

Chapter 5 & 11
Biodiversity


Conservation of Biodiversity Video

Evolution & Natural Selection

- **Biological evolution** = genetic change in populations of organisms across generations
- **Natural Selection** = the process by which traits that enhance survival and reproduction are passed on more frequently to future generations than those that do not

↓ Causes

- **Biological Diversity (biodiversity)** = An area's sum total of all organisms
 - The diversity of species
 - Their genes
 - Their populations
 - Their communities



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Natural selection

- In 1858, **Darwin and Wallace** both proposed natural selection as the mechanism of evolution
 - Organisms face a constant struggle to survive and reproduce
 - Organisms tend to produce more offspring than can survive
 - Individuals of a species vary in their characteristics due to genes and the environment
 - Some individuals are better suited to their environment and will survive and pass their genes on in their offspring

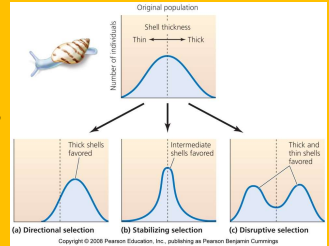
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Natural selection acts on genetic variation

- **Directional selection** = drives a feature in one direction (one extreme)
- **Stabilizing selection** = produces intermediate traits, preserving the status quo
- **Disruptive selection** = traits diverge in two or more directions (two extremes)

Leads to two new species (speciation)

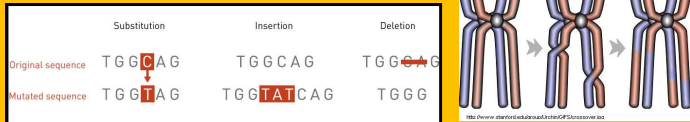
If the environment changes, a trait may no longer be adaptive



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Genetic variation

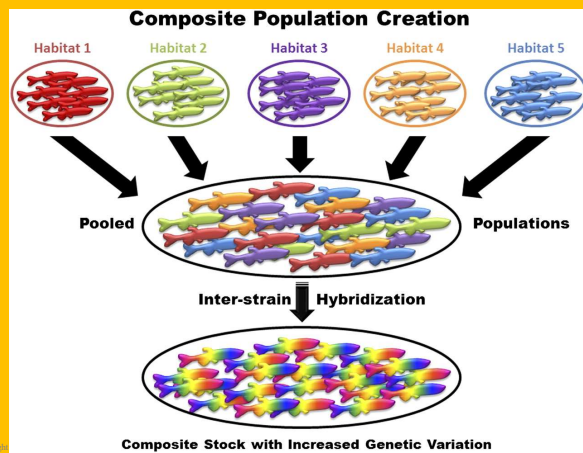
- **Adaptive Trait (Adaptation)** = a trait that promotes reproductive success
- **Mutations** = accidental changes in DNA that may be passed on to the next generation
 - Non-lethal mutations provide the genetic variation on which natural selection acts
- **Recombination:** Sexual reproduction also leads to genetic variation through crossing over.



Genetic diversity

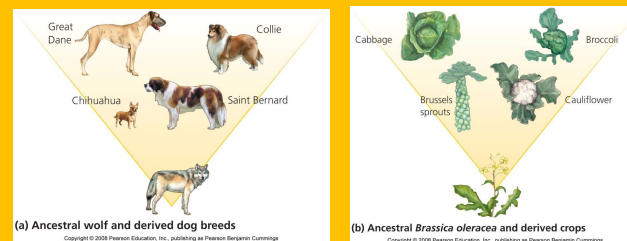
- Allows for adaptation to local conditions
- Populations with higher genetic diversity have a better chance at coping with environmental change
- Populations with low genetic diversity are vulnerable
 - To environmental change
 - Disease
 - **Inbreeding depression** = genetically similar parents mate and produce inferior offspring

Genetic Diversity



Artificial selection

- **Artificial Selection** = the process of selection conducted under **HUMAN** direction
 - For example, artificial selection has led to the great variety of dog breeds



Speciation

- Speciation: process of generating new species
 - A single species can generate multiple species

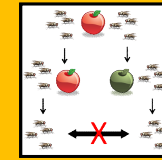
- **Allopatric speciation** = species formation due to physical separation of populations
 - Can be separated by glaciers, rivers, mountains
 - The main mode of species creation



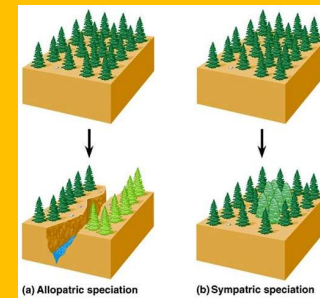
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Speciation

- **Sympatric speciation** = species form from populations that become reproductively isolated within the same area



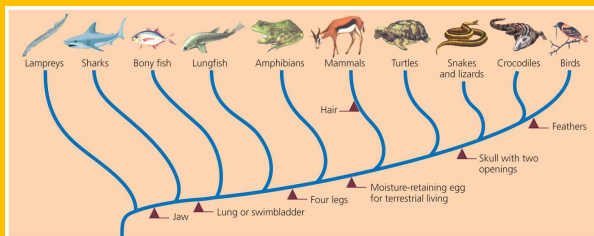
- No geographic barrier
- Population in same area
- Feed in different areas, mate in different seasons
- Hybridization between two species
- Mutations



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Speciation

- Speciation generates complex patterns of diversity above the species level
- **Phylogenetic trees (Cladograms)** = Represents the history of species divergence
 - Scientists can trace when certain traits evolved
 - Show relationships between species



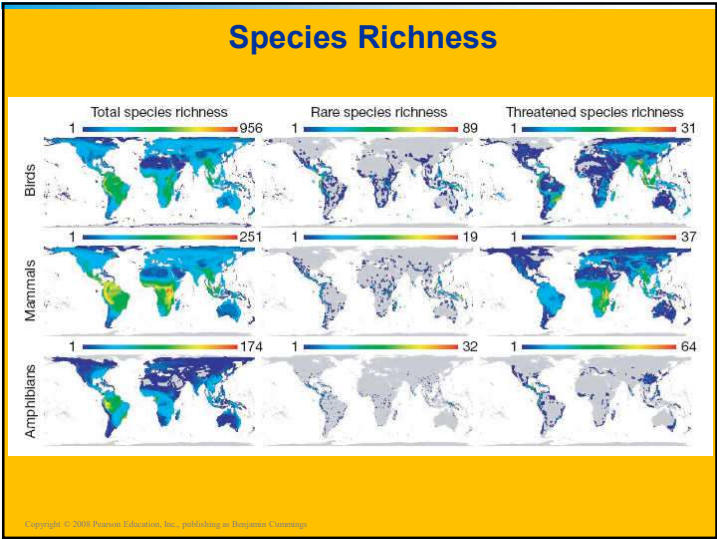
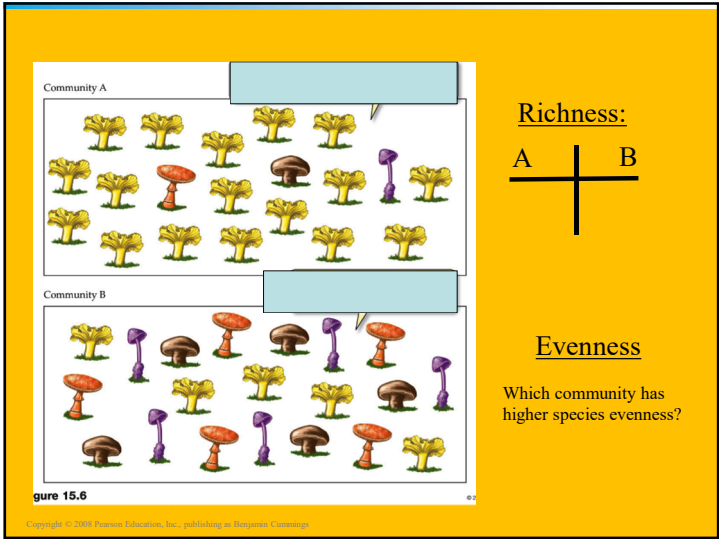
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Species diversity

- **Species Diversity** = the number or variety of species in the world or in a particular region
 - **Richness** = the number of species
 - **Evenness** or **relative abundance** = extent to which numbers of individuals of different species are equal or skewed
 - Speciation generates new species and adds to species richness
 - Extinction reduces species richness
- *Which is a better measurement of biodiversity?

[Video](#)

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Ecosystem diversity

- **Ecosystem diversity** = the number and variety of ecosystems
- Also encompasses differing communities and habitats
- Rapid vegetation change and varying landscapes within an ecosystem promote higher levels of biodiversity

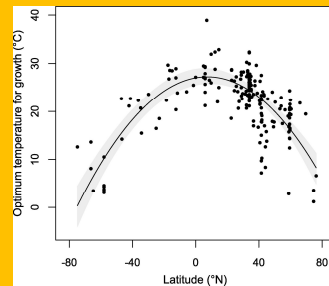
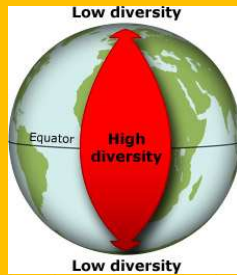
Aquatic Ecosystems

Measuring biodiversity is not easy

- Out of the estimated 3 - 100 million species on Earth, only 1.7 - 2 million species have been successfully catalogued
- Very difficult to identify species
 - Many remote spots on Earth remain unexplored
 - Small organisms are easily overlooked
 - Many species look identical until thoroughly examined

Biodiversity is unevenly distributed






- Living things are distributed unevenly across Earth
- **Latitudinal gradient** = species richness increases towards the equator



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Ecology

- Ecology and evolution are tightly intertwined
- **Biosphere** = the total living things on Earth and the areas they inhabit
- **Ecosystem** = communities and the nonliving material and forces they interact with
- **Community** = interacting species that live in the same area

Levels of Ecological Organization		
	Biosphere	The sum total of living things on Earth and the areas they inhabit
	Ecosystem	A functional system consisting of a community, its nonliving environment, and the interactions between them
	Community	A set of populations of different species living together in a particular area
	Population	A group of individuals of a species that live in a particular area
	Organism	An individual living thing

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Ecology-Habitat

- **Habitat use** = each organism thrives in certain habitats, but not in others
- **Habitat selection** = the process by which organisms actively select habitats in which to live
- Availability and quality of habitat are crucial to an organism's well-being
- Human developments conflict with this process



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Ecology: Niche

- **Niche** = an organism's use of resources and its functional role in a community
 - Habitat use, food selection, role in energy and nutrient flow
 - Interactions with other individuals
- **Specialists** = species with narrow niches and very specific requirements
 - Extremely good at what they do, but vulnerable to change
- **Generalists** = species with broad niches that can use a wide array of habitats and resources
 - Able to live in many different places

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Population characteristics

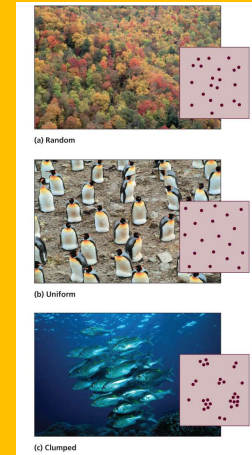
- **Population size** = the number of individual organisms present at a given time
 - Numbers can increase, decrease, cycle or remain the same
- **Population density** = the number of individuals within a population per unit area
 - High densities make it easier to find mates, but increase competition, and vulnerability to predation
 - Low densities make it harder to find mates, but individuals enjoy plentiful resources and space



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Population characteristics

- **Population distribution (dispersion)** = spatial arrangement of organisms within an area
 - *Random* – haphazardly located individuals, with no pattern
 - *Uniform* – individuals are evenly spaced due to territoriality
 - *Clumped* – arranged according to availability of resources
 - Most common in nature

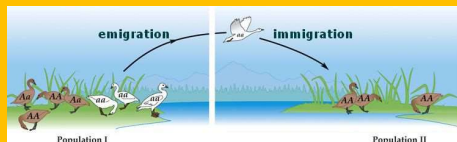


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Population Change

Four Factors:

1. **Natality** = births within the population
2. **Mortality** = deaths within the population
3. **Immigration** = moving into a new area (population)
4. **Emigration** = leaving (exiting) of individuals from the population

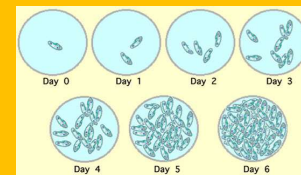
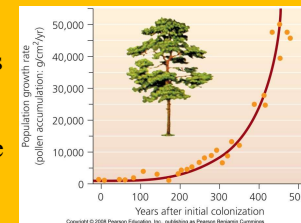


- Growth rate formula =
(Crude birth rate + immigration rate) - (Crude death rate + emigration rate) = Growth rate

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Exponential Population Growth

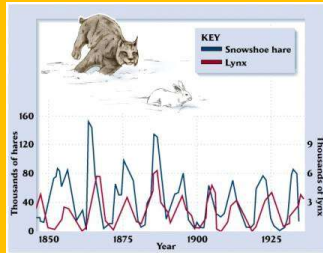
- **Exponential population growth** caused by steady rates
 - J-shaped curve graph
- Exponential growth cannot be sustained indefinitely
 - It occurs in nature with a small population and ideal conditions
 - Resources are limited



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Limiting Factors

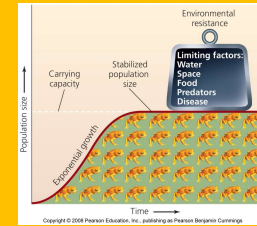
- **Limiting factors** = physical, chemical and biological characteristics that restrain population growth
 - Water, space, food, predators, and disease
- **Environmental resistance** = All limiting factors taken together



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Carrying capacity

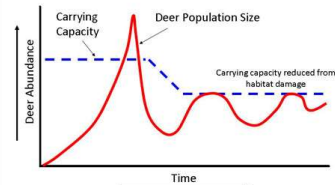
- **Carrying capacity** = the maximum population size of a species that its environment can sustain
 - Carrying capacity change



Logistic Population Growth

- An S-shaped curve
- Limiting factors slow and stop exponential growth

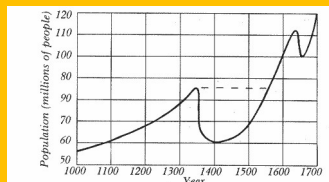
Unrestricted deer population growth may diminish the habitat's carrying capacity



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Population density affects limiting factors

- **Density-dependent factors** = limiting factors whose influence is affected by population density
 - Predation
 - Competition
 - Diseases
- **Density-independent factors** = limiting factors whose influence is not affected by population density
 - Natural Disasters
 - Unusual weather
 - Human Impact



Recovery of European population following the plagues of 1347 was only two hundred years—an insignificant moment in the evolutionary time scale. (After Langer 1963; author)



Reproductive Strategies

- **Biotic potential** = the ability of an organism to produce offspring
- **K-selected species** = animals with long gestation periods and few offspring
 - Low fecundity
 - Long generation time
 - Stable environment
 - High parental care
 - Large body size
- **r-selected species** = animals which reproduce quickly
 - High fecundity
 - Short generation time
 - Little parental care
 - Small body size
 - Asexual reproduction

• Mammals



• Insects
 • Plants



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K-selected vs. r-selected species

TABLE 5.4 Traits of r-selected and K-selected species

r-selected species	K-selected species
Small size	Large size
Fast development	Slow development
Short-lived	Long-lived
Reproduction early in life	Reproduction later in life
Many small offspring	Few large offspring
Fast population growth rate	Slow population growth rate
No parental care	Parental care
Weak competitive ability	Strong competitive ability
Variable population size, often well below carrying capacity	Constant population size, close to carrying capacity
Variable and unpredictable mortality	More constant and mortality predictable

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Extinction

- **Extinction** = the disappearance of a species from Earth

- Happens naturally and by human



- Occurs when a species cannot adapt quickly enough to a changing environment
- Speciation and extinction affect species numbers
- Extinction is irreversible: once a species is lost, it is lost forever
- Many other factors also cause extinction
 - Severe weather
 - New species
 - Specialized species

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Extirpation

- **Extirpation** = the disappearance of a particular population from a given area, but not the entire species globally (can lead to extinction)



Extinction

- Extinction occurs when the environment changes too rapidly for natural selection to keep up
 - Some species are more vulnerable than others.
- **Endemic species** = An organism found in a single geographic area and no where else.
 - Very susceptible to extinction
 - Usually have small populations



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Mass extinctions

- **Background extinction rate** = extinction usually occurs one species at a time
- **Mass extinction events** = 5 events in Earth's history that killed off massive numbers of species at once
- **Sixth mass extinction**- caused by humans (Currently happening)

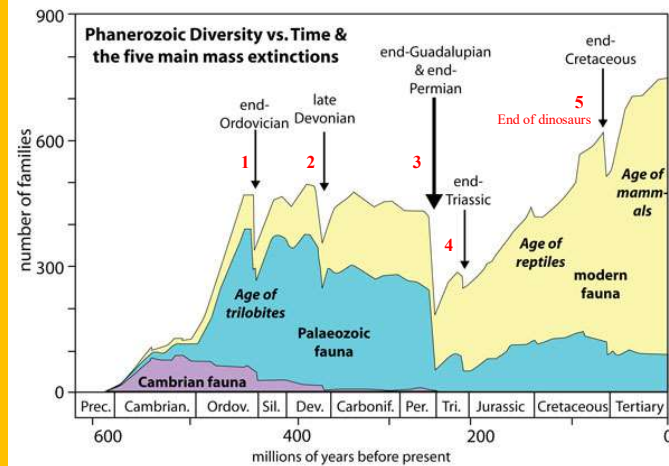
- Resource depletion
- Population growth
- Development

Mass Extinctions		
Geological Period	Mass Extinction Name	Time (millions of years ago)
Ordovician-Silurian	end-Ordovician O-S	450-440
Late Devonian	end-Devonian	375-360
Permian-Triassic	end-Permian	251
Triassic-Jurassic	end-Triassic	205
Cretaceous-Paleogene	end-Cretaceous K-Pg (K-T)	65.5

- Paleontologists estimate 99% of all species that ever lived are now extinct
- The current global extinction rate is 100 to 1,000 times greater than the background rate

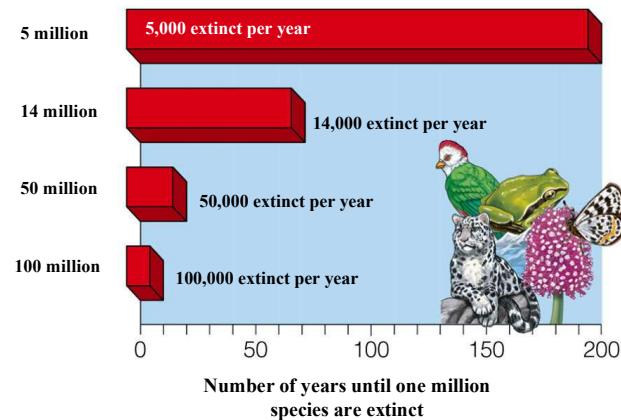
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5 Mass Extinction



Number of species existing

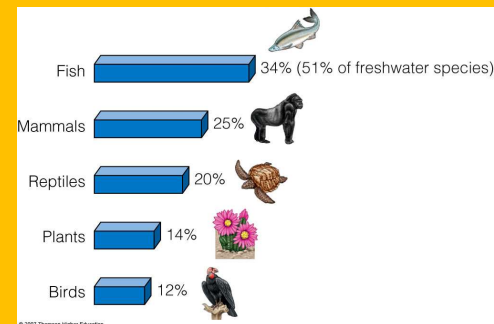
Effects of a 0.1% extinction rate



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Fig. 11-6, p. 226

SPECIES EXTINCTION



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- Percentage of various species types threatened with premature extinction from human activities.

Figure 11-5

Current extinction rates are higher than normal



- **The Red List** = an updated list of species facing high risks of extinctions; est. by the World Conservation Union

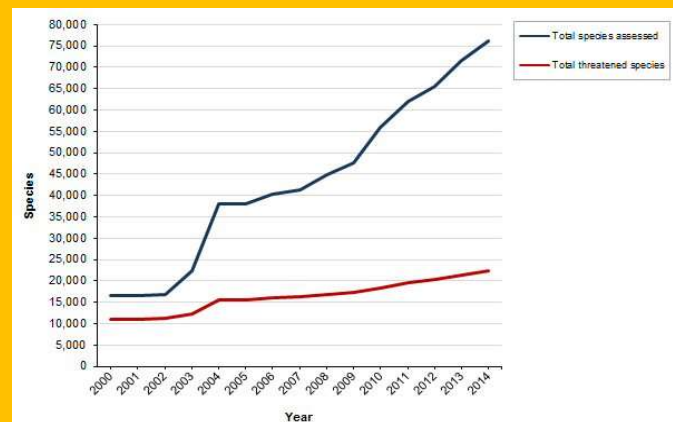
- 23% of mammal species
- 12% of bird species
- 31 - 86% of all other species
- In the U.S., in the last 500 years, 236 animal and 17 plant species are confirmed extinct
- Actual numbers are undoubtedly higher



Pygmy Rabbit

[Red List Video](#)

Red List



HIPPCO

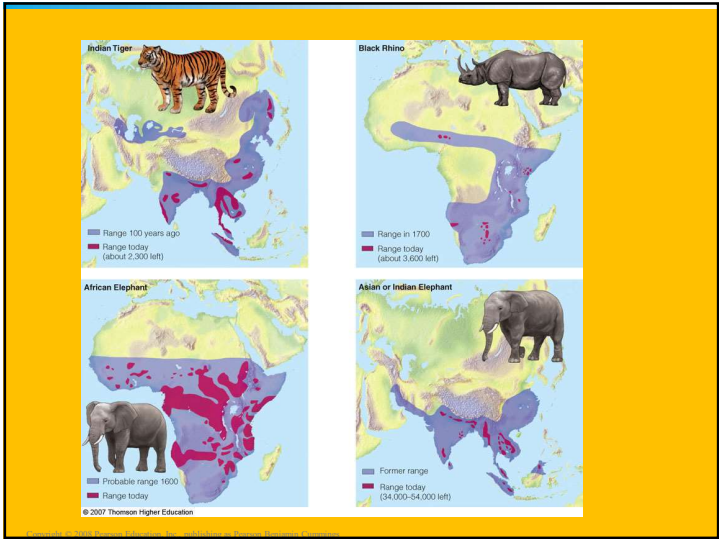
- Five primary causes of biodiversity loss are:
 - **H**abitat alteration
 - **I**nvasive species
 - **P**opulation Dynamics and Resources
 - **P**ollution
 - **C**limate change
 - **O**verharvesting

HIPPCO: The acronym was created by Edward O. Wilson.

Habitat alteration causes biodiversity loss

- The greatest cause of biodiversity loss
 - **Farming** simplifies communities
 - **Grazing** modifies the grassland structure and species composition
 - **Clearing forests** removes resources organisms need
 - **Hydroelectric dams** turn rivers into reservoirs upstream
 - **Urbanization** and suburban sprawl reduce natural communities







Invasive species cause biodiversity loss

- Introduction of non-native species to new environments
 - Accidental: zebra mussels
 - Deliberate: food crops
- Island species are especially vulnerable
- Invaders have no natural predators, competitors, or parasites
- Cost billions of dollars in economic damage

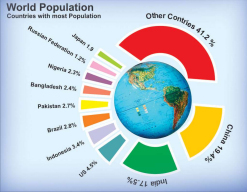
[Cane Toad Video](#)


Ontario Ministry of Natural Resources

Population causes biodiversity loss

- Population plays a very big part in the world.
- Humans have a population of 7.2 billions around the world.
- Resources are necessary to maintain human population.
- Small number population of a species die off faster.



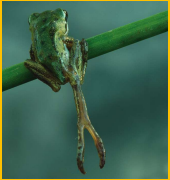


Country	Percentage
Other Countries	41.2%
China	19.8%
USA	4.8%
Indonesia	4.4%
Brazil	3.8%
Pakistan	2.7%
Bangladesh	2.5%
Russian Federation	2.4%
Japan	1.8%



Pollution causes biodiversity loss

- Human activity can pollute the water, air, soil on both the local and global level
 - Water: sewage, fertilizers, chemical and oil
 - Soil-pesticides, herbicides
 - Air: smoke and gases that lead to climate change

DDT

PSC Photo/Art Korber

Climate change causes biodiversity loss

- Climate change caused by global warming could lead to the extinction of up to 25% of all plants and animals by year 2100.
- Many extinction will occur in the upper latitudes (polar bears)
 - Modifies global weather patterns and more extreme weather events
 - Forces organisms to shift their geographic ranges



Overharvesting causes biodiversity loss

- Over-exploitation
- Vulnerable species are large, few in number, long-lived, and have few young (K-selected species)
- Increased poaching



Ecosystem Services

- Helps maintain ecosystem services
 - Ex: Photosynthesis
- Enhances food security
- Provides medicines
- Generates economic benefits through tourism and recreation



People value and seek out nature

Biophilia = connections that humans subconsciously seek with life

- Our love for parks and wildlife
- Having pets
- Liking of real estate with views of natural lands



Nature deficit disorder = alienation from the natural environment
 May be behind the emotional and physical problems of the young

Do we have ethical obligations toward other species?

Conservation Biology

- **Conservation biology** = devoted to understanding the factors that influence the loss, protection, and restoration of biodiversity



[Northern Spotted Owl Video](#)

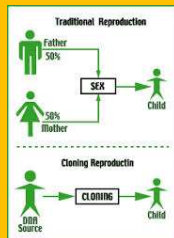
Protecting biodiversity

- **Captive breeding** - individuals are bred and raised with the intent of reintroducing them into the wild
 - Zoos and botanical gardens
- Some reintroductions are controversial
 - Ranchers opposed the reintroduction of wolves to Yellowstone National Park
 - Some habitat is so fragmented, a species cannot survive



Protecting biodiversity

- **Cloning** - a technique to create more individuals and save species from extinction
 - Most biologists agree that these efforts are not adequate to recreate the lost biodiversity
- Ample habitat and protection in the wild are needed to save species



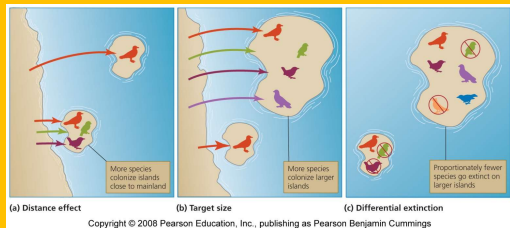
Umbrella species

- Conservation biologists use particular species as tools to conserve communities and ecosystems
 - Protecting the habitat of these **umbrella species** helps protect less-charismatic animals that would not have generated public interest
- **Flagship species** - large and charismatic species used as spearheads for biodiversity conservation



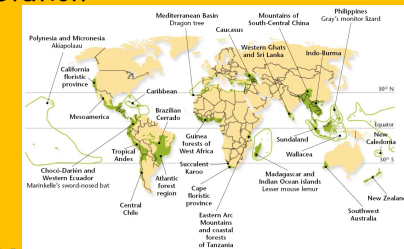
Island biogeography

- **Equilibrium theory of island biogeography** = explains how species come to be distributed among oceanic islands
- Fewer species colonize an island far from the mainland
- Large islands have higher immigration rates
- Large islands have lower extinction rates



Biodiversity Hotspots

- **biodiversity hotspots:** most threatened areas of high species diversity (tropical rainforests, coastal areas, and islands)
- Have high numbers of **endemic** species & are threatened by humans
- Most have lost at least 70 percent of their original natural vegetation



Federal law

Endangered Species Act: 1973

Major Provisions of the Endangered Species Act

- The U.S. Fish and Wildlife Service (USFWS) must compile a list of all endangered and threatened species.
- Endangered and threatened animal species may not be caught or killed. Endangered and threatened plants on federal land may not be uprooted. No part of an endangered and threatened species may be sold or traded.
- The federal government may not carry out any project that jeopardizes endangered species.
- The U.S. Fish and Wildlife Service must prepare a species recovery plan for each endangered and threatened species.

Federal Law: Lacey Act

- It is unlawful to import, export, sell, acquire, or purchase fish, wildlife or plants that are taken, possessed, transported, or sold: 1) in violation of U.S. or Indian law, or 2) in interstate or foreign commerce involving any fish, wildlife, or plants taken possessed or sold in violation of State or foreign law.
- In 2008, the [Lacey Act was amended](#) to include a wider variety of prohibited plants and plant products, including products made from illegally logged woods, for import.
- Today it regulates the import of any species protected by international or domestic law and prevents the spread of invasive, or non-native, species.

International conservation efforts

- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) (CITES)** - protects endangered species by banning international transport of their body parts
- **Convention on Biological Diversity (1992)** -
 - Seeks to conserve biodiversity, use it sustainably, and ensure fair distribution of its benefits
 - By 2007, 188 nations had signed on



Private Conservation Organizations

- World Wildlife Fund encourages the sustainable use of resources and supports wildlife protection
- Nature Conservancy helped purchase habitat preserves in 29 countries
- Conservation International helps identify biodiversity hotspots
- Greenpeace International organizes direct and sometimes confrontational actions.

