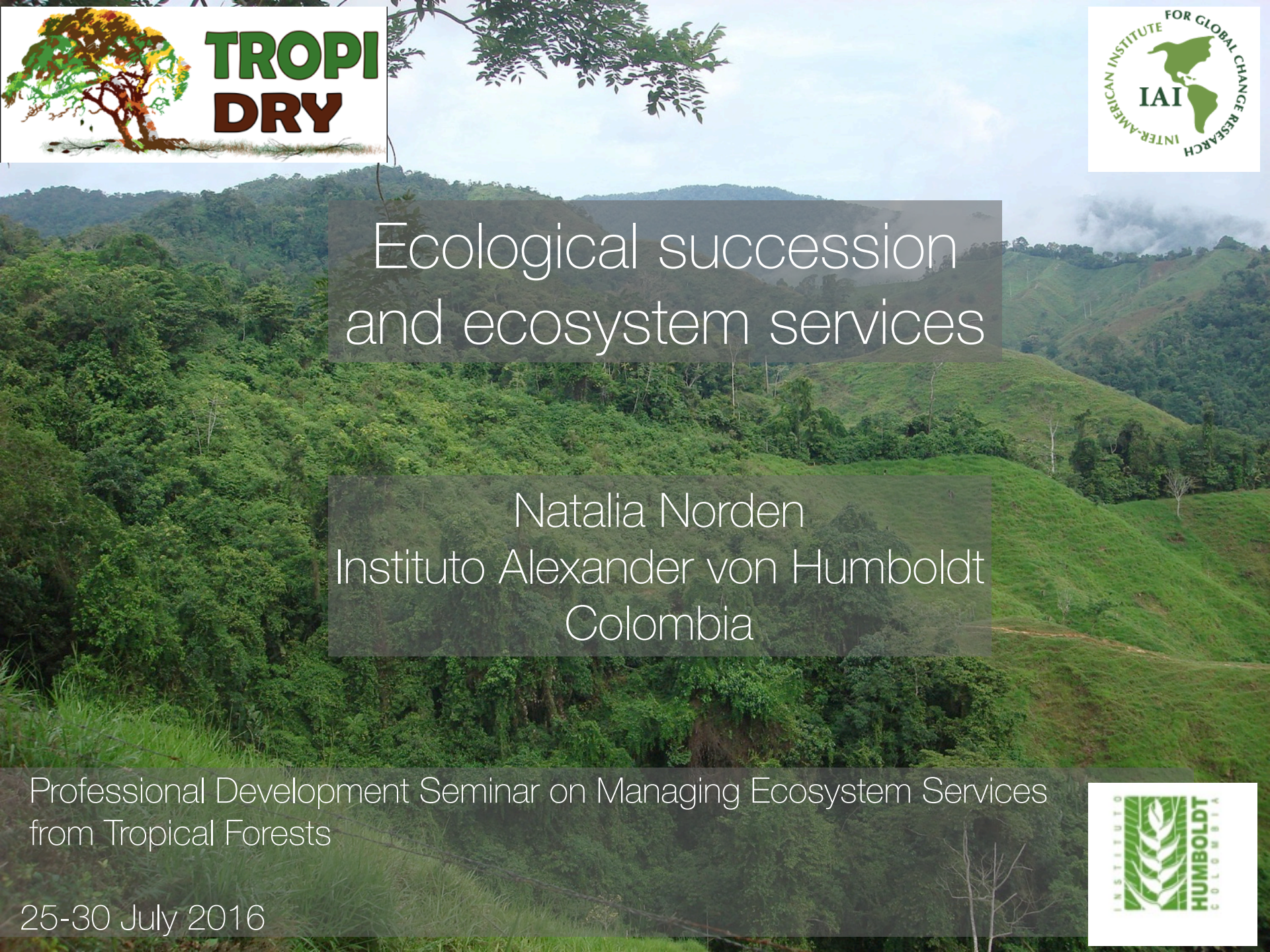


Ecological succession and ecosystem services

Natalia Norden
Instituto Alexander von Humboldt
Colombia

Professional Development Seminar on Managing Ecosystem Services from Tropical Forests

25-30 July 2016

French Guiana

Photo: Natalia Norden

definition

Temporal change observed in a community after a disturbance, where the sequential replacement of pioneer species by shade-tolerant species drive the system to a stable, equilibrium state

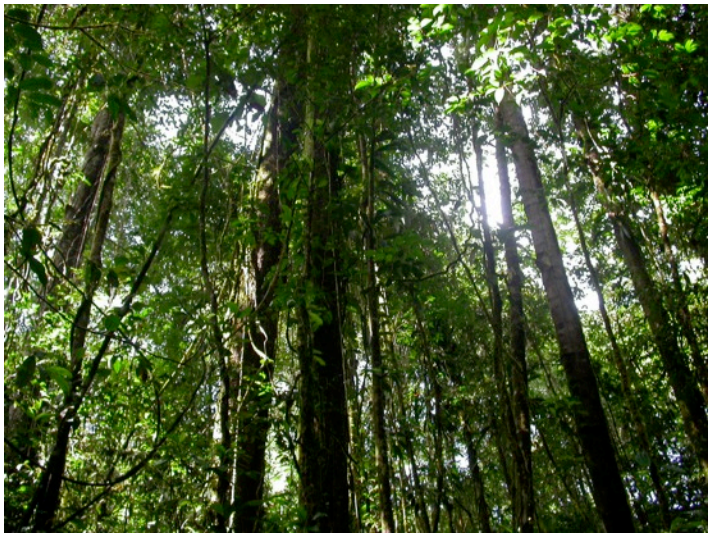
Changes in species abundance over time predicted by life history attributes

classical model of succession

succession

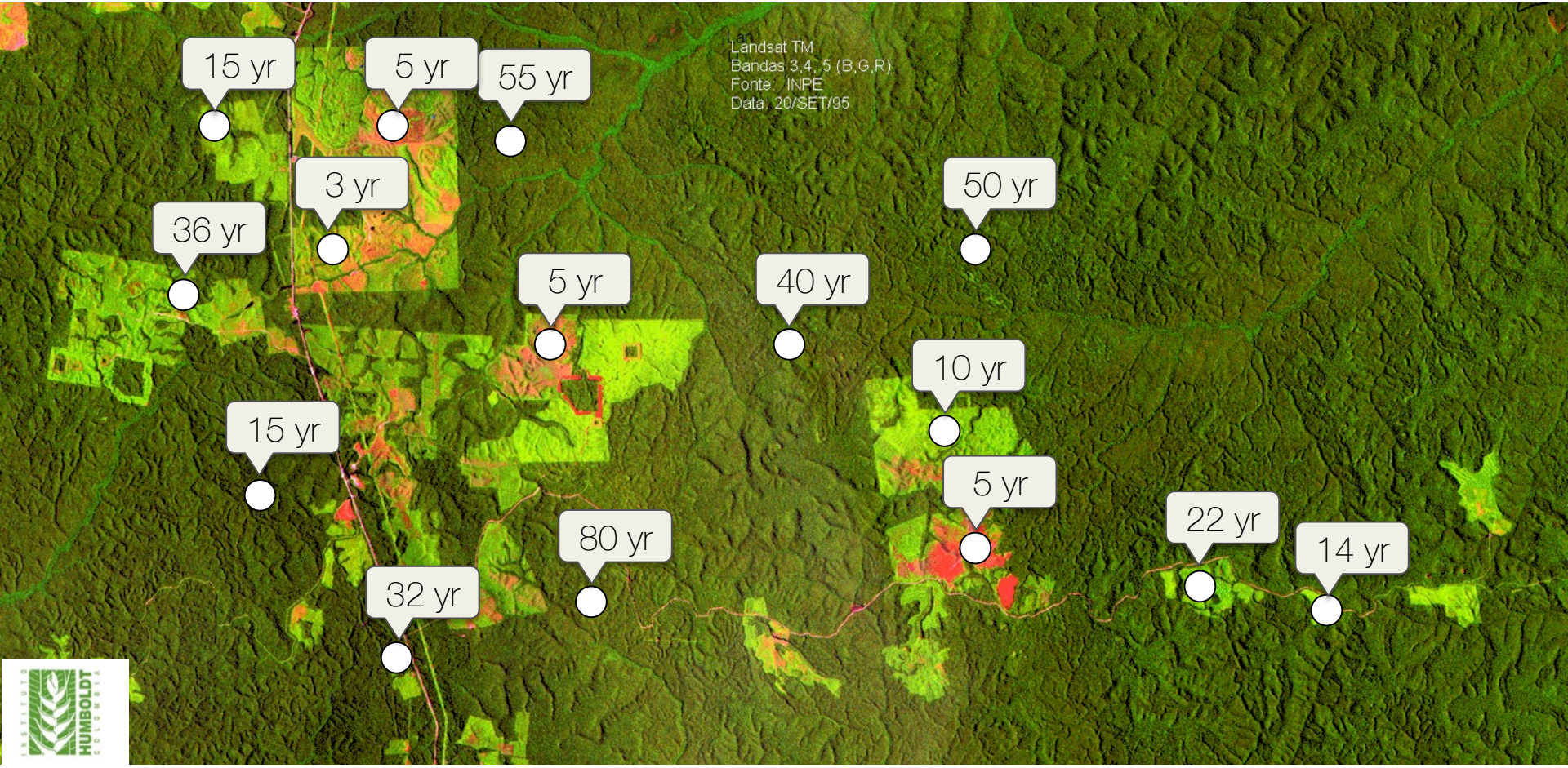
- high growth rates
- short lifespan
- low survival in the understorey

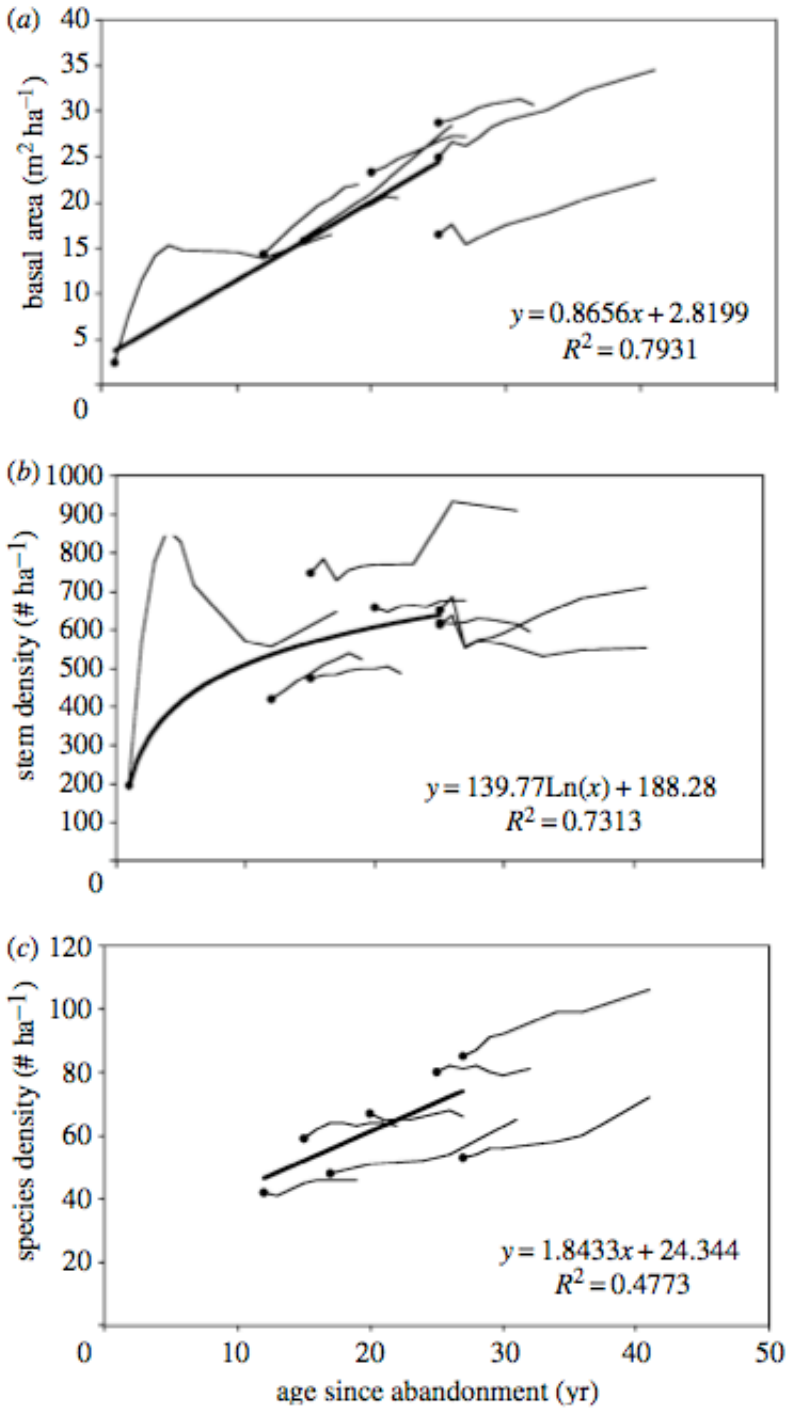
- low growth rates
- long lifespan
- high survival in the understorey



succession viewed as a deterministic process

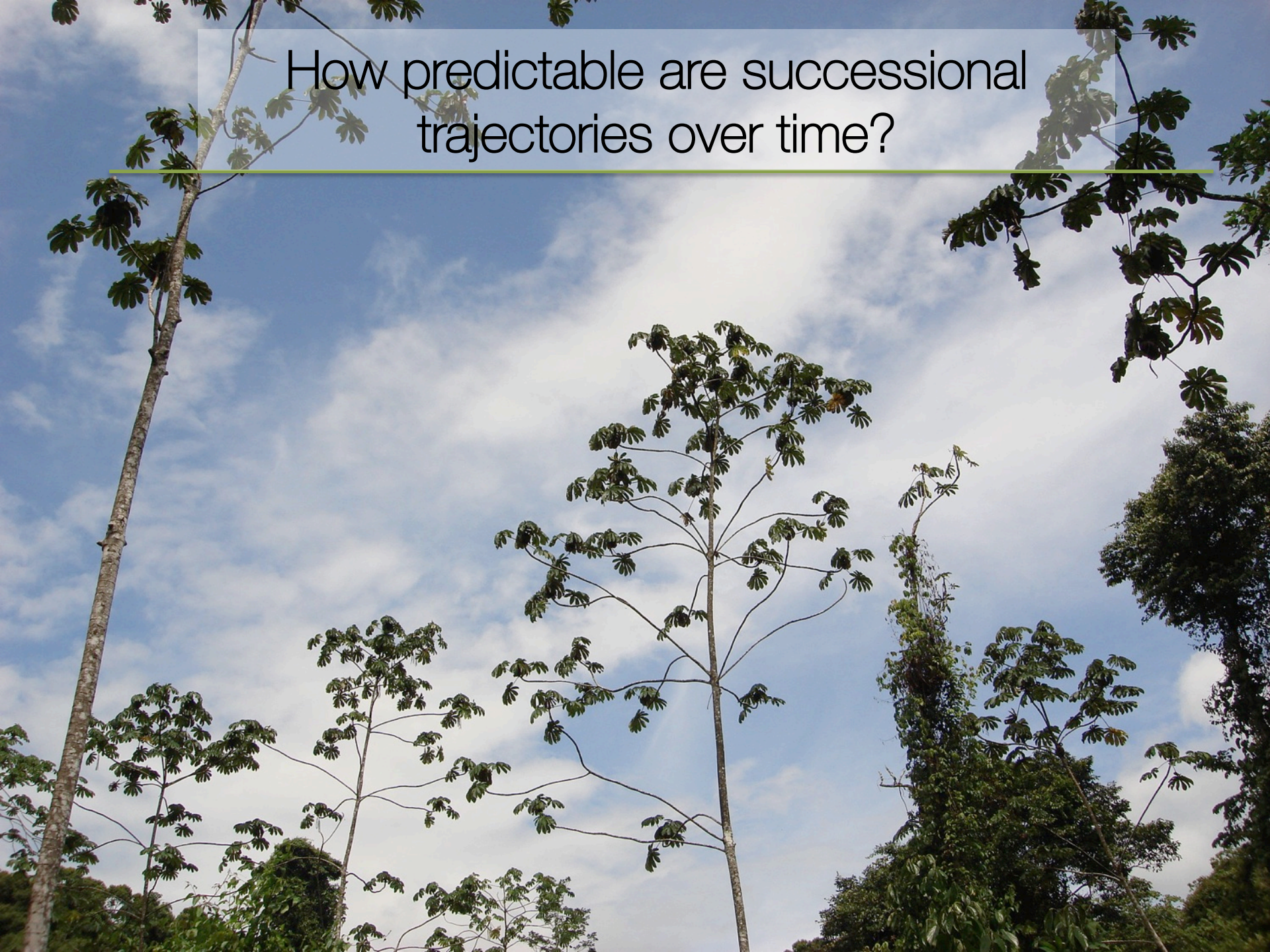
Chronosequence: space-time replacement where temporal changes are inferred from a single time investigation of a set of forest stands of different ages since disturbance





How can we evaluate variability among successional trajectories to estimate rates of change in secondary forests?

Chazdon et al. 2007 *PTRS B*


How predictable are successional trajectories over time?

Mexico wet (agriculture):
11 0.05-ha plots
10+ yrs of census data
initial stand age: 1-17 yrs

Mexico dry (agriculture):
14 0.04-ha plots
3+ yrs of census data
initial stand age: 3-60 yrs

Brazil:
28 transects 0.025-0.06 ha
10+ yrs of census data
initial stand age: 2-19 yrs

Nicaragua (hurricane):
17 0.05-ha plots
10+ yrs of census data
initial stand age: 1-17 yrs

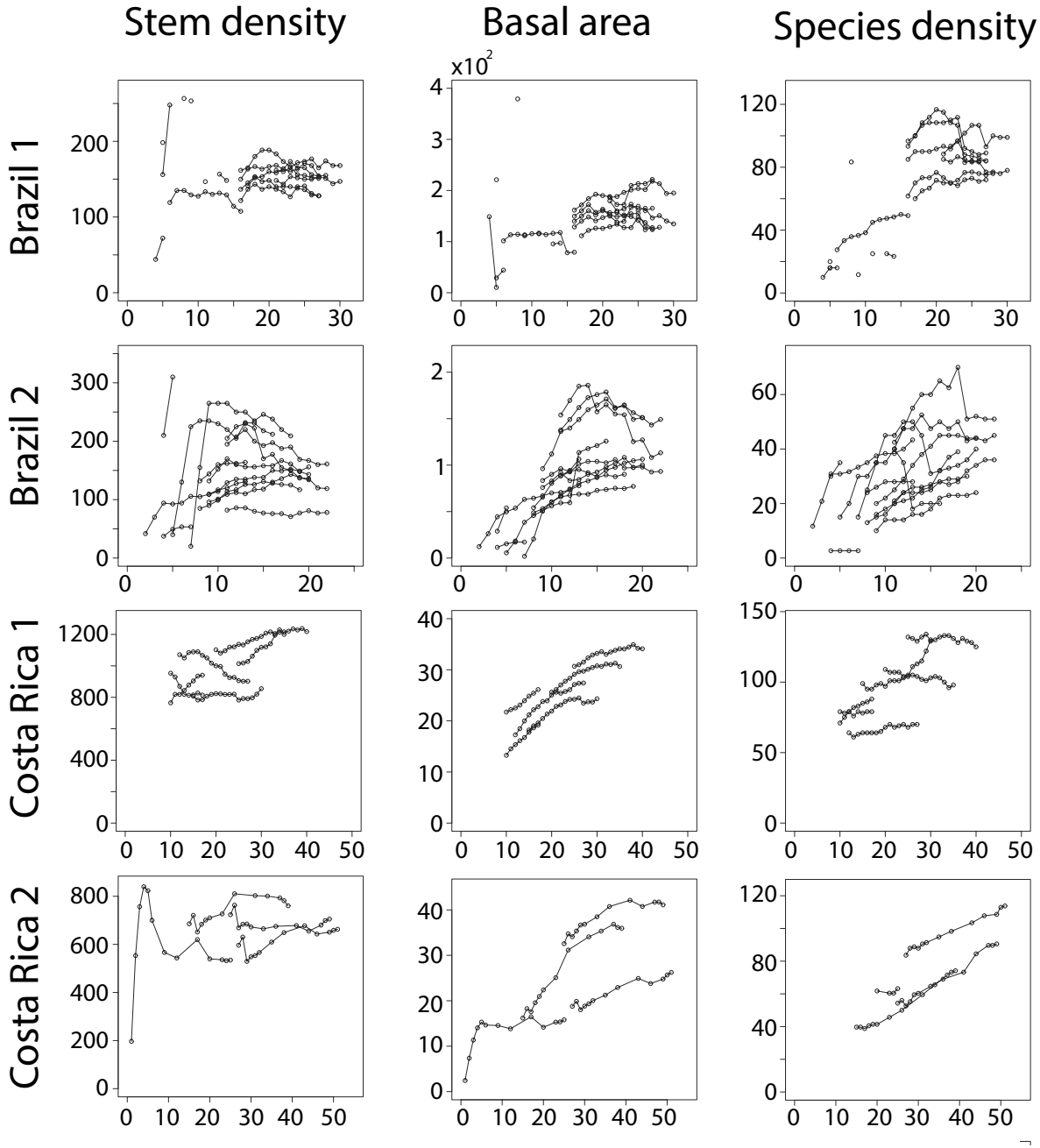
Vismia transects (pasture)

Cecropia transects (clearcut)

Costa Rica 1 (pasture):
6 1-ha plots plots
15+ yrs of census data
initial stand age: 10-25 yrs

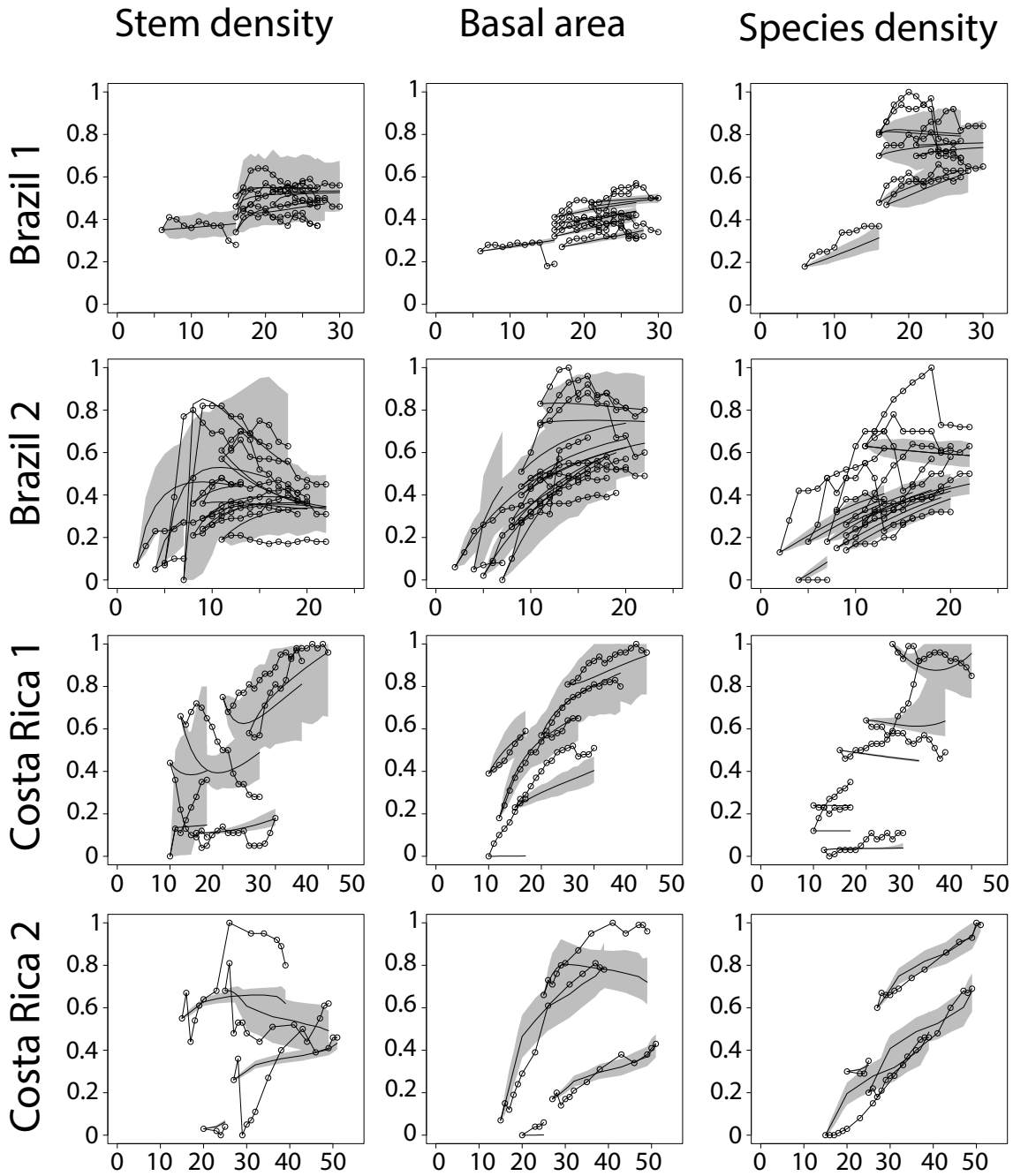
Costa Rica 2 (clearcut):
4 1.16-ha plots
25+ yrs of census data
initial stand age: 1-25 yrs

www.neoselvas.org



multi-site comparison
meta-analysis

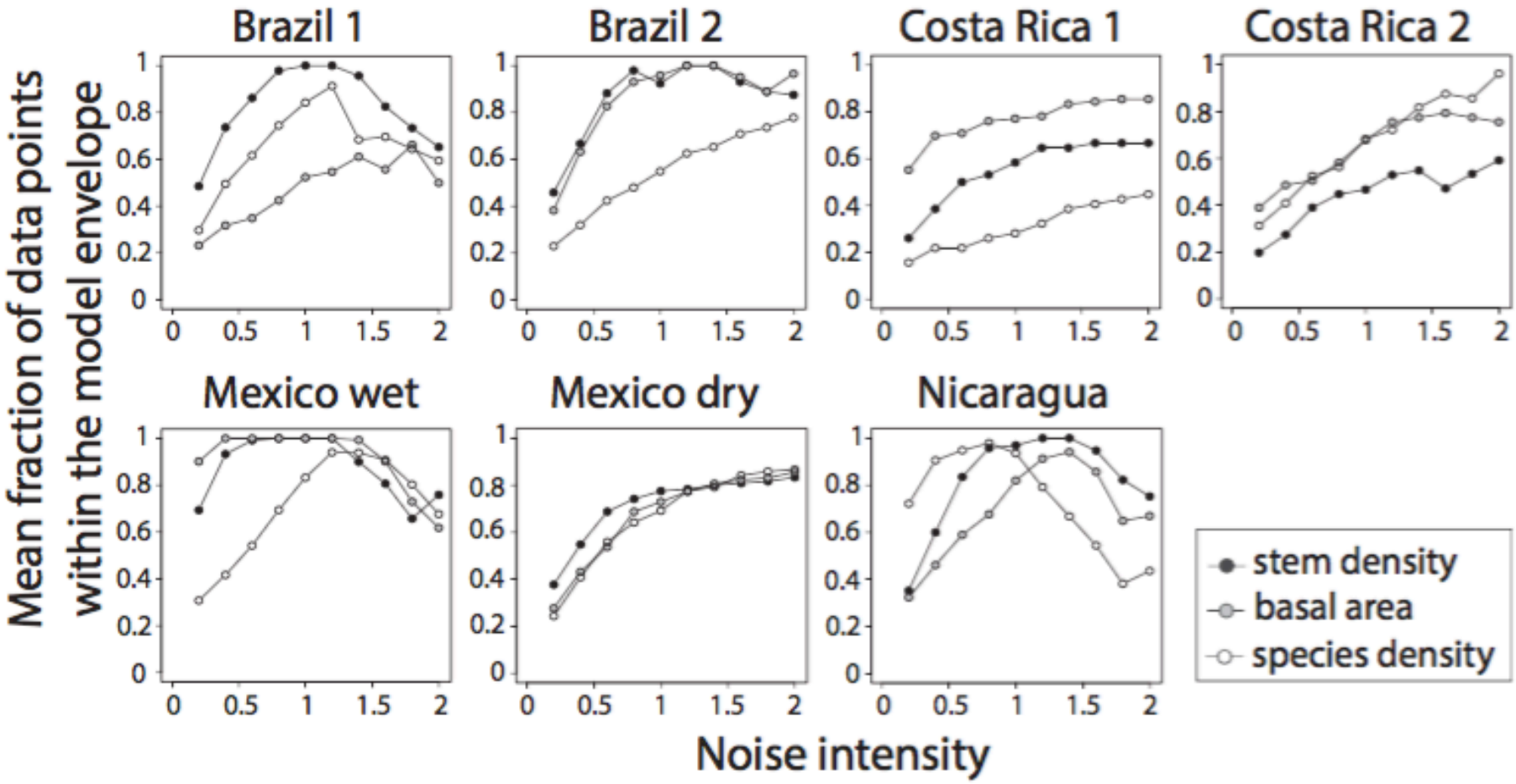
Norden et al. 2015 *PNAS*



high levels of uncertainty

Norden et al. 2015 *PNAS*

uncertainty



Norden et al. 2015 *PNAS*

general conclusions

Successional trajectories highly idiosyncratic

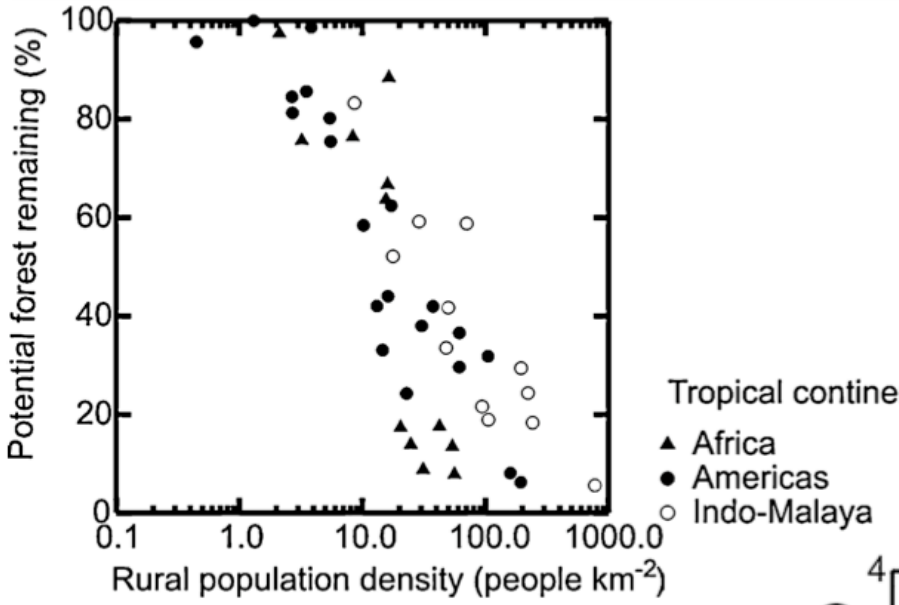
Predictability did not show consistent trends across forest attributes, sites or land-use history

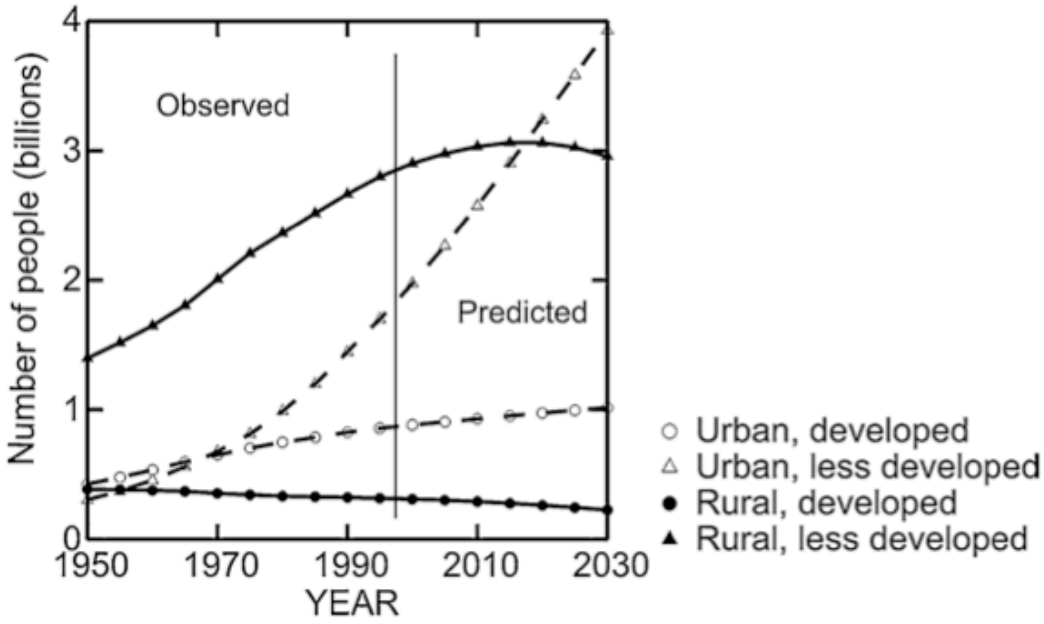
Complexity of site factors and their association with land use challenge our ability to predict succession

Deterministic factors that have not been included?
→ too many “unknown unknowns”

What is the regeneration potential of secondary forests?

future of tropical forests





Wright & Muller-Landau, 2006, *Biotropica*

controversy: real value of secondary forests?

The Future of Tropical Forest Species[1]

S. Joseph Wright[2]
Smithsonian Tropical Rese
and
Helene C. Muller-Landau
Department of Ecology, Ev

"… most secondary forests (…) have the potential to attain a structure and species compostion similar to primary forests in the long term (…)'

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Predicting the Uncertain Future of Tropical Forest Species in a Data Vacuum

Toby A. Gardner[1,4], Jos Barlow[1,2], Luke W. Parry[1,3], and Carlos A. Peres[1]

"We challenge the validity of this assumption (…). We believe that [these] optimistic predictions undermine the importance of [maintaining existing primary forests reserves]'

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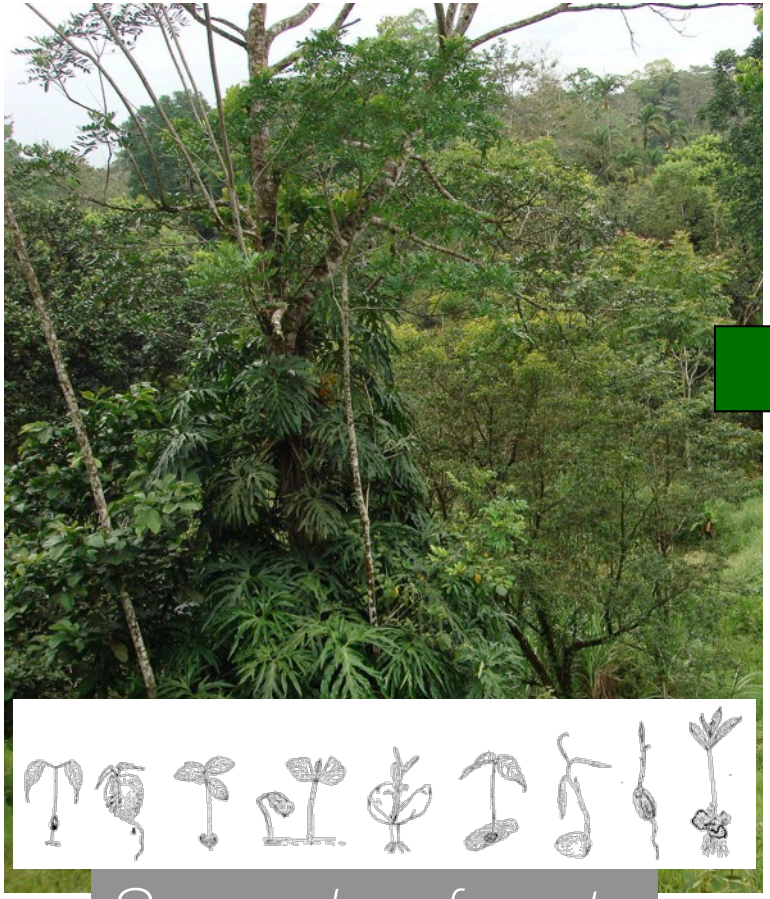
Momentum Drives the Crash: Mass Extinction in the Tropics[1]

Barry W. Brook[2], Corey J. A. Bradshaw
School for Environmental Research, Charles
Lian Pin Koh
Department of Ecology and Evolutionary Bio
and
Navjot S. Sodhi
Department of Biological Sciences, National

'(…) secondary forests represent a depauperate community with a reduction or loss of ecosystems services.'

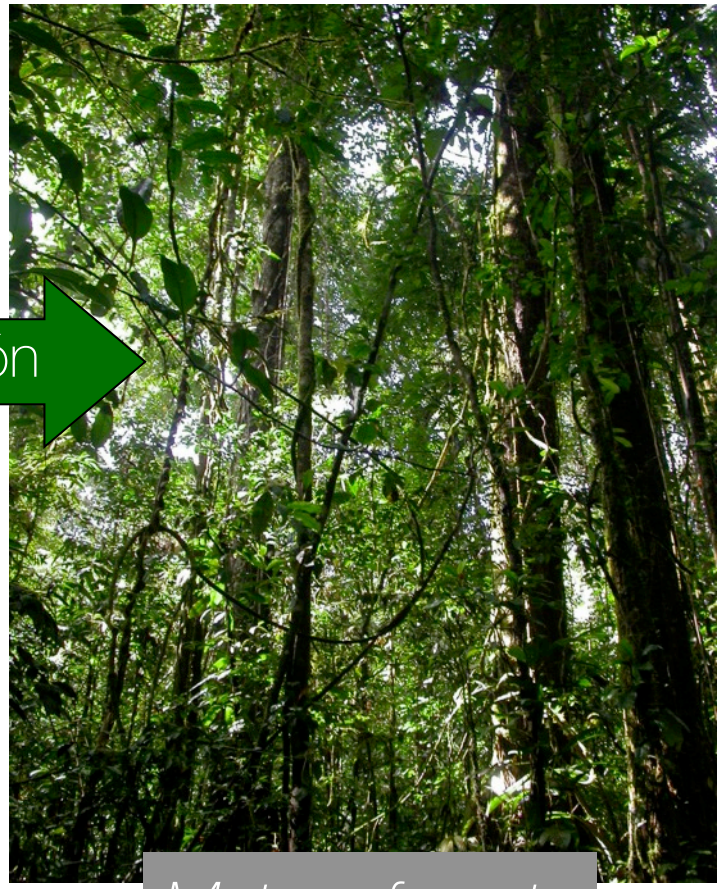
regeneration potential of secondary forests?



Secondary forests

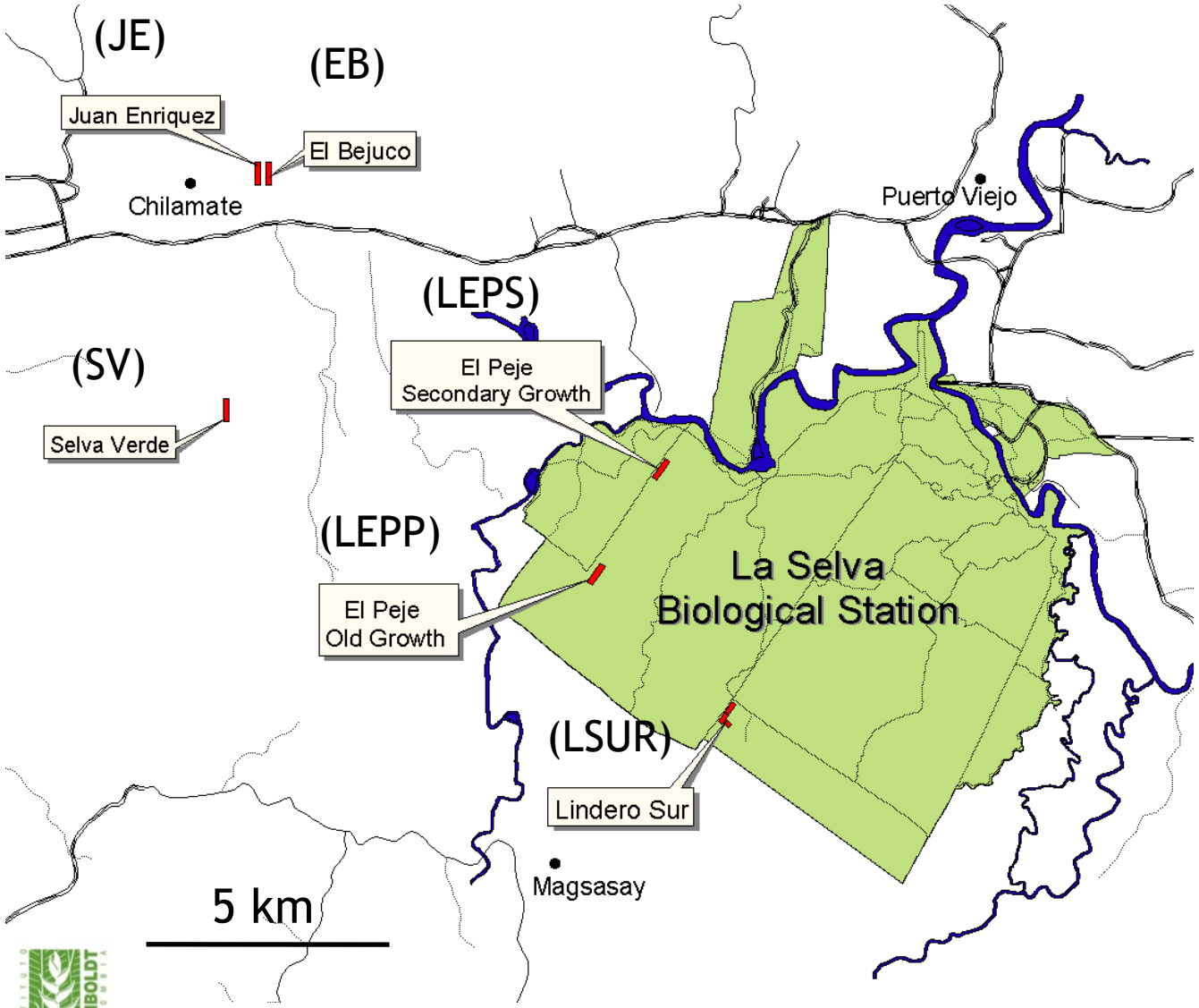
?

Sucesión



Mature forests

case study I: Costa Rica

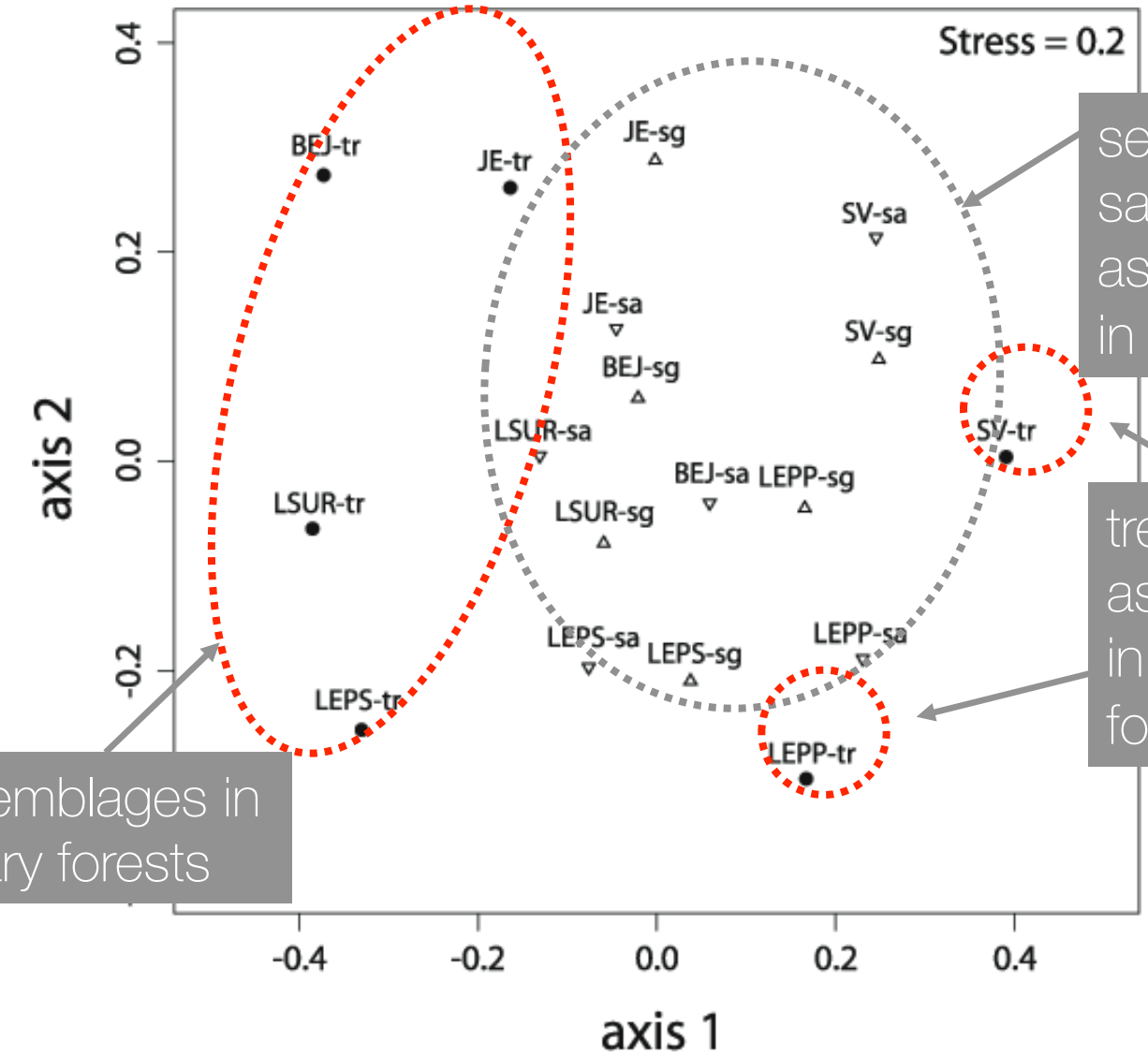


JE & EB:
young

LEPS & LSUR:
intermediate

LEPP & SV:
mature

case study I: Costa Rica



seedling and sapling assemblages in all forests

tree assemblages in mature forests

tree assemblages in secondary forests

tr = tree
sa = sapling
sg = seedling

Norden *et al*. 2009 *Ecology Letters*

case study I: Costa Rica

➔ natural regeneration is an excellent tool to infer successional trajectories over time

➔ three key factors:

- presence of old-growth forest remnants
- high abundance of generalist species in the regional flora
- high levels of seed dispersal

BEST CASE SCENARIO



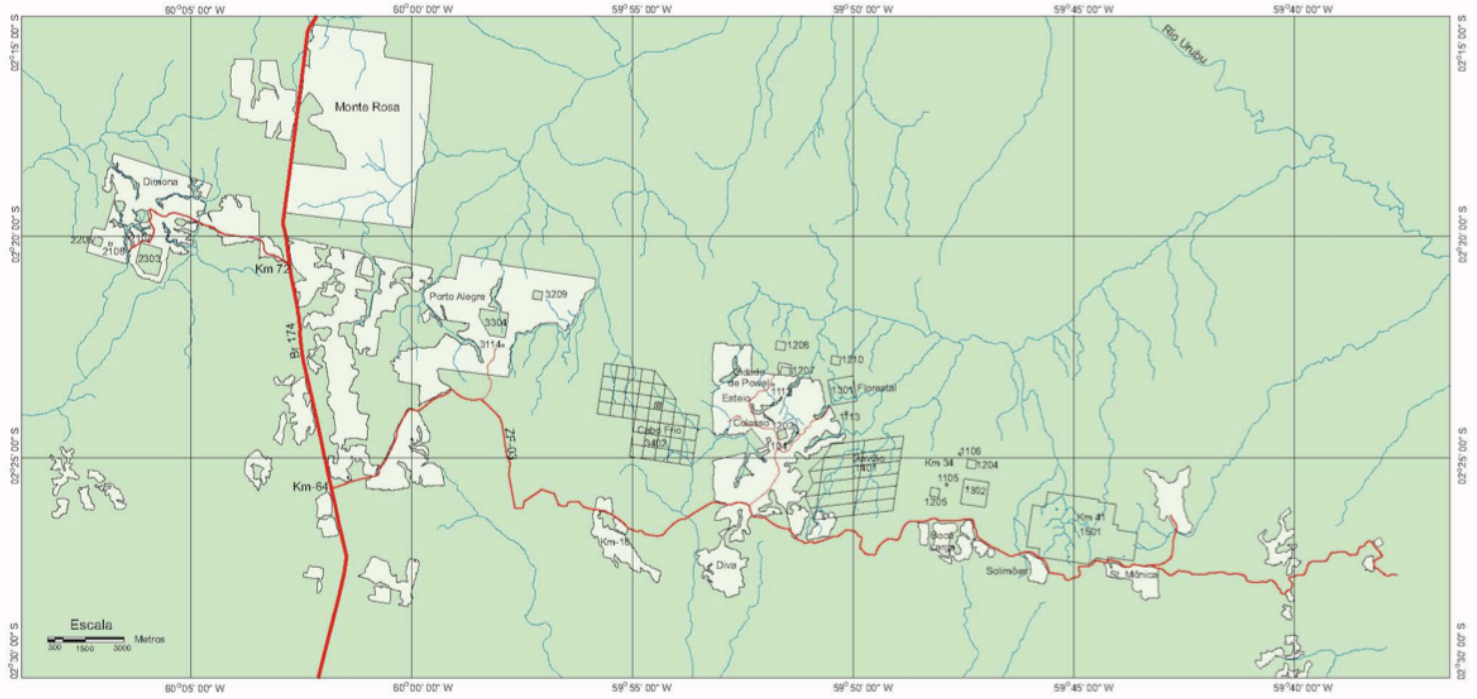
case study II: Brazil

Journal of Ecology 2001
89, 528–537

Alternative successional pathways in the Amazon Basin

RITA C.G. MESQUITA*, KALAN ICKES*†, GISLENE GANADE‡ and G. BRUCE WILLIAMSON*†

Reservas do Projeto Dinâmica Biológica de Fragmentos Florestais

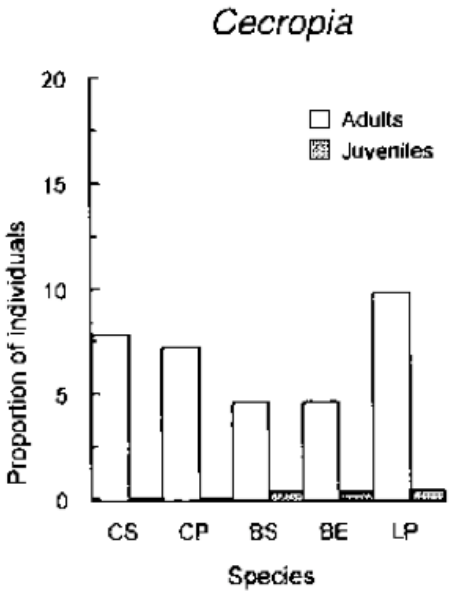


Legenda

Fonte: INPE Landsat TM 5,4,3 - RGB, 1995. Elaborado em junho de 1998 por Venticinque, E. M. and Fernandes, T. L. N.

case study II: Brazil

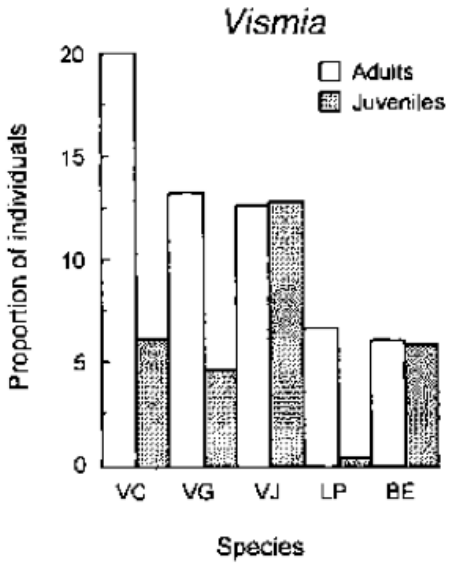
When no burning:
Classic successional trajectory
→ initial dominance of *Cecropia*
→ *low* recruitment of *Cecropia*



Mesquita *et al*. 2001 *Journal of Ecology*

case study II: Brazil

When burning:
Arrested succession
→ initial dominance of *Vismia spp*
→ ***high*** recruitment of *Vismia*



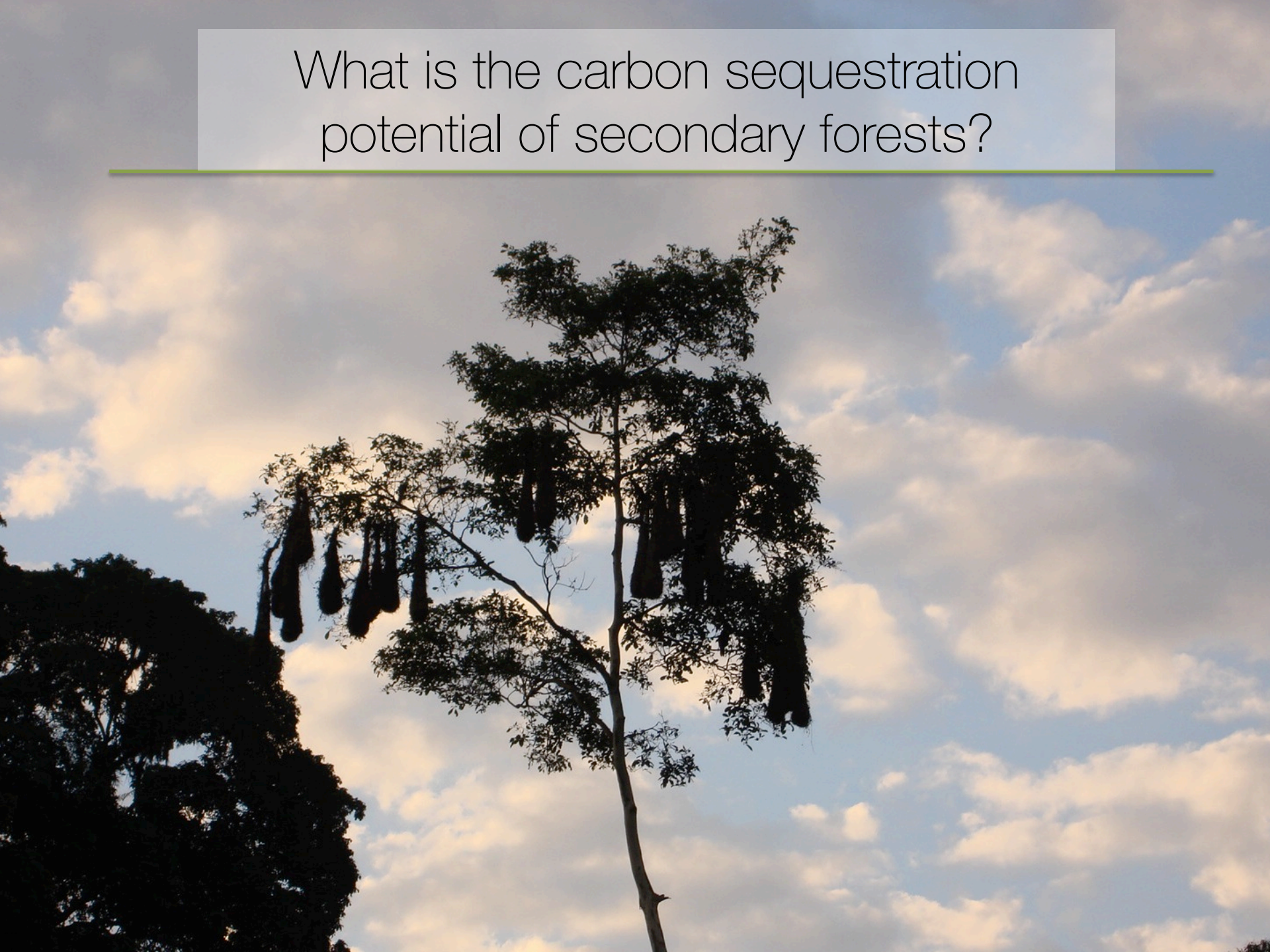
Mesquita *et al*. 2001 *Journal of Ecology*

general conclusions

Successional trajectory determined by the regeneration potential of a stand

→ previous land use
→ seed dispersal assemblage
→ regional species pool

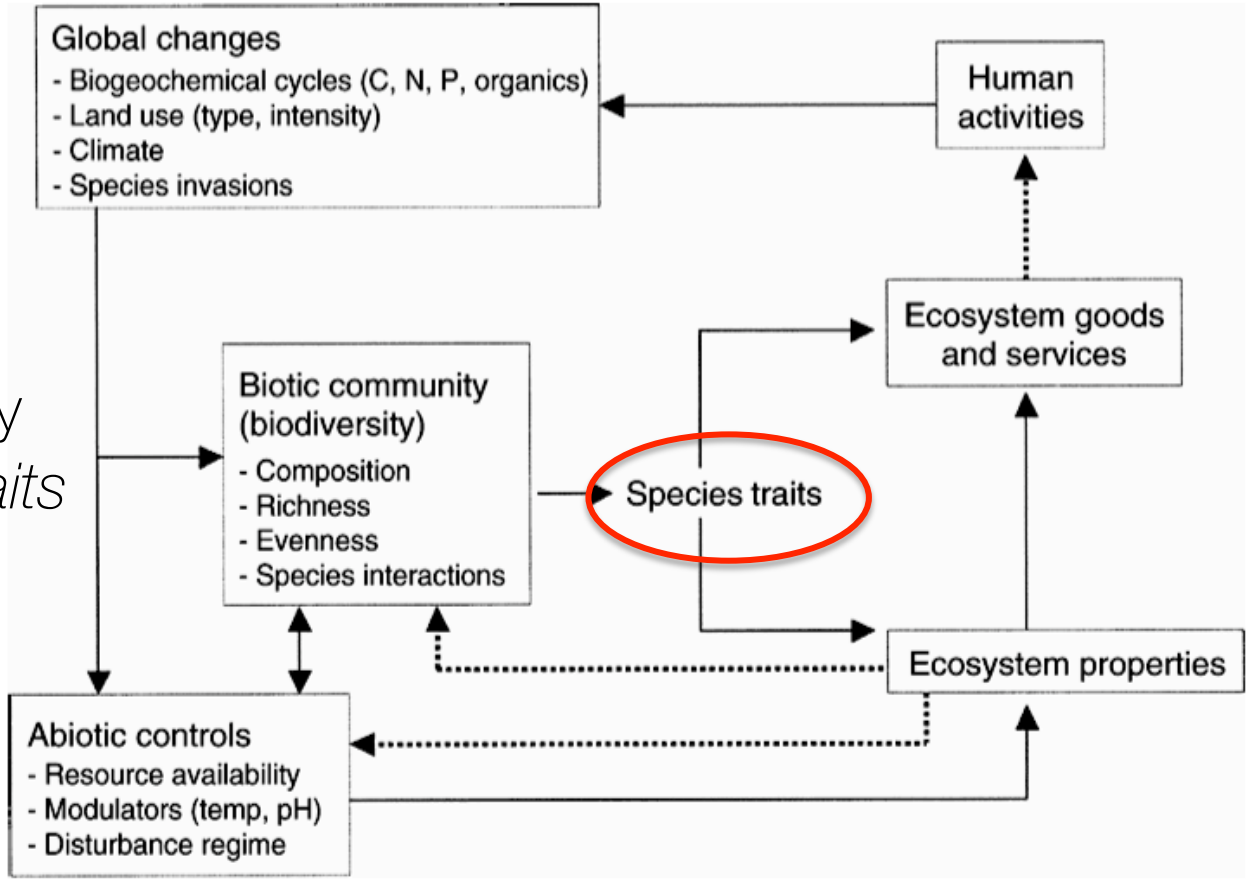
What is the carbon sequestration potential of secondary forests?



How do forests respond to climate change?

link between traditional view in community ecology and ecological processes?

→ shift from ecology based on *species composition* to ecology based on *functional traits*



Hooper et al. 2005 *Ecology*

functional traits

A functional trait is any characteristic morphological, physiological or phenological, measurable at the individual level, from the cell to the level of the whole organism, independently of environment

FT determine species responses to environmental variation, and have effects on ecosystem functioning

which are the key variables to measure?

$$AGB = F\left(\rho\left(\frac{\pi D^2}{4}\right)H\right)^{\beta}$$

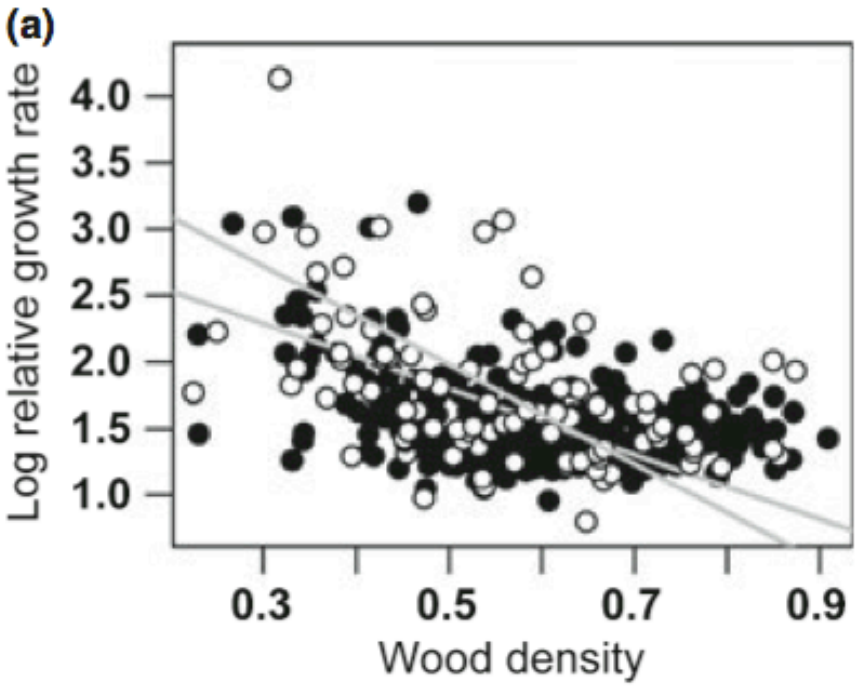
trunk shape

wood density

basal area

height

Chave *et al.* 2005 *Oecologia*



succession

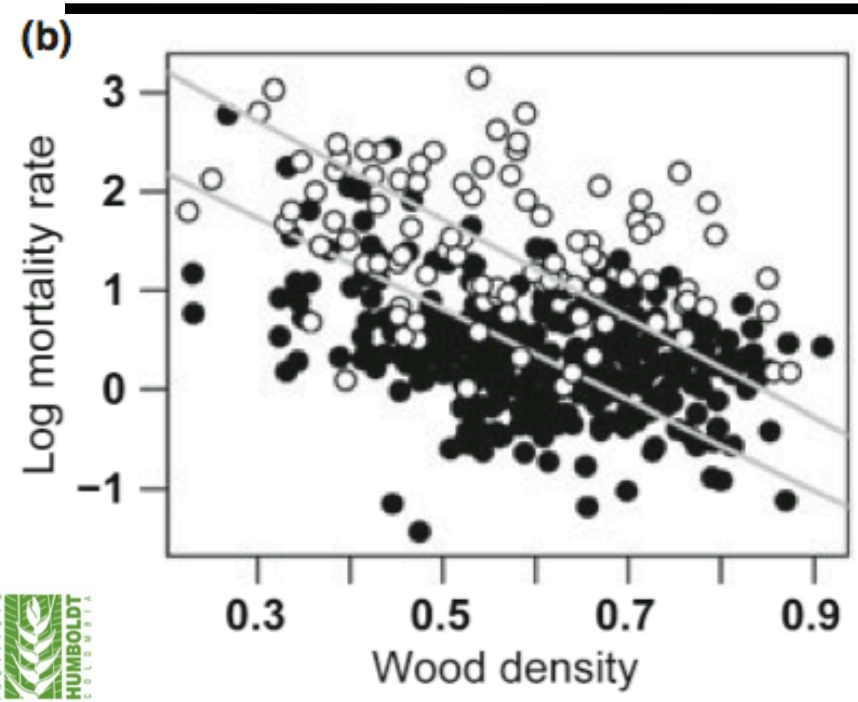
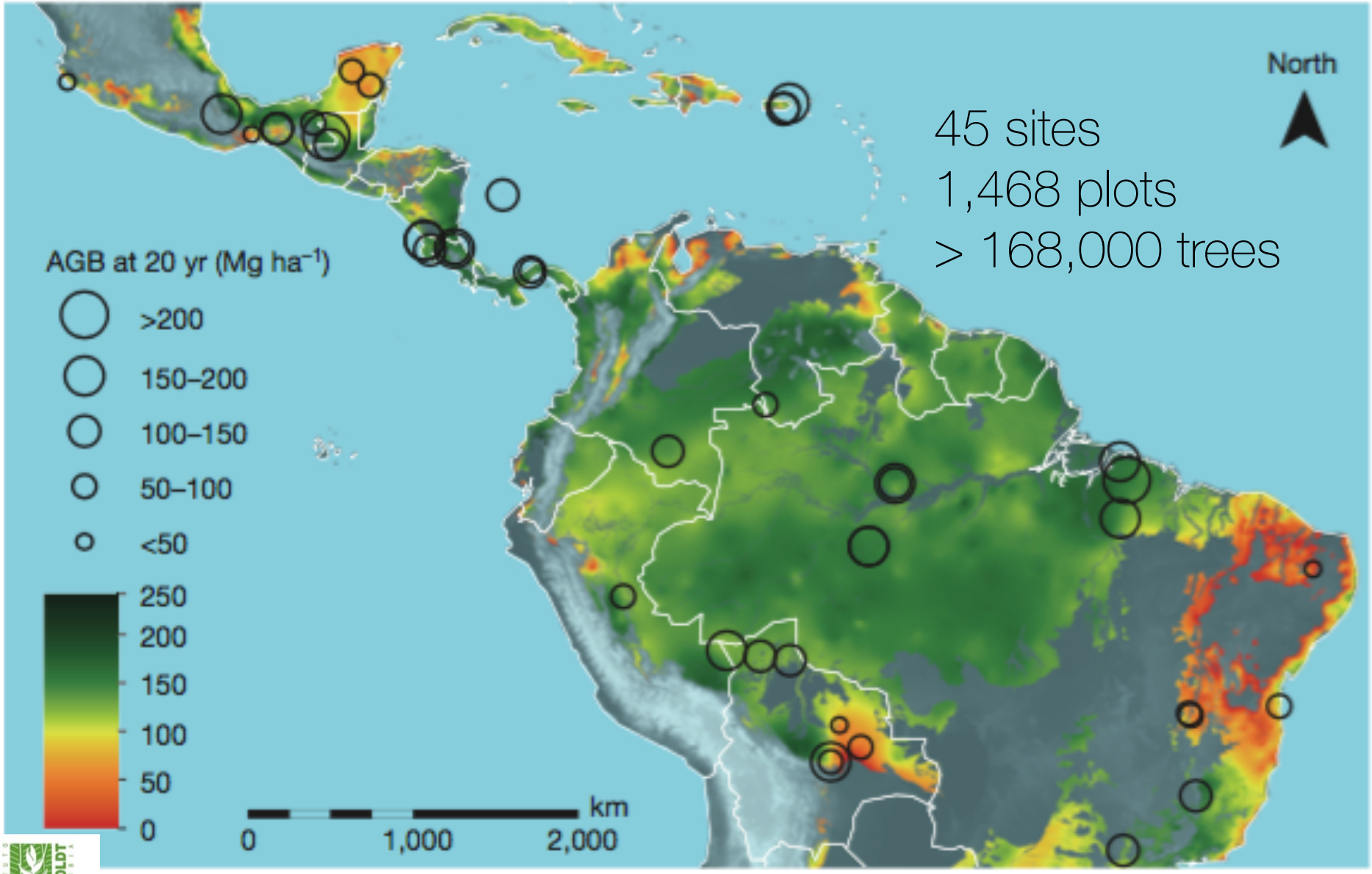


Figure 5 Relationship between wood density and relative growth rate (log-transformed, a), and mortality rate (log-transformed, b), for two tropical forest sites (Barro Colorado Island, Panama, white circles, and Pasoh, Malaysia, black circles). All correlations were highly significant ($P < 0.001$), and the correlation coefficients ranged between $r^2 = 0.13$ and 0.19. Demographic data were collected from saplings 1–5 cm in diameter under the auspices of the Center for Tropical Forest Science (see Chave *et al.* 2008, and Appendix 6).

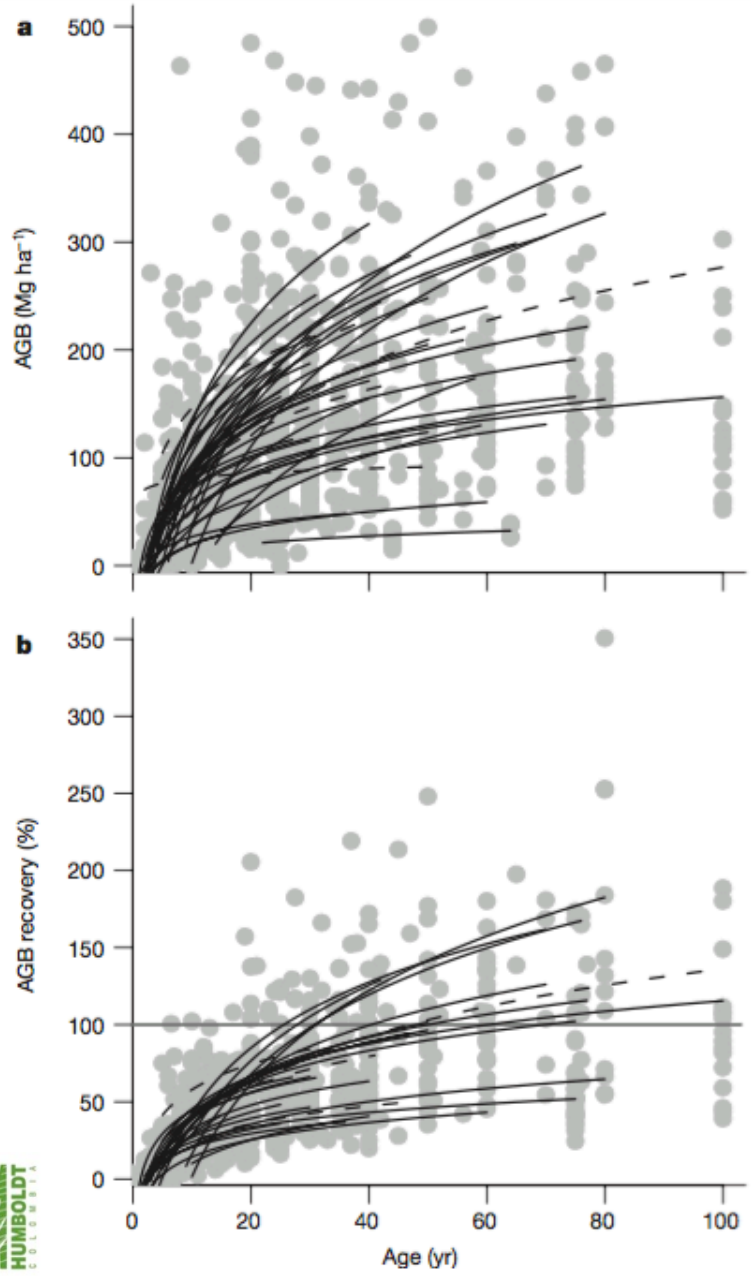
Chave *et al.* 2009 *Ecology Letters*

biomass resilience



Poorter et al. 2016. *Nature*

biomass accumulation

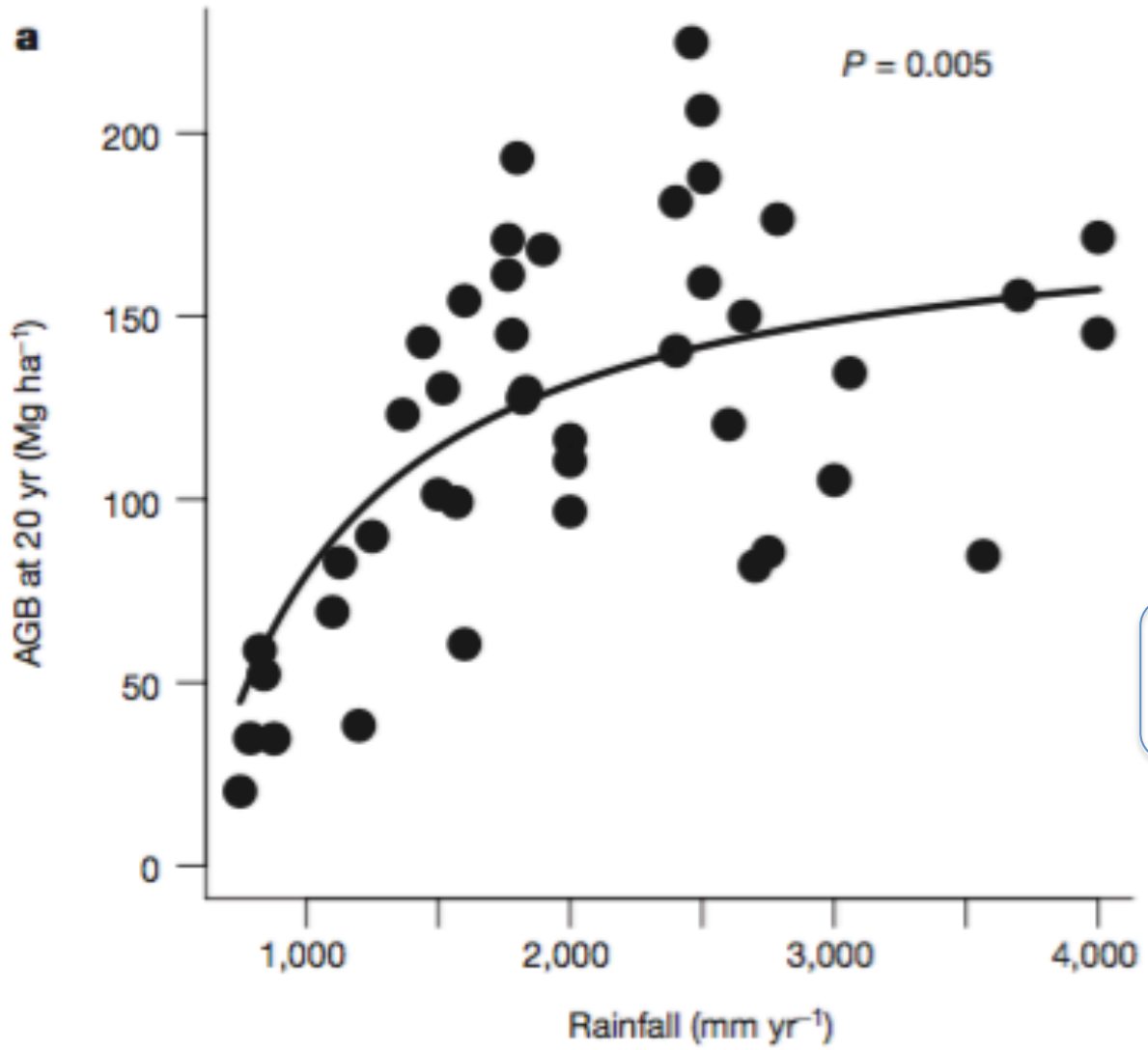


20-225 Mg C/ha after 20 yrs
average of 3.05 Mg C/ha/yr
→ rates 11 times higher than mature forests

in some sites, relative recovery higher than in mature forests

Poorter et al. 2016. *Nature*

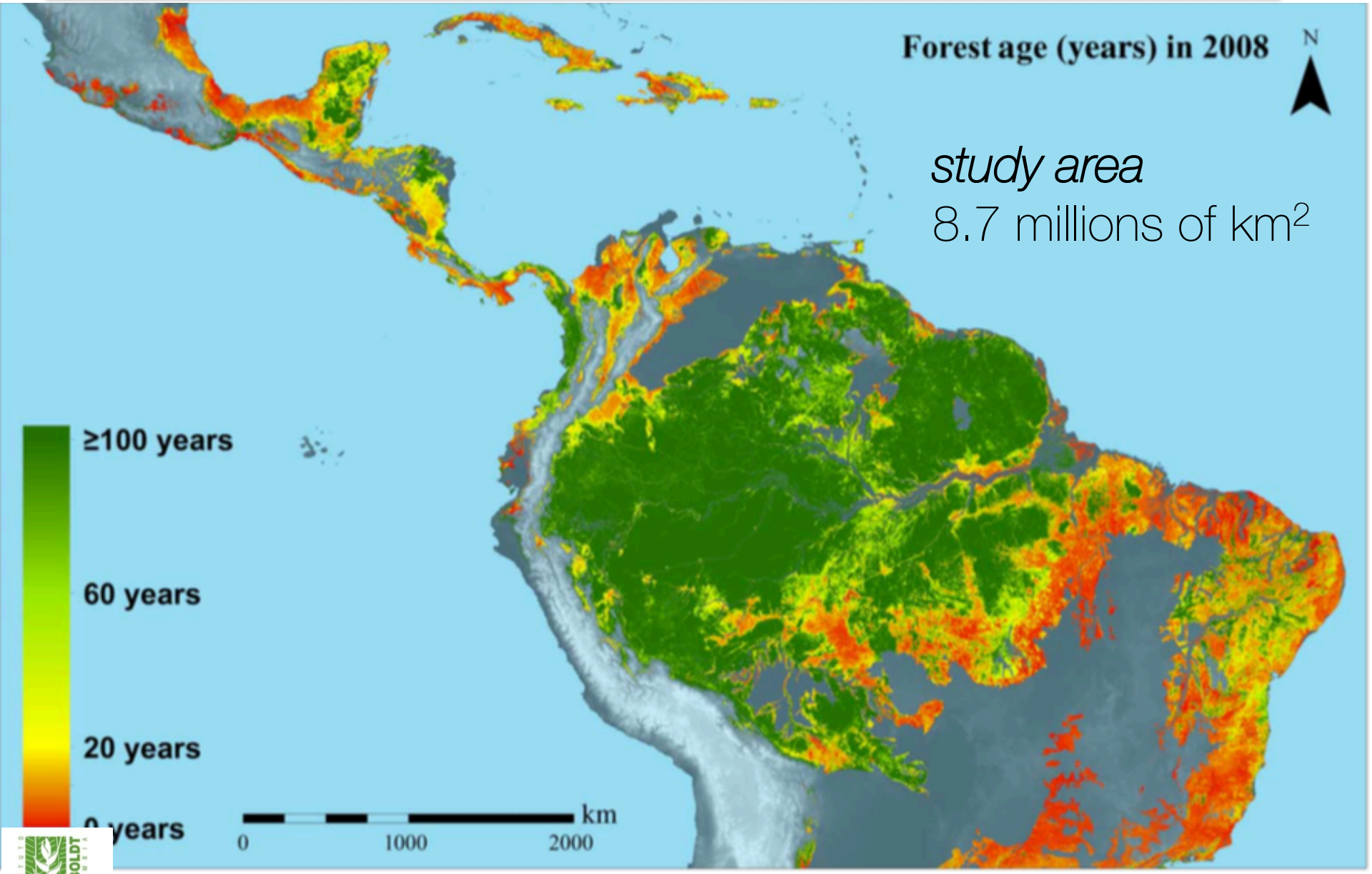
determinant factors of biomass accumulation



water availability

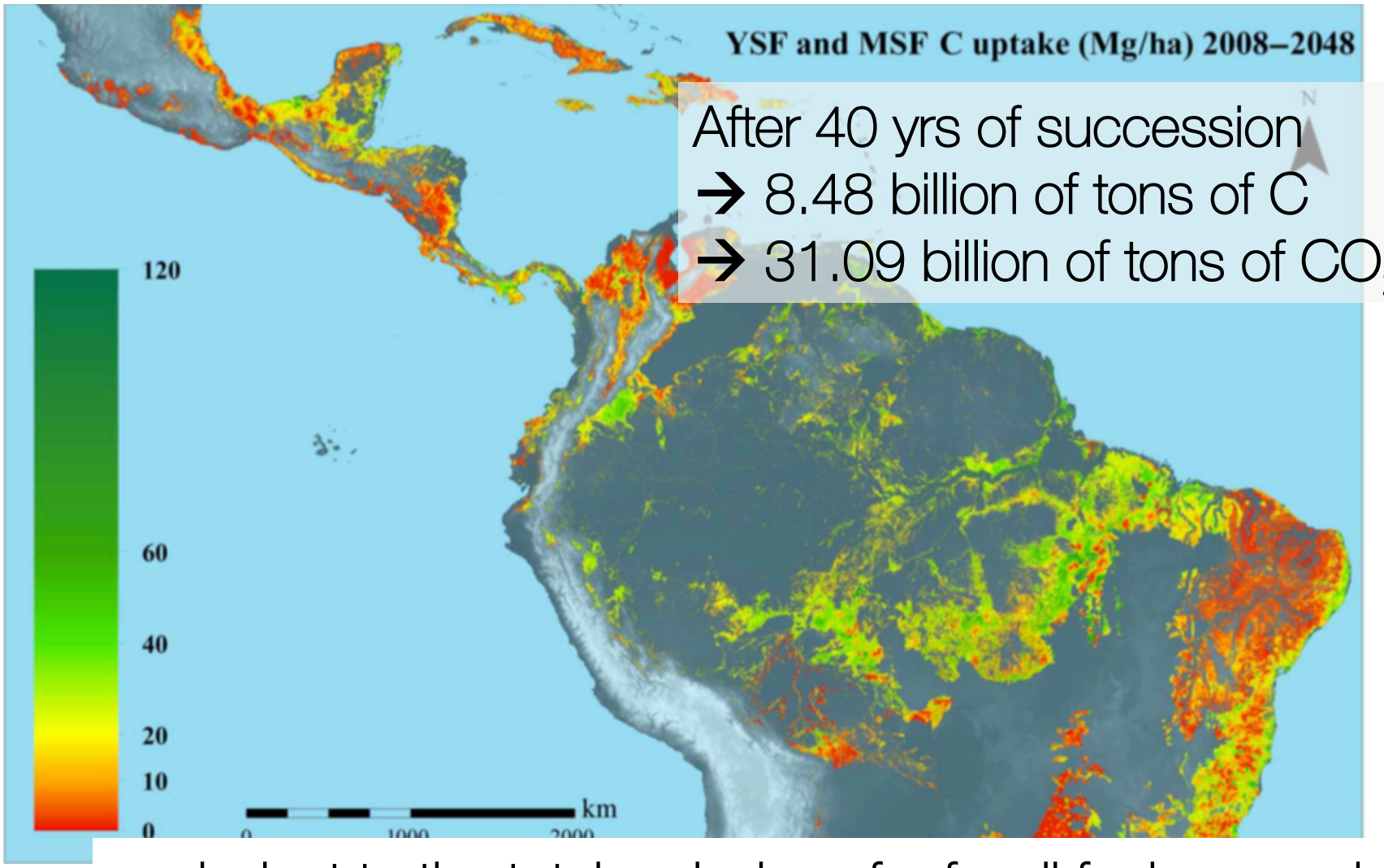
Poorter et al. 2016. *Nature*

carbon sequestration potential



Chazdon et al. 2016 *Science Advances*

carbon sequestration potential



After 40 yrs of succession
→ 8.48 billion of tons of C
→ 31.09 billion of tons of CO_2

equivalent to the total emissions for fossil fuel use and industrial activities in Latin-America from 1993 to 2014

Chazdon et al. 2016 *Science Advances*

Conclusions

High variability in secondary forest biomass resilience

→ dry and moist forests differ in their ability to recover

→ overall, median time of 66 yrs to recover to 90% of OG values

Recovery map

→ identify areas with high carbon sequestration potential

→ identify areas that should be treated with extra-caution (e.g. dry forests)

→ collapse after a certain threshold?

Instituto de Investigación de Recursos Biológicos
Alexander von Humboldt

Photo: Felipe Villegas