Amazon Forest Dynamics and Carbon Balance since 1980

Oliver Phillips

and the RAINFOR consortium (Red Amazónica de Inventarios Forestales)

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Outline

1. RAINFOR objectives and methods
2. On-the-ground evidence for recent changes in Amazon forests
3. Some future prospects

Main objectives of RAINFOR

With long-term observations, research the biomass dynamics, carbon processes, soils, and biodiversity of Amazonian forests, to understand how and why they vary

1. in space

2. through time

Combine the "botanical approach"… (floristics) with…

Caxiuana, Brasil

… the "forestry approach" (biomass and growth), with…

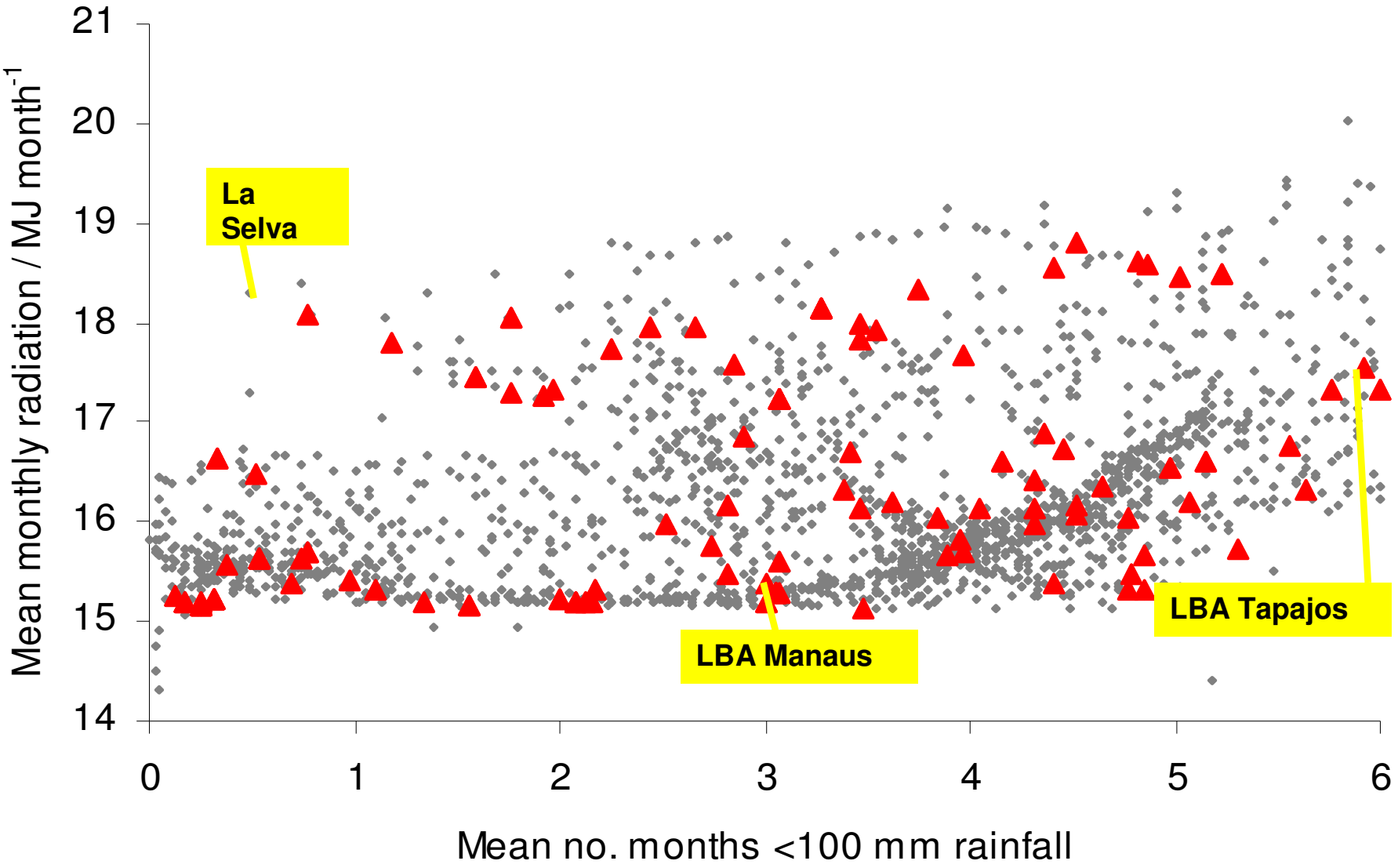
… the "ecophysiological approach"… soils, leaf area, carbon processes

Field Campaigns 2001-2007 in permanent plots

How representative are our sites of the Amazon environment?

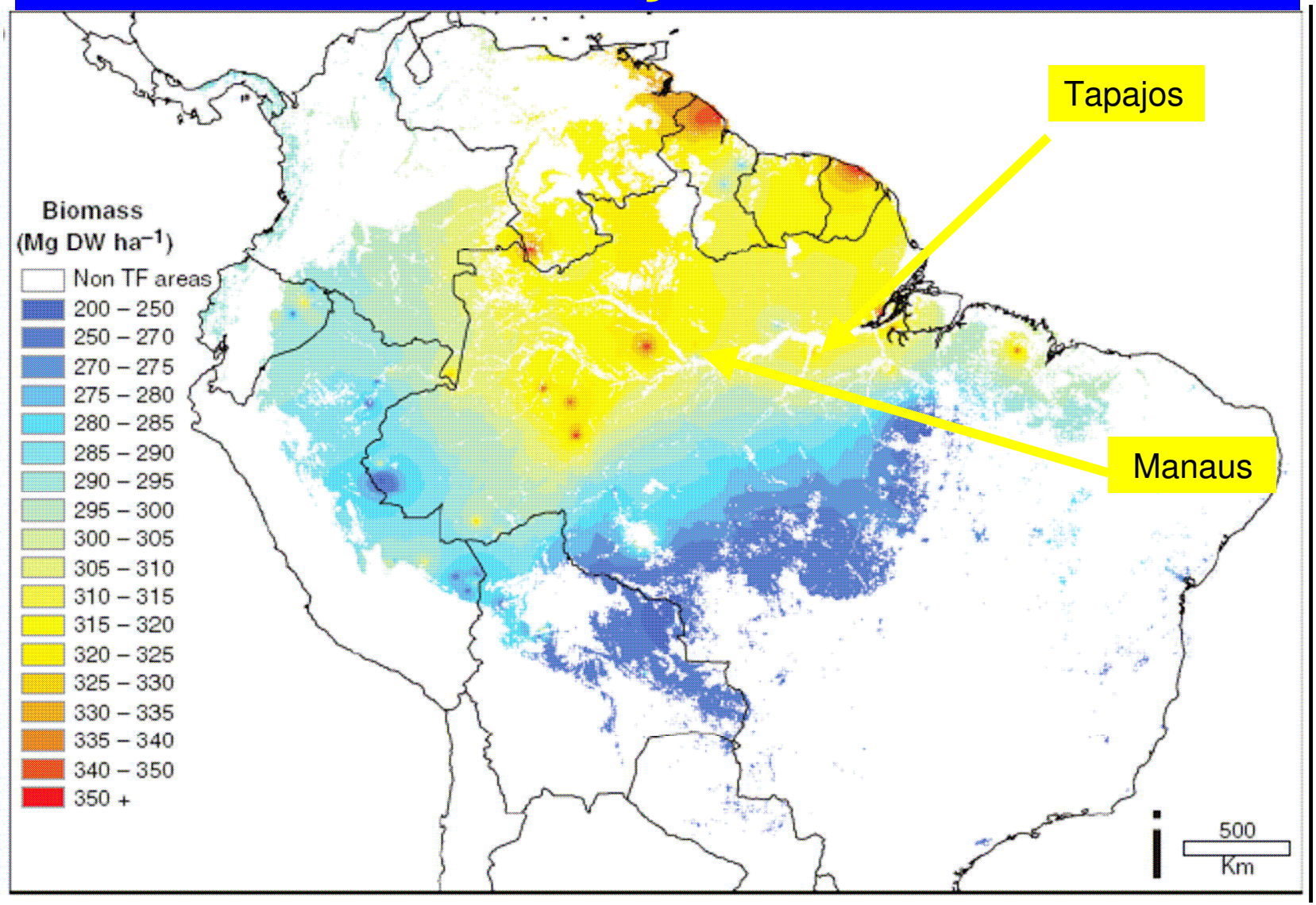
Climate Variability across the Neotropics

All forested Neotropical 0.5 degree squares (grey), long-term plots (red), and other sites shown.



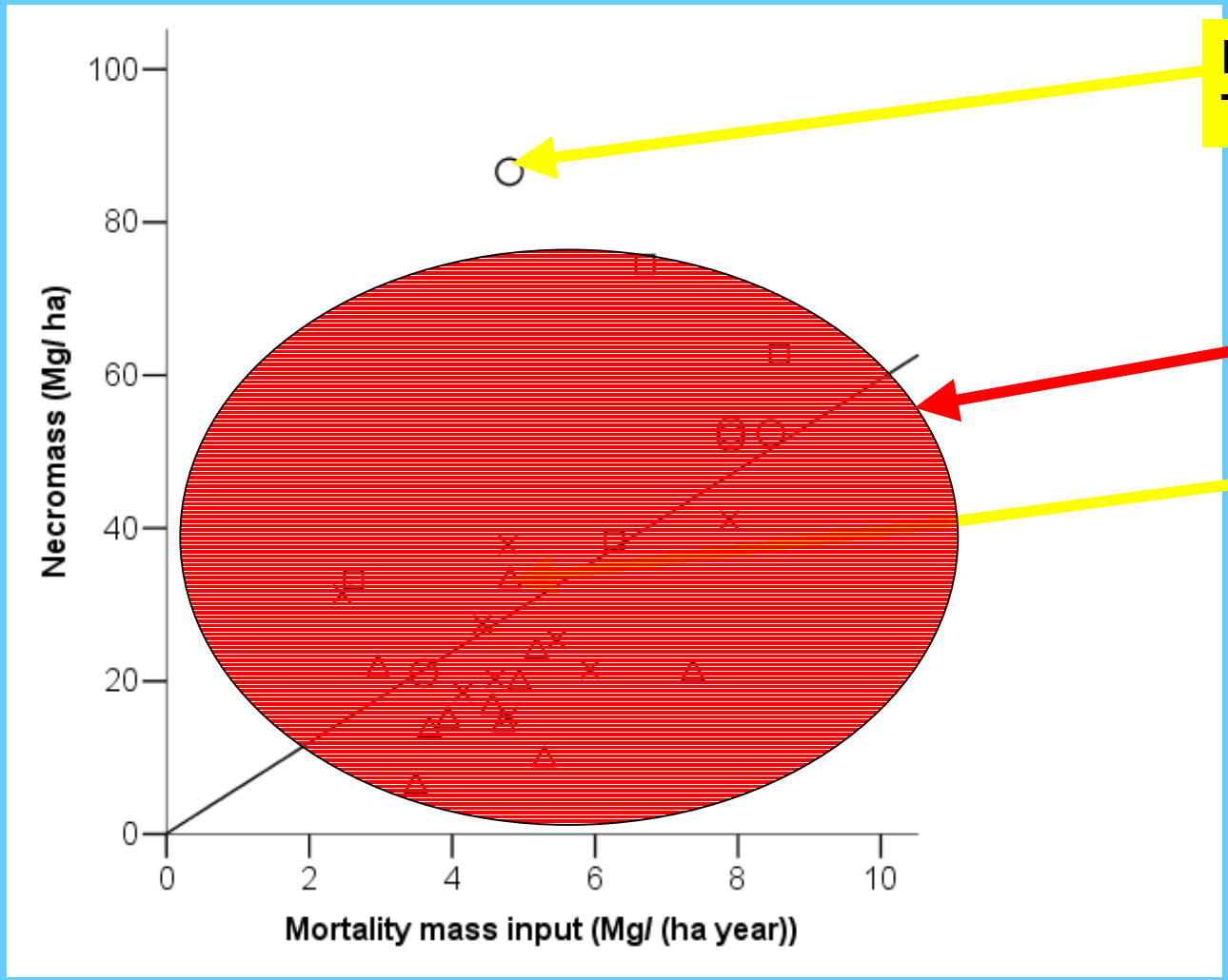
Baker, Malhi et al., unpublished analysis, using 1961-90 neotropical climatology (New et al 2000)

Biomass variability across Amazonia



From Malhi et al (2006) Global Change Biology

Necromass variability across Amazonia



LBA Tapajos

Mostly RAINFOR sites

Manaus

Data from Baker et al. 2007, Palace et al 2007, Chao et al. in press 2007, Chao et al. in review

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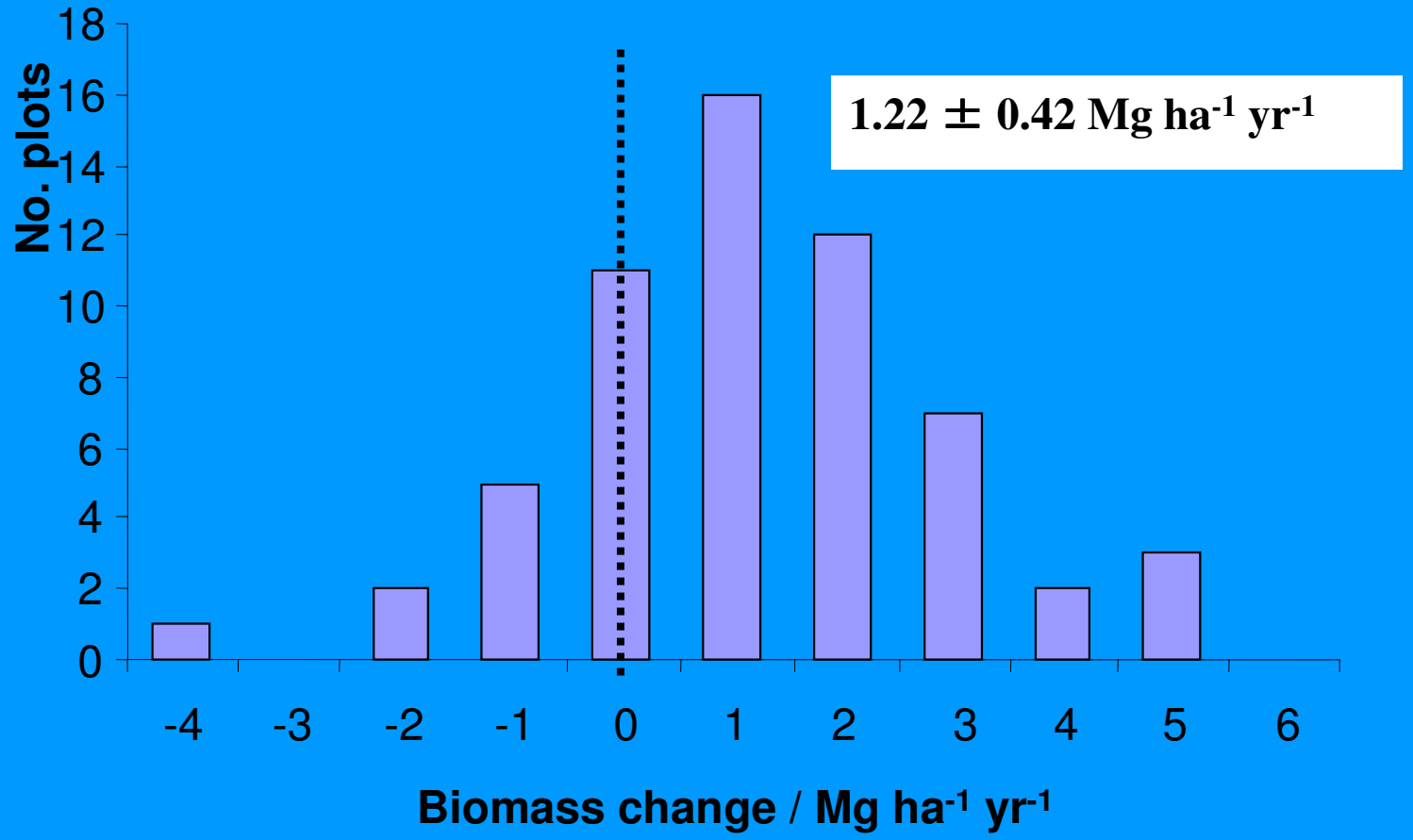
Rate of change in biomass in Amazon forest plots 1980-2000



Estimated Amazon biomass carbon flux = 0.3-0.6 Pg C per year;

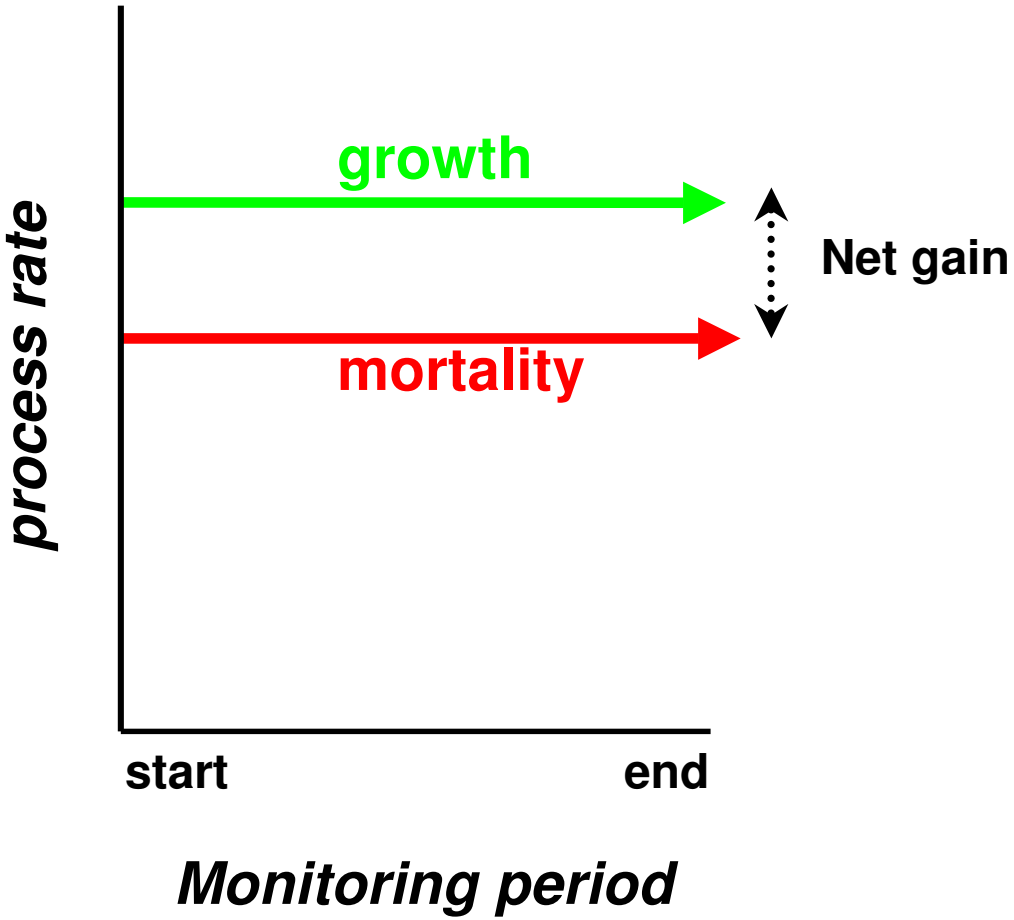
Period spans intense La Niña and El Niño events

Baker *et al* (2004), *Philosophical Transactions of the Royal Society of London*.

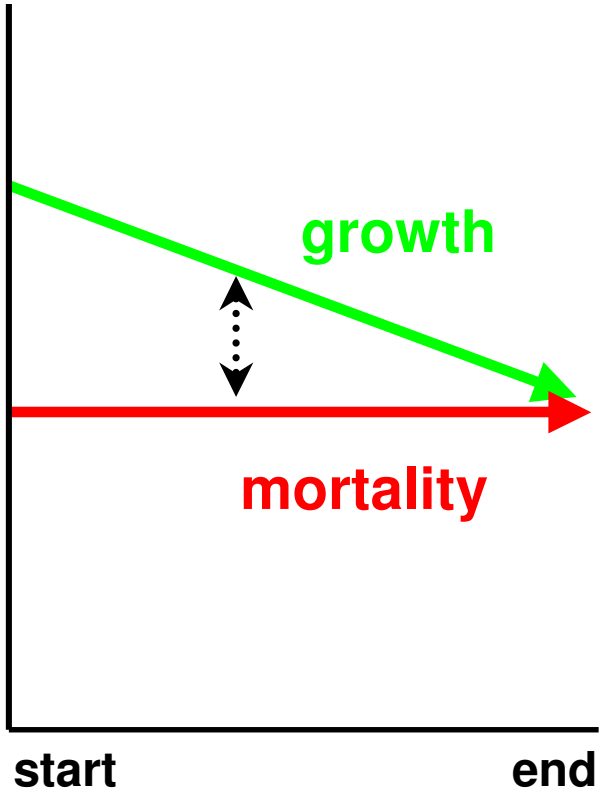
So…

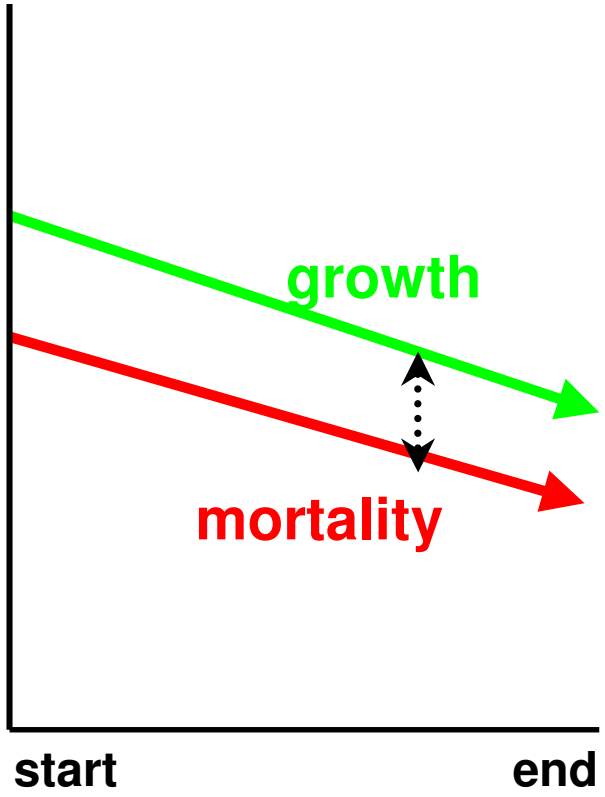
Q. ***Why*** has biomass increased in Amazon plots, since at least 1980?

a “Stable” system ?

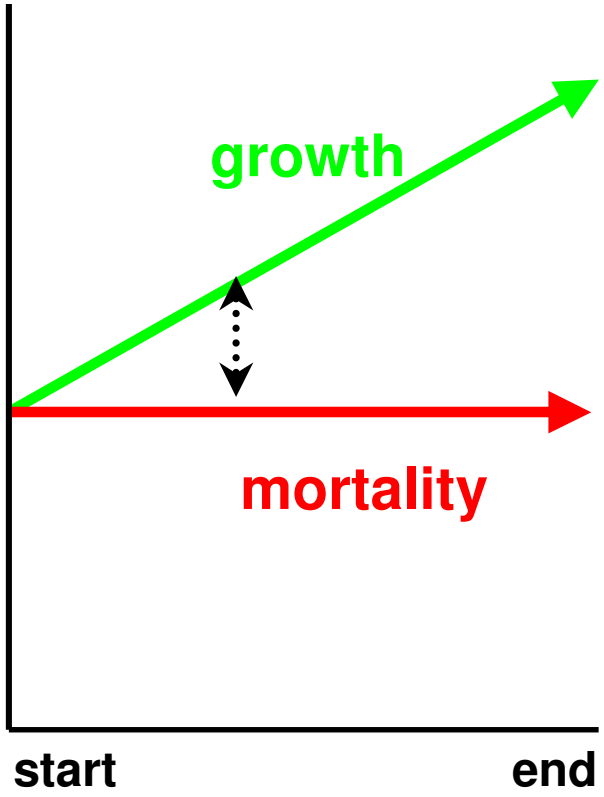


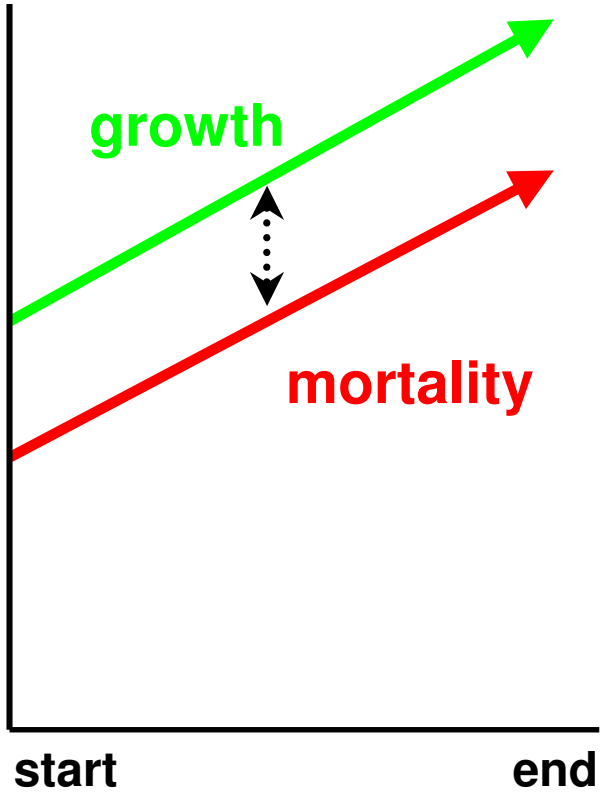
a Slowing system ?



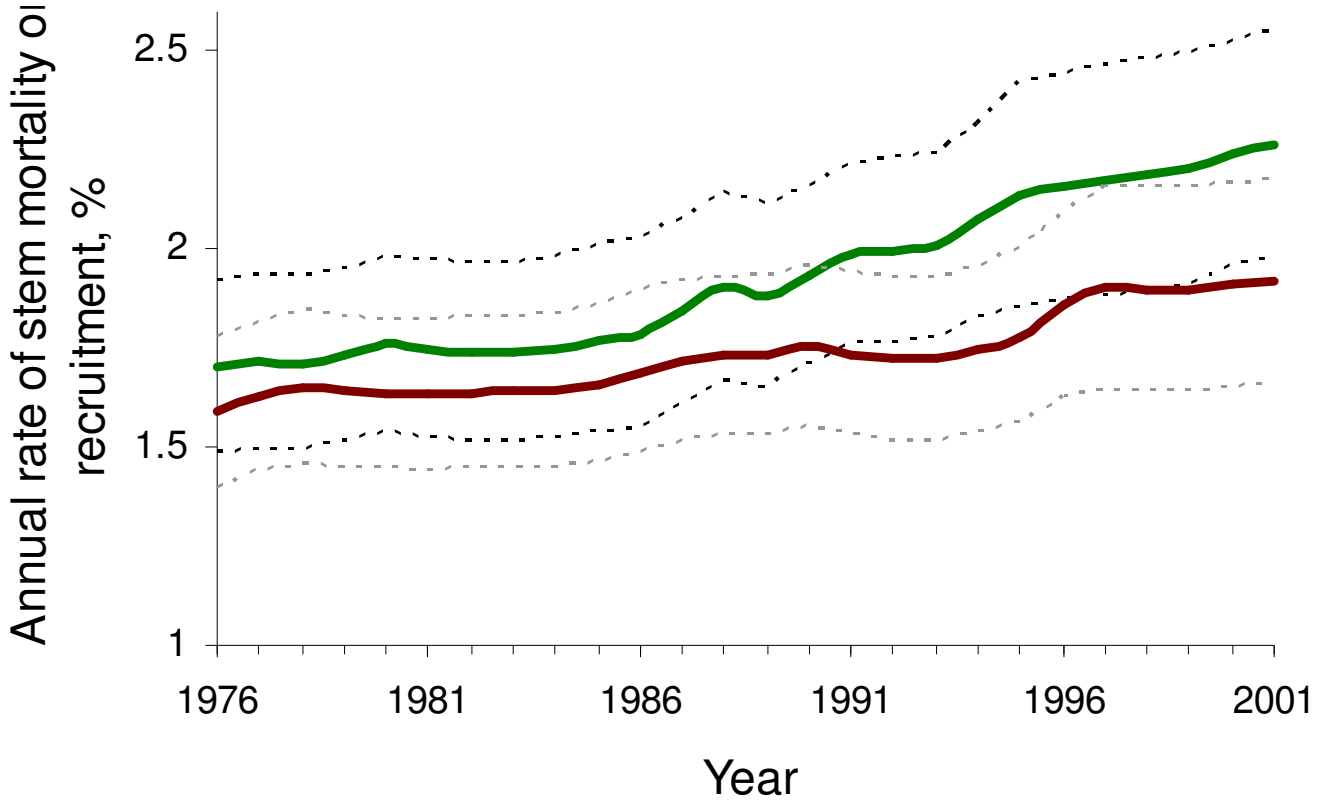


an Accelerating system





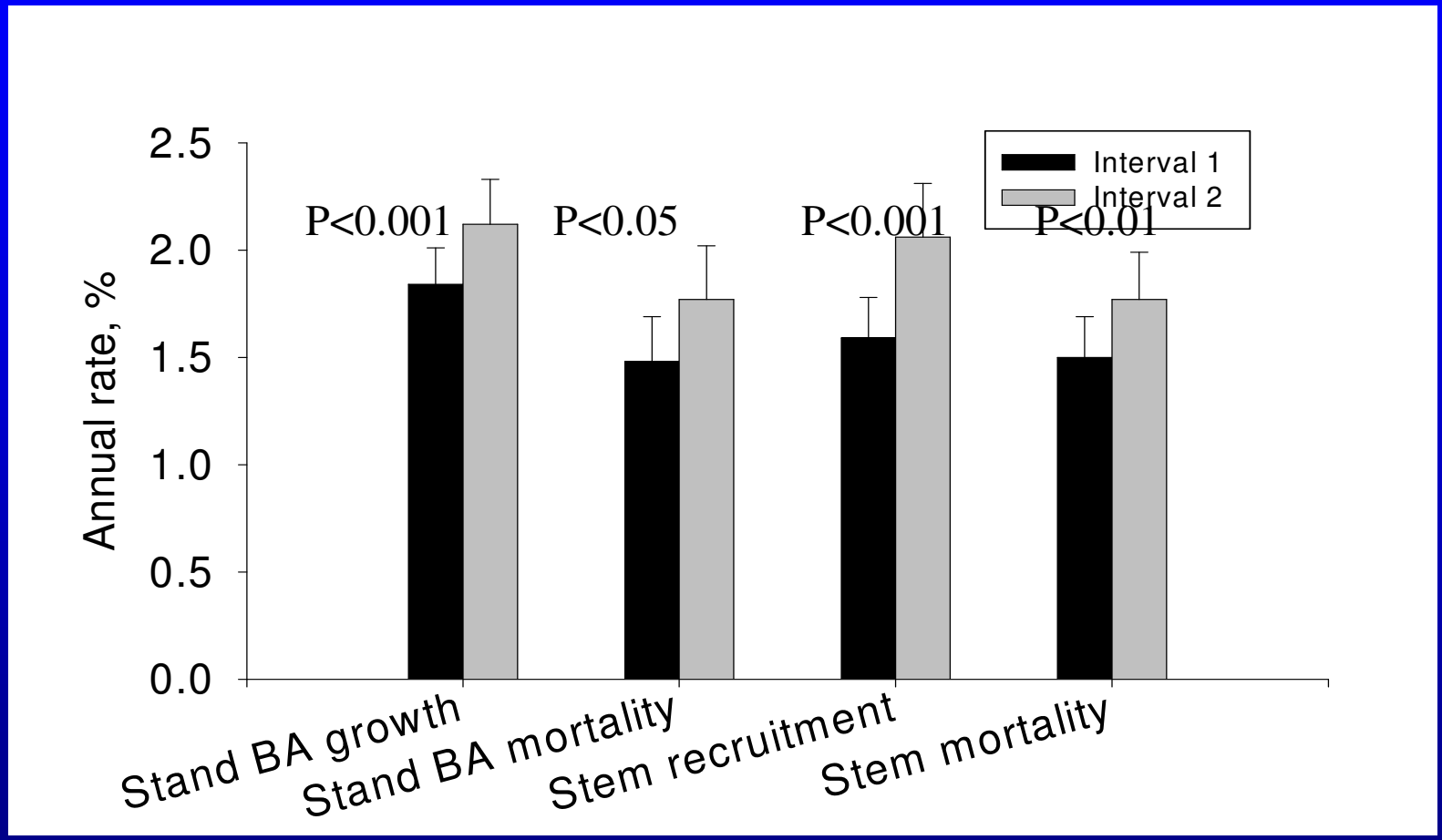
Across all RAINFOR plots, *both* tree recruitment (green) *and* mortality (brown) increased



Forests are becoming increasingly dynamic.
Mortality gains are lagging the recruitment gains

Phillips et al, 2004. *Phil. Trans. Roy. Society*

Within plots, *both* growth *and* mortality increased



Forests are becoming increasingly dynamic.
Mortality gains are lagging growth gains

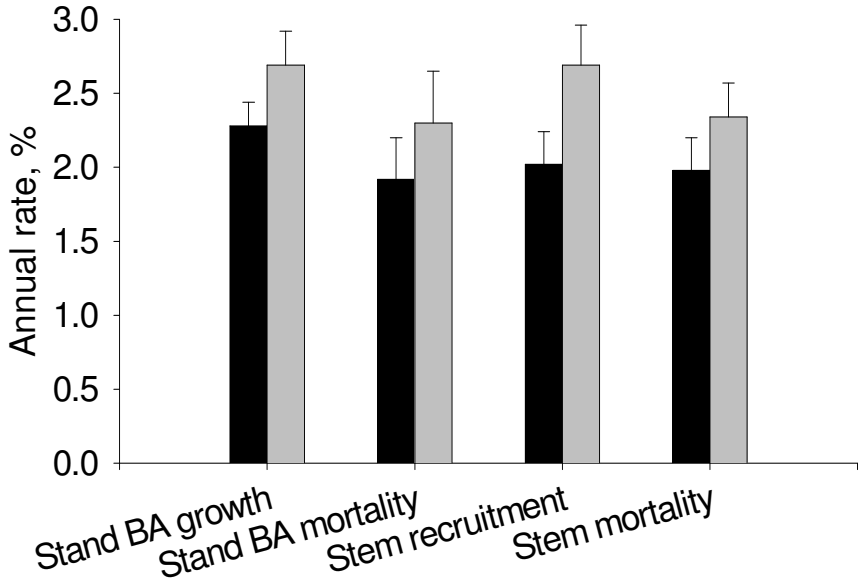
Lewis et al. 2004 *Phil Trans Roy. Soc. London*

Western Amazonia

Central & Eastern Amazonia

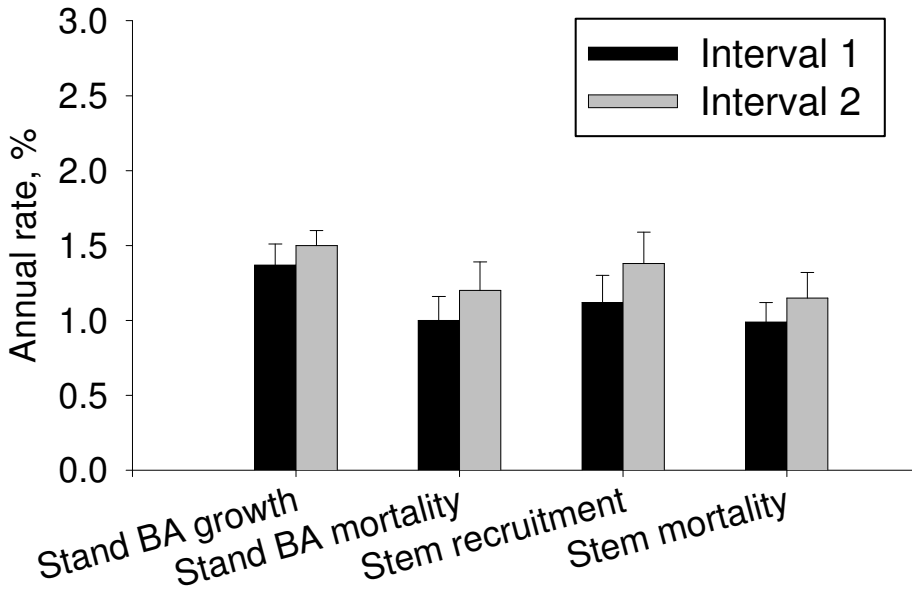
Western Amazonia

FAST FORESTS



Eastern & Central Amazonia

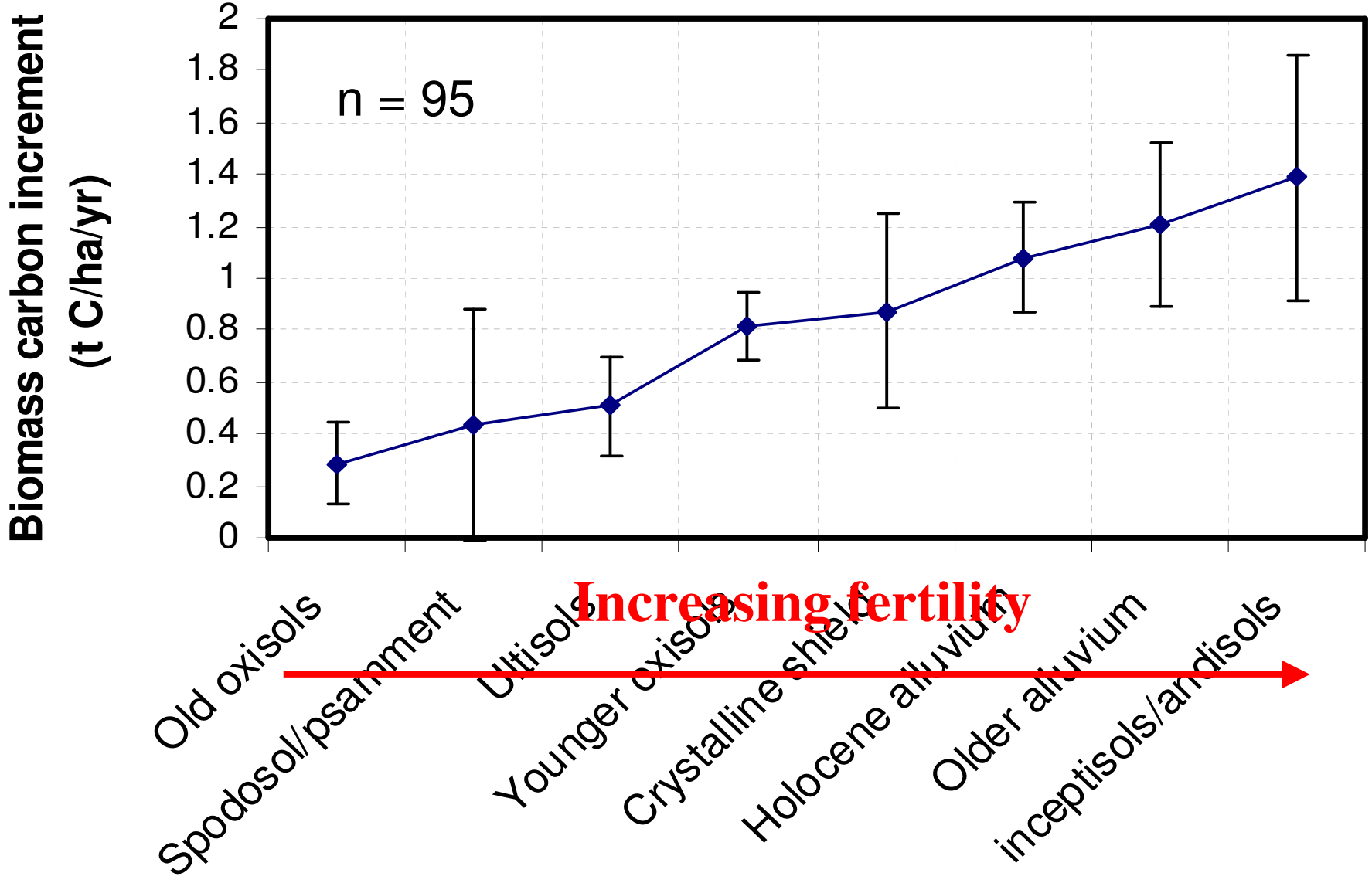
SLOW FORESTS



Forests are becoming increasingly dynamic everywhere.
Mortality gains are lagging growth gains.

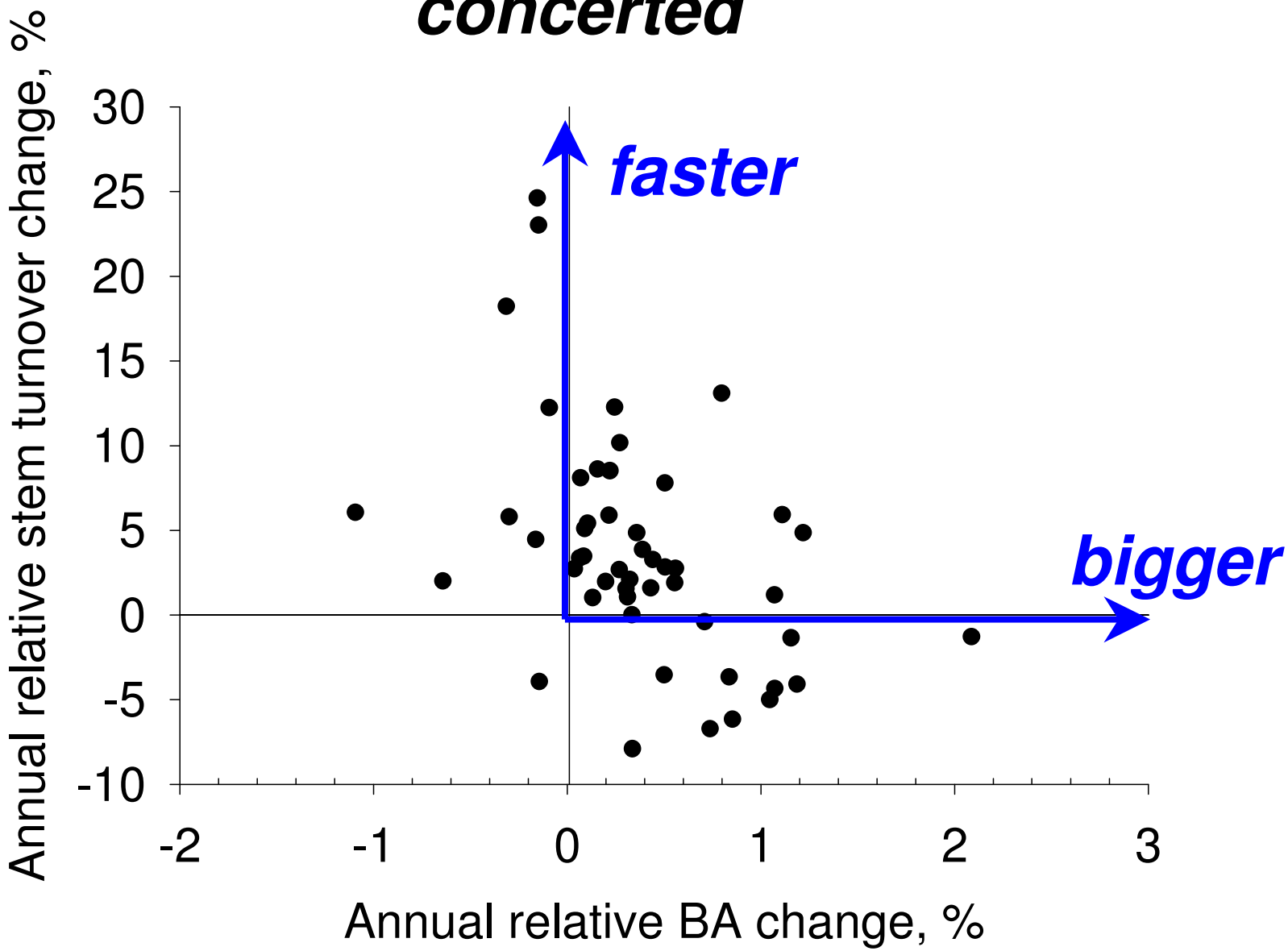
Lewis et al. 2004 *Phil. Trans. Roy. Soc.*

Net rate of biomass gain ca. 1980-2000 appears to relate to soil fertility



unpublished RAINFOR data

The changes in structure and dynamics are ***concerted***



unpublished RAINFOR data

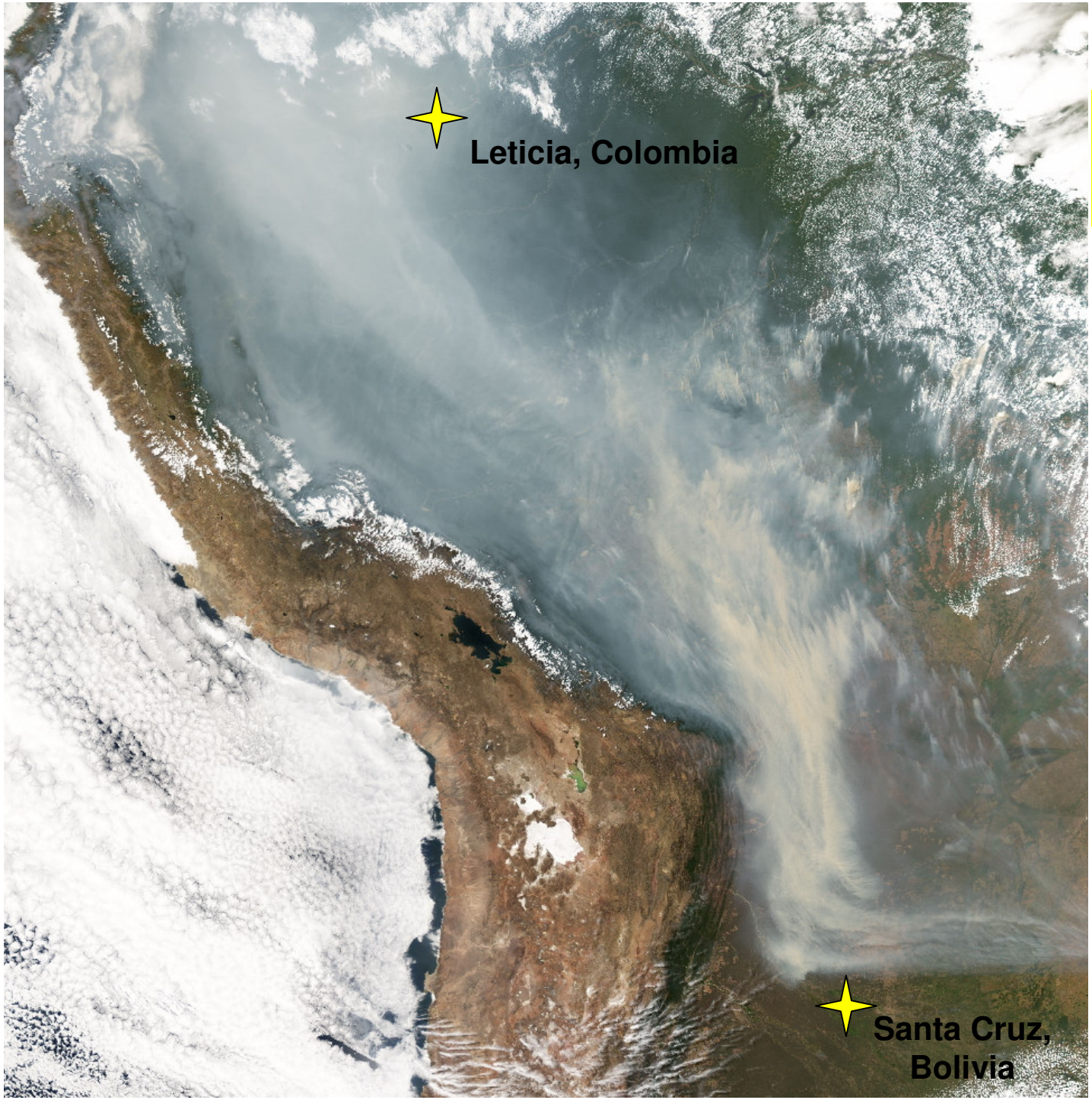
So…

Q. ***Why*** has biomass increased in Amazonia since at least 1980?

A. Accelerating Growth, which is leading accelerating Mortality

And so, the *dominant* driver(s) of change*:*

1. **Caused growth to increase**
2. **Caused mortality to increase**
3. **Caused stem density to increase**
4. **Acted across Amazonia (at least)**
5. **Acted for at least 20 yrs and through multiple ENSO events**
6. **Had greatest impact on nutrient-rich soils**



The Anthropocene

West Amazonia, Sep 14th 2004

Datos de NASA
http://modis.gsfc.nasa.gov

Outline

1. RAINFOR objectives and methods
2. Recent changes in Amazon forests
3. **Some future prospects**

How vulnerable is the mature forest biomass sink?

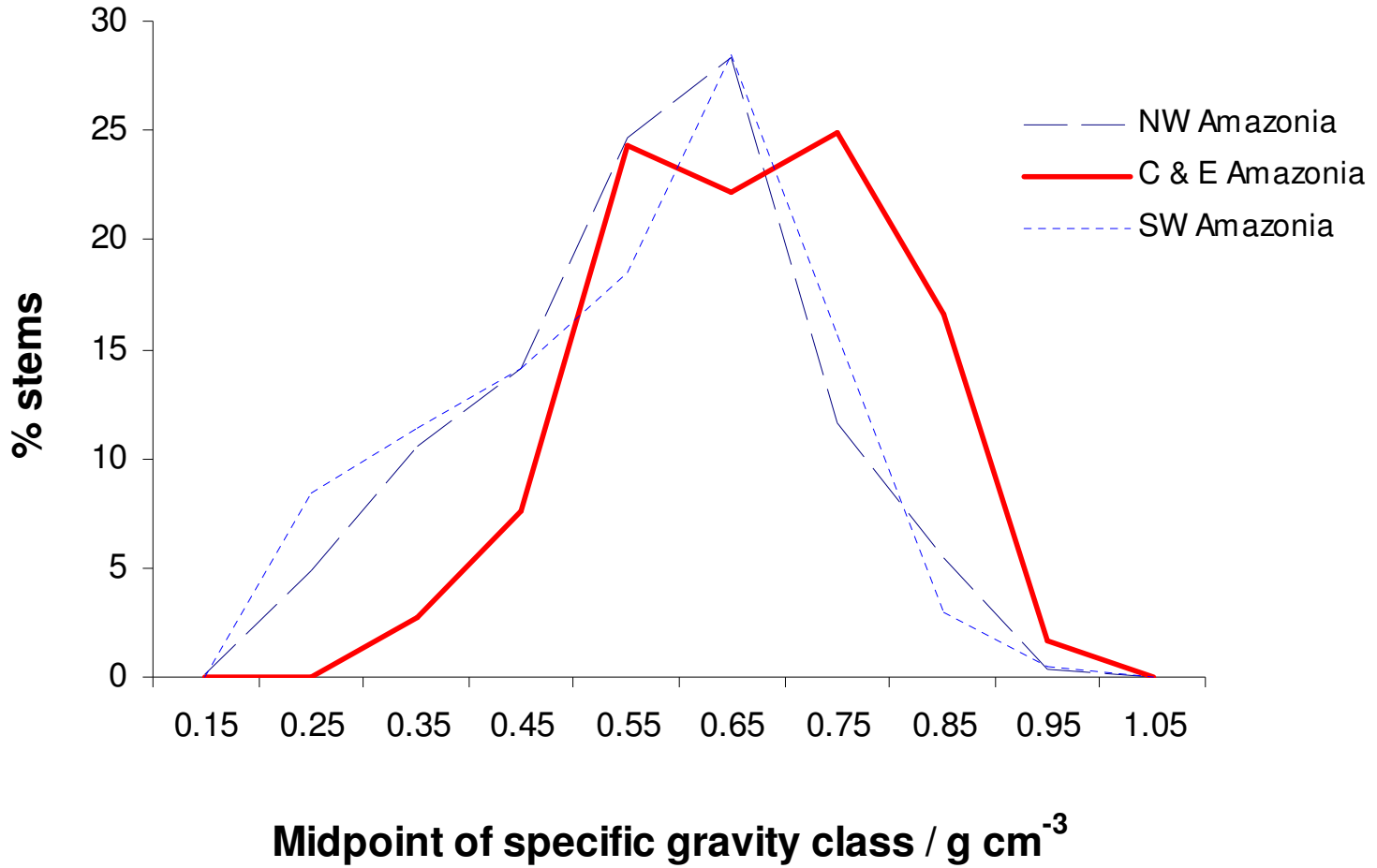
(Many threats)

Could increasing turnover rates (growth or mortality) impact species composition?

How might increases in turnover affect species composition and biomass?

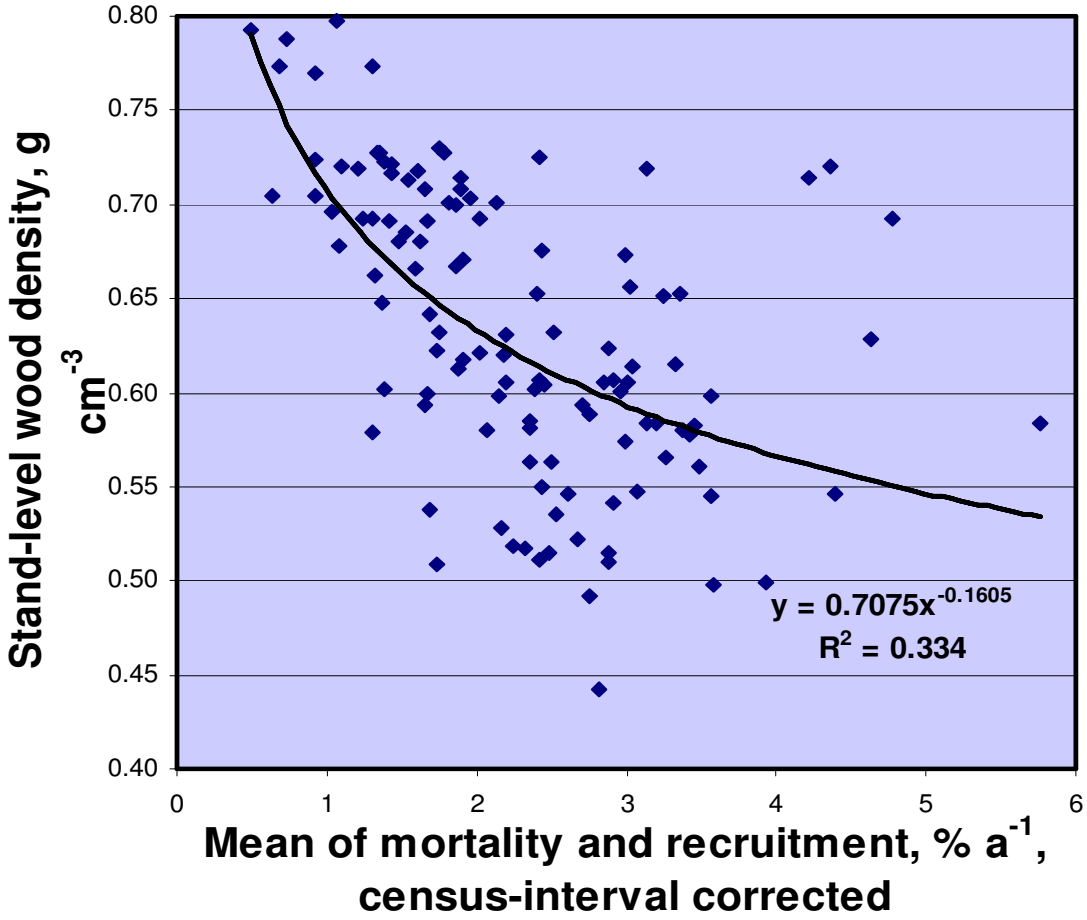
- Faster turnover = faster gap formation, favouring fast-growing, light-wooded species
- Potential for positive feedback on turnover rates
- Amazonia has great functional diversity

Diversity in wood density



*Baker et al. (2004), Global Change Biology, **10**, 545-562.*

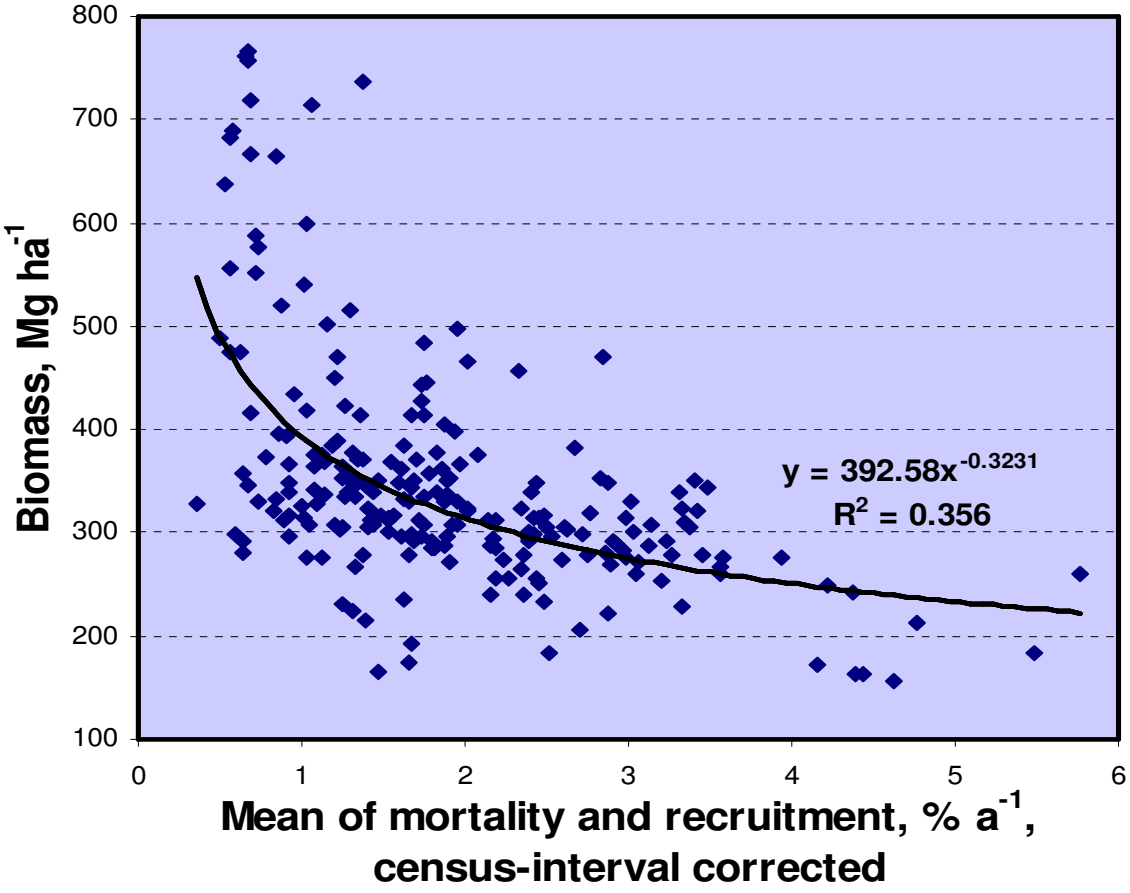
Stand-level mean wood density as a function of annual stem turnover; 127 lowland plots across South America



Increasing turnover could affect *wood density…*

Increasing turnover could drive changes in wood density and therefore *biomass*

Biomass as a function of stem turnover; 229 lowland forest plots across South America, Africa, Australia



unpublished RAINFOR data

Compositional changes already reported from Amazon plots, 1980-2000:

- Liana density has increased across Western Amazonia (Phillips et al. 2002)

- Tree species with dense wood have declined north of Manaus (Laurance et al. 2004)

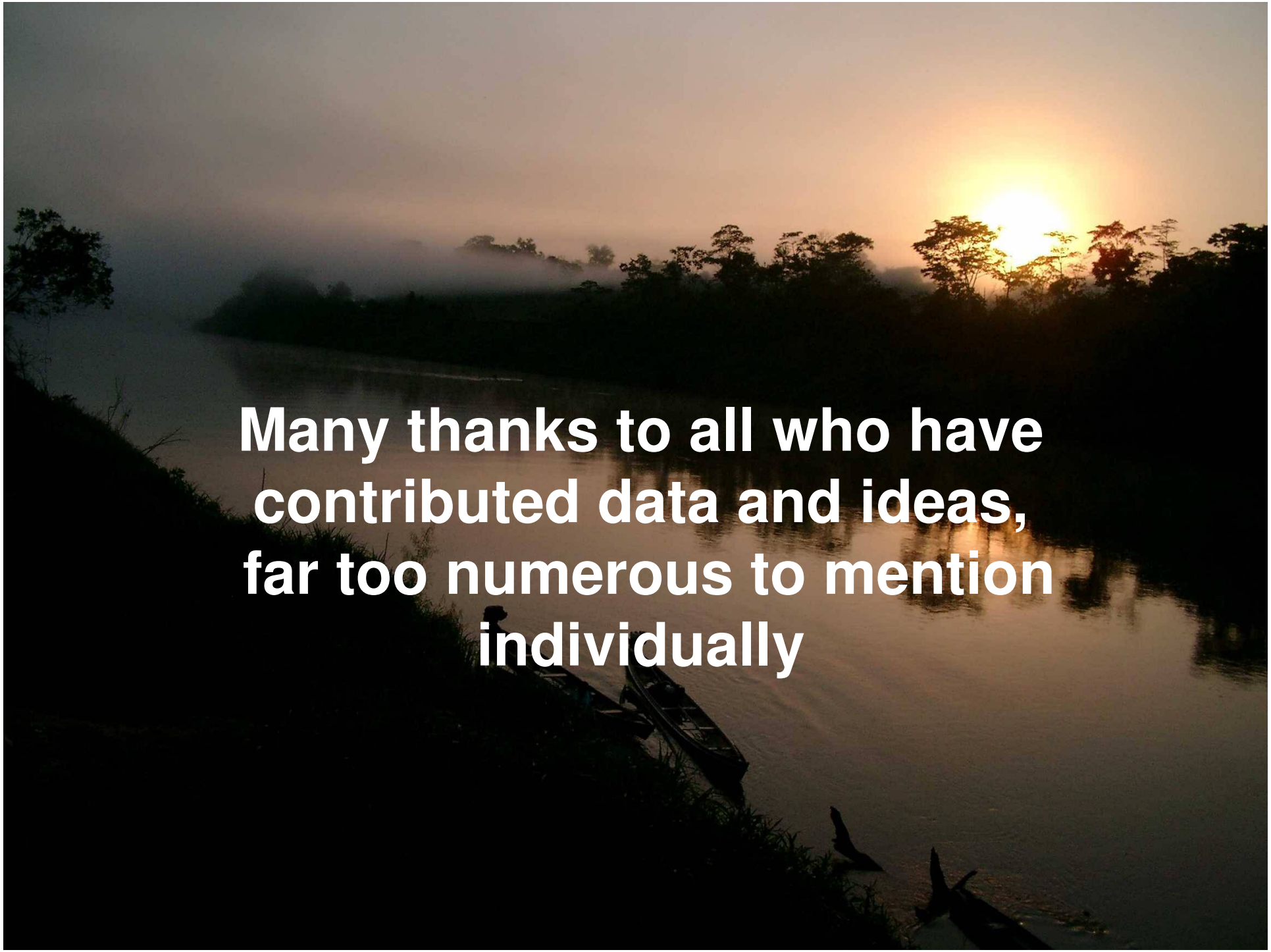
Conclusions

Permanent Plots reveal Amazon forests:

Have accelerated (tree growth and mortality have increased)

Have gained biomass (~0.6 Mg C per hectare per year), for at least two decades

Anticipated changes in composition put the biomass sink at risk, even before considering climate change and land-use change


Many thanks to all who have
contributed data and ideas,
far too numerous to mention
individually