

Biodiversity

Chapter 9

What is Biodiversity?

The variety of life in the world or in a particular habitat or ecosystem.

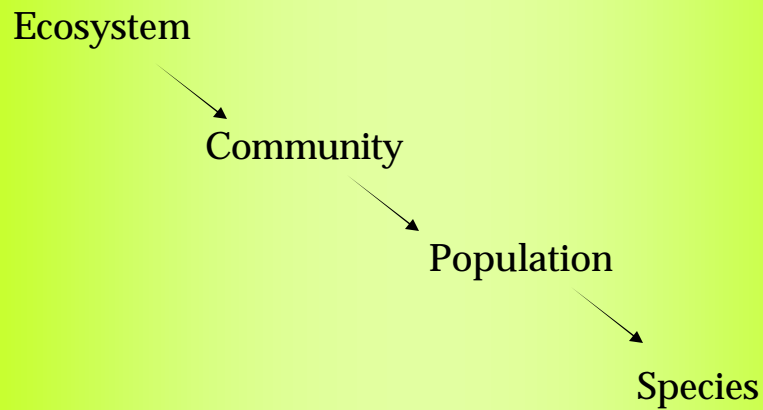
Why is Biodiversity Important?

- It is assumed the Earth's health can be measured by the number of species it supports

But:

- Does the planet's health **depend** on biodiversity?
- Is global biodiversity an indicator of the of the functional status of the earth system?

Structure of the Biosphere



Ecosystem

- Definition: “ An **ecosystem** is a biological community of interacting organisms and their physical environment that supports them.”

QuickTime™ and a
None decompressor
are needed to see this picture.

Community

- Definition: “A **community** is a group of interdependent organisms of different species growing or living together in a specified habitat.”

QuickTime™ and a
None decompressor
are needed to see this picture.

Population

- Definition: “A **population** is all the members of one species inhabiting a specified habitat.”

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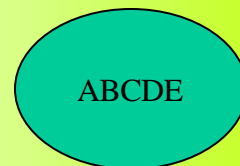
Species

- Definition: “ A **species** is one specific kind of organism (plant, animal, fungus, or microbe). It is the principle taxonomic unit.

QuickTime™ and a
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How do we measure biodiversity?

- The number of species present in a community is: **Species Richness**
- Simple to measure
 - Community I has 5 species
 - Community II has 7 species
- Community II is more diverse!
- But **Species Richness** is not the only way to describe diversity!



Problem of measuring only *Species Richness*:

- Example pg 184
 - Community I has 2 species
 - Community II has 2 species
- Species richness does not account for the rarity of a species in a community
 - To accurately measure biodiversity, one must also measure the relative abundance of the species:

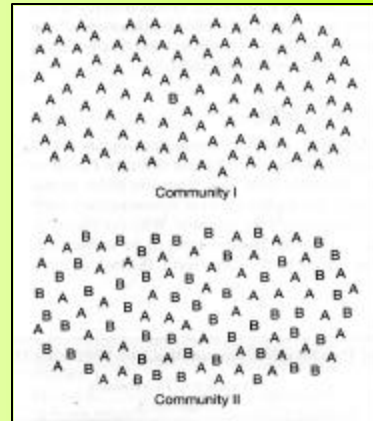


Figure 9-7

- *Species Evenness*

Species Richness vs. Species Evenness

Species Richness

Total number of species present in a community

Species Evenness

Relative number of species present in a community

Homogeneity vs. Heterogeneity

Is the community comprised of mainly one species or is a mix of several DIVERSE species?

How can both species richness and species evenness be measured?

- **Simpson's Diversity Index**

- Formula for calculating:

$$\text{Simpson's Diversity} = 1 - [(\text{proportion of species A})^2 + (\text{proportion of species B})^2 + \dots]$$

- Take home message:

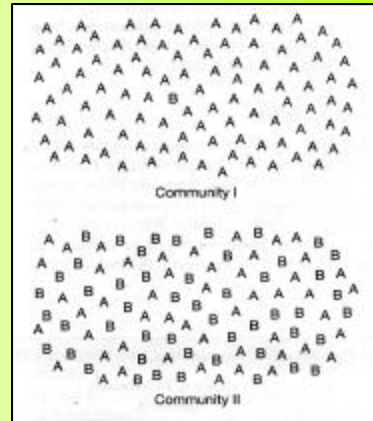
- When species numbers are small and uneven, Simpson values are close to zero
- When species numbers are large and even, Simpson values are close to 1

Fun Classroom Activity

Return to example from pg 184:

- Simpson's Diversity Index for the two communities:
- Community I = 0.02
- Community II = 0.50
- Community II is more diverse

Fig 9-7



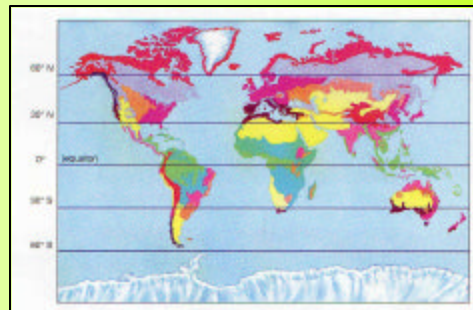
	Number of Individuals, Species A	Number of Individuals, Species B	Simpson's Diversity Index
Community I	90	1	0.02
Community II	50	50	0.50

Table 9-2

Biodiversity and Stability H1:

- Generally, diversity increases from the poles to the tropics:
- **Time Stability Hypothesis**
 - In tropics: seasonal variation small, long-term variation small:
ENVIRONMENTAL STABILITY = HIGH DIVERSITY

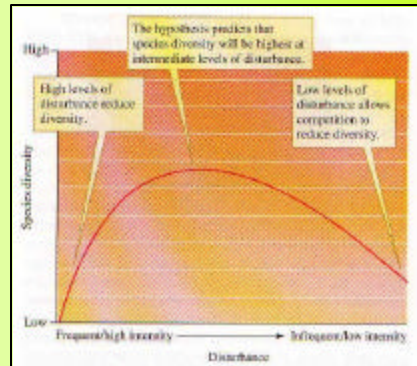
Low diversity ↓
High diversity ↑
Low diversity ↓



Biodiversity and Stability H2:

- **Intermediate Disturbance Hypothesis**

- “At intermediate levels of disturbance, there is sufficient time between disturbances for a wide variety of species to colonize, but not enough time for *competitive exclusion* (local extinction)”
- This hypothesis helps explain local *patchiness* of biodiversity within the general global trend

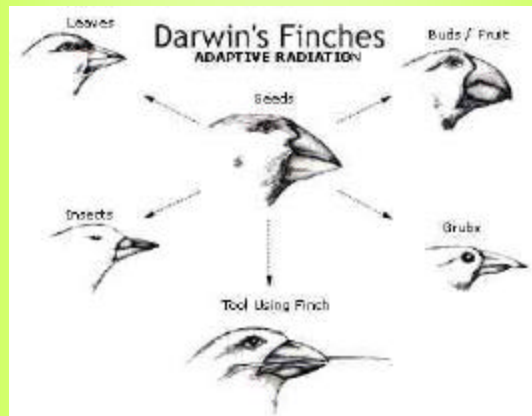


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Biodiversity through Earth History

- **Evolution**: the descent, with modification, of preexisting species
- **Adaptations**: characteristics that enhance an organism's survival and/or reproductive success
- **Natural Selection**: The process whereby organisms better adapted to their environment tend to survive and produce more offspring.
- **Extinction**: the loss of all individuals within a species

Adaptation Example



Biodiversity numbers are Dynamic:

- Species continually evolve...
- And species continually go extinct.

$$\text{Rate of change in number of species on earth} = \text{Origination rate} - \text{Extinction rate}$$

- Typically 10-25 species naturally originate per year, and 10-25 species per year naturally go extinct -- these are average rates of origination and extinction as a result of natural selection

Evolution & Extinction

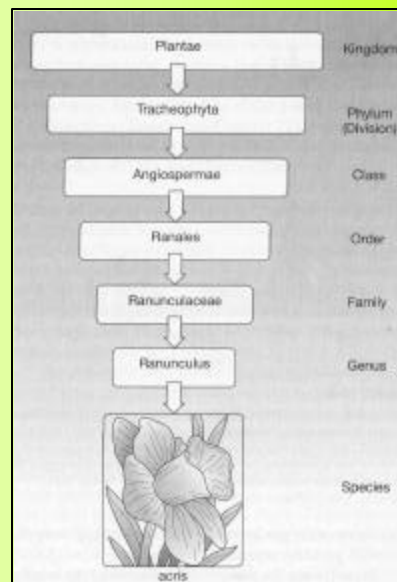
Certain intervals of earth's history exhibit much greater rates of species origination and extinction or **mass extinctions**

- Total number of species has increased over the history of life on earth
- How do we know?

Fossil Records

The Fossil Record of Biodiversity #1:

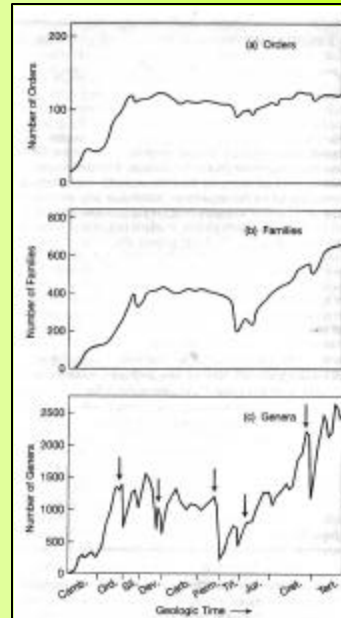
- Species are organized by a hierarchical grouping method called **taxonomy**
- The occurrence of a single specimen of a species confirms the existence of its higher taxonomic levels
- If a species is found in the fossil record then the upper levels of hierarchy are present



The Fossil Record of Biodiversity #2:

(Marine Organisms w/ shells or skeletons)

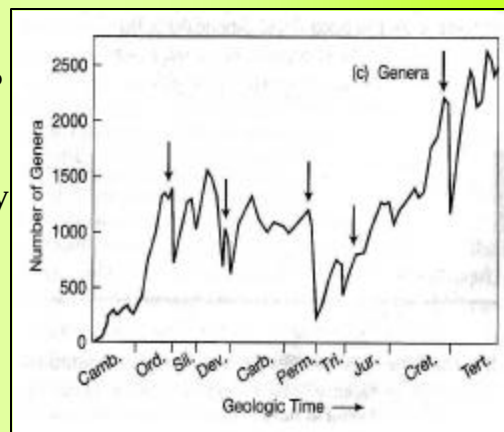
- Most orders evolved early - within 100 million years
- Important perturbations in the Family and Genera levels
- Arrows indicate *Mass Extinction* Events



544mya → 1.8mya

Mass Extinctions

- All appear sudden
- In each, more than 40% of genera went extinct
- Each followed by a long period of recovery
- Largest was the Permian: ~ 95% of all species on earth went extinct



544mya → 1.8mya

Cretaceous-Tertiary Mass Extinction

- Most recent event
- ~75% of all species went extinct
- Ended the dinosaur era

What caused the K/T event?

- Sea level change and climate change
- Volcanic eruptions
- *Meteorite impact* ←
- Alien invasion

Evidence for Meteorite Impact:

- *Global Iridium-Enriched Clay Layer*
 - Iridium is an element that is rare at the earth's surface but common in extraterrestrial rocks
 - Anomalously high levels of iridium are found in a clay layer deposited at the end of the Cretaceous
 - The enriched iridium layer has been found in more than 75 locations worldwide
- *Chixulub crater*
 - Subsurface impact crater found on the coast of the Yucatan Peninsula
 - The age of the crater is 65 million years old -- same as the end of the Cretaceous
 - Crater is ~200km across

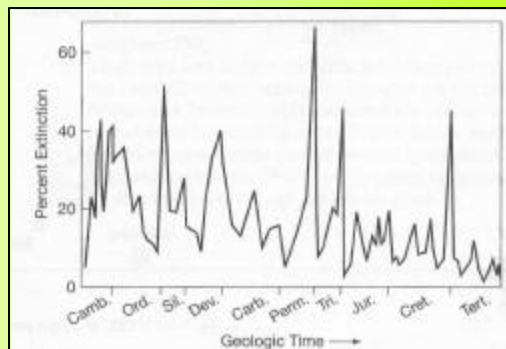


Environmental consequences of the K/T boundary meteor impact:

- Impact
 - Huge Explosion!
 - Tsunamis
 - Massive wildfires
- Short-term cooling (1-10 years)
 - Dust and debris ejected to atmosphere blocks sun
 - Soot released from fires also blocks sun
 - Sulfur containing rocks at impact site released huge amounts of sulfuric acid aerosols to atmosphere, blocks sun
- Long-term warming (10 -? Years)
 - Limestone at impact site also releases carbon dioxide, increases greenhouse effect

Other Biodiversity Cycles

- Detailed analysis of pollen records indicate a recurring 26 million year pattern in the global rate of extinction
- Why? *Unknown*



Human Threats To Biodiversity

- Definition of an *ecosystem*:
 - A community of plants, animals, fungi, microbes and the physical environment that supports it: interdependency
- Possible link between diversity, community stability and environmental stability
- Perturbation in one part of the system can have impacts throughout the entire system

Food Web

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Trophic: of or relating to feeding and nutrition

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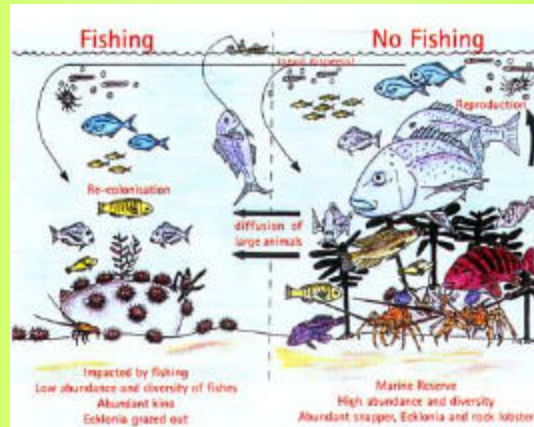
Trophic level: hierarchical level in food chain

2

1

Ecosystems Continued:

- Trophic cascade
 - any impact to one part of the ecosystem has cascading effects throughout the whole system



Species Roles

- *Keystone species*

a species whose very presence contributes to a diversity of life and whose extinction would consequently lead to the extinction of other forms of life.

- *Indicator species*

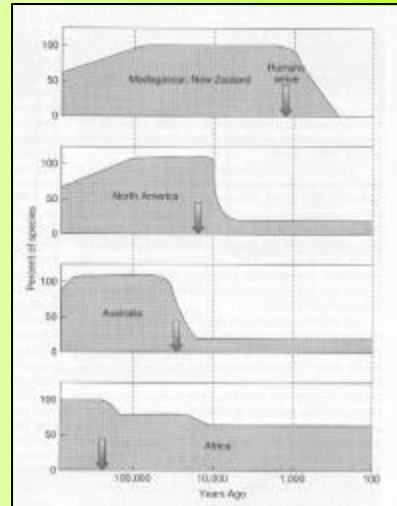
are “at risk” species whose existence requires a stable and functioning ecosystem, they offer a signal of the biological condition of an ecosystem

Interactions among some species may be more important than others

The Modern Extinction

The Beginnings

- The arrival of humans to new continents interestingly correlates with the extinction of large percentages of large mammals and flightless birds -- *the overhunting hypothesis*
- Climate change likely also played an important role



The Modern Extinction

The Present Day

Habitat Loss -**Tropical deforestation:**
greatest rate of species lost found today

Impacts:

- Original forest may never return
- Loss of organic matter
- Number of species related to area of forest cover
- Average loss: 10 species/ year vs. Estimated loss: 27,000 species/year

The Modern Extinction

The Present Day

Habitat loss- **Hot Spots:**

Areas where habitat has been reduced to less than 10% of its original cover or is expected to be reduced, outside of tropical forests



Neglects
the
OCEANS!

QuickTime™ and a
None decompressor
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Why should we care about biodiversity?

- Ecologists propose that species have value:

- **Instrumental value:**

The degree to which a species benefits another species some way

- Humans are normally the other species
- The value is usually economic: agriculture, medicine, recreation, commerce, science, etc.

- **Intrinsic value**

Value for its own sake, regardless of the benefit to other species

The Loss of Biodiversity

The Rivet Hypothesis:

- Paul and Anne Erlich (Stanford University)
- Like rivets on a plane, each species has a small but important role to play in the overall functioning of the ecosystem
- If you remove the rivets one by one, sooner or later the stress on the system becomes so great that it fails: the plane falls from the sky and crashes....everything on the plane is destroyed

Including US!!!!

The Loss of Biodiversity

The Redundancy Hypothesis:

- Brian Walker, ACIRO
- Most species are superfluous and the functionality of the system is maintained by only a few keystone species
- Loss of biodiversity is not a problem as long as you do not lose the keystone species

Original Questions

- Does the planet's health **depend** on biodiversity?
 - Yes they do, but it is unclear how much biodiversity is required to maintain the functionality of the biosphere expected by humans
- Is global biodiversity an indicator of the functional status of the earth system?
 - Possibly. We should pay attention to biodiversity because biodiversity of the planet is often related to environmental stability and health.

The Take-Home Message:

- Evidence demonstrates that life on Earth is resilient and has recovered from global-scale perturbations in the past
- But, whenever large extinction events have happened, the species that were at the top of the food chain before the event were no longer there when it was all over....US!!!