Insect diversity

- What is it?
- How is it distributed across the planet?
- What are the causes, consequences, and cures for biodiversity loss?
- Why do we need it?
- Ecology as a guide to conservation strategy

What is biodiversity?
(Wilson 1991, CBD 1992)

- Biodiversity – variety of organisms at all levels, from genetic variants belong to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels; includes the variety of ecosystems, which includes communities of organisms within particular habitats and the physical conditions under which they live

- Most common definition: **Number of species**

Biogeographical realms

Local evolution and barriers to dispersal create distinct biotas and species

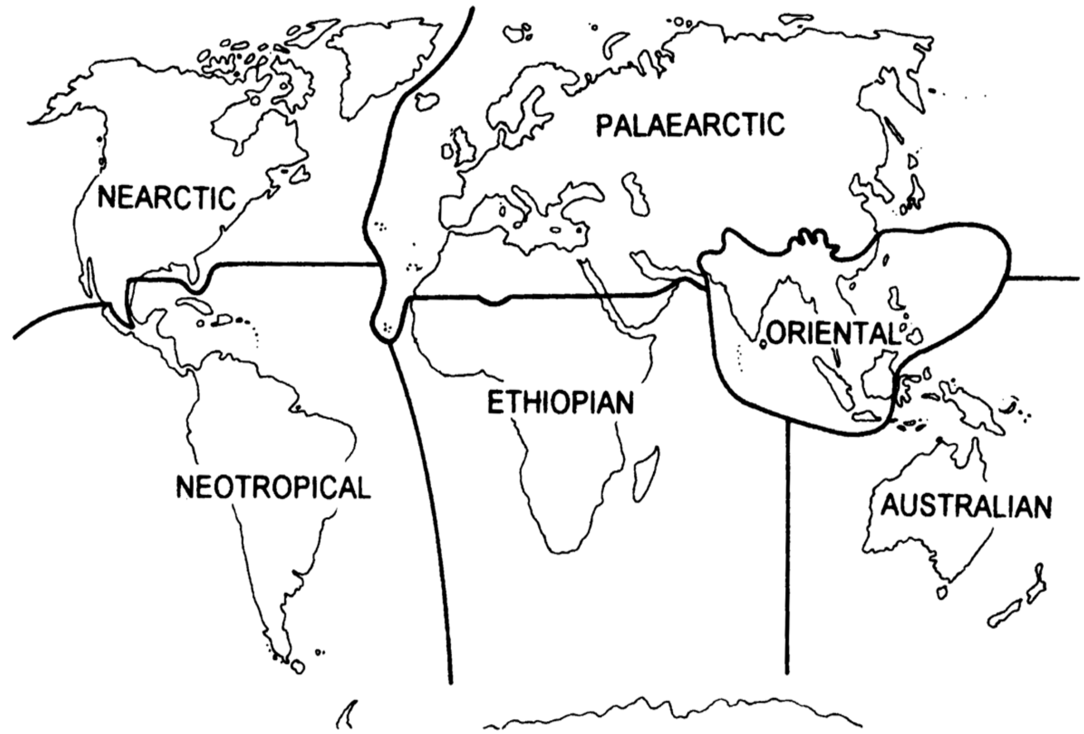
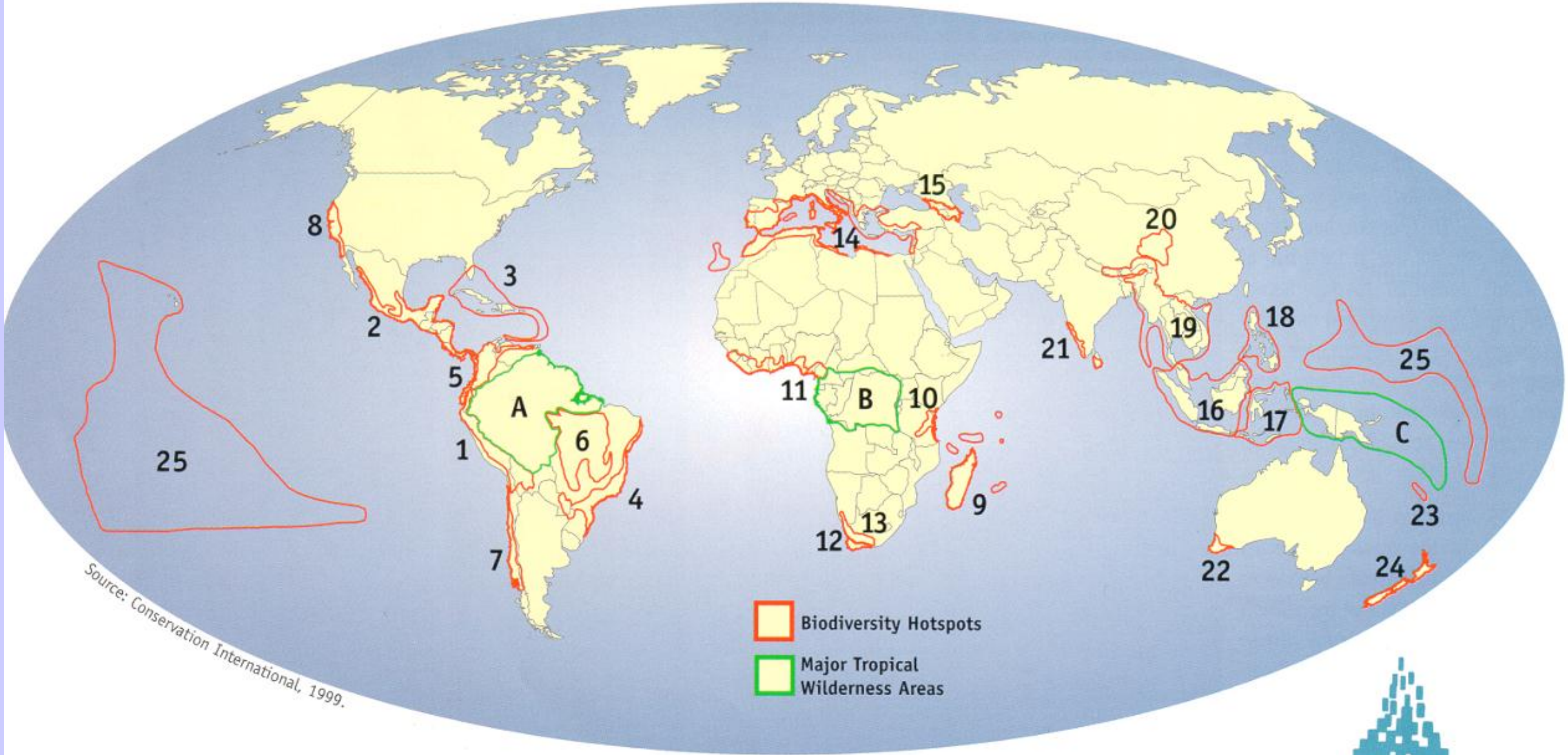


Figure 2.1 Wallace's six realms. Different authors use slightly different boundaries in some places. (From Wallace, 1876; illustration by Mike Hill.)

25 Biodiversity hot spots

People and Biological Diversity



The Global Biodiversity Hotspots and Major Tropical Wilderness Areas

Hotspots

1. Tropical Andes
2. Mesoamerica
3. Caribbean
4. Atlantic Forest Region
5. Chocó-Darién-Western Ecuador
6. Brazilian Cerrado
7. Central Chile
8. California Floristic Province
9. Madagascar and Indian Ocean Islands
10. Eastern Arc Mountains and Coastal Forests of Tanzania and Kenya
11. Guinean Forests of West Africa
12. Cape Floristic Province
13. Succulent Karoo
14. Mediterranean Basin
15. Caucasus
16. Sundaland
17. Wallacea
18. Philippines
19. Indo-Burma
20. Mountains of South-Central China
21. Western Ghats and Sri Lanka
22. Southwest Australia
23. New Caledonia
24. New Zealand
25. Polynesia/Micronesia

Major Tropical Wilderness Areas

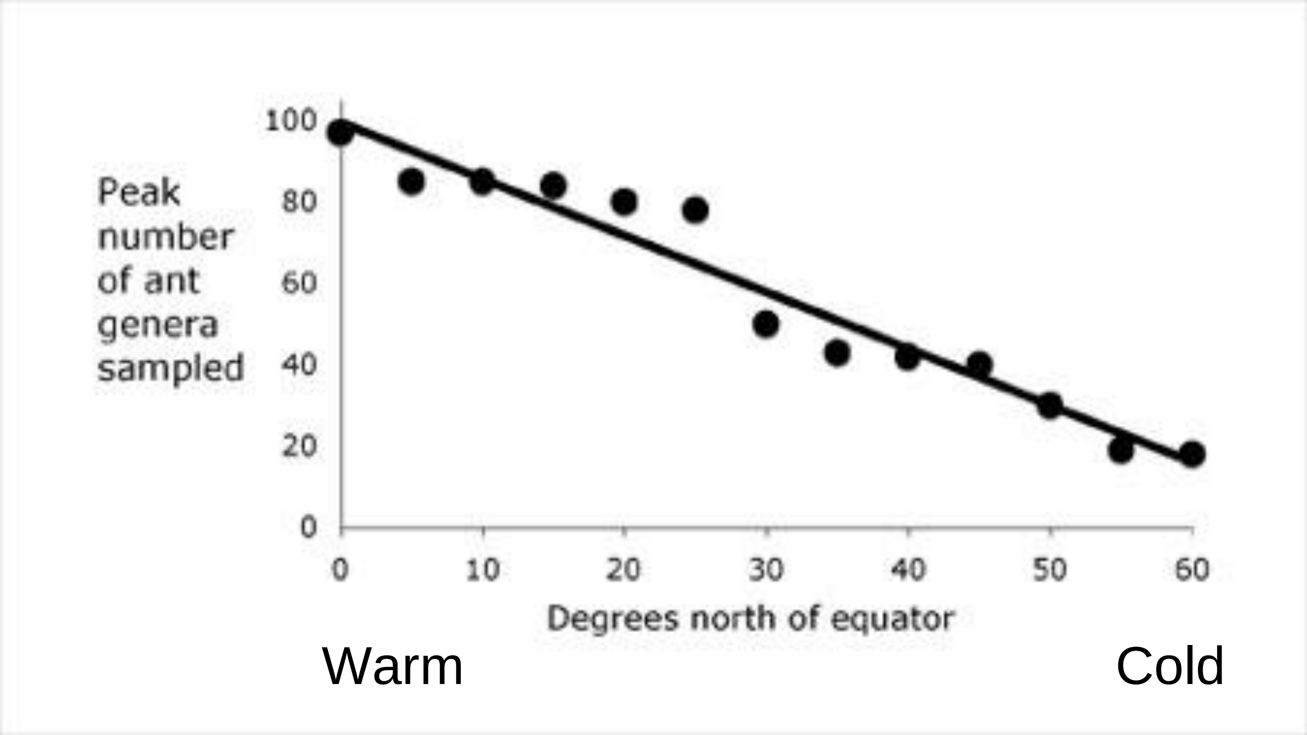
A. Upper Amazonia and Guyana Shield
B. Congo Basin
C. New Guinea and Melanesian Islands

Population Action International

From *Nature's Place: Population and the Future of Biodiversity*. Order additional copies from pubinq@popact.org

On the Web at: http://www.populationaction.org/naturesplace

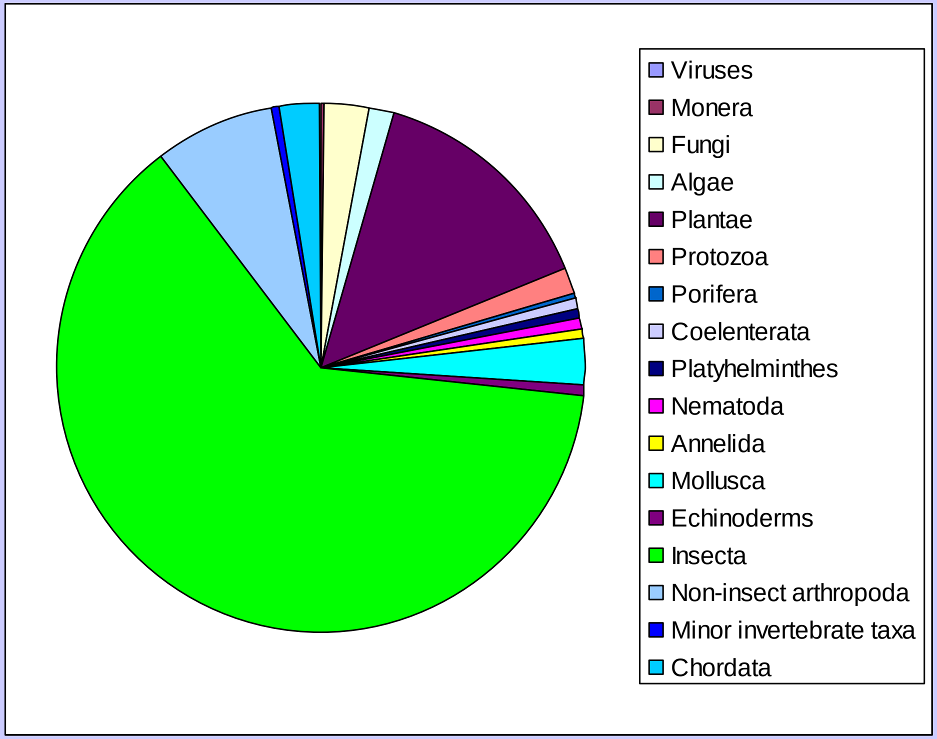
Positive species-energy relationship



Warm tropical regions are more diverse than cold regions

Same patterns along elevational gradients

Approximate number of described species



Insects alone 64%

With other arthropods 72%

Viruses	1,000
Monera	5,000
Fungi	47,000
Algae	27,000
Plantae	250,000
Protozoa	31,000
Porifera	5,000
Coelenterata	9,000
Platyhelminthes	12,000
Nematoda	12,000
Annelida	12,000
Mollusca	50,000
Echinoderms	6,000
Insecta	***1,112,000***
Non-insect arthropoda	125,000
Minor invertebrate taxa	10,000
Chordata	44,000
Total	1,758,000

Estimating Biodiversity (May 1989)

Numbers of species in relation to body size:

compensating for the neglect of small organisms by extrapolation

World insect species richness 15

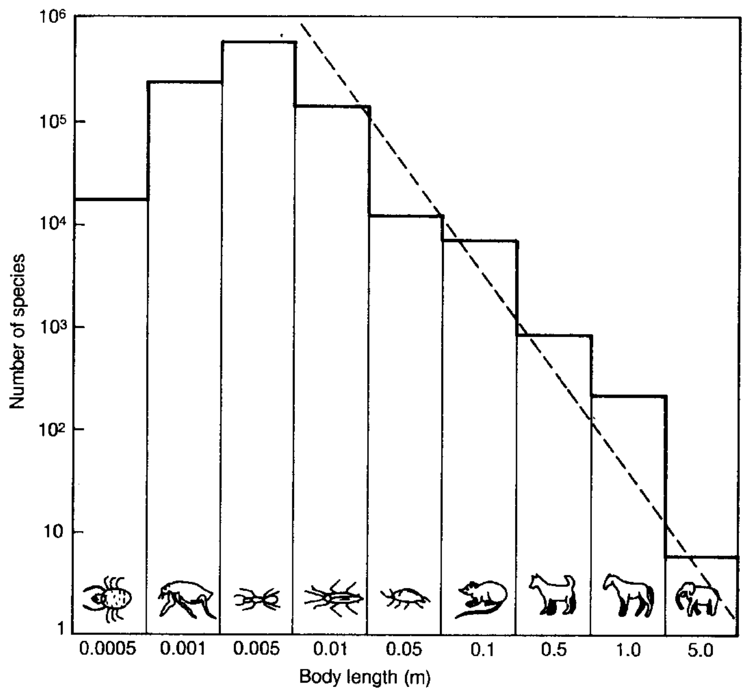
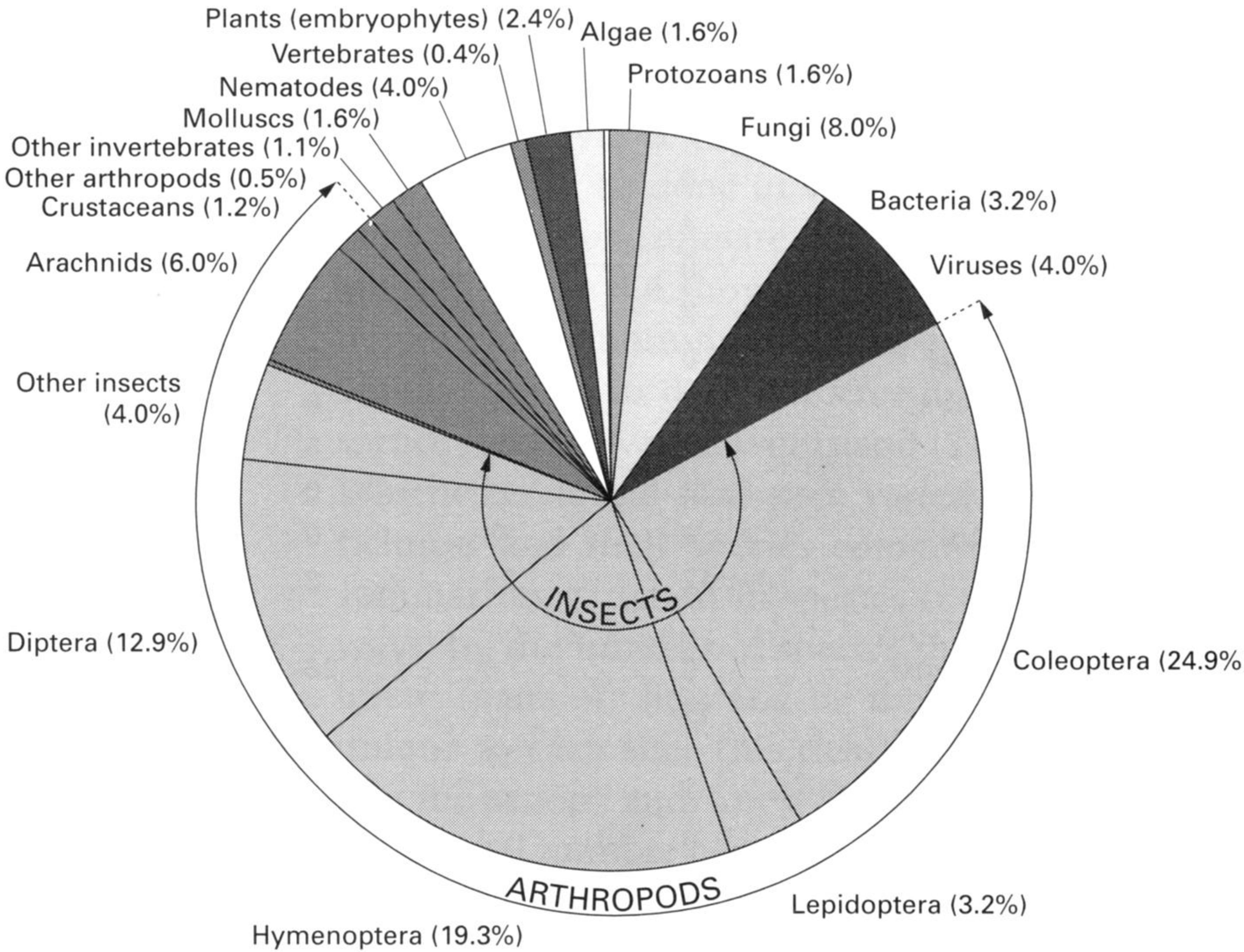


Figure 1.6 An approximation of the numbers of all described (the histogram) terrestrial animals categorized according to body length. The total number of species, undescribed as well as described, would change the shape of the left-hand side of the histogram, and increase the height of the bars. A much greater proportion of the larger animals have been described, with the right-hand side of the histogram having a characteristic slope. (From May, 1989.)

Number of species declines with body size according to a mathematical rule

By extrapolating to the left, conclude many species of small organisms have yet to be discovered and described


Plants (embryophytes) (2.4%)
Algae (1.6%)
Vertebrates (0.4%)
Protozoans (1.6%)
Nematodes (4.0%)
Molluscs (1.6%)
Fungi (8.0%)
Other invertebrates (1.1%)
Other arthropods (0.5%)
Crustaceans (1.2%)
Bacteria (3.2%)
Arachnids (6.0%)
Viruses (4.0%)
Other insects (4.0%)
INSECTS
Diptera (12.9%)
Coleoptera (24.9%)
ARTHROPODS
Lepidoptera (3.2%)
Hymenoptera (19.3%)

Sampling insect diversity in space and time

Populations or communities

A **population** is all the organisms that both belong to the same species and live in the same geographical area

A **community** is an assemblage of two or more populations of different species occupying the same geographical area

We need to define what a site is (e.g. a forest, a tree, a meadow, a river…)

Sampling insect communities

Unlike monitoring population of single species, we usually need sampling techniques to maximize the number of species collected

Detection probability should be equal between species

We need to standardize time and space to make diversity measures comparable between sites

Generic trapping systems or direct observation methods

Transect count (fixed time and space)

Walking and counting individuals and species

Insects living in canopies

Fogging forest canopy with insecticides

Tropical forests

Ground-dwelling insects

Pitfall traps

Insects in grassland swards

Sweep netting

Box quadrat

'Vortis' insect suction sampler

Flying insects

Interception traps

Pan traps (colour)

Light traps

Malaise traps

You never sample all the species!!!

Insects in rivers

Trap for catching insects **emerging from water**

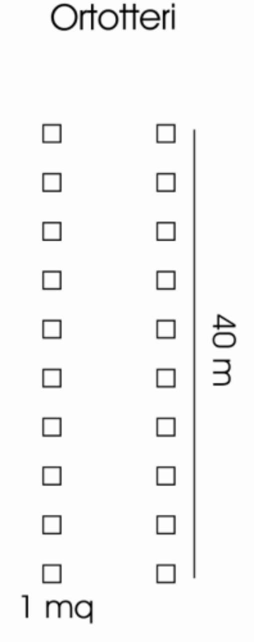
Netting of larvae and neanids

Sampling in space

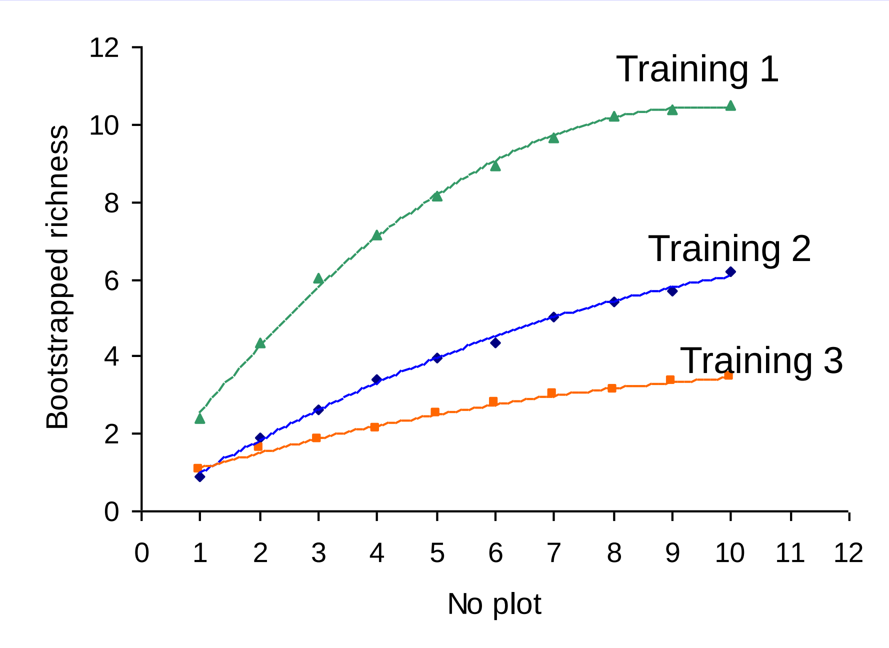
- Density of sampling points?

- Location of sampling points?

Enough points to sample the whole community



Orthopteran sampling in grassland



Sampling in time

Optimal timing of sampling depends upon the life history and behavior patterns of the insects and environmental conditions

Enough sampling effort to capture species with different phenology

Example:
Orthopterans: 2-3 times during summer
Butterflies: 3-5 times
Moths: every 2 weeks

Biodiversity data

Community data

	Site 1	Site 2	Site 3	…
Species A	1	0	0	
Species B	2	0	0	
Species C	7	0	0	
Species D	9	71	0	
Species E	23	49	143	
Species F	7	0	0	
Species G	15	0	0	
Species H	76	74	7	
…	1	1	42	

Presence/absence
or
abundance

How to measure diversity from this data?

Measuring diversity

Aim

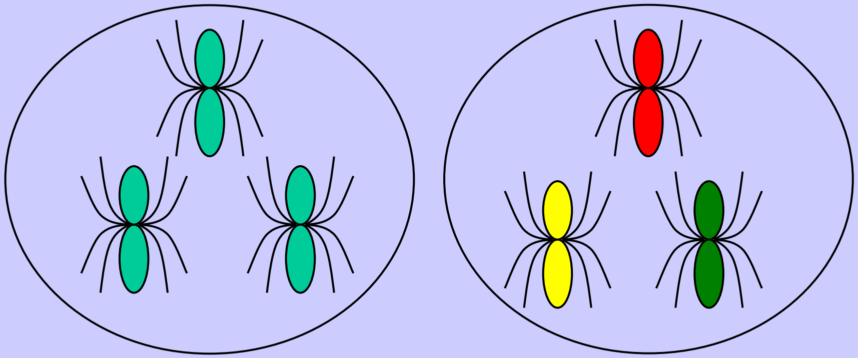
- Compare and describe diversity of different communities (sites)

- Definition of diversity by Magurran:

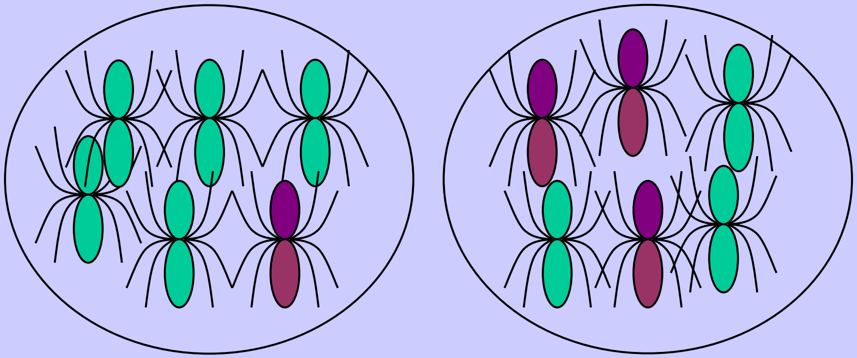
  ”the variety and abundance of species in a defined unit of study”

Some definitions:

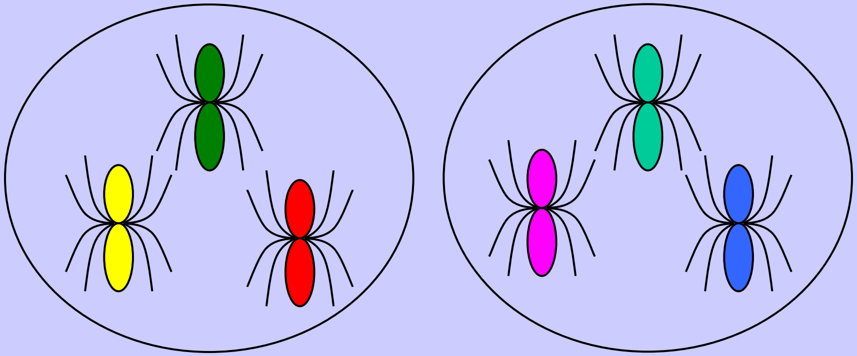
1. Species richness



2. Relative abundance



3. Species composition



Assumptions

- Species are equal
- Individuals are equal
- Species abundance has been recorded using appropriate and comparable units

Which system is more diverse?

System 1

Sp. A	Sp. B	Sp. C
10	10	10

System 2

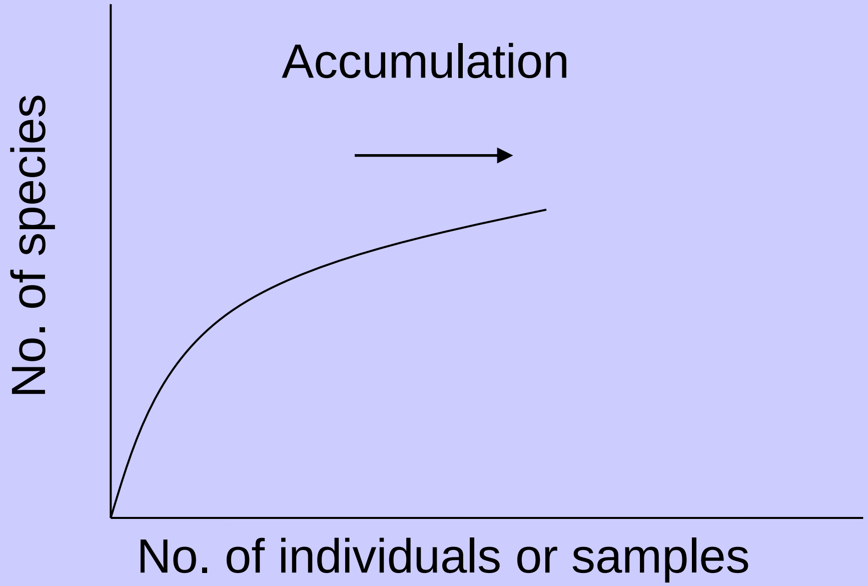
Sp. A	Sp. B	Sp. C
1	1	28

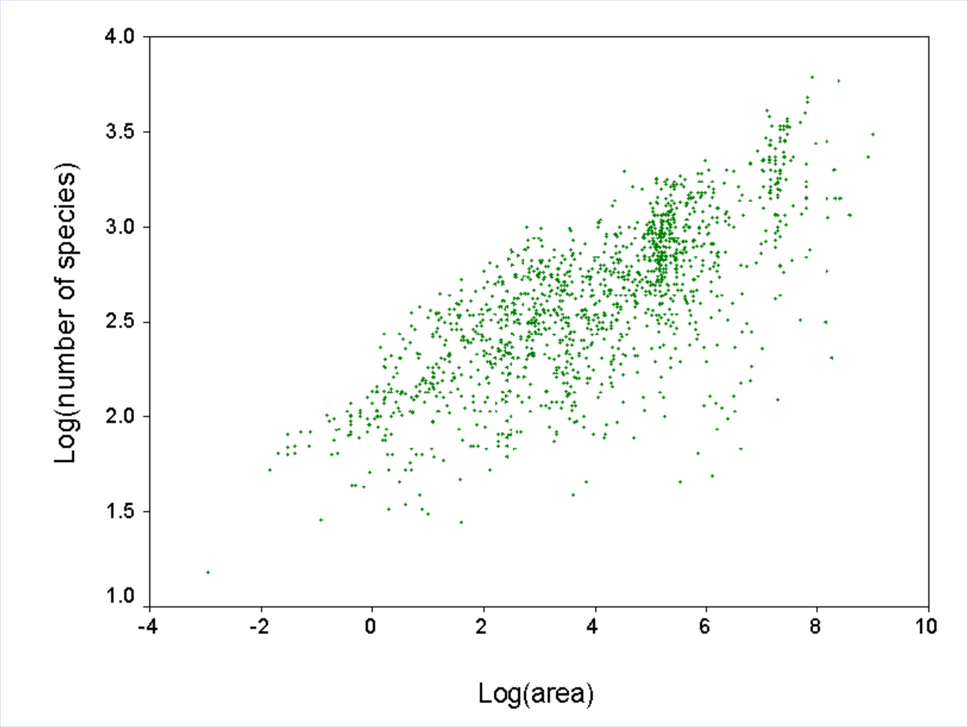
System 3

Sp. A	Sp. B	Sp. C	Sp. D	Sp. E	Sp. F
10	2	3	1	1	1

Species richness (α-diversity)

- Observed species richness
- Species accumulation





No information about abundance!

Relative abundance

- Evenness
- Rank abundance plots
- Shannon’s index (H)

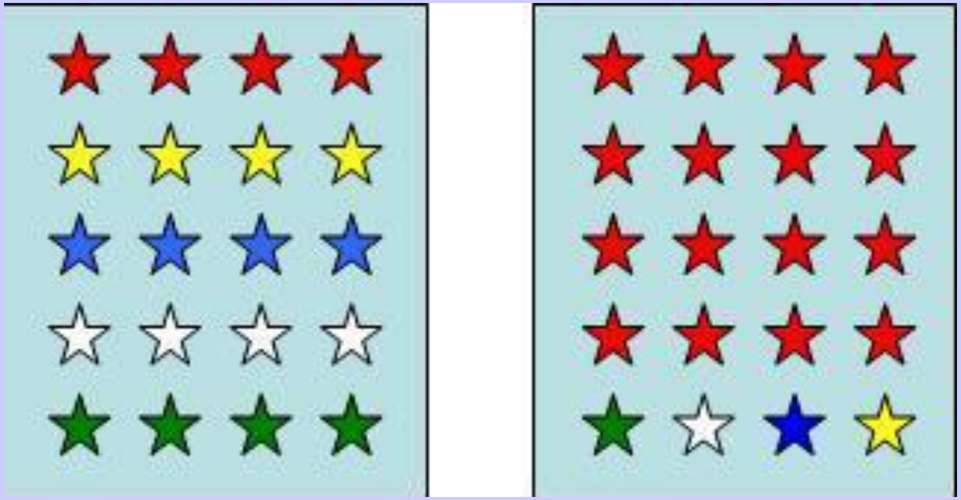
Evenness

- How abundant is each species in comparison with other species in the assemblage?
- Equally abundant species; high evenness
- Few dominant species in a community; low evenness
- High evenness imply high diversity
- Rarely are all species equally abundant
  - Some are better competitors, more fecund, more abundant in general than others

Shannon evenness (E)

$E = H / H_{max}$ ($H_{max} = \ln S$)

- E = 1 implies total evenness
- $E \approx 0$ implies dominance

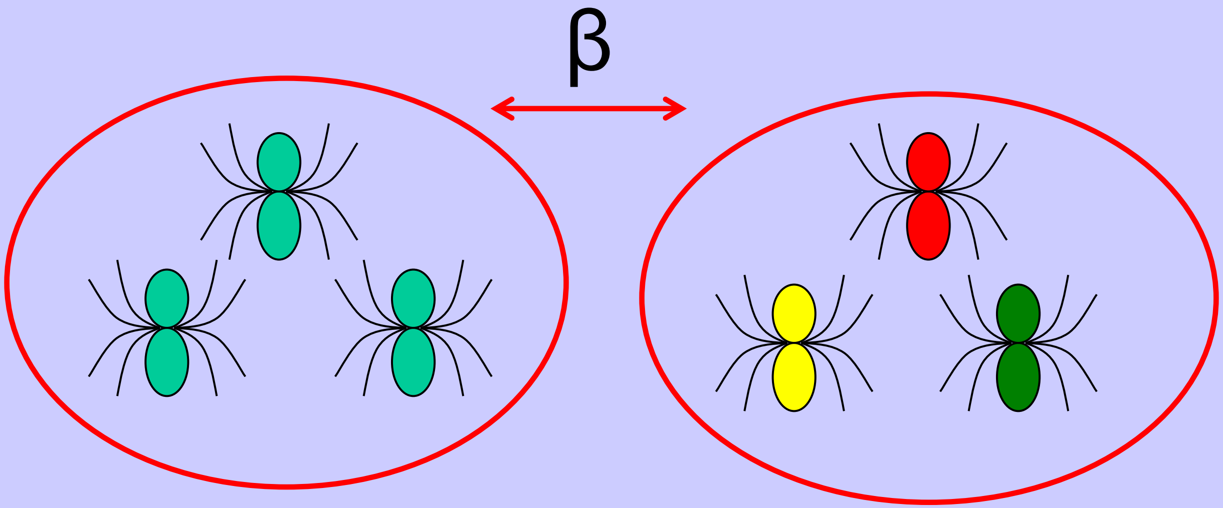


Large evenness Small evenness

Why evenness can be important for ecosystem functioning?

β-diversity

- β (beta) diversity is a measure biodiversity which works by comparing the species diversity **between** ecosystems or along environmental gradients.



β-diversity measures how different are the two communities

Why do we need insect diversity?

- Conservation of single species (populations)
- Conservation of communities
- Ecosystem services delivered by insects (pest control, pollination, nutrient cycling…)

Threats to biodiversity

1. Land-use change
2. Climate change
3. Invasions of exotic organisms

Conservation biology evaluates the impact of these pressures on biodiversity

OR

the effectiveness of mitigation measures

Conservation of single species (populations)

Extinctions of rare species: some species are conserved because rare and endangered

-Saproxylic beetles (Osmoderma eremita, Lucanus cervus…)

-Butterflies (Parnassius apollo, Lycaena phlaes)

-Dragonflies …

Conservation of single species (populations)

Osmoderma eremita

Umbrella species:

Species used as indicator of high quality habitat and large biodiversity

Conservation of communities

We usually try to conserve communities with large number of species and evenness

More biodiversity = better ecosystem functioning?

Ecosystem Services

- Primary productions
- maintenance of the gaseous composition of the atmosphere
- control of regional climates
- generation and maintenance of soils
- waste disposal
- nutrient cycling
- pollination
- pest control

Insects deliver various ecosystem services

Ecosystem services are benefits from a multitude of resources and processes that are supplied by natural ecosystems

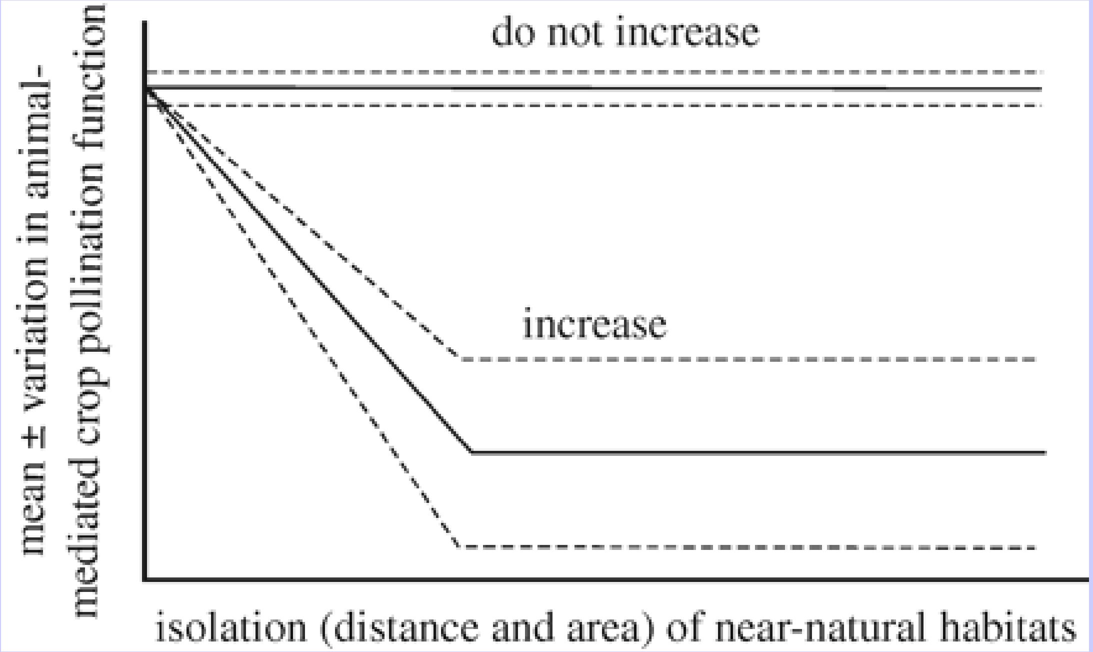
Pollination (bees and other insects pollinating crops and wild plants)

Pest control (predators and parasitoids of pests)

Nutrient cycling (e.g. dung beetles promote decomposition of dung into labile forms of nitrogen that can be assimilated, saproxylic in forests, collembola in soil…)

Pollination

The ecological and financial importance of natural pollination by insects to agricultural crops, improving their quality and quantity



The vicinity of a forest or wild grasslands with native pollinators near agricultural crops

Pest control

Many potential crop pests are controlled by natural enemies, including many spiders, parasitic wasps, flies, and lady bugs. These natural biological control agents save farmers billions of euros annually by protecting crops and reducing the need for chemical control

The cover of semi-natural habitats increase pest control