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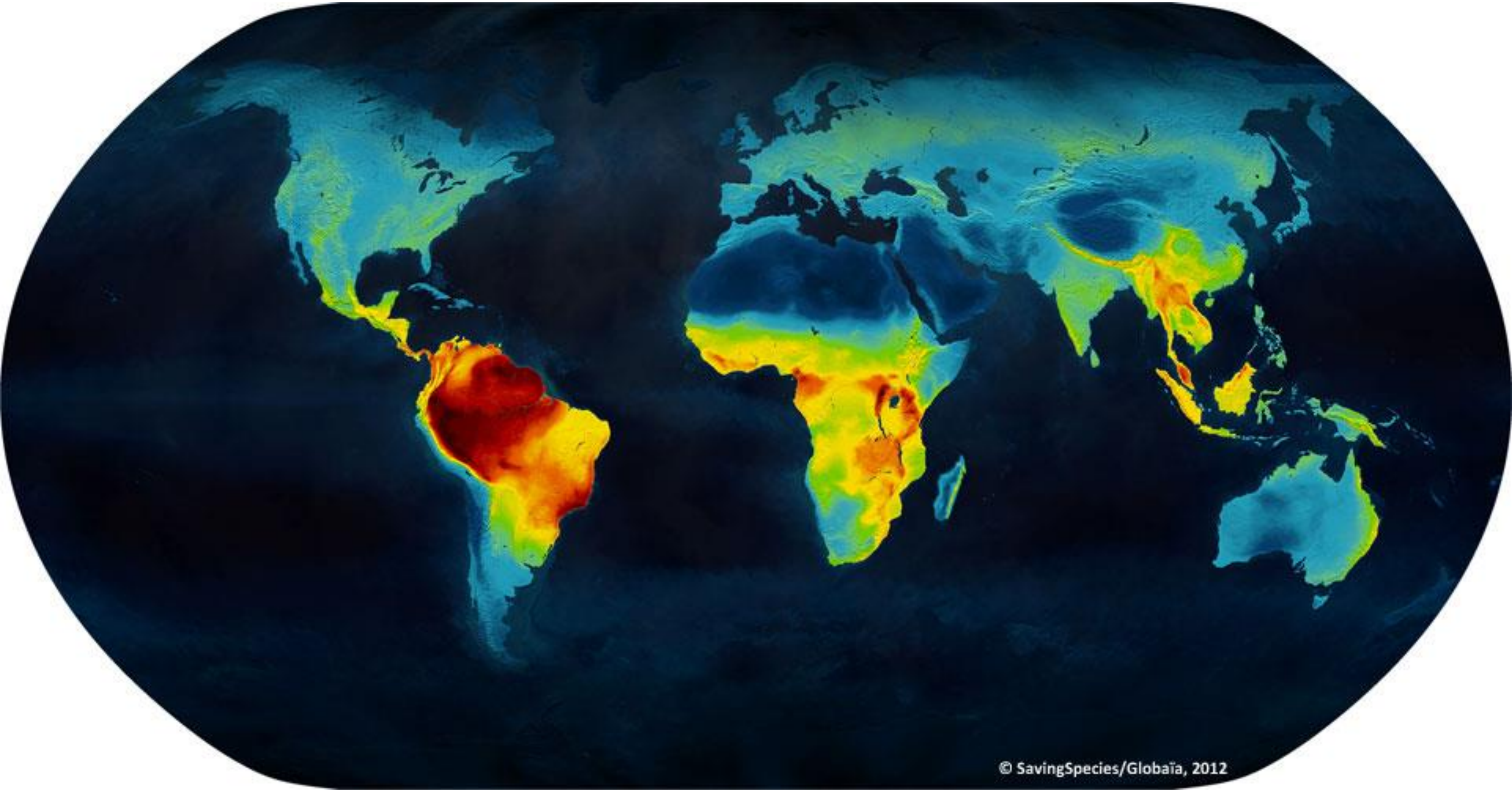
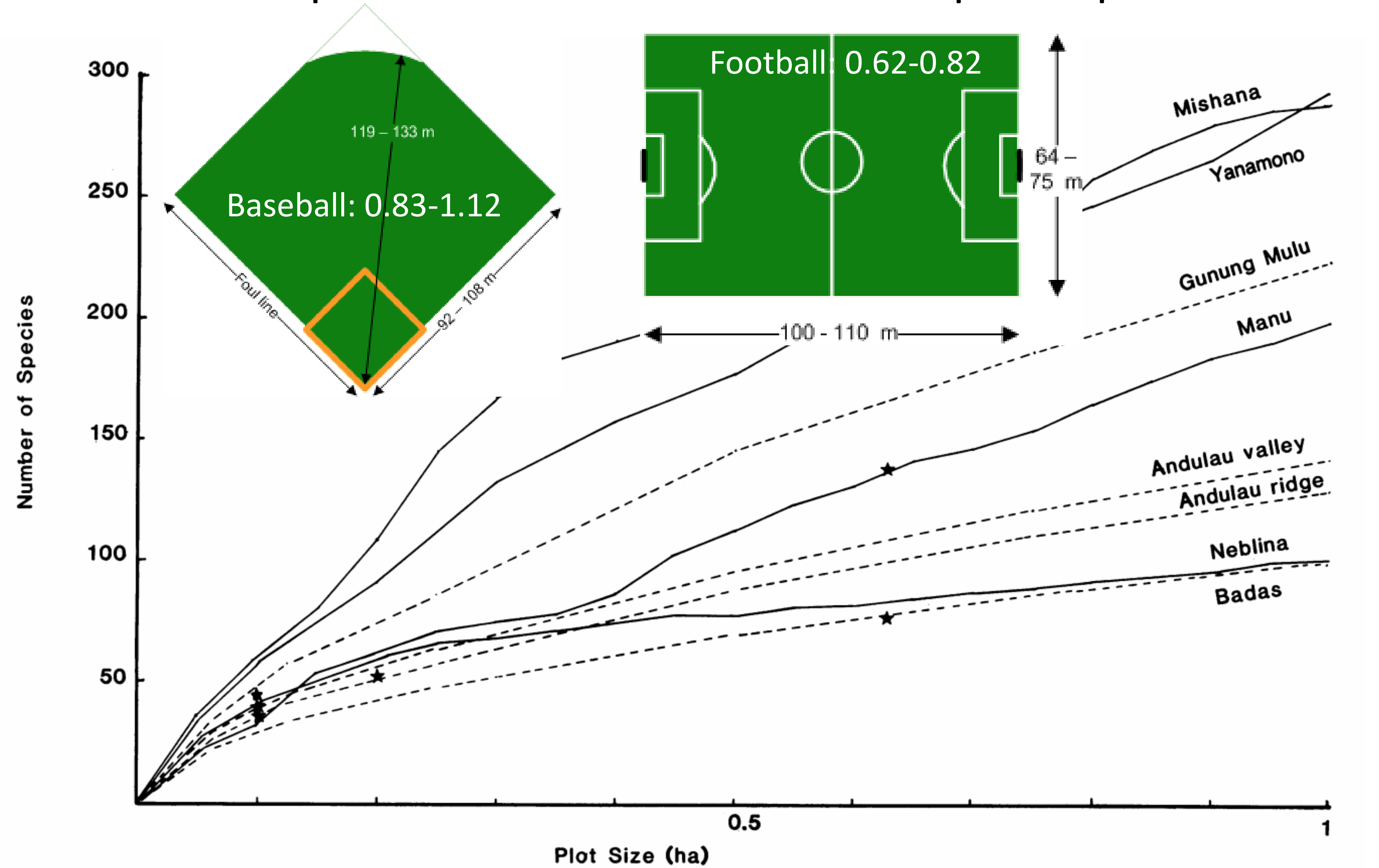
Are past human activities related to observed biodiversity and carbon dynamics in Amazonian forests?

Vertebrate species richness



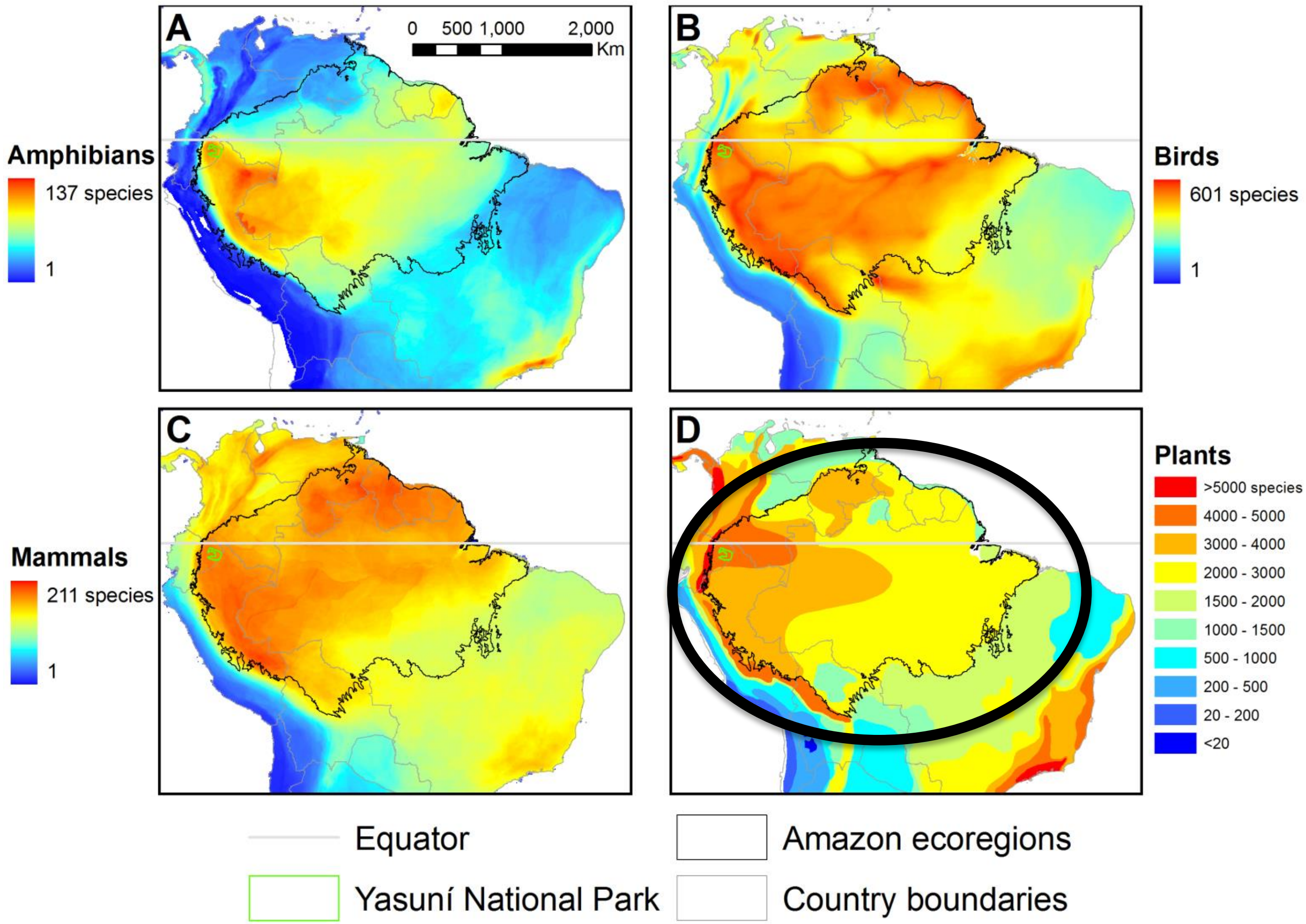
modified from Jenkins, C.N., et al (2013). Global patterns of terrestrial vertebrate diversity and conservation. *Proceedings of the National Academy of Sciences*, 110, E2602-E2610.

What about plants? You can find over 300 species per hectare



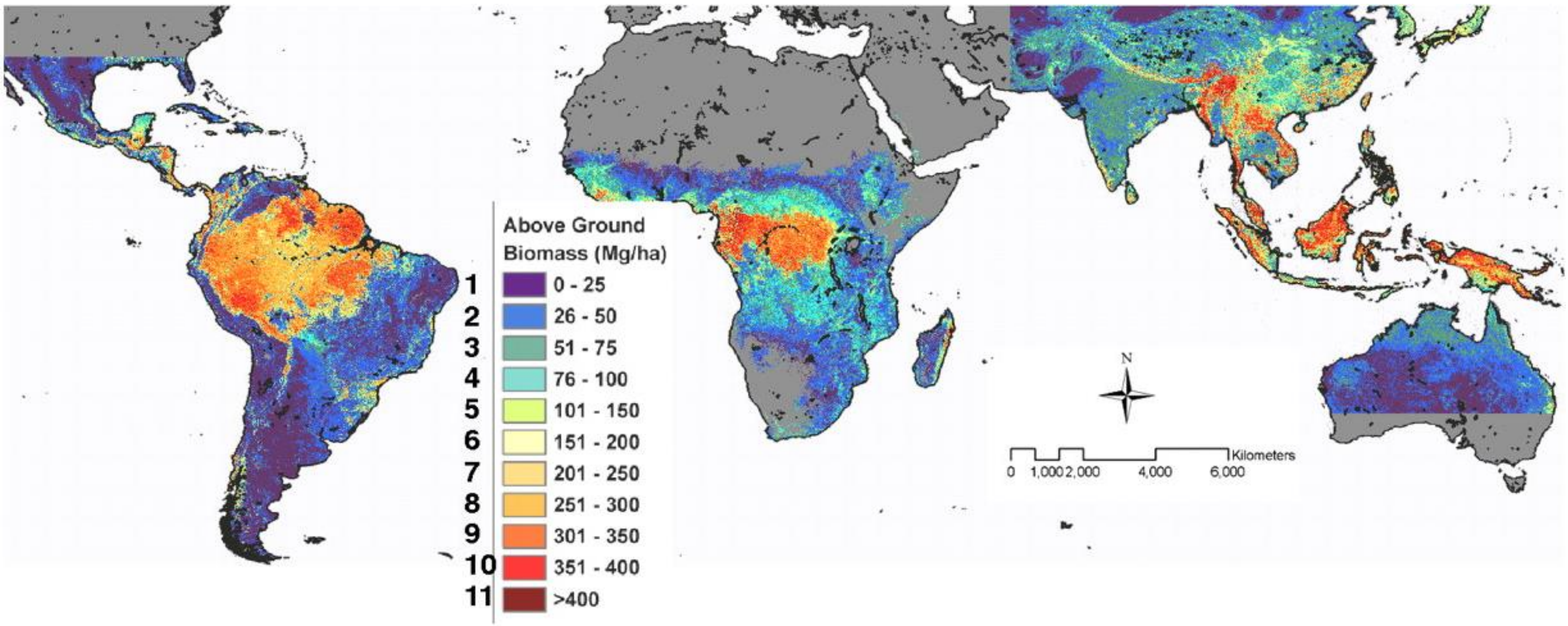
Gentry, A.H. (1988). Tree species richness of upper Amazonian forests. *Proceedings of the National Academy of Sciences*, 85, 156.

Species richness in Amazonia (per 100 km^2 area)



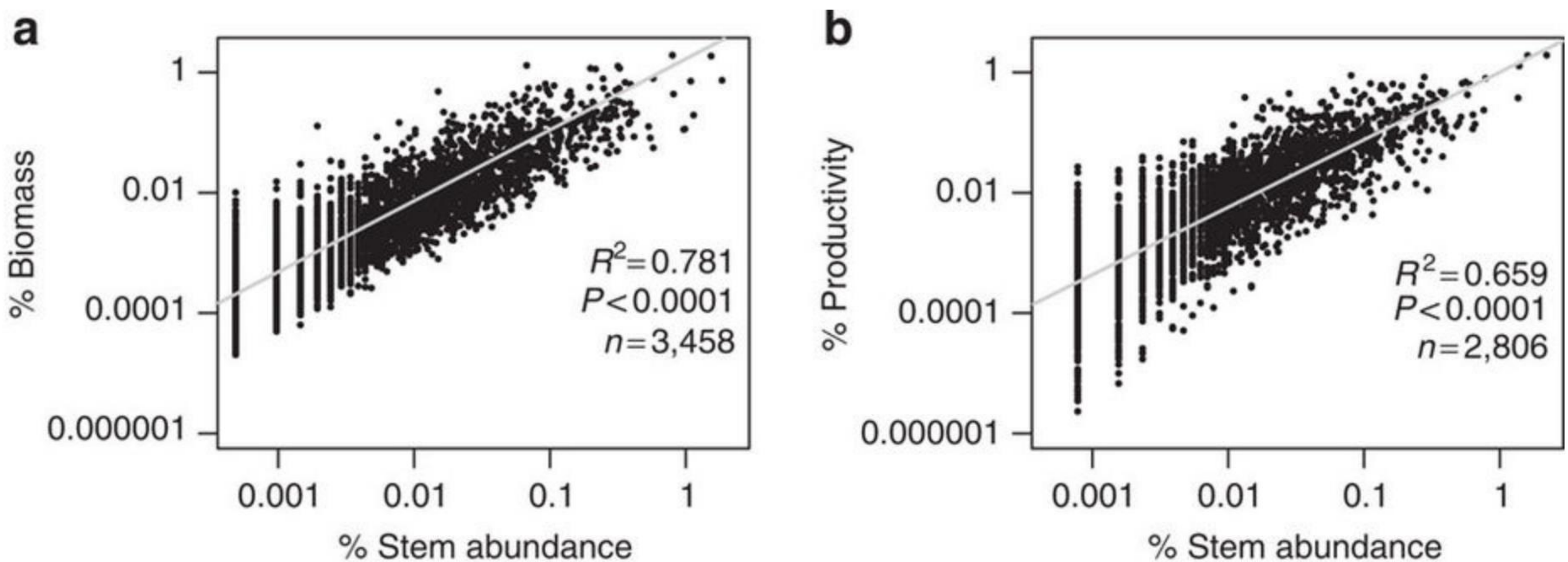
Bass, M.S., *et al.* (2010). Global conservation significance of Ecuador's Yasuní National Park. *PloS one*, 5, e8767.

Besides its incredible diversity, Amazonia is also a large contributor to global carbon stocks



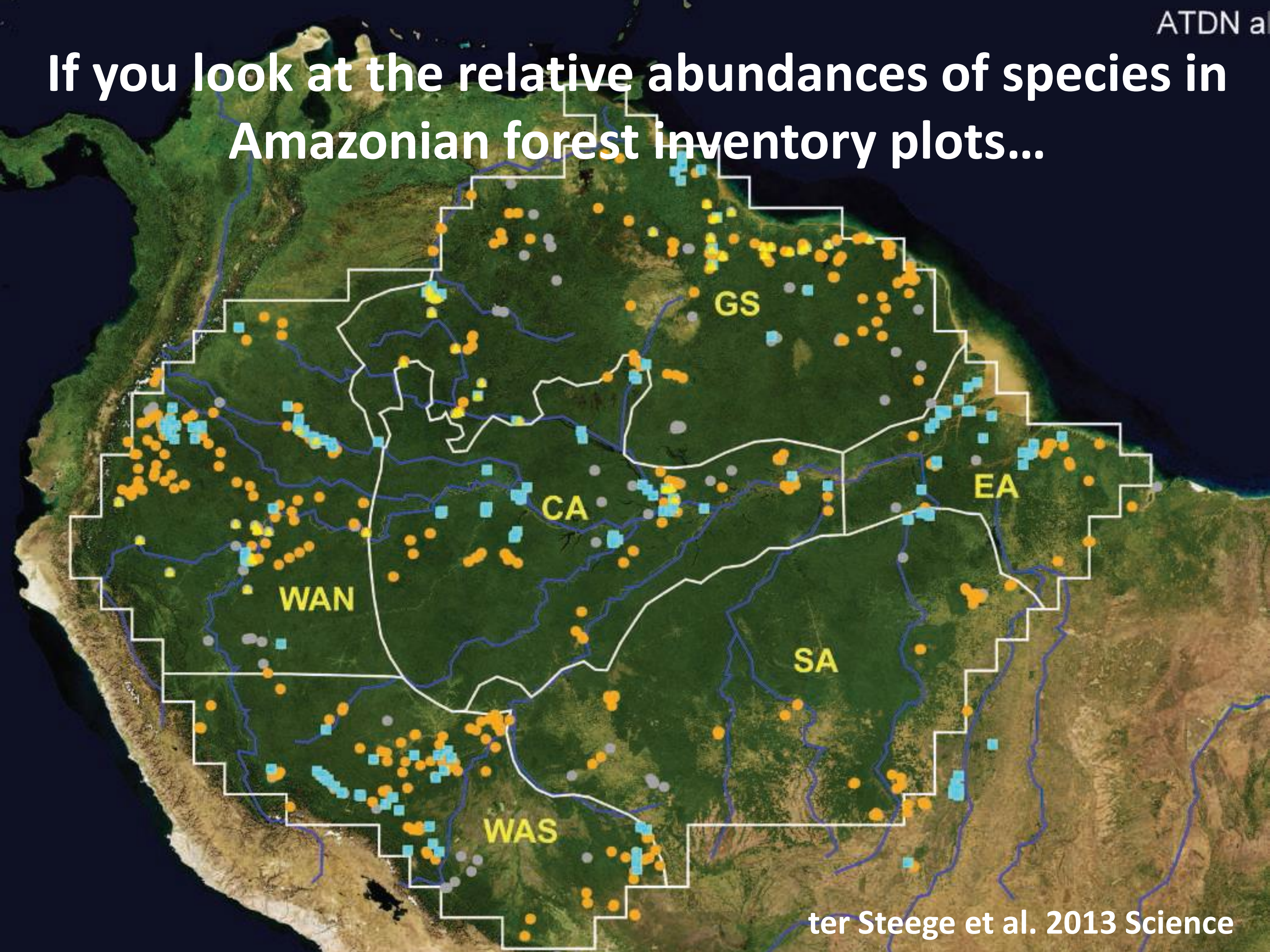
Saatchi, S.S., *et al.* (2011). Benchmark map of forest carbon stocks in tropical regions across three continents. *Proceedings of the National Academy of Sciences*, 108, 9899.

Species abundance is linked to the carbon storage potential in Amazonia



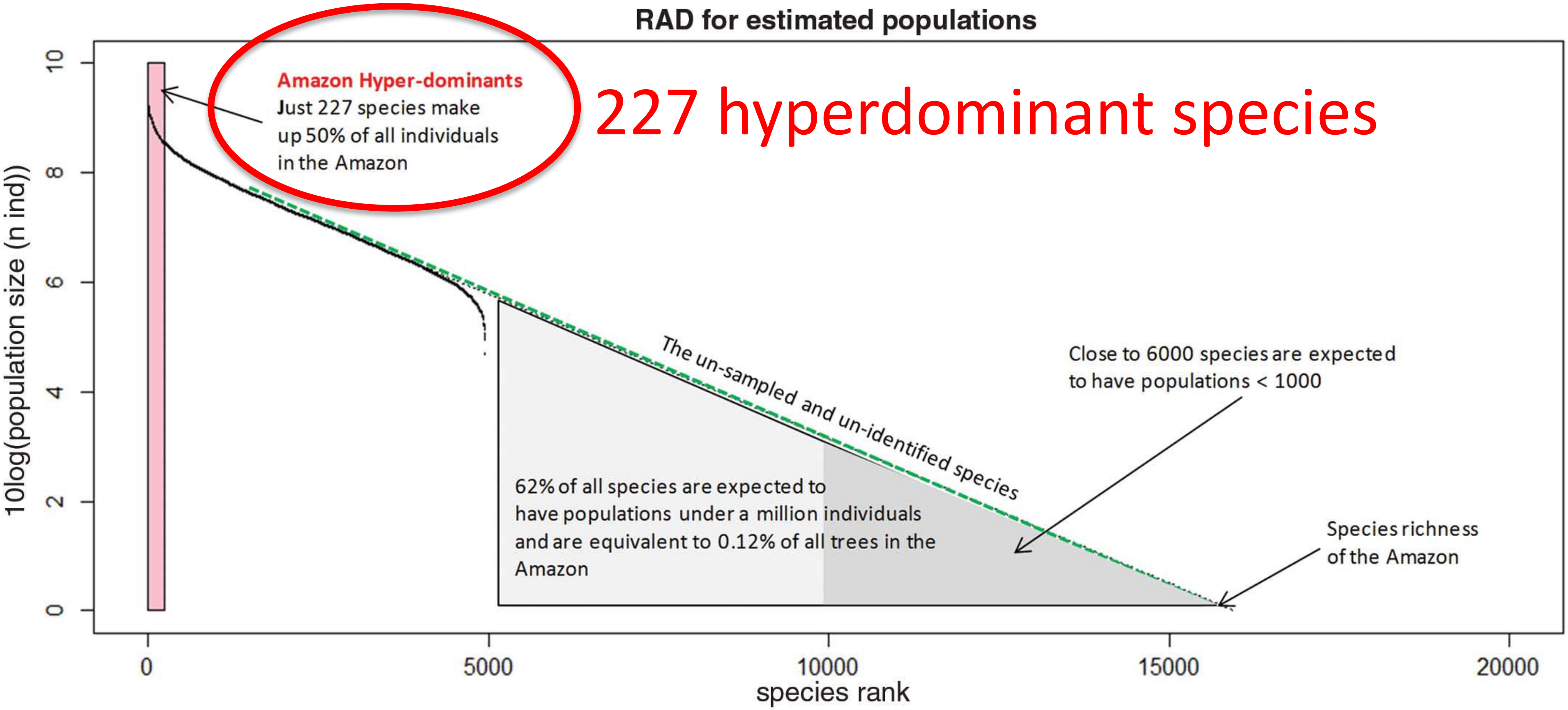
Fauset, S., *et al.* (2015). Hyperdominance in Amazonian forest carbon cycling. *Nature Communications*, 6, 6857.

If you look at the relative abundances of species in Amazonian forest inventory plots…

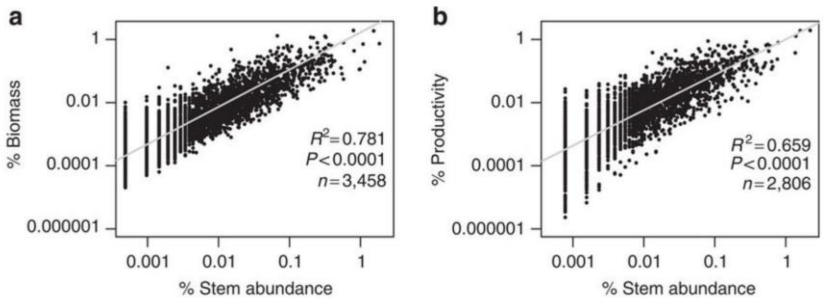


ter Steege et al. 2013 Science

Hyperdominance in the Amazonian Tree Flora



ter Steege, H., *et al.* (2013). Hyperdominance in the Amazonian Tree Flora. *Science*, 342, 1243092.



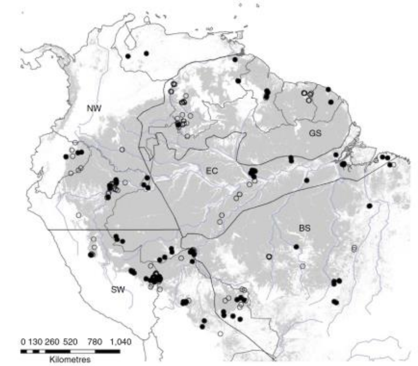


Table 2 | Top 20 most dominant species by aboveground woody biomass.

Family	Species	Biomass (Mg)	% Total biomass	Cumulative % biomass	Rank by stem abundance	Rank by productivity*
Fabaceae	*Eperua falcata*	2,217	1.93	1.93	8	8
Lecythidaceae	*Eschweilera coriacea*	2,142	1.87	3.80	2	2
Lecythidaceae	*Bertholletia excelsa*	1,498	1.31	5.11	243	4
Vochysiaceae	*Qualea rosea*	1,452	1.27	6.37	30	88
Lauraceae	*Chlorocardium rodiei*	1,340	1.17	7.54	71	13
Fabaceae	*Vouacapoua americana*	1,340	1.17	8.71	27	5
Goupiaceae	*Goupia glabra*	1,299	1.13	9.84	61	10
Burseraceae	*Tetragastris altissima*	908	0.79	10.64	10	6
Fabaceae	*Dicorynia guianensis*	898	0.78	11.42	56	16
Arecaceae	*Iriartea deltoidea*	847	0.74	12.16	1	1
Moraceae	*Pseudolmedia laevis*	819	0.71	12.87	4	3
Lecythidaceae	*Eschweilera sagotiana*	784	0.68	13.55	22	62
Sapotaceae	*Pradosia cochlearia*	736	0.64	14.19	176	275
Chrysobalanaceae	*Licania alba*	724	0.63	14.83	17	90
Caryocaraceae	*Caryocar glabrum*	689	0.60	15.43	149	50
Apocynaceae	*Aspidosperma excelsum*	648	0.57	15.99	74	14
Sapotaceae	*Pouteria guianensis*	625	0.54	16.54	55	53
Fabaceae	*Swartzia polyphylla*	624	0.54	17.08	203	19
Fabaceae	*Dicymbe altsonii*	623	0.54	17.62	233	9
Olacaceae	*Minquartia guianensis*	623	0.54	18.17	29	21

*Productivity ranks are based on the 221 plot productivity data set.

Fauset, S., *et al.* (2015). Hyperdominance in Amazonian forest carbon cycling. *Nature Communications*, 6, 6857.

What drives these patterns of species abundances (and thus patterns of carbon cycling)?

- ☑ Long-term evolutionary and ecological processes
- ☑ Stochastic processes
- ☑ Biotic interactions
- ☑ Environmental gradients
- ? Past human influence/ past disturbances

  *the focus of this talk!

Why is it important to look at long-term (100s of years) disturbances?

Amazonian trees commonly live several hundreds of years

Disturbances prior to the observational record could have altered successional patterns – thus C dynamics

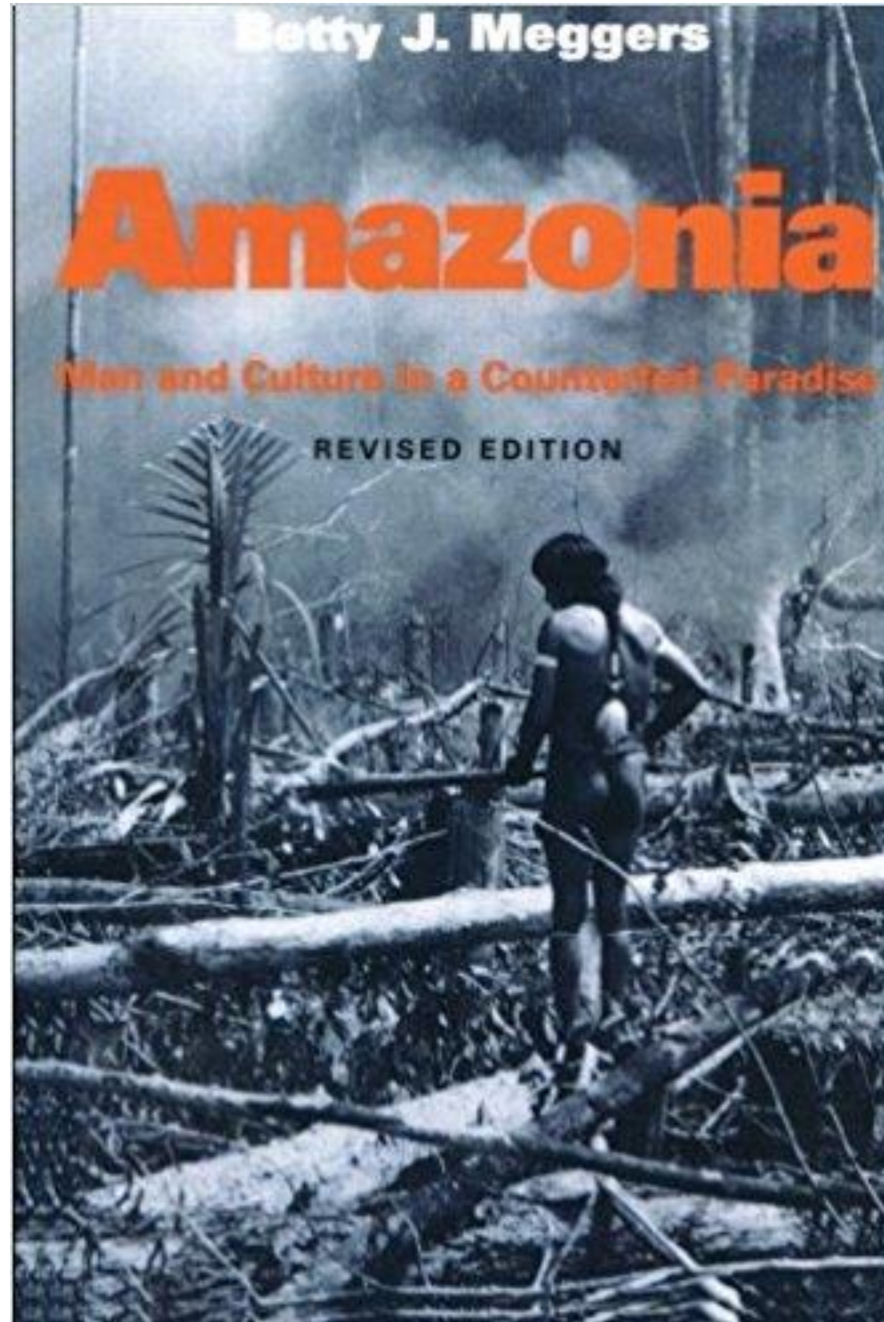
Full recovery from past disturbances can take centuries

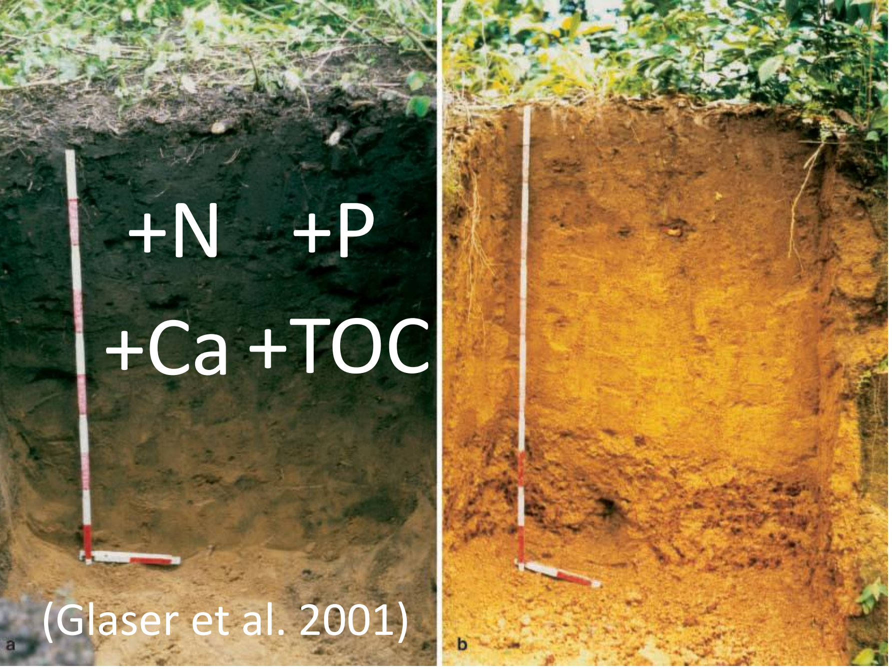
Past human activities as mechanisms of disturbance?

The potential for past disturbances was considered minimal for many years

Amazonia was a ‘counterfeit paradise’ or a ‘virgin wilderness’

Harsh environmental conditions (e.g. poor soils, super-wet conditions, fungi, etc) were believed to limit societal growth and development





Amazonian Dark Earths

Clay-rich oxisol

This idea held up until...

Geoglyphs

RESEARCH ARTICLE

Persistent effects of pre-Columbian plant domestication on Amazonian forest composition

C. Levis*,†, F. R. C. Costa, F. Bongers, M. Peña-Claros, C. R. Clement, A. B. Junqueira, E. G. Neves, E. K. Tamanaha, F. O. G. ...

+ See all authors and affiliations

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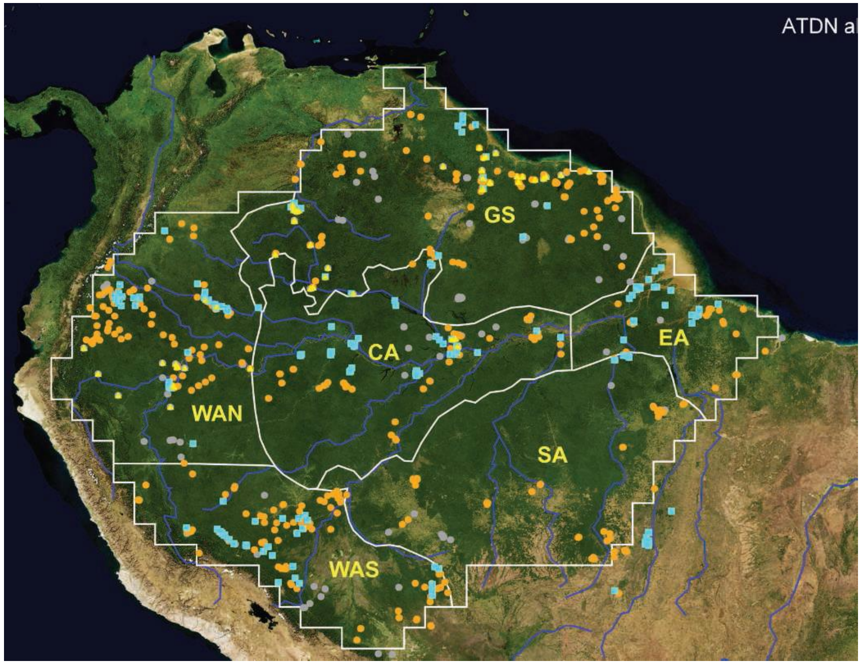
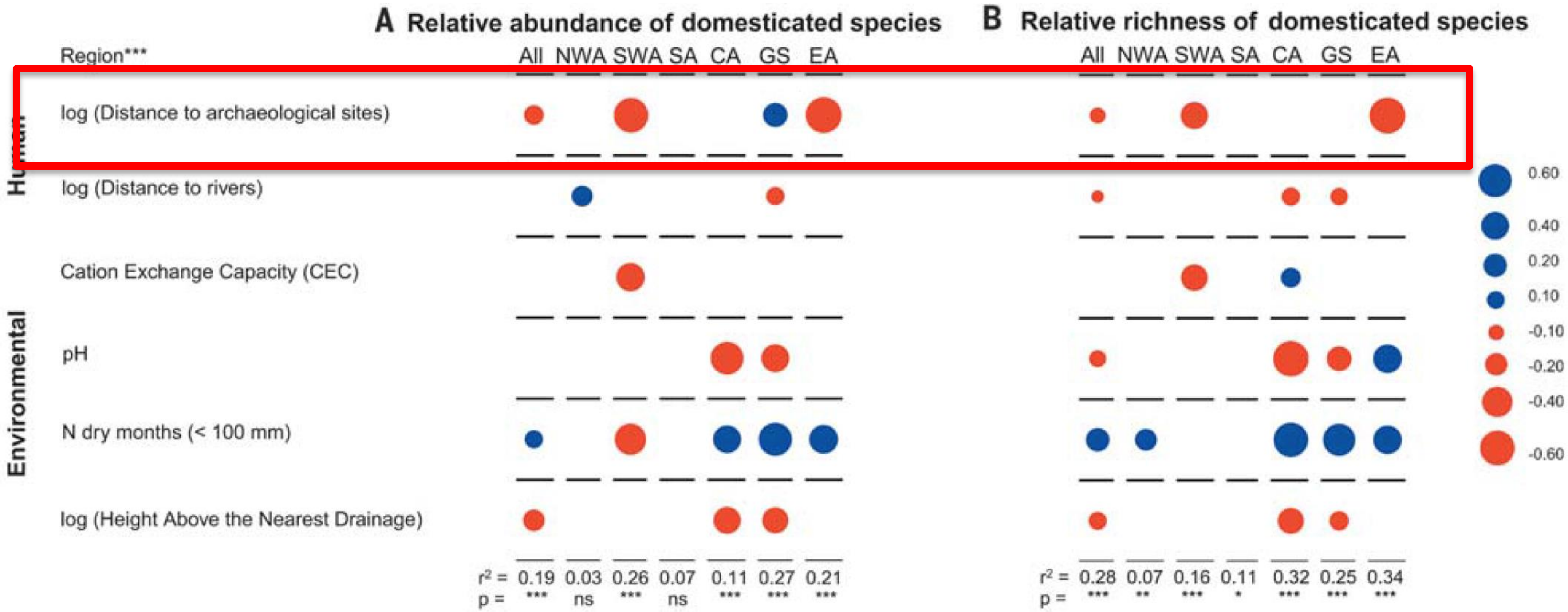
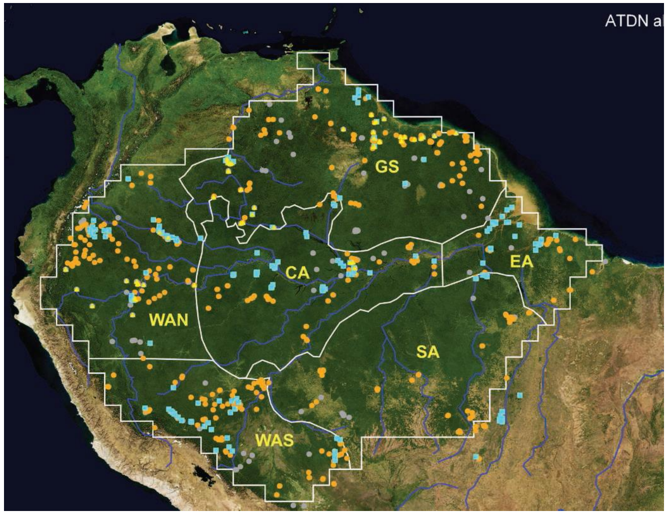
Vol. 355, Issue 6328, pp. 925-931
DOI: 10.1126/science.aal0157



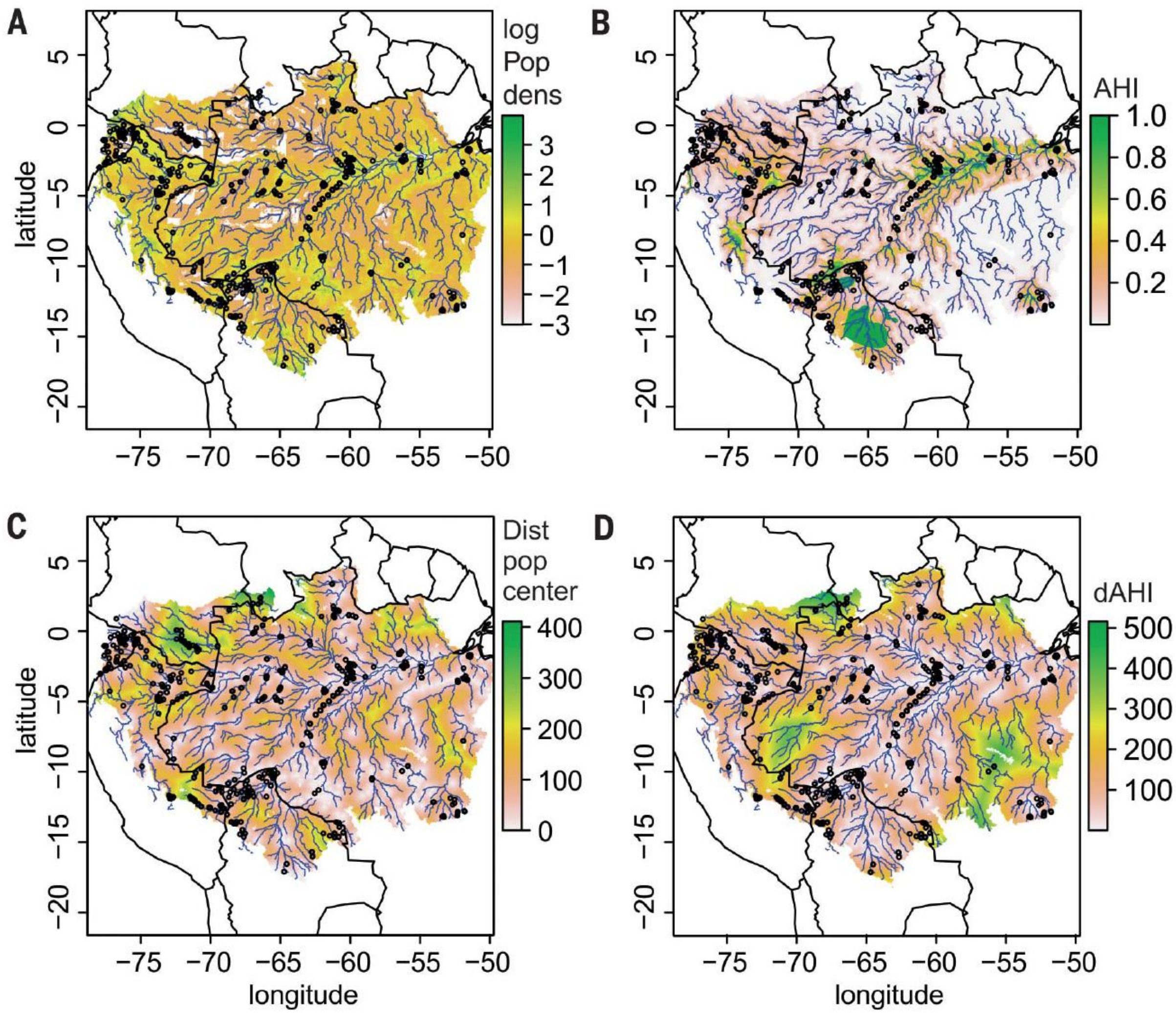




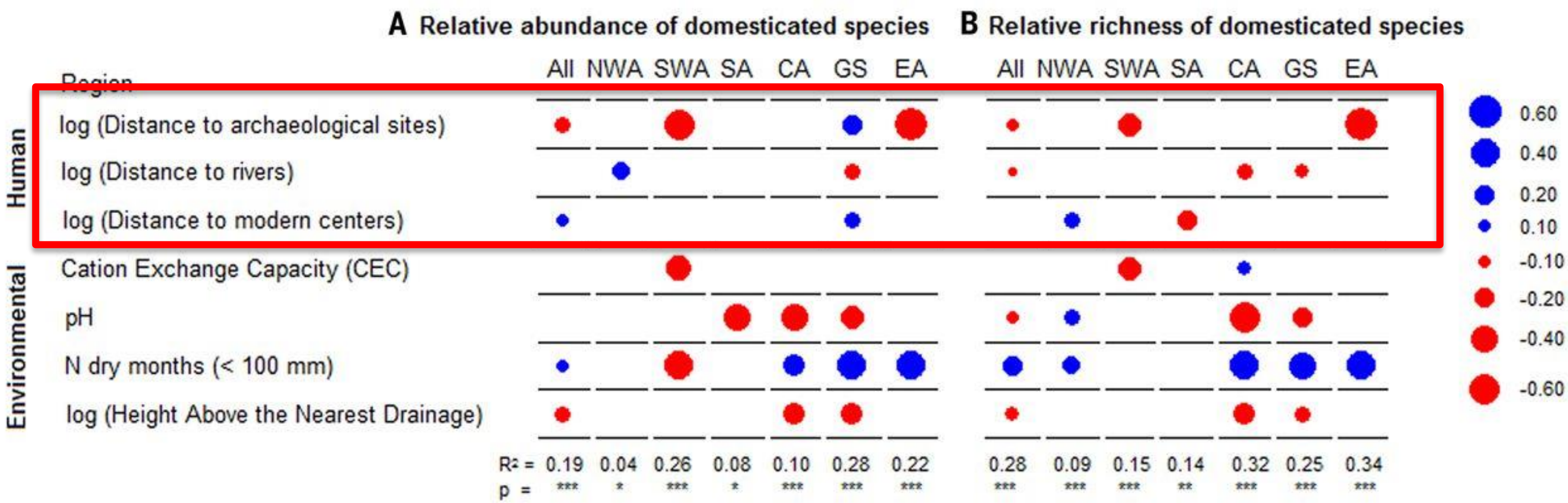
Levis, C., *et al.* (2017). Persistent effects of pre-Columbian plant domestication on Amazonian forest composition. *Science*, 355, 925-931.

But is it definitely because of pre-Columbian influences?

modern distributions **pre-Columbian distributions**



McMichael, C.H., et al. (2017). Comment on "Persistent effects of pre-Columbian plant domestication on Amazonian forest composition". *Science*, 358.



Junqueira, A.B., *et al.* (2017). Response to Comment on "Persistent effects of pre-Columbian plant domestication on Amazonian forest composition". *Science*, 358.

A condensed version of Amazonian history…

terra preta

‘geoglyphs’

large settlements

1541

Carvajal expedition

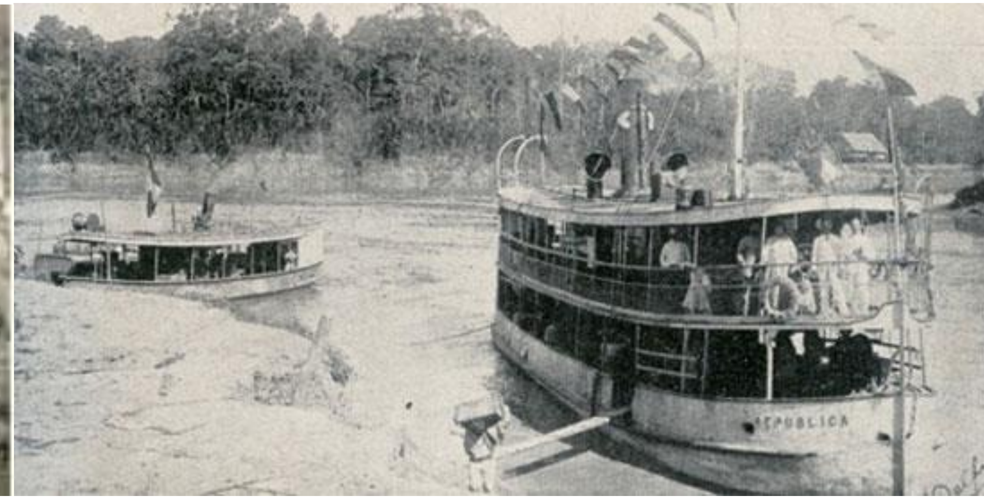
1707 map of Amazonia

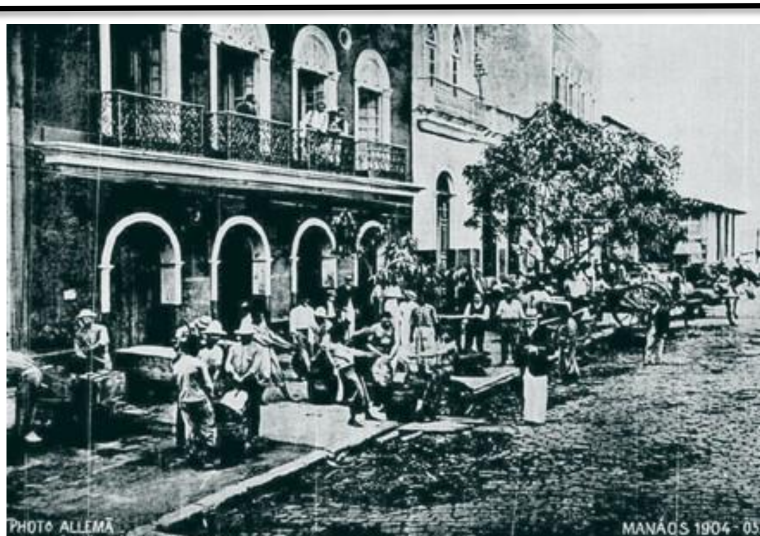
1752 map of Bolivia (Llanos)

1600 - 1850

European Colonization

"The Putumayo, the Devil's Paradise"
(1912)





1850 - 1920

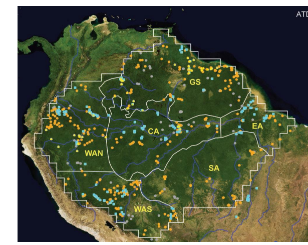
Rubber boom

A condensed version of Amazonian history...

What about the post-Columbian influence?

pre-Columbian

modern



1541
Carvajal expedition

1600 - 1850
European Colonization

1850 - 1920
Rubber boom

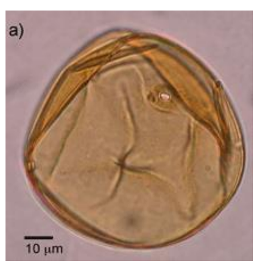
2017
forest plots

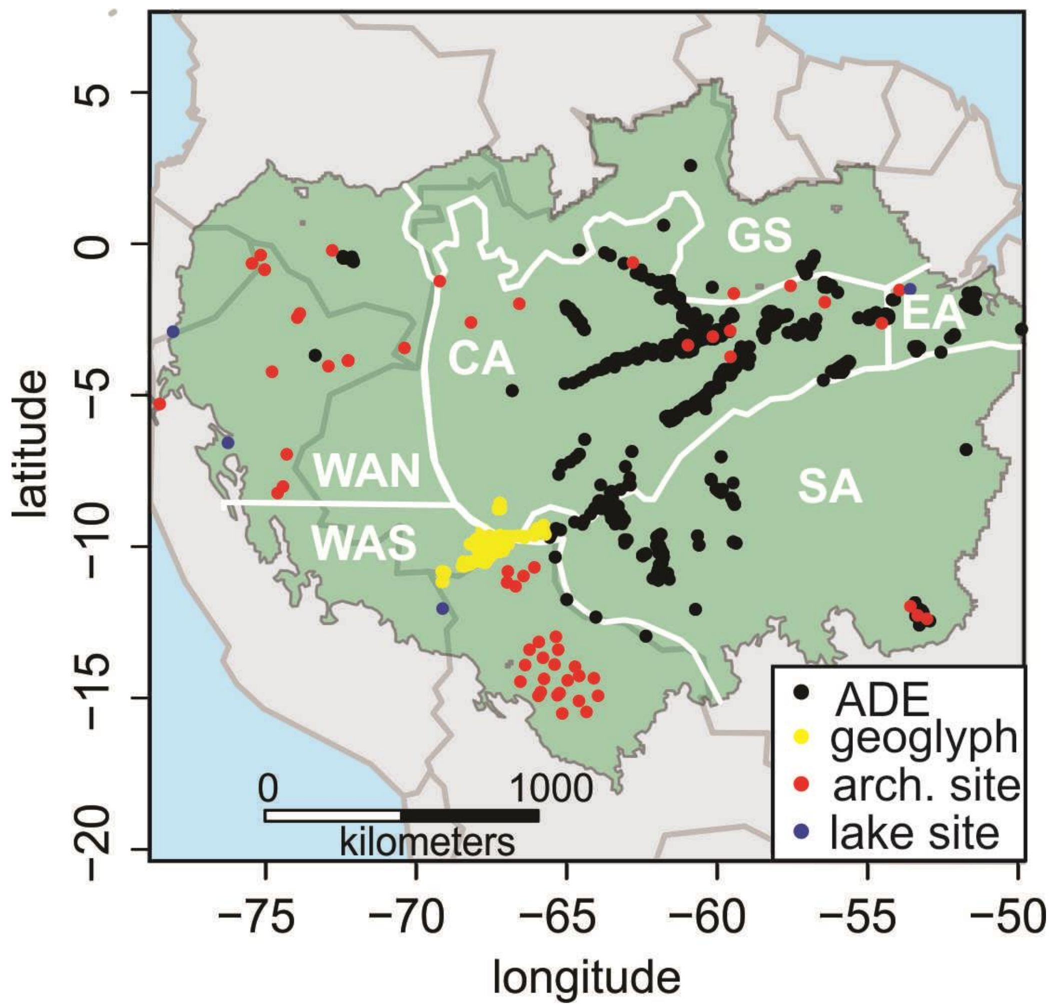
Approach

1. Predict the distributions of people during the pre-Columbian, European colonization, and rubber boom era
2. Examine the distribution of past people in relation to forest plot locations
3. Compare the predicted distributions with observations used to estimate the carbon sequestration potential of Amazonia
   - aboveground biomass
   - woody productivity rates
   - woody loss rates
   - stem mortality rates

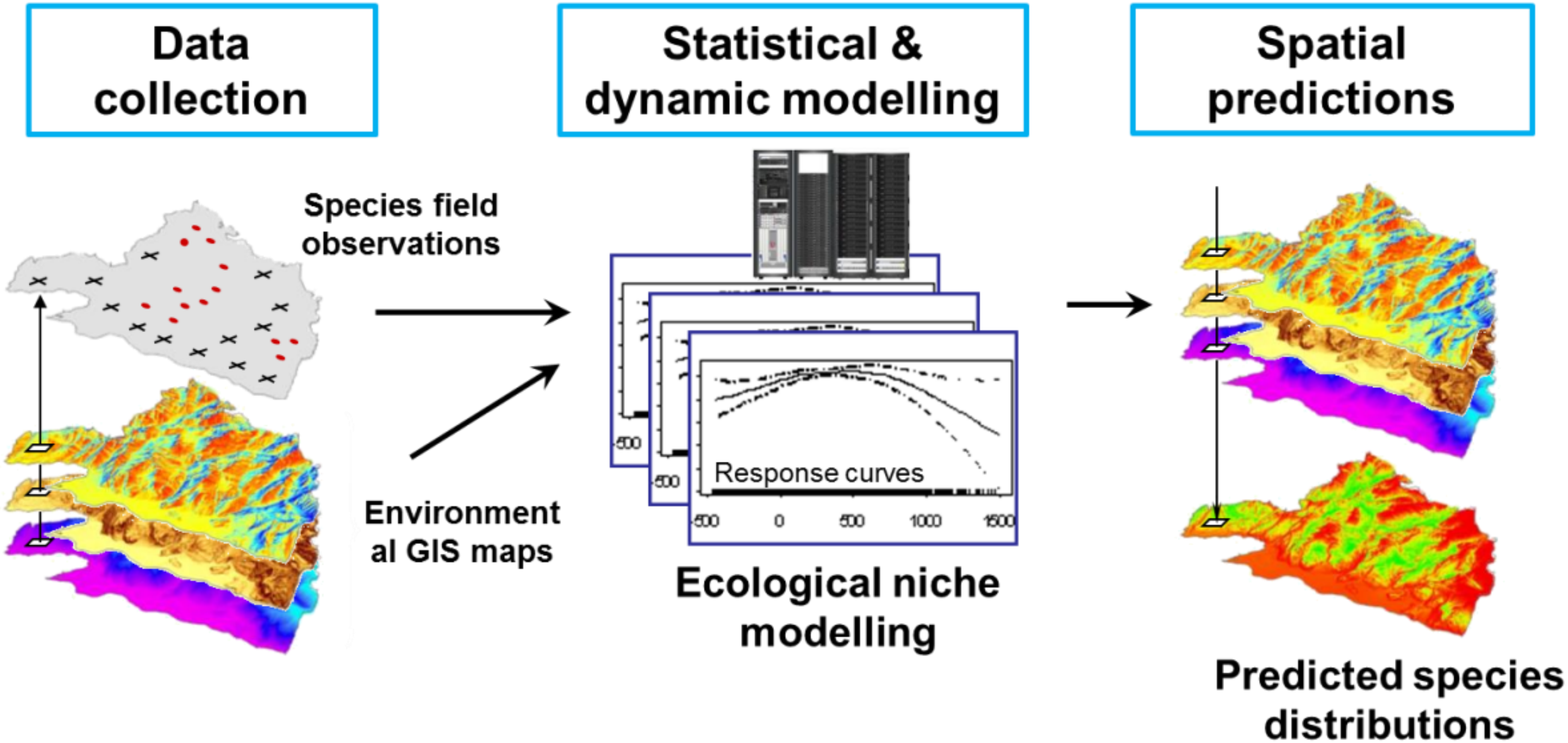
Where is the evidence for pre-Columbian people?

compiled archaeological and paleoecological datasets





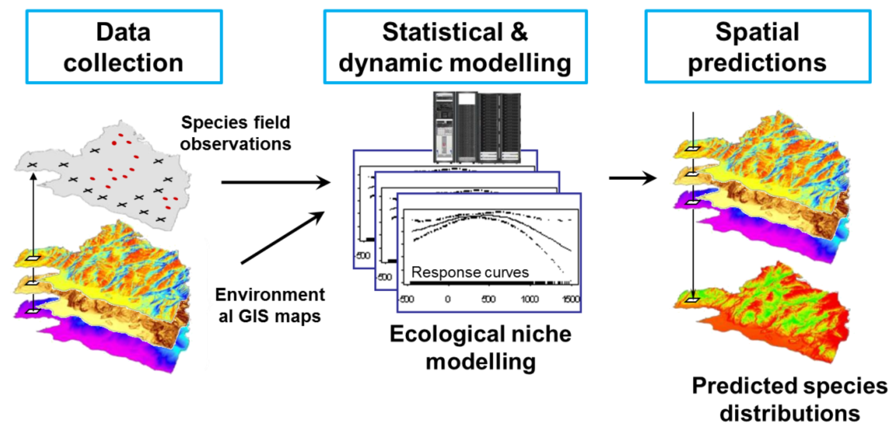
Generating predictive models of past people



Ecological niche modeling applied to archaeological, paleoecological, and historical datasets

Generating predictive models of past people: the pre-Columbian era

Maximum entropy models



Occurrence points (N = 1677):

archaeological sites

paleoecological sites

Environmental predictors (N = 22) :

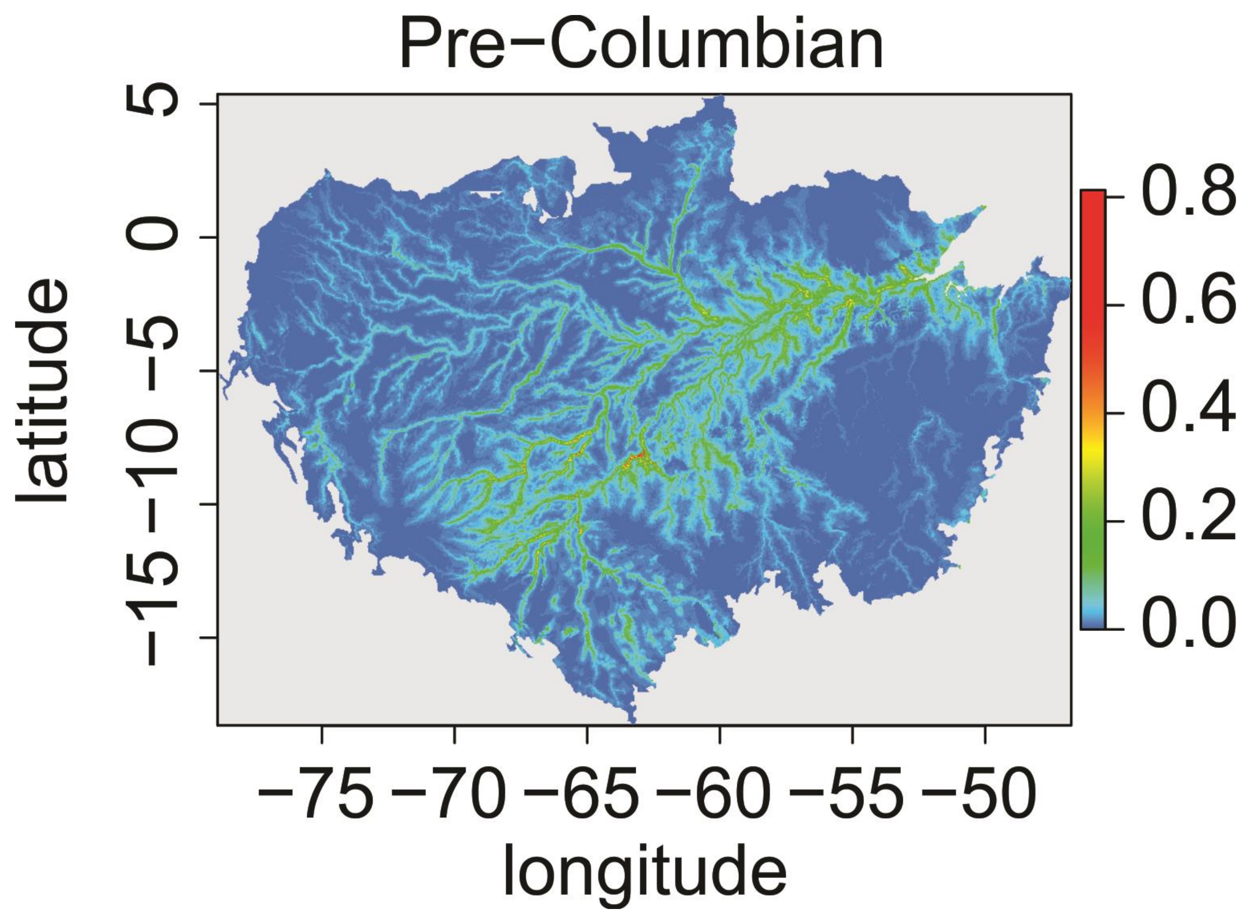
climate (WorldClim)

soils (FAO)

terrain (SRTM)

geospatial (distance to river)

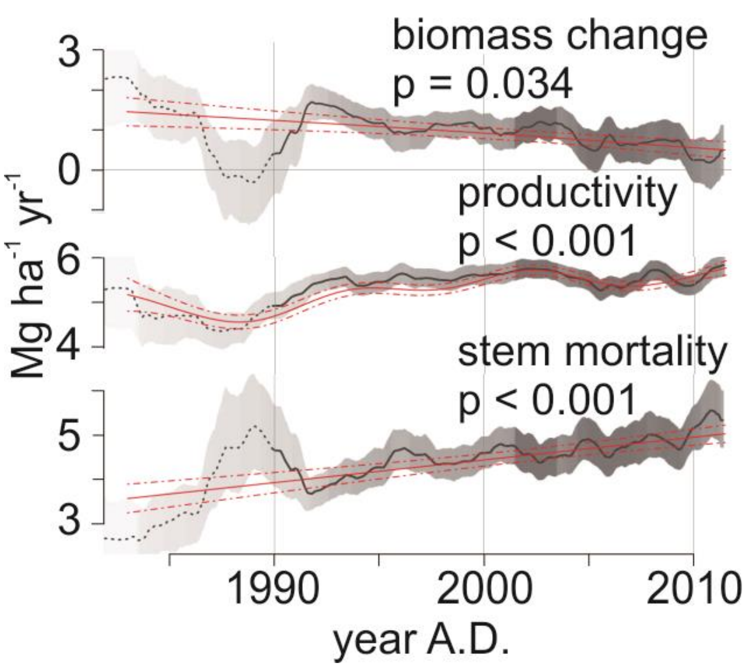
Distributions of people in the pre-Columbian era

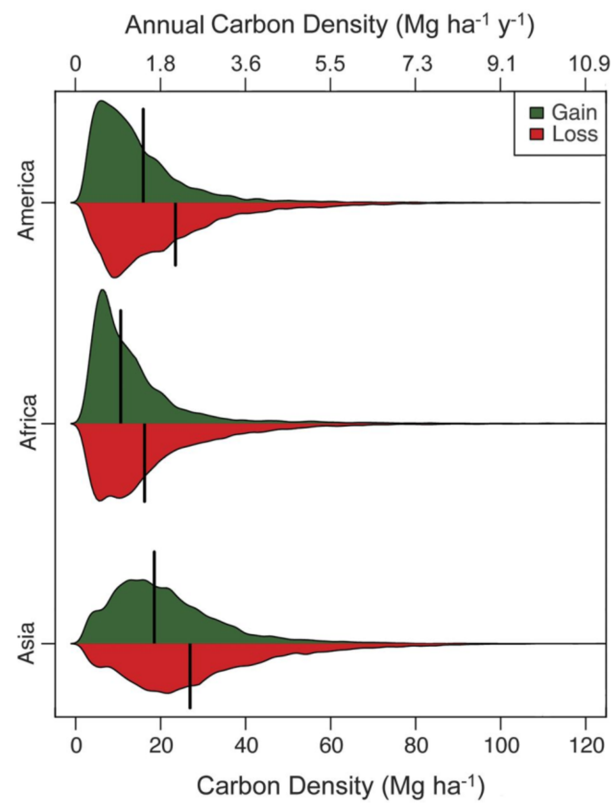


McMichael, C.N., (2017). Ancient human disturbances may be skewing our understanding of Amazonian forests. *Proceedings of the National Academy of Sciences*, 114, 522-527.

Why does this matter?

Amazonia was long thought to be a carbon sink, but its recent carbon storage potential has been declining



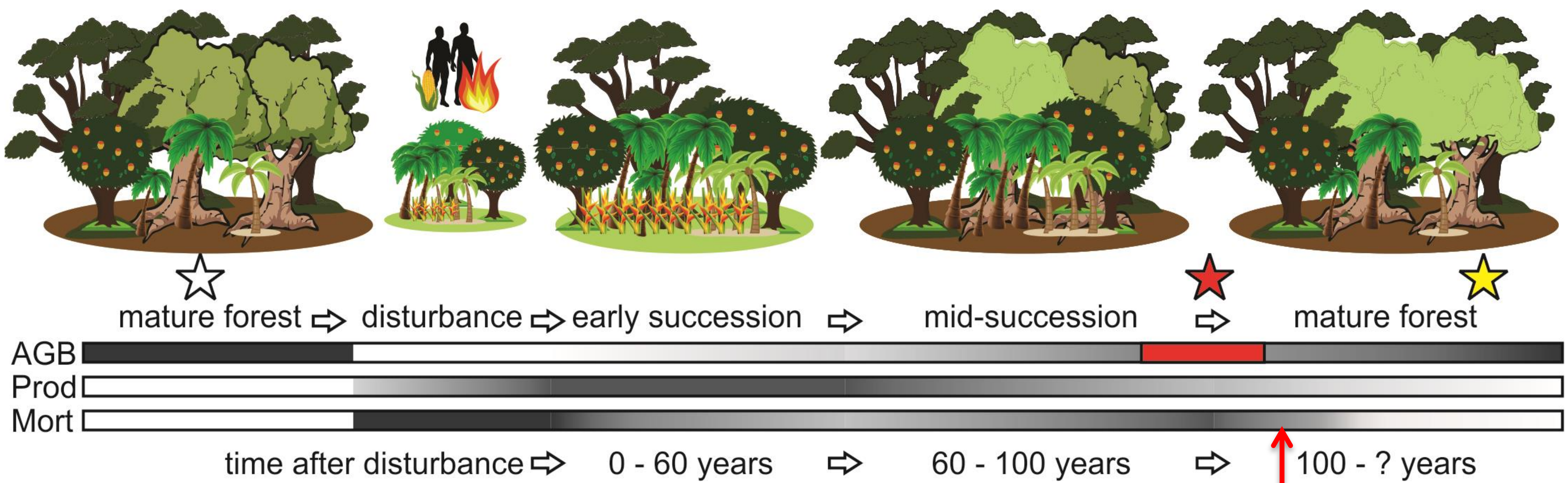


Brienen, R.J.W., *et al.* (2015). Long-term decline of the Amazon carbon sink. *Nature*, 519, 344-348.

Baccini, A., et al. (2017). Tropical forests are a net carbon source based on aboveground measurements of gain and loss. *Science*.

Do observed data reflect forests recovering from past disturbances?

Are we overestimating the carbon storage potential of Amazonia?



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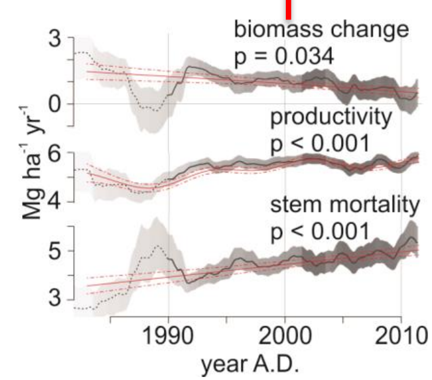

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Ecology of the Past: https://ecologyofthepast.info/

Thank you!

University of Amsterdam

IBED

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William D. Gosling: University of Amsterdam

*Rick de Regt: University of Amsterdam – BSc student