BIODIVERSITY, CONSERVATION BIOLOGY & LAND PROTECTION –
PART 1

WHAT IS BIODIVERSITY?

Bio = living **diversity = variety**

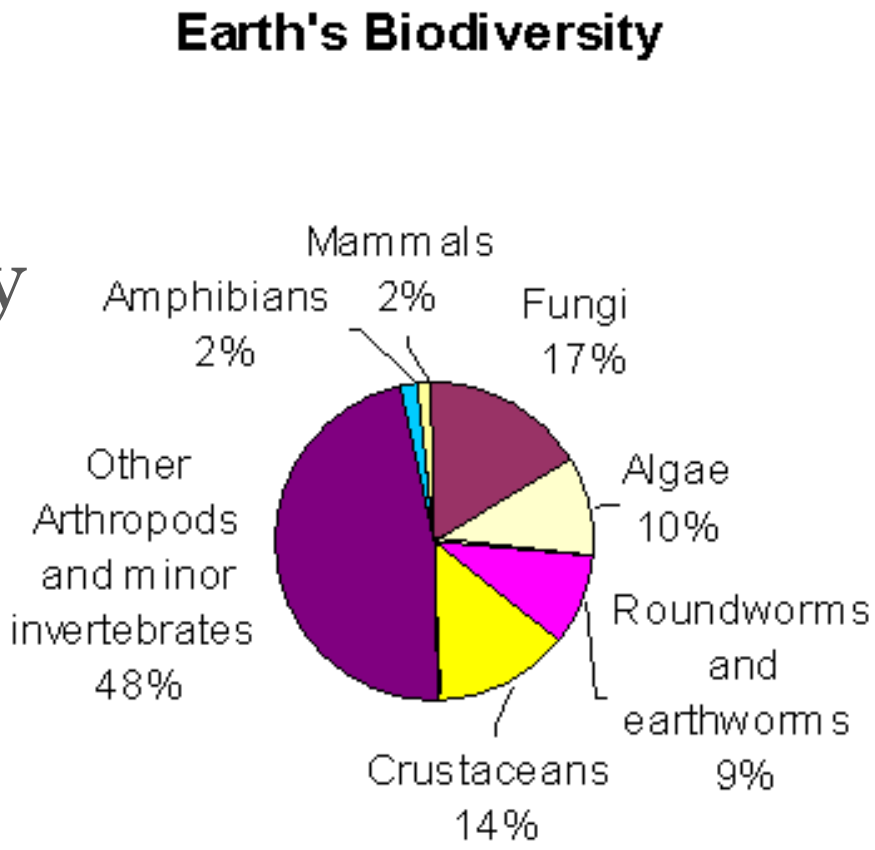
- Biodiversity is the variety of life on Earth.
- Ecosystems depend on biodiversity because each species has a different role (niche) that benefits the whole system.

OVERVIEW

- Identify the different types of biodiversity
  - Species, Genetic, and Ecosystem diversity
- Understand the basics of taxonomy – the naming of species
- Know the benefits of biodiversity
  - Agriculture/food
  - Pharmaceuticals/medicines
  - Recreational/eco-tourism
  - Research
  - Ecological services
  - Intrinsic value
- Know the difference between extinction and extirpation and that these reduce biodiversity
- Understand and know the threats to biodiversity – HIPPO + climate change.

3 TYPES OF BIODIVERSITY

- Species diversity
- Genetic diversity
- Ecosystem diversity



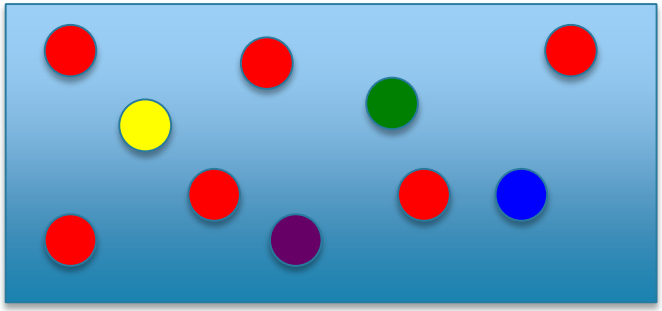
SPECIES DIVERSITY

- **Species diversity**: this is the number or variety of species in the world, or in a particular region.

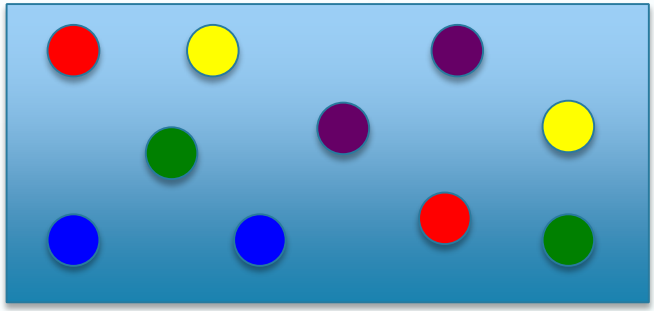
- 2 different measures to calculate an area's biodiversity:
  1. **Species richness**: this is the number of species in an area/habitat. More species = greater species richness.
  2. **Relative abundance**: this is how common or rare a species is relative to other species in an area. Some species have larger populations while others have smaller populations.

Speciation adds to species richness where extinction reduces species richness

RELATIVE ABUNDANCE



Habitat A



Habitat B

- One species dominates the habitat
- A few other species are present

Low Biodiversity

- No species dominates the habitat
- same number of species as Habitat A

High Biodiversity

GENETIC DIVERSITY

- Encompasses the differences in DNA among individuals **within** species and within populations
  - Measures the raw material for adaptation to local conditions
- Populations with higher genetic diversity are better able to survive.
- Populations with low genetic diversity are vulnerable.
  - To environmental change
  - Disease
  - **Inbreeding depression**: genetically similar parents mate and produce defective offspring

ECOSYSTEM DIVERSITY

- **Ecosystem diversity**: this type of biodiversity focuses above the species level, it refers to the number and variety of ecosystems on Earth, or within a specific area.
- It also encompasses differing communities and habitats.
  - Sizes, shapes, and interconnectedness of patches within habitats, communities, or ecosystems
  - Number of niches: You can also look at ecosystem diversity in terms of the variety and number of different niches filled by organisms

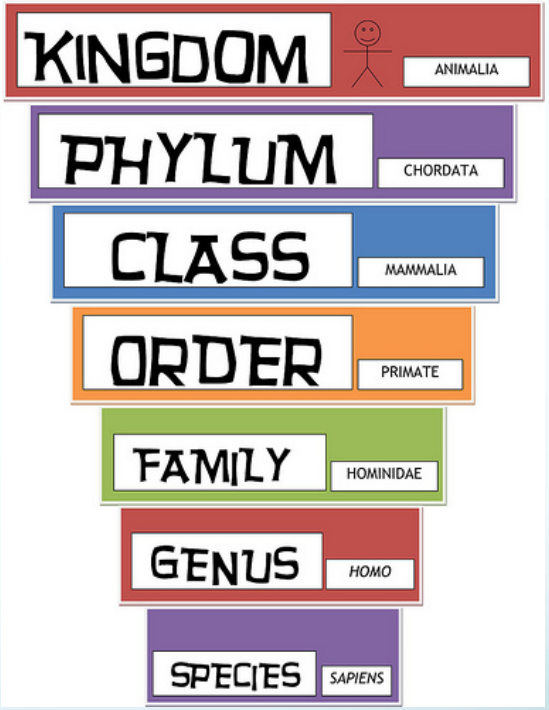
NOT AN EASY MEASUREMENT

- Best estimate is that there are 5–30 million species on Earth - only 1.7–2 million species have been identified and described.
- Very difficult to identify species
  - Small organisms are easily overlooked.
  - Many species look identical until closely examined.
  - Many remote spots on Earth remain unexplored.

BASIC TAXONOMY

TAXONOMY

- Taxonomy is the cataloging of species and the naming of new species.
- Taxonomists are the scientists who closely study species and help determine whether a new species has been discovered or not.
- Taxonomy allows us to understand what species are out there, to identify those in the most trouble.



BASIC TAXONOMY:

NAMING OF SPECIES

- Species are classified by their physical appearance and genetic make-up, as well as their common ancestry, or evolutionary relationship.
- A species usually has 2 names: a common name and a scientific name
  - The common name is the one most commonly used by most people. Such as "song sparrow," "white rose," or "mountain lion." The common name often differs among regions.
    - A "buzzard" in England is a hawk (predator). A "buzzard" in the US is a vulture (decomposer).
    - Another example, the mountain lion's scientific name is *Felis concolor* (meaning, cat of one color). It's common name can be mountain lion, or cougar, or puma, or panther, which can be confusing. The scientific name allows us to specify exactly which species we are talking about. We can have only one scientific name for each species while there may be multiple common names.

BASIC TAXONOMY:
NAMING OF SPECIES

- The first part is the genus – this is the group within the family that the species belongs to and is capitalized. *Felis* = smaller, non-roaring felines.
- The second name is the species name – it is often a descriptive word, or sometimes the name of the person who discovered the species. It is in lower case. *concolor* = one overall color, brown.
- The taxonomic name for our local desert tortoise is *Gopherus agassizii*.

- The first name puts this species in the group/genus of gopher tortoises (tortoises that live on land and dig burrows)
- The second name, or species name, is in honor of a Swiss-American zoologist, Jean Louis Rodolphe Agassiz

BENEFITS OF BIODIVERSITY

WHY DO WE CARE?

- There are 6 major reasons that we need to protect biodiversity:

1. Agriculture/food
2. Pharmaceuticals/medicines
3. Recreational/eco-tourism
4. Research
5. Ecological services
6. Intrinsic value

ECOSYSTEM SERVICES

- "Ecosystem Services are the processes by which the environment produces resources that we use and often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants." (Ecological Society of America)
  - For example, decreasing predator populations leads to increases in herbivores. This may result in over-browsing and changes in foraging behavior and, ultimately, degradation of the ecosystem.

Healthy ecosystems provide free "services" to human communities, including: water filtration, groundwater recharging, stormwater control, air purification, nutrient recycling, crop pollination, and soil enrichment.

Image copied from http://www.conservationvalue.blogspot.com

3 Categories of Ecosystem Services

1. Provisioning
2. Regulating
3. Cultural

PROVISIONING SERVICES

These are direct resources/commodities that ecosystems provide. Some examples include:

- Food
- Clean Water
- Fuel
- Wood, Fiber
- Minerals, Metals
- Medicine
- Genetic Material

Can you think of others?

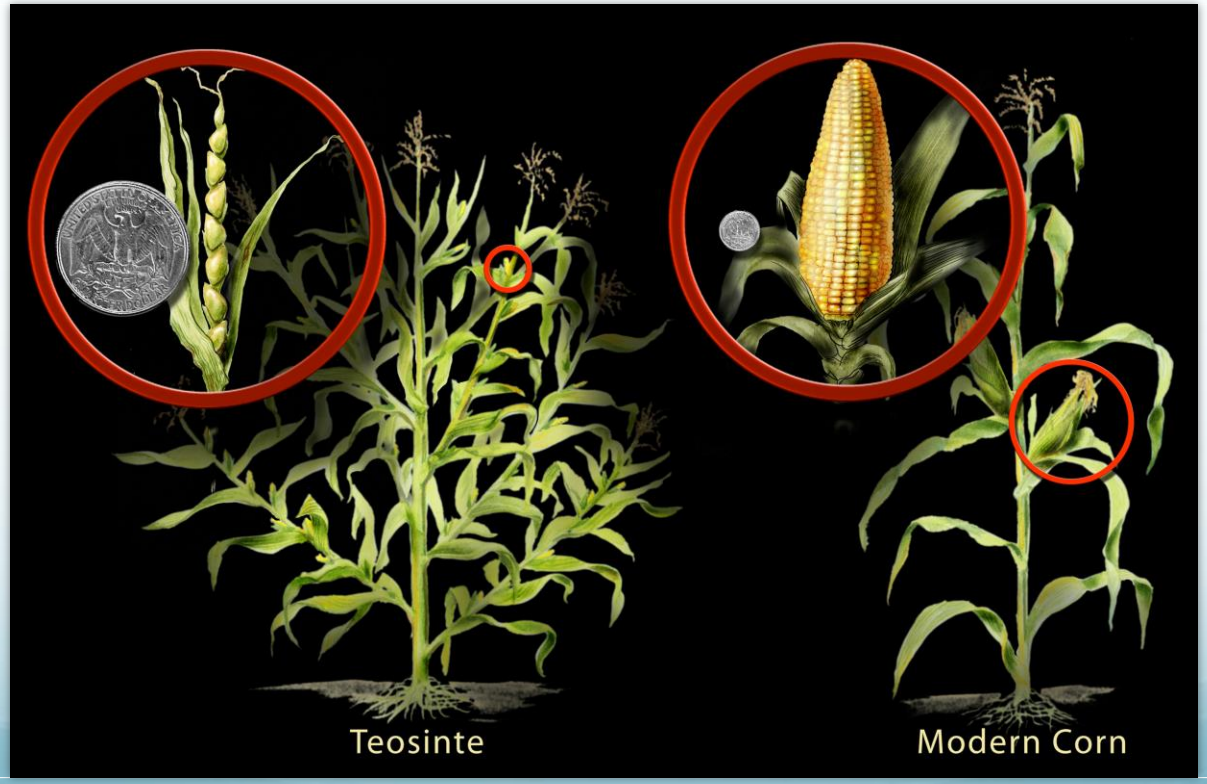
Agriculture/Food

- Ultimately, all our food originated from the wild – we took those wild forms and selectively bred and inbred them to get many of the crops we have today.
  - BUT – this selective breeding reduces the gene pool, making our crops vulnerable to disease and unable to cope with environmental changes such as drought.

    -What is the answer to this problem? . . . Breeding with wild plants when possible to re-diversify the gene pool.

Corn in the Wild

- As it turns out, biologists recently discovered a relative of a corn plant that has genes that will be useful for our crops.
- This plant happens to possess immunity to 7 of the 9 most common viruses that destroy corn.



Pharmaceuticals

- We need to protect biodiversity because of its untapped potential (bio-prospecting).
- More than half of all of medicines are derived directly from organisms found in the wild.

REGULATING SERVICES

These are ongoing functions that maintain habitat health and keep the habitat producing the commodities.

- Water Filtration/Purification
- Climate Regulation
- Air Quality
- Nutrient Cycling (carbon, nitrogen cycles)
- Soil Formation
- Disease/Pest Control (snakes eating rats, bats eating mosquitoes)
- Pollination (bees pollinate about ¾ of the food we eat)
- Storm/Flood Protection (buffer zones along the coast that absorb large waves, forests that absorb storm water)

2004 Tsunami along Indian Ocean coastlines

Coastlines with intact mangrove forests suffered almost no damage.

Flood Protection is a Regulating Service: Across the globe, coastal ecosystem such as marshes, mangrove swamps & kelp beds have been removed for other uses such as shipping lanes, oil transport, certain types of fish farming. These coastal ecosystems evolved with storms and provide inland protection from the storms.

In 1993, the Mississippi River flooded & caused 12 billion dollars worth of damage to homes, farms, & businesses. The damage would have been far less if the natural wetlands along the river had not been altered into farmland.

Depending on where you live, the fresh water from your tap may have been filtered by a nearby forest. The many organisms that keep the forest alive are also what keeps the water clean. The birds & rodents that disperse tree seeds and the fungi & bacteria that recycle nutrients to maintain healthy forest soil are examples of how biodiversity provides services for all.

ENDANGERED SPECIES

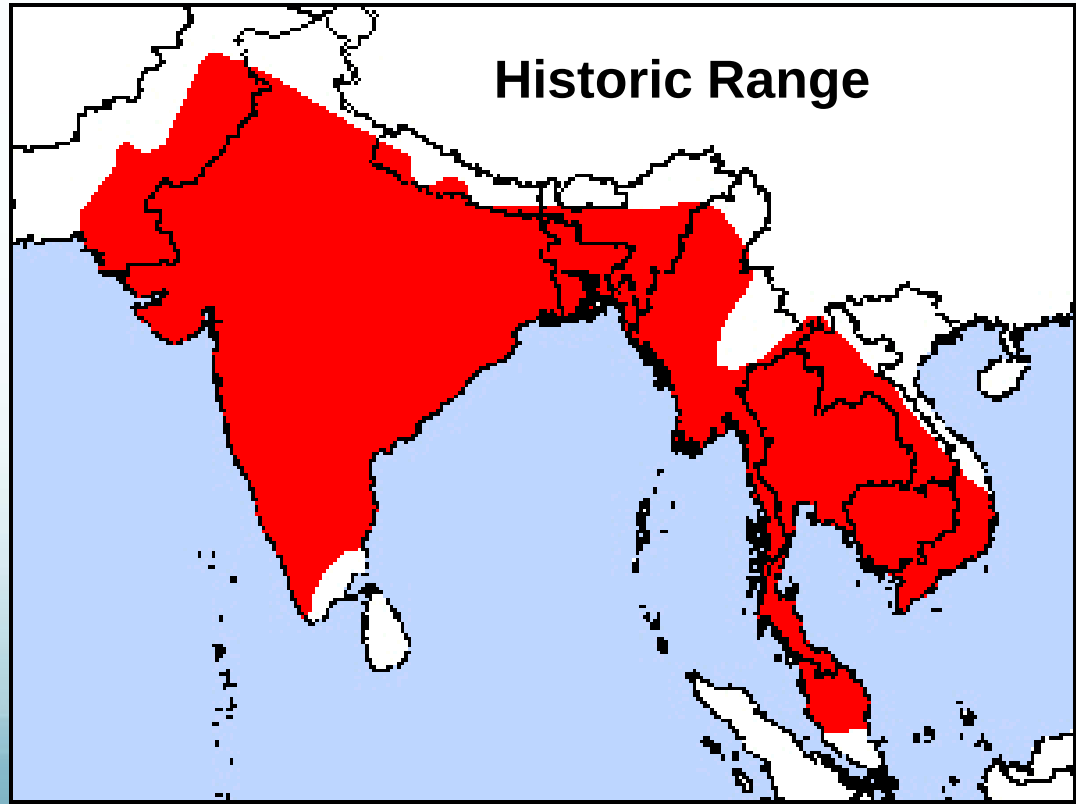
IUCN Red List =
Critically Endangered

Long-billed Vulture

Gyps indicus

Indian white-backed vulture

Gyps bengalensis



Historically, these vulture species ranged across Asia. Now they are on the verge of extinction.
WHY? And why do we care?

Diclofenac = Anti-inflammatory drug given to older cattle to relieve pain.

When the vultures eat the cattle carcasses at local dumps, they ingest the drug which causes renal failure.

Vulture populations have fallen by 97% over the last 12 years.

This is one of the fastest documented declines of a species.

The ecosystem service that the vultures provide is the consumption and recycling of the cattle carcasses that were left at dumpsites.

Now that there are so few vultures, feral dogs are eating the cattle carcasses leading to increases in their populations. Many of the feral dogs in these Indian towns carry rabies and there has been an increase in rabies in humans. So, the decline of vultures directly contributes to the increase in rabies.

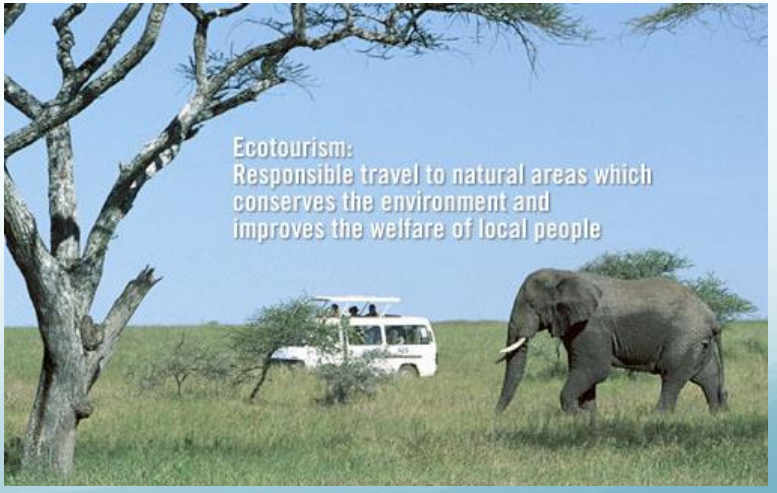
CULTURAL SERVICES

These services provide us with opportunities to interact with nature on a more personal level.

- Aesthetic
- Recreation
- Spiritual
- Education

Recreation/Ecotourism

- This includes a large variety of activities that millions of people participate in each year
  - ❖ Fishing, hiking, camping, bird watching, hunting, etc.
- These activities generate money and boost our economy
  - ❖ Gas, gear, permits, park passes, etc.



Giant Sequoia trees: largest living organisms in the world.

Sequoia & Kings Canyon

Aesthetic Value

- Contact with nature can be emotionally restorative
- Having nature in our lives, protecting its biodiversity, has it's own value. It adds beauty to our world and brings peace and joy to many people.

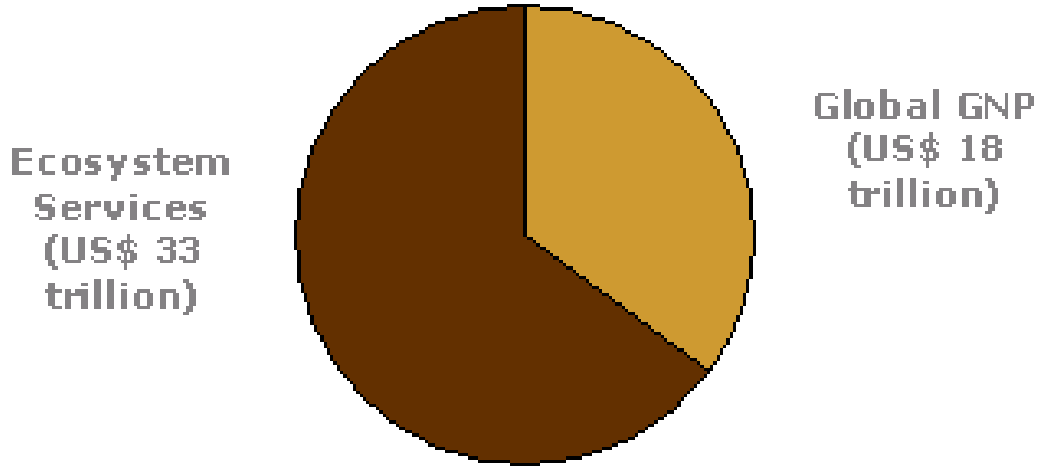
The $ Value of Ecosystem Services

- Remember, these services are provided free of charge.
- The costs involved are in the harvesting of the resources (our tools and infrastructure), as well as in the restoration of the resources when we overuse them, or compromise them so much that they cease to function. (New Orleans' lack of flood control during Hurricane Katrina)
- We can calculate the approximate economic benefit of maintaining healthy ecosystem services by two different methods:
  1. Ask people what they would be willing to pay for each service if the service was no longer free. (What would you pay for a gallon of clean water?)
  2. If humans implemented technology to produce goods and regulate ecosystems, how much would the technology cost? And how much would it cost to run that equipment 24 hours a day 365 days a year?
     - Could we recycle carbon as efficiently as plants? What would that cost?

PRICE OF ECOSYSTEM SERVICES

How Much Are Nature's Services Worth?

Figure 1: Estimates of Human Economic Activities and Ecosystem Services, 1997



Source: Costanza et al. 1997:256.

A recent trend in determining the value of biodiversity is to evaluate the cost of performing the same functions with human technology. See World Resources Institute website. While the numbers are approximate, we can still see that nature provides valuable services which would be impossible and/or very expensive for humans to duplicate. *Today, $33 trillion is actually @ $44 trillion.*

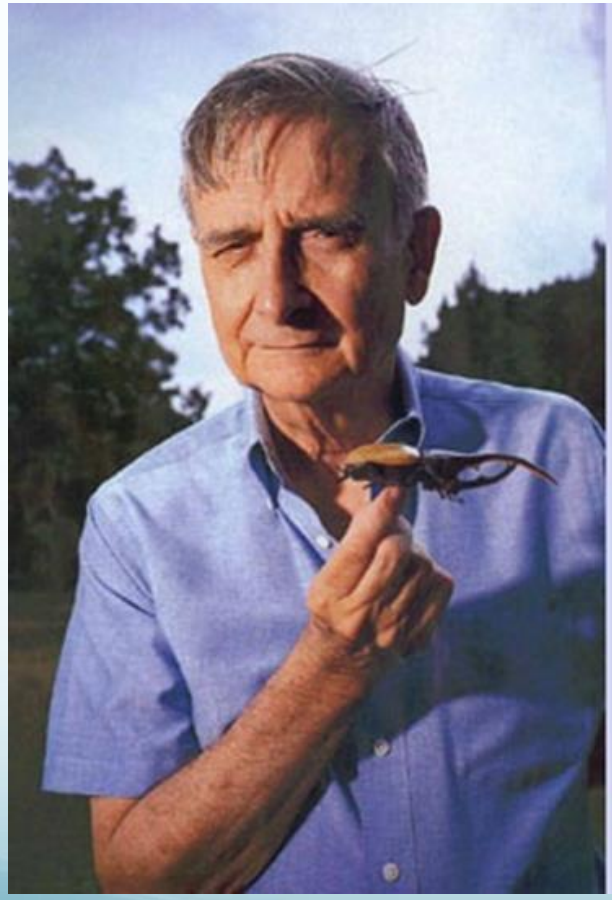
INTRINSIC VALUE vs. ECONOMIC VALUE

- *Intrinsic Value*: "The biocentric view, forwarded by the deep ecology movement holds that all species have intrinsic value and that humans are no more important than other species. Thus everything has an equal right to exist simply because it already exists." (http://cnx.org/content/m12160/latest/)

- But, not everyone cares about the intrinsic value of things – and that is one's right to be disinterested in intrinsic value.

- *However, everyone at least comprehends the economic value of things. Therefore, it is important to understand that biodiversity not only has intrinsic value, but also has a very real economic value. This is why we try to calculate the cost of ecosystem services.*

THREATS TO BIODIVERSITY = HIPPO



"We should preserve every scrap of biodiversity as priceless while we learn to use it and come to understand what it means to humanity."

E. O. Wilson

THREATS TO BIODIVERSITY: HIPPO

- E.O. Wilson coined the acronym HIPPO to encapsulate threats to biodiversity.

Habitat Alteration

Invasive Species

Pollution

Population Growth (human)

Overharvesting (overhunting, deforestation, etc.)

H is for Habitat Alteration

- The following are three types of habitat loss:

  - Fragmentation
  - Simplification
  - Conversion

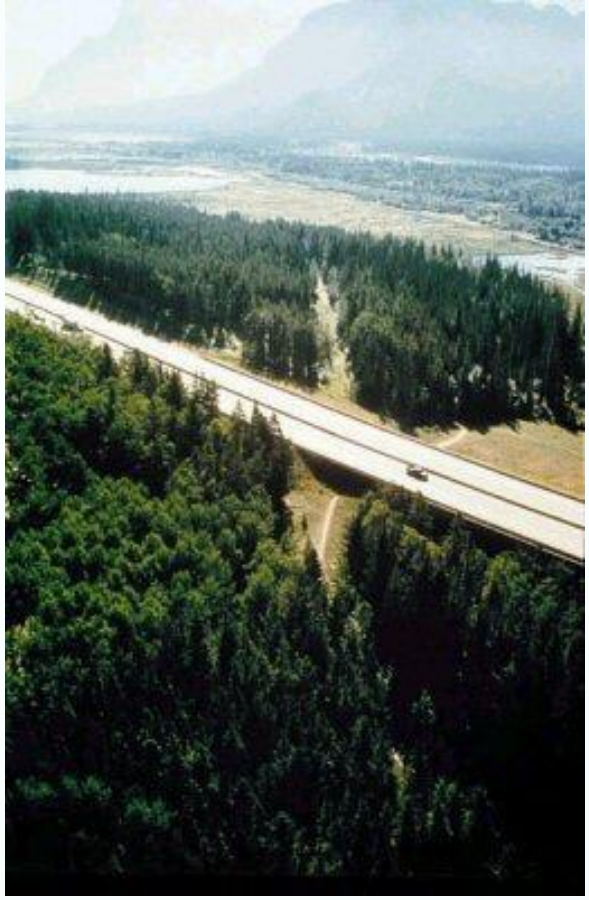
1. FRAGMENTATION: splitting apart of natural habitat and leaving little to no core area. Remaining parcel is mostly the edge.

The core of a habitat is the inner portion that contains the true elements of that habitat.

Unlike the edges that contain both elements of the core and also of neighboring habitats.

A neighboring habitat in this case could be a suburb, or highway, or agricultural fields – not much ecosystem value.

Wildlife corridors are built under or over highways to prevent collisions with wildlife. They help mitigate fragmentation.



Wildlife Bridges a way to mitigate fragmentation.

2. SIMPLIFICATION: the complexity of a habitat is reduced, hence the number of niches is reduced.

Pine Forest: many species of trees?

Natural Grassland with many types of grasses and flowers.

Wheat Field with one type of plant.

CALIFORNIA FAN PALM

- The California Fan Palm is a local example of simplification
- This palm, in its natural state, is a very complex habitat, which provides for many species – similar to the Baobab tree (a Keystone Species).
  - The Fan Palm's skirt (dead fronds that are folded downward) provides habitat for nesting birds, lizards, ringtail cats, native rodents, etc. It also protects the palm from cold temps in the winter, hot temps in the summer, and fire.
- But we chop off the dead fronds – it's called skinning the palm – and simplify the habitat it provides, making it non-useful to wildlife.
- FIGHT THE URGE TO SKIN! If you have a landscape company come to your house, tell them not to skin the palms. Talk to your landlord and tell them how vital the fronds are to the tree and the wildlife dependent on it! It won't take long before you notice a much wider array of wildlife visiting your yard.

Fan Palms

This is what the tree looks like in its natural state – this is what you want in your yard for wildlife.

This palm has been skinned and provides little habitat for wildlife.

3. Conversion: Major transformation of an ecosystem to a human habitat.

- The Coachella Valley and most of Southern California are examples of habitat conversion.
- Much of the desert ecosystem has been converted into houses and golf courses.
- Most native species do not benefit from the changes.
- Exotic species such as house sparrows, European Starlings, tamarisk, Olive trees and Oleander thrive here and provide little habitat for native species.

3. CONVERSION

Anza-Borrego State Park

Golf course in a desert

Used as a hedge plant throughout the Coachella Valley, the Oleander is a poisonous plant. Native species do not benefit from it & some are killed by eating it (e.g. bighorn sheep)

One way you can help: Xeriscape - landscaping for dry climates.

Planting native plants, such as desert mallow, attract native wildlife, such as the Costa's Hummingbird.

The largest contributor to habitat loss is agriculture. Soil erosion, overwatering, and pesticide use make industrial food production unsustainable.

70% of all grain is grown for livestock feed. One cow eats as much as 12 humans.

The animal waste from modern farming practices pollutes the water, air and soil – this is due to too many animals in a confined space and inadequate methods to deal with the waste.

I is for Invasive Species

- Introduction of invasive species to new environments can be accidental or intentional.
  - Remember that invasive species have no natural predators, competitors, or parasites and often thrive in their new location.
  - Cost billions of dollars in economic damage each year

Tamarisk

Nutria

P IS FOR POLLUTION

Pollution causes biodiversity loss

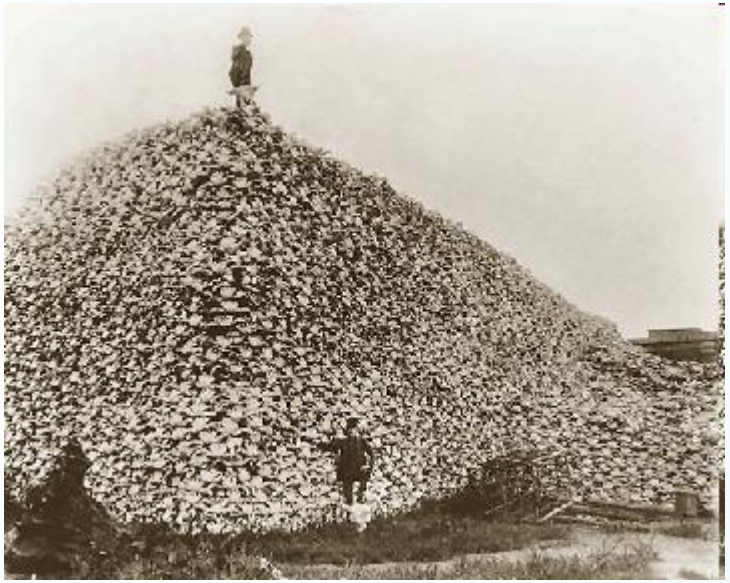
- Harms organisms in many ways
  - Air pollution degrades forest ecosystems.
  - Water pollution adversely affects fish and amphibians.
  - Agricultural runoff harms terrestrial and aquatic species.
  - The effects of oil and chemical spills on wildlife are dramatic and well known.
- Although pollution is a substantial threat…
  - It tends to cause less damage than habitat alteration or invasive species.

P IS ALSO FOR POPULATION GROWTH

Human population growth impacts biodiversity by increasing the amount of habitat loss, invasive species, pollution and overharvesting.

O IS FOR OVERHARVESTING/ OVER-USE (TRAGEDY OF THE COMMONS)

Bycatch



Bison skulls

Bycatch from shrimp trawling. This is the non-target catch that was also caught but now is not returned to the ocean.

Overharvesting causes biodiversity loss

- Vulnerable species are large, few in number, long-lived, and have few young (K-selected species).
  - Examples include the Siberian tiger, Atlantic gray whale, sharks, and gorillas

Today the oceans contain only 10% of the large animals they once did.

Forestry Practices

- **Deforestation**: clearance or clearing is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use.
- **Clear-cutting:** All of the trees in a large area are removed
  - **Patch-work clear-cutting**: Smaller areas among untouched
- **Reforestation:** re-planting with seeds
- **Selective harvesting:** Only taking highest value trees
- **Plantation harvesting:** Single species plantations

Tropical Deforestation

- Greatest Biodiversity
- Soil has low fertility and is highly erodible
- Not likely to regenerate
- Few managed for long-term stability
- Lost at a rate of 0.6 percent per year (humidity in air and carbon sequestration)

Methods for mitigating human impacts on forests

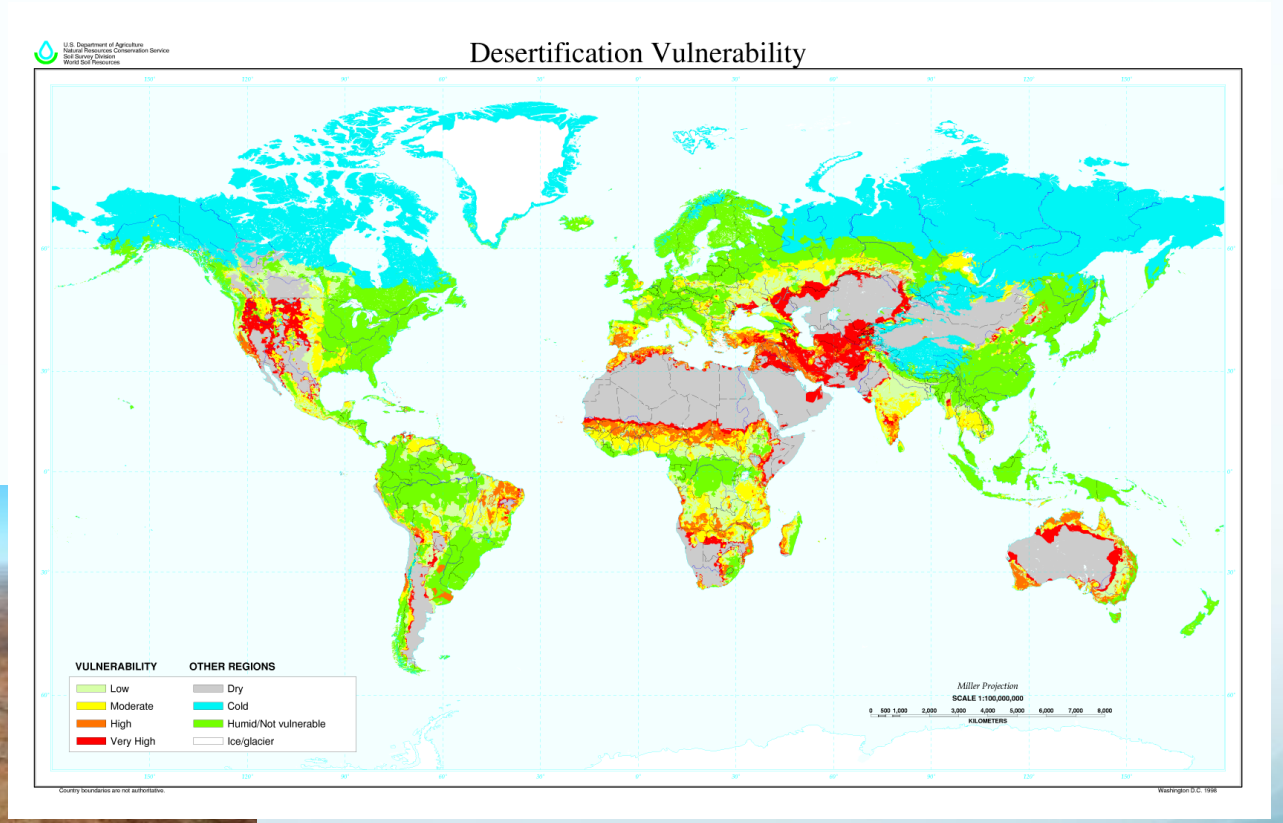
- Reforestation
- Using/buying wood harvested by ecologically sustainable forestry techniques
- Re-using wood

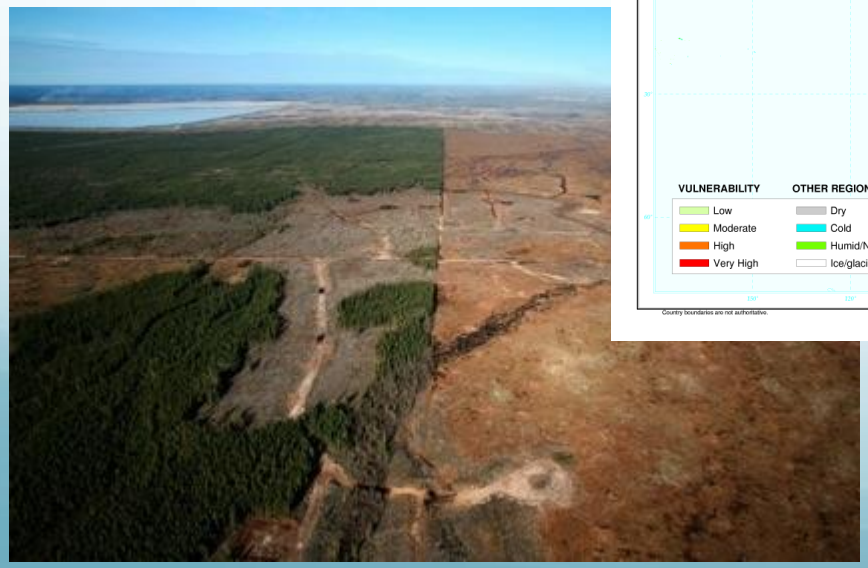
Methods to protect forests from pathogens and insects

- **Integrated Pest Management (IPM):** Ecosystem-based strategy combining techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed (last resort).
- Removal of affected trees

Desertification

- Process of converting arid and semi-arid land into desert because of improper use by humans.





Habitat loss in aquatic ecosystems

- **Endemism**: local species found nowhere else (higher amount in rivers and lakes due to isolation and evolution.
  - Threats to aquatic ecosystems:
    - Channelized for navigation
    - Dams change flow and temperature
    - Pollution
    - Exotic species introductions
    - Overharvested
    - Water removal
    - Siltation and warming from deforestation

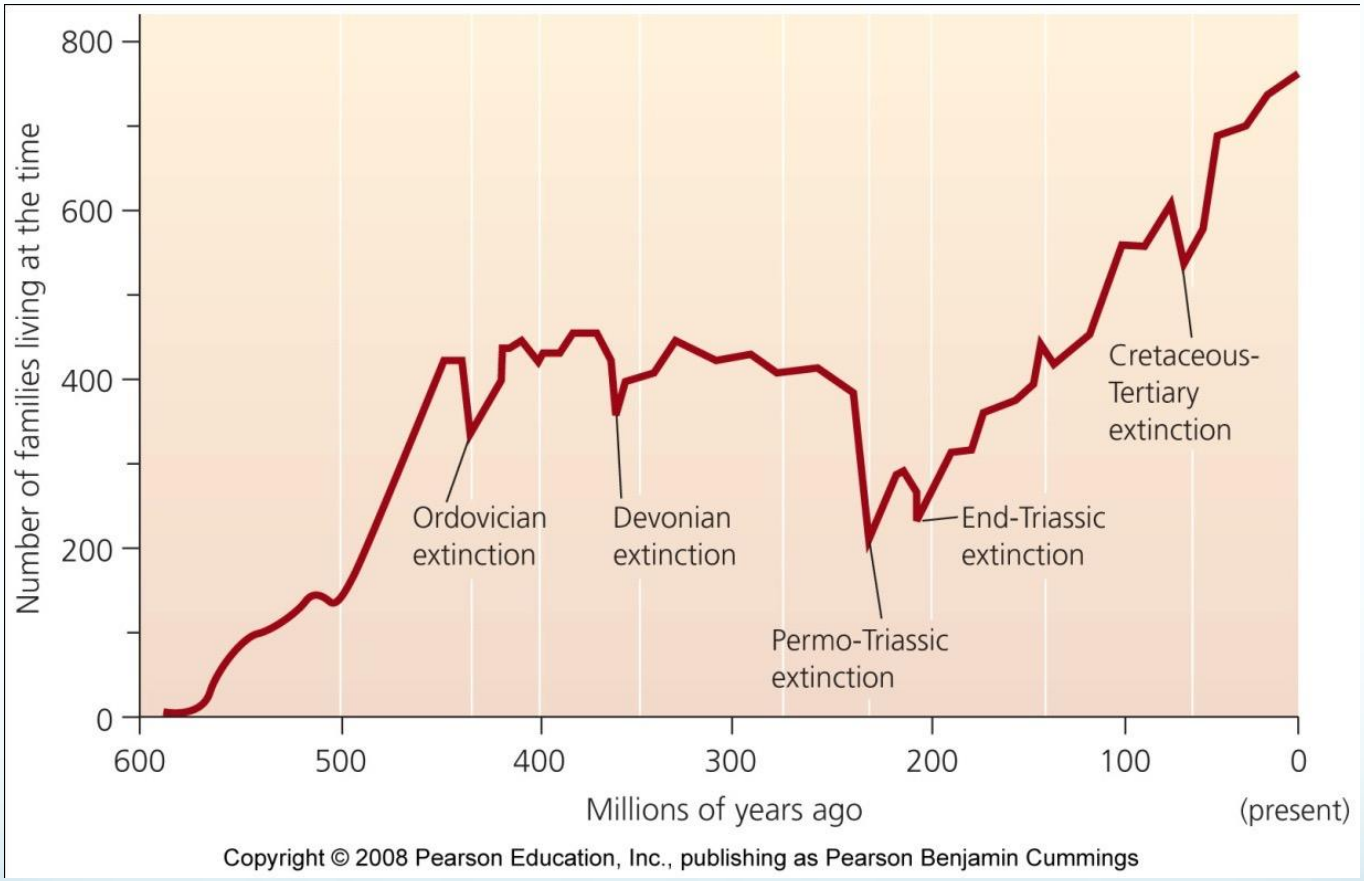
CLIMATE CHANGE: A NEW THREAT

- Climate change is another threat to biodiversity – this one is not included in HIPPO, as it is a newer threat.
- Our manipulation of earth's climate system is having global impacts on biodiversity.
- Emissions of greenhouse gases (CO_2 - carbon dioxide, CH_3 - methane) warm temperatures. This:
  - Alters global weather patterns and increases the frequency of extreme weather events
  - Increases stress on populations and forces organisms to shift their geographic ranges

EXTINCTION VS. EXTIRPATION

- "Extirpation" means that the species has disappeared from a particular region, but the species has not completely disappeared because there are other populations that continue to exist.
  - The Mexican wolf (subspecies of the grey wolf) was extirpated from the US, but smaller populations continued to survive in Mexico and in captivity.
- It is important to understand that extirpation can lead to extinction by fragmenting and isolating populations which reduces a species' gene pool, thereby reducing their source for beneficial mutations.
- Although extinction is a process that occurs naturally, humans have greatly accelerated the rate of extinction.
- Various human-caused threats to biodiversity can lead to extinction, which is elimination of a species altogether.

Earth has experienced five mass extinctions



- In the past 440 million years, mass extinctions have eliminated at least 50% of all species.

Rate of Extinction

The question is NOT whether extinction occurs.

In places where humans do not live, one species goes extinct every ten years on average.

Instead, the question is: how much has the rate of extinction been accelerated by human causes?

In places where humans live, the combined rate of extinction is 10,000 species & subspecies per year.

The current mass extinction is human-caused

- During our modern era (Quaternary period), we may lose more than half of all species.
- Today's extinction event differs from others because it is…
  - ❖ **Caused by humans**
- The current global extinction rate is 100 to 1,000 times greater than the background rate.

“The great auk, now extinct, is depicted in a hand-colored engraving by John James Audubon and Robert Havell, circa 1827–30.”

This was the first species in North America to go extinct due to human activity. They were hunted by explorers, fishermen, & whalers for food, eggs and down. The great auk is estimated to have numbered in the millions on the shores and islands of Northern Europe and North America two centuries ago.
By 1845 it was extinct (last one was seen in 1844).

OTHER SPECIES EXTINCTIONS CAUSED BY HUMANS

Carolina Parakeet (N. America)

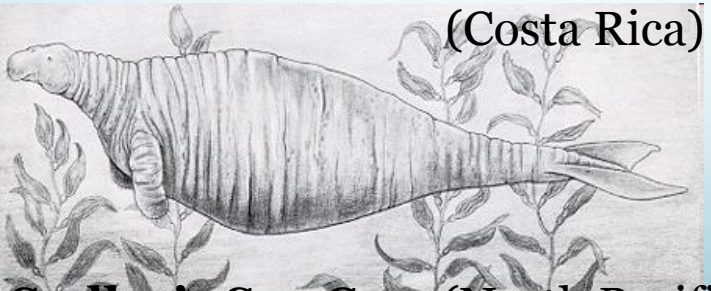
Passenger Pigeon (N. America)

Golden Toad (Costa Rica)

Labrador Duck (N. America)

Xerces Blue (N. America)

Dusky Seaside Sparrow (N. America)



Stellar's Sea Cow (North Pacific)

Caribbean Monk Seal (Caribbean Sea & Gulf of Mexico)

CONCLUSION

- Loss of biodiversity threatens to result in a mass extinction event equivalent to mass extinctions of the past.
- The primary reasons to protect biodiversity are:
  - Agriculture/food, Pharmaceuticals/medicines, Recreational/eco-tourism, Research, Ecological services, and Intrinsic value.
- Primary causes of biodiversity loss are:
  - HIPPO (habitat alteration, invasive species, population, pollution, overharvesting of biotic resources) and climate change.

Strategies to Protect Populations of Species

- Criminalize poaching
- Protect habitats
- Legislation
- Promote sustainable use practices
- Restore lost habitats

OBJECTIVES REVIEWED

- You should now be able to:
- Identify the different types of biodiversity
  - Species, Genetic, and Ecosystem diversity
- Understand the basics of taxonomy – the naming of species
- Know the benefits of biodiversity
  - Agriculture/food
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