Lecture Outlines

Chapter 11

Environment: The Science behind the Stories

4th Edition

Withgott/Brennan

This lecture will help you understand:

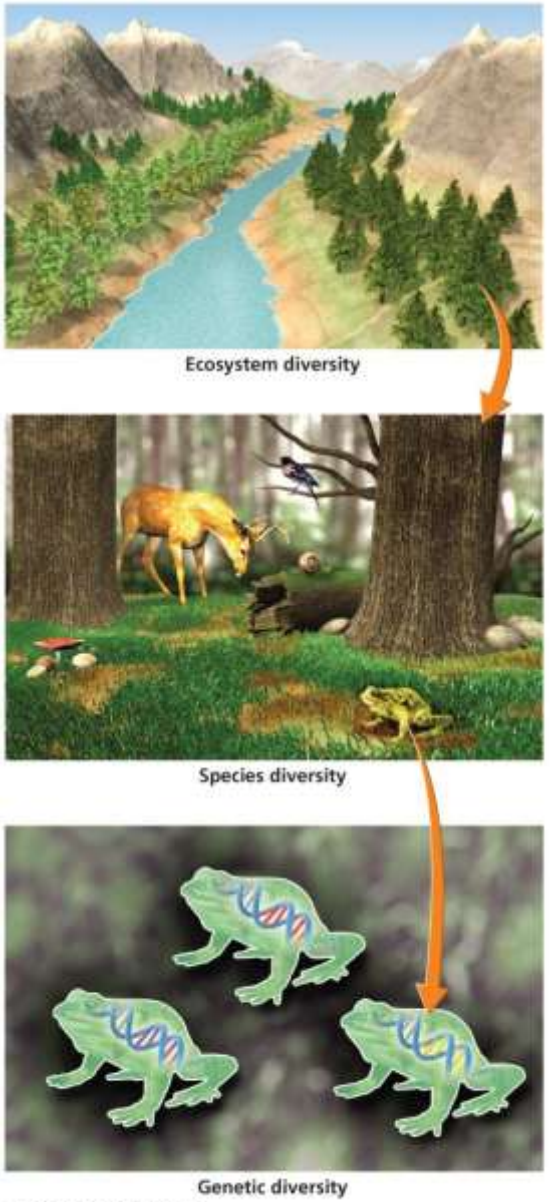
- The scope of Earth's biodiversity
- Background extinction rates and mass extinctions
- Causes of biodiversity loss
- The benefits of biodiversity
- Conservation biology
- Conservation of species
- Conservation above the species level

Central Case: Saving the Siberian tiger

- Tigers are going extinct
- The last Siberian tigers live in the Russian Far East mountains
- They are hunted and poached, and their habitat was destroyed
- International conservation groups are trying to save the species from extinction
- Research, education, zoos, and captive breeding programs help

Levels of biological diversity (biodiversity)

- Humans are reducing Earth's diversity of life
- **Biodiversity** = variety of life at all levels of organization
  - Species diversity
  - Genetic diversity
  - Ecosystem diversity



Type 1: Species diversity

- **Species** = a set of individuals that share certain characteristics and can interbreed in nature (captivity doesn't count)
  - Producing fertile offspring

	Lion ♀	Tiger ♀	Jaguar ♀	Leopard ♀
Lion ♂	Lion	Liger	Liguar	Lipard
Tiger ♂	Tigon	Tiger	Tiguar	Tigard
Jaguar ♂	Jaglion	Jagger	Jaguar	Jagupard
Leopard ♂	Leopon	Dogla	Leguar	Leopard

Species diversity = the number or variety of species in a particular region

- ***Richness*** = the number of species
  - Speciation adds to species richness
    - Extinction reduces species richness

- ***Evenness*** (*relative abundance*) = the similarity in numbers between species

- **Dominance*** = charactizes the most abundant species (highest # of indiv/total indiv)

Species diversity and evenness

Compared with the boxed area at the top:

Which area has greater species richness? Why?

Which has reduced richness? Why?

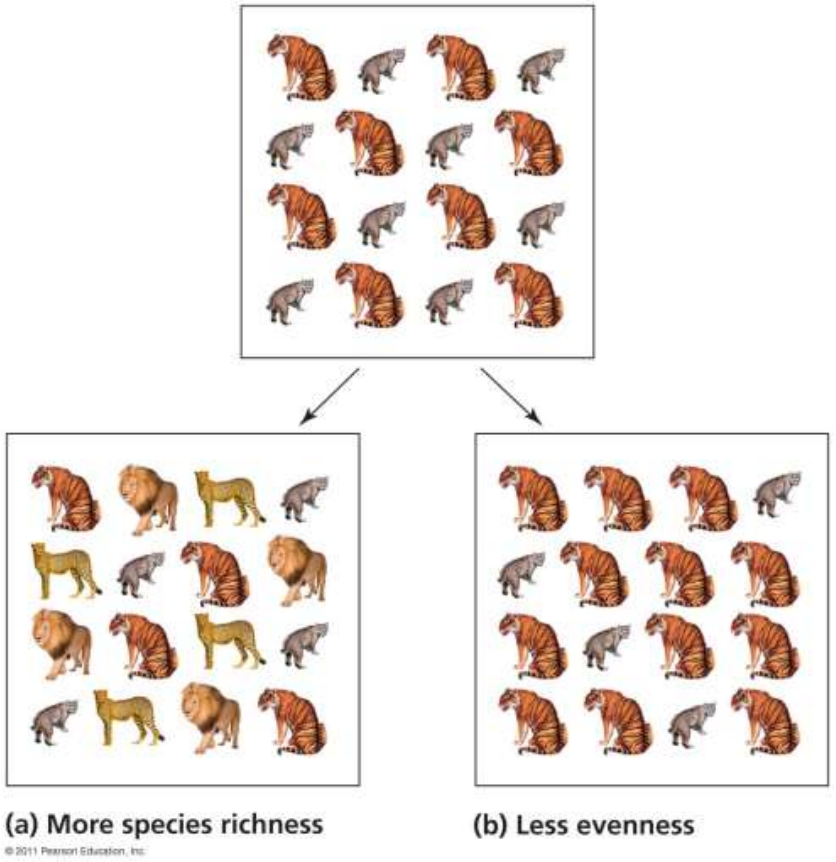


Fig 7.3 Diagram illustrating the difference between species evenness and species richness.

Both have the same richness but different evenness.

10 Species

100 Individuals

82 Elephants

18 Others (2 each)

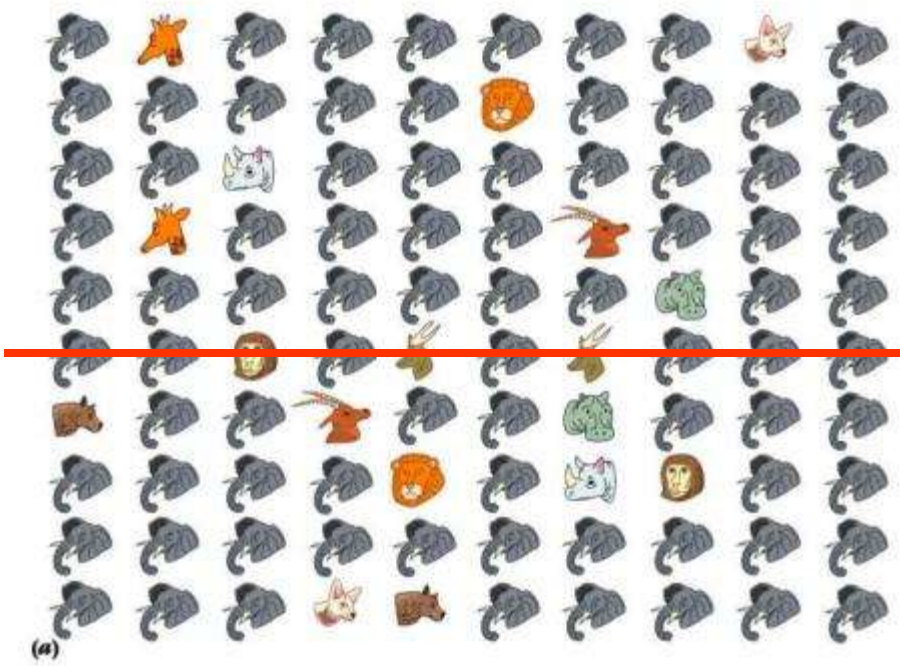
10 Species

100 Individuals

10 Individuals per species

Fig 7.3 Diagram illustrating the difference between species evenness and species richness.

Both have the same richness but different evenness.



3 species

10 species

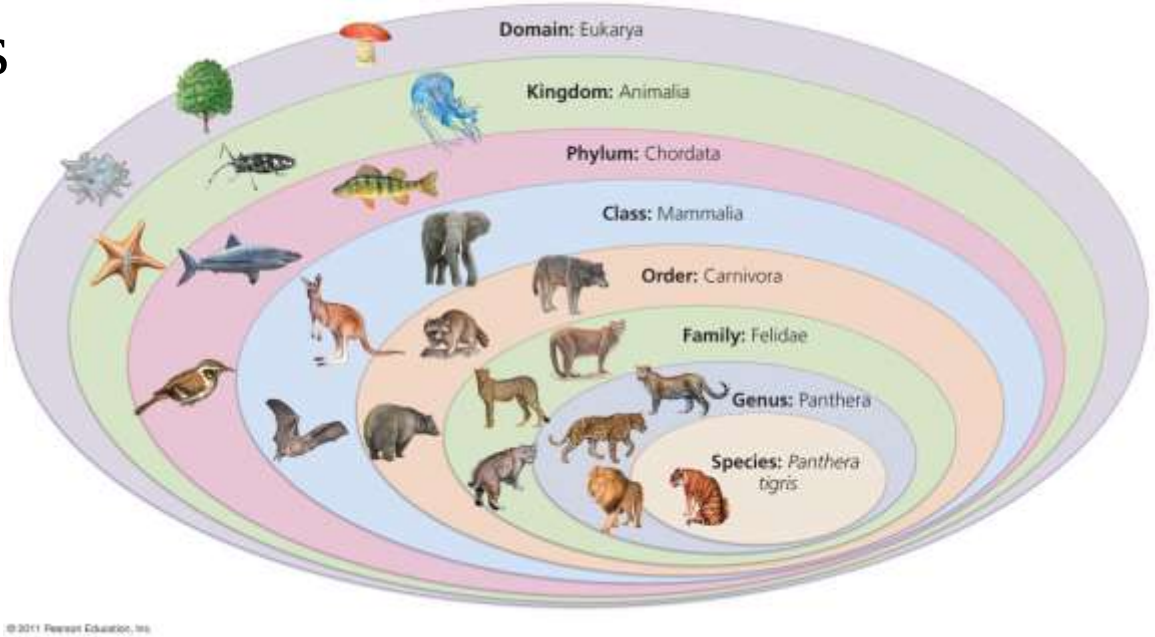
Evenness?

Richness?

Species dominance?

The taxonomy of species

- *Taxonomists* = scientists who classify species
  - Similarities reflect evolutionary relationships
  - *Genera* = groups of related species
  - *Families* = groups of genera
- Every species has a two-part scientific name
  - Genus and species



Subspecies: the level below a species

- *Subspecies* = populations of species that occur in different areas and differ slightly from each other
  - Divergence stops short of separating the species
  - Subspecies are denoted with a third part of the scientific name

Bengal tiger = *Panthera tigris tigris*

Siberian tiger = *Panthera tigris altaica*

Type 2: Genetic diversity

- Encompasses the differences in DNA among individuals
- The raw material for adaptation to local conditions
- Populations with higher genetic diversity can survive
  - They can cope with environmental change
- Populations with low genetic diversity are vulnerable to environmental change or disease
- *Inbreeding depression* = genetically similar parents mate and produce inferior offspring
  - Cheetahs, bison, elephant seals

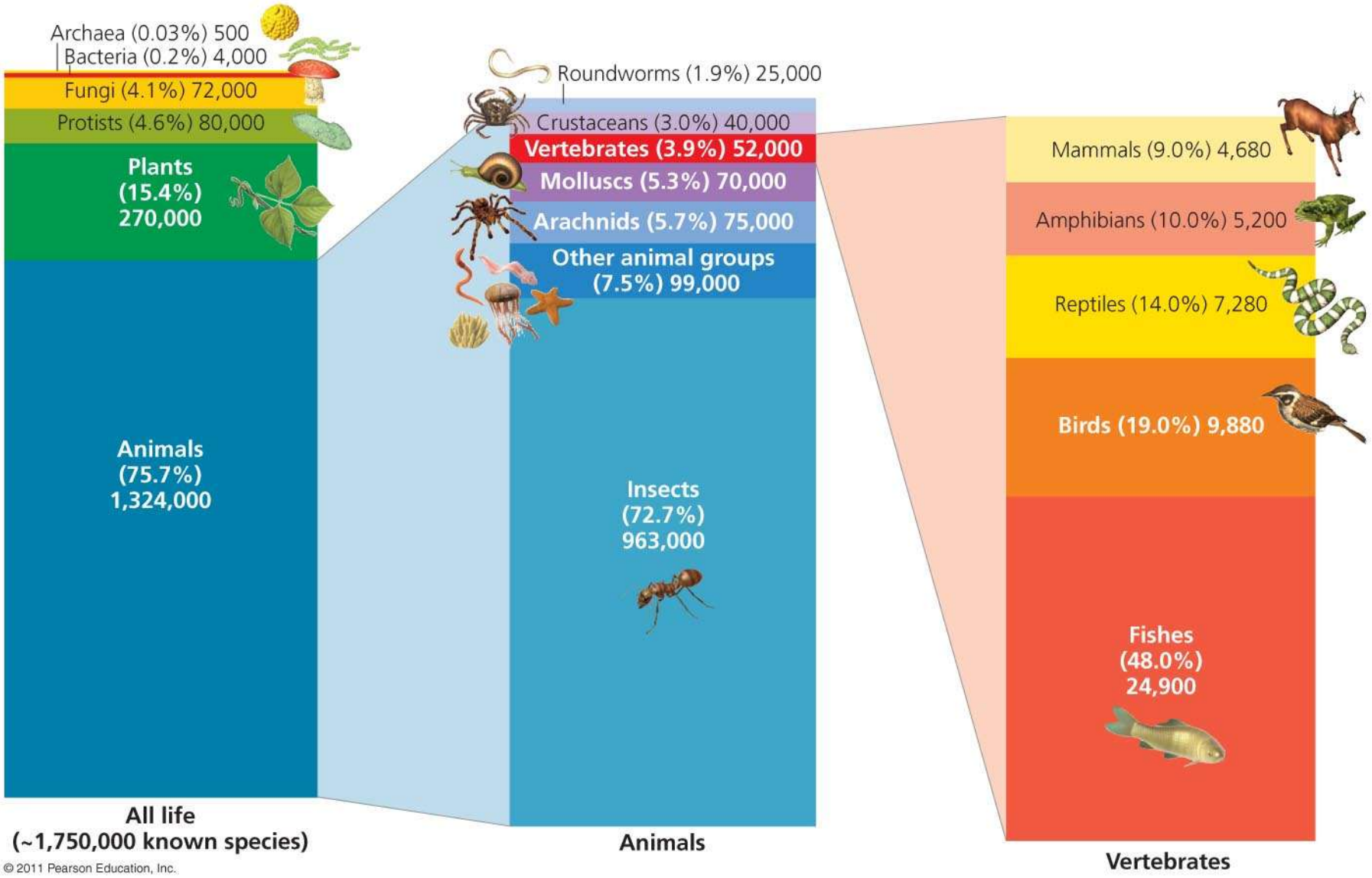
Type 3: Ecosystem diversity

- *Ecosystem diversity* = the number and variety of ecosystems
  - Including different communities and habitats in an area
- May include habitats, communities, or ecosystems at the landscape level
  - Sizes, shapes, and connections among patches
  - Beaches, cliffs, coral reefs, ocean waters
- An area with a variety of vegetation holds more biodiversity than the same size area with one plant type

Some groups have more species than others

- Species are not evenly distributed among taxonomic groups
  - Insects predominate over all other life-forms
  - 40% of insects are beetles
- Groups accumulate species by:
  - Adapting to local conditions
  - Allopatric speciation
  - Low rates of extinction

Insects outnumber all other species



How many species are there on Earth?

Measuring biodiversity is not easy

- Out of the estimated **3–100 million species** on Earth, 1.8 million species have been identified and described
- Most widely accepted estimate of the number of species?
  - **14 million**
- It is very difficult to know how many species exist
  - Small organisms are easily overlooked
  - Many species look identical until thoroughly examined
  - Many remote spots on Earth remain unexplored

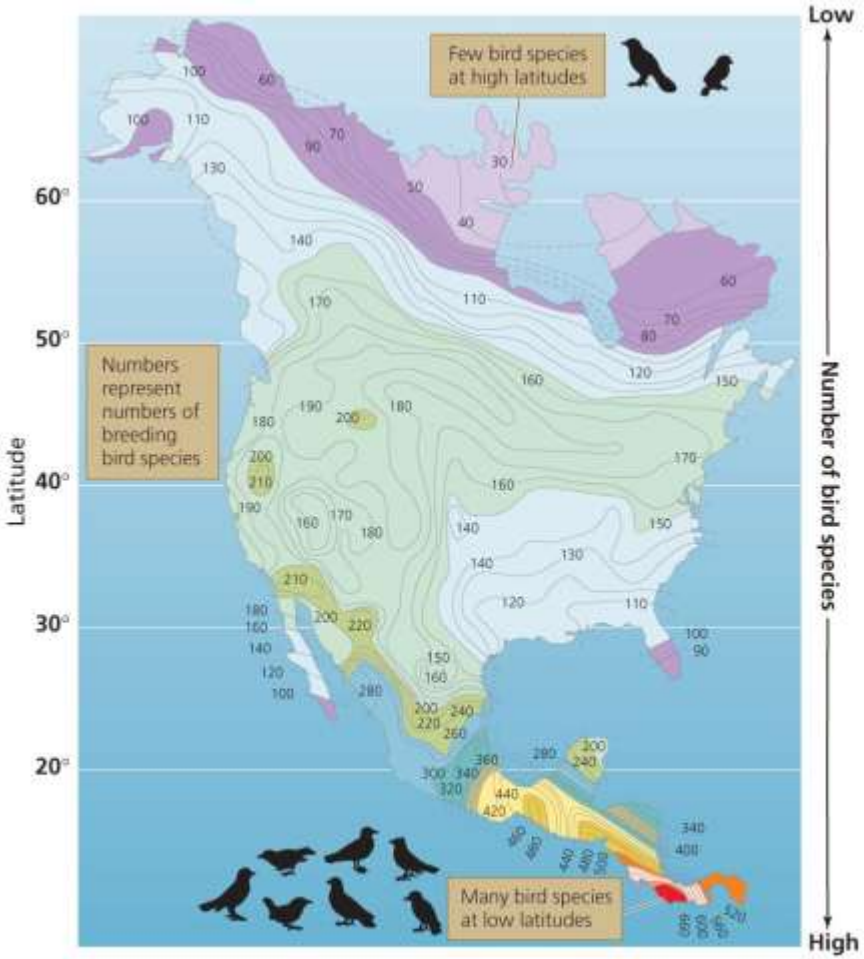
How many species did Terry Erwin find in one tree, *Luehea seemannii*?

- Entomologist Terry Erwin found 163 beetle species living on one tree species
- Video clip (see tape)

Biodiversity is unevenly distributed

- Living things are not distributed evenly on Earth
- *Latitudinal gradient* = species richness increases toward the equator

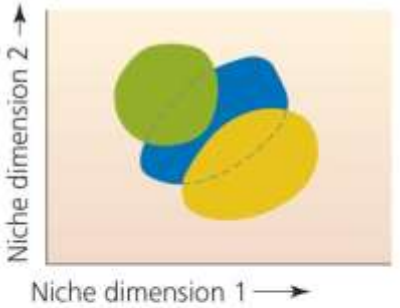
Canada has 30–100 species of breeding birds, while Costa Rica has more than 600 species



(a) Latitudinal gradient in species richness for birds in North America

Latitudinal gradient has many causes

- Climate stability, high plant productivity, no glaciation
  - More niches, species coexistence
- Diverse habitats increase species diversity and evenness
  - Tropical rainforests and drylands, ecotones
- Human disturbance can increase habitat diversity
  - But only at the local level



Temperate and polar latitudes: Variable climate favors fewer species, and species that are widespread generalists.

Tropical latitudes: Greater solar energy, heat, and humidity promote more plant growth to support more organisms. Stable climate favors specialist species. Together these encourage greater diversity of species.

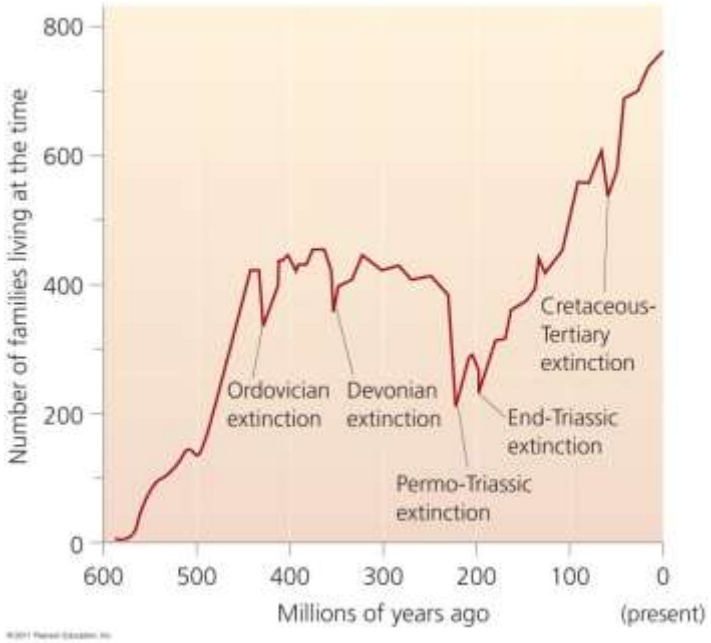
(b) One hypothesis to explain the latitudinal gradient

Biodiversity loss and species extinction

- **Extinction** = occurs when the last member of a species dies and the species ceases to exist
- Extinction is a natural process
  - 99% of all species that ever lived are now extinct
- **Background rate of extinction** = natural extinctions
  - For mammal or marine species: each year 1 species out of every 1–10 million goes extinct

Earth has had five mass extinctions

- Earth has had five **mass extinctions** in the past 440 million years
  - Each event eliminated at least 50% of all species
- Humans are causing this sixth extinction event
  - We will suffer as a result



Humans are causing this mass extinction

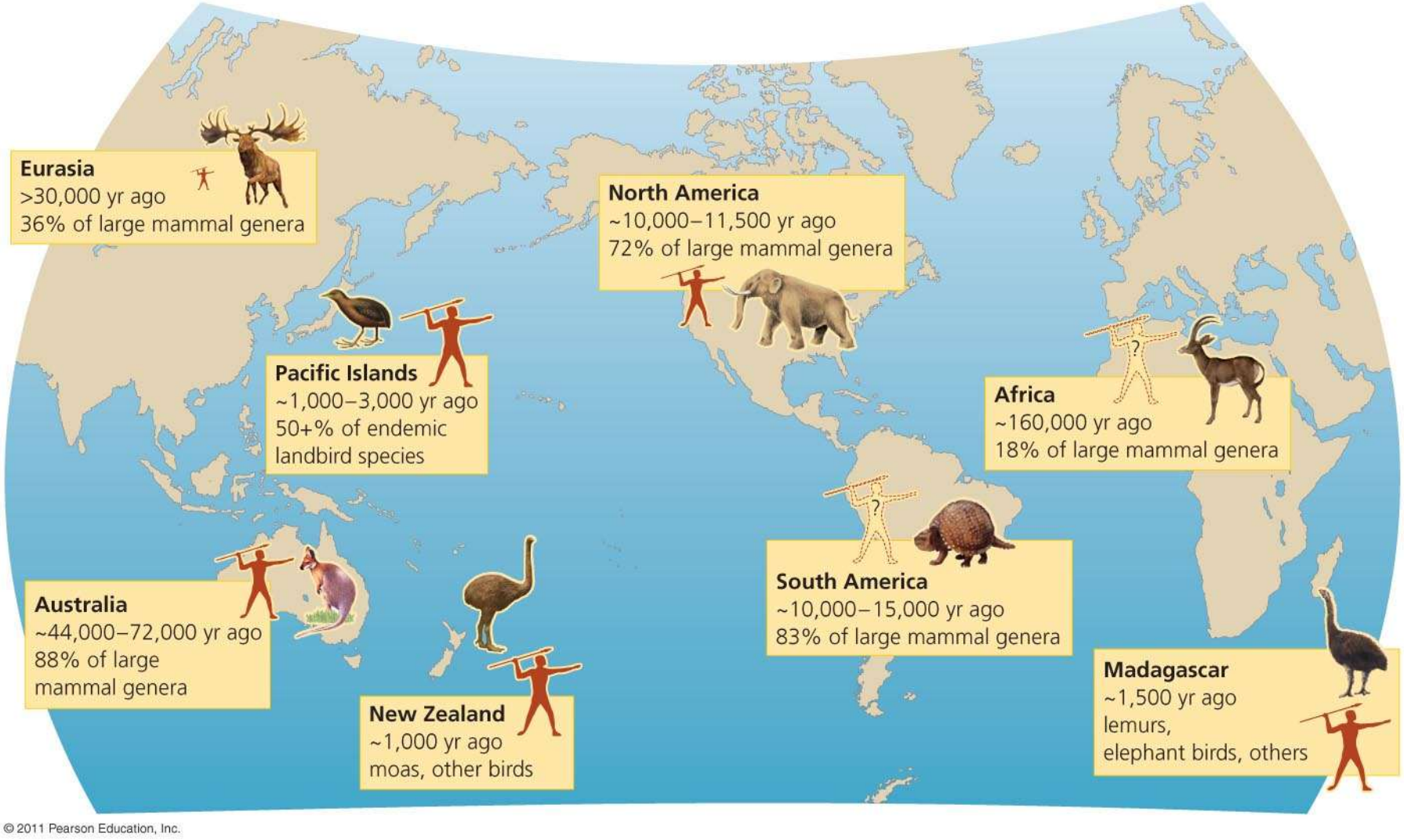
- Humans have driven hundreds of species to extinction
  - Dodo bird, Carolina parakeet, passenger pigeon
- Multitudes of others teeter on the brink of extinction
  - Whooping crane, Kirtland's warbler, California condor

The ivory-billed woodpecker may not be extinct

Baiji – Yangtze River Dolphin

- Arkive entry

People have hunted species to extinction



Extinctions followed human arrival on islands and continents

Current extinction rates are higher than normal

- The current extinction rate is 100 to 1,000 times greater than the background rate
- This rate will increase tenfold in future decades
  - Human population growth and resource consumption
- **The Red List** = species facing high risks of extinction
  - Mammal species (21%), bird species (12%)
  - 17–74% of all other species
- In the U.S., in the last 500 years, 237 animal and 30 plant species have been confirmed extinct
  - Actual numbers are undoubtedly higher

What is extirpation?

- the disappearance of a population from a given area, but not the entire species globally
  - Can lead to extinction

- Ex. #1
  - Bald Eagle was extirpated from RI, but is now back

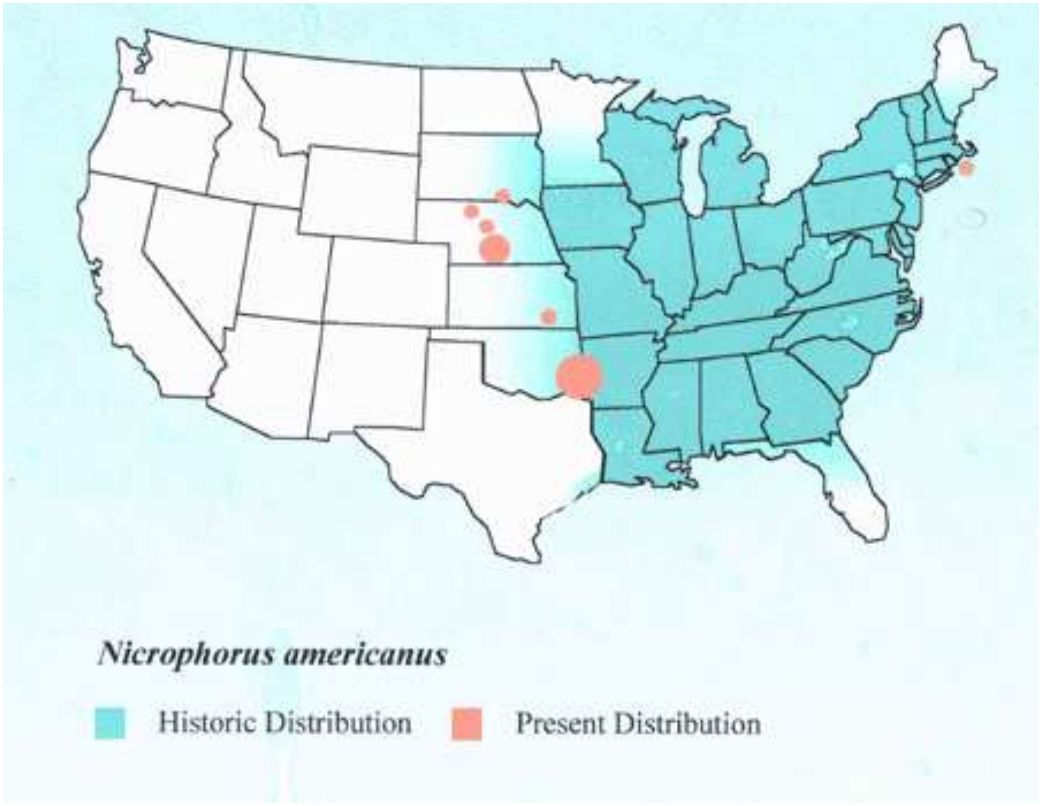
Scituate Reservoir off 116

http://www.pbase.com/kbphotos/ri_bald_eagles

http://www.pbase.com/kbphotos/ri_bald_eagles

- Ex. #2
  - American Burying Beetle is *extirpated* from almost all of it's range except Block Island on East Coast

Click image for video

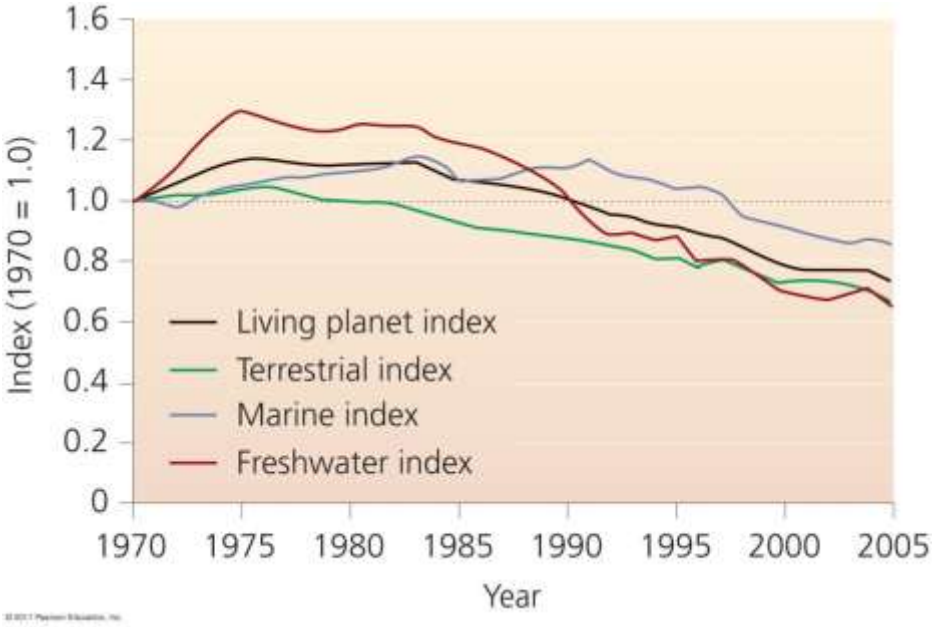


Your examples of Endangered Species?

Biodiversity loss is more than extinction

- Smaller populations have smaller species' geographic ranges
- The *Living Planet Index* summarizes population trends
  - Between 1970 and 2005, the index fell by 28%

Genetic, ecosystem, and species diversity is being lost



Living Planet Index

- What does the LPI tell us?
- What are the current trends?

- LPI Web Page

Causes of species extinction

- Primary causes spell “HIPPO - C”:
  - **H**abitat alteration
  - **I**nvasive species
  - **P**ollution
  - **P**opulation growth
  - **O**verexploitation
  - **C** – Carbon Caused Climate Change

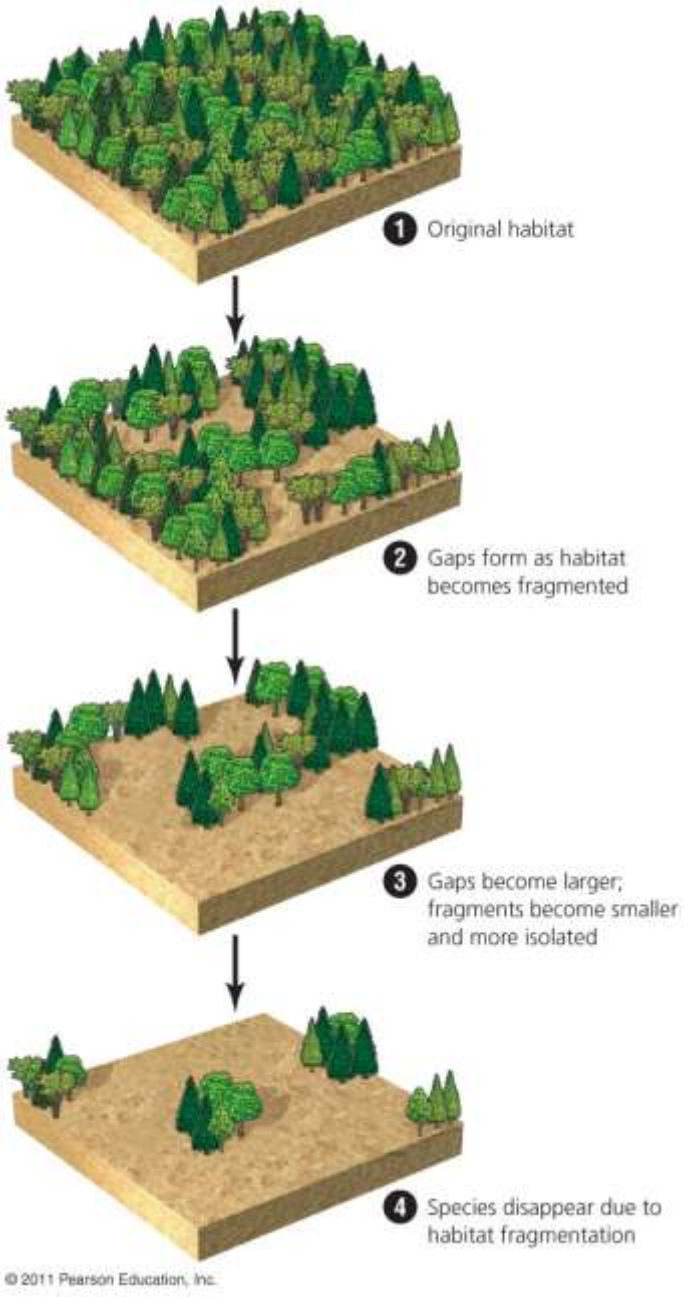
"HIPPO": Habitat alteration

- The greatest cause of biodiversity loss
- Habitats are destroyed, fragmented, and degraded
  - Farming simplifies communities
  - Grazing modifies grassland structure and composition
  - Clearing forests removes resources organisms need
  - Hydroelectric dams turn rivers into reservoirs
  - Suburban sprawl replaces natural communities

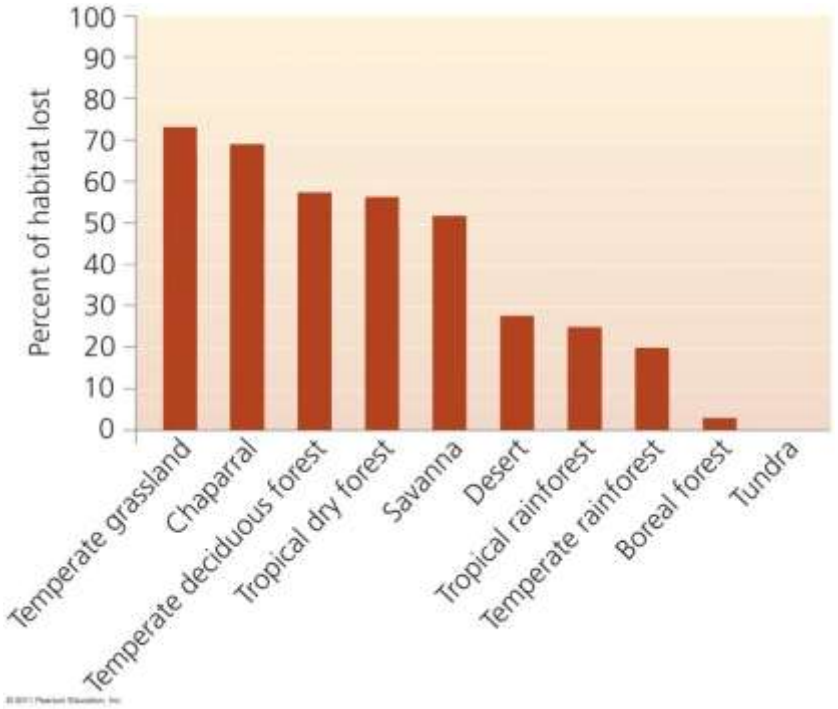
A few species (e.g., pigeons, rats) benefit from changing habitats

Habitat fragmentation

- **Habitat fragmentation** = gradual, piecemeal degradation of habitat
  - Farming, roads, logging, etc.
- Continuous habitats are broken into patches
  - Species needing that habitat disappear
- Landscape-level strategies try to optimize areas to be preserved



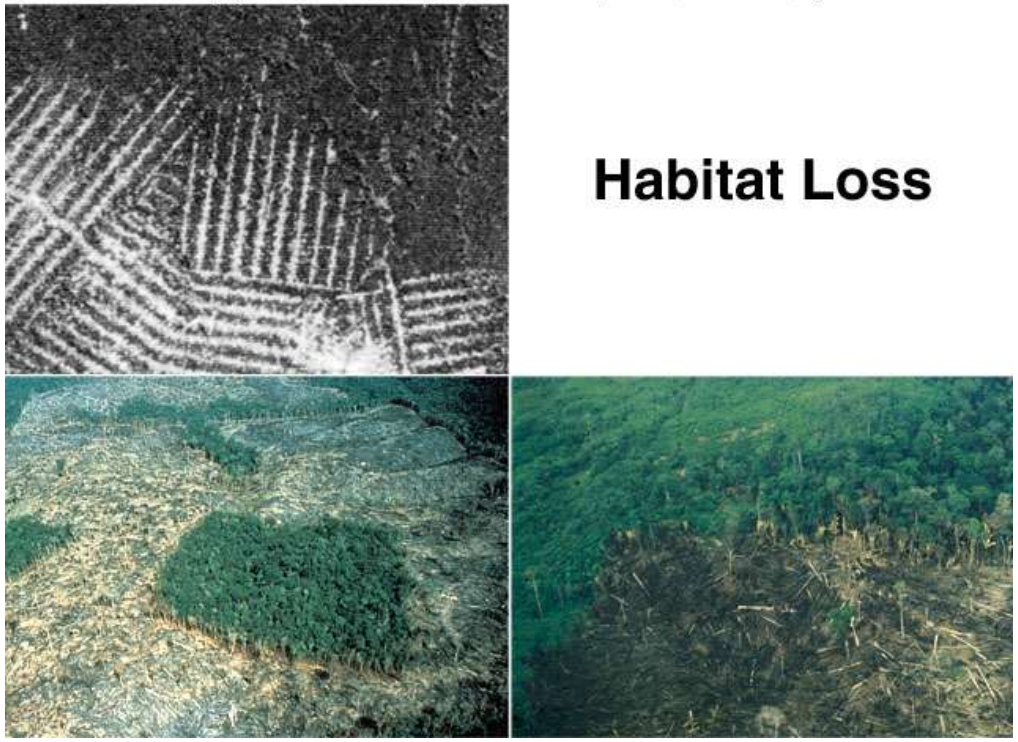
Habitat loss occurs in every biome



- Habitat loss is responsible for declines for 83% of mammals and 85% of birds
- 99% of U.S. prairies have been converted to agriculture
  - Grassland birds have declined 82–99%

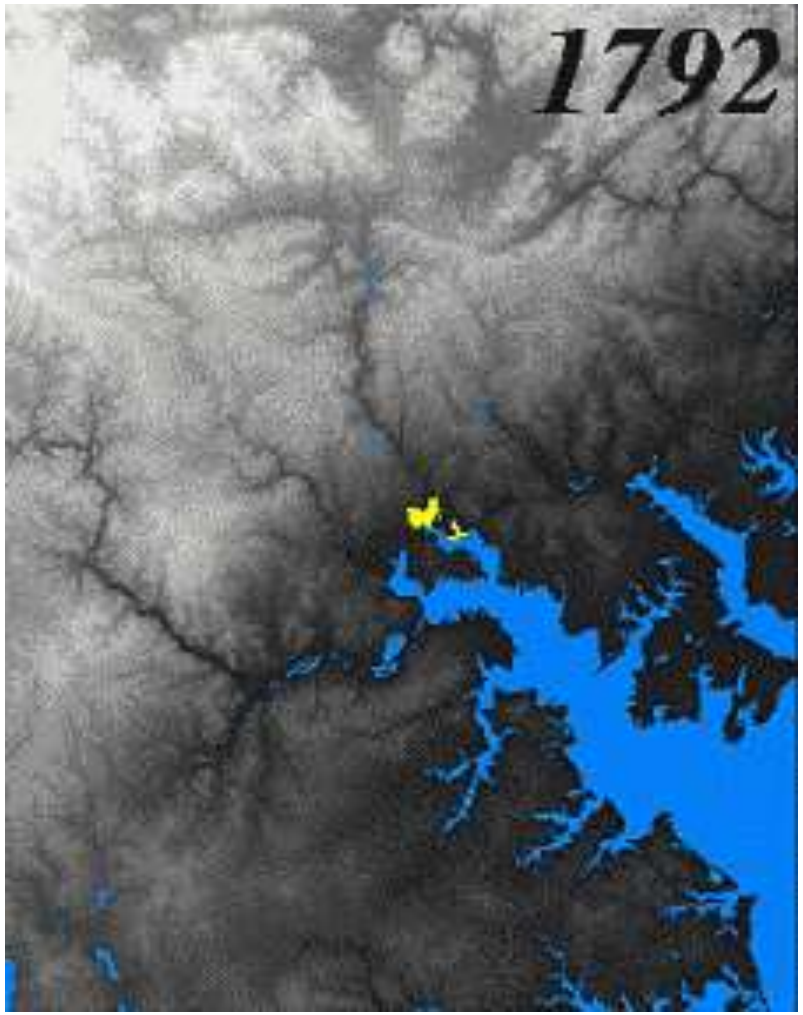
Role of Habitat Loss and Fragmentation

- Reduction of habitats by occupation or degradation is the biggest threat to all wild species.
- Tropical deforestation is the biggest threat, followed by destruction of coral reefs, grasslands, and pollution of water.



New housing development in CT begins to fragment forest.

Urban Sprawl Outside Atlanta



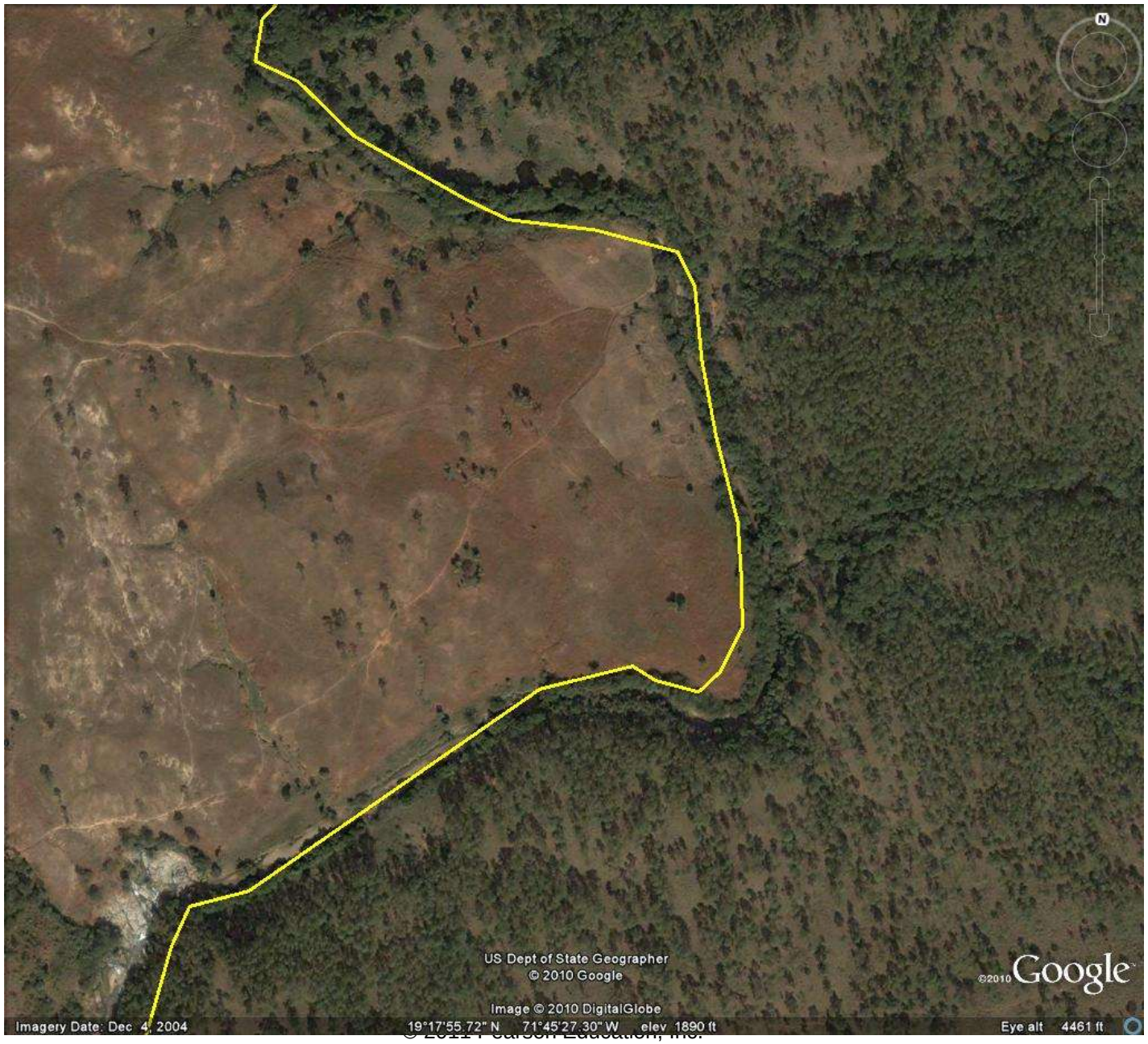
Urban Sprawl around Baltimore

Amazon Road Building


COSTA RICA
1940 - 1983 FOREST CHANGE
1940 FOREST
1983 FOREST
PRIMARY ROADS
SECONDARY ROADS
UNIMPROVED/TRAILS
RAILROADS

Haiti

D.R.



"HIPPO": Invasive species

•Accidental or intentional introduction of exotic species to new areas

•Most do not establish or expand, but some do—likely because they are "released" from limitations imposed by their native predators, parasites, and competitors.

•In today's globalizing world,

- invasive species have become perhaps the second-worst threat to native biota.

Invasive species cause biodiversity loss

- Island species are especially vulnerable
- Invaders lack natural predators, competitors, or parasites
- *Invaders cost billions of dollars in damage each year*

Invasive Species

Species	Invasive in...	Effects
Gypsy moth *(Lymantria dispar)* 	Northeastern United States (Native to Eurasia)	In the 1860s, a scientist introduced the gypsy moth to Massachusetts in the belief that it might help produce a commercial-quality silk. The moth failed to start a silk industry, and instead spread through the northeastern United States, where its outbreaks defoliate trees over large regions every few years.
European starling *(Sturnus vulgaris)* 	North America (Native to Europe)	The bird was first introduced to New York City in the late 19th century by Shakespeare devotees intent on bringing every bird mentioned in Shakespeare's plays to America. It only took 75 years for starlings to spread to all corners of North America, becoming one of the continent's most abundant birds. Starlings are thought to outcompete native birds for nest holes.
Cheatgrass *(Bromus tectorum)* 	Western United States (Native to Eurasia)	In just 30 years after its introduction to Washington state in the 1890s, cheatgrass has spread across much of the western United States. It crowds out other plants, uses up the soil's nitrogen, and burns readily. Fire kills many of the native plants, but not cheatgrass, which grows back even stronger amid the lack of competition.
Brown tree snake *(Boiga irregularis)* 	Guam (Native to Southeast Asia)	Nearly all native forest bird species on the South Pacific island of Guam have disappeared. The culprit is the brown tree snake, brought to the island inadvertantly as stowaways in cargo bays of military planes in World War II. Guam's birds had not evolved with tree snakes, and so had no defenses against the snake's nighttime predation. The snakes have spread to other islands where they are repeating their ecological devastation. The arrival of this snake is the greatest fear of conservation biologists in Hawaii.
Kudzu *(Pueraria montana)* 	Southeastern United States (Native to Japan)	Kudzu is a vine that can grow 30 m (100 ft) in a single season. The U.S. Soil Conservation Service introduced kudzu in the 1930s to help control erosion. Adaptable and extraordinarily fast-growing, kudzu has taken over thousands of hectares of forests, fields, and roadsides.
Asian long-horned beetles *(Anoplophora glabripennis)* 	United States (Native to Asia)	Having arrived in imported lumber in the 1990s, these beetles burrow into trees and interfere with the trees' ability to absorb and process water and nutrients. They may wipe out the majority of hardwood trees in an area. Several U.S. cities, including Chicago and Seattle, have cleared thousands of trees after detecting these invaders.
Rosy wolfsnail *(Euglandina rosea)* 	Hawaii (Native to Southeastern United States and Latin America)	In the 1950s, well-meaning scientists introduced the rosy wolfsnail to Hawaii to prey upon and reduce the population of another invasive species, the giant African land snail. Within a few decades, however, the carnivorous rosy wolfsnail had instead driven more than half of Hawaii's native species of banded tree snails to extinction.

Asian Carp

- Discovery Magazine Video

Strange Days - Invaders Video Clip?

"HIPPO": Pollution

- Pollution harms organisms in many ways
  - Air pollution degrades forest ecosystems
  - Water pollution impairs fish and amphibians
  - Agricultural runoff harms terrestrial and aquatic species
  - Toxins, garbage, oil, and chemicals impact organisms
- Damage to wildlife and ecosystems caused by pollution can be severe
  - But it is less than the damage caused by habitat alteration or invasive species

"HIPPO": Population growth

•*Human population growth exacerbates every other environmental problem.*

•Magnifies effects of the other elements of HIPPO:

- More people means more habitat change, more invasive species, more pollution, more overexploitation.

•Along with increased resource consumption, **it is the *ultimate* reason behind proximate threats to biodiversity**.

"HIPPO": Overexploitation

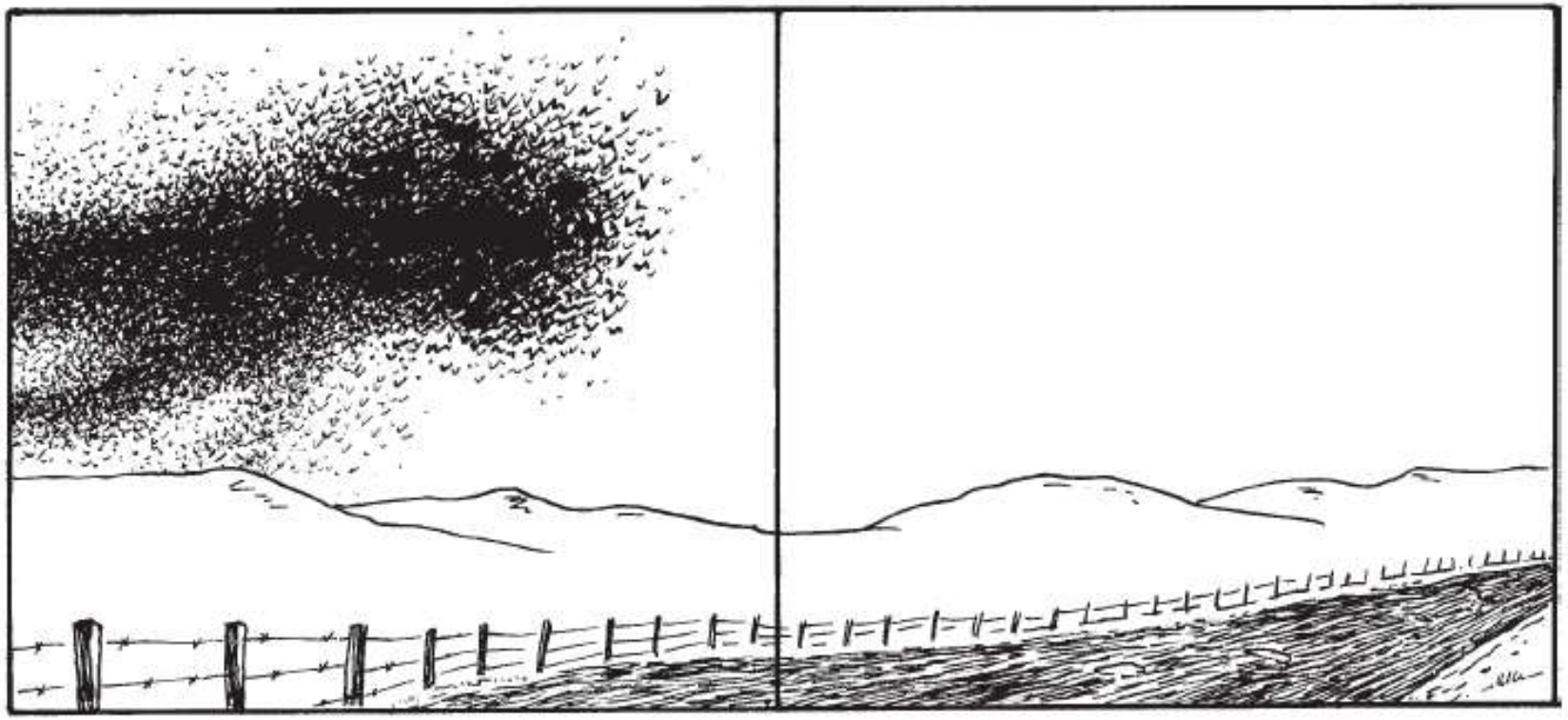
- Vulnerable species: K-selected
  - Large, few in number, long-lived, and have few young
- The Siberian tiger is hunted without rules and regulations
  - Powerful economic incentives increase poaching
- Many other species are affected
  - Whales, sharks, gorillas
  - The oceans contain only 10% of the large animals they once did

"HIPPO": Overexploitation

- Two meanings:
  - Overharvesting of species from the wild
  - *(too much hunting, fishing…)*
  - Overconsumption of resources
  - *(too much timber cutting, fossil fuel use…)*
- Usually overexploitation is not the sole cause of extinction, but it often contributes in tandem with other causes.

Passenger Pigeon

PASSENGER PIGEONS...



1814...

...1914

Around one hundred and eighty years ago, a famous birdwatcher called John James Audubon wrote about the arrival of one flock:

"...Everything was ready and all eyes were fixed on the clear sky that could be glimpsed amidst the tall tree tops... Suddenly a general cry burst forth 'Here they come!' The noise they made, even though still distant, reminded me of a gale at sea. As the birds arrived and passed over me, I could feel a blast of air from their wings. Then I saw a magnificent, wonderful, terrifying sight. The pigeons, arriving by their thousands, landed everywhere, until solid masses were formed on the branches all around. Here and there perches gave way with a crack under the weight, and fell to the ground, destroying hundreds of birds underneath. The scene was one of uproar and confusion. The birds made so much noise that I found it quite useless to speak, or even shout, to the persons next to me. Even the sounds of the hunters' guns could not be heard...

"The uproar continued the whole night. I was anxious to know how far the sound could be heard, so I sent off a man used to roaming the forests, who returned in two hours to tell me that he heard it distinctly five kilometres away from the roosting place.."

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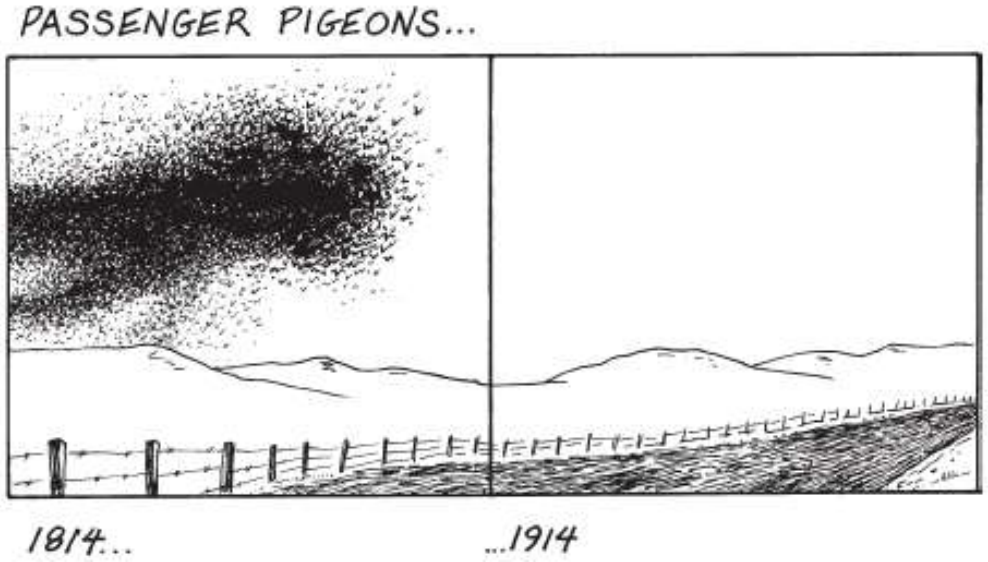
Just one hundred years after this was written, a solitary bird sat in a cage in the St. Louis zoo. Its long tail and bright feathers showed that it was a Passenger Pigeon. A sign on the door proclaimed that its name was Martha. She would often sit with her head cocked to one side, looking at the sky intently as if waiting for a huge flock of Passenger Pigeons to fly over. But no more flocks would ever darken the skies again, no feathered wings would ever fan the air into a wind: for Martha was the last of her kind, the last passenger pigeon to live on the earth. On September the First, in the year nineteen hundred and fourteen, Martha died, and the Passenger Pigeon became extinct.



Martha

- Martha, thought to be the world's last passenger pigeon, died on September 1, 1914, in Cincinnati, Ohio.

African Elephant

Overfishing and Aquatic Biodiversity

- Fisheries are concentrations of particular aquatic species used for commercial harvesting in a given ocean area or inland body of water.

Methods for Harvesting Fish

- Trawling – catching demersal fish by dragging a funnel shaped net along the ocean bottom

- Purse-seine fishing – locating a school of fish and surrounding it with a circular net.

Methods for Harvesting Fish

- Longlining – dragging long lines up to 130 kilometers with thousands of baited hooks
- Drift-net fishing – monster nets drifting in water, one side being pulled by a boat. This netting catches fish by their gills.

Drift-Netting

- Drift-Netting is the most dangerous of all methods. In 1990, the U.N. declared a moratorium on the use of drift nets due to their danger. It is impossible to monitor the size of all nets in the ocean, so compliance is voluntary.

Biodiversity of Freshwater and Marine Systems

- Freshwater is the most vulnerable water
- Only 1% of the earth's surface is freshwater, but it is home to 12% of all known species (including 41% of all known fish species).

Fishy Problems

- Currently, 34% of the known fish species are at risk of being extinct.
- Coastal developments threaten marine diversity in half of the world's coasts. Europe and Asia have the worst problems with 86 and 69% of their coasts being affected, respectively.

Add Climate Change to the List of Major Causes of Extinction

Changing climates will affect many species including:

- Arctic and Antarctic Species
  - Polar bears
  - Penguins
- Mountain species
- All ocean $CaCO_3$ based species due to acidification
- Species already under threat – lessens room for error

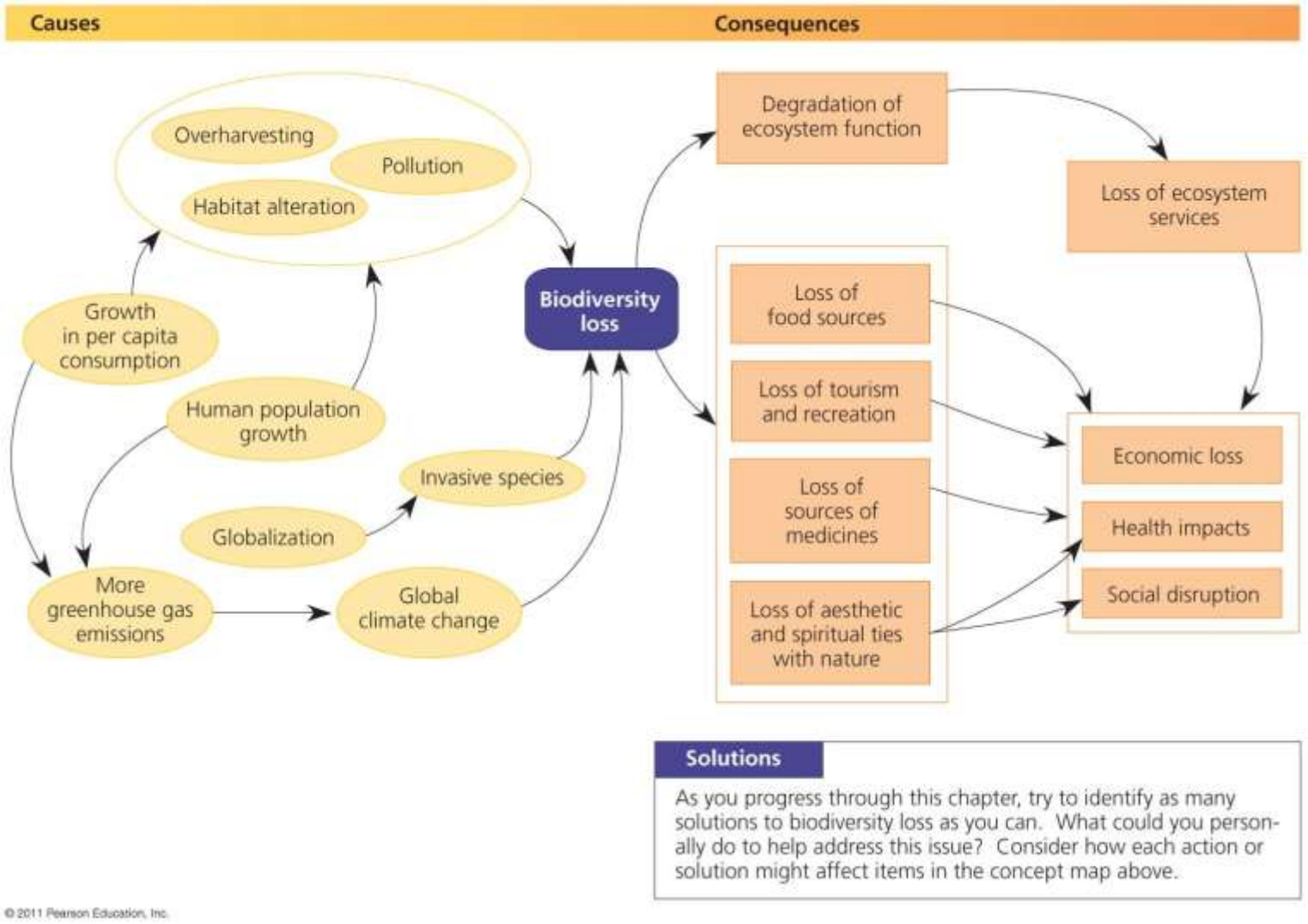
Climate change causes biodiversity loss

- Human manipulation of Earth's climate system has global impacts on biodiversity
- Emission of greenhouse gases warms temperatures
  - Modifying global weather patterns
- The frequency of extreme weather events increases
  - Droughts, etc.
- Increased stress forces organisms to shift their geographic ranges
  - Most animals and plants will not be able to adapt
  - 20–30% of species are at increased risk of extinction

Warming has been the greatest in the Arctic

Because of melting ice, polar bears can't hunt seals, so they were added to the endangered species list in 2008

Causes and consequences of biodiversity loss



Biodiversity provides free ecosystem services

- Provides food, fuel, fiber, and shelter
- Purifies air and water and detoxifies wastes
- Stabilizes climate, moderates floods, droughts, wind, temperature
- Cycles nutrients, renews soil fertility
- Pollinates plants and controls pests and disease
- Maintains genetic resources
- Provides cultural and aesthetic benefits
- Allows us to adapt to change

The value of 17 ecosystem services = $46 trillion per year

Biodiversity helps maintain ecosystem function

- It increases stability and resilience of natural systems
- Decreased biodiversity reduces a system's ability to function and provide services to our society
- The loss of a species affects ecosystems differently
  - If the species can be functionally replaced by others, it may make little difference
  - Loss of keystone species, ecosystem engineers, or top predators causes other species to decline or disappear
- "To keep every cog and wheel is the first precaution of intelligent tinkering" (Aldo Leopold)

Biodiversity enhances food security

- Industrial agriculture has narrowed our diet
  - Wild and rare species can improve food security
- New potential food crops are waiting to be used
  - Serendipity berry is 3,000 times sweeter than sugar
- Genetic diversity within crops is enormously valuable
  - Turkey's wheat crops received $50 billion worth of disease resistance from wild wheat
- Wild strains provide disease resistance
  - Many grow back year after year without being replanted

Some potential new food sources

Food Security and Biodiversity: Potential new food sources

Species	Native to...	Potential uses and benefits
Amaranths (three species of *Amaranthus*) 	Tropical and Andean America	Grain and leafy vegetable; livestock feed; rapid growth, drought resistant
Buriti palm *(Mauritia flexuosa)* 	Amazon lowlands	"Tree of life" to Amerindians; vitamin-rich fruit; pith as source for bread; palm heart from shoots
Maca *(Lepidium meyenii)* 	Andes Mountains	Cold-resistant root vegetable resembling radish, with distinctive flavor; near extinction
Babirusa *(Babyrousa babyrussa)* 	Indonesia: Moluccas and Sulawesi	A deep-forest pig; thrives on vegetation high in cellulose and hence less dependent on grain
Capybara *(Hydrochoeris hydrochoeris)* 	South America	World's largest rodent; meat esteemed; easily ranched in open habitats near water
Vicuna *(Lama vicugna)* 	Central Andes	Threatened species related to llama; source of meat, fur, and hides; can be profitably ranched
Chachalacas (*Ortalis*, many species) 	South and Central America	Tropical birds; adaptable to human habitations; fast-growing

Organisms provide drugs and medicines

- Wild species produce $150 billion/year of drugs
- Every species that goes extinct is a lost opportunity to cure disease

Medicines and Biodiversity: Natural sources of pharmaceuticals

Plant	Drug	Medical application
Pineapple (*Ananas comosus*) 	Bromelain	Controls tissue inflammation
Autumn crocus (*Colchicum autumnale*) 	Colchicine	Anticancer agent
Yellow cinchona (*Cinchona ledgeriana*) 	Quinine	Antimalarial
Common thyme (*Thymus vulgaris*) 	Thymol	Cures fungal infection
Pacific yew (*Taxus brevifolia*) 	Taxol	Anticancer (especially ovarian cancer)
Velvet bean (*Mucuna deeringiana*) 	L-Dopa	Parkinson's disease suppressant
Common foxglove (*Digitalis purpurea*) 	Digitoxin	Cardiac stimulant

Pacific Yew and Taxol

Spider find. A compound in the venom of black widow spiders found in the Negev Desert in Israel may hold promise for treating strokes.

Rosy periwinkle (*Catharanthus roseus*) gave rise to two important drugs, vinblastine and vincristine, which are used to treat Hodgkin's disease and childhood leukemia, respectively.

Together, the two drugs, manufactured primarily by Eli Lilly, net $100 million dollars annually, yet the source countries have never received a penny in royalties or other compensation.

Bioprospecting

- Pharmaceuticals
- Genes for improving food
- Microbes for metal extraction
- Microbes and plants for toxic waste cleanup

PCB Degrader

Species may go extinct before they can help

Gastric brooding frogs went extinct in the 1980s—taking their medical secrets with them forever

Major types of animals that offer potential medical benefits but that are threatened with extinction of key species

Animal	Potential medical uses	Extinction risks
Amphibians 	• Antibiotics, alkaloids for pain-killers, chemicals for treating heart disease and high blood pressure • Natural adhesives for treating tissue damage • Study of newts and salamanders that can regenerate organs and tissues could suggest how we might, too. • "Antifreeze" compounds that allow frogs to survive freezing might help us preserve organs for transplants.	30% of all species are threatened with extinction (see The Science behind the Story, pp. 294–295).
Bears 	• An acid from bears' gall bladders already treats gallstones and liver disease, and prevents bile buildup during pregnancy. • While hibernating, bears build bone mass. If we learn how they do it, we could treat osteoporosis and hip fractures, which lead to 740,000 deaths per year. • Hibernating bears excrete no waste for months. If we can learn how, this could help treat renal disease, which kills 80,000 people in the U.S. each year.	Nine species are at risk of extinction.
Cone snails 	• Compounds found from these snails include one that may prevent death of brain cells from head injuries or strokes, and a pain-killer 1,000 times more potent than morphine. But so far just a few hundred of the 70,000–140,000 compounds these snails produce have been studied.	Most live in coral reefs, which are threatened ecosystems (pp. 439–442).
Sharks 	• Squalamine from sharks' livers could lead to novel antibiotics, appetite-suppressants, drugs to shrink tumors, and drugs to fight vision loss. • Study of sharks' salt glands is helping address kidney diseases. • Study of sharks' immune systems may shed light on our own.	Overfishing has reduced populations of most species, and some now risk extinction.
Horseshoe crabs 	• A number of antibiotics are being developed. • The compound T140 may be more effective than AZT in treating AIDS, and could also help treat arthritis and several cancers. • Cells from blood can help detect cerebral meningitis in people.	Overfishing is sharply diminishing populations.

Biodiversity generates economic benefits

- Biodiversity generates income through tourism
  - Especially in developing countries
- Costa Rica: rainforests
- Australia: Great Barrier Reef
- Belize: reefs, caves, and rainforests
- Tanzania: savanna wildlife
- A powerful incentive to preserve natural areas
  - Reduce impacts on the landscape and species
- But too many visitors to natural areas can degrade the outdoor experience and disturb wildlife

Biomimicry (not in book)

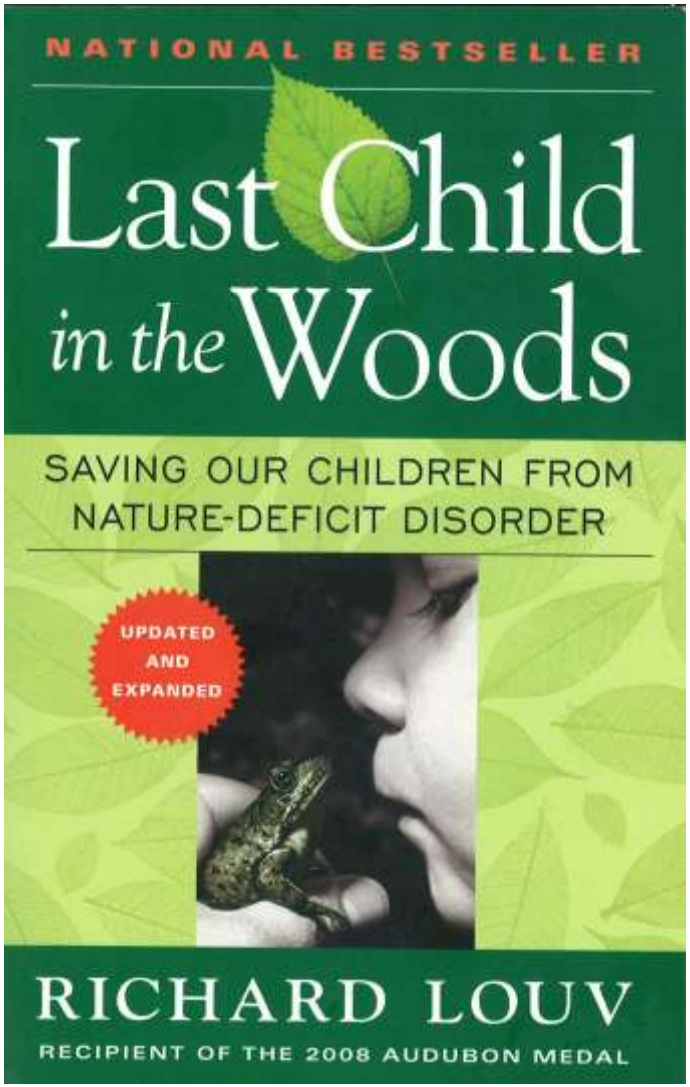
- TED Talk – Biomimicry in Action

People value and seek out nature

- **Biophilia** = humans love nature and have an emotional bond with other living things
  - We have an affinity for parks and wildlife
  - We love our pets
  - We value real estate with views of natural lands

“Nature deficit disorder” = alienation from biodiversity and nature

- May be behind the emotional and physical problems of the young



Biophilia

E. O. Wilson popularized the notion of biophilia

We have an emotional bond with other living things

Do we have ethical obligations to other species?

- Many people feel that other organisms have an inherent right to exist
  - "If species aren't worthy of saving, then what are we all about? What is worth saving?"

Conservation biology: the search for solutions

- **Conservation biology** = studies the factors behind the loss, protection, and restoration of biodiversity
  - Scientists became alarmed at the degradation of natural systems
  - Relatively new: Term first used in 1978

- An applied and goal-oriented science
- Conservation biologists integrate evolution, extinction, ecology, and environmental systems
  - Design, test, and enact ways to decrease our impacts

Conservation biology: the search for solutions

- *Conservation geneticists* = study genetic attributes of organisms to infer the status of their populations
- *Minimum viable population size* = how small a population can become before it runs into problems
- *Metapopulations* = a network of subpopulations
  - Small populations are most vulnerable to extinction and need special attention

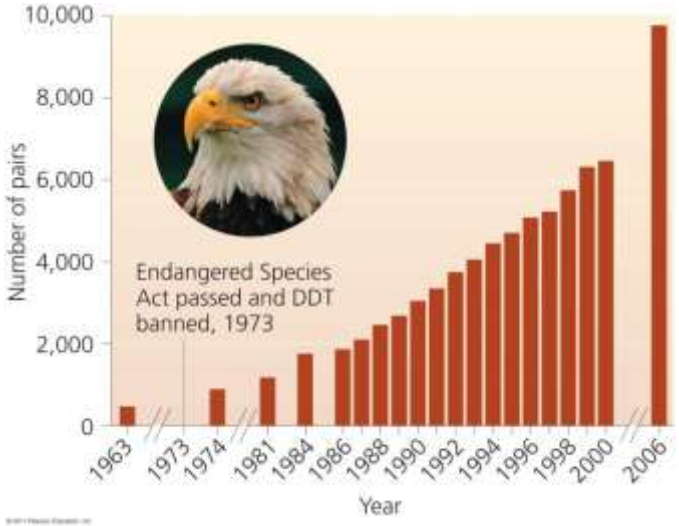
Conservation focuses on endangered species

- **Endangered Species Act** (**ESA**) (1973) = the primary U.S. legislation for protecting biodiversity
- It forbids the government and citizens from taking actions that destroy endangered species or their habitats
  - Or trading in products made from endangered species
- The ESA's goal is to prevent extinction
  - Stabilize declining populations
  - Enable populations to recover
- In 2010, the U.S. had 1,010 species listed as endangered and 314 listed as threatened

The ESA has been successful

- Intensive management has saved or stabilized species
  - 40% of declining populations are now stable
- These successes occur despite problems
  - Underfunding of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service
  - Recent political forces have tried to weaken the ESA

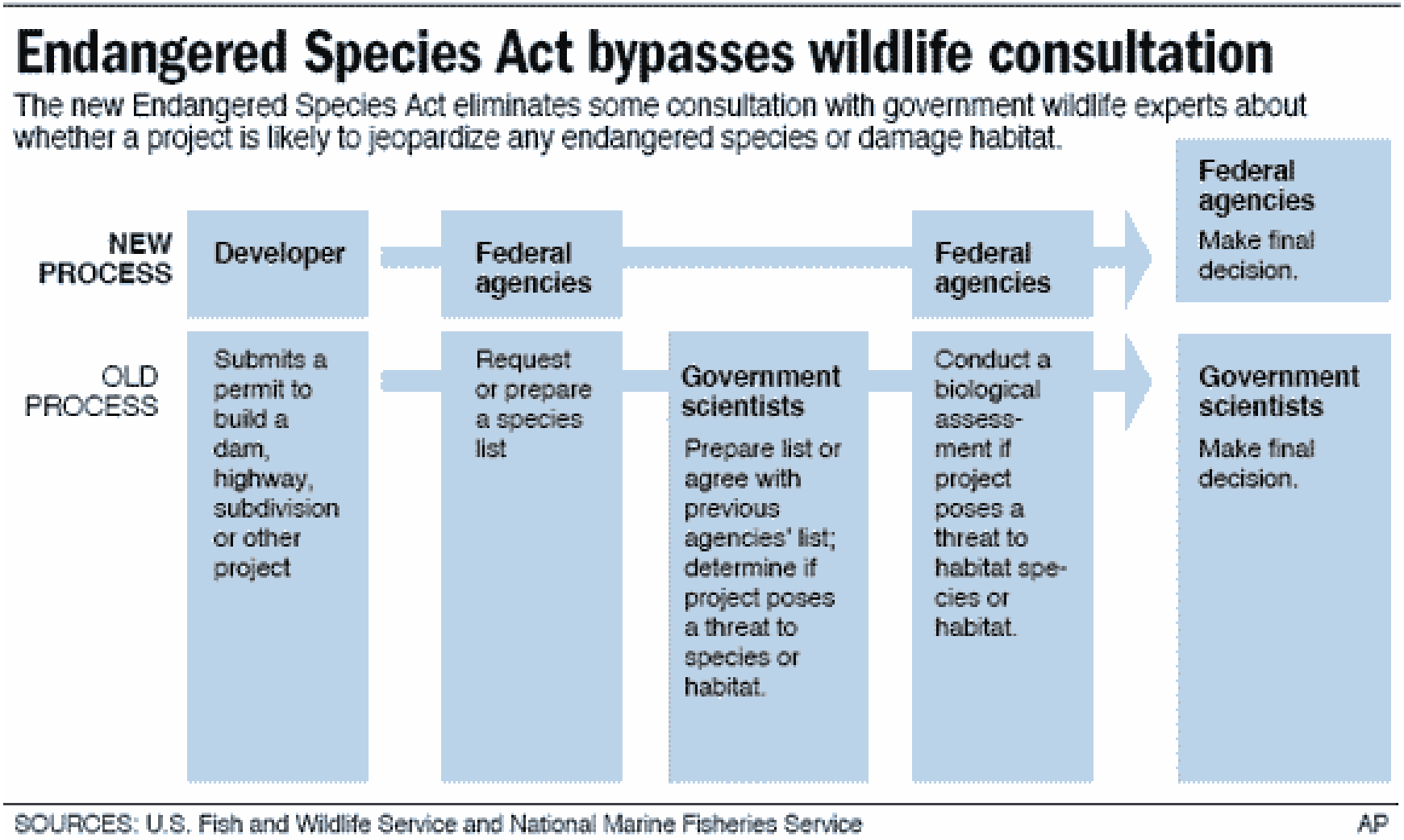
Peregrine falcons, brown pelicans, bald eagles, and others have recovered and are no longer listed



The ESA is controversial

- Many Americans support protecting endangered species
- Opponents feel that the ESA values endangered organisms more than the livelihood of people
  - Protection will restrict land use and cost jobs
  - "Shoot, shovel, and shut up" = landowners conceal the presence of endangered species on their land
  - But the ESA has stopped few development projects
- *Habitat conservation plans* and *safe harbor agreements*
  - Landowners can harm species if they improve habitat for the species in other places

Changes Done (below) and Undone (link)…



Species protection can be controversial

- Protecting the northern spotted owl slowed logging in old-growth rainforests
- Loggers feared for their jobs
  - Landowners feared restrictions

Other countries protect species

- *Species at Risk Act* (*SARA*) (2002) = Canada's endangered species law
  - Stresses cooperation between landowners and provincial governments
  - Criticized as being too weak
- Other nations' laws are underfunded or not enforced
  - The Wildlife Conservation Society has to help pay for Russians to enforce their own anti-poaching laws

International conservation efforts

- **UN 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 biodiversity in a sustainable manner
  - Ensure the fair distribution of biodiversity's benefits
- By 2010, 193 nations had signed on to the Convention
  - Only Andorra, the Vatican, and the U.S. did not join

The Convention on Biological Diversity

- The Convention aims to:
  - Provide incentives to conserve biodiversity
  - Manage access to and use of genetic resources
  - Transfer technology (including biotechnology)
  - Promote scientific cooperation
  - Assess human effects on biodiversity
  - Promote biodiversity education and awareness
  - Provide funding for critical activities
  - Encourage nations to report on conservation efforts
- Despite some successes, biodiversity is still being lost

Protecting biodiversity: captive breeding

- **Captive breeding** = individuals are bred and raised so they can be reintroduced into the wild
  - 65 plant and animal species exist *only* in captivity
- Reintroductions can be controversial
  - Ranchers opposed reintroducing wolves to Yellowstone National Park
  - Fragmented habitat must be improved before releasing animals

Biologists have raised condor chicks in captivity with the help of hand puppets that look like the heads of adult condors

Protecting biodiversity: cloning

- Cloning creates more individuals and saves species from extinction
  - DNA from an endangered species is inserted into an egg without a nucleus
  - The egg is inserted into a closely related species
- Several mammal species have been cloned
  - But these efforts are not enough to recreate lost biodiversity
- Without ample habitat and protection in the wild, having cloned animals in a zoo does little good

Forensics protects threatened species

- *Forensic science* (*forensics*) = analyzes evidence to identify or answer questions relating to a crime
- Conservation scientists use forensics to protect species
  - Researchers use DNA to identify a species or subspecies and its geographic origin
- Detecting illegal activity helps enforce laws protecting wildlife
  - For example, whale meat is analyzed in Asian markets
  - DNA from killed elephants shows many more were killed than the Zambian government admitted

Umbrella species protect others

- Conservation biologists use particular species as tools to conserve communities and ecosystems
- ***Umbrella species*** = species that, when protected, also help protect other, less charismatic species
  - Often large species that need large amounts of habitat
  - Protecting their habitat automatically protects others

- *Flagship species* = large and charismatic species used as spearheads for biodiversity conservation
  - The World Wildlife Fund's panda bear

- Some organizations are moving beyond the single-species approach to focus on whole landscapes

Parks and protected areas

- Setting aside land in parks and preserves conserves habitats, communities, ecosystems, and landscapes
  - 12% of the world's area is in parks, wilderness, reserves, etc.
- But these areas are not all managed for biodiversity
  - They are used for recreation, water protection, etc.
  - They are also illegally logged, etc.
  - Many are not large enough to preserve whole systems

- ***Park boundaries*** tend to be ecologically ***arbitrary***; thus, parks usually do not include entire ecosystems.

Lake Manyara National Park, Tanzania

- Migration patterns of elephants weren't taken into account
- Farms on Northern boundary were established and promptly raided by elephants
- Solution was to move boundary

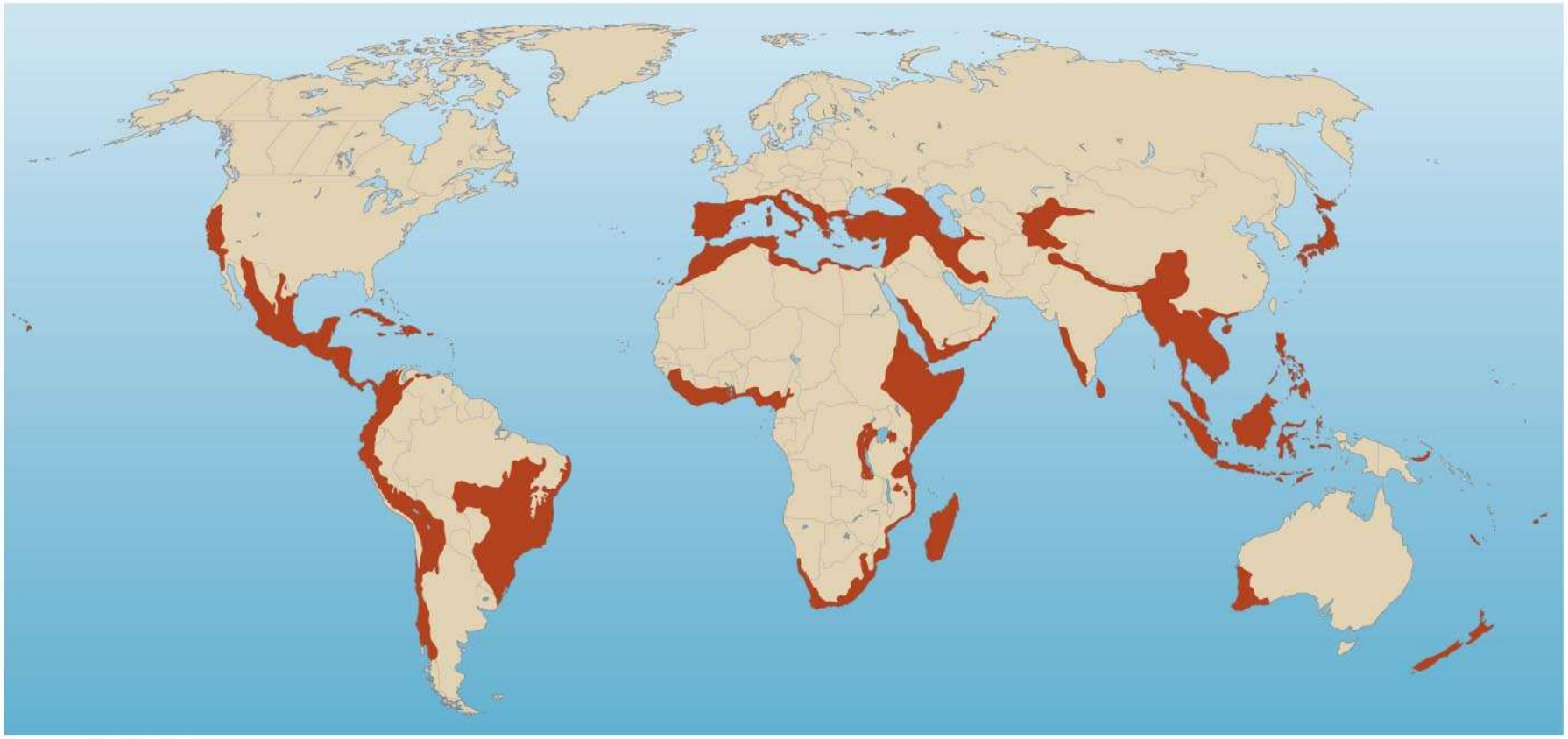
Biodiversity hotspots

- **Biodiversity hotspots** = prioritizes regions most important globally for biodiversity
  - Support a great number of **endemic species** = species found nowhere else in the world
- The area must have at least 1,500 endemic plant species (0.5% of the world total)
  - It must have lost 70% of its habitat due to humans

Focusing on hotspots protects the greatest number of species per unit effort

There are 34 global biodiversity hotspots

2.3% of the planet's land surface contains 50% of the world's plant species and 42% of all terrestrial vertebrate species



Using innovative economic strategies

- *Debt-for-nature swap* = a conservation organization pays off a portion of a developing country's international debt
- In exchange, the country promises to set aside reserves to:
  - Fund environmental education and
  - Better manage protected areas
- The U.S.'s Tropical Forest Conservation Act
  - Paid $218 million in debt payments to 13 developing countries for conservation efforts

Conservation concession = conservation organizations pay nations to conserve, and not sell, resources

- Example: Guyana's conservation concession
  - Video Link
  - Site Link

We can restore degraded ecosystems

- The best way to safeguard biodiversity and natural systems?
  - Protect natural areas before they become degraded
- **Ecological restoration** = restores degraded areas to some semblance of their former condition
- *Restoration ecology* = restoring damaged systems to bring back species and reestablish ecological processes
  - Filter pollutants, clean water and air, build soil, etc.

Restoring Iraq's wetlands

- Southern Iraq's wetlands were drained in the 1970s and 1980s under Saddam Hussein, devastating the area
- After the 2003 U.S. invasion, a multi-million dollar international restoration effort began
  - Although successful, 2010's drought caused Turkey and Syria to divert water from the rivers

Nature: Braving Iraq

Drainage and Restoration

(a) Extent of Iraq's marshes

Community-based conservation

- Developing nations often do not support conservationists from developed nations trying to preserve areas
- **Community-based conservation** = conservation biologists engage local people to protect land and wildlife
  - It offers education, health care, and development aid
- Conservation efforts help local people
  - People are retrained and income is supplemented
  - Poaching is reduced
- It ensures that local resources can be sustainably used
- NPR – Namibia's community conservation

Conclusion

- Biodiversity is being lost rapidly and visibly
  - Threatening mass extinction
- Primary causes of biodiversity loss are habitat alteration, invasive species, pollution, overharvesting, and climate change
- Human society cannot function without biodiversity's benefits
- Science can help save species, preserve habitats, restore populations, and keep natural ecosystems intact

Last Yangze Turtles

- Video
- Text

Time – The New Age of Extinction

- Click for graphic
- Madagascar video

Madagascar

QUESTION: Review

Which concept describes the *number* of species in an area?

a) Species evenness
b) Species richness
c) Relative abundance
d) All of the above describe the number of species in an area.

QUESTION: Review

What does “inbreeding depression” result in?

a) The species becoming too large for the resource base
b) Inferior offspring when genetically similar parents mate
c) Superior offspring when genetically similar parents mate
d) Increased number and variety of species

QUESTION: Review

Why does Costa Rica have more bird species than Canada?

a) Costa Rica has a more stable climate.
b) Canada has a more stable climate.
c) Prehistoric glaciers carved out more niches in Costa Rica.
d) Canada has higher plant productivity, but lower bird species.

QUESTION: Review

Which of the following is the major cause of extinction?

a) Invasive species
b) Pollution
c) Habitat loss
d) Overharvesting

QUESTION: Review

Biodiversity does all of the following, EXCEPT:

a) Provide ecosystem services
b) Increase food security
c) Decrease ecosystem function
d) Provide aesthetic benefits

QUESTION: Review

Which branch of science studies factors behind the loss, protection, and restoration of biodiversity?

a) Conservation biology
b) Ecosystem ecology
c) Population genetics
d) Demography

QUESTION: Review

Which statement about biodiversity hotspots is not correct?

a) It must have lost a large percent of habitat due to humans.
b) It must have lost a large percent of habitat due to a variety of factors.
c) It must have many plant species.
d) It contains a large number of endemic species.

QUESTION: Weighing the Issues

The Convention of Biological Diversity, which aims to protect biodiversity, has been signed by 193 nations. Only the Vatican, Andorra, and the United States refuse to sign it. Should the United States sign it?

a) Yes, it's pathetic that the U.S. won't sign a treaty to protect diversity when other countries will.

b) Yes, but only if it does not hurt our economy.

c) No, the U.S. is in the right about not signing it.

d) No, because the Vatican and Andorra are leaders in doing what's right for biodiversity.

QUESTION: Weighing the Issues

Have you ever experienced the biophilia hypothesis?

a) Yes, I frequently feel a connection to other living things and nature
b) Yes, sometimes, on a particularly lovely day
c) Maybe, but I'm not sure
d) Definitely not, unless I was earning money from using nature

QUESTION: Interpreting Graphs and Data

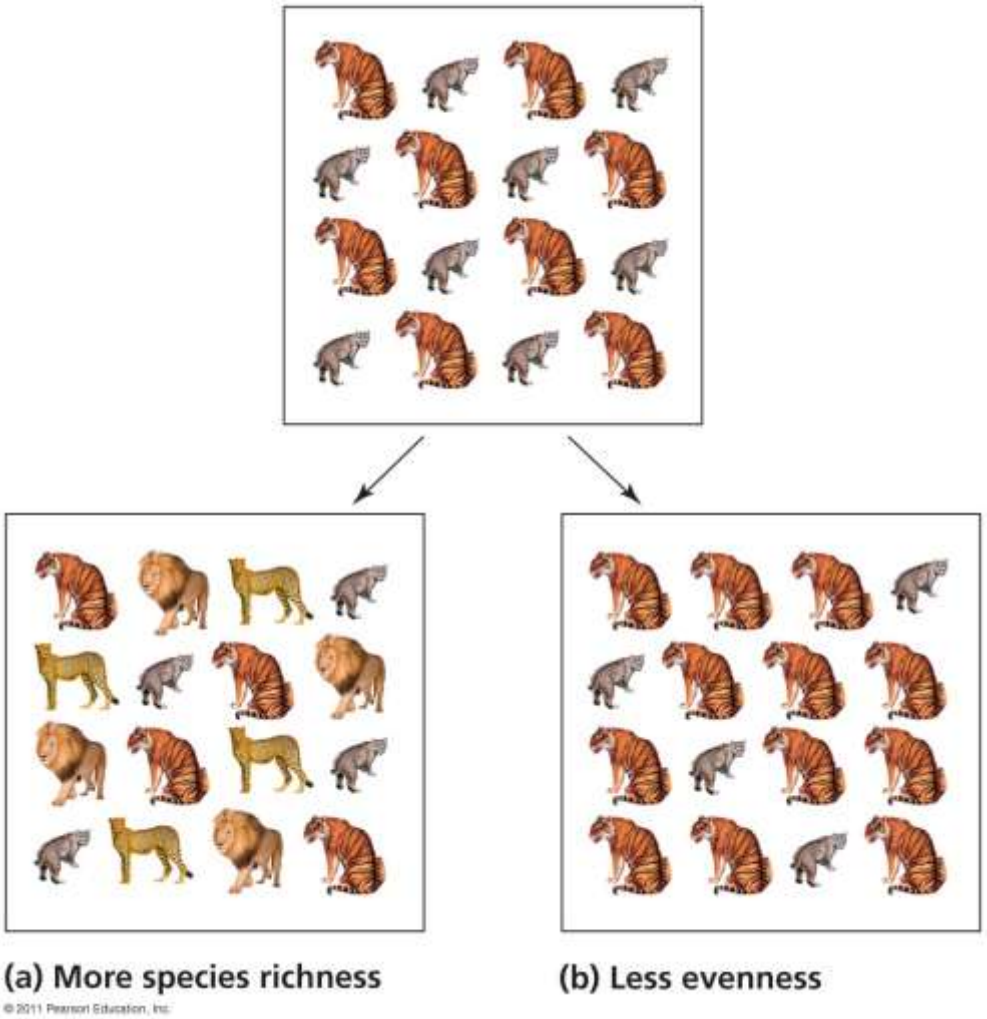
Which area has lower species richness?

a) a

b) b

c) They have equal richness

d) Neither one



QUESTION: Interpreting Graphs and Data

Which biome has lost the most area?

a) Tropical dry forest
b) Desert
c) Savanna
d) Temperate rainforest