Phylogenetic Diversity and distribution patterns of the Compositae family in the high Andes of South America

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BIODIVERSITY

Defined by the International Convention on Biological Diversity :

"Comprises all variety of living species on Earth and the natural patterns that conform it, result of **millions of years of Evolution**. It also comprises the variety of Ecosystems and genetic differences within each species that allow the combination of multiple life forms and whose mutual interactions, and with the environment, sustain life on Earth".

Conservation of Biodiversity

Ideally, we would like to preserve ALL exisitng biodiversity

However ...

Some problems associated to conservation

McNeely et al., 1990

- The Evaluation problem: How to evaluate the contributions of taxa and ecosystems to biodiversity. Accepted units of biodiversity (species) can be hard to ID

- The resources problem: Limiting resources impose practical limitations

THIS FORCES US TO ESTABLISH A
PRIORITY SYSTEM

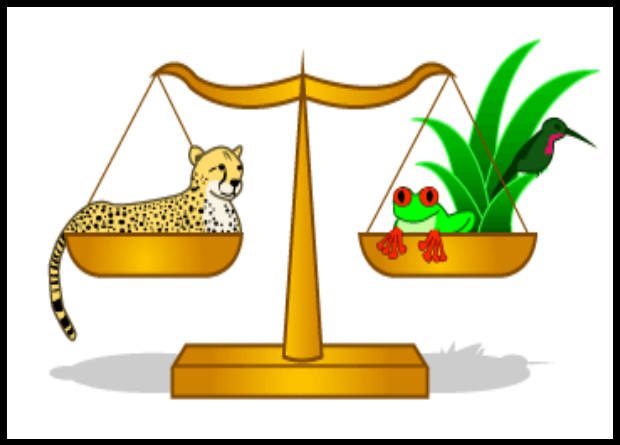
Where is Biodiversity?

25 hotspots, defined by: **Myers, 2000**

Large number of species – Richness
Large percentage of endemic species
Species with restricted distribution

What to preserve?

"The agony of choice"
(Vane-Wright et al 1991)

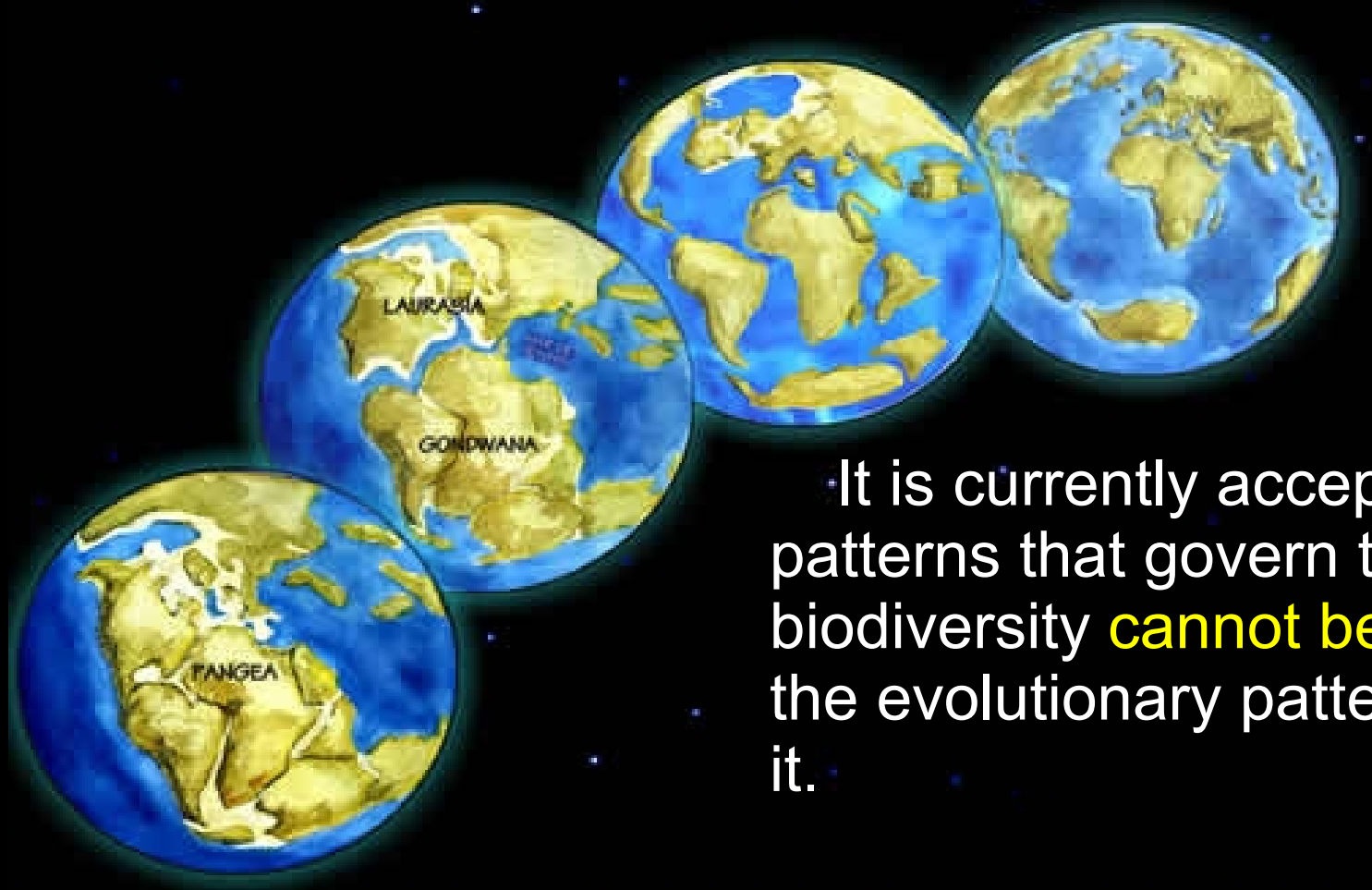


The highest number of species possible...

The highest number of attributes possible...

Evolutionary knowledge of the taxa in an ecosystem can help make decisions for biodiversity conservation

BIODIVERSITY



It is currently accepted that the patterns that govern the distribution of biodiversity cannot be decoupled from the evolutionary patterns that conform it.

Evolutionary indices for conservation

At the level of community/ecosystem

Phylogenetic diversity
(Faith 1992)

Community structure
(Webb et al 2000)

How much evolutionary history is contained in a given area

At the level of species/individuals (taxa)

Taxonomic diversity
(Clarke & Warwick 1995)

Taxonomic distinctness
(Vane-Wright et al 1992)

Evolutionary distinctness
(Isaac et al 2007)

How much does a taxon "weight" with respect to its evolutinary history

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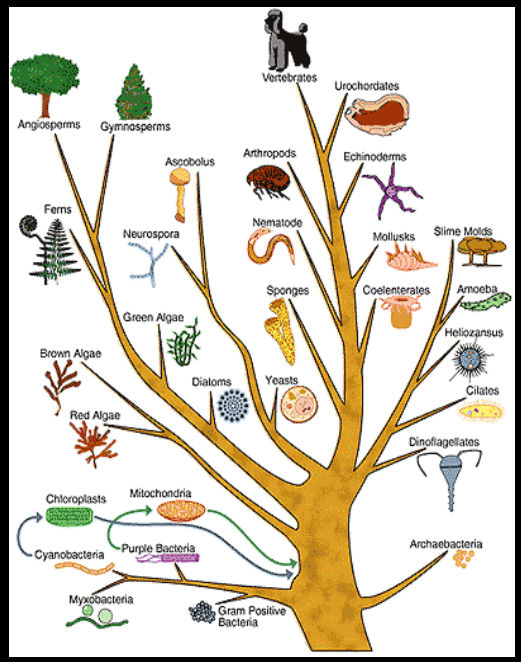
How much does a taxon "weight" with respect to its evolutionary history

THE CONCEPT

- PHYLOGENETIC DIVERSITY (PD) measures the evolutionary branches that connect taxa in an area

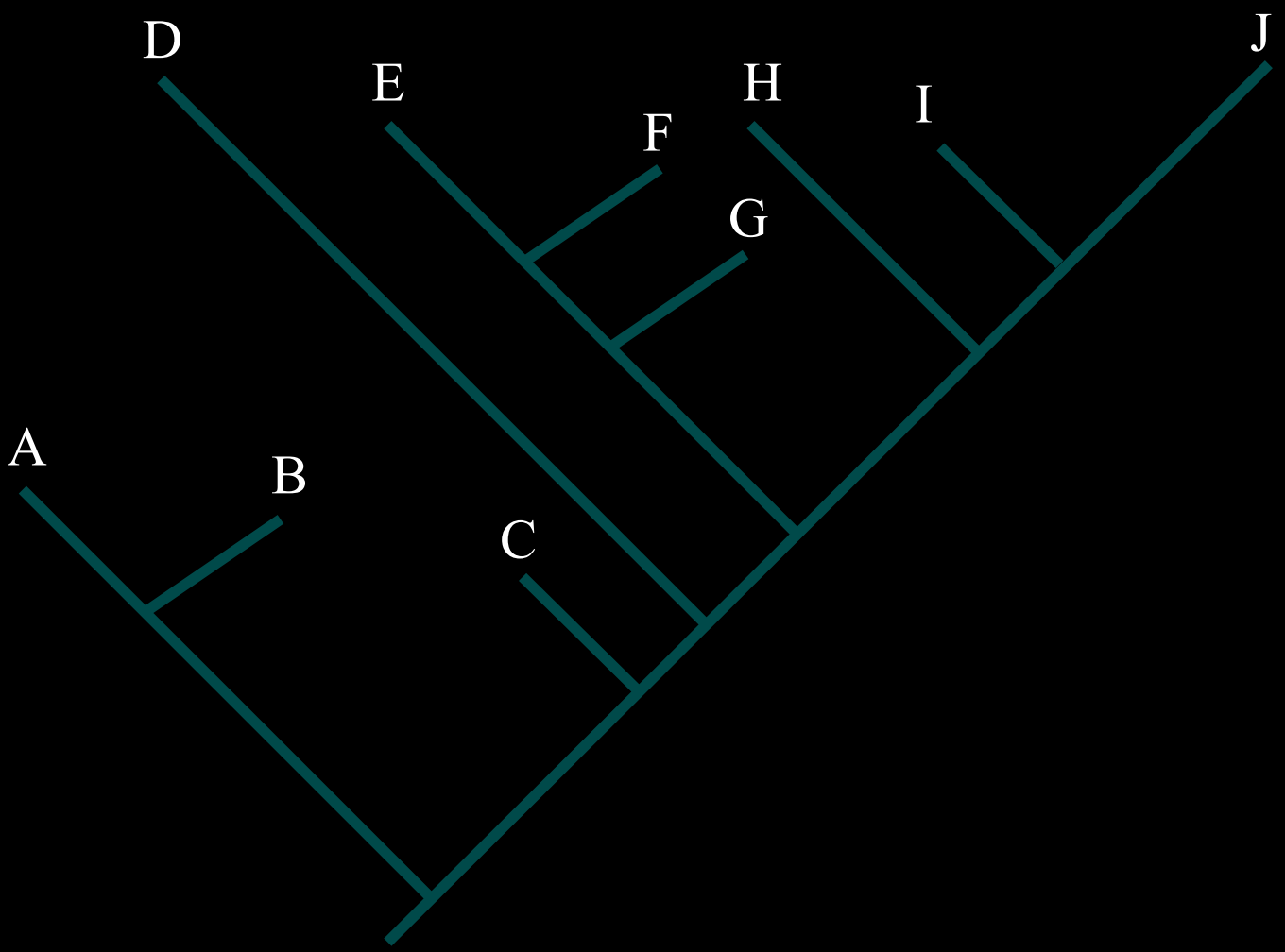
- How much evolutionary history would be lost if the biodiversity of an area was not preserved?

- The idea is to protect a group of taxa that maximize character diversity (resilience to future change)



A theoretical example (PD *sensu* Faith 1992)

Area	Taxa
1	ABC
2	EFG
3	ADEJ
4	EFGD



Area	Taxa
1	ABC
2	EFG
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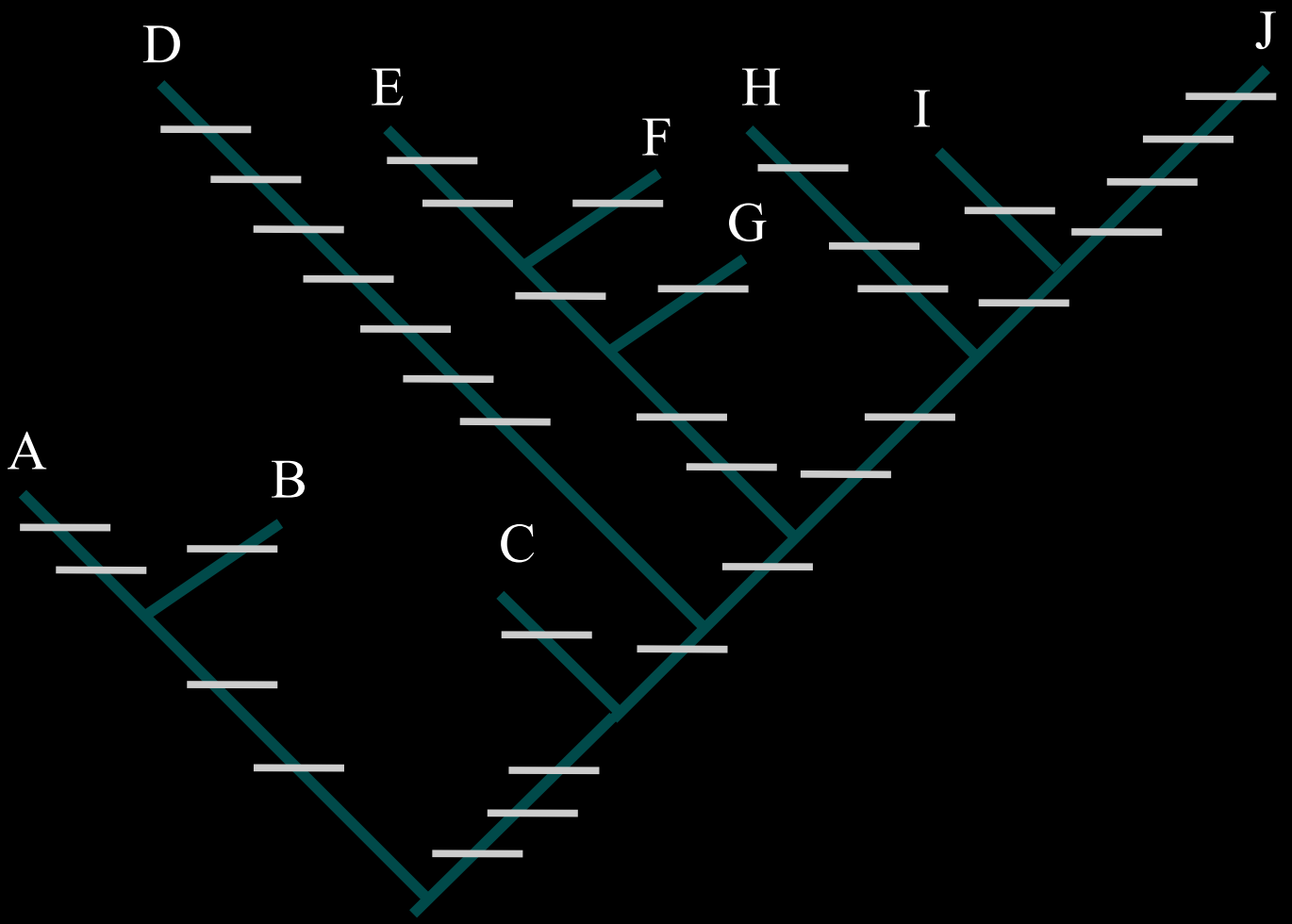
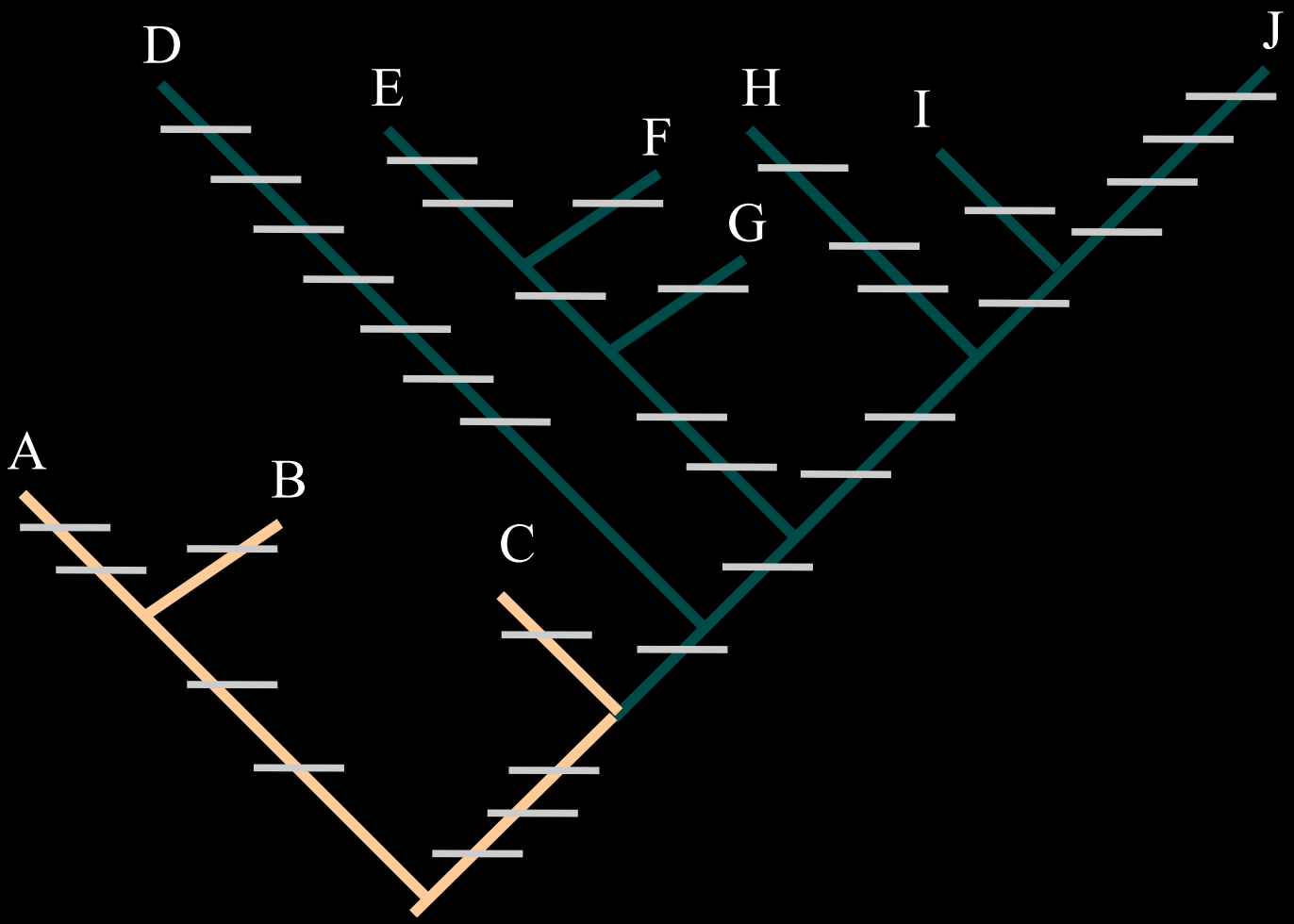
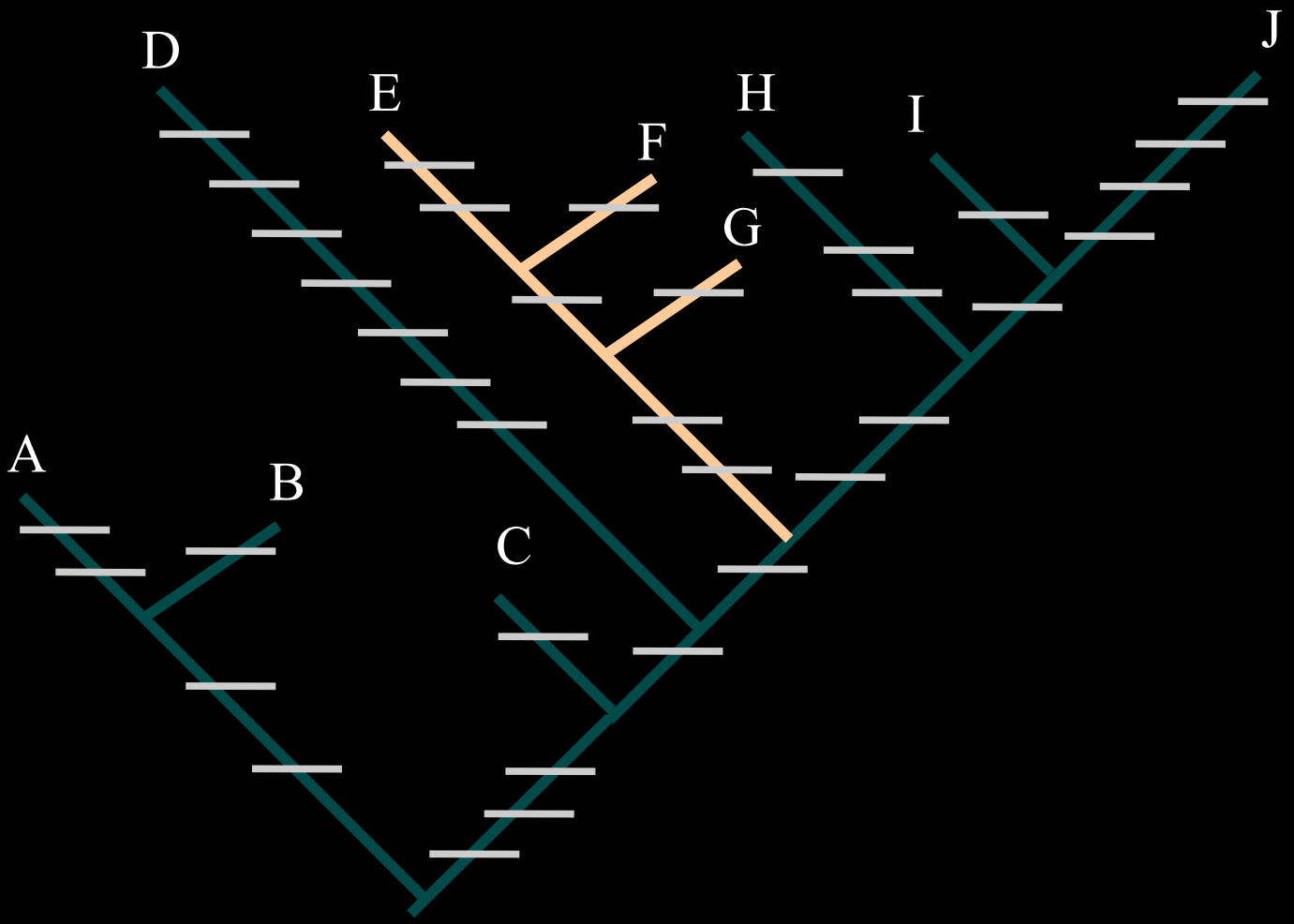


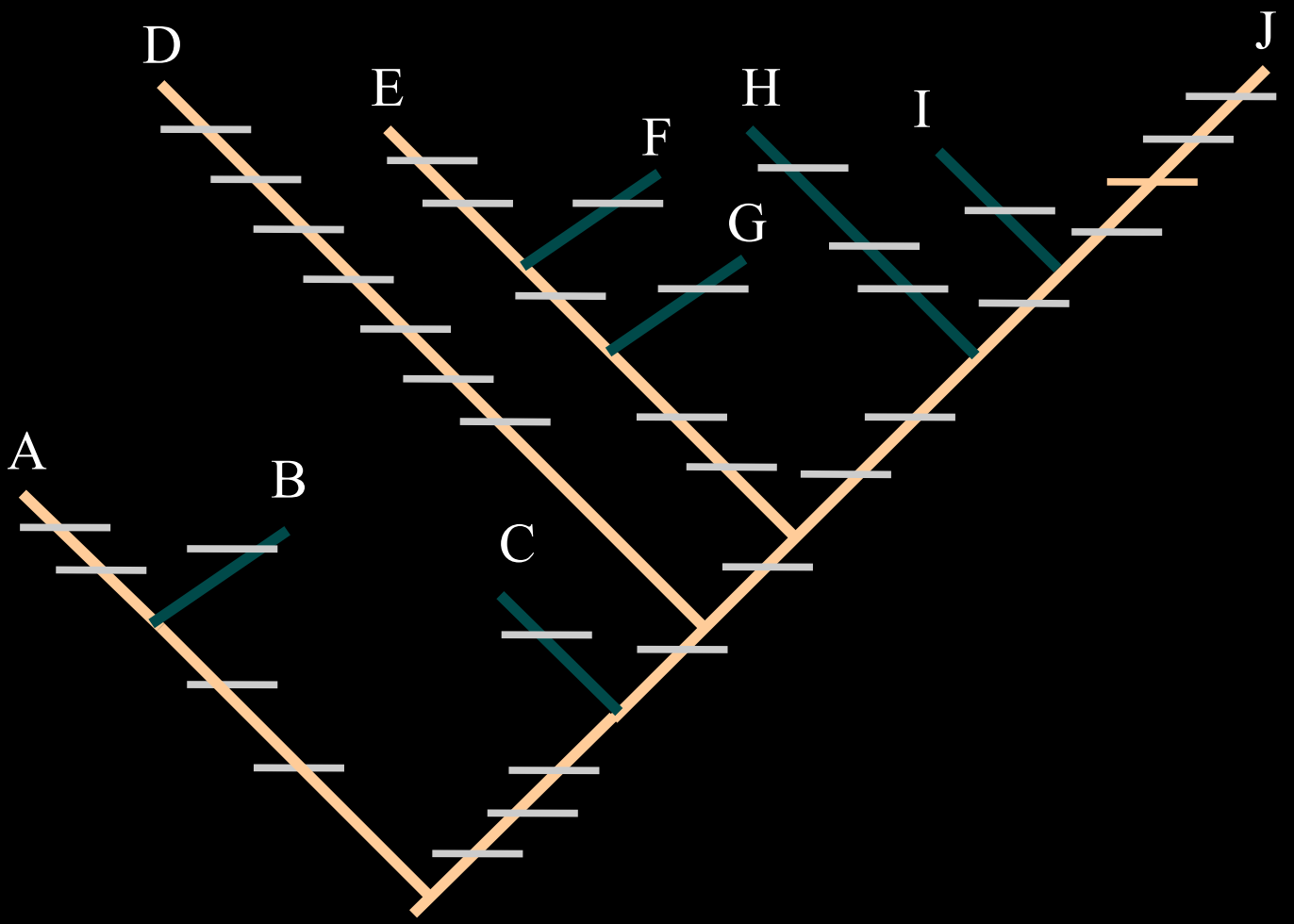
Area	Taxa	PD
1	ABC	9
2	EFG	
3	ADEJ	
4	EFGD	



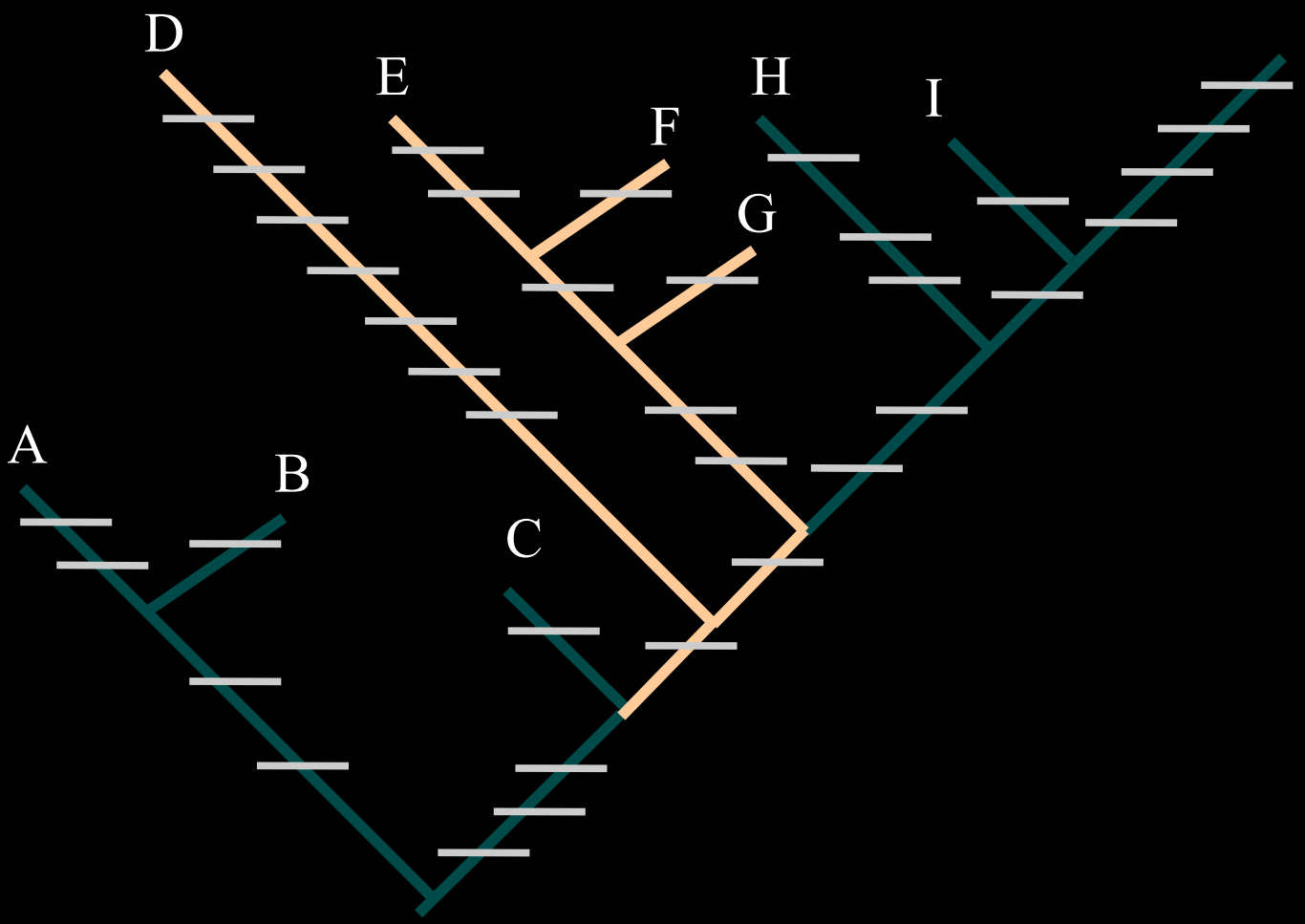
Area	Taxa	PD
1	ABC	9
2	EFG	7
3	ADEJ	
4	EFGD	



Area	Taxa	PD
1	ABC	9
2	EFG	7
3	ADEJ	29
4	EFGD	



Area	Taxa	PD
1	ABC	9
2	EFG	7
3	ADEJ	29
4	EFGD	16



OUR FIRST QUESTION

Is there a relationship between taxon richness and PD in the flora of the high Andes?

Model:
Compositae Family in the high Andes of South America, largest representation of the flora above tree line
159 genera

Areas:
Páramo (PAR) 11°N - 8°S
Puna (PUN) 9° S - 27°S
Southern Andean Steppe (SAS)
29° S - 55° S

Database on the flora of the high Andes

Literature sources

Brako & Zarruchi 1993

Zuloaga et al 2008

Ulloa et al 2004

Luteyn 1999

Herbaria and floral databases

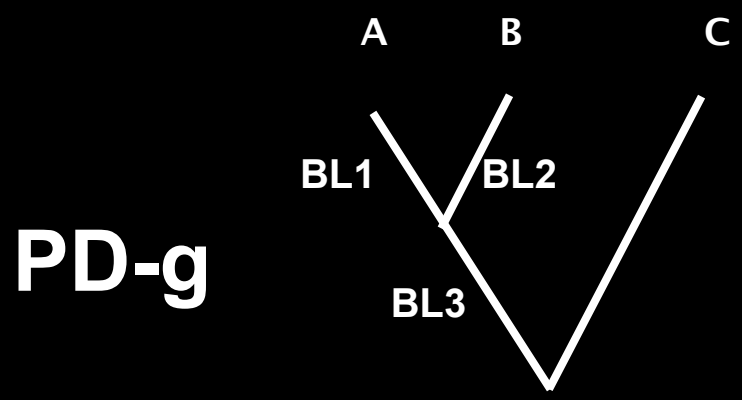
Field work

Phylogenetic trees and PD calculation

Approximation at the genus level: 1 sp per genus

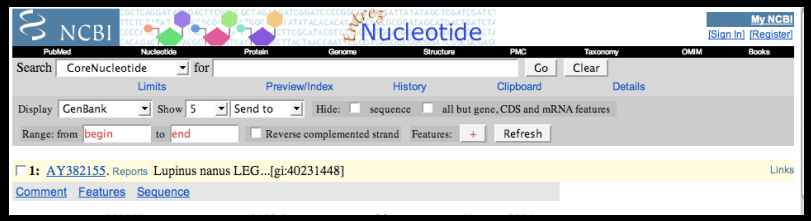
PD: Sum of branch lengths of each area to the root of the sampled taxa

PD-g (A,B) = LR1 + LR2 + LR3

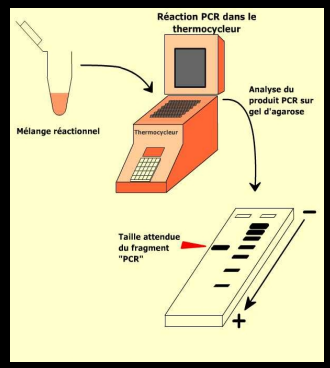


To facilitate the interpretation of results, PD and richness for each area were expressed as percentages of total PD and total richness

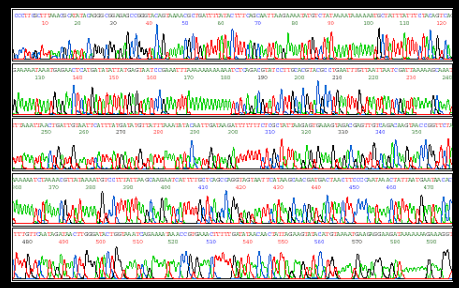
PHYLOGENETIC TREES



GenBank:



ITS
trnL-F

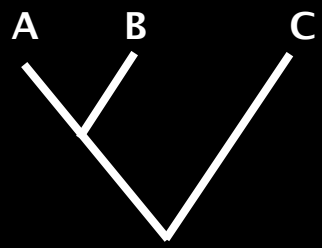


PCR
Sequencing

Alignment

Model of evolution
Modeltest

Mr. Bayes 3.1



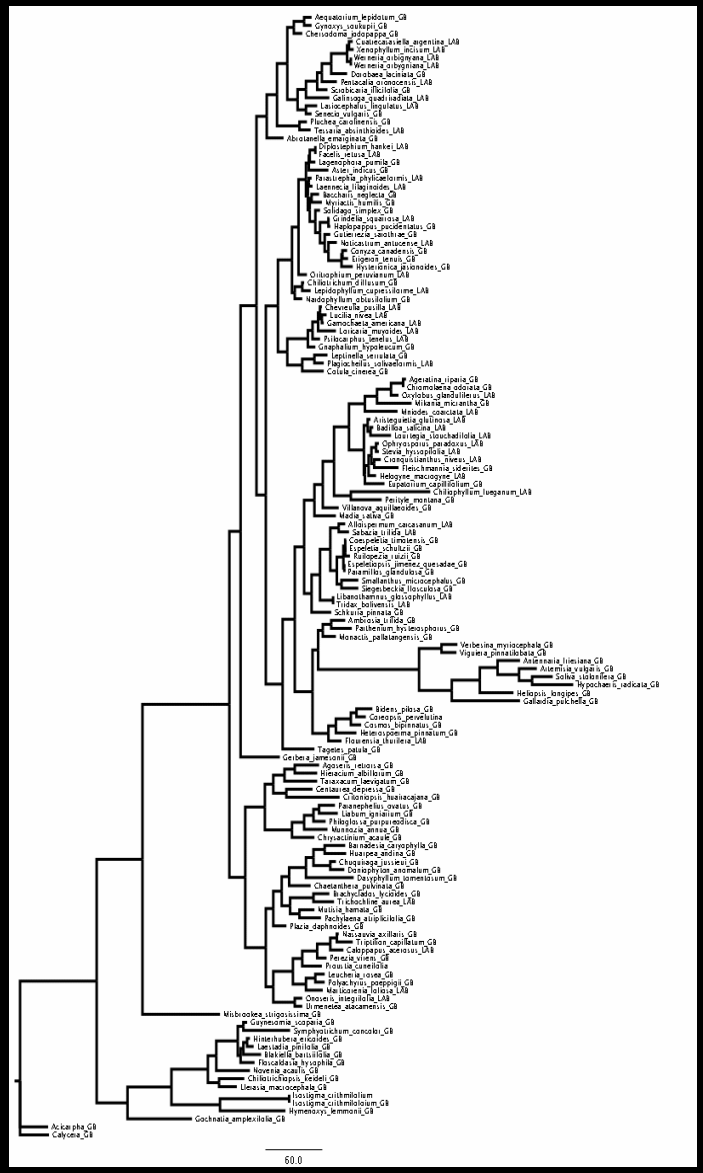
Phylogenetic trees

Evolutionary models and statistical support

- Phylogenetic trees:
  - ITS: GTR+G
  - Statistical support by posterior probabilities

- PD: accounting for variability
  - Confidence intervals derived from calculating PD in 35 trees randomly chosen from the Bayesian trees after burnin

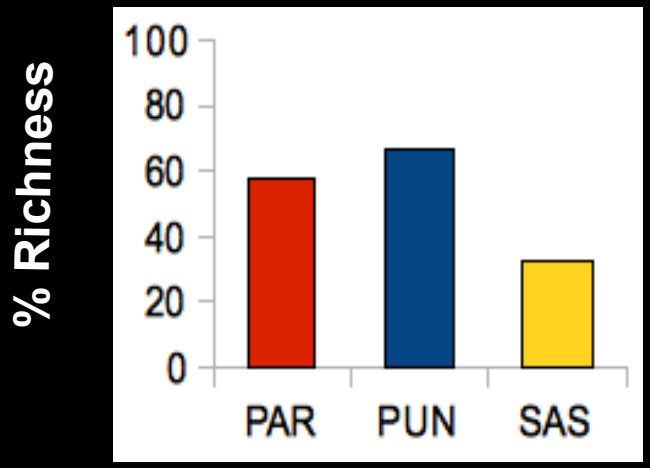
RESULTS: One phylogeny
139 taxa (87% representation)



Most branches have god Bayesian support

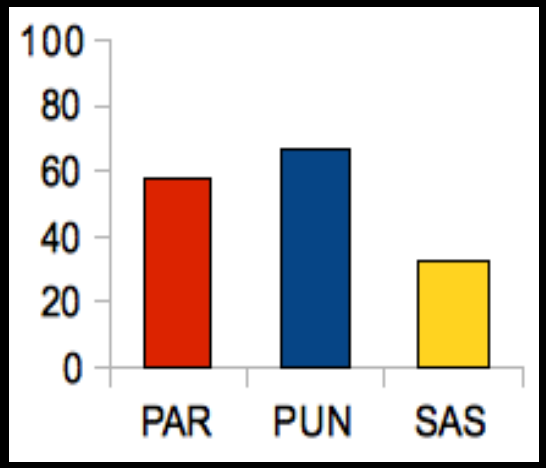
RESULTS: Richness by area

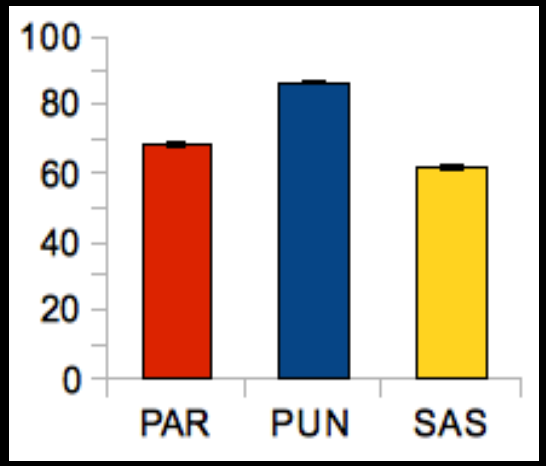
Compositae



RESULTS

Compositae

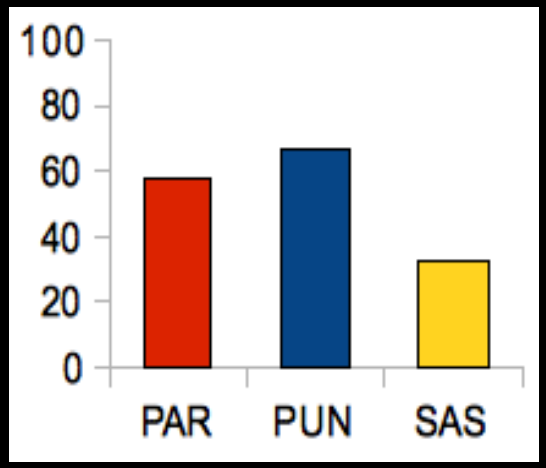


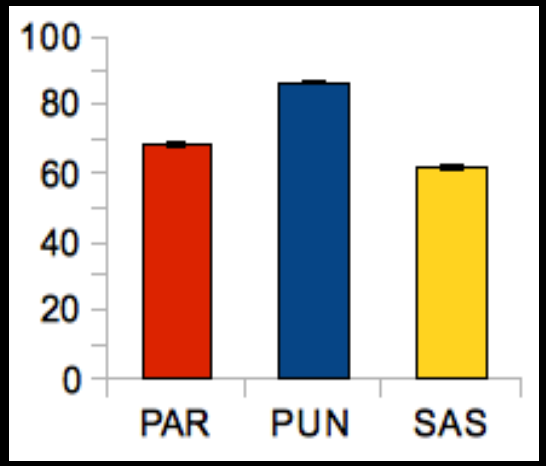


How does PD compare to richness?

RESULTS

Compositae

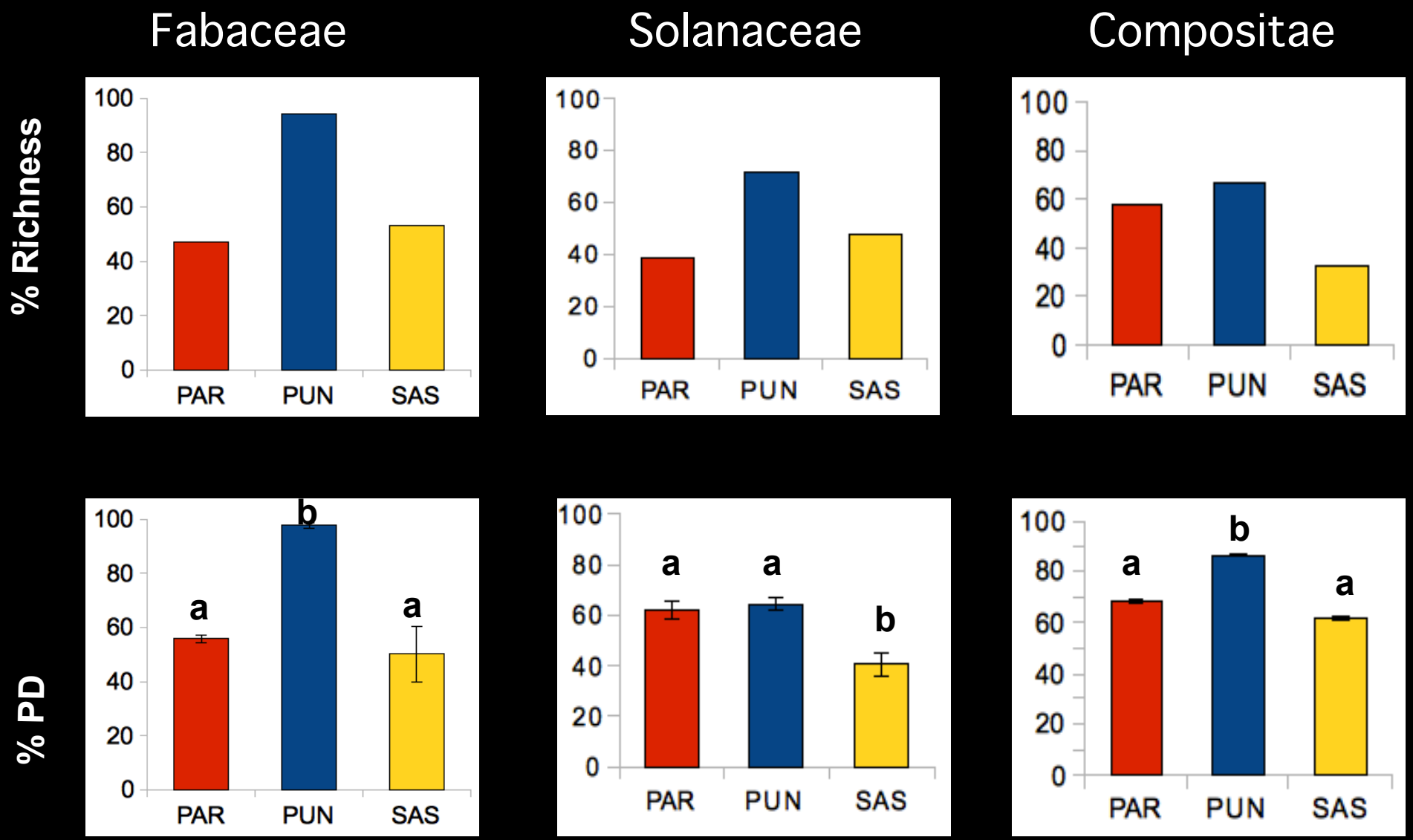




How does PD compare to richness?

At least for the SAS, taxon richness seems to underestimate evolutionary richness

What happens in other families?



Is there a relationship between taxon richness and PD?

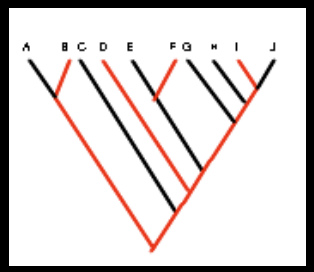
For the high Andes of South America there seems to be no pattern of relationship between richness and PD in the families tested

For the Compositae, the Southern area seems to have an evolutionary richness that is not captured by taxon richness. The same is observed for the Solanaceae in the Páramo

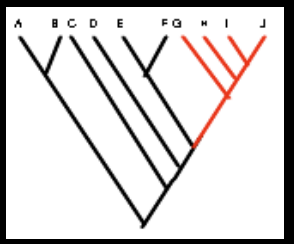
OUR SECOND QUESTION

What drives the pattern of PD observed in the Compositae of the Southern Andes?

Predictions based on PD:



The SAS contains species that are phylogenetically more dispersed than expected by chance



The SAS contains taxa with unique evolutionary history that contribute more to PD

Testing for clustering or disperssion

Null model approach

100 randomly chosen sets of taxa to create a distribution of PD

Testing whether our calculated PD for each tree and area falls within the distribution

Testing for clustering or disperssion

Null model approach (computed in R)

100 randomly chosen sets of taxa to create a distribution of PD

Testing whether our calculated PD for each tree and area falls within the distribution

Calculated PDs did not differ significantly from the null model in any of the trees or areas tested

Testing for evolutionary distinctness

At the level of community/ecosystem

Phylogenetic diversity
(Faith 1992)

Community structure
(Webb et al 2000)

How much evolutionary history is contained in a given area

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Taxonomic distinctness
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Evolutionary distinctness
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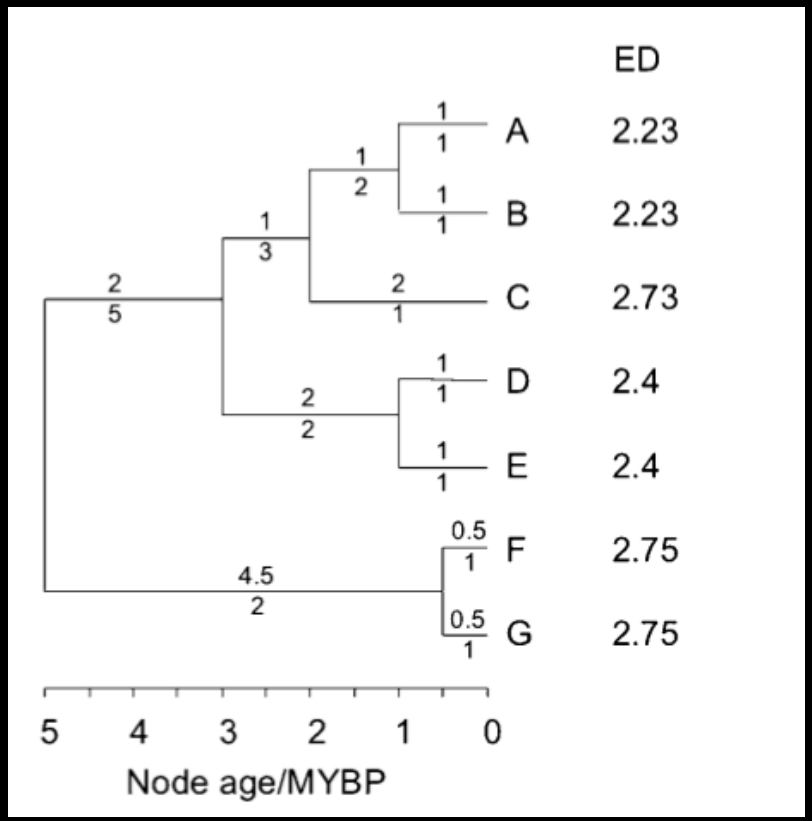
How much does a taxon "weight" with respect to its evolutionary history

Evolutionary Distinctness (ED)

(Isaac et al 2007)



ED for a taxon is a measure of how unique it is with respect to the phylogeny

Considers the length of each branch (upper value) and how many terminal taxa are sustained by each node (lower value)

Ex. Taxon A: 1/1 + ½ + 1/3 + 2/5 = 2.23

ED for a given taxon will be larger the lower number of nodes connected to it and the larger the branches

ED in the Compositae family of the high Andes

ED was calculated using the software Tuatara v1.01 (Maddison and Mooers, 2009) implemented in the Mesquite phylogenetic package

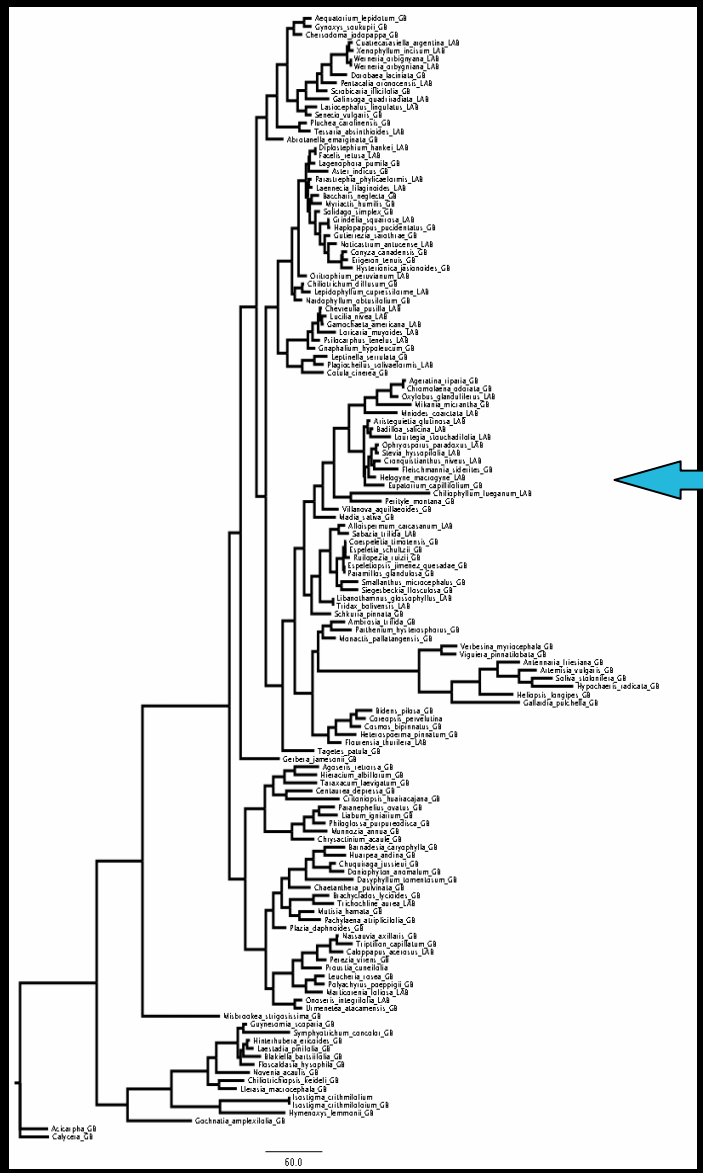
One phylogenetic tree obtained in the Bayesian analyses was used as the input

ED in the Compositae family of the high Andes

The 4 genera with the highest ED value

Gallardia Fougeroux
Chiliotrichum Cass.
Hypochaeris L.
Antennaria Gaertn.

Genera with highest ED value



Chiliotrichum

Hypochaeris
Antennaria
Gaillardia

ED in the Compositae family of the high Andes

The 4 genera with the highest ED value

Gallardia Fougeroux
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ED in the Compositae family of the high Andes

The 4 genera with the highest ED value

Gallardia Fougeroux
Chiliotrichum Cass.
Hypochaeris L.
Antennaria Gaertn.

Chiliotrichum: endemic to southern Chile and Argentina, with only 2 species

OUR QUESTIONS

1.- Is there a relationship between taxon richness and PD in the Compositae of the high Andes?

The SAS shows a higher PD than expected by its taxon richness. This area has an evolutionary diversity that richness does not account for.

OUR QUESTIONS

2.- What drives the pattern of PD especially in the South?

In Compositae, our analyses suggest that phylogenetic structure is not playing a critical role

More likely the pattern is given by genera in large and unique branches: from the 4 genera with the highest ED value, 3 are present in the SAS.

The genus Chiliotrichum should be looked at more closely because of its low species number, endemism and evolutionary distinctness

We are working on

Calculate compound indices with extinction probabilities (HEDGE, EDGE)

Working with reduced systems at the species level

EDGE: Evolutionary Distinctness coupled with conservation coefficient

EDGE = Evolutionary Distinct Globally Endagered

$$EDGE = \ln(1 + ED) + GE * \ln(2)$$

EDGE incorporates a coefficient taken from the conservation status according to IUCN

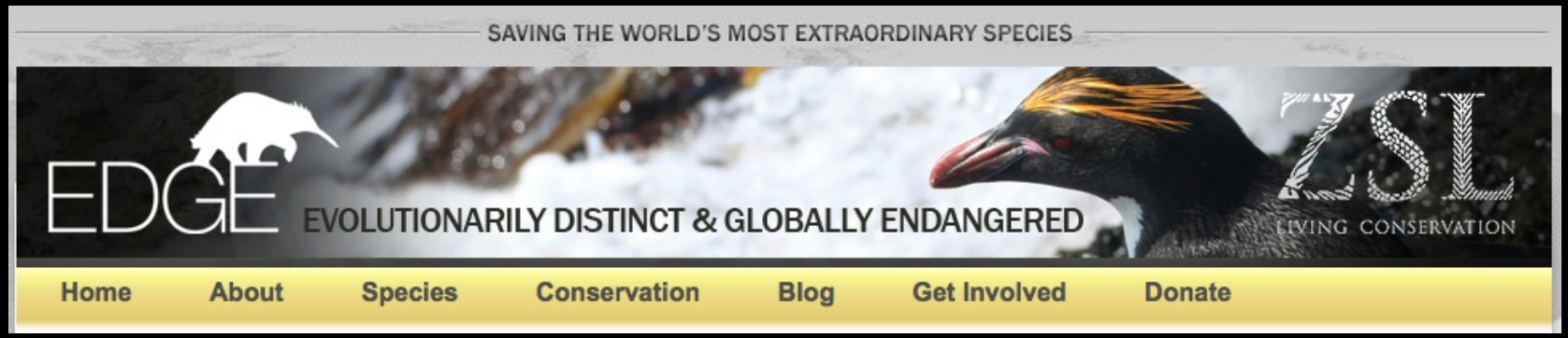
Categories are transformed into extinction risk intervals

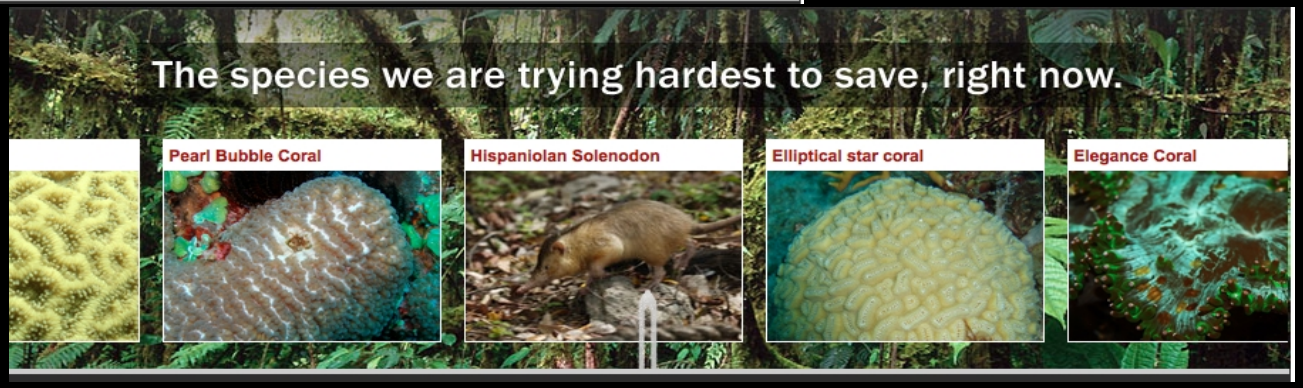
GE:

0 = Least concern
1 = Almost threatened
2 = Vulnerable
3 = Endangered
4 = Critically endangered

EDGE OF EXISTENCE

www.edgeofexistence.org





However in plants, the IUCN information is very incomplete

We are working on developing compound indices to account for extinction probabilities

At the genus level:

- Number of spp
- Distribution
- Endemicity
- IUCN categories
- And maybe using niche models for global change scenarios

Implications for conservation

- Importance of considering evolutionary relationships in choosing areas or taxa to preseve – attributes
- PD can be a useful indicator of the biodiversity not evidenced by taxon counts, but results cannot be extrapolated among families
- Technique in progress...

Implications for conservation

- Importance of areas in addition to the hotspots (ex.Southern area of the Andes in Compositae)

- ED and other taxon-based indices can help narrowing the focus on specific genera or species for conservation priority

- There is not a single solution to the problem of biodiversity conservation. Each case should be evaluated individually

MANY THANKS TO ...

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- Mauricio Bonifacino

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