Biodiversity

What is Biodiversity?
‘The total variability of life on earth’

Knowledge of biodiversity, its loss, patterns of loss and effects of that loss will provide us with a greater understanding of future threats to our livelihoods.

This is a class about Global Environmental issues, and one of the best ways to understand human effects on the environment is to understand species loss and the destruction of biodiversity across the globe.
Issue 1: What level of biodiversity should be protected? population? genes? Species? Genera? What is the appropriate unit for conservation?
Types of Biodiversity:

• Genetic Diversity:
  • variation within populations of animals measured in variation between genes or DNA sequences

• Species diversity – ‘alpha’ biodiversity:
  • Diversity within a given place or area
  • ‘richness’ (number of species) versus ‘evenness’ (relative abundance, question of species dominance)

• Ecological diversity (community diversity, beta diversity’): how much does diversity vary across space?

• Landscape biodiversity – ‘gamma biodiversity’
  • biodiversity by increasing the complexity of niches across space
Where does diversity come from?

1. Evolutionary mechanisms produce biodiversity
   i. Variation
   ii. selection

Human evolution and diversity:

Views of evolution:

Fig 1: Tree (dated, but important – reflects a particular View of nature) versus bush (contemporary view)
History of biodiversity:
500 Million Years ago: the Cambrian Explosion

The original ‘diversity-through-interaction’ symbiosis:
Mitochondria as a symbiotic organism within the genome:

‘powerhouse of the cell’, Separate DNA, Permitted the rise of genetic complexity by allowing mitochondrial simplicity!
Where does Biodiversity come from?

2. Relations *between* species:
   - coevolutionary relationships: mutualism, symbiosis,
   - Allopathy – Separation of species
BIODIVERSITY LOSS: Question of our age: Are humans causing the sixth great (*anthropogenic*) mass extinction?

Are we on the verge of triggering a sixth worldwide collapse in species diversity?

![Graph showing the timeline of biodiversity and population index from 1970 to 2000.](image-url)
Examples of Biodiversity: 1) ancient (paleo) biodiversity

Biodiversity during the Phanerozoic

- All Genera
- Well-Resolved Genera
- Long-Term Trend
- The "Big 5" Mass Extinctions
- Other Extinction Events

Thousands of Genera vs. Millions of Years Ago

Genera: N, Pg, K, J, Tr, P, C, D, S, O, Cm
So what?
why should we care about biodiversity?
What has biodiversity done for me lately?

a. beauty of biodiversity, the ‘spice of life’, children develop better when exposed to greater diversity, both microbiologically and psychologically.

Diversity is beautiful!
b. Lifeforms provide important sources for medicines, fibers, materials: losing biodiversity means also a loss in access to important biologically active compounds

25% of medicines currently in use are plant-based
c. Biodiversity provides important environmental services such as carbon sequestration and water capture.
d. Biodiversity in number of crops increases total productivity by 10% by making better use of space: polycultures

- Genetic diversity in crop plants and plants increases the stability of both global and local food sources by protecting populations from diseases.

Banana variety risks wipeout from deadly fungus wilt

World’s most popular banana variety could disappear because of a fungus spreading across the globe, and FAO warns it could cost $47m to save the species.
E. A final concern for biodiversity: Collapse due to ecological dependency or species interrelations: how many species may be lost before the web of life begins to collapse?
Biodiversity moral: no reason not to expend necessary resources to protect existing diversity of life:
• there is plenty of food, fiber, and other items without expanding acreages under cultivation or stripping old-growth forests, or drilling new oil wells
• We can’t replace lost biodiversity
How do we measure biodiversity?

1. **Uncertainty** is a central problem

Numbers of species

- 1.75 million species scientifically identified.
- Estimated 30 million species on earth.
- Estimated 40,000 species rendered extinct annually.

### Biodiversity part 2

Analyzing biodiversity

<table>
<thead>
<tr>
<th>Described species</th>
<th>Number of estimated species</th>
<th>Working figure</th>
<th>Accuracy of working figure</th>
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<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
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<tr>
<td><strong>Viruses</strong></td>
<td>4</td>
<td>1000</td>
<td>50</td>
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<tr>
<td><strong>Bacteria</strong></td>
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<tr>
<td><strong>Fungi</strong></td>
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<tr>
<td><strong>Protozoa</strong></td>
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<td>200</td>
<td>60</td>
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<tr>
<td><strong>Algae</strong></td>
<td>40</td>
<td>1000</td>
<td>150</td>
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<tr>
<td><strong>Plants</strong></td>
<td>270</td>
<td>500</td>
<td>300</td>
</tr>
<tr>
<td><strong>Nematodes</strong></td>
<td>25</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td><strong>Arthropods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crustaceans</strong></td>
<td>40</td>
<td>200</td>
<td>75</td>
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<tr>
<td><strong>Arachnids</strong></td>
<td>75</td>
<td>1000</td>
<td>300</td>
</tr>
<tr>
<td><strong>Insects</strong></td>
<td>950</td>
<td>100000</td>
<td>2000</td>
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<tr>
<td><strong>Molluscs</strong></td>
<td>70</td>
<td>200</td>
<td>100</td>
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<td><strong>Chordates</strong></td>
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<td>55</td>
<td>50</td>
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<td>[Others]</td>
<td>115</td>
<td>800</td>
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<tr>
<td><strong>Totals</strong></td>
<td>1750</td>
<td>111655</td>
<td>3635</td>
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</tbody>
</table>
Issue 2: Niche complexity & spatial distribution within a patch, what biodiversity do we protect? How are they interrelated?
Issue 4: biodiversity hot spots:

what is a biodiversity ‘hot spot’?

how do types of biodiversity and processes of biodiversification create in hot spots?
Conservation 1: Balancing between human exploitation and habitat conservation

Satellite Photo: Spread of farming

Biodiversity part 3 Conservation
Conservation 2: separating background versus Proximate Causes:
Where to best attack biodiversity loss?
Issue 3: how to use our knowledge of biodiversity mechanisms to design functional conservation schemes?

Do we **mitigate?**

When to Design conservation areas and policies

Without addressing background causes?

Mesoamerican bio-corridor
Issue 4: The politics of biodiversity: What do we know? How do we know it? Convention on Biodiversity: the US is supposed to measure biodiversity, but has limited funds for the US Biological Survey and HAS NOT signed the
Review: 1. Biodiversity, what is it good for?

a. Genetic Diversity Within Species:
   protecting from disease and permitting adaptation

b. Species Diversity: stabilizing environments
   agroecological

Web of Life:
More connections = reduced likelihood of collapse

vulnerable

Versus

robust
Review: 2. Biodiversity, Where is it?

a. Problem of knowledge: measuring and surveying

Species numbers

<table>
<thead>
<tr>
<th>Species group</th>
<th>Discovered</th>
<th>To discover</th>
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<tbody>
<tr>
<td>Insects</td>
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<td>4800000</td>
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<tr>
<td>Plants</td>
<td>380000</td>
<td>750000</td>
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<td>Arachnids</td>
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<tr>
<td>Crustaceans</td>
<td>180000</td>
<td>200000</td>
</tr>
<tr>
<td>Other invertebrates</td>
<td>400000</td>
<td>400000</td>
</tr>
</tbody>
</table>

spatiality

b. Global Distribution

Biodiversity hot spots

Species number per ecoregion

- < 500
- 500-1000
- 1000-2000
- 2000-3000
- 3000-5000
- > 5000
“All that is solid, Melts into air...
all that is holy is profaned, and [we are]
at last compelled to face with sober senses
[our] real conditions of life”

— ??

FIN
i. species loss rates
   a. absolute loss
Issue 3: Distribution of populations and sampling problematic

- Nearly uniform
- Random
- Clumped
Biodiversity across landscapes:
The importance of landscape organization

Rainforest canopy

Biodiversity in spatial heterogeneity: Guinea-Bissau coastline
Global Background Economic Drivers, what about the future?

MAP: Biodiversity loss:
4 Scenarios for 2050.

i. Markets unfettered (growth)
ii. Policy-driven (military) security driven
iii. Sustainable economies

United Nations environmental program Study

Mean Species Abundance Index
- < 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100 %

Decrease in Mean Species Abundance Index
- 25 >
- 20 - 25
- 15 - 20
- 10 - 15
- < 10 %
Design: biological corridors, species migrations, conservation

- Butterflies
- Whales
- Birds
Which group has the greatest percentage of endangered members?

A. amphibians
B. birds
C. reptiles
D. mammals
Issue 2: Scale and Geography: evenness versus dominance:

oaks versus lilies.

Patch versus Matrix:

dimensions

geometry:
edge effects
Example: Distribution of Biodiversity in Africa:

Biodiversity Differs By Group (e.g., birds, Plants, Mammals) Each have Own biogeography

Figure 1: Distribution of biodiversity
f. Finally, let’s recollect again: Biodiversity isn’t just ‘out there’ but also ‘in here’!

A concern for any environmental course: How to avoid the creation of artificial distinctions between ‘the environment’ over there and ‘humans’ in here?

i. Biodiversity within: the human gut symbiosis of digestion and disease
   90% of cells in human body are non-human play critical role in digestion and disease prevention

ii. Food, air, allergens, environmental disease

iii. Over-medication through antibiotics can promote ecological imbalance in the human intestine

iv. CASE: Fecal transplants—recent research on fecal transplants shows that some diseases may be cured by changing intestinal bacteria: weight-loss, cancer, even autism? (I remain dubious on this one…)