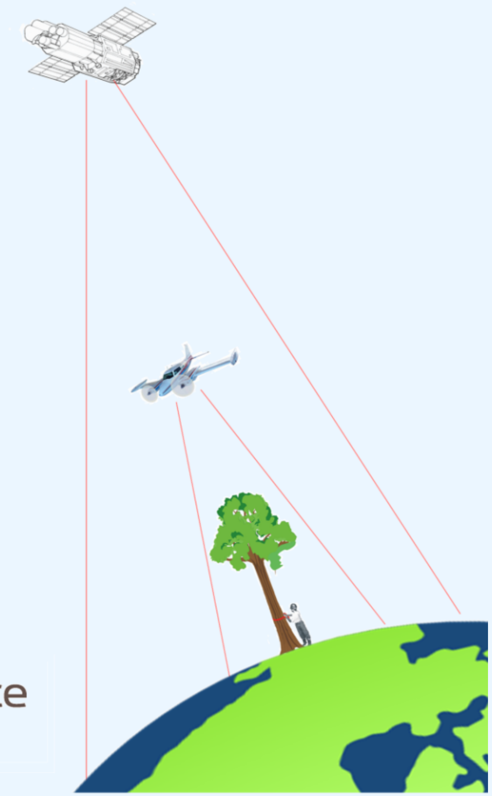
Universidade de Brasília

Monitoring of forest dynamics: carbon stocks, greenhouse gas fluxes and biodiversity

Mercedes Bustamante and Iris Roitman



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INVITED REVIEW

Toward an integrated monitoring framework to assess the effects of tropical forest degradation and recovery on carbon stocks and biodiversity

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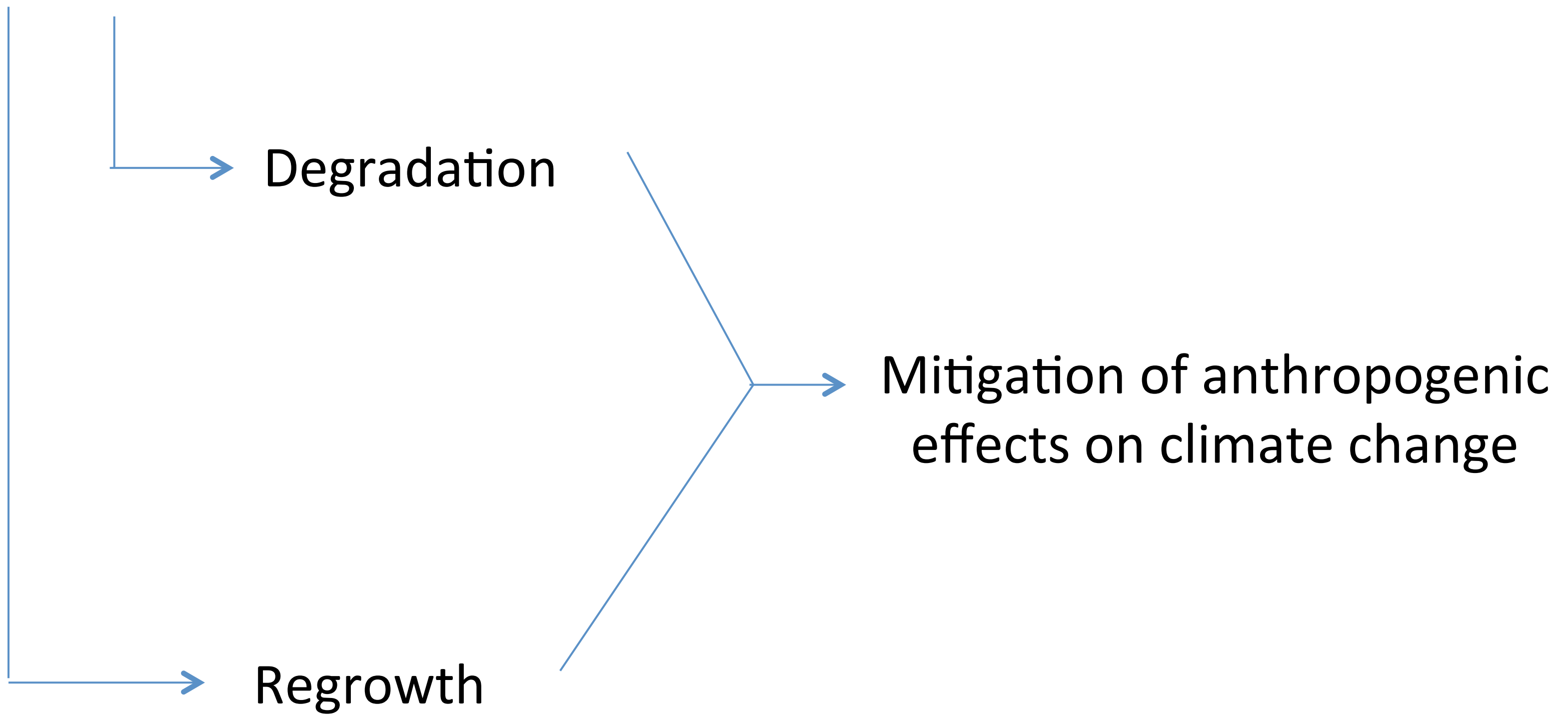
Forest Dynamics



Mitigation of anthropogenic effects on climate change

The Kyoto Protocol (1997) — Maintain forests to reduce emissions from deforestation.

Compensated reduction
Santili et al. (2005), COP 11 (2005)
— Incentives for developing countries detaining tropical forests to reduce emissions from deforestation.

Reduced Emissions due to Deforestation and Forest Degradation (REDD) strategy
COP 13 (2007)
— Reduce emissions and prevent leakage: ↓ deforestation ↑ degradation
Skutch and Trines 2008

REDD +
COP 14 (2008)
— role of conservation, sustainable management, and enhancement of forest carbon stocks.

Biodiversity conservation
Díaz et al (2009)
CBD(2011).

Carbon storage and resilience → Species composition and key functional relationships between them. Thompson et al. (2009).

Ensure REDD+ projects impacts are positive on biodiversity, especially in low-carbon and highly diverse forests.
(Harrison et al. 2011).

Mitigation → Accuracy → Large-scale monitoring carbon changes and biodiversity

↓ Promising tools

Remote sensing + Field inventories

Strong potential

DeFries 2007
Goetz et al. 2009

Problem

Cannot deliver the required precision to assess changes in carbon stocks due to degradation and recovery.

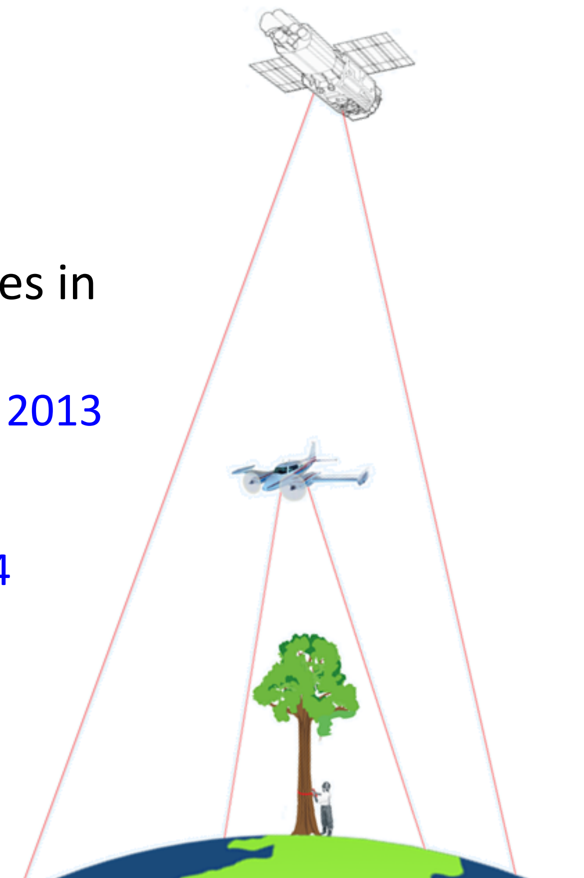
Asner et al. 2005, GOCF-GOLD 2013

High uncertainty in biomass carbon stocks and fluxes.

IPCC 2014

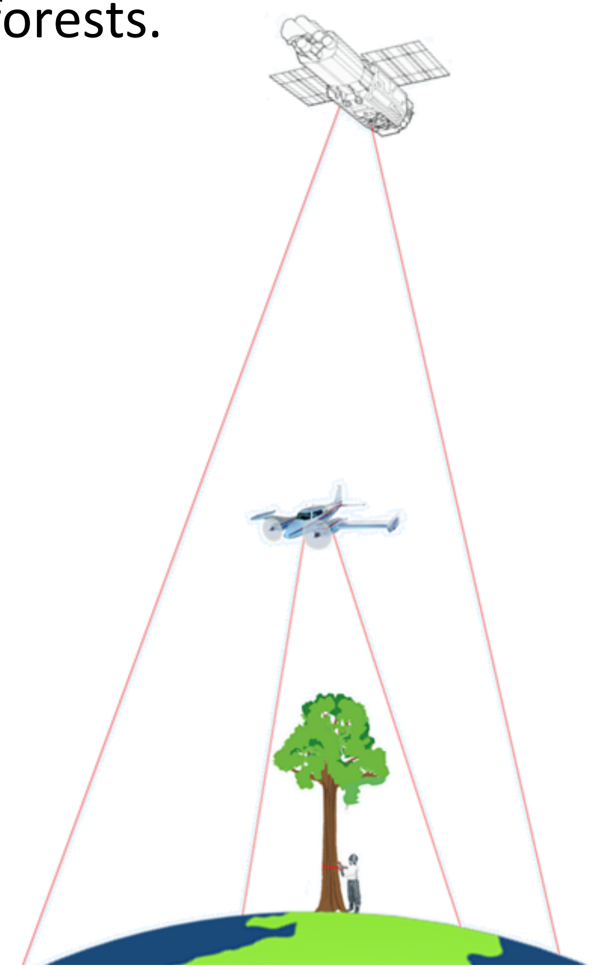
Quantifying forest degradation and regrowth remains a major constraint in the implementation of REDD+.

Mitchard et al. 2014, Ometto et al. 2014



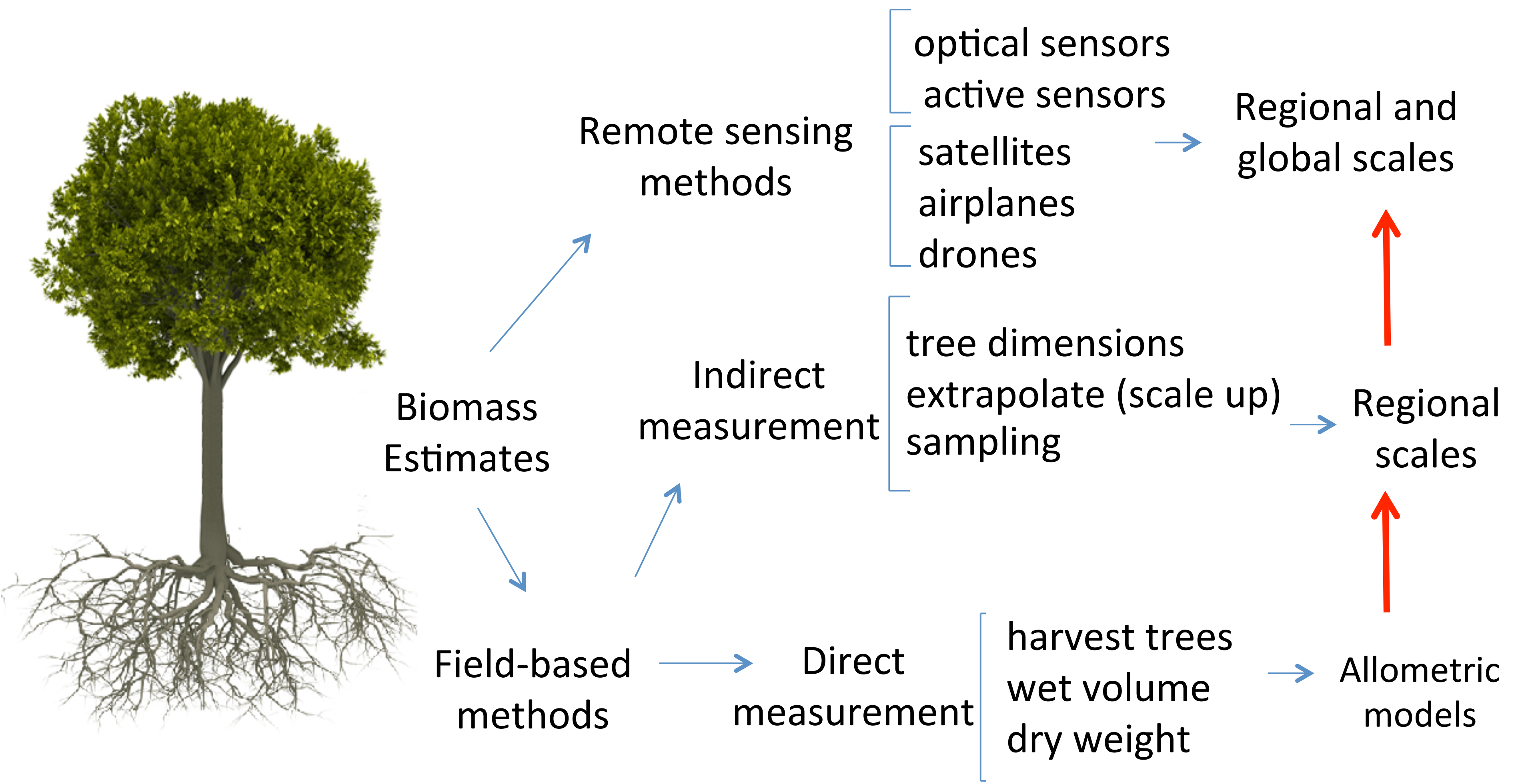
Objectives

Present a research agenda and roadmap needed to improve **monitoring of GHG fluxes and biodiversity** caused by degradation and regrowth of tropical forests.



- Evaluating changes in forests: combination of field inventories and remote sensing
- Monitoring carbon and biodiversity – need for a unified strategy
- Integrating monitoring and ecosystem modeling: move toward more process-oriented approaches

Carbon estimation methods:



Challenges and limitaitons: capacity building

Variation in countries remote sensing and national forest inventory capacities

Ronjin et al. 2009

Affects →

Global estimates
(eg. FAO-FRA and EDGAR)

Brown 1997, Grainger 2008
van der Werf et al. 2010

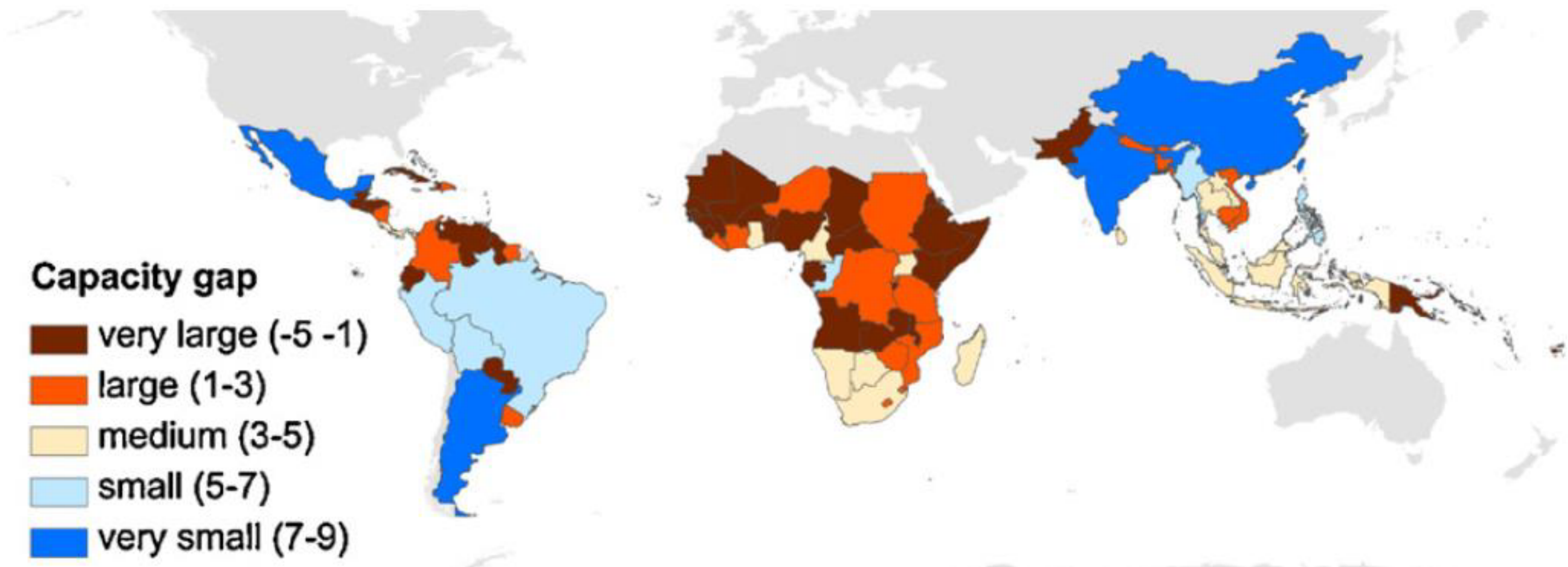


Fig. 1 – Spatial distribution of the national forest inventory capacity gap for REDD++ in 99 tropical non-Annex I countries.

Extracted from Ronjin et al. 2009

Challenges and limitations: carbon stock estimates

Most studies: limited (number, spatial distribution)

possibly biased studies

→ Many divergent biomass maps.

Houghton et al. 2001
Houghton et al. 2009
GOFC-GOLD 2013
Ometto et al. 2014
Mitchard et al. 2014

Include variation

↗ topography, soil — Ometto et al. 2014

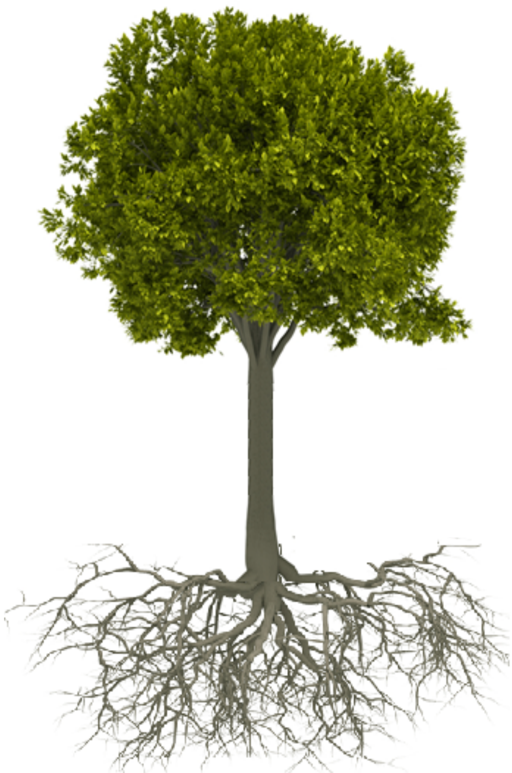
↘ wood density, allometry — Fearnside et al. 1997

Challenge:

We cannot reliably map wood density nor species assemblages from space.

Mitchard et al. 2014

Challenge : Integration of methods for Carbon estimation



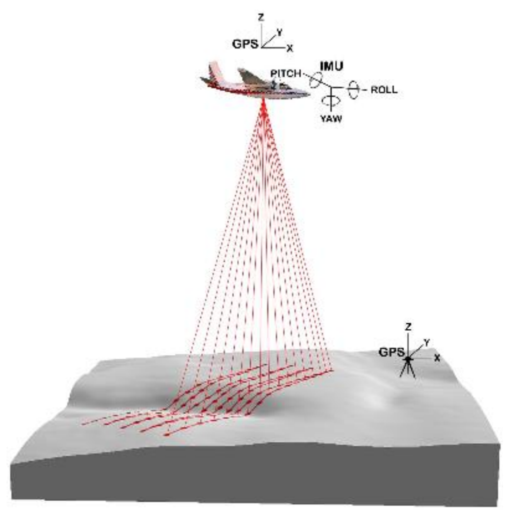
Remote sensing

- Optical sensors
- Active sensors

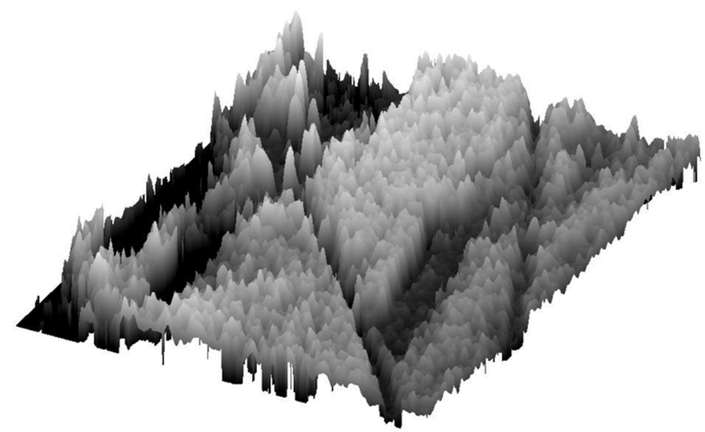
- satellites
- airplanes
- drones

→ Global and regional scales

LiDAR (laser)
Forest height
Vertical structure



Radar (microwaves, radio)
Vertical structure



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Monitoring Vegetation Biodiversity

Remote sensing has strong potential to monitor plant <u>functional traits</u> .

Homolová et al. 2013

Schimel et al. 2013

- leaf biochemistry
- photosynthetic processes
- canopy structure.
- chlorophyll content
- water content
- leaf area index

Multispectral imaging → few spectral bands

<u>Novel hyperspectral imaging</u>

Can capture reflectance in hundreds of narrow spectral bands, resolving fine spectral features associated with the chemical traits.

Goetz et al. 1985

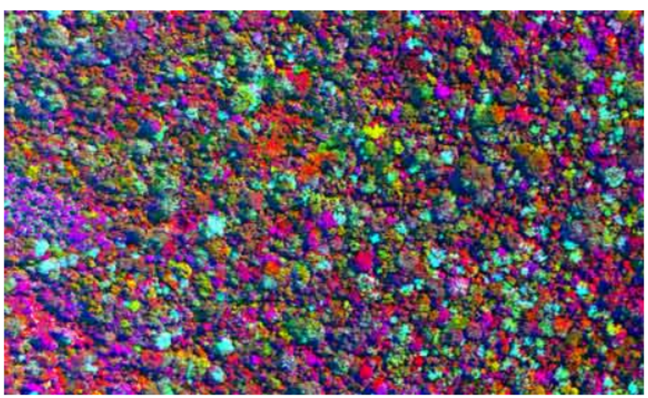


Photo: Carnegie Department of Global Ecology/Stanford University

<u>Remains a very diffcult task:</u>

Because field-based studies are limited and satellites still cannot dissect forest canopies into taxonomic maps. Asner and Martins 2009

Monitoring Animal Biodiversity

Photo by: Eduardo Rivero

Camera trapping → effective for medium-to-large animals

Bioacoustics

→ Bats (bioindicators) O'Brien et al. 2010

→ Automated digital recording for a wide range of species. Aide et al. 2014

A single protocol for all potential REDD+ sites is unrealistic because of great differences among the world's forests.

Harrisson et al. 2014

Monitoring biodiversity in larger scales is an important challenge.

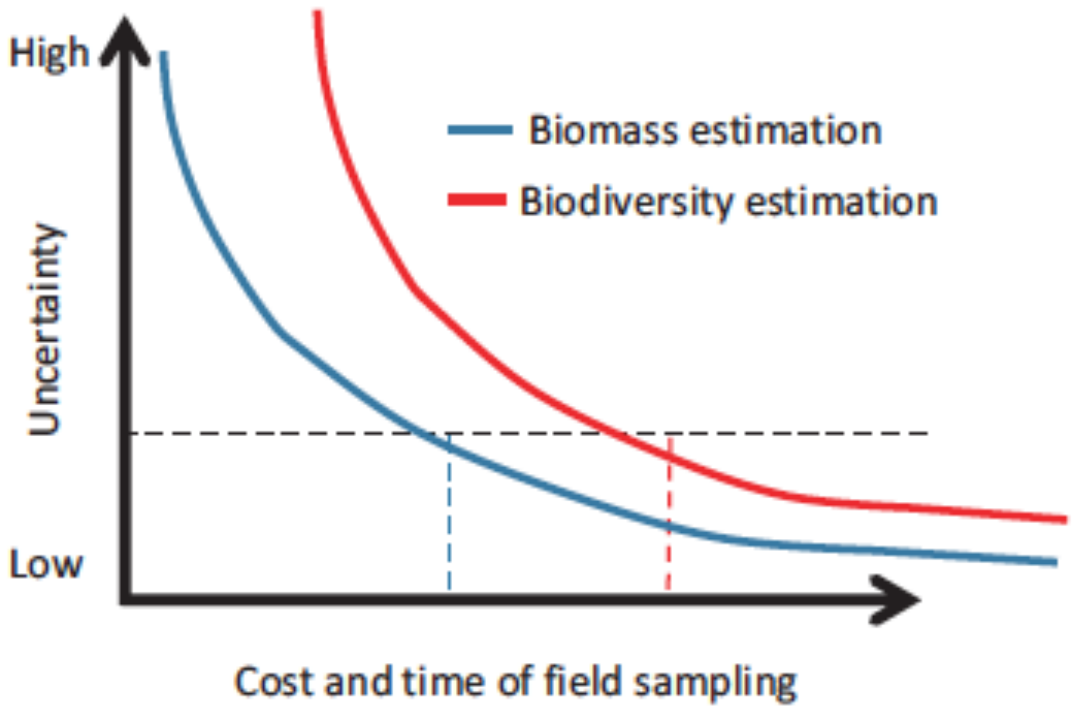
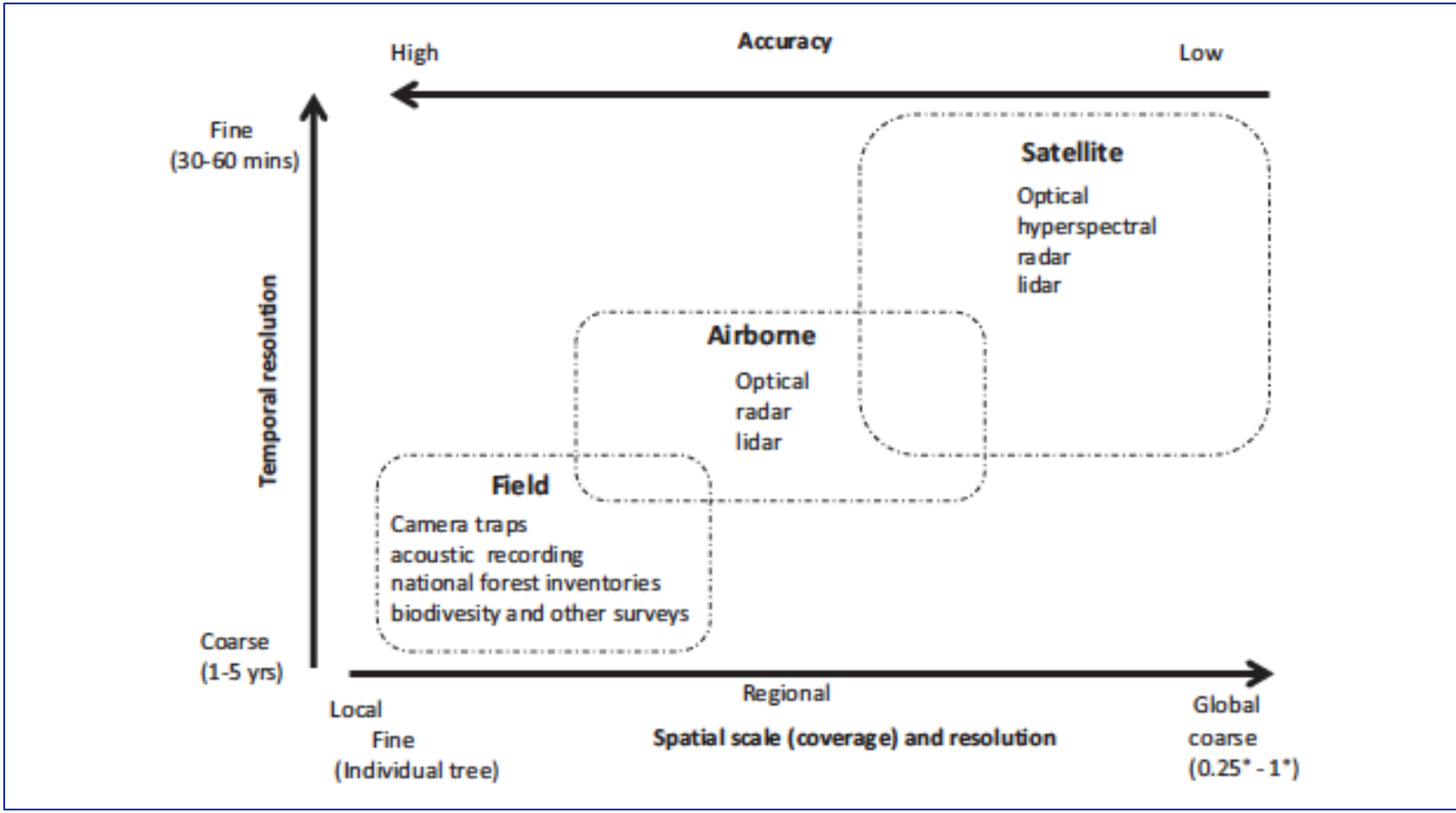


Fig. 2 Relationship between accuracy and costs and time of measuring forest carbon stocks and biodiversity.

Bustamante et al. 2016



Spatial scale and temporal resolution of different methods for monitoring forest carbon stocks and biodiversity

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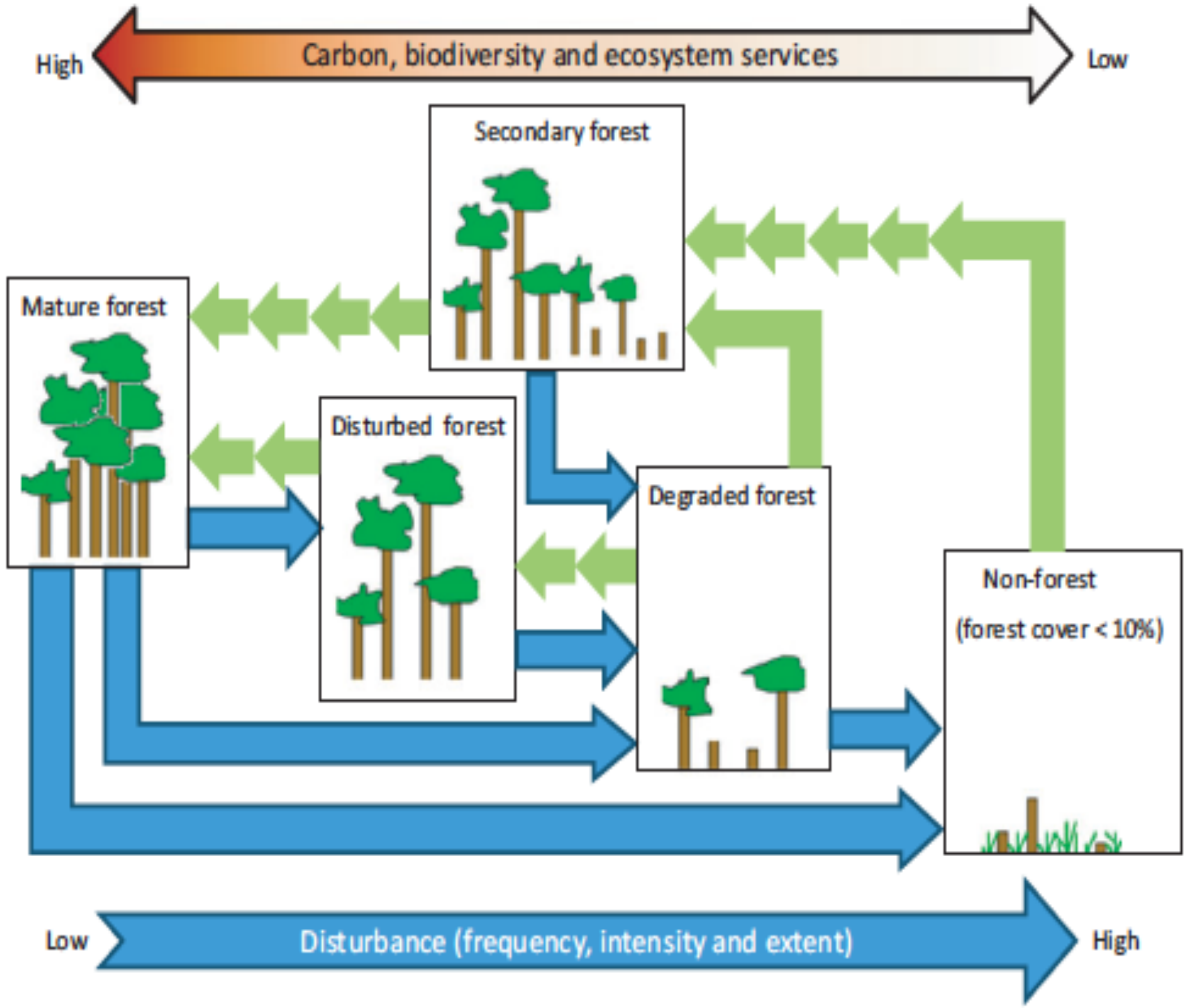
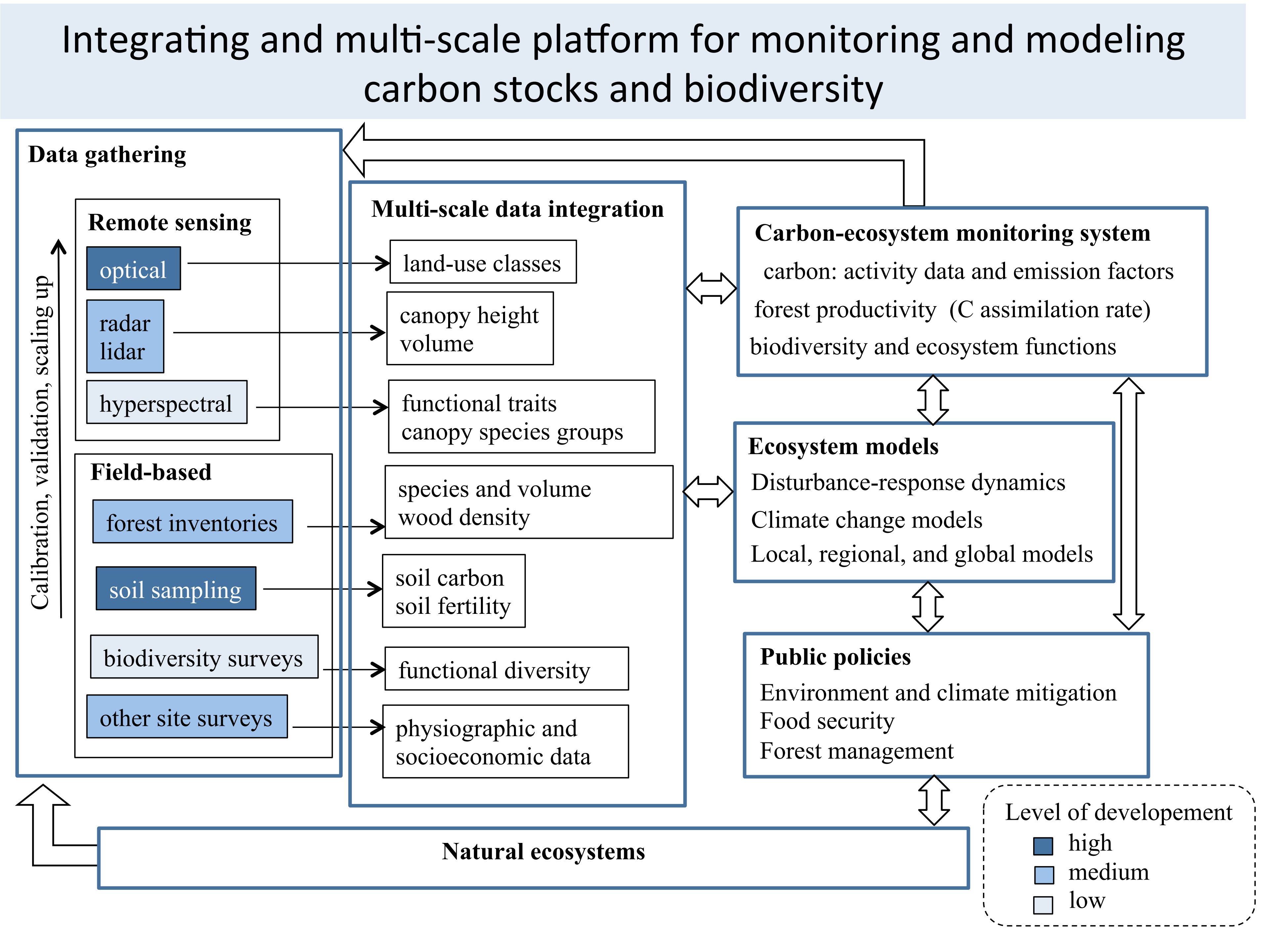


Bustamante et al. 2016

Fig. 1 Possible trajectories of forests under different levels of disturbance (intensity, frequency and extent). Blue arrows represent disturbances, and green arrows indicate regrowth of forests.



Integrating and multi-scale platform for monitoring and modeling carbon stocks and biodiversity
Data gathering
Calibration, validation, scaling up
Remote sensing
optical
radar
lidar
hyperspectral
Field-based
forest inventories
soil sampling
biodiversity surveys
other site surveys
Multi-scale data integration
land-use classes
canopy height
volume
functional traits
canopy species groups
species and volume
wood density
soil carbon
soil fertility
functional diversity
physiographic and
socioeconomic data
Carbon-ecosystem monitoring system
carbon: activity data and emission factors
forest productivity (C assimilation rate)
biodiversity and ecosystem functions
Ecosystem models
Disturbance-response dynamics
Climate change models
Local, regional, and global models
Public policies
Environment and climate mitigation
Food security
Forest management
Natural ecosystems
Level of developement
high
medium
low

Summary of research priorities and practical recommendations to help achieve an integrated framework

1. Mobilization of stakeholders and scientific community to include an integrated framework in the political agenda
2. Harmonization of national monitoring programs and existing initiatives
3. Integration and optimization of ecosystem models to improve process-level understanding carbon and forest dynamics
4. Development of a permanent plot field network to calibrate, validate, and combine multiscale sampling and monitoring methods
5. Improvement of the understanding of forest drivers and post-disturbance trajectories
6. Inclusion of parameters related to forest fire drivers and impacts in a monitoring program
7. Evaluation of biodiversity and carbon values under a unified strategy

Thank you