



‘Islands in the Sky’ - Tepuis

- Guayana Shield centered in southern Venezuela
- $1.2 \times 10^6 \text{ m}^2$
- sandstone table mountains of Roraima Formation

Autana, 1300 m

‘Islands in the Sky’ - Tepuis

- Roraima Formation - Precambrian, highly leached sandy marine sediments laid down 1.5 - 1.8 billions years ago

FORCES OF EROSION

High sea levels
Tectonic plate
Roraima Plateau
Orinoco River
Sinking sea levels
Tepui forming

Tepui rising as much as 5,000 feet (1,500 m) above the forest below

The extraordinary shape of tepuis results from millions of years of erosion across an ancient sandstone plateau. Immense forces in the Earth's crust may have lifted and fractured the plateau. Rivers then carved deep gorges and gradually separated the remains into ever-shrinking blocks.

- Roraima Formation uplifted during formation of Atlantic in Cretaceous
- tepuis formed with erosion of major river systems (Orinoco) – vicariance?
- tepuis are resistant (quartzite) mesas

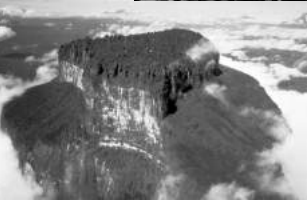


'Islands in the Sky' - Tepuis

- tepuis basis for Sir Arthur Conan Doyle's "The Lost World"
- actually home to one of the world's largest set of plant "carnivores"



Heliophora - sun pitcher



'Islands in the Sky' - Tepuis

- tepuis basis for opening scene of *Arachnophobia*

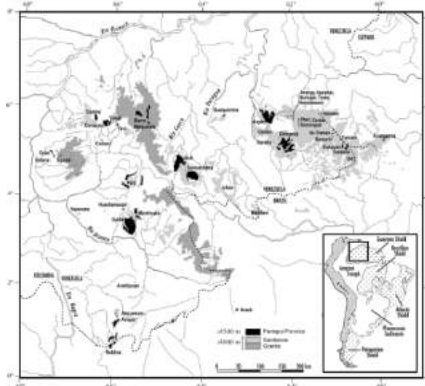


Canaima National Park



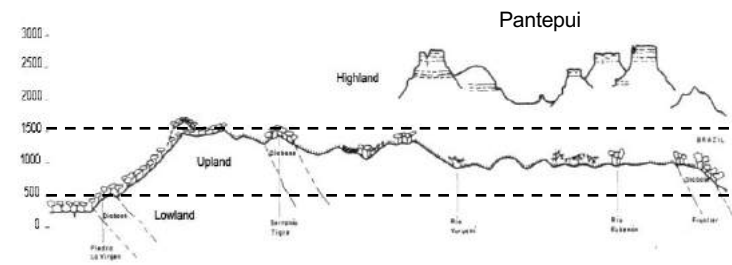
'Islands in the Sky' - Tepuis

- Pantepui - biogeographic province proposed by the Phelps for high elevation "island" portion over 1500 m



'Islands in the Sky' - Tepuis

- Pantepui - biogeographic province proposed by the Phelps for high elevation "island" portion over 1500 m
- characterized by a combination of extreme conditions: cool weather, heavy rainfalls, dense clouds, strong winds, high solar radiation, and extremely infertile substrates



'Islands in the Sky' - Tepuis

- Pantepui - biogeographic province proposed by the Phelps for high elevation portion over 1500 m
- Distinctive biota



Tepui vireo



Redbanded fruiteater



Tepui manakin



Rana



Asteraceae



Tepui Flora



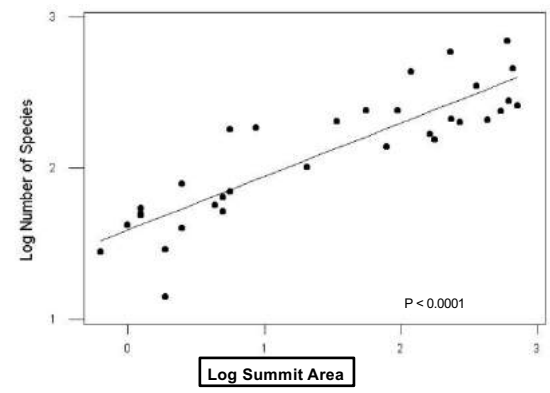
Do the tepuis function as islands?



Ricarda Riina
M.S. thesis (2003)

Tepui Flora

- Pantepui - island like species/area relationship
Riki Olivares - M.S. thesis



Tepui Flora

- Pantepui - island like endemism

Overall plant richness and endemism

| | Pantepui taxa | Shield endemics | Pantepui endemics | Single tepui endemics |
|-----------------|---------------|-----------------|-------------------|-----------------------|
| Families | 156 | 2 | 0 | 0 |
| Genera | 626 | 80 | 23 (4%) | 13 (2%) |
| Species | 2447 | 1517 | 1034 (42%) | 617 (25%) |

Riki Olivares - M.S. thesis

Tepui Flora



- Floristic relationships among tepuis
- Is there a biogeographical pattern?

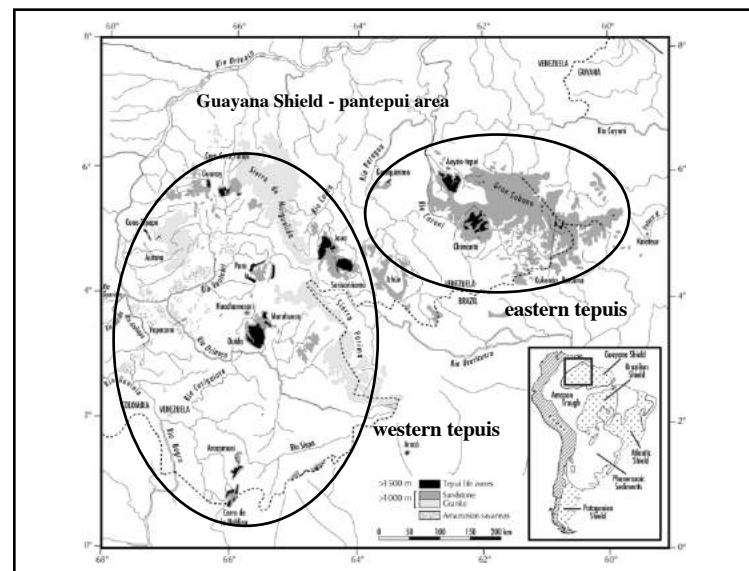
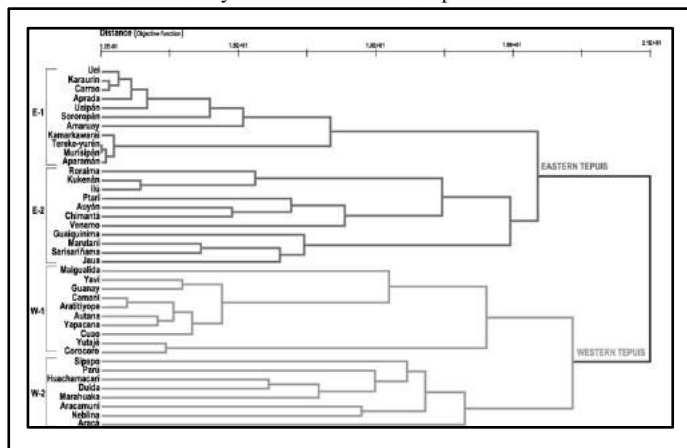
– vicariance formed by river erosion?

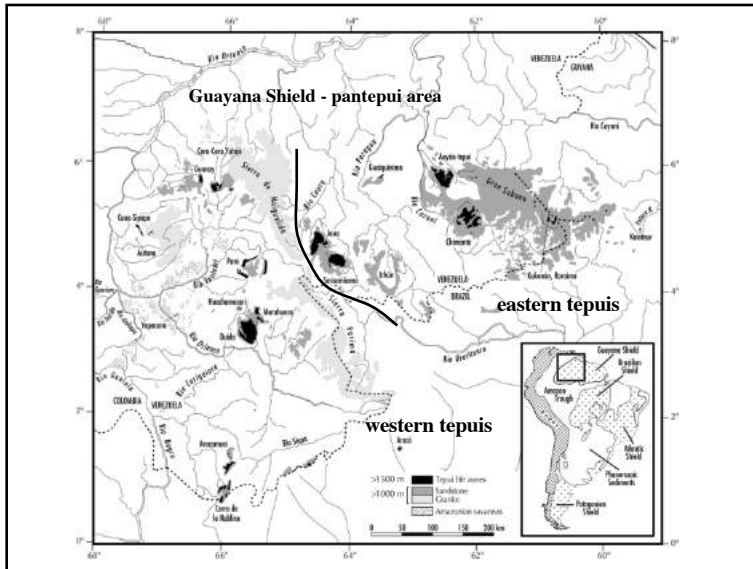


Vicki Funk - Smithsonian

Tepui Flora

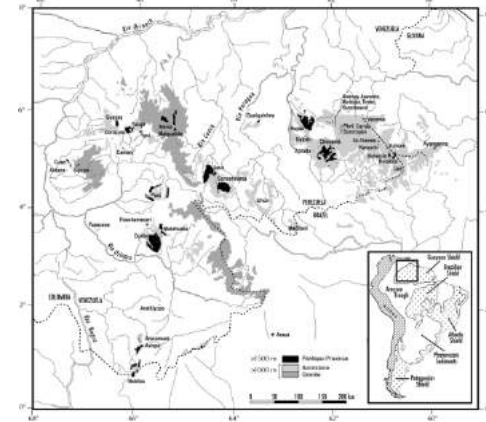
Cluster Analysis based on floristic composition





Tepui Flora

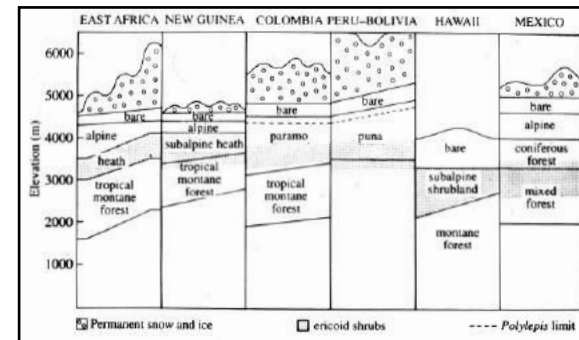
- positive significant ($P = 0.001$) correlation between the floristic distance matrix and the among-tepui geographic distance matrix (Mantel Test)



Islands in the Sky - Paramo, Afroalpine

'Islands in the Sky' - Paramo, Afroalpine

- convergent biome types across high elevation areas of the tropics
- depending on elevation, often occur as 'islands'



'Islands in the Sky' - Paramo, Afroalpine

- South American paramo and East African afroalpine ('Ethiopian') best studied floristically as islands

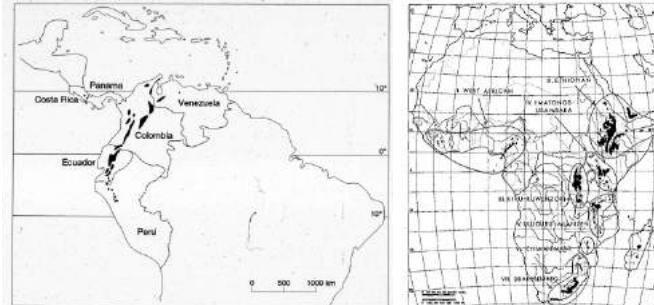


Figure 1. Distribution of paramos in the Neotropics along the cordilleras from Costa Rica and Panama to northern Peru.

Fig. 1. Map showing distribution of the islands of the Afroalpine and alpine in the nearctic region and various regions in the Neotropics.

'Islands in the Sky' - Paramo, Afroalpine

- ecology is harsh and unvarying: 'winter by night, summer by day'

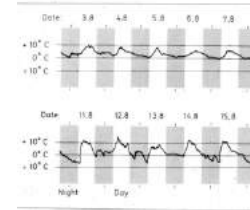


Figure 2. Thermogram from Teleki Valley, Mt. Kenya (4200 m). Upper thermogram recorded on the valley slope, 50 cm above the ground between a few big boulders. Lower one obtained on flat valley bottom, 10 cm above the surface, in shadow of *Dendrosenecio* leucostictus leaves. Horizontal distance is 50 m; difference in altitude is less than 5 m (modified from Heideberg, 1944b).



'Islands in the Sky' - Paramo, Afroalpine

- Convergent life forms occur in both areas as a response to these ecological conditions

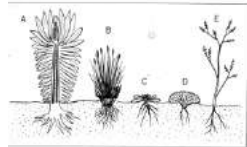


Figure 3. The five most important life forms of the afroalpine belt. A. giant tussock plant, B. tussock grass, C. scabrescent rosette plant, D. cushion plant, E. sclerophyllous shrub (modified from Heideberg, 1944a).

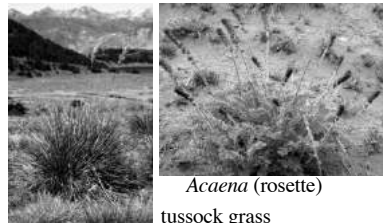
Hypericum (sclerophyll)



Erica (sclerophyll)



Viola (cushion)



Acaena (rosette)

tussock grass

'Islands in the Sky' - Paramo, Afroalpine

- Convergent life forms occur in both areas as a response to these ecological conditions

Afroalpine

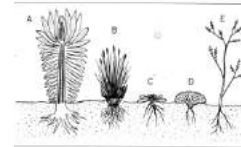


Figure 3. The five most important life forms of the afroalpine belt. A. giant tussock plant, B. tussock grass, C. scabrescent rosette plant, D. cushion plant, E. sclerophyllous shrub (modified from Heideberg, 1944a).

Dendrosenecio (Asteraceae)



Lobelia (Lobeliaceae)



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Paramo

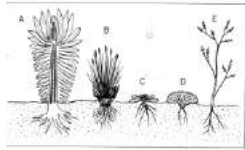


Figure 3. The five most important life forms of the afroalpine belt. A: giant rosette plant, B: tussock grass, C: tussock-like rosette plant, D: cushion plant, E: sclerophyllous shrub (modified from Holberg, 1964).

Puya (Bromeliaceae)

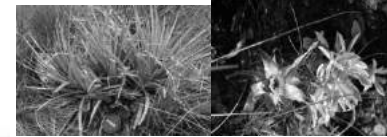


Espeletia (Asteraceae)



Radiation in Andean *Puya* (Bromeliaceae)

Rachel Schmidt Jabaily



Puya raimondii, Aucash, Peru

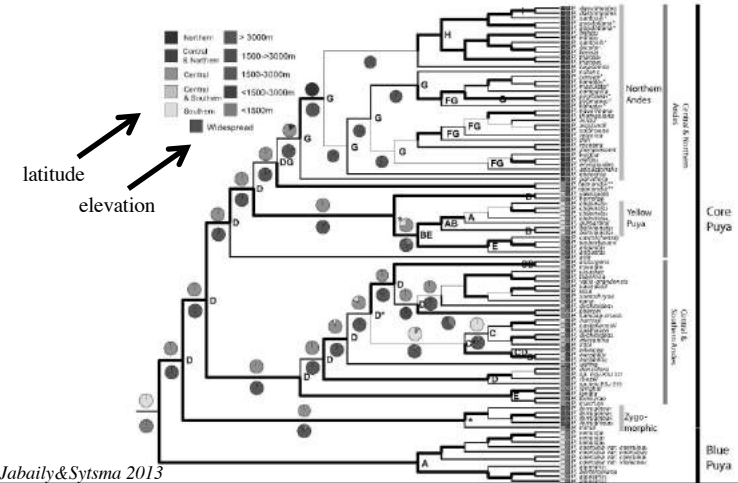
Radiation in Andean *Puya* (Bromeliaceae)

Direction of latitudinal and elevation shifts?



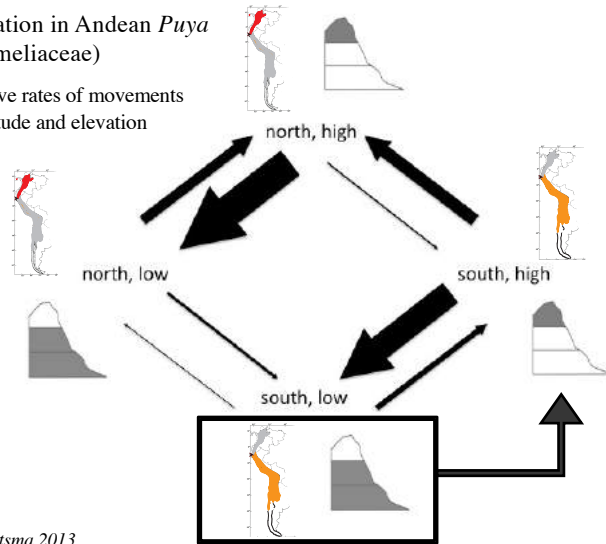
Radiation in Andean *Puya* (Bromeliaceae)

"mapping" on latitude & elevation on DNA tree



Radiation in Andean *Puya* (Bromeliaceae)

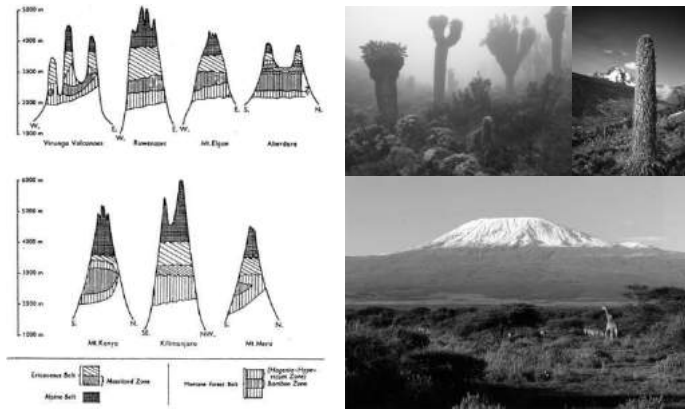
Relative rates of movements in latitude and elevation



Jabaily&Sytsma 2013

'Islands in the Sky' - Paramo, Afroalpine

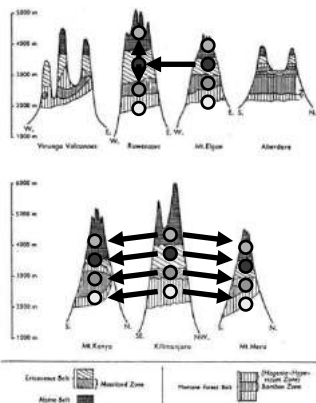
- Biogeography of afroalpine flora – adaptive radiation of *Dendrosenecio* (Asteraceae)



'Islands in the Sky' - Paramo, Afroalpine

- Biogeography of afroalpine flora – adaptive radiation of *Dendrosenecio* (Asteraceae) Which pattern?

- Inter-island dispersal followed by elevation shifts
- Multiple dispersals from similar elevations



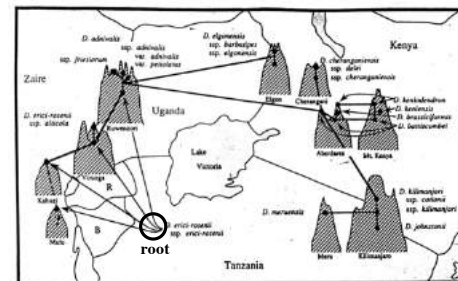
8 species adapted to 4 life zones (in color)

Eric Knox



'Islands in the Sky' - Paramo, Afroalpine

- Biogeography of afroalpine flora – adaptive radiation of *Dendrosenecio* (Asteraceae) Which pattern?
- Inter-island dispersal followed by elevation shifts
 - Multiple dispersals from similar elevations
- Convergence of species adapted to similar elevations!



Phylogeny superimposed on biogeography

