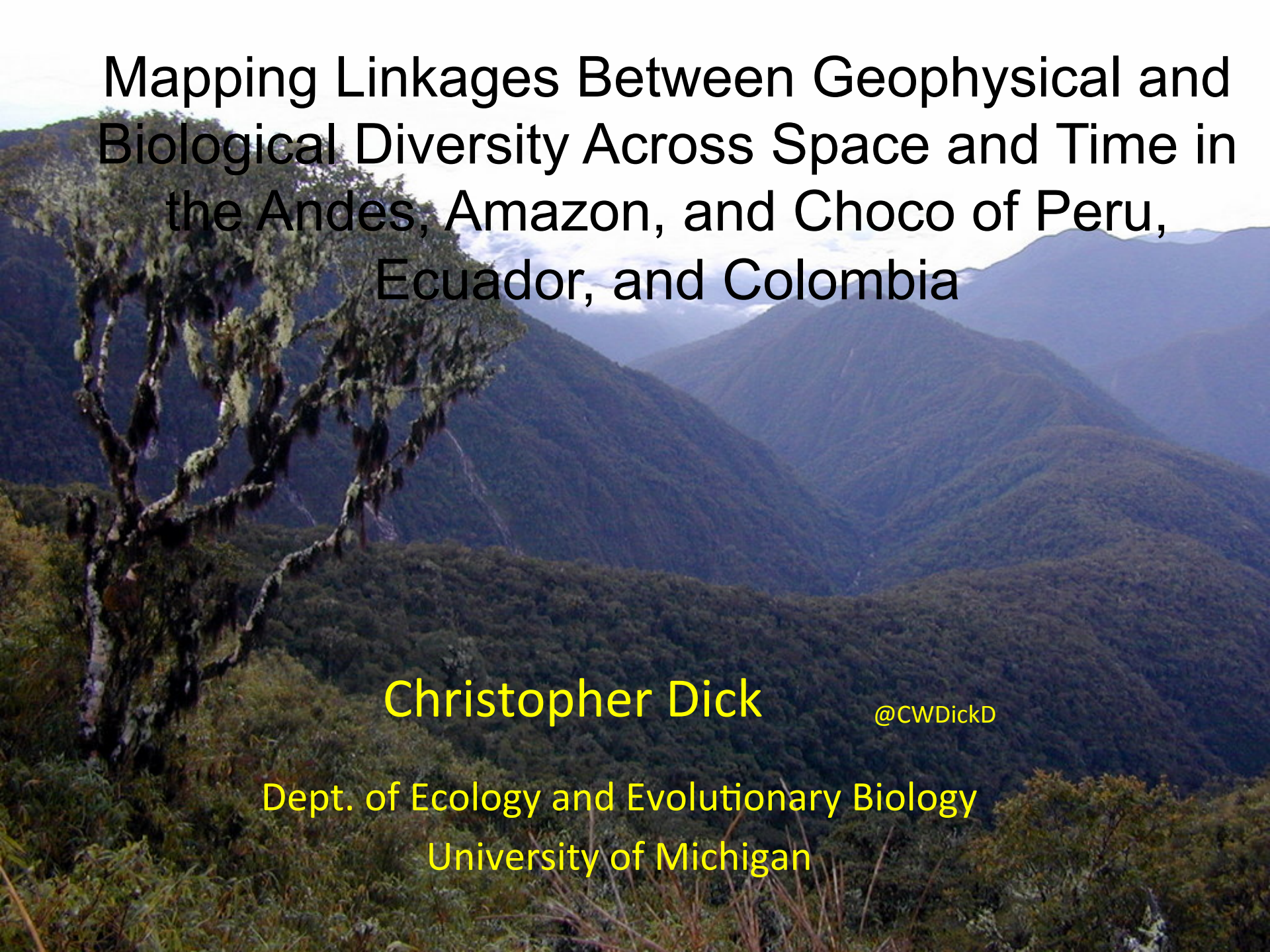
Mapping Linkages Between Geophysical and Biological Diversity Across Space and Time in the Andes, Amazon, and Choco of Peru, Ecuador, and Colombia



Christopher Dick @CWDickD

Dept. of Ecology and Evolutionary Biology
University of Michigan

2017 Workshops

February 2017 – Nebraska, first meeting
December 2017 – Ecuador, second meeting

Investigatorn	Institution	Expertise
Sherilyn C. Fritz* PI	University of Nebraska	Paleoclimate, paleoecology
Greg Asner*	Carnegie Institution	Remote sensing, tropical ecology
Paul Baker*	Duke University, Yachay Tech	Paleoclimate, geochemistry
David Battisti	University of Washington	Climate modeling
Christopher Dick*	University of Michigan	Plant systematics/phylogeography
Brian Horton	University of Texas	Tectonics
Sassan Saatchi	Jet Propulsion Lab	Remote sensing, tropical ecology
Miles Silman*	Wake Forest University	Tropical Ecology
Oscar Vargas	University of Michigan	Post-doc, Plant Systematics
Alexander Wheatley	Duke University	PhD Student, geology

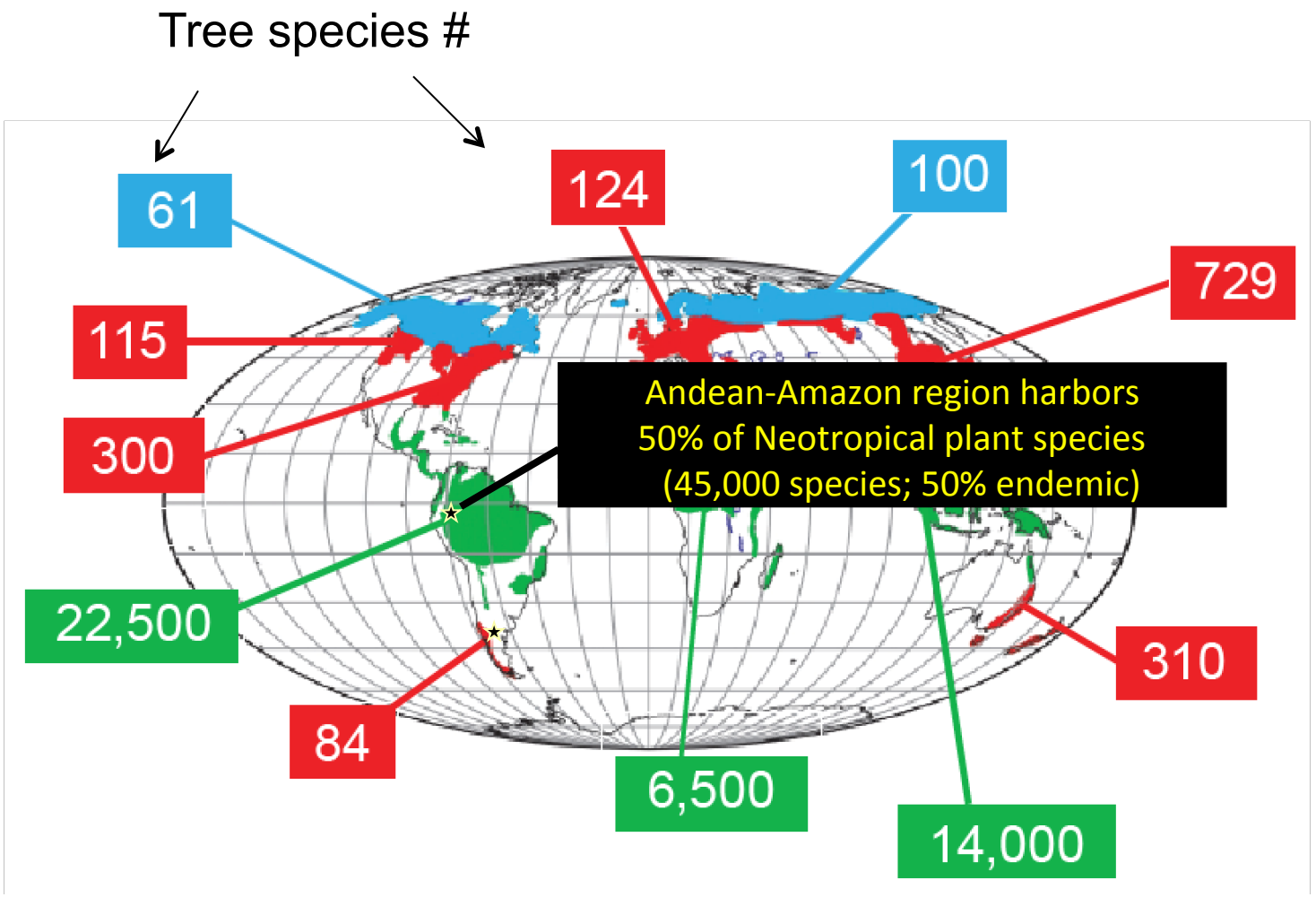
* Participated in February meeting

Global context

Boreal
161 sp.

Temperate
1662 sp.

Tropical
43000 sp.

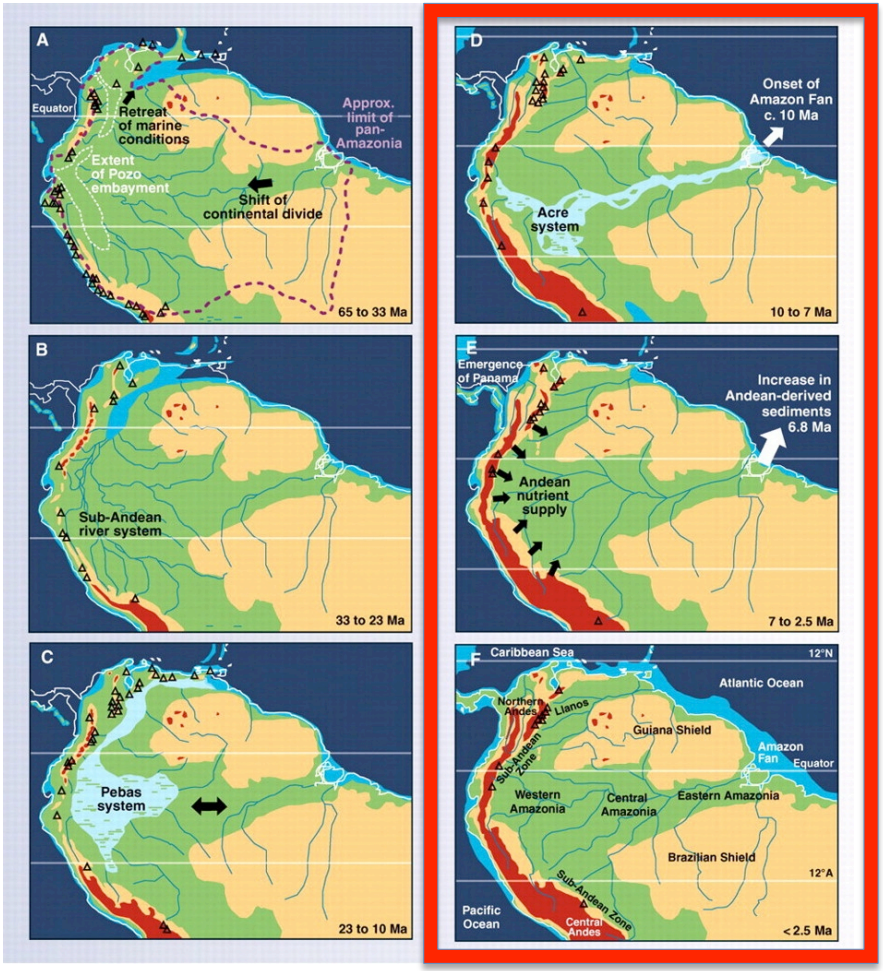


Estimates from Fine & Ree (2006) Am Nat 168:796

The Andean contribution to Neotropical biodiversity

65-10 Ma

10 Ma - present



Uplifting Northern Andes created Pebas wetland and subsequently Amazon basin

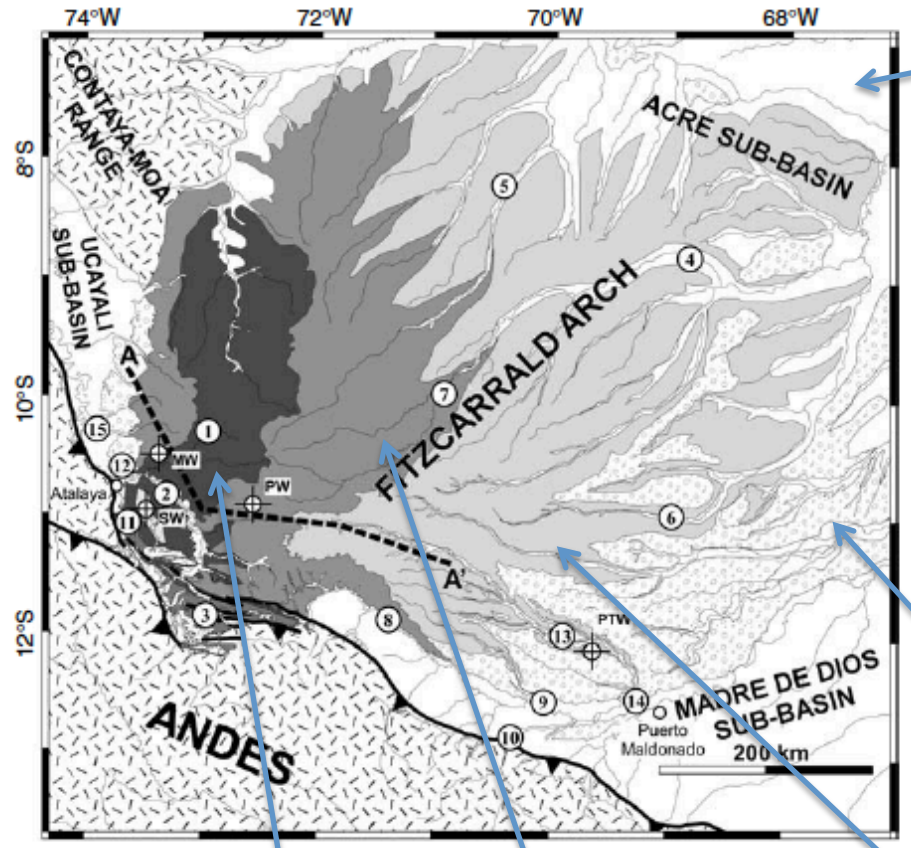
Major influence on regional precipitation, soils and hydrology

Heterogeneous, Andean-generated geological formations underlie Amazon forests.

Yet we know little of their impacts on the generation and maintenance of biodiversity

Figure from Hoorn et al. 2010 *Science*

Geological setting for biotic diversification



Pleistocene

Geological formations differ in deposition history and fertility

not widely studied as a factor in speciation

Pliocene (3-4 Ma)

Late Miocene ~ 9 Ma

Mid Miocene >13 Ma

Mid Miocene ~13 Ma

NASA workshop builds upon NSF FESD **GeoGenomics** project

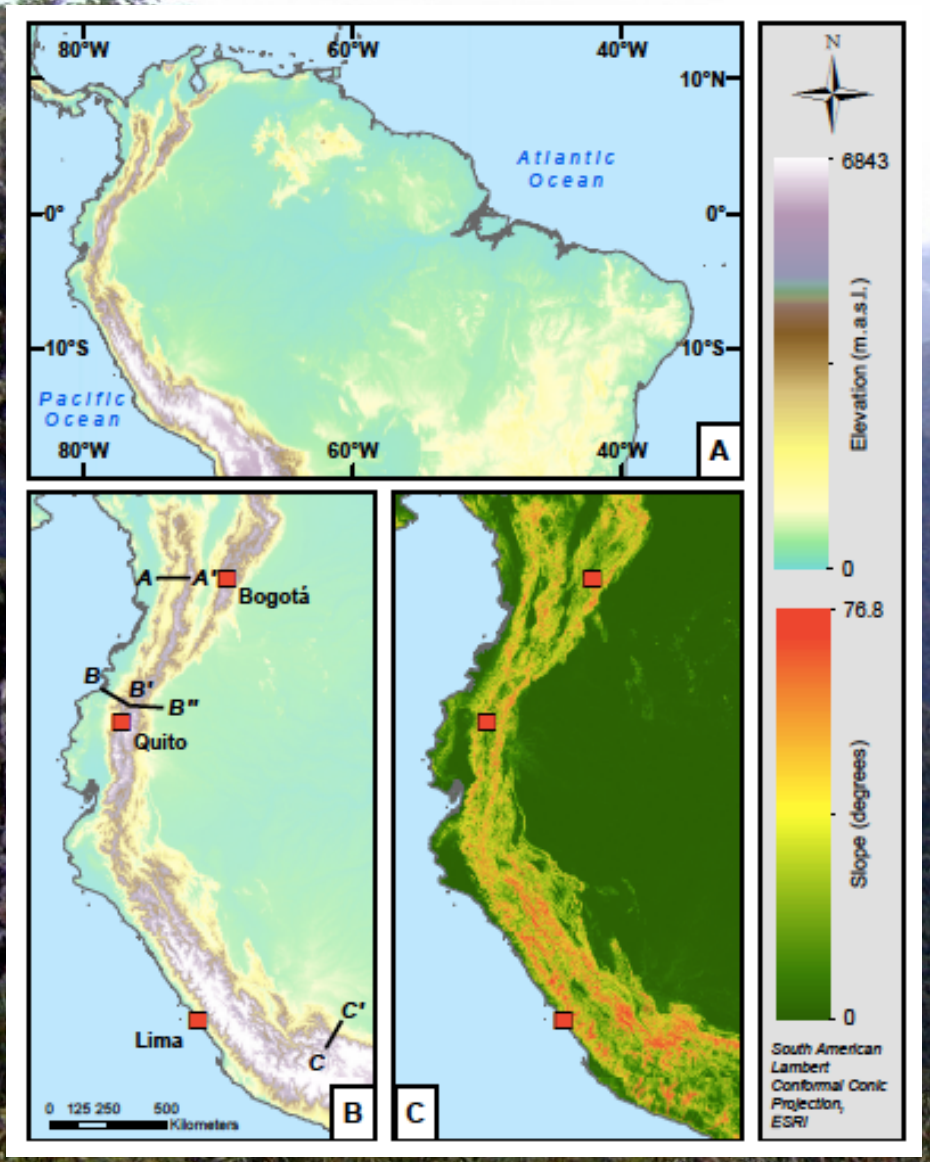
- Late Cenozoic history of Amazon river formation
- Andean uplift history and impacts on climate/landscape/diversity

At NASA workshop: what can we learn by integrating Remote sensing, forest inventory and plant molecular genetics?

NSF FESD Award 2012-2017 The Dynamics of Mountains, Landscapes and Climate in the Distribution and Generation of Biodiversity of the Amazon/Andean Forest

Baker, Fritz, Dick et al. (2014) The emerging field of geogenomics: constraining geological problems with genetic data *Earth Science Reviews*

Proposed Amazon-Andes forest transects



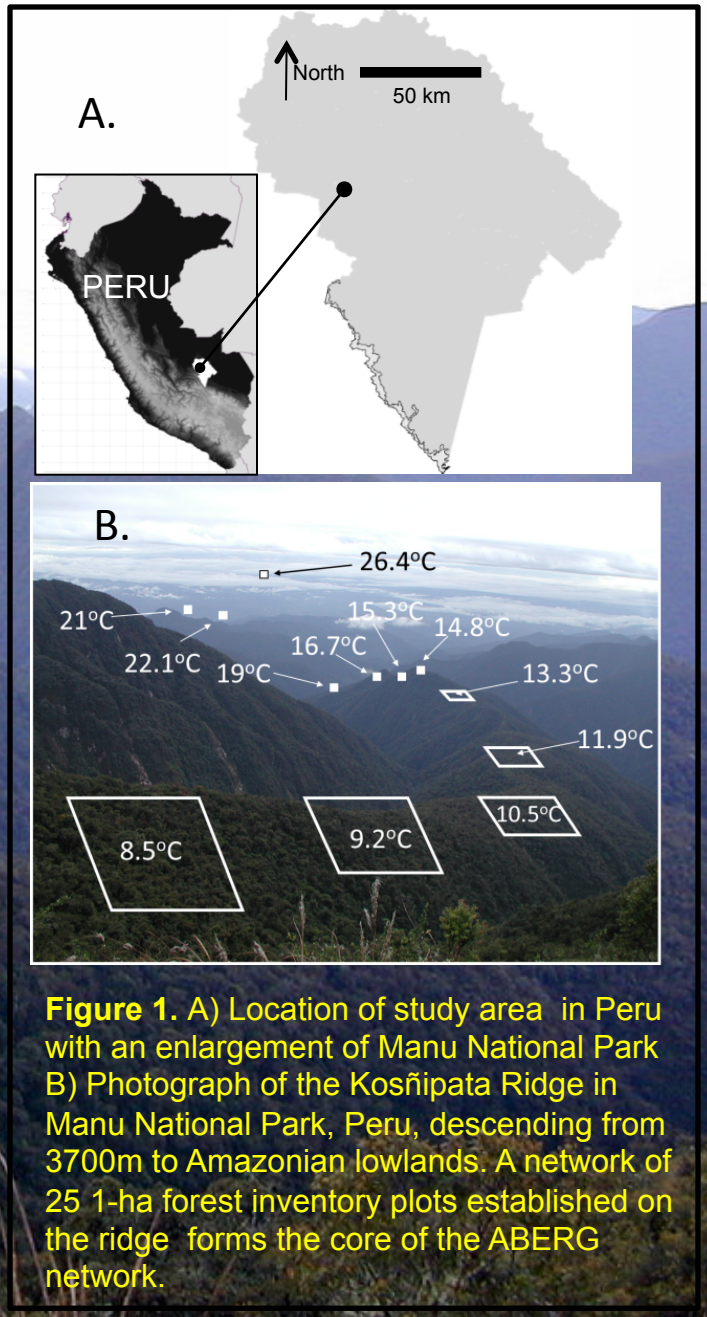
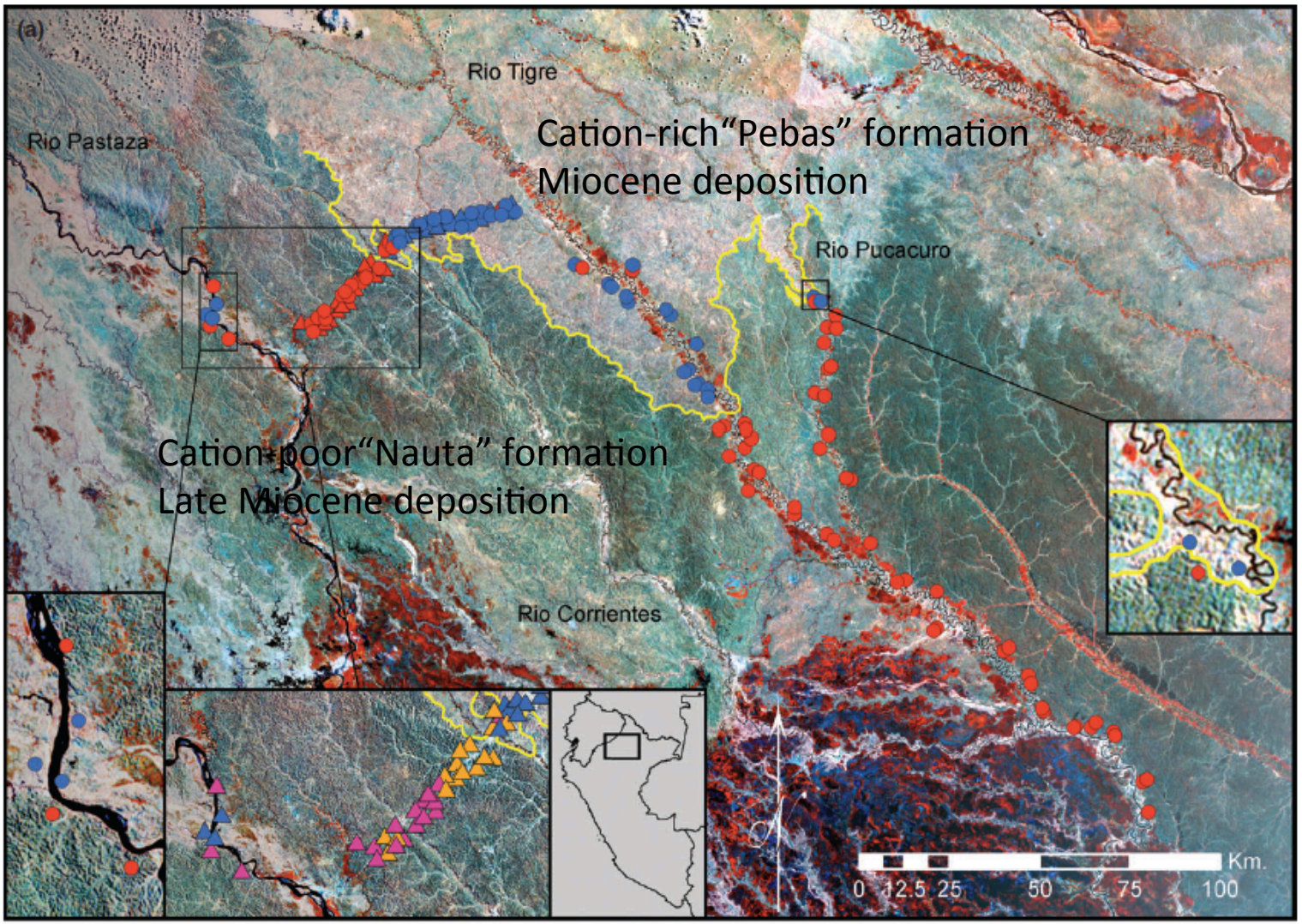


Figure 1. A) Location of study area in Peru with an enlargement of Manu National Park B) Photograph of the Kosñipata Ridge in Manu National Park, Peru, descending from 3700m to Amazonian lowlands. A network of 25 1-ha forest inventory plots established on the ridge forms the core of the ABERG network.

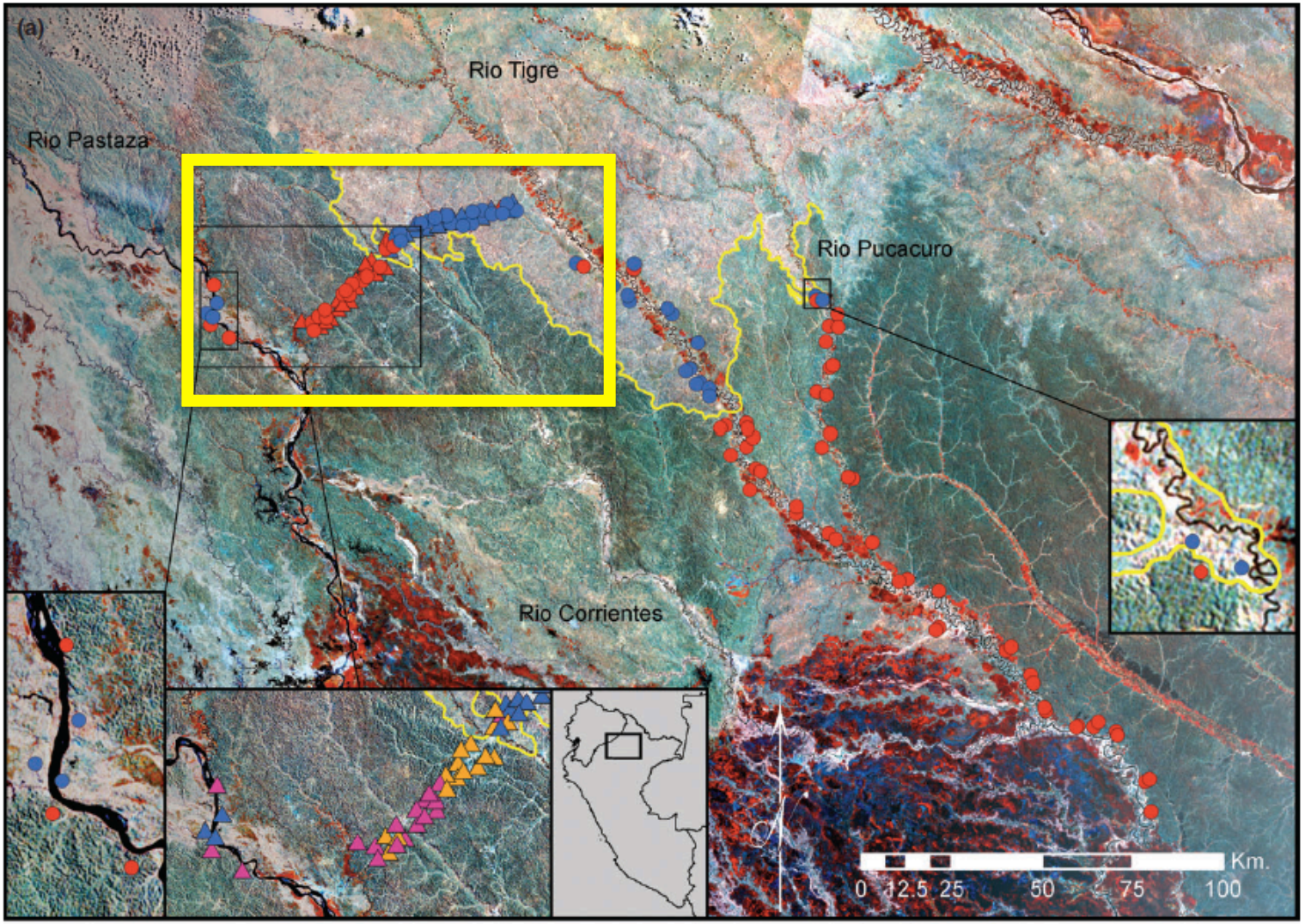
Miles Silman, photo credit

Landsat reveal geological substrates and vegetation



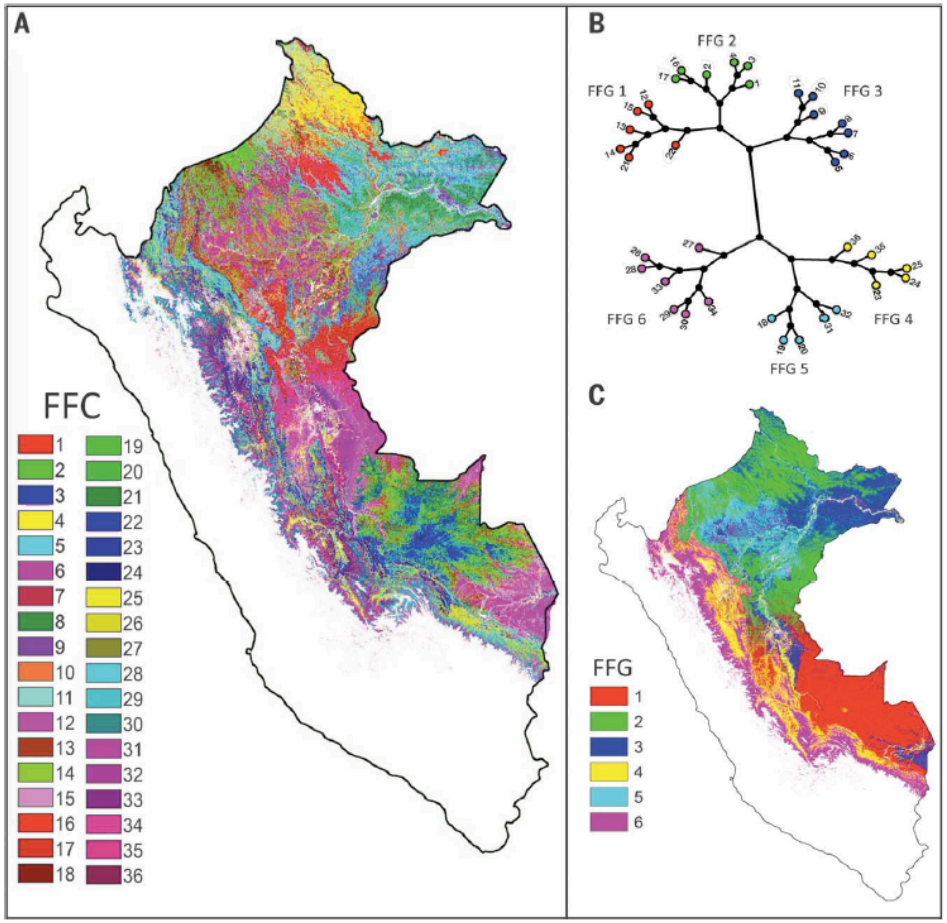
Higgins et al. (2011) J. Biogeography 38, 2136–2149

Floristic inventories show striking species turnover across geological units (shrub family Melastomataceae and ferns)



Higgins et al. (2011) J. Biogeography 38, 2136–2149

Functional trait biogeography



Asner *et al.*, *Science* **355**, 385–389 (2017) 27 January 2017

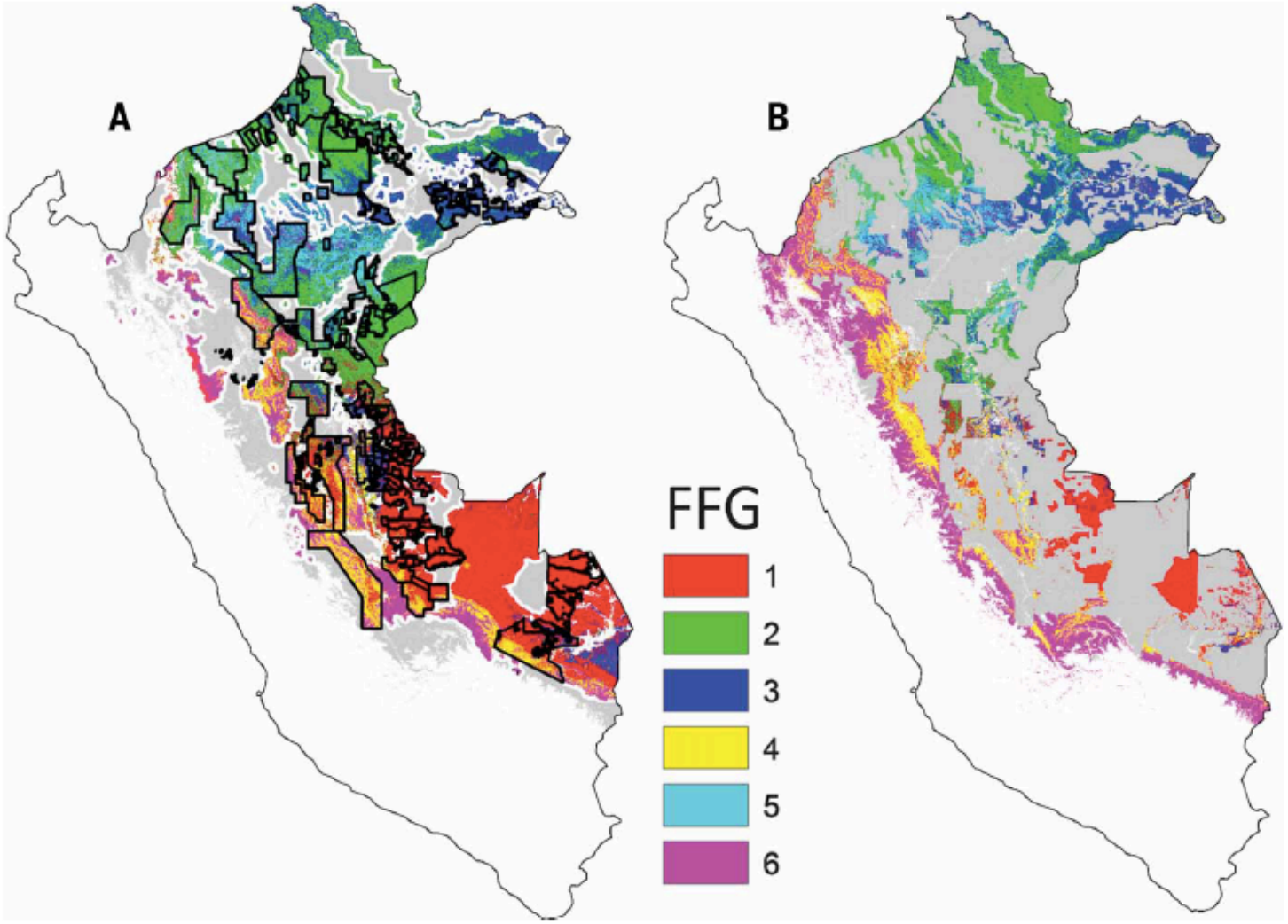
Airborne laser-guided imaging spectroscopy to map forest trait diversity and guide conservation

G. P. Asner,[1]* R. E. Martin,[1] D. E. Knapp,[1] R. Tupayachi,[1] C. B. Anderson,[1] F. Sinca,[1] N. R. Vaughn,[1] W. Llactayo[2]

Geospatial variation in 7 canopy traits was explained by variation in geology, hydrology, topography and climate

Discrimination of forest types across Andean-Amazon region of Peruvian

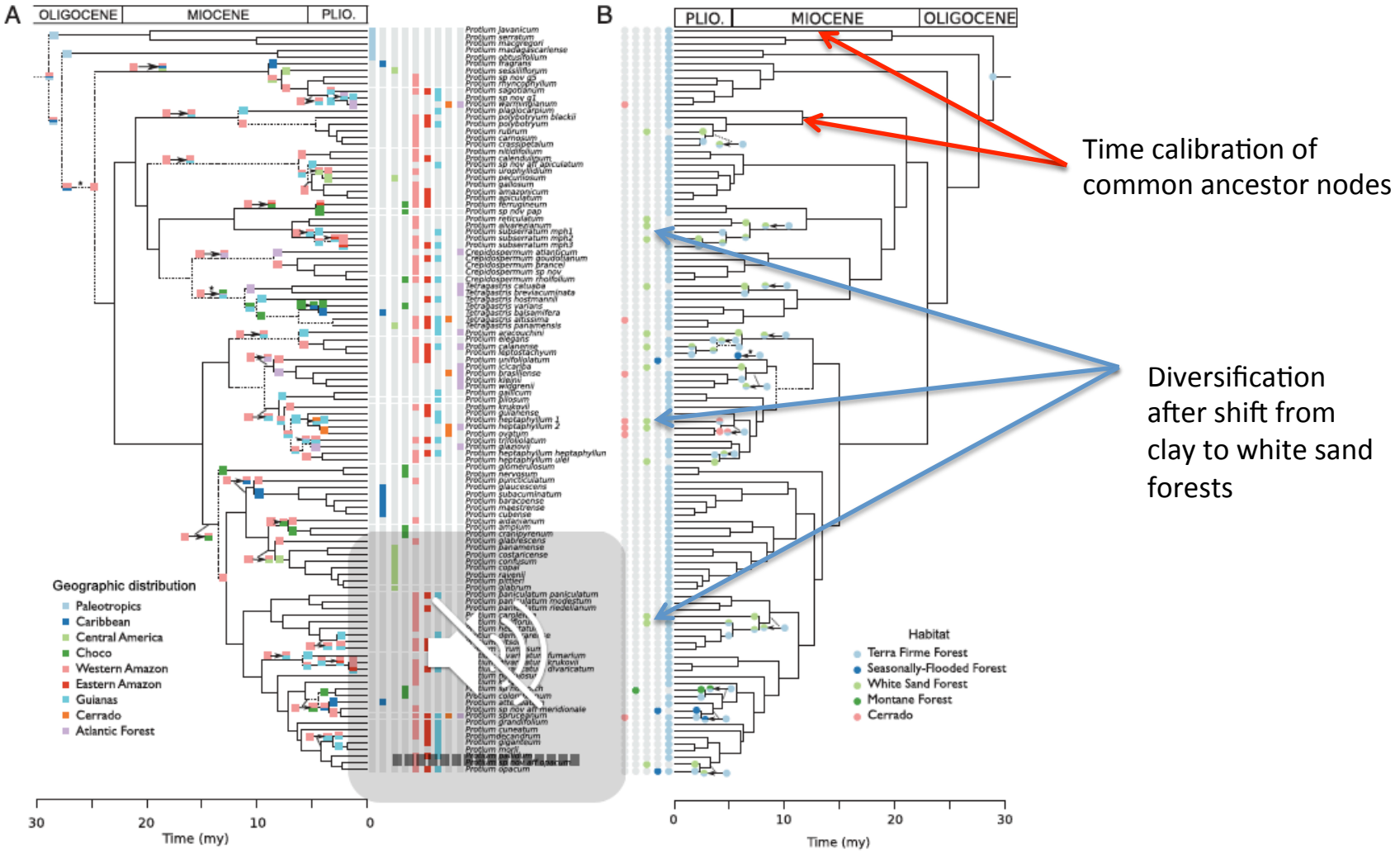
LIDAR-based designation of forest types and conservation status



Geophysical & vegetation mapping through time and space

- LIDAR Permits mapping of forest types based on plant functional traits (that have spectral signature)
- Forest types cluster with environmental features, permitting geophysical mapping
- Role in plant diversification can be inferred from phylogenetic analyses of associated clades

Habitat/Geographic mapping to phylogenies help to understand drivers of speciation

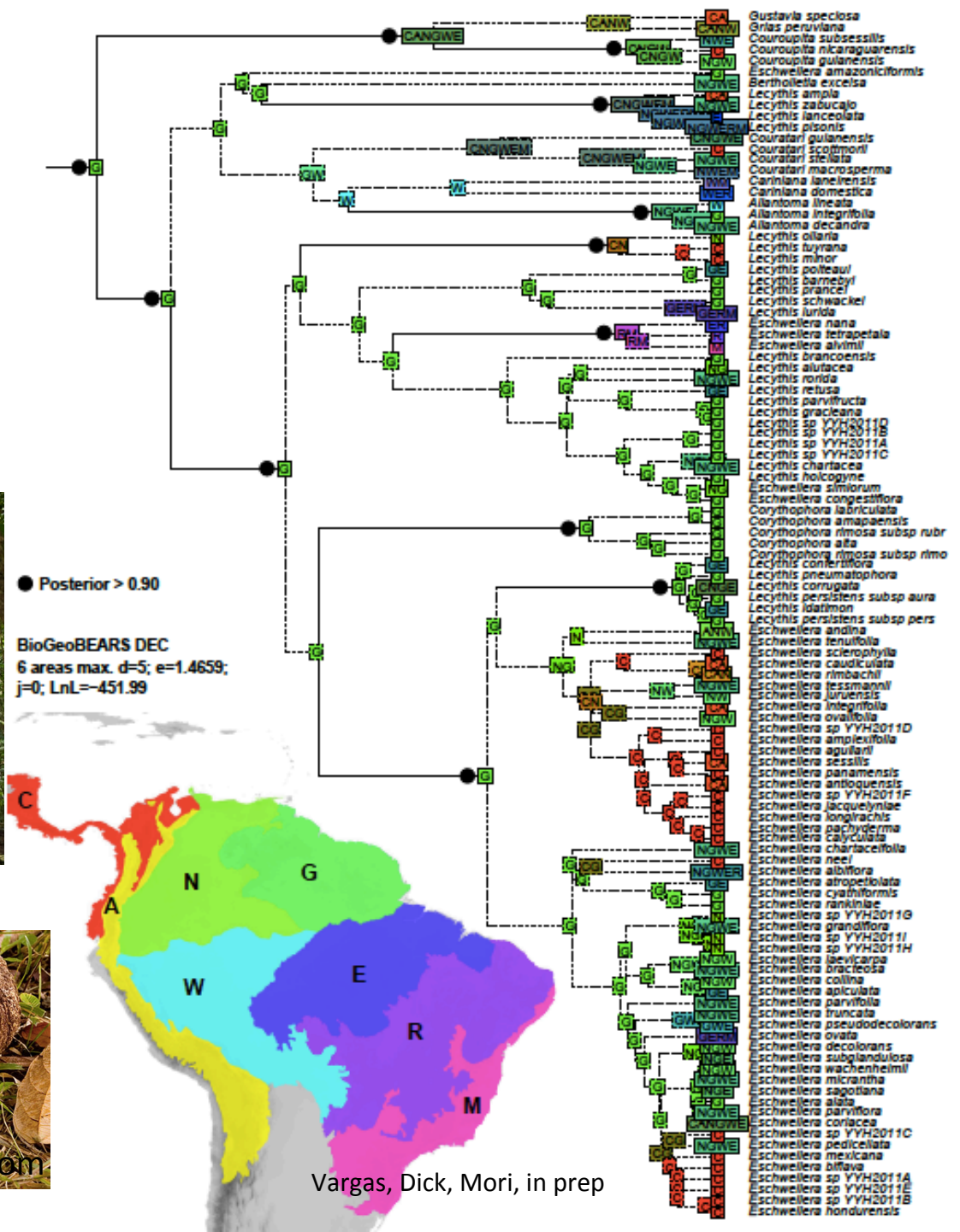


Example from Protieae clade (Burseraceae) Fine et al (2014)

Focal clades

Brazil-nut family Lecythidaceae

Brazil nut tree
&
Brazil nut seeds

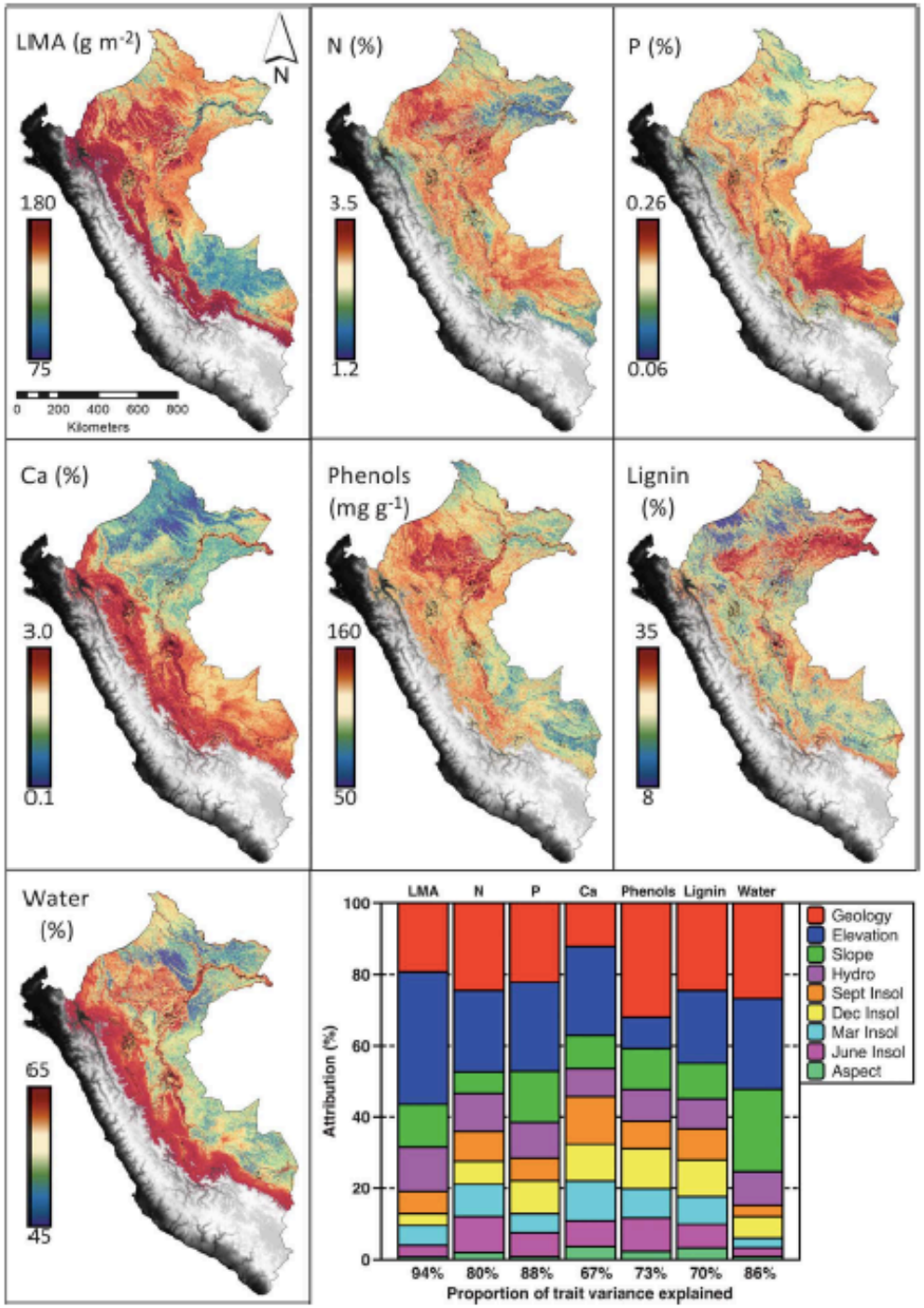


Vargas, Dick, Mori, in prep

Big questions

- How many forest types can be found within the Amazon-Amazon and Andean-Chocó regions?
- Does the heterogeneity of geological formations drive lowland biotic diversification?
- Can understanding of these processes help guide conservation efforts?

Thank you


LMA (g m-2)
N
180
75
0 200 400 600 800
Kilometers
N (%)
3.5
1.2
P (%)
0.26
0.06
Ca (%)
3.0
0.1
Phenols (mg g-1)
160
50
Lignin (%)
35
8
Water (%)
65
45
LMA N P Ca Phenols Lignin Water
Attribution (%)
0 20 40 60 80 100
94% 80% 88% 67% 73% 70% 86%
Proportion of trait variance explained
Geology
Elevation
Slope
Hydro
Sept Insol
Dec Insol
Mar Insol
June Insol
Aspect

PP.CV