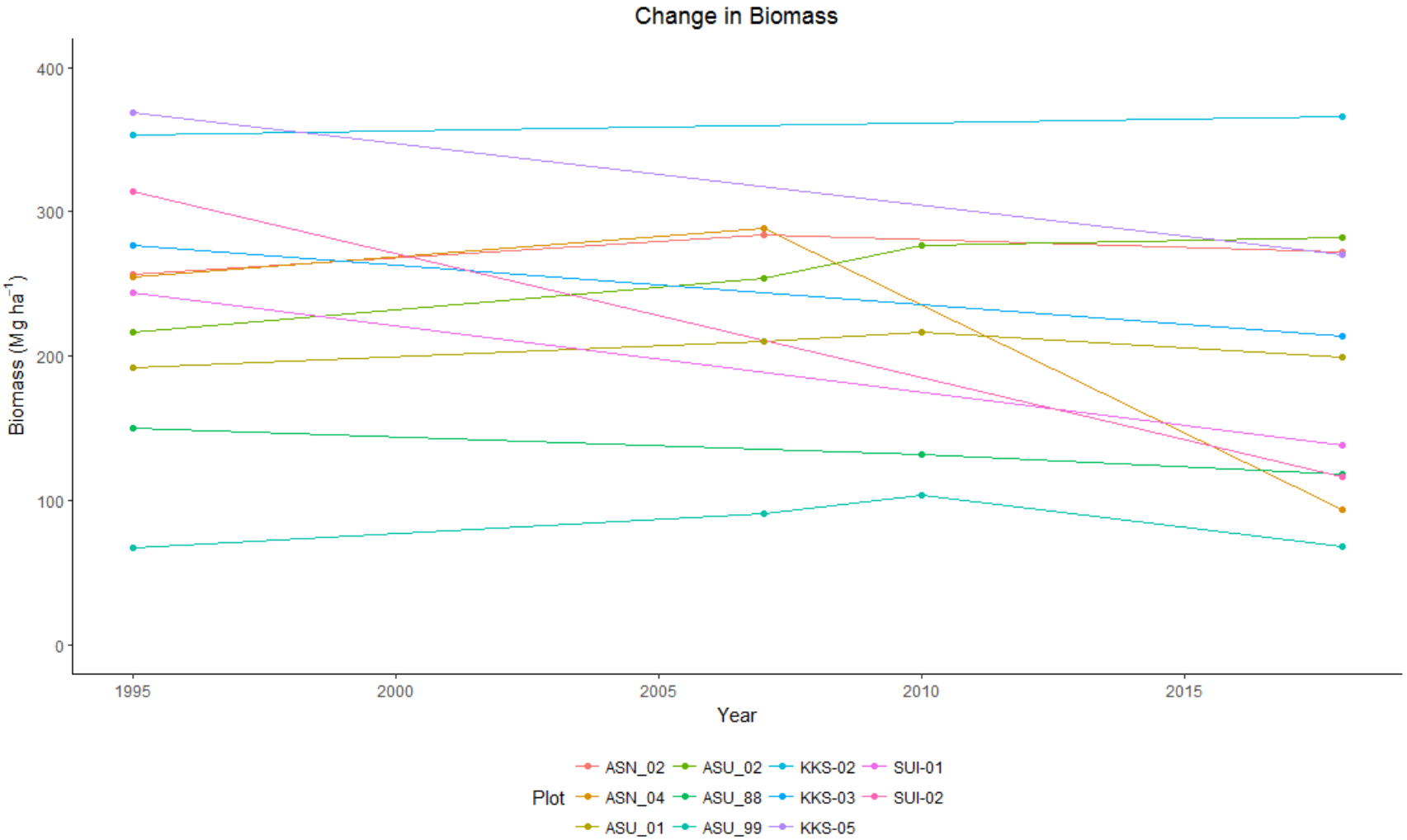
Degradation in Ghana

Forest affected by:

- Selective logging
- Agricultural encroachment (E.g. Casava, banana)
- Agro-industry (E.g. Cocoa)

THE UNIVERSITY of EDINBURGH
School of GeoSciences

Ghana - Results



Ghana - AGB

Over 20 years

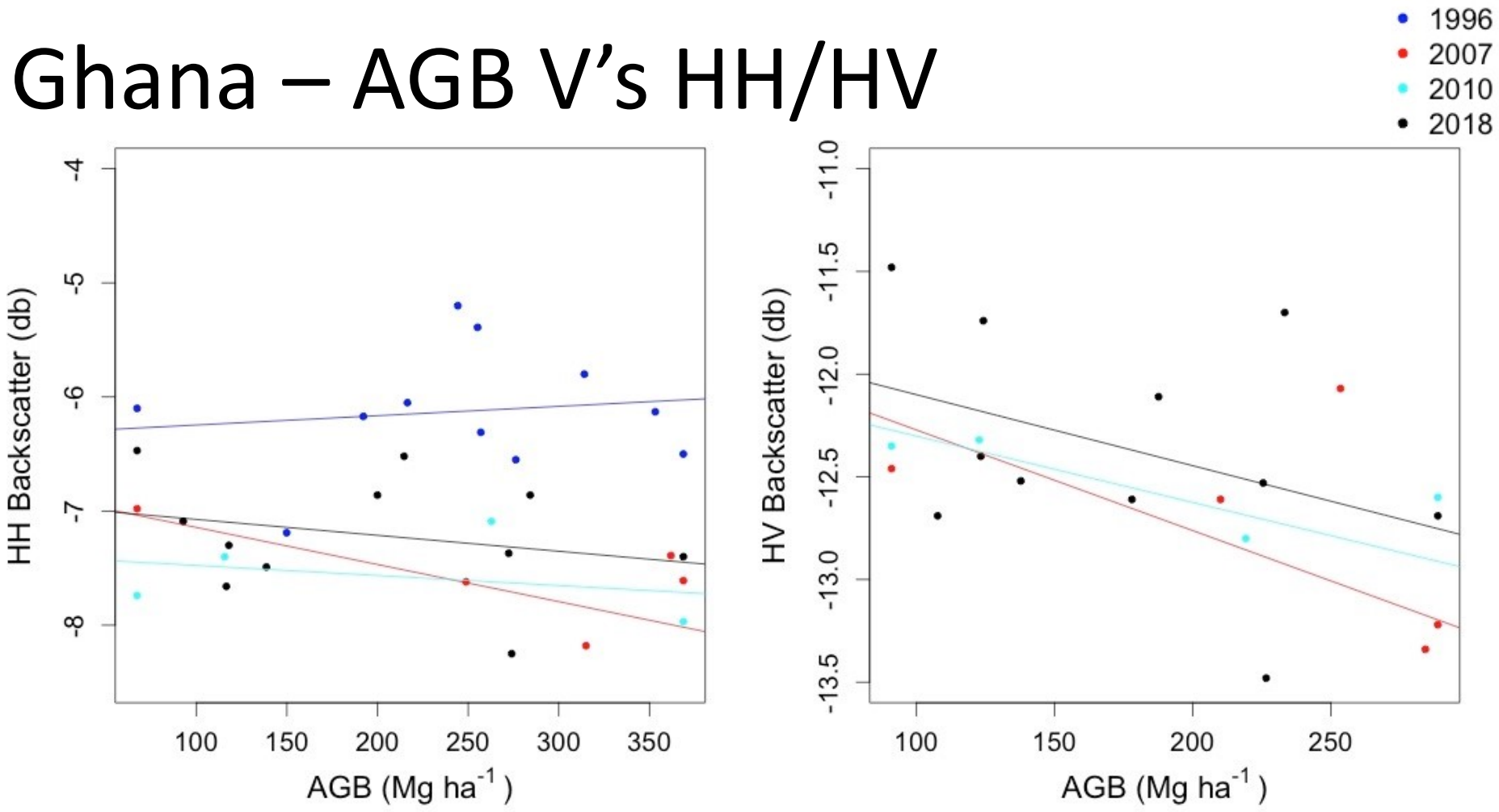
In some plots there is substantial AGB loss (>100 Mg ha^{-1})

Losses >60% of AGB in some cases

Mainly due to selective logging

Plot	AGB 1996 (Mg ha^{-1})	AGB 2018 (Mg ha^{-1})	AGB Change (96-18)	% Change (96 – 18)
ASU_99	67.4	68.3	1.0	1.4
ASU_88	149.9	118.3	-31.6	-21.1
ASU_01	192.2	199.2	7.0	3.7
ASU_02	216.5	282.4	65.9	30.4
SUI_01	244.3	138.7	-105.6	-43.2
ASN_04	255.2	93.4	-161.8	-63.8
ASN_02	257.0	272.3	15.2	5.9
KKS_03	276.3	213.7	-62.6	-22.6
SUI_02	314.1	116.9	-197.3	-62.8
KKS_02	353.2	365.8	12.6	3.6
KKS_05	368.7	270.7	-97.9	-26.6

Ghana – AGB V's HH/HV

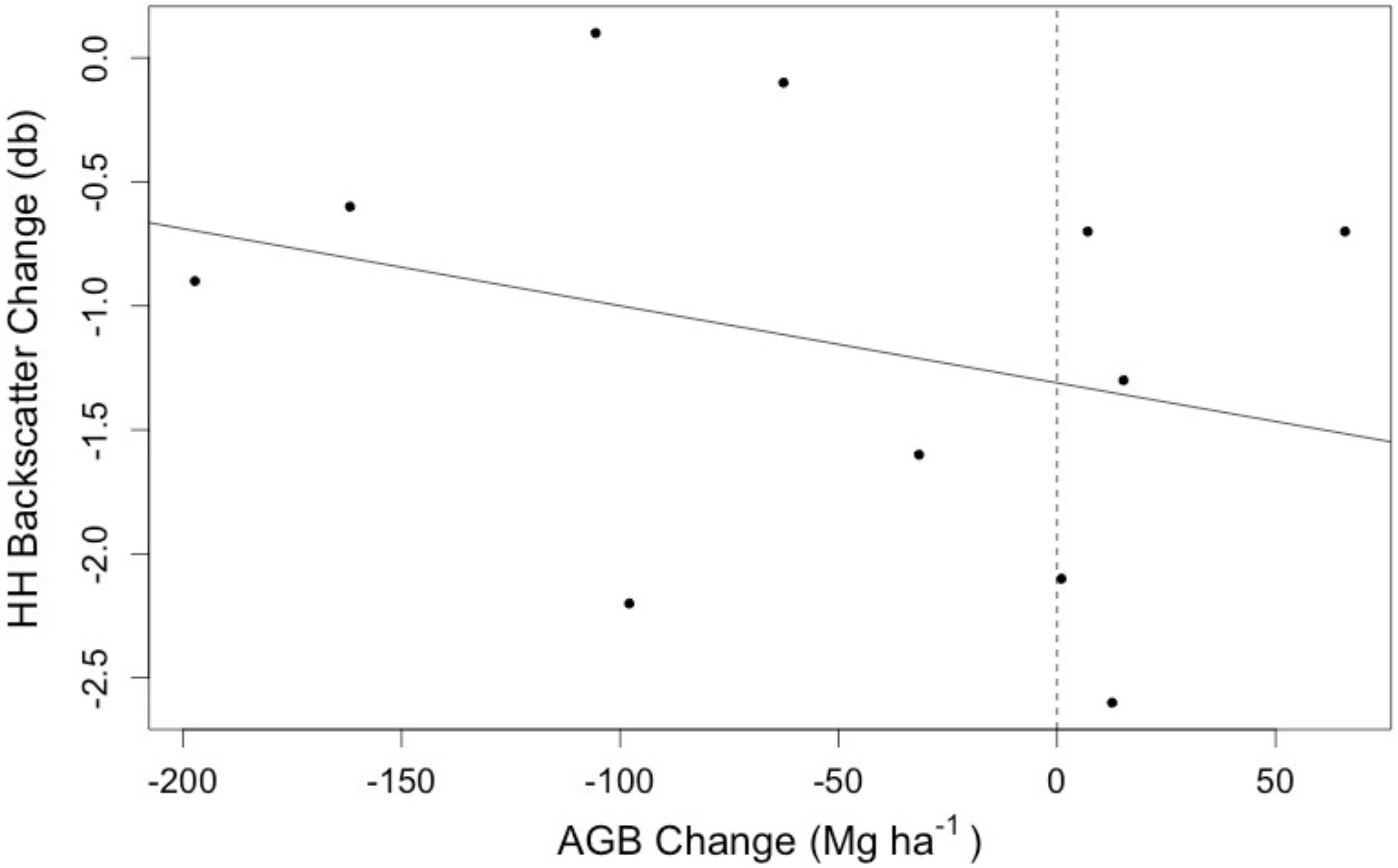


No relationship between plot data & HH/HV backscatter

Apparent downward trend in HV – Very low predictive power to convert HV to AGB

Saturation of HH/HV backscatter signal in High AGB plots

Ghana – HH Change Signal



Also checked relationship between change in HH backscatter and change in AGB between 1996-2018 but not relationship

Summary

- We are able to detect forest degradation from losses in AGB in lower AGB forest
- Plots in degraded forest are invaluable – we need ground data to pick these processes up and understand them better
- BUT In high AGB forest even large changes are not detected.

This is worrying

- Alos Palsar isn't detecting major degradation events in high AGB forest
- Other instruments might detects major degradation (related to changes in canopy cover)
  - BUT they don't map minor degradation or quantify the losses of AGB
  - We show Minor degradation covers much larger area than major degradation so we are potentially missing lots of emissions.