Amazonia is the Primary Source of Neotropical Biodiversity

ALEXANDRE ANTONELLI, ALEXANDER ZIZKA, FERNANDA ANTUNES CARVALHO, RUUD SCHARN, CHRISTINE D. BACON, DANIELE SILVESTRO, & FABIEN L. CONDAMINE

Neotropical Biodiversity

- American tropics, also known as the Neotropics
- One of the most species-rich realms
- Researches how different regions and taxonomies have responded differently to geological and climactic changes
- How Neotropical biodiversity was assembled over evolutionary timescales

Answers the following…

- Was the amount of biotic interchange similar among Neotropical regions?
- Have particular regions contributed substantially more or less than others?
- How often were dispersal events associated with shifts between major biome types?
- To what extent was the direction of interchange determined by taxonomic group?
- Did biotic interchange among these regions occur evenly through time, or were there periods of more frequent dispersal events?
- Which general descriptors of a region and its biota predict the amount of biotic interchange with other regions?

Methods

DIVERSIFICATION OF SPECIES AND COMMUNITIES WAS ESTABLISHED IN EACH UNIQUE REGION AND BIOME

USED MOLECULAR PHYLOGENIES

INTEGRATED WITH LARGE SPECIES OCCURRENCE DATASETS

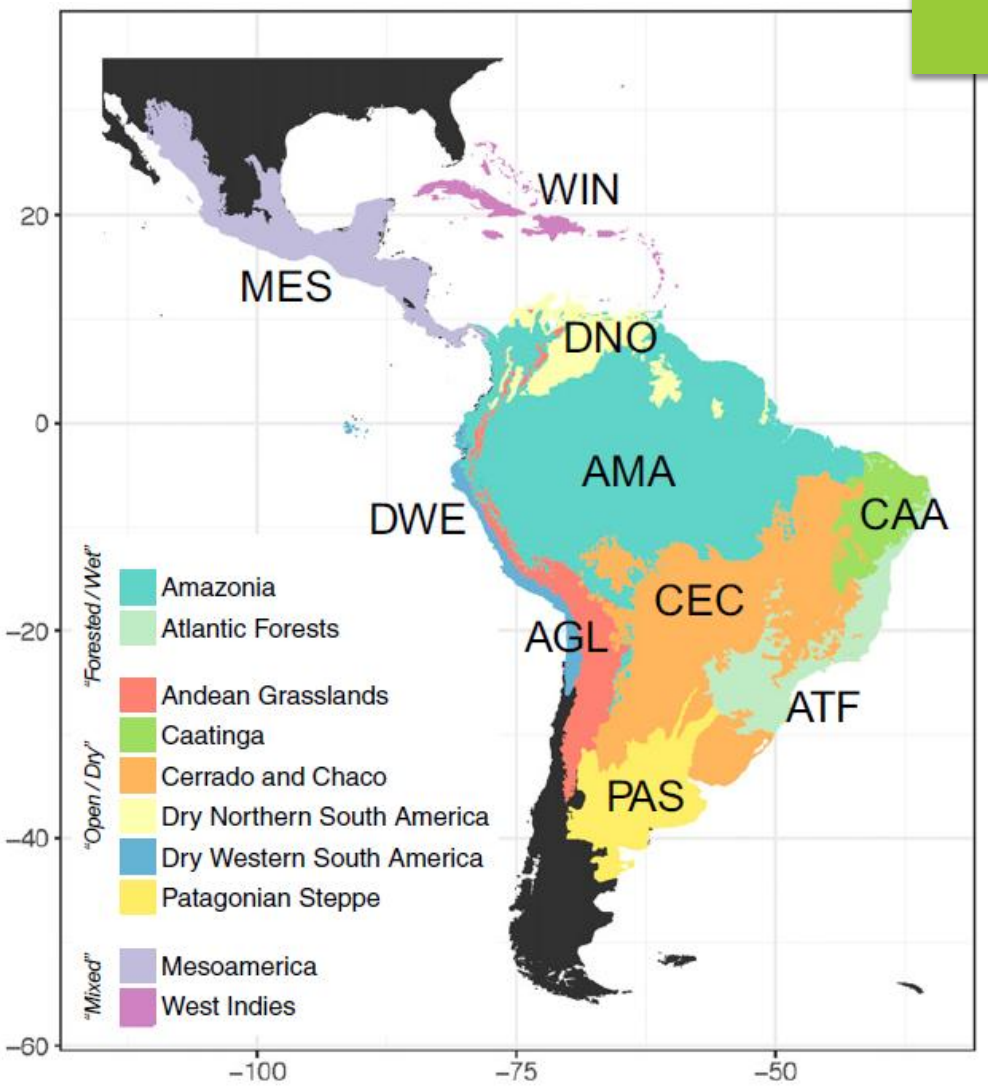
SPATIAL INFORMATION OF NEOTROPICAL REGIONS AND BIOMES,

EVOLUTION AND CONNECTIVITY THROUGH TIME

FOSSIL RECORDS TOO SCARCE FOR MOST PERIODS TO BE USEFUL FOR INFERRING BIOGEOGRAPHIC HISTORY

The Neotropical Realm

- From Mexico to southern South America (including the West Indies)
- Includes many different biomes and habitats such as:
  - Seasonally dry forests
  - Arid zones
  - High-elevation grasslands
  - Young and old mountain systems
  - Extensive rainforests (Atlantic forests and Amazonia)



Diversification from Biotic and Abiotic Interaction

Abiotic

- Hydraulic and topographic changes brought by mountain uplift
- Global climactic changes
- Regional climactic changes

Biotic

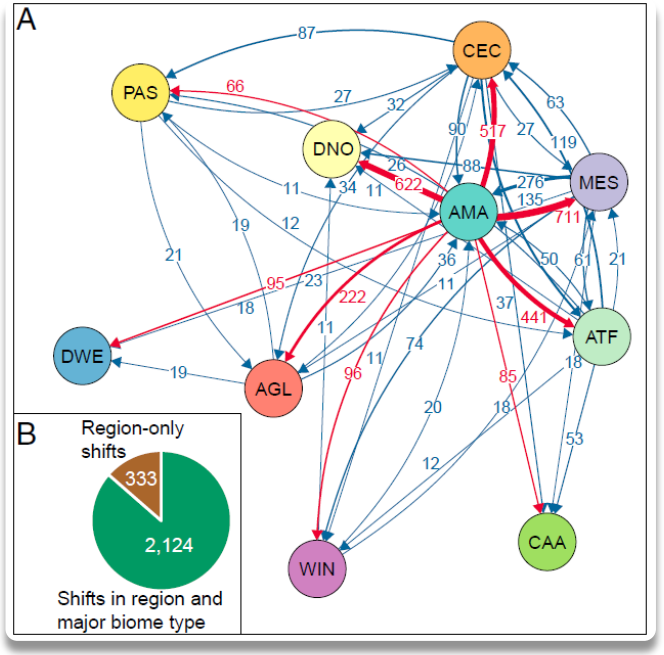
- Species interactions
- Soil adaptations
- Species interactions
- Evolution of organism-specific traits

Intrinsic Factors

- Dispersal Ability

Interchange

- Large number of shifts between major biome types rather than dispersals to other regions but within the same major biome type
- All regions and biomes comprise mosaics of different fine-scale habitats
  - Served as entrance pathways to colonizing lineages without requiring immediate adaptations
- Abundance and environmental tolerance of species were strong predictors of their ability to occupy both regions
- All taxa showed a substantial interchange between Amazonia and Mesoamerica



Results & Findings

- Biogeographic analyses indicate that all regions have served as both sources of sinks and lineages
  - Defined as providers and receivers of lineages
- Amazonia was the most important and primary source of diversity
  - Providing 2855 lineages to other neotropical regions
- Mesoamerica shown to be the primary sink of biodiversity
  - Receiving the highest number of lineages

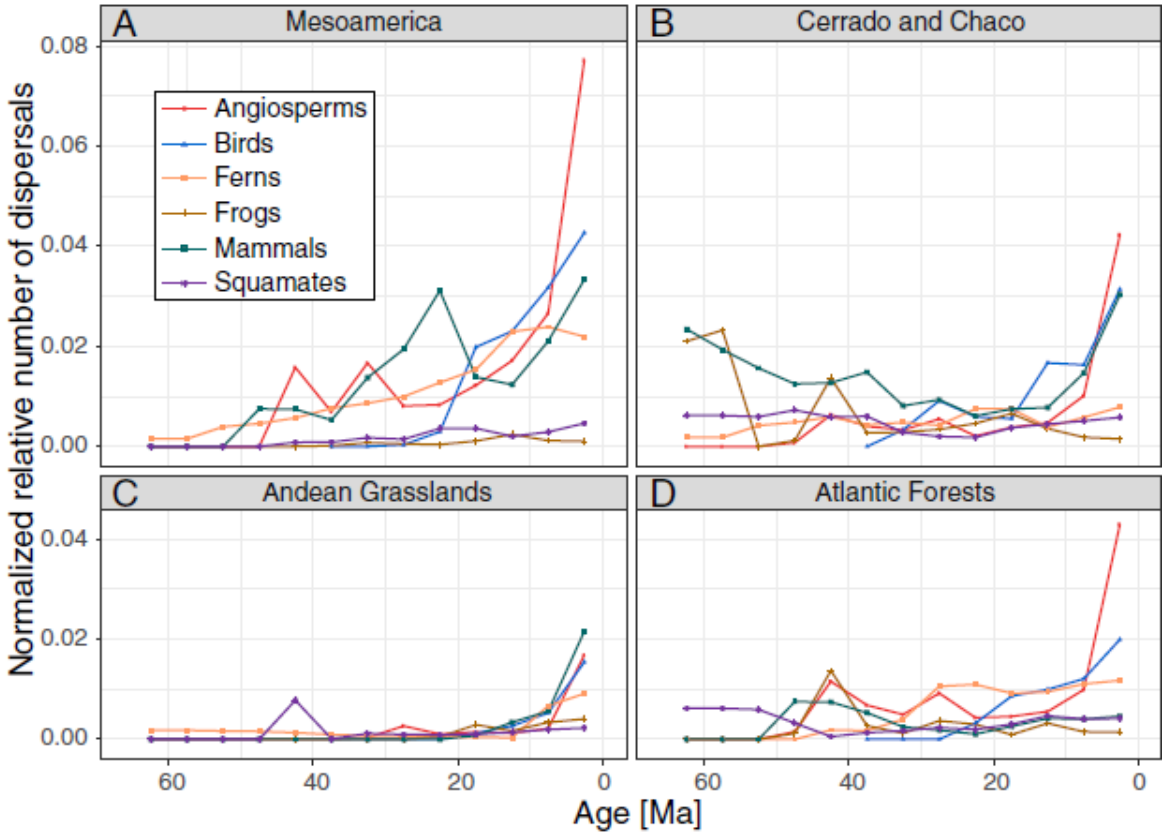


Fig. 4. Taxon-specific interchange between Amazonia and (*A*) Mesoamerica, (*B*) Cerrado and Chado, (*C*) Andean Grasslands, and (*D*) Atlantic Forests throughout the Cenozoic (older events are pruned from the figure but included in the total calculation of events). Dispersal rates are normalized in relation to the number of available lineages in each phylogeny. Age in millions of years ago (Ma).

Phylogenetic Classification of the World's Tropical Forests

Tropical Forests

REGIONAL DIFFERENCES

FOREST STRUCTURE

DIVERSITY

COMPOSITION

DYNAMICS

INDO-PACIFIC
SUBTROPICAL
AFRICAN
AMERICAN
DRY FORESTS

Regions

Majority Rule Consensus Tree

- Developed Pan-tropical biogeographic analyses based on comparison of higher taxonomic levels
  - Genus
  - Family
- Compiled a standardized dataset of old-growth tropical forest inventories
  - angiosperm trees
- Generated 20 cluster analyses
  - Related the clusters to create a *majority rule consensus tree*

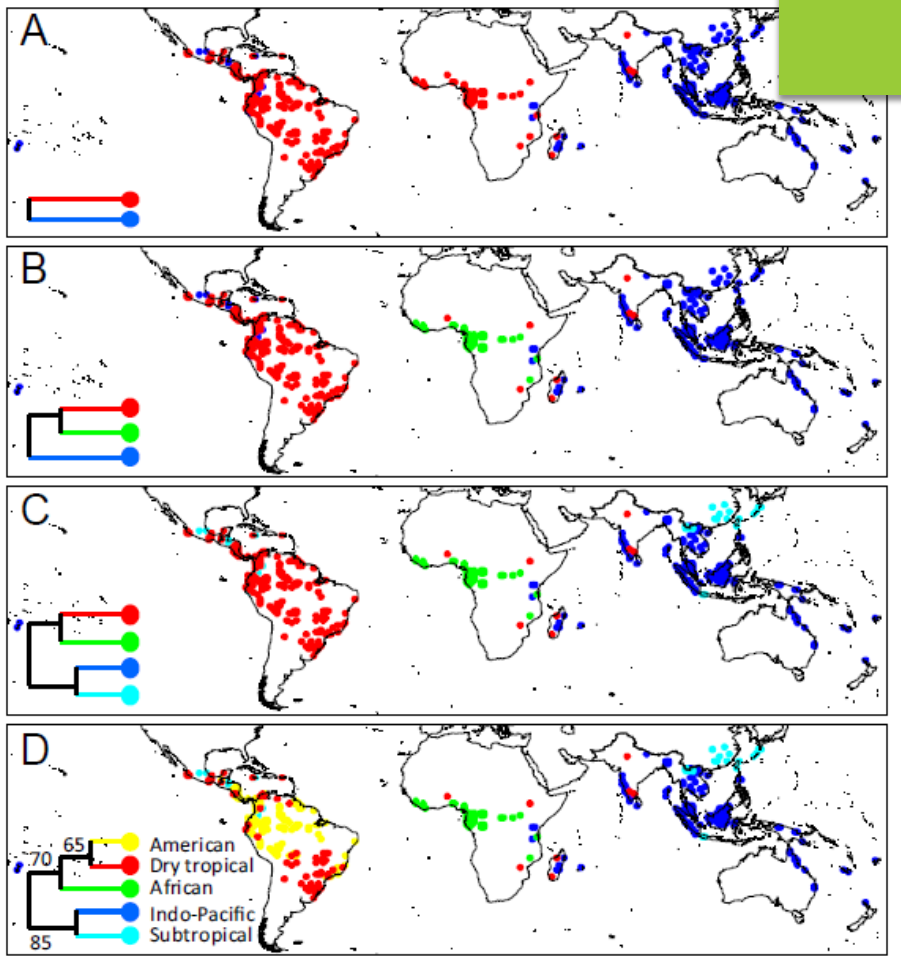


Fig. 1. Classification maps of the world's tropical forests, showing two (*A*), three (*B*), four (*C*), and five (*D*) clusters. Cluster result represents a majority rule consensus tree, with the percentage of times that each grouping was observed in the 20 separate cluster analyses shown in *D*. Only locations that could be classified with certainty ($P < 0.05$) are shown ($n = 392$).

Results

- PHYLOGENETIC CLUSTER INDICATED TROPICAL FORESTS DIVIDED INTO TWO MAJOR FLORISTIC REGIONS
  - *AMERICAN-AFRICAN*
  - *INDO-PACIFIC*
- CONTRADICTS PREVIOUS HYPOTHESES OF MAJOR GLOBAL REALMS
  - USUALLY RECOGNIZED AS NEO VERSUS PALEOTROPICAL REGIONS

Results Continued…

Findings from the paper already recognized

- Noted high generic-level similarity of American and African forests
- Despite severing of direct land connections between African and South American plates 96 Mya ,long-distance dispersal continued
- Attributed to Cretaceous and Cenozoic plate tectonic history

The shared origin and trans-Atlantic migration may explain connection between South American and African forests

Indo-Pacific Floristic Region

- Eastern Africa
- Madagascar
- India
- Southeast Asia
- Australia
- Pacific Islands

Strong evidence of significant plant migration

- Homogenizing effect

Attributed to biotic exchange between India and Southeast Asia (45 Mya) and Southeast Asia and Australia, New Guinea, and the Pacific Islands (15 Mya).

Presence of Indo-Pacific forests in eastern Africa reflects eastern Gondwanan origin or dispersal within the Indo-Pacific region.

Significance

- PRESENTED ANALYSES WHICH SERVED AS MODEL FOR CLASSIFYING REGIONAL FLORAS
- RECONSIDERATION OF PREVIOUSLY ESTABLISHED BIOGEOGRAPHIC IDEAS
- IMPORTANT TO IDENTIFY AND EXPLAIN DIFFERENCES IN TROPICAL FORESTS
- ANTICIPATE REGION-SPECIFIC RESPONSES TO GLOBAL ENVIRONMENTAL CHANGE