

Biodiversity

Fundamental to understanding
community ecology

Of major conservation concern

Questions

What is biodiversity ?

How is it measured ?

What is happening to it ?

Why does this matter ?

Biodiversity is a scientific
measure of the total difference
within a biological system

The United Nations Official Definition

The variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems

CBD Article 2. UNEP 1992

The United Nations Official Definition

Variability within species

Variability among species

Complexity of ecosystems

Variation among ecosystems

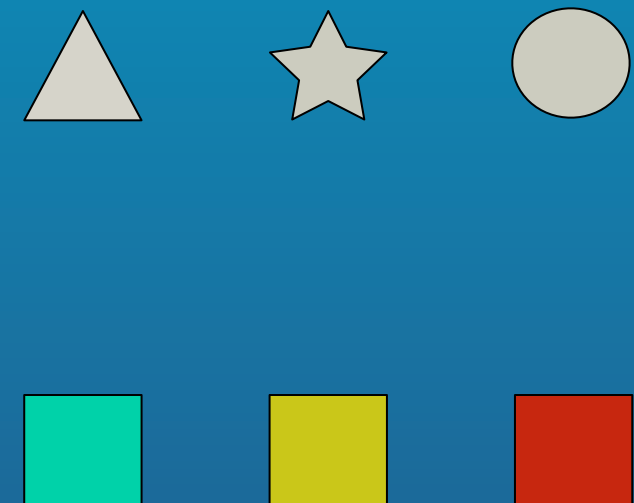
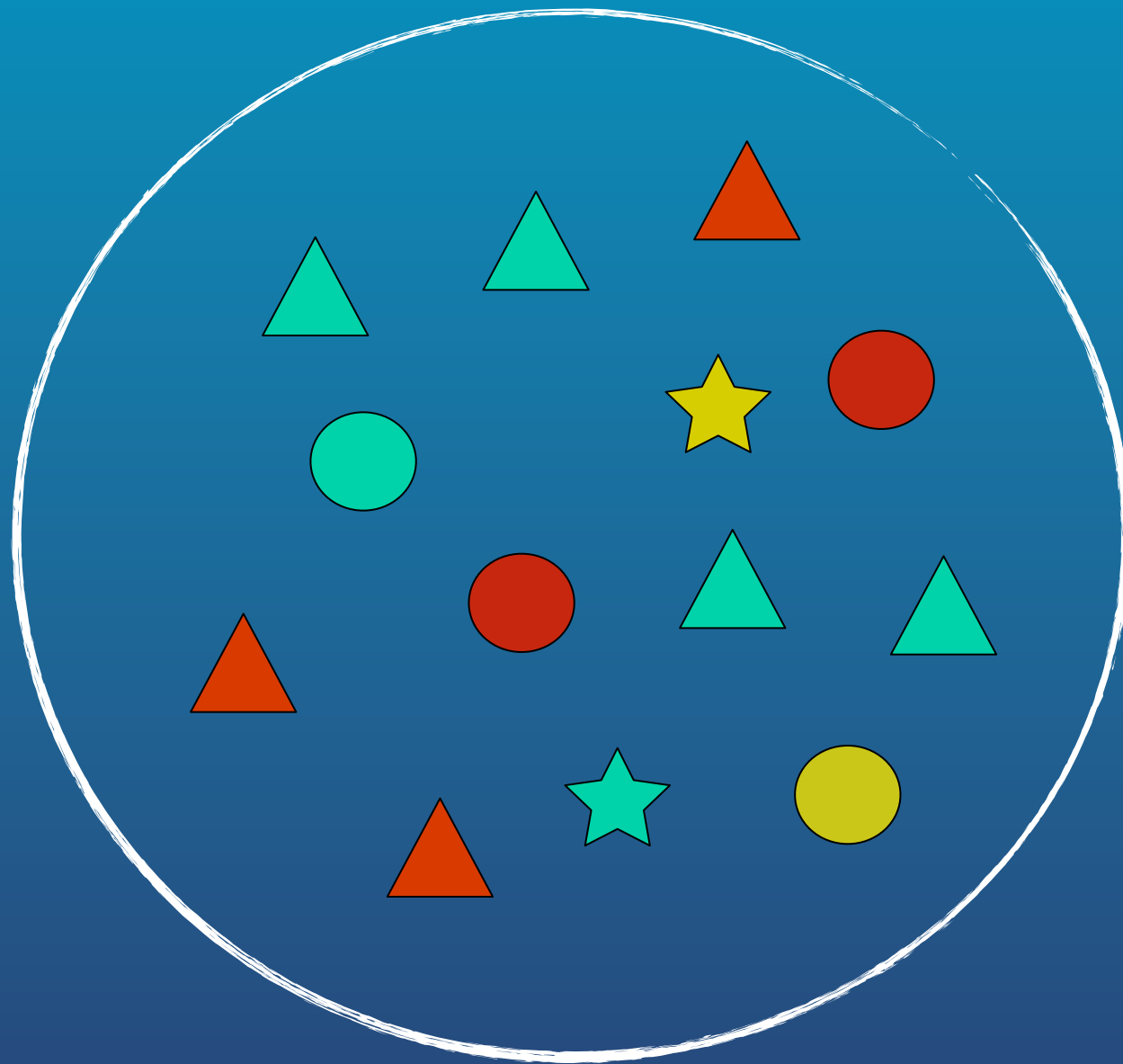
Diversity = difference

We are going to quantify the total difference in living systems

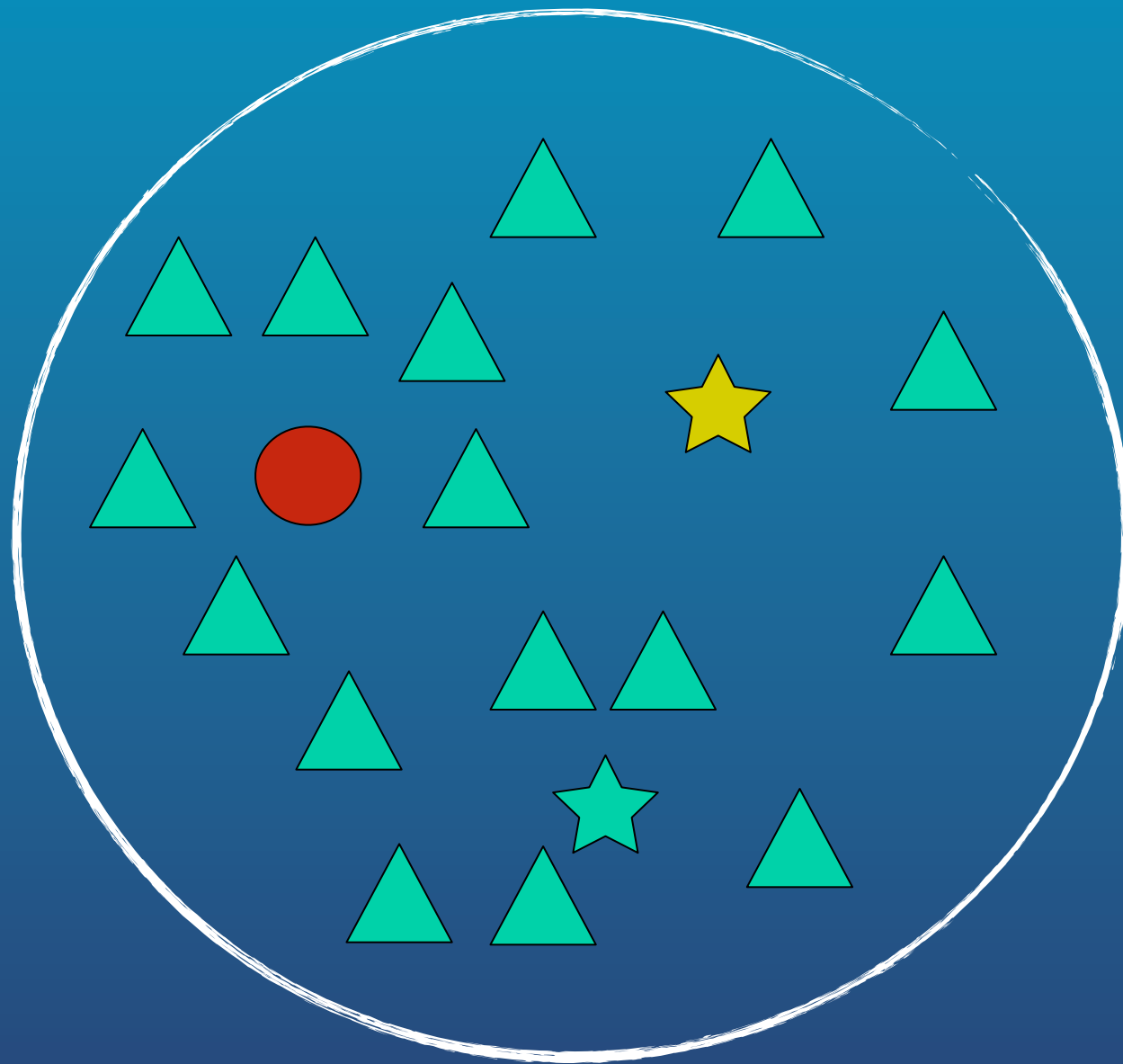
This can be how many different things there are (e.g. species), or how different these are from each other. In fact it is both.

Just to see what
we are up against:

What is the diversity?

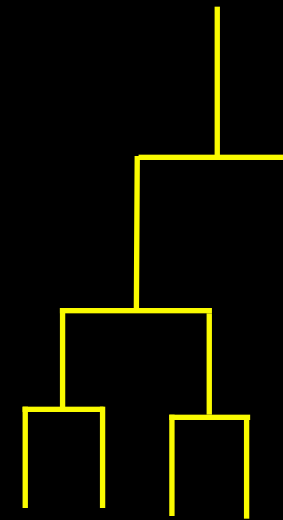


What is the diversity?



Three Major Axes of Biodiversity

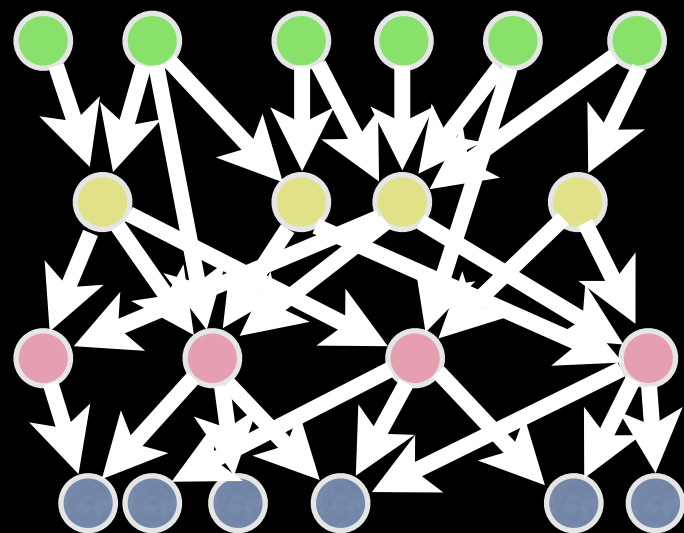
Phylogeny



Ecological Function



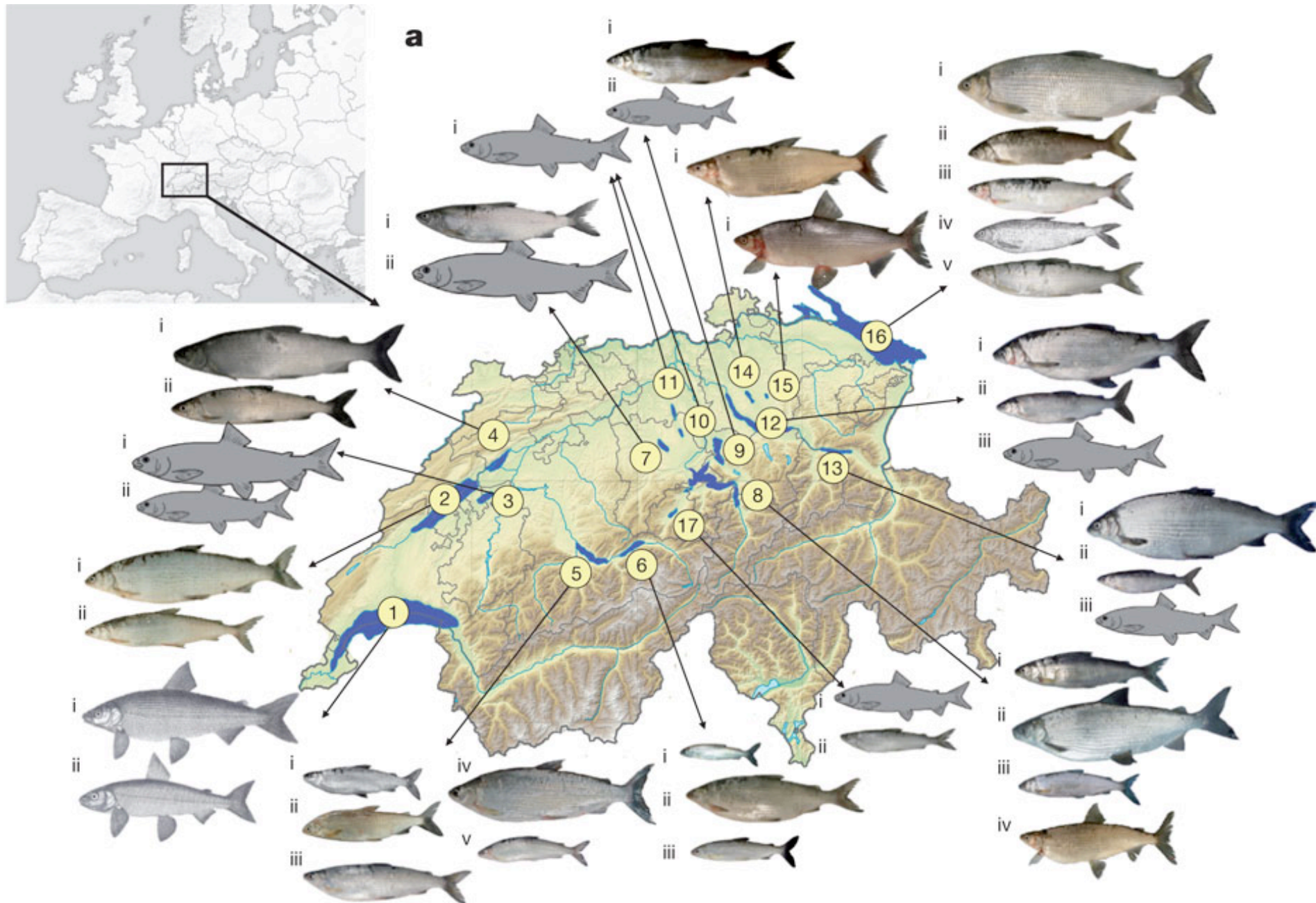
Ecological Structure



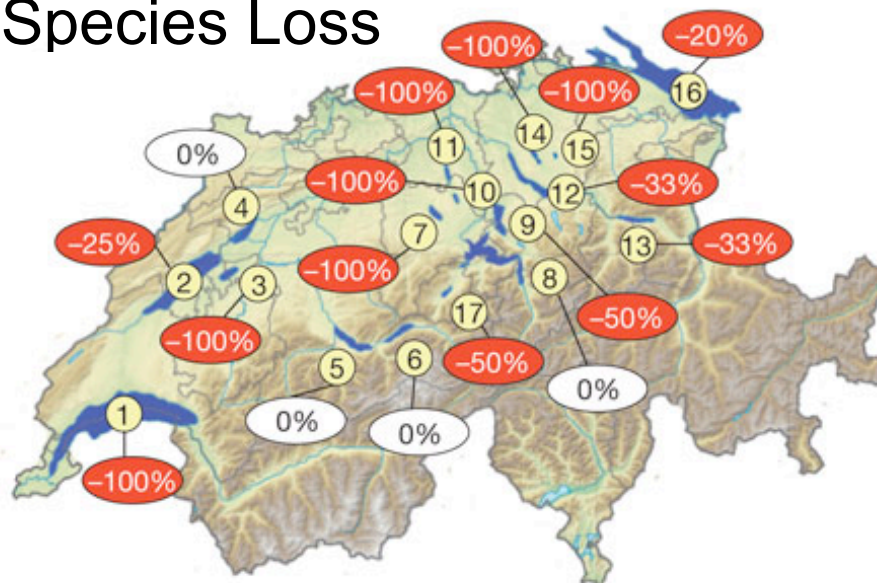
Functional Diversity

(Diversity of things organisms do)

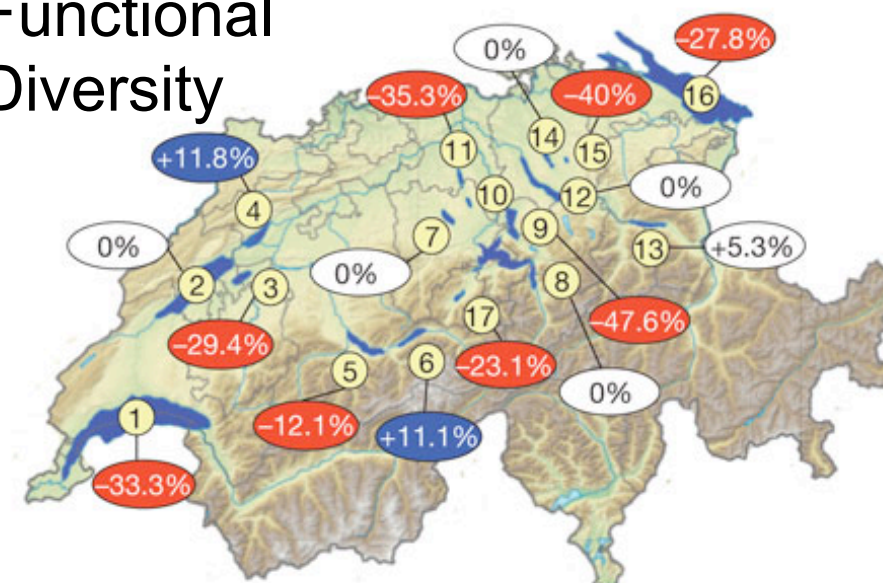
Studying this aspect of biodiversity is still quite rare and underdeveloped: to be fair it is very hard.



Species Loss



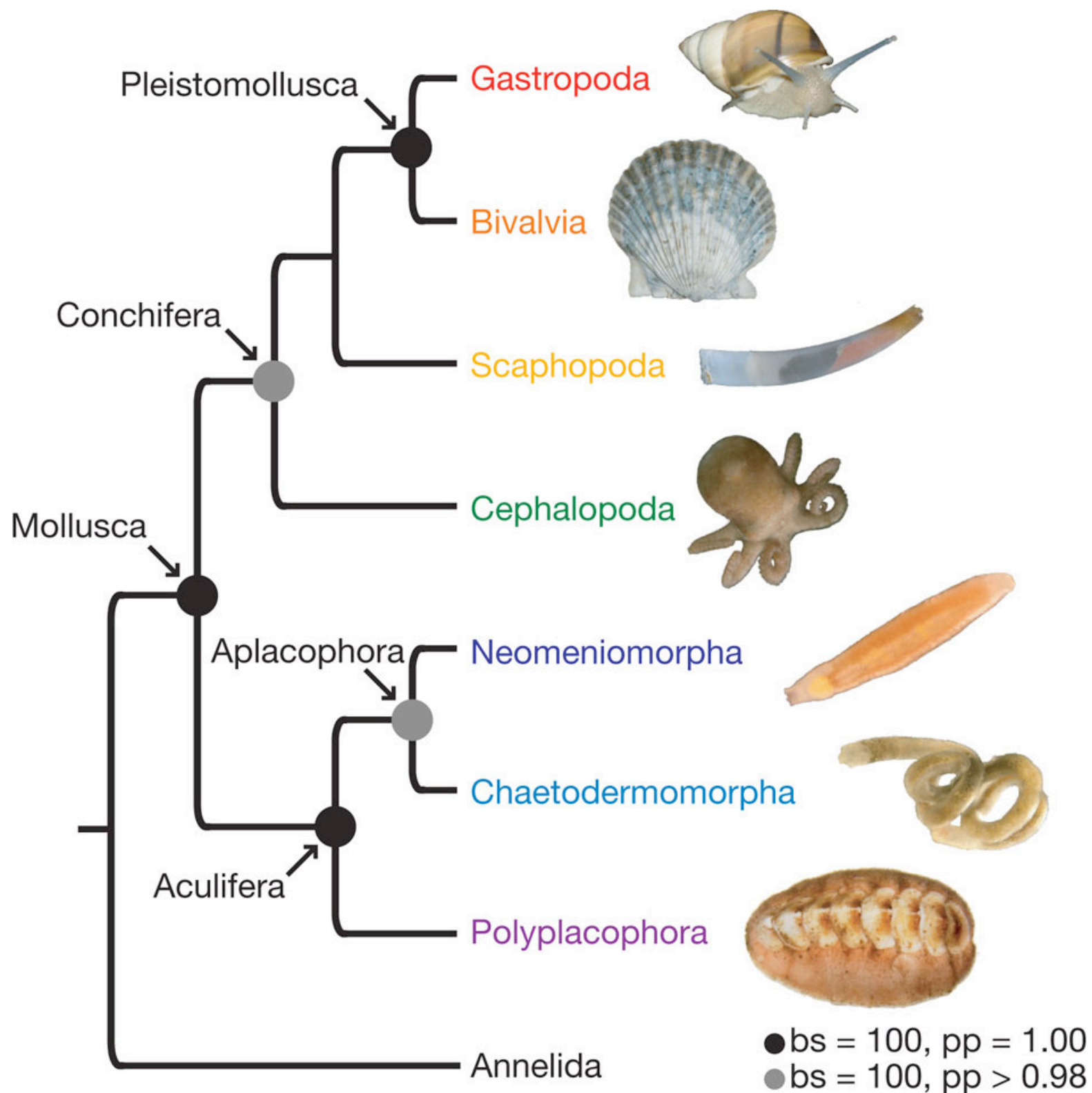
Functional Diversity



Vonlanthen et al. Nature. 2012 482:357-362.

Phylogenetic Diversity

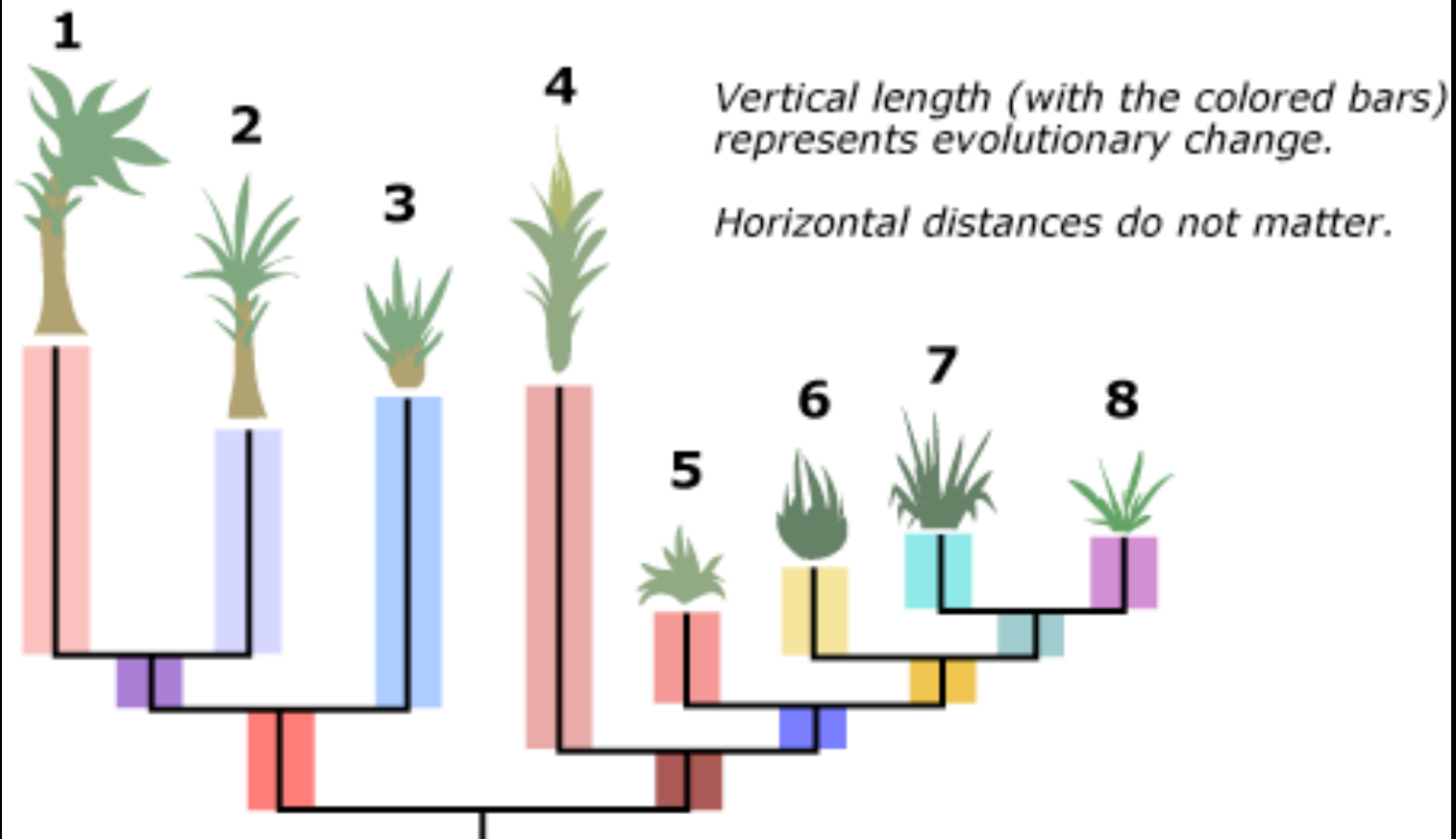
This has got a bit further, but is still relatively rare.



Phylogeny may be traditional **taxonomy** or **genetic** and reflects the branching of the evolutionary tree.

Species
 Genus
 Family
 Order
 Class
 Phylum
 Kingdom

Sample phylogeny of 8 plant species



Group A: species 1, 3, 4 and 8



lots of evolutionary diversity

Group B: species 5, 6, 7 and 8



little evolutionary diversity

Ecosystem with species from group A:



*More evolutionary diversity,
more biomass.*

Ecosystem with species from group B:



*Less evolutionary diversity,
less biomass.*

Genetic diversity as
evolutionary diversity*:
How different species
are from one another,
as well as how many of
them are there.

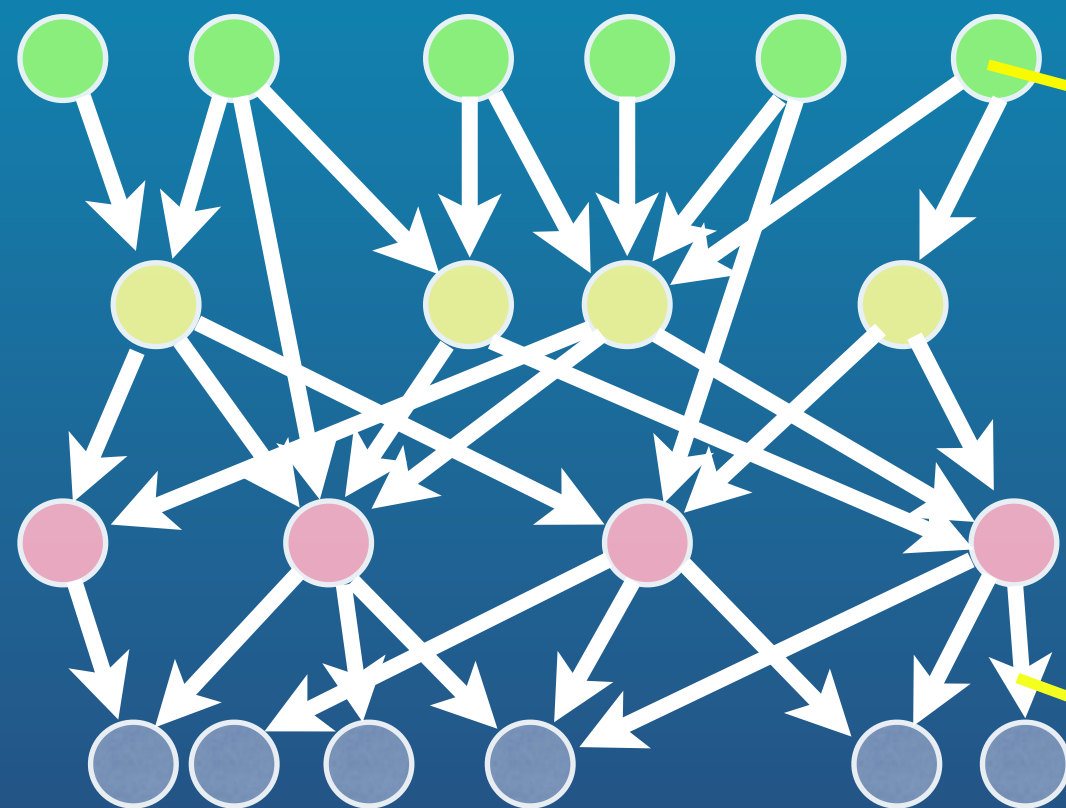
*Often referred to as
Taxonomic Distinctness.

<http://evolution.berkeley.edu>

Structural Diversity (Ecosystem Structure)

Probably the least fundamental of the three kinds of biodiversity, this is by far the most popular and well reported.

Structural Diversity (Ecosystem Structure)



Phylogenetic Units

We count these

Link Diversity

We don't know what to
do with these

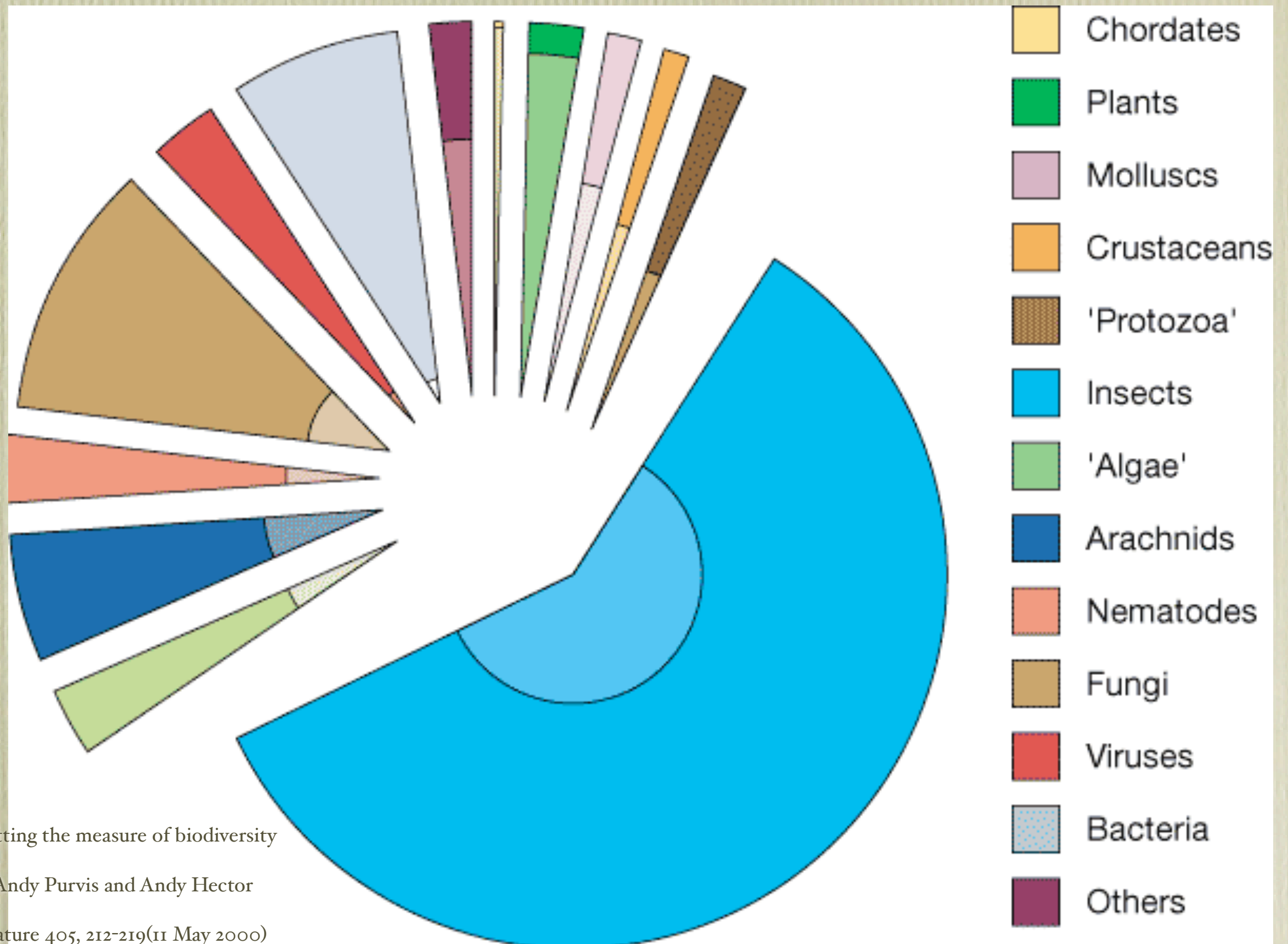
Counting Species

The best estimates to date give the total number of eukariotic species to be about 9 million, with around 6 million prokariotic species to make a total of about **15 million species**. We have described about 10-15% of them so far.

Number of Species in a sample
=
species richness

But what are all these species?

Number of Species in Kingdoms and Phyla



Getting the measure of biodiversity

Andy Purvis and Andy Hector

Nature 405, 212-219(11 May 2000)

Ecosystem Structure: the distribution of numbers among species

Keystone Species: Its effect is disproportionately large for its abundance
probably rare

Dominant Species: Has a big effect because of its large abundance
very common

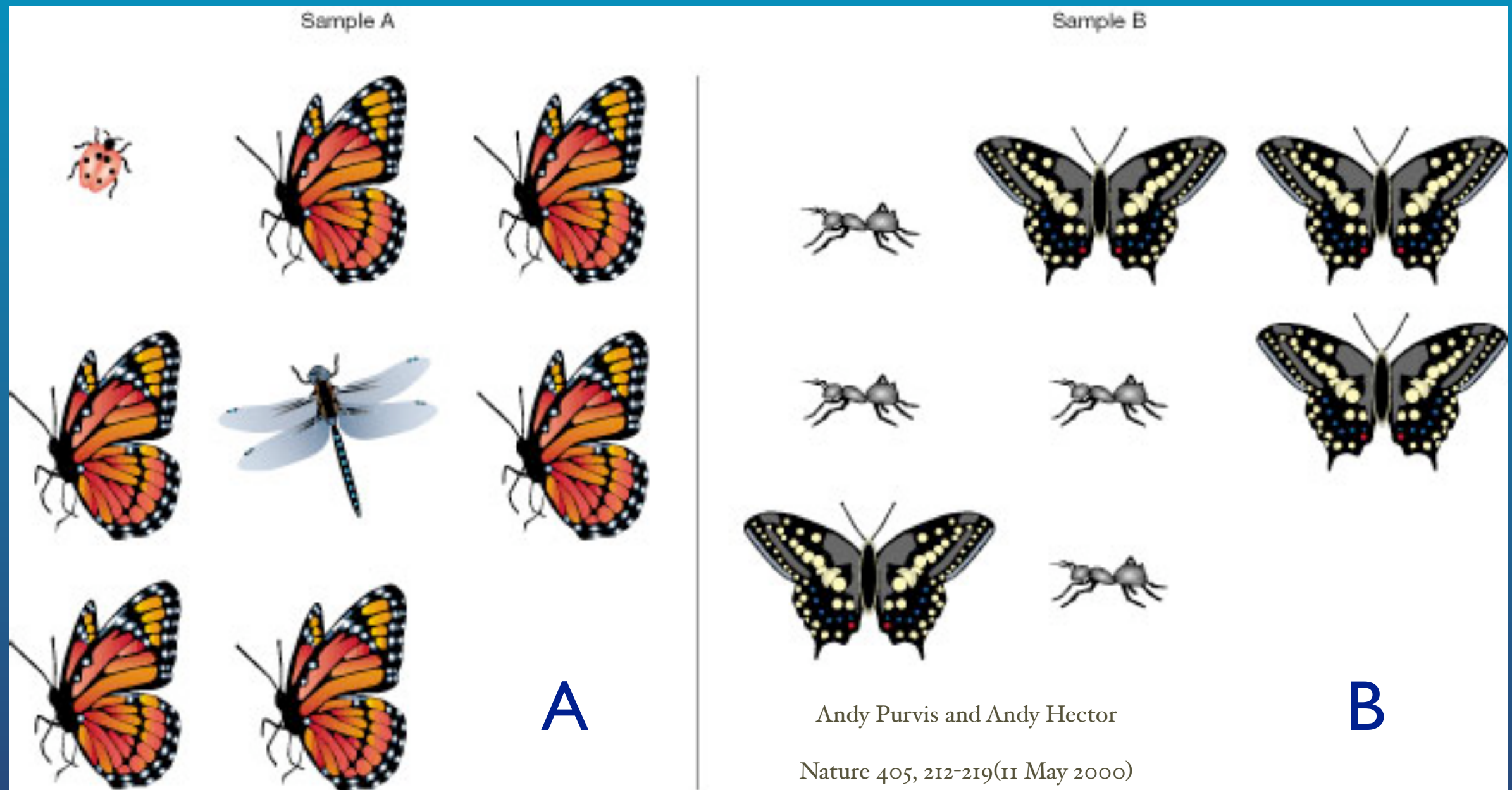
Structural Diversity

(Ecosystem Structure)

has become a matter of species richness
and the **distribution** of population sizes
among species.

This is called: **Species Evenness**

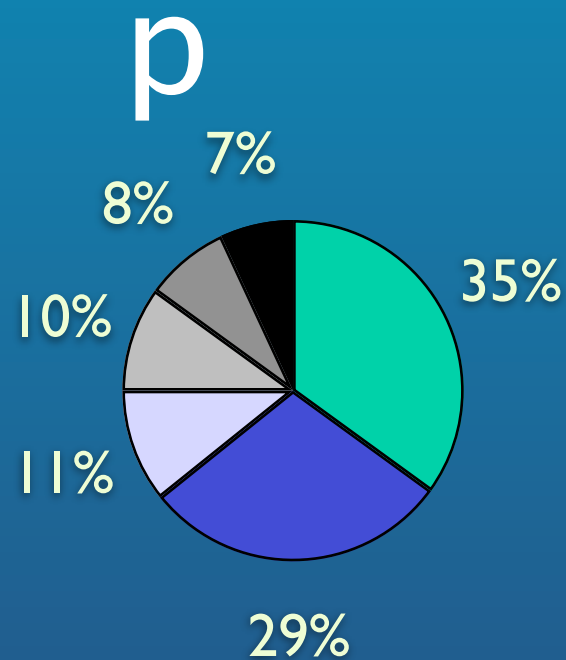
Which is more Diverse? Sample A or Sample B?



more Species Richness

more Species Evenness

Evenness - structural diversity indices



p is the proportion in the sample

Simpson's

$$D = \sum_i^S p_i^2$$

Shannon-
Wiener

$$H = - \sum_i^S p_i \ln p_i$$

-actually just two of many

Field Ecologists

spend a lot of time measuring species richness and evenness in lots of samples.



University of San Diego

Diversity within and among samples

R. H. Whitaker

α -Diversity : within your sample.

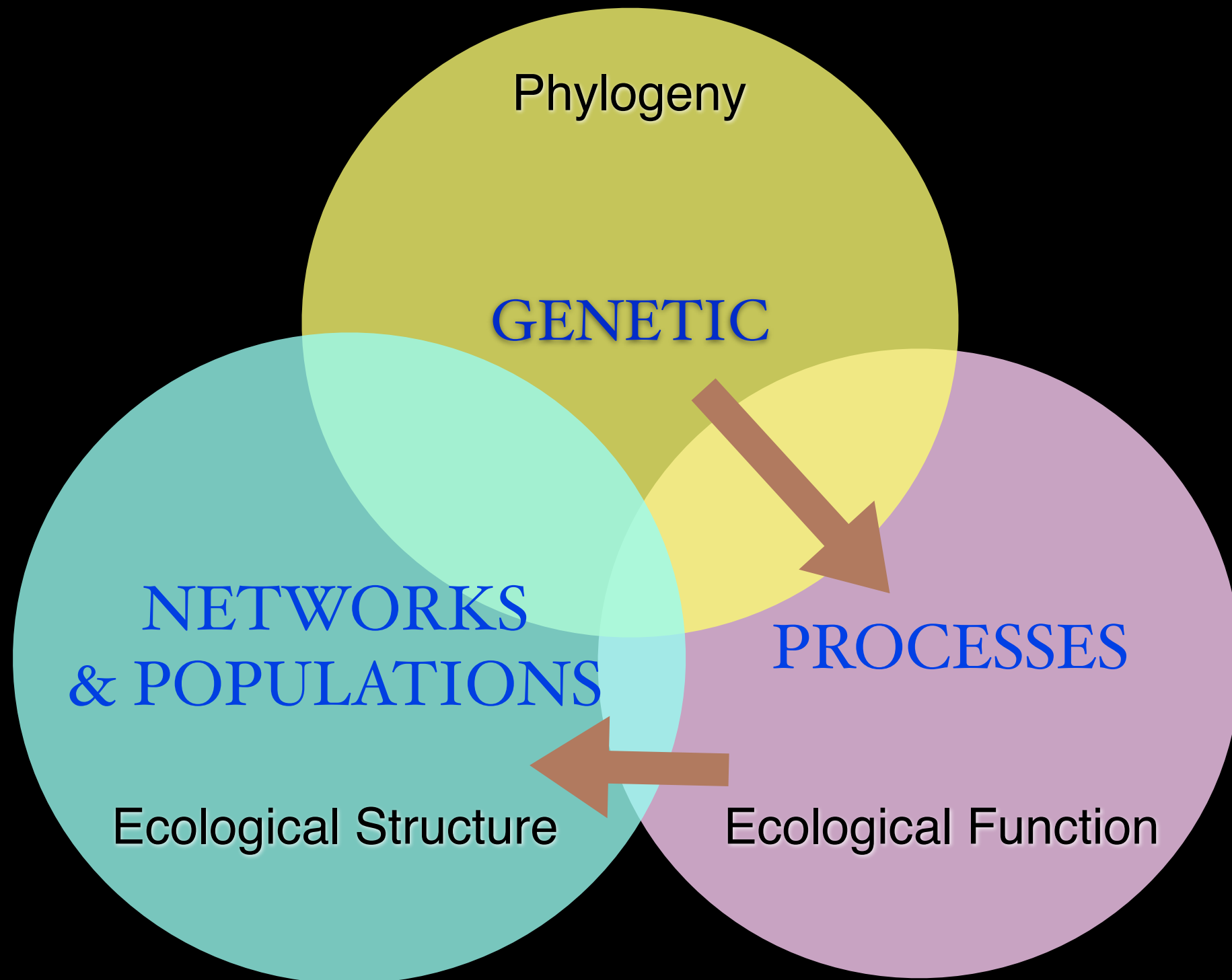
β -Diversity : difference among samples.

γ -Diversity : diversity of the whole lot

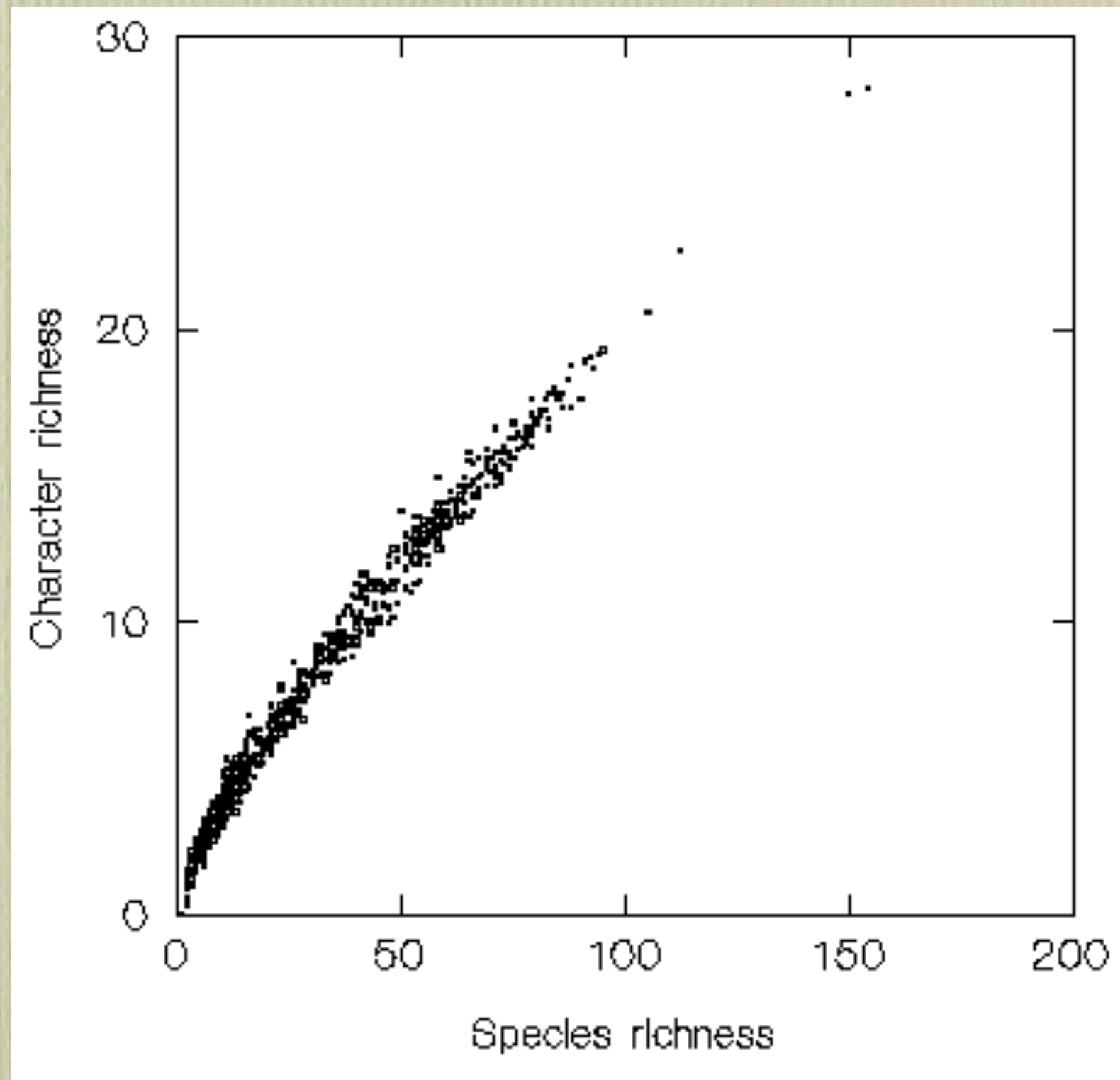
from the field course...

Species	Hedge	Meadow	Woodland
A	X		
B	X		
C	X		X
D	X		
E	X	X	
F	X	X	
G		X	X
H		X	X
I			X
J			X
α	6	4	5
β	H v M = 6	M v W = 5	H v W = 9
γ	10		

Three Major Axes of Diversity



Luckily: Species Richness is a reasonable surrogate for function

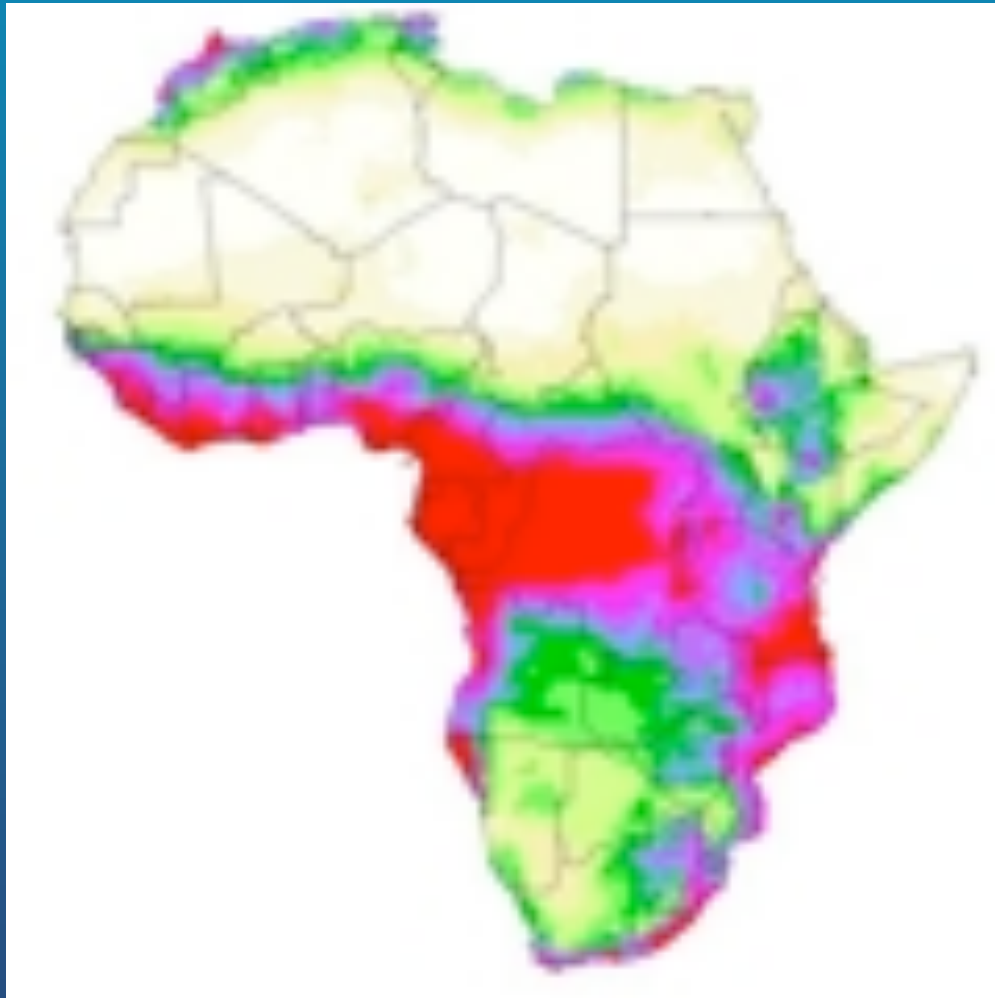


Williams, P. H. (1996)

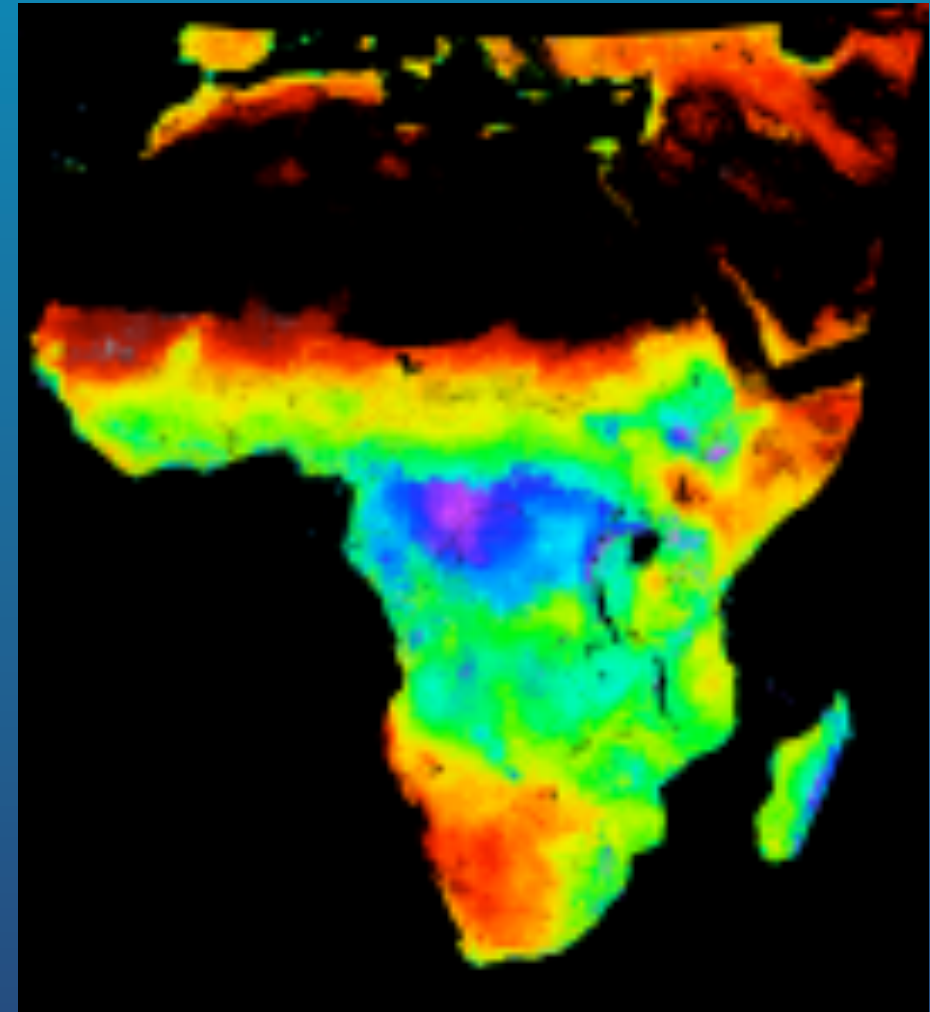
World Conservation [formerly IUCN Bulletin], 1: 12-14.

The Distribution of Biodiversity

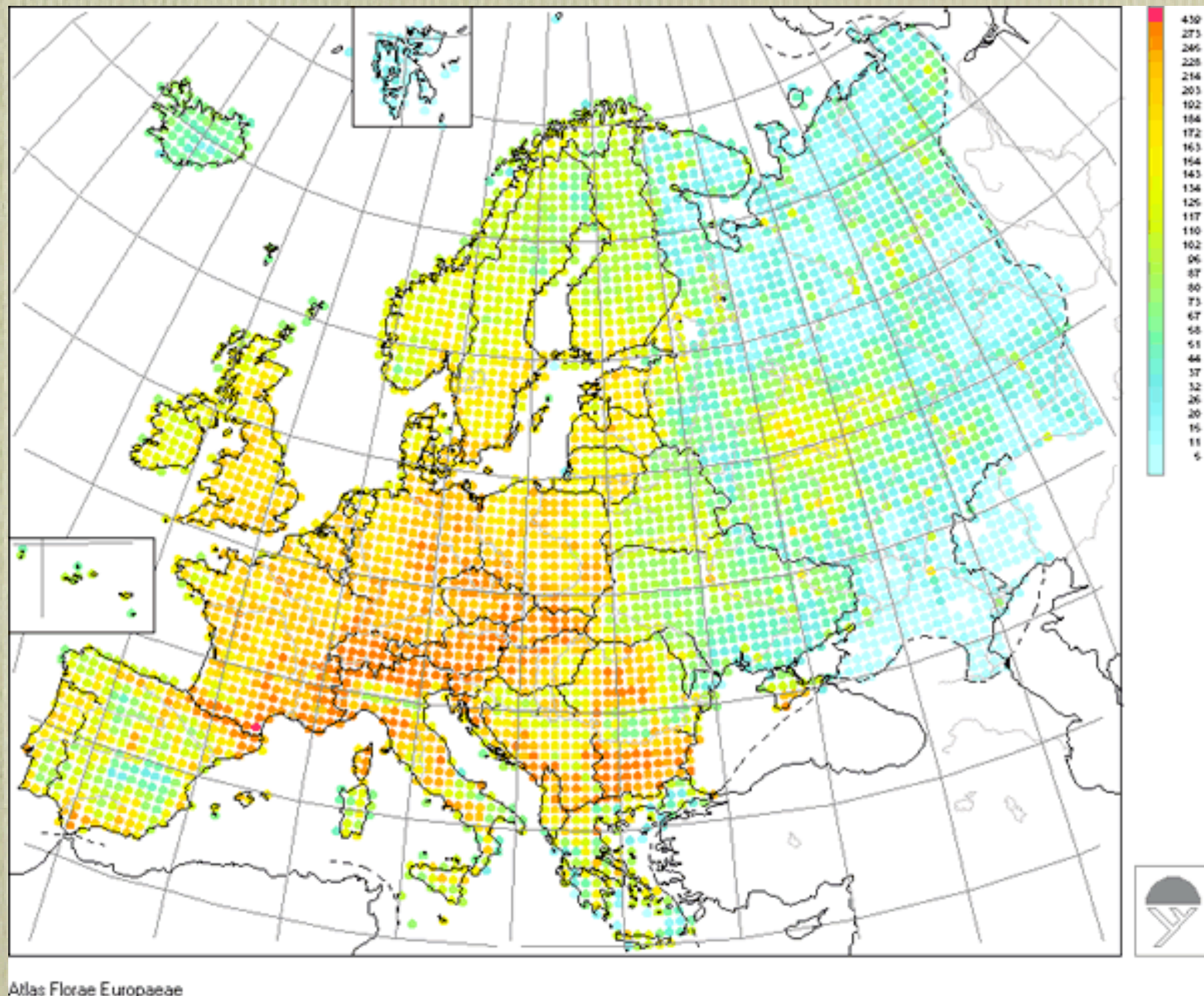
(over the Earth's land surface)



Species Richness



NPP



Natural History Museum

<http://www.nhm.ac.uk/research-curation/research/projects/worldmap/diversity/fig2.htm>

Biodiversity Hotspots

Norman Myers

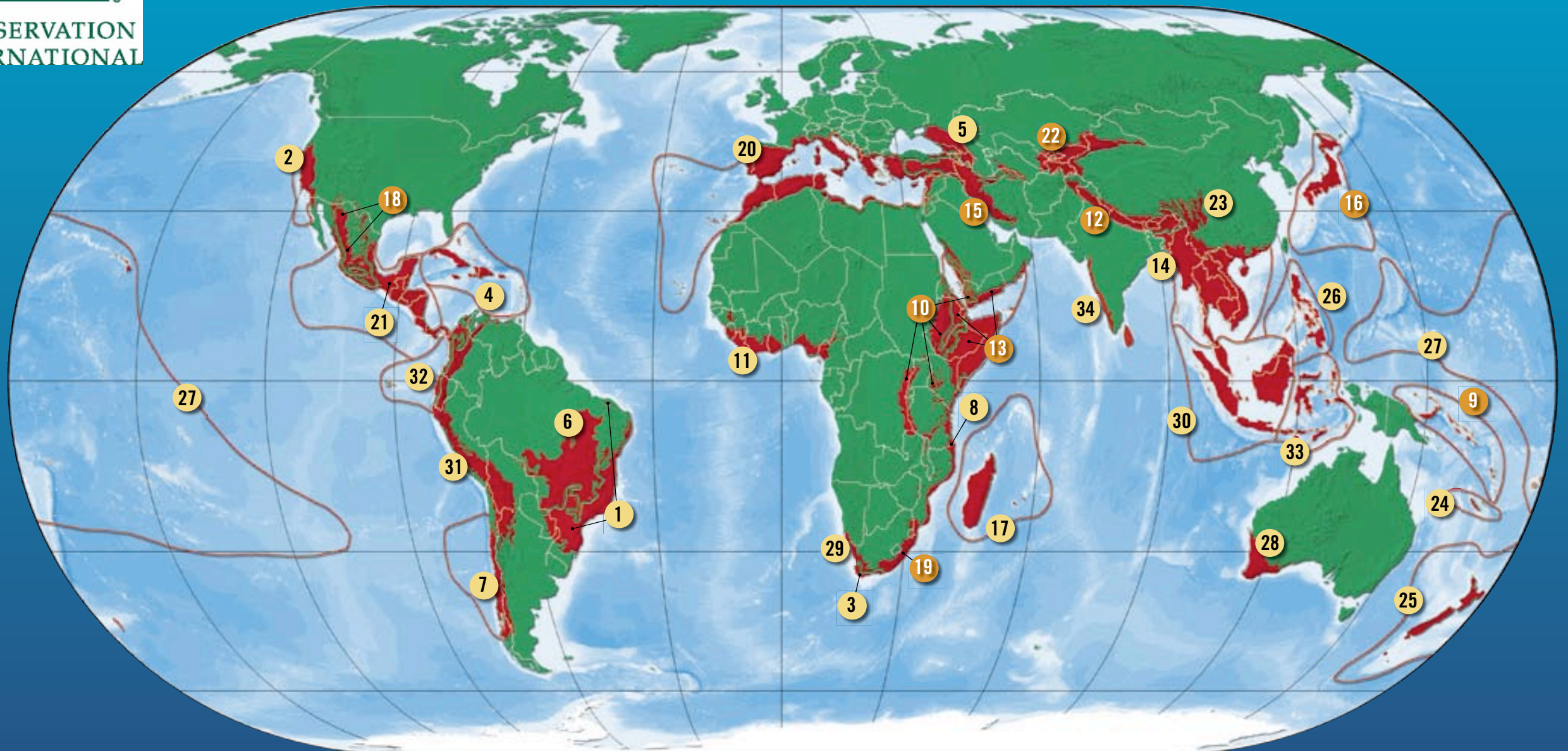
> 0.5% Global **Endemic** Terrestrial Species

So far 34 biodiversity hotspots designated.

Contain 50% of world's total endemic species of terrestrial plants and 42% of endemic terrestrial vertebrates.

These have declined from 15.7% to only 2.3 % of the Earth's land surface. 86 % of the hotspots' habitat has already been destroyed.

Biodiversity Hotspots



- | | | | |
|---|---|---------------------------------|-----------------------------------|
| 1 Atlantic Forest | 9 East Melanesian Islands | 18 Madrean Pine-Oak Woodlands | 28 Southwest Australia |
| 2 California Floristic Province | 10 Eastern Afrotropical | 19 Maputaland-Pondoland-Albany | 29 Succulent Karoo |
| 3 Cape Floristic Region | 11 Guinean Forests of West Africa | 20 Mediterranean Basin | 30 Sundaland |
| 4 Caribbean Islands | 12 Himalaya | 21 Mesoamerica | 31 Tropical Andes |
| 5 Caucasus | 13 Horn of Africa | 22 Mountains of Central Asia | 32 Tumbes-Chocó-Magdalena |
| 6 Cerrado | 14 Indo-Burma | 23 Mountains of Southwest China | 33 Wallacea |
| 7 Chilean Winter Rainfall-
Valdivian Forests | 15 Irano-Anatolian | 24 New Caledonia | 34 Western Ghats and
Sri Lanka |
| 8 Coastal Forests of
Eastern Africa | 16 Japan | 25 New Zealand | |
| | 17 Madagascar and Indian Ocean
Islands | 26 Philippines | |
| | | 27 Polynesia-Micronesia | |

Why Biodiversity Matters

It's a source of novel products

Ecological Services depend on it

many also argue that we gain psychological benefits from biodiversity and that we have a moral duty to conserve it.

Examples of Products depending on biodiversity

Pharmaceuticals (e.g. antibiotics)

Special materials (e.g. silk and dyes)

Variety for food resources

Notice that these really depend on
genetic ➡ **functional** diversity

Examples of Ecosystem Services

Climate regulation

Nutrient cycling

Oxygen production

Wild food production

These entirely depend on functional diversity.

Genetic Diversity

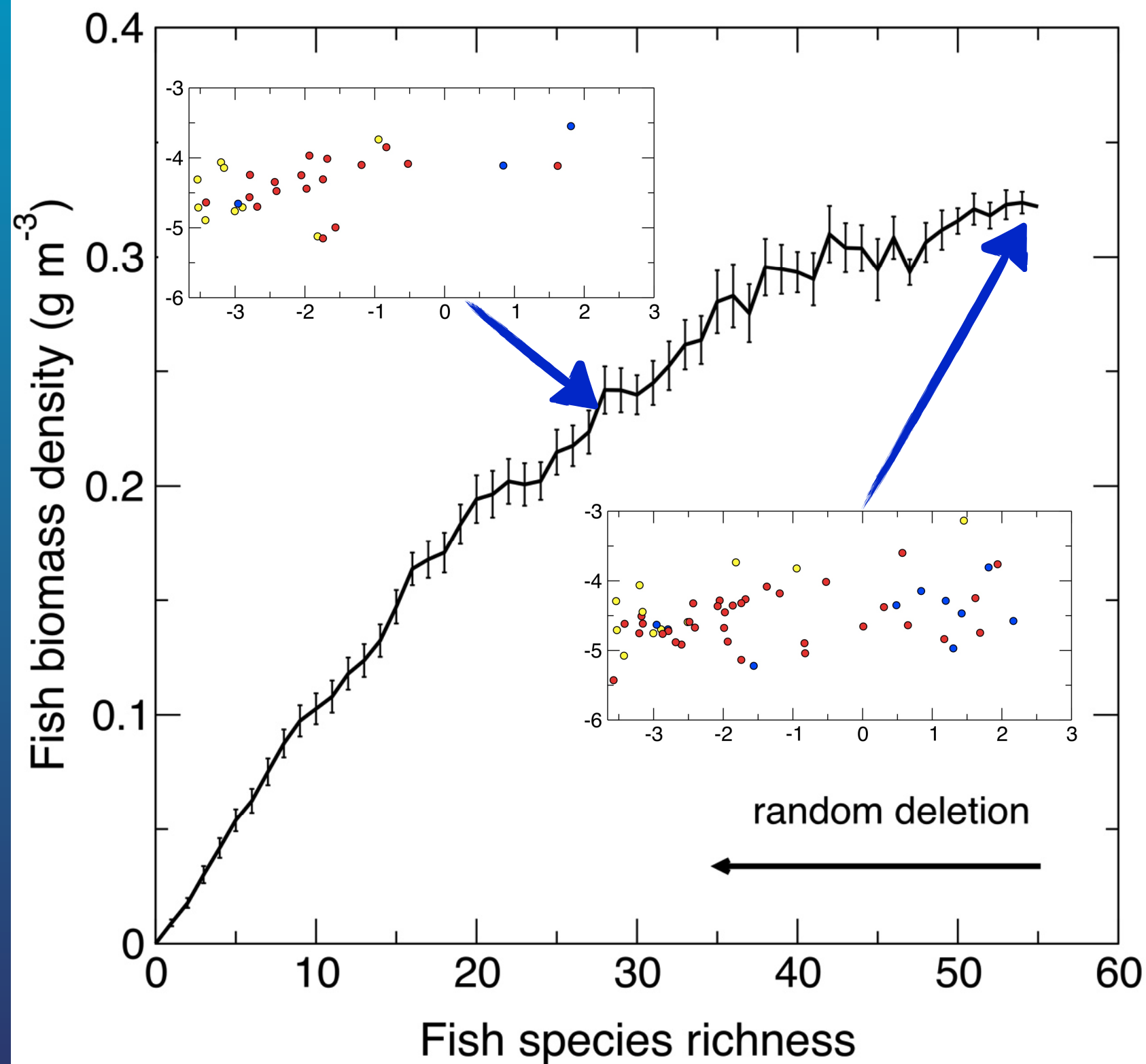
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graph TD; A[Genetic Diversity] --> B[Functional Diversity]; B --> C[Ecological Functions]; C --> D[Ecosystem Services];
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A flowchart illustrating the relationship between different levels of biodiversity and ecosystem services. It consists of four ovals connected by arrows. The top oval is light brown and contains the text 'Genetic Diversity'. An arrow points down from it to a second light brown oval on the left containing 'Functional Diversity'. An arrow points right from this oval to a teal oval on the right containing 'Ecological Functions'. Finally, an arrow points down from the teal oval to a bottom teal oval containing 'Ecosystem Services'.

Functional Diversity

Ecological Functions

Ecosystem Services



**Biodiversity
enhances
ecosystem
function**

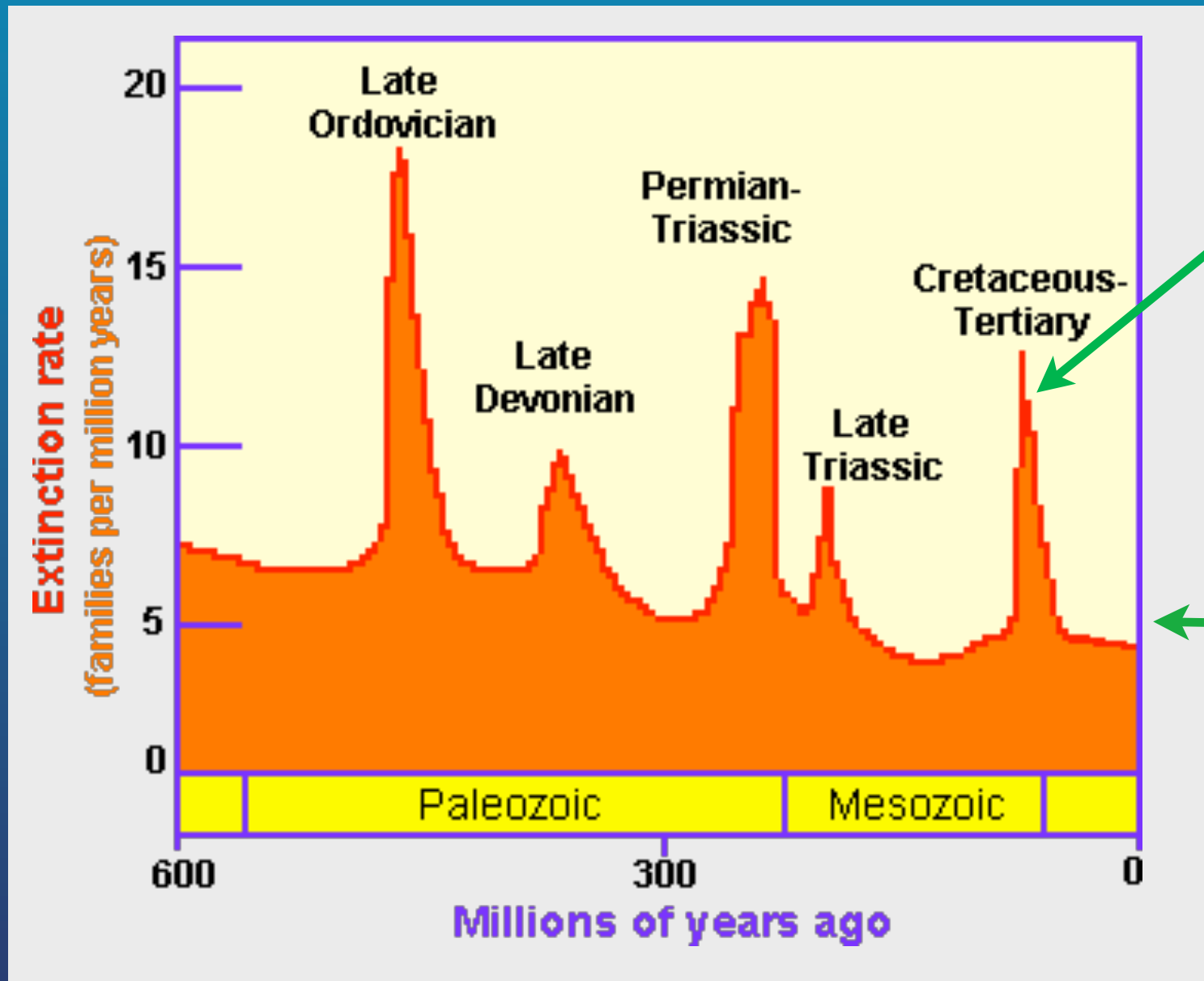
Farnsworth et al. 2012.
Ecol. Complex.

The future for Biodiversity

Biodiversity is currently being lost on a global scale and at a rate that has led some to call our time - the 6th great extinction.

Decline in Biodiversity

Species diversity is maintained by a balance between speciation and extinction rates.



Mass extinction event
5 of these

Background
extinction rate

<10 species / year

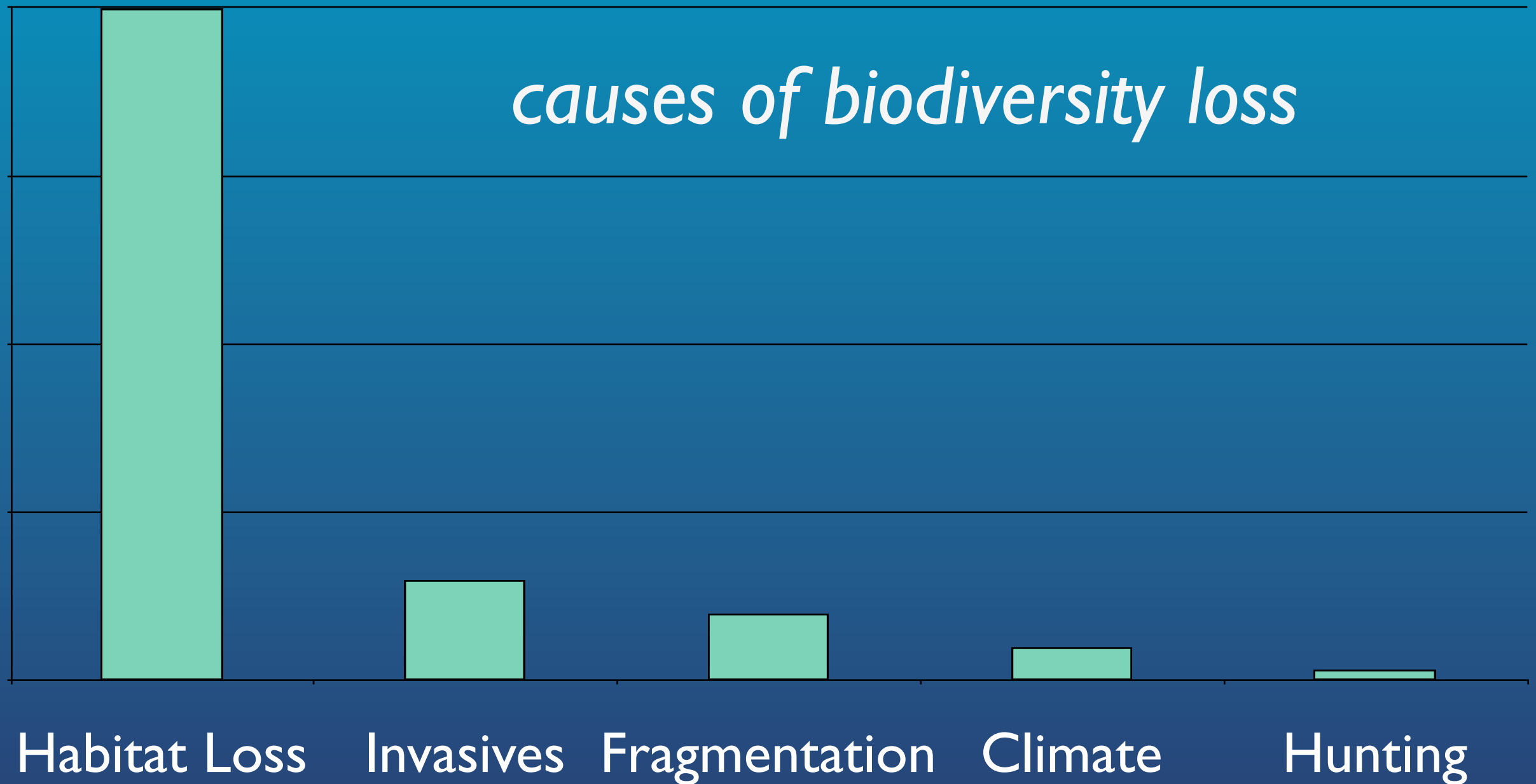
Species Loss

Present rate of loss is 1000 - 10000 species per year (we don't really know).

This seems to be about the same rate as during one of the five natural mass extinctions.

That is why some call this the 6th mass extinction, but the accumulated numbers lost so far is nowhere near the level of the other five... yet.

Why is this happening?





Martha - the last
passenger pigeon

Farewell to species



Lonesome George:
the last of his kind



Benjamin - the last thylacine



Baíjí Dolphin

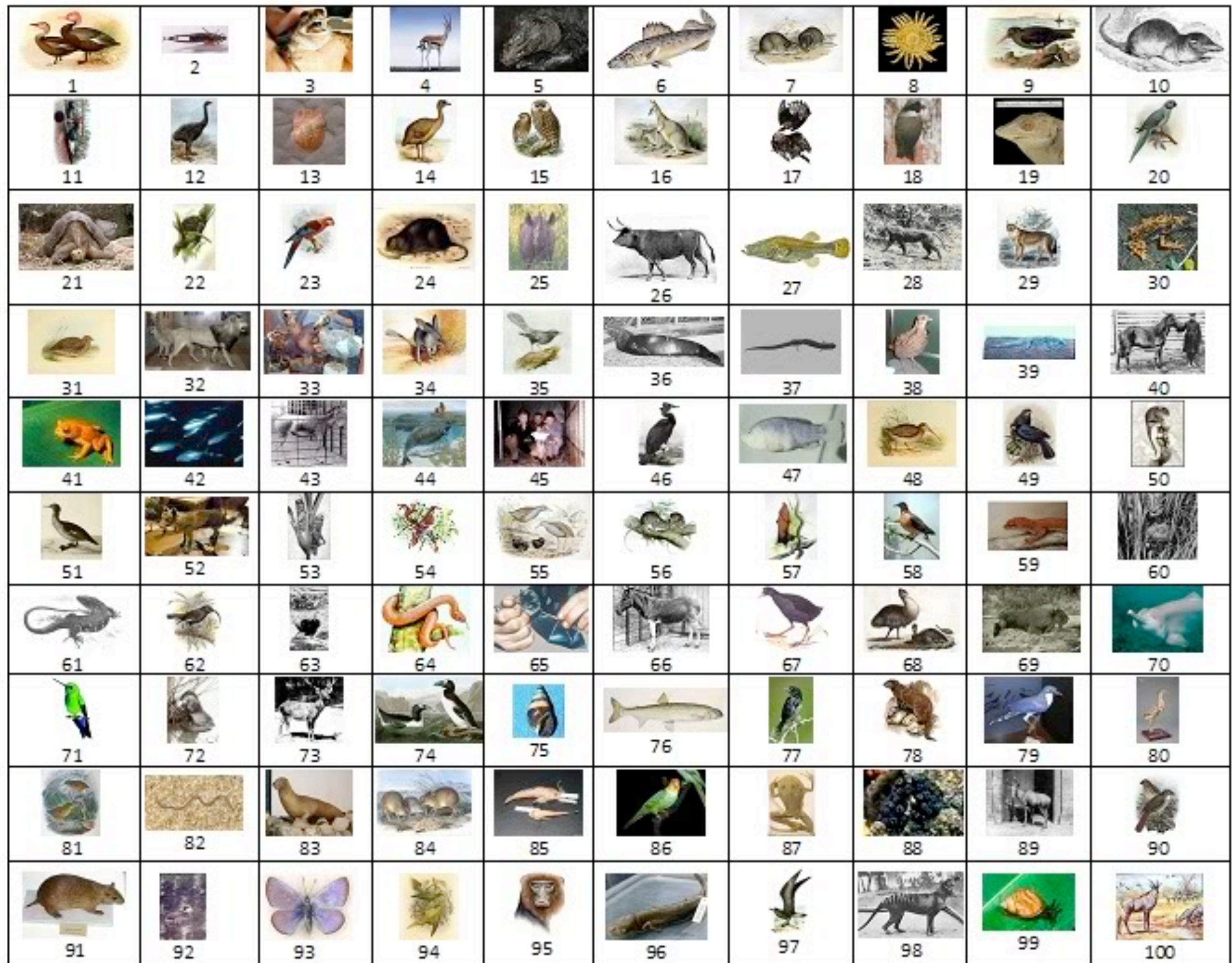


Golden Toad



Pyrenean Ibix

Recently extinct



Summary

Biodiversity is fundamentally genetic diversity, leading to taxonomic differences and so functional diversity.

Still we mostly just measure species richness and evenness to represent biodiversity (missing the degree of difference among organisms).

Most diversity remains unaccounted for, but we know we are losing it fast, mainly due to habitat loss.