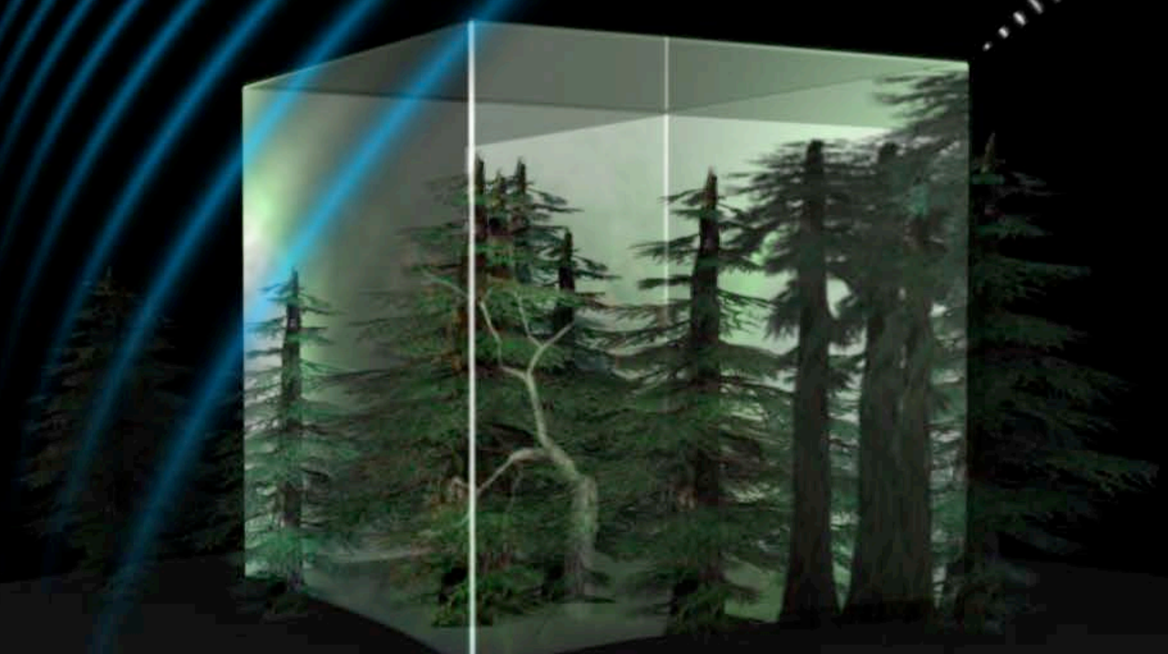
biomass

The BIOMASS mission: Science and Background



BIOMASS 1st Science Workshop, ESRIN, Italy

An Earth Explorer to observe forest biomass

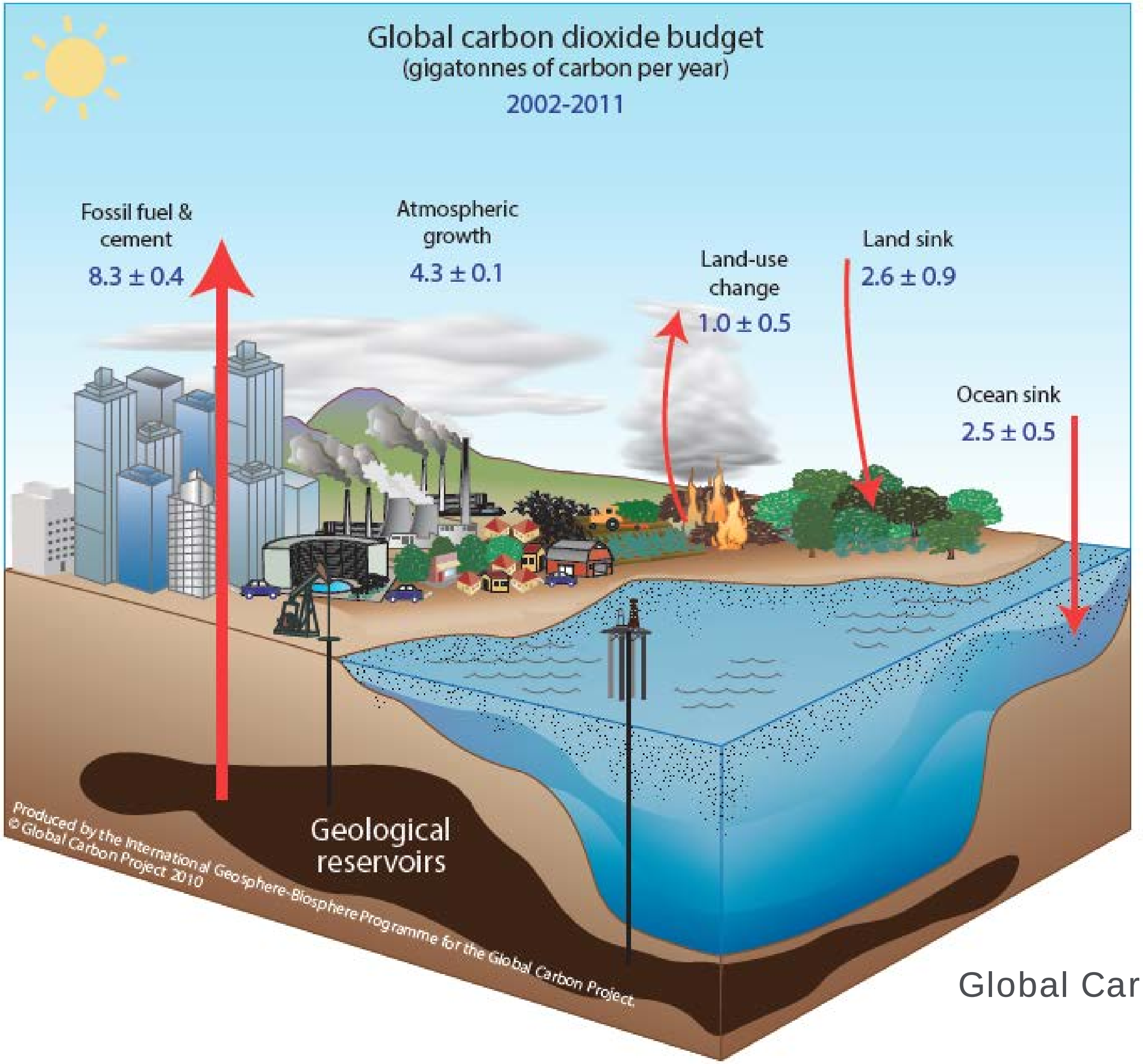
European Space Agency

BIOMASS Mission Advisory Group – Presenter: M Williams

BIOMASS will map global forest biomass and forest height

Forest biomass **Forest height** **Disturbances**

What is the role of biomass in the global carbon cycle?



Global Carbon Project, 2012

Fate of Anthropogenic CO_2 Emissions (2002-2011)

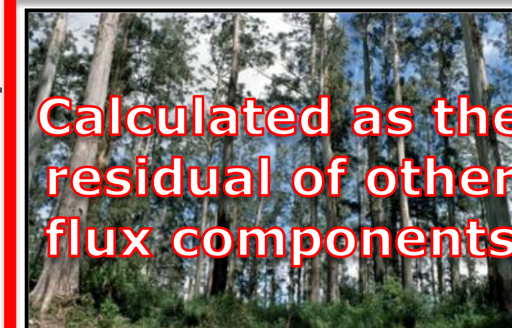
8.3±0.4 GtC/yr

1.0±0.5 GtC/yr net flux

+

4.3±0.1 GtC/yr

2.6±0.9 GtC/yr

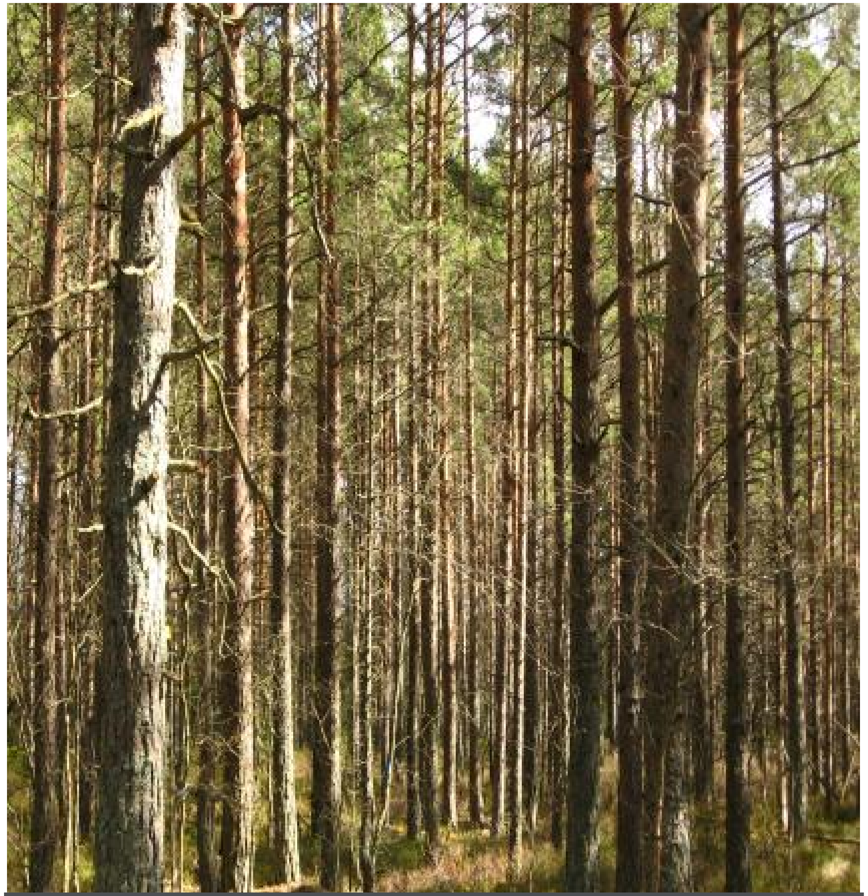


2.5±0.5 GtC/yr

Global Carbon Project, 2012

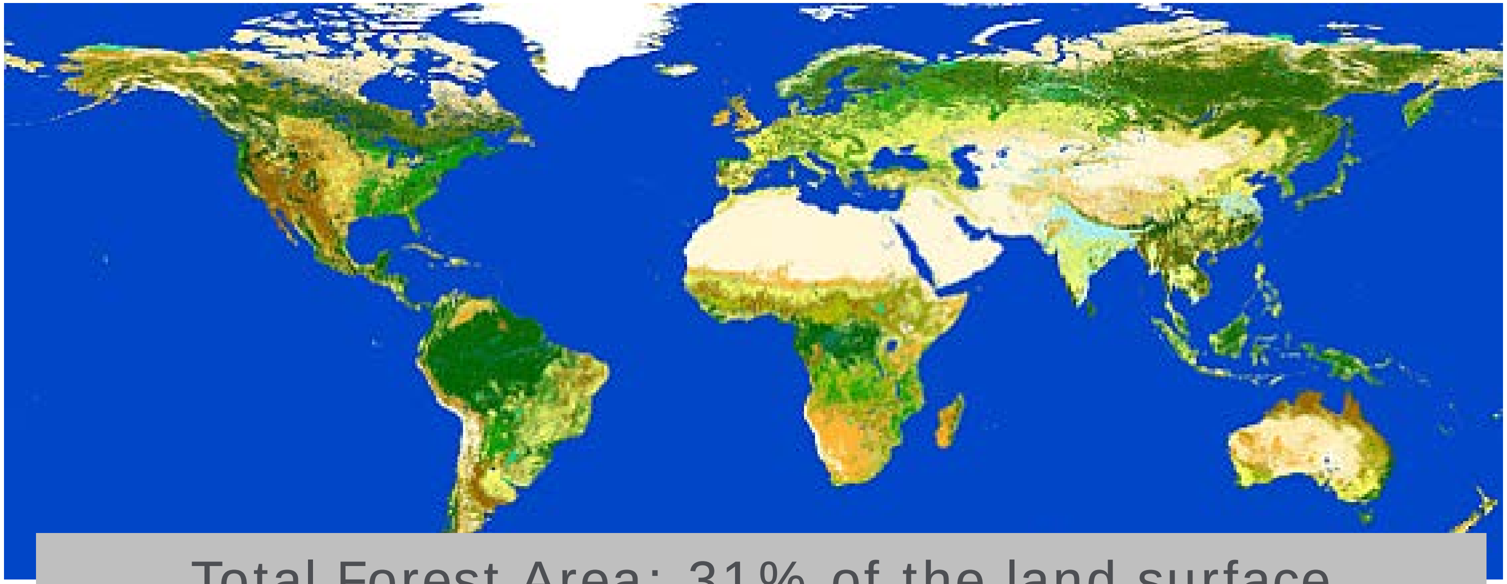
Forest biomass is a key component in the carbon cycle

1. Biomass is ~50% carbon
2. Forests hold 70–90% of Earth's above-ground biomass, with the majority of forest biomass located within the Tropics
3. Forest biomass is very poorly known and is a major source of uncertainty in carbon flux estimation.



Biomass = dry weight of woody matter + leaves (tons/hectare)

Global forest cover & biomass distribution is concentrated within the tropics



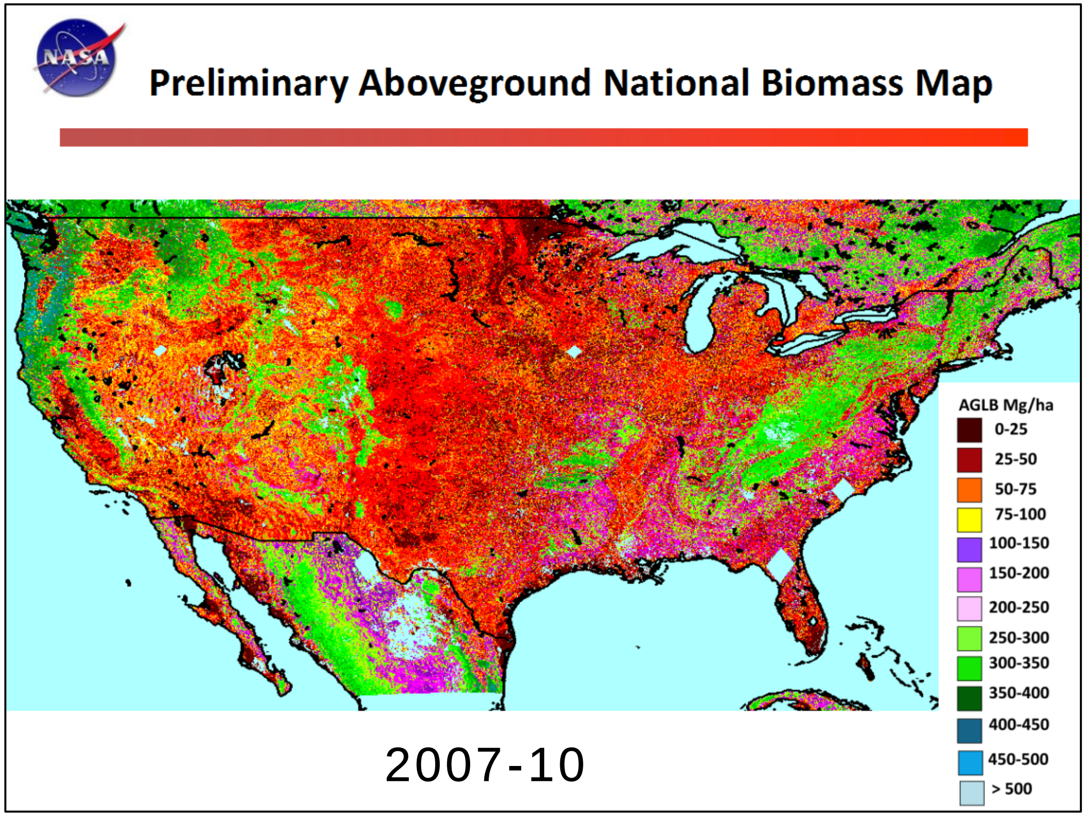
Total Forest Area: 31% of the land surface

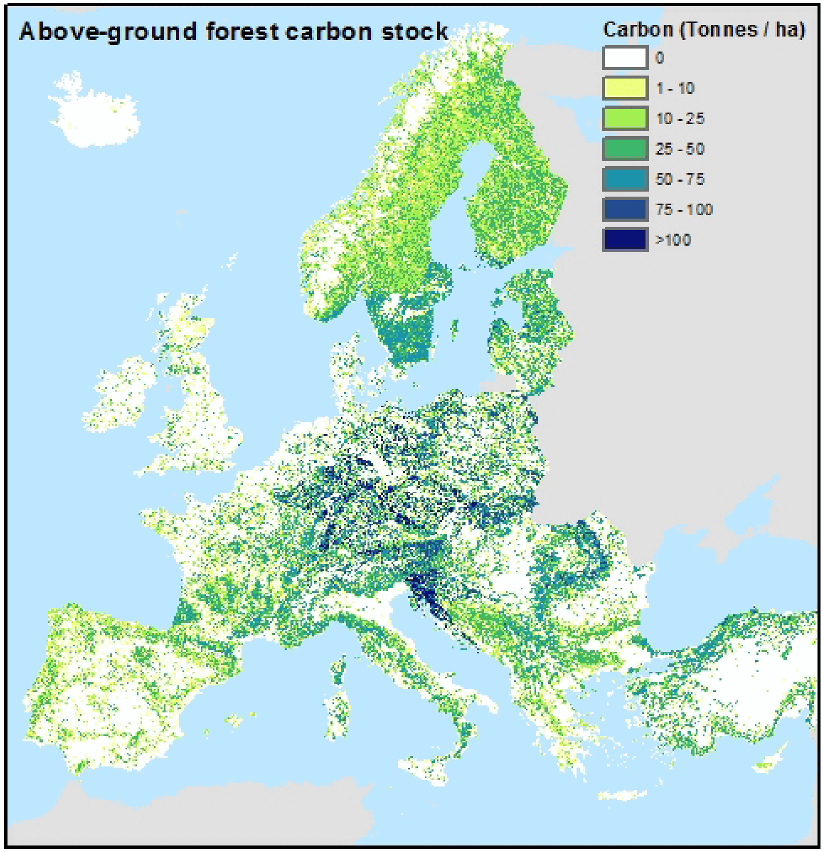
Forest Biome	Area (Millions of hectares)	Biomass (tons/hectare)	Total Biomass (gigatons)
Boreal	1372	83-128	110-176
Temperate	1038	114-270	118-280
Tropical	1755	190-390	350-680
TOTAL	4165	mean 129-262	718-1300

Pan et al., 2011;
Hougton et al.,2009

Western nations (USA, Europe, Canada) have excellent forest biomass datasets

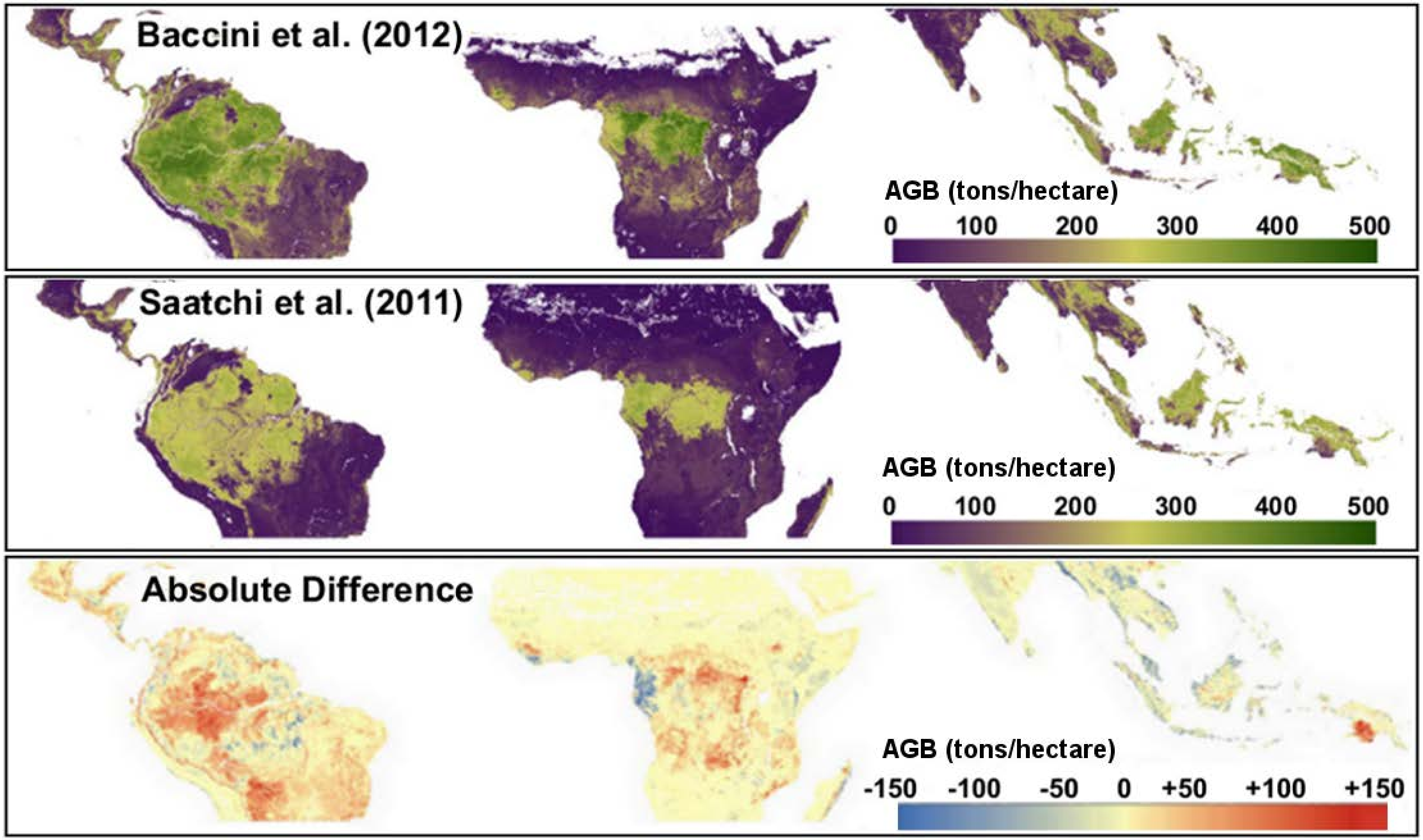
NASA/Carbon Monitoring System
Nationwide Forest Inventory
ALOS-PALSAR, error estimates





JRC BIOMASS MAP 2010
Very large national inventories

Latest tropical above-ground biomass (AGB) maps use non-optimal data and have large biases



Largely based on ICEsat–no longer available

Why are tropical data most uncertain and so important?

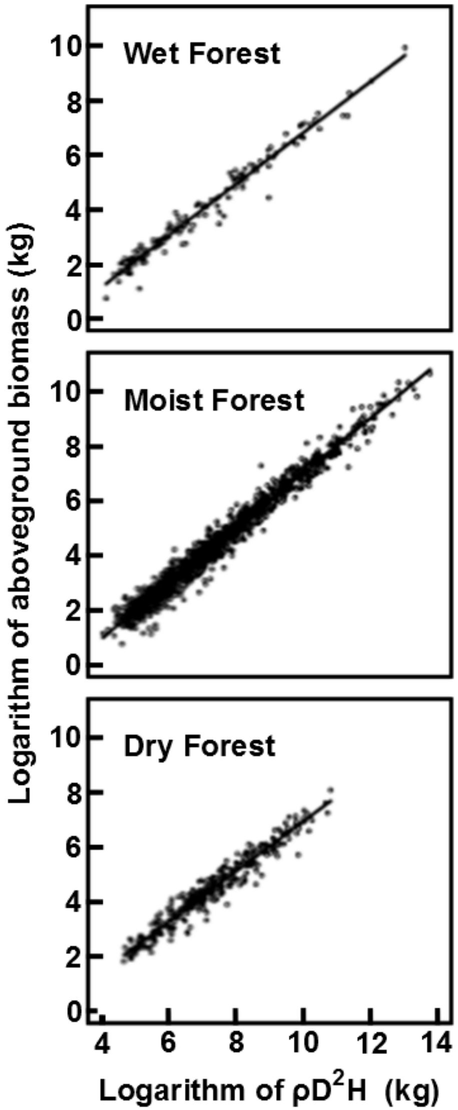
1. Tropical biomass = 350-680 billion tons
2. Uncertain due to biodiversity and poorly coordinated/sparse measurements

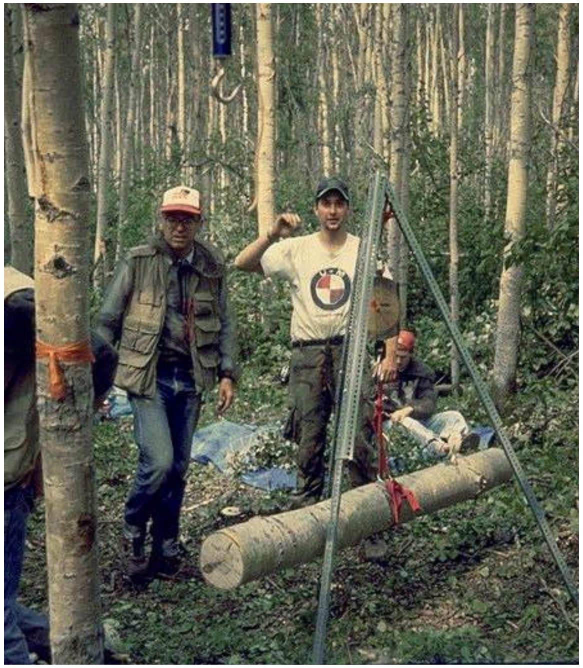
Global Forest Carbon Budget is most uncertain in the Tropics

C sink / source	GtC per year
Boreal	0.5±0.1
Temperate	0.7±0.1
Tropical Intact	1.0±0.5
Tropical regrowth	1.7±0.5
Tropical de-forestation	-2.8±0.5

Pan et al., 2011

How do we estimate biomass?

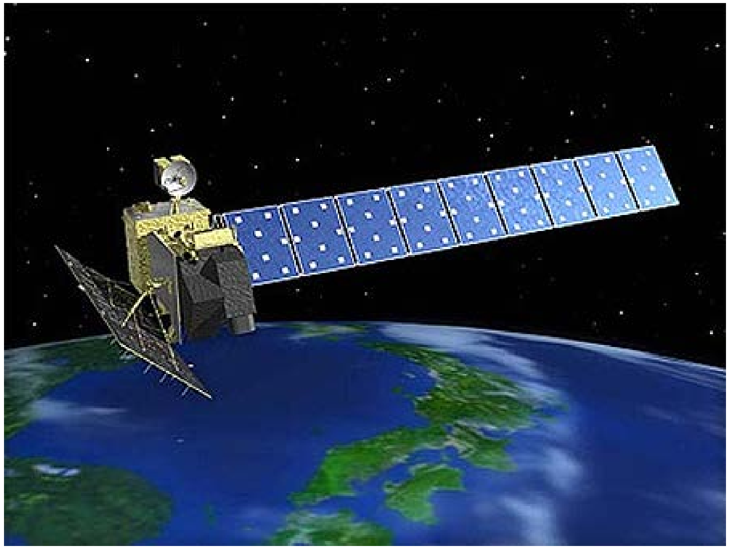




Tree allometry links biomass to

1. *Diameter (D)*
2. *Height (H)*

Upscaling beyond plots requires algorithm calibration of remotely sensed data



Allometric upscaling leads to ~20% error at 1 hectare scale for natural forests

Carbon emission estimates from deforestation and degradation are uncertain

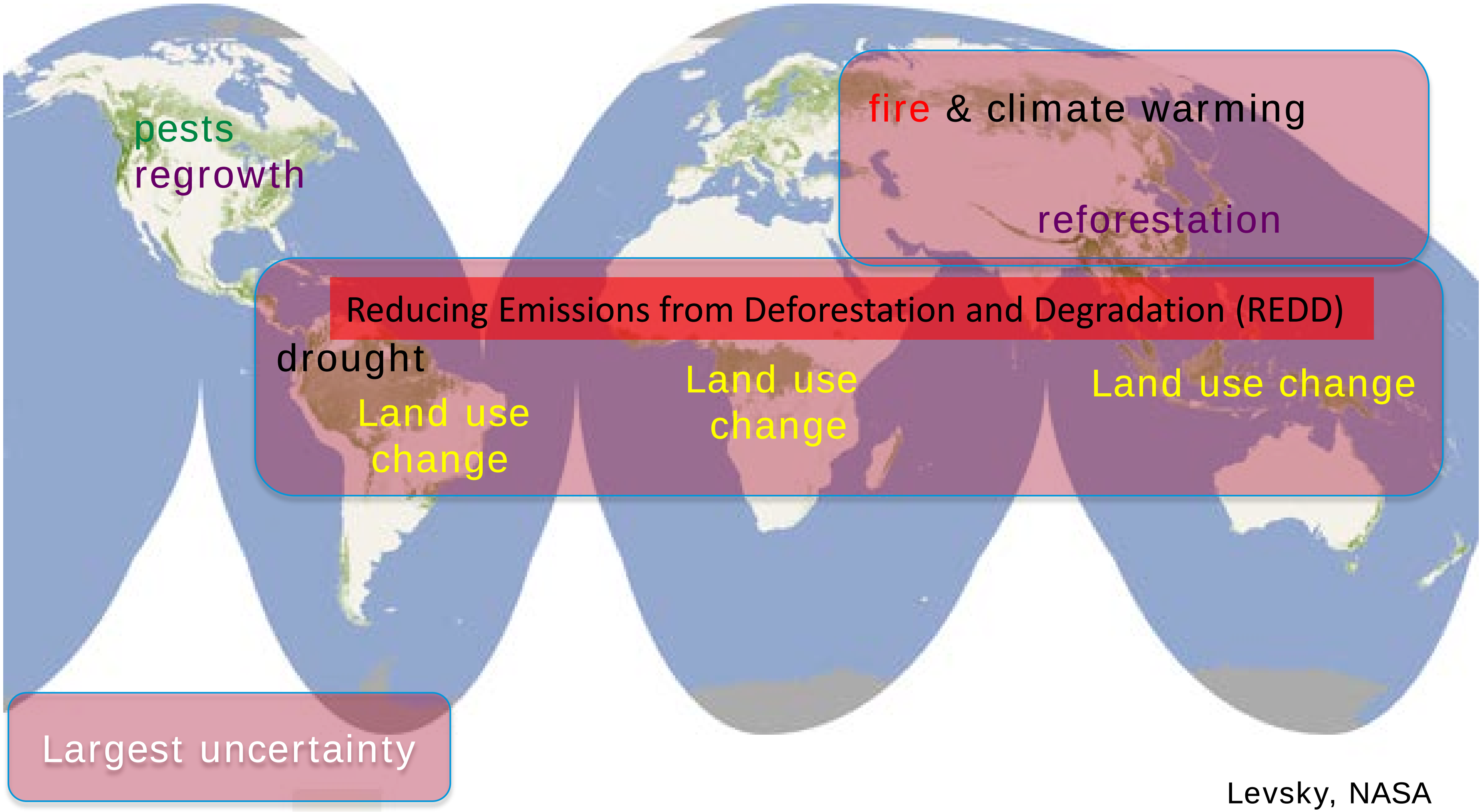
Gross carbon emissions

$$\Delta C = \square\ \Delta A \square B \square E \quad + \quad \square\ A \square \Delta B \square E$$

where A is the area of forest type, with biomass B and an emission efficiency factor E

BIOMASS will provide a direct measurement of biomass change exactly where deforestation and degradation occur

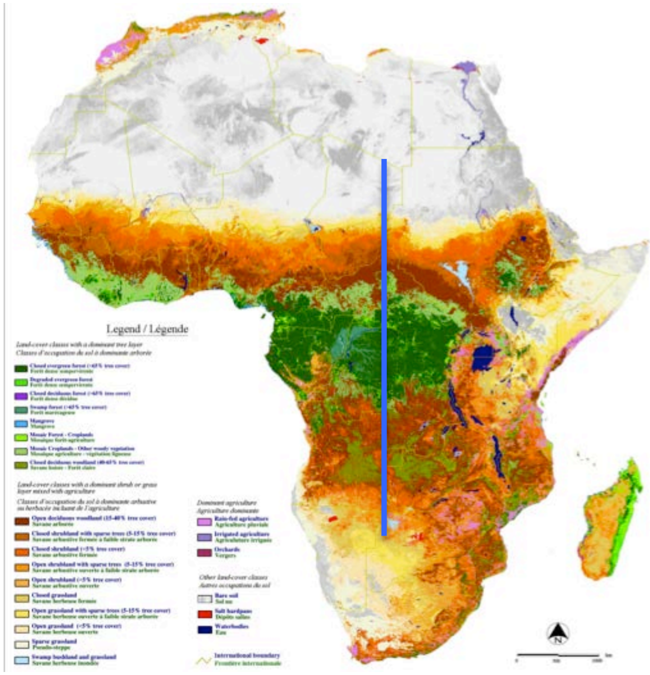
Where are biomass estimates most uncertain and where are the critical zones of forest change?

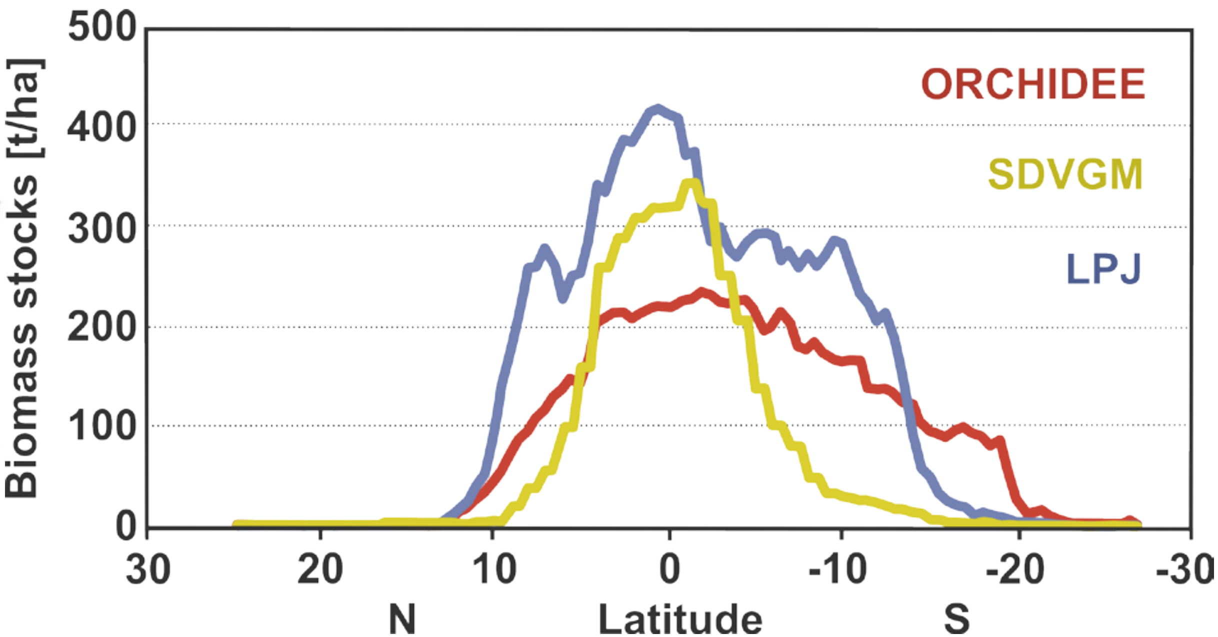


Levsky, NASA

Model estimates of biomass are questionable

Biomass estimates from 3 state-of-the-art Dynamic Vegetation Models

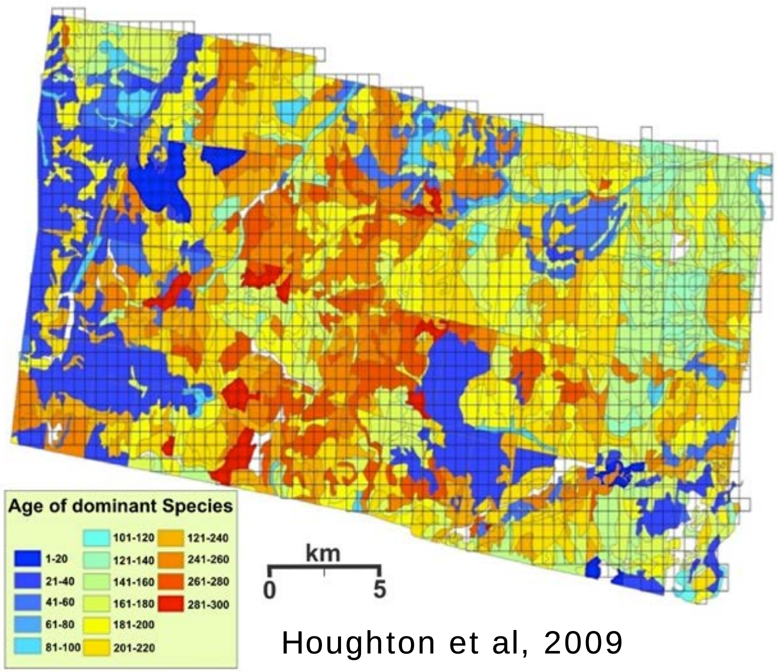




Carbon cycle models need to be evaluated against independent biomass maps

Forest biomass varies over a range of spatial scales

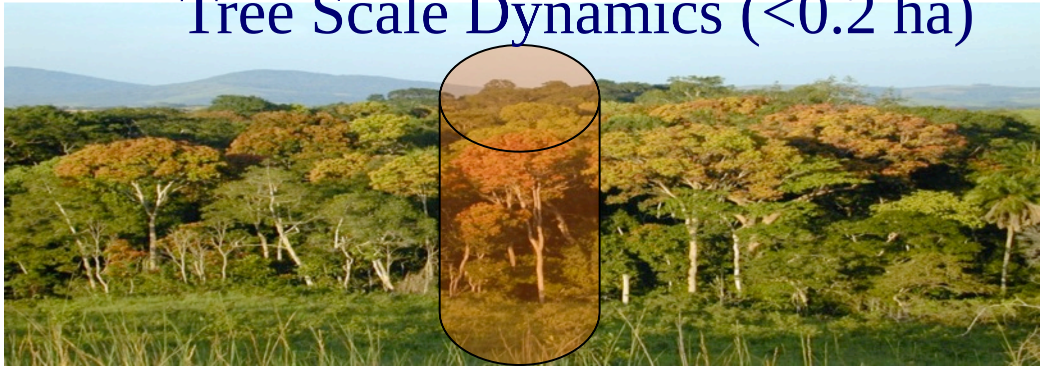
Variation is driven by patterns of production, respiration, mortality, recruitment, disturbance, linked to abiotic factors such as soil, topography, water, climate.



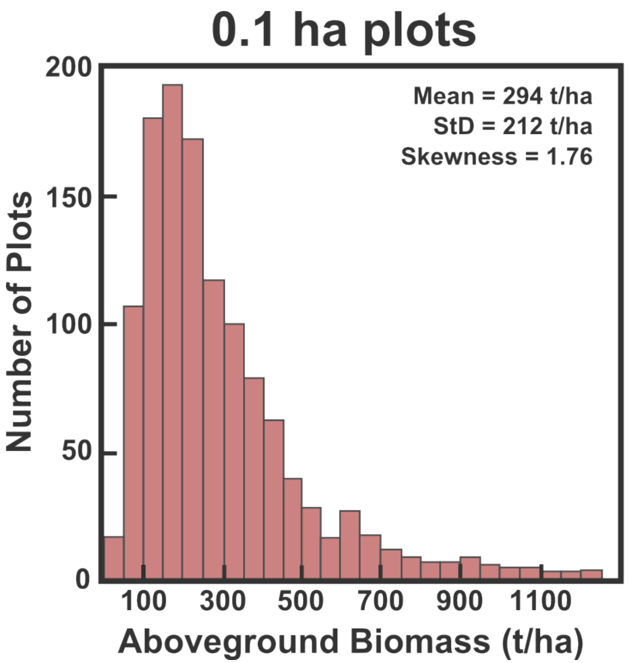
Houghton et al, 2009

Different ages of forest stands in Krasnoyarsk, central Russia

≠

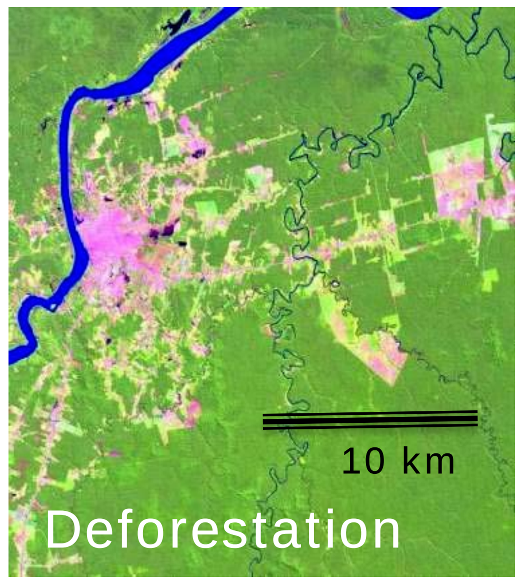


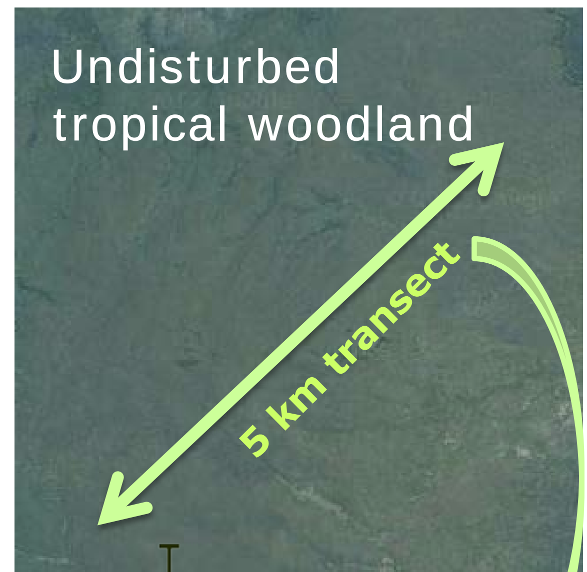
Tree-scale dynamics determine minimum resolution for biomass estimation

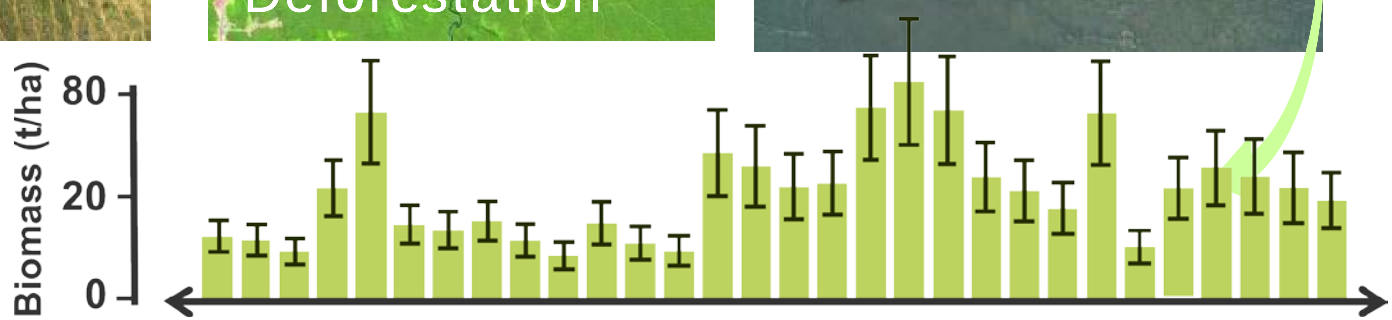


A minimum plot size of 1 hectare is required to estimate biomass for natural forests

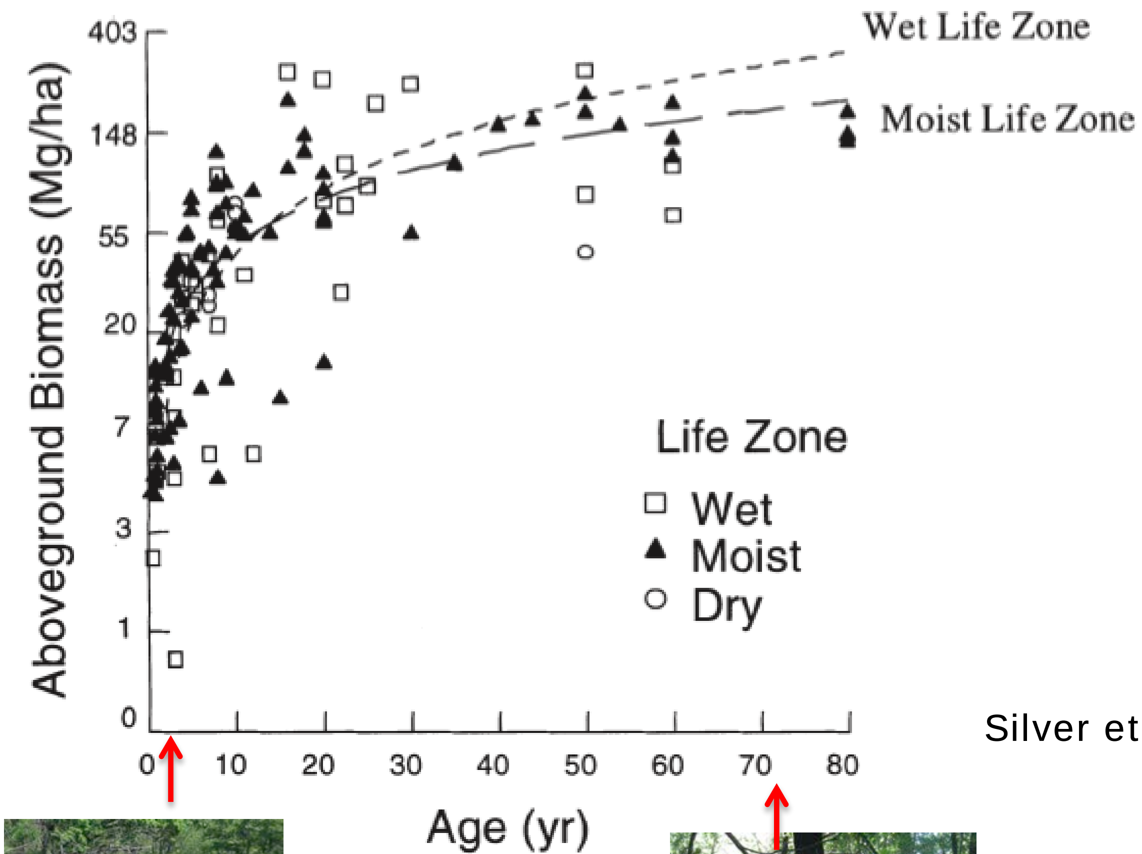
Landscape dynamics generate hectare-scale heterogeneity







Forest biomass is a dynamic property, with rapid tropical re-growth



Silver et al. 2000

Biomass accumulates following disturbance

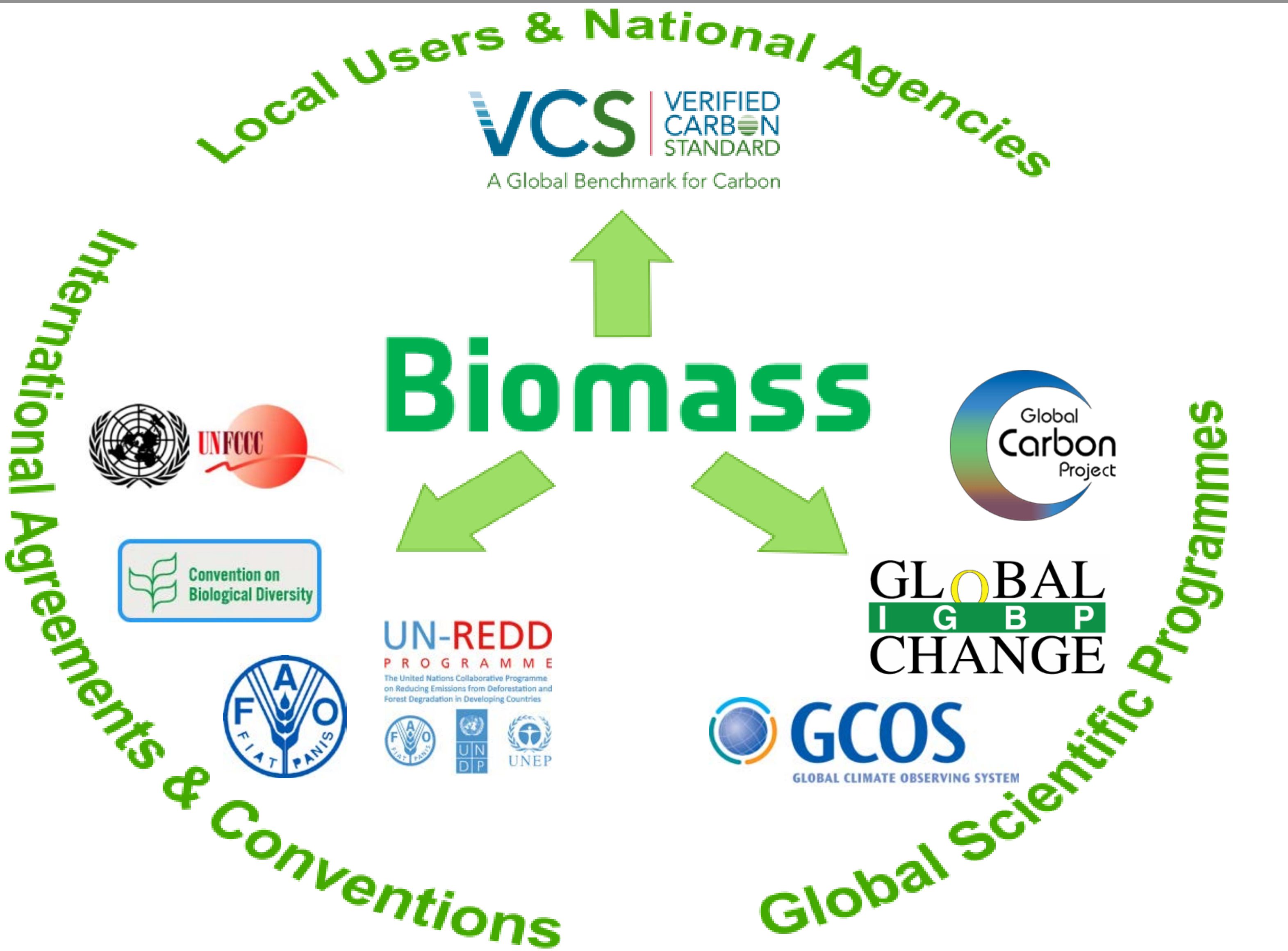
Primary Mission Objectives

1. Reducing the major uncertainties in carbon fluxes linked to Land Use Change, forest degradation and regrowth
2. Providing support for International Agreements (UNFCCC and REDD+)
3. Inferring landscape carbon dynamics and supporting predictions
4. Initialising and testing the land component of Earth System models
5. Providing key information on forest resources, ecosystem services, biodiversity and conservation

Secondary objectives

1. Sub-surface geology in deserts
2. DTMs under dense vegetation
3. Glacier and ice sheet velocities

International context and users



Required measurement properties

1. The **crucial information gap** is in the tropics:
    - deforestation (~95% of the Land Use Change flux)
    - regrowth (~50% of the global biomass sink)
    - UN-REDD+
2. Biomass measurements are needed where the changes occur and at the **effective scale of change**: 4 hectares
3. A biomass accuracy of 20% at 4 hectares, **comparable to ground-based observations**
4. Forest height to provide **a further constraint** on biomass estimates
5. **Detection** of deforestation at 0.25 ha
6. **Repeated measurements** over multiple years to identify deforestation and growth

Biomass product requirements

Above-ground biomass (tons / hectare)

- 200 m resolution
- 1 map every 6 months for 4 years
- global coverage of forested areas
- accuracy of 20%, or 10 t ha^{-1} for biomass < 50 t ha^{-1}

Upper canopy height (meter)

- 200 m resolution
- 1 map every 6 months for 4 years
- global coverage of forested areas
- accuracy of 20-30%

Areas of forest clearing (hectare)

- 50 m resolution
- 1 map every 6 months for 4 years
- global coverage of forested areas
- 90% classification accuracy

Urgently required for IPCC, UNFCCC, REDD, national forest planning