Chapter 9 & 10 Sustaining Terrestrial Biodiversity- Part 2

Habitat Destruction, Degradation, & Fragmentation

Loss of habitat is the single greatest threat to biodiversity.

- **Habitat fragmentation**
  - Large intact habitat divided by roads, crops, urban development
  - Leaves habitat islands
  - Blocks migration routes
  - Divides populations
  - Inhibits migrations and colonization
  - Inhibits finding food
- National parks and nature reserves as habitat islands

Theory of Island Biogeography: *Diversity varies with geographical location*
Number of types of species influenced by size & distance from mainland

- Size: larger habitats have more species
- Distance: Closer to mainland and or other habitat = more species

Island biogeography was originally applied to oceanic islands; it has since been applied to the concept of habitat fragmentation, in which areas of more intact habitat exist within greater areas of less hospitable environments.

Fragmentation creates habitat islands with their own metapopulations.

Metapopulation:

- A group of spatially distinct populations that are connected by occasional movements between them.
  Example:
  - Populations of cougars live in separate mountain ranges in New Mexico.
  - Occasionally, however individuals move between mountain ranges.
  - These movements can recolonize mountain ranges with extinct populations and add individuals and genetic diversity to existing populations.

Habitat Corridor:

- A strip of land that aids in the movement of species between disconnected areas of their natural habitat.
  - Provides connectivity between habitat fragments
  - Increase genetic diversity through gene flow
  - Decreases human wildlife conflict
  - Help support more species and allows for migration

Edge Habitat: Habitat that occurs where two different communities come together, typically forming an abrupt transition, such as where grassy field meets forest.

- As habitats are fragmented the area of edge habitat increases along fragment borders
- Increases interaction and competition between species that do not normally interact
- Sometimes these interactions may cause the demise of one species; reduction in biodiversity

Single Large Or Several Small

The SLOSS debate was a debate in ecology & conservation biology during the 1970s and 1980s as to whether a single large or several small (SLOSS) reserves were a superior means of conserving biodiversity in a fragmented habitat.

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Conservation of Biodiversity

Why protect biodiversity? *Functioning ecosystems provide valuable ecosystem services.*

Ecosystem Services

- Provisioning
- Regulating
- Cultural
- Supporting

Provisioning Ecosystem Services

A provisioning service is any type of benefit to people that can be extracted from nature.

- Fruits, vegetables, trees, fish and livestock are available to us as direct products of ecosystems.
- Along with food, other types of provisioning services include:
    - Drinking water
    - Timber
    - Wood fuel, natural gas and oils
    - Plants that can be made into clothes and other materials
    - Medicinal benefits

Regulating Ecosystem Services

Ecosystems provide many of the basic services that make life possible for people. Plants clean air and filter water, bacteria decompose wastes, bees pollinate flowers and tree roots hold soil in place to prevent erosion. All these processes work together to make ecosystems clean, sustainable, functional and resilient to change.

Regulating services include:

- Pollination
- Decomposition
- Water purification
- Erosion and flood control
- Carbon storage and climate regulation

Supporting Ecosystem Services

- Crop pollination
- Natural pest control

Cultural Ecosystem Services

- Aesthetic benefits such as the beauty of nature

Resilience depends greatly on species diversity and in this way, may too be considered an ecosystem service.

- Resilience ensures an ecosystem will continue in its current state and continue to provide benefits to humans.
- Resilience depends greatly on species diversity.
  Example: If a pollutant kills one species that contains nitrogen-fixing bacteria, but does not kill all the plant species that contains nitrogen-fixing bacteria, the ecosystem can continue to fix nitrogen.

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Protecting Ecosystem Services

The Convention on Biodiversity: An international treaty to help protect biodiversity (1992)

- Objectives conserve biodiversity
- Sustainably use biodiversity
- Share benefits of biodiversity

U.N. Millennium Ecosystem Assessment: 2005

- 4-year study; 1,360 scientists; 95 countries; $7 million
- Assessed conditions and trends in the world's ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems.
- Over the past 50 years humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth.
- Human activities have degraded or overused 60% of the earth's natural services.
- Solution: Foster cooperation among residents (often high poverty levels), government and scientists to protect people and biodiversity.

In 2010 the convention evaluated current trends in biodiversity around the world and concluded that:

- On average, species at risk have moved closer to extinction.
- One-quarter of all plant species are still threatened with extinction.
- Natural habitats are becoming smaller and more fragmented.
- The genetic diversity of crops and livestock is still declining.
- There is widespread loss of ecosystem function.
- The causes of biodiversity loss have either stayed the same or increased in intensity.
- The ecological footprint of humans has increased.

Protecting Biodiversity

Globally, National Parks Face Many Environmental Threats

Worldwide: 1100 major national parks

Parks in developing countries have the greatest biodiversity of all parks globally, but only 1% are protected.

Threats to these parks include:

- Illegal animal poaching (illegal hunting)
- Illegal logging and mining

Nature Reserves Occupy Only a Small Part of the Earth's Land

- Currently less than 13% is protected
- Conservationists goal: protect 20%
- Cooperation between government, private groups and individuals

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Biosphere Reserves: The Buffer Zone Concept
Developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO).
669 biosphere reserves in 120 countries
Biosphere reserves have three zones:

1. **Core area**: a strictly protected ecosystem; conservation of landscapes, ecosystems, species and genetic variation.
2. **Buffer zone**: surrounds core areas; activities compatible with sound ecological practices that can reinforce scientific research, monitoring, training and education.
3. **Transition area**: part of the reserve where the greatest activity is allowed; economic and human development that is socio-culturally and ecologically sustainable.

Case Study: Costa Rica- Tropical Rain Forest Conservation
A Global Conservation Leader

- 1963–1983: cleared much of the forest; cattle ranching
- 1986–2006: forests grew from 26% to 51%
- ¼ of land in nature reserves and natural parks Estimated 500,000 plant and animal species
- Earns $1 billion per year in tourism → *Ecotourism*
- Parks & Reserves
    - 8-Mega-reserves

Government eliminated logging subsidies; now pays landowners to manage forest.
Buffer Zones: used for sustainable logging, crop farming, cattle grazing

Biodiversity Hotspots
How can we support the most species at the least cost?
One way is to identify areas where exceptional concentrations of endemic species are undergoing exceptional loss of habitat.
36 biodiversity hotspots
What are the criteria for classification?

1) 1,500 endemic vascular plant species, i.e. found nowhere else;
2) 30% or less of its original natural vegetation, i.e. must be threatened.

They represent just 2.3% of Earth's land surface, but they support more than half of the world's plant species as endemics — i.e., species found no place else — and nearly 43% of bird, mammal, reptile and amphibian species as endemics. 1.2 billion people live in these fragile places and depend on their ecosystem services.

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Sustaining Terrestrial Biodiversity- The Species Approach

Species Extinction: Extinction occurs when the last member of a species dies.

Extinction Rates

Extinctions Are Natural but Sometimes They Increase Sharply

→ All species eventually become extinct.

Extinction rate: percentage or number of species that go extinct in a certain time period

Background extinction rate: the natural low rate of extinction

During the 3.5 billion years that life has existed on Earth there has been a natural, low rate of species extinctions known as the background extinction rate: one extinction per million species per year or .0001%

Extinction Rates Are Increasing Rapidly

UN Millennium Ecosystem Assessment (2005) estimated that the current extinction rate is estimated to be 1,000 times higher during the past 50 years than during any other time in human history and rivals the rates observed during the mass extinction event that eliminated the dinosaurs 65 million years ago.

Human activity has disturbed at least half of the earth's land surface:

- Filling in wetlands
- Converting grasslands and forests to crop fields and urban areas
- Pollution of land and water
- Human population growth will increase this loss
  - ✧ Rates are higher where there are more endangered species
  - ✧ Tropical forests and coral reefs, wetlands and estuaries—sites of new species—being destroyed

Speciation crisis: speciation is the formation of a new species through evolution by means of natural selection; currently, due to habitat loss speciation is decreasing.

Three Levels of Extinction & Mass Extinction

- Local Extinction: not found in parts of range/area it once inhabited but is found other places
- Ecological Extinction: numbers so low it can no longer fulfill niche in communities where it is found
- Biological Extinction: Gone! No individual of the species alive anywhere on the planet.

Mass extinction

- 3-5 events over 500 million years
- 50-95% of species became extinct
- From global changes in environmental conditions: major climate change, volcanoes, asteroid impacts

The Five Mass Extinctions

- **End Ordovician Extinction** (440 million years ago)
  - Supercontinent moves to South Pole; Tectonic uplift and weathering
  - Environmental Factors: Glacial and interglacial episodes caused sea level to rise and fall dramatically, moving shorelines repeatedly. Continental erosion changed atmosphere and ocean temperature.
  - Affected species: 80% extinct; Trilobites, corals, brachiopods, bryozoans, echinoderms, graptolites, nautiloids, conodonts.
- **Late Devonian Extinction** (419 million to 359 million years ago)
  - Rapid growth of land plants
  - Environmental Factors: Land plants consumed atmospheric carbon dioxide (CO_2), which caused global cooling. Weathering plant roots released nutrients into the sea, causing algal blooms and oxygen depletion.
  - Affected species: 75% extinct; Armored fish, corals
- **End Permian Extinction** (299 million to 252 million years ago)
  - Massive volcanic activity in Siberia
  - Environmental Factors: Basalt lava covered vast areas of land. Huge clouds of sulfur dioxide (SO_2) and carbon dioxide (CO_2) caused acid rain, ocean acidification, and global warming.
  - Affected species: 96% extinct; Amphibians, early reptiles, insects, trilobites, sea scorpions, corals

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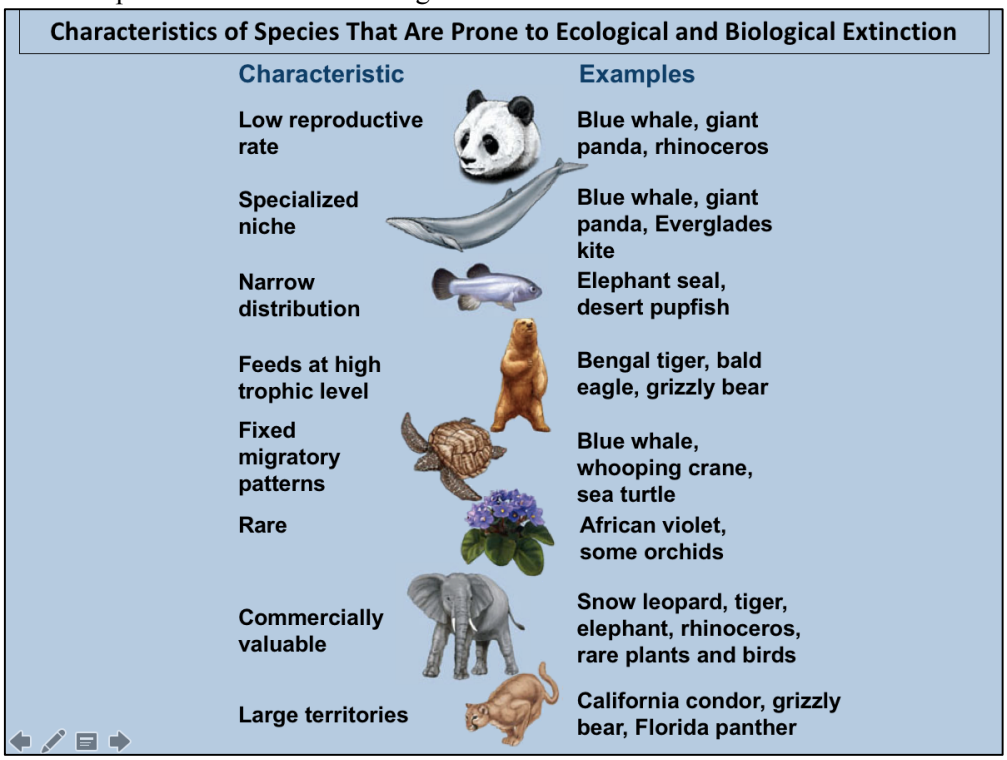
- **Triassic Extinction** (252 million to 201 million years ago)
  - Underwater volcanic activity
  - Environmental Factors: Atmospheric carbon dioxide (CO_2) levels rose, causing global warming and ocean acidification.
  - Affected species: 80% extinct; Amphibians, reptiles, bivalves, conodonts, corals, ammonites, brachiopods
- **Cretaceous Extinction** (66 million years ago)
  - Asteroid impact (Yucatán Peninsula, Mexico)
  - Environmental Factors: Volcanic activity prior to impact acidified oceans and increased global temperatures. Tectonic uplift and erosion enriched oceans with nutrients and depleted them of oxygen. Asteroid impact caused brief superheating followed by rapid cooling and pushed already stressed species over the edge.
  - Affected species: 76% extinct; Dinosaurs, pterosaurs, mosasaurs, plesiosaurs, mammals, ammonites, shell-building species, plants
- **Anthropocene Extinction?**
  - Human activity
  - Environmental Factors: Many environmental factors linked to past extinctions exist today. Burning fossil fuels, farming, and deforestation elevate carbon dioxide (CO_2) levels that cause ocean acidification, global warming, and rising sea levels. Pollutants alter the chemistry of the atmosphere, soil, and water; algal blooms deplete oceans and lakes of oxygen. Habitat loss, overfishing, and introduction of invasive species disrupt ecosystems and reduce biodiversity.

4 reasons to prevent extinctions

1. Species provide natural resources and natural services
   - Insects for pollination
   - Birds for pest control
2. Most species contribute economic services
   - Plants for food, fuel, lumber, medicine
   - Ecotourism
3. It will take 5-10 million years to regain species biodiversity
4. Many people believe species have an intrinsic right to exist



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Paths to Extinction

→ ***Endemic species:*** *are species that are found only in one particular area particularly vulnerable to extinction*

- International Union for Conservation of Nature (IUCN)
- **The IUCN Red List of Threatened Species**, established in 1964, is the world's most comprehensive information source on the global conservation status of animal, fungi and plant species.
- Critical indicator of the health of the world's biodiversity.
- Provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions.
  - Least concern species: species that are widespread and abundant.
  - Near-threatened species: Species that are very likely to become threatened in the near future.
  - Threatened species: still abundant in natural range but many populations showing a decline and therefore at risk for extinction (i.e. Vulnerable species).
  - Endangered species: so few individuals that the species could soon become extinct over all or most of its natural range; they may soon disappear

    Examples:
    - Sumatran Tiger: Less than 60 in Sumatra, Indonesia
    - Mexican gray wolf: About 60 in the forests of Arizona and New Mexico
    - Whooping Crane: 210 in North America
    - California Condor: 172 in Southwestern U.S.

Species at the Brink of Extinction

- **Endangered Orangutans in a Tropical Forest**
  - Endangered due to habitat loss: rapidly disappearing tropical forest. 1900: 315,000 & 2016: <56,000
  - Illegal smuggling & Clearing of tropical forest for palm oil plantations.
- **Hyacinth macaw**
  - Species of parrot; Endangered due popularity; removed from the wild & sold as pets (sometimes illegally)

Protecting Endangered & Threatened Species

CITES: Convention on International Trade in Endangered Species

- A 1973 treaty (173 countries) formed to control the international trade of threatened plants and animals. Based on the IUCN Red List of threatened species that cannot be commercially traded as live specimens or for their parts or products and restricts trade on thousands of plants and animal. Hard to enforce; much corruption.

Endangered Species Act (ESA)

1973 US law; one of the world's most far-reaching and controversial environmental laws.

- Many amendments; 1982, 1985, & 1988
- Designed to identify and protect endangered species
- U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) identify and list plant and animal species
- Any decision to add or remove a species must be based on biological factors alone, not economic or political.
- Forbids federal agencies to carry out or fund a project that would jeopardize the a species or their habitat
- Can not buy or sell product made from species; can not hunt, kill, collect or injure
- USFWS & NMFS prepare plans & designate habitat to help each species recover; conservation action plan (CAP)

Encouraging Private Landowners

- Eighty percent of habitat for more than half of endangered species is on nonpublic property.
- Federal law obligates private landowners, to maintain critical habitat for endangered species in the case that one such species inhabits their land.
- USFWS negotiates Habitat Conservation Plans with private landowners.
- *Habitat Conservation Plans:* Landowners allowed to harvest resources or build on part of land as long as endangered species benefits
- *Safe Harbor Agreement:* Landowners get financial and technical assistance to restore, improve or maintain habitat

Lacey Act: A U.S. act that prohibits interstate shipping of all illegally harvested plants and animals. Established in 1900, it is one of the earliest laws to in the U.S. to control the trade of wildlife.

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Several human activities are direct causes of declining biodiversity and species extinction. These can be remembered using the acronym **HIPPCO**.

- **H**abitat destruction, degradation, and fragmentation
- **I**nvasive (nonnative) species
- **P**opulation and resource use growth
- **P**ollution
- **C**limate change
- **O**verexploitation

Bird Populations Are Threatened

- 1/3 of 800 bird species in U.S. are endangered or threatened
- Habitat loss and fragmentation of the birds' breeding habitats
- Forests cleared for farms, lumber plantations, roads, and development
- Intentional or accidental introduction of nonnative species; outcompete or prey on native birds
- Seabirds caught and drown in fishing equipment
- Migrating birds fly into power lines, communication towers, skyscrapers, *wind turbines*
- ***Other threats*: Oil spills, Pesticides, Herbicides, Ingestion of toxic lead shotgun pellets**
- Birds Environmental indicators; i.e. **indicator species**

Greatest new threat: Climate change → Can the Birds Adapt?

- Impacting where birds breed, migrate and overwinter
- Bird ranges are shifting in response to shifting conditions
- The timing of migration and breeding are changing, affecting the availability of food needed to raise their young.
- Vegetation zones are shifting zones; coniferous forests migrating into alpine tundra (summer wetlands).
- Deciduous forests are moving up mountains, crowding out alpine coniferous habitats.

Amphibian Populations Are Threatened

Importance of amphibians

- Sensitive biological indicators of environmental changes
- Important ecological roles in biological communities (natural pest control; eat insects)
- Genetic storehouse of pharmaceutical products waiting to be discovered

Why Are Amphibians Vanishing?

- Habitat loss and fragmentation
- Prolonged drought
- Pollution
- Increase in UV radiation
- Climate change
- Overhunting
- Nonnative predators and competitors
- Parasites
- Viruses
- **Fungal diseases**
  - *Batrachochytrium dendrobatidis*, also known as *Bd* or the amphibian ***chytrid*** fungus, is a fungus that causes the disease chytridiomycosis in amphibians.
  - In the decade after it was first discovered in 1998, the disease devastated amphibian populations around the world (particularly Latin America), in a global decline towards multiple extinctions.
  - No one knows exactly where the disease originated, or how it moved around the world, but it showed up on different continents almost simultaneously, which means that, almost certainly, it was transported by people
  - Likely due to shipping containers and global animal trade.

- Among the approximately 4,700 species of amphibians, 49 percent are either threatened or near threatened.
- An Estimated 200 species have gone extinct since the 1970's.

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Overexploitation

Illegally killing, capturing, and selling of wild species threatens biodiversity

- **Poaching**: illegally killed for parts; e.g.
  - elephant tusks for ivory,
  - rhino horns for dagger handles,
  - other animal parts for medicinal purposes i.e. traditional Chinese medicines,
  - Bengal tiger fur = $100,000 on black market
- **Smuggling:** illegal transport of plants and animals across international borders.
  - Wild pets; e.g. parrots, tigers, monkeys
  - Rare tropical fish for personal aquariums
  - Exotic plants; e.g. Rare orchids and cacti
    - **Solutions**: *Convert poachers to eco-tourism guides and conservation researchers*
- **Bush meat**
  - Indigenous people sustained by **bush meat**
  - In west and central Africa, indigenous hunters try to provide food for rapidly growing populations by hunting animals such as monkeys, gorillas, antelope etc.
  - Logging roads have made it easier for hunters (and poachers) to access once in-accessible forests.
  - Butchering bush meat facilitates the spread of some diseases from animals to humans; e.g. HIV/AIDS and Ebola from animals to humans.
  - In coastal western Africa, declining fish stocks are forcing people into the forest to hunt bush meat.

Pollution

Persistent organic pollutants (**POPs**)

- POP's are organic compounds that do not breakdown through natural chemical, biological, and photolytic processes in our environment.
- Because of their persistence in our environment, POPs bioaccumulate and have been shown to have adverse impacts on human health (endocrine disruptors and carcinogens) and to individual species and ecosystems.
- Many POPs are or were in the past used as pesticides, solvents, pharmaceuticals, and industrial chemicals.
  - Examples: chlorinated hydrocarbons such as the pesticide DDT (banned in the U.S. in 1972) and Polychlorinated Biphenyl's (PCBs) used as industrial lubricants, in electrical transmission, and in building materials.
- **Bioaccumulation**
  - The gradual build up of toxic substances in fat tissue of an organism.
  - Concentrations increase until threshold level is reached whereby neurological, endocrine, and reproductive disorders may manifest.
  - Collectively these toxins are referred to as *persistent bioaccumulative toxic chemicals (PBTs)*; e.g. lead, mercury, PCB's, dioxins, DDT.
- **Biomagnification**
  - Biomagnification is also called Bioamplification.
  - It is simply the increase in concentration of substances such as Persistent Organic Pollutants (POP's) in a food chain, not an organism.

Tends to impact organisms at higher trophic levels the most e.g. Bald eagles, orcas, etc.

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Honeybees & Pesticides

- Honeybees responsible for 80% of insect-pollinated plants and nearly 1/3 human food
- 2006: 30% drop in honeybee populations
- Colony collapse disorder (CCD) is a phenomenon in which honeybees disappear from their hives.
- Researchers have identified the source of CCD as a class of pesticides known as neonicotinoids — insecticides that also act as nerve poisons and mimic the effects of nicotine.
- 3-neonicotinoids are banned in the European Union, but still used in the U.S. Most corn planted in the U.S., is treated with neonicotinoids; while bees don't pollinate corn, they are exposed to the chemical since the corn's pollen floats to flowers and other crops nearby.
- One-third of the food we eat depends on insect pollination, mostly by honeybees; raised/managed by beekeepers.
- Everything from apples and cherries to broccoli, pumpkins, and almonds depends on honeybees.

Cattle Drug Threatens Vultures

Vultures, Wild Dogs, and Rabies: Unexpected Scientific Connections

- In 2004 three species of vultures were placed on ICUN critically endangered list.
- In India, in the early 1990's dairy cows were being fed diclofenac, an anti-inflammatory drug that helps increase milk production.
- Vultures that fed on cow carcasses were poisoned by diclofenac, dying of kidney failure.
- Populations fell by 97% by late 90's
- In the absence of vultures wild dog populations exploded due to greatly increased food supply.
- Rabies virus thrives in rotting carcasses.
- The number of dogs with rabies increased; in 1997 30,000 people in India died of rabies deaths; more than half of the world total that year.

Climate Change

Polar Bears and Global Warming

- 20,000-25,000 polar bears remain in the Arctic.
- Warming is occurring twice as fast in the Artic than the rest of the world.
- Annual winter ice expansion is decreasing rapidly.
- Polar bears hunt for seals on floating winter ice and calories in fat during summer months.
- Winter ice is breaking up earlier each year and freezing later = less time to hunt.
- Decreasing area of ice = habitat loss
- 2008: USFWS Threatened species list
- Currently Vulnerable ICUN Red List

Protecting Endangered Species

Gene Banks, Botanical Gardens, and Wildlife Farms

- Gene or seed banks
  - Preserve genetic material of endangered plants
    - National Center for Genetic Resources Preservation at Colorado State University, Fort Collins
    - Svalbard Global Seed Vault in northern Norway; International storage area for many varieties of crop seeds from throughout the world.
- Botanical gardens and arboreta
  - Living plants
- Farms to raise organisms for commercial sale

Zoos and Aquariums

- Techniques for preserving endangered terrestrial species: Egg pulling, ***Captive breeding,*** Artificial insemination, Embryo transfer, Use of incubators, Cross-fostering

Goal of ultimately releasing/reintroducing populations to the wild

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Case Studies- California Condor
- Largest land bird in N. America
- Range: Baja to Washington State
- Scavenger; feeds on the carcasses of large mammals; e.g. deer, cattle, whales.
- Critically endangered; slow to reproduce; captive breeding program; Pop. increased from 22 (1987) to 410 (2016).
- Threats:
  - Habitat loss, degradation, fragmentation; urban development; loss of food supply as land use shifts.
  - Pollution: Primary cause of death lead poisoning from lead pellets in carcasses left over from hunting.
  - Power lines & wind turbines; a serious threat.

Case Studies- Whooping Crane
- N. America's tallest bird
- Status: endangered
- Traditional range: gulf states to N. Canada
- Drivers: habitat loss and hunting drastically reduced the whooping crane population.
- The species declined to around 20 birds in the 1940s.
- **Conservation strategies**: captive breeding, wetland management, teaching young cranes how to migrate
- Outcome: Increased population to about 600 (2016).

Non-Native and Invasive Species
- **Native species** are species that have historically occurred as part of an ecosystem in a specific location. Native species are also called *indigenous* species.
- **Non-native species** are species that have been introduced into new areas that have not historically been part of their native range.
- "***Exotic***", "***alien***", "***nonindigenous***", and "***introduced***" are all synonymous terms referring to non-native species.
- Exotic species have the potential to become *invasive* when they are released into a new environment.
- Invasive nonindigenous species are those species whose introduction causes, or is likely to cause, significant economic or ecological harm.
- ***Trade, transport, and agriculture are three of the more common routes, or "pathways," through which invasive species arrive.***

Some Deliberately Introduced Species Can Disrupt Ecosystems
- Intentional introductions are often for purposes of livestock or agricultural production, e.g., introduction of domesticated cattle, goats, pigs, and honeybees from Europe to the New World in centuries past.
- Many of these have greatly benefited humans.
- Cultivated plants of genus ***Citrus*** originated in tropical to subtropical southeast Asia and India and were introduced to Florida and the New World by Spanish explorer Ponce de Leon in 1513.

Most species introductions are beneficial: Food, Shelter, Medicine, Aesthetic enjoyment

Species co-evolve with other organisms in their natural environment. Many introduced organisms may now exist free from the natural forces (enemy release) that keep populations in check within their native range.

Such natural forces include:
- predators
- competitors
- parasites
- diseases

The species is now free from environmental limiting factors.
- ✧ When released from these controls, populations may become established and to grow unchecked to the point where they achieve ***invasive species*** status.
- ✧ Invasive populations may outcompete or otherwise negatively impact native populations, establishing dominance, displacing them, and depleting environmental resources.

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Harmful Deliberately Introduced Species

- Purple loosestrife
- European starling
- African honeybee ("Killer bee")
- Nutria
- Salt cedar (Tamarisk)
- Marine toad (Giant toad)
- Water hyacinth
- Japanese beetle
- Hydrilla
- European wild boar (Feral pig)

The Kudzu Vine: A deliberately introduce invasive species

- Imported from Japan in the 1930's in an attempt to control soil erosion.
- Kudzu can out-grow and out-compete native plants and ruin entire forested areas.
- Mitigation: continuous mowing and *grazing*: both cattle & goats will eat kudzu; weaken and eventually control the plant; *Herbicides*
- U.S. Forest Service reports that kudzu occupies much less area in the south than initially thought.
- The ***Japanese kudzu bug*** hitched a plane ride and is now infesting vines throughout the South. The vines are so crippled they can't keep up with the other roadside weeds.
- *A study of one site showed a 1/3 reduction in kudzu biomass in 2-years.*

Eucalyptus Trees

- After extensive clear-cutting of native forests throughout the world, logging, agriculture, and fuel wood, eucalyptus trees were introduced from Australia in the 1800's to supply fuel wood and helped prevent soil erosion.
- Once established, the trees can alter local soil moisture, light availability, fire patterns, nitrogen mineralization rates and soil chemistry.
- Invade neighboring plant communities and disrupt ecological relationships among species that co-evolved over millennia.
- Exotic species like eucalyptus, wreak havoc on the soil, with each tree sucking about 5-10 gallons (20 to 40 liters) of water out of the ground every day.
- In Ecuador, Indigenous farmers fight eucalyptus damage to water source.

Harmful Accidentally Introduced Species

- Sea lamprey (attached to lake trout)
- Argentina fire ant
- Brown tree snake
- Eurasian ruffe
- Common pigeon (Rock dove)
- Formosan termite
- Zebra mussel
- Asian long-horned beetle
- Asian tiger mosquito
- Gypsy moth larvae

Prevention Is the Best Way to Reduce Threats from Invasive Species

- Prevent them from becoming established
- Learn the characteristics of the species
- Set up research programs
- Try to find natural ways to control them
- International treaties
- Public education

Controlling Invasive Species

- Do not capture or buy wild plants and animals.
- Do not remove wild plants from their natural areas.
- Do not release wild pets back into nature.
- Do not dump contents of an aquarium into waterways, wetlands, or storm drains.
- When camping, use wood found near your campsite instead of brining firewood from somewhere else.
- Do not dump unused bait into waterways.
- After dogs visit woods or water, brush them off before taking them home.
- After each use, clean your mountain bike, canoe, boat, motor, and trailer, all fishing tackle, hiking boots, and other gear before heading home.

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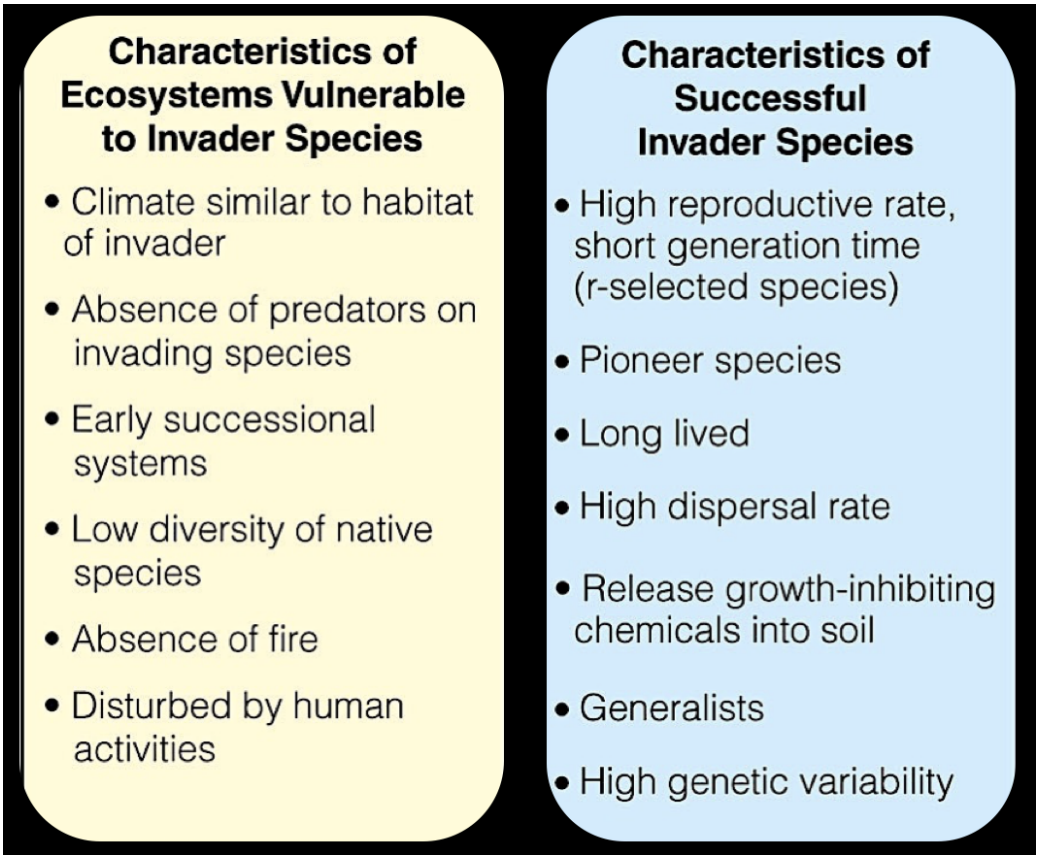
Case Studies- Brown Tree Snake (*Borgia irregularis*)
- Native to Papua New Guinea & Northern Australia.
- Accidentally introduced to Guam in 1940's likely in military cargo.
- Guam's fauna unprepared for Brown Tree Snake (BTS); Guam's largest native snake was the size of a worm.
- Enemy release; BTS population irruption.
- Consumed most of the islands native birds, small mammals, and reptiles.

Case Studies- Chestnut Blight (Microbe)
- The fungus *Cryphonectria parasitica* is the cause of chestnut blight, a devastating disease of the American chestnut tree that in the early 1900's caused a rapid, widespread die-off of the once plentiful and dominant tree from its historic range, in the Eastern United States.
- The chestnut blight was accidentally introduced to North America around 1904 from Japanese nursery stock of Asian chestnuts; which carried the fungus but were unaffected (co-evolution).
- Genetic engineering programs and selective breeding programs are working to bring back the American chestnut.
    - A hybrid, being cultivated by Penn State University's arboretum and the Chestnut Foundation—that is approximately15⁄16^{ths} American and 1⁄16^{ths} Chinese chestnut— has shown "promising" blight-resistance

Case Studies- White-Nose Syndrome (Microbe)
- White-nose syndrome (WNS) is a disease of hibernating bats caused by the fungus Geomyces destructans. Named for the white fungus that appears on the muzzle and other body parts of hibernating bats.
- Cause bats to die, effectively, of dehydration.
- Impact: a population decline of 72 to 88 percent of hibernating species in the northeastern U.S.
- Most likely introduced by human activity, possibly by a visitor from Europe to a cave in New York.

Case Studies- Joshua Tree National Park Threatened Invasive Species
Invasive Grasses & Nitrogen
- The spread of the invasive grass, red brome (native to the Mediterranean)
- Fuels intensely hot wildfires that can incinerate even the largest Joshua trees.
- Fires are becoming larger, more frequent, and more destructive since 1945 (park records).
- Atmospheric nitrogen deposition from SoCal auto exhaust is driving (fertilizing) spread of the grass.
- Fertilizes desert soil facilitating rapid spread of red brome.
- Outcompeting native plants, changing species composition, and making fires more likely which is detrimental to young Joshua trees.

Case Studies- Rocky Mountain National Park Ecosystems Threatened by Invasive Species
Cheat Grass
- Aggressive invasive exotic species
- Introduced from Europe; invaded Rocky Mountain ecosystem
- Very specialized grass: a high-volume seed producer, opportunistic & can outcompetes native plants and establish dominance
- Invasion can convert intermountain sagebrush scrubland to Cheat grass monocultures
- This reduces abundance and genetic diversity of native plants, leading to an overall reduction in biological diversity
- Outcompete native plants because it depletes the soil of water, altering soil ecology and biogeochemical cycles
- Highly flammable and increases potential and frequency of wildfires
- Changes plant communities; therefore it affects wildlife habitat
- Such changes reduce the availability of appropriate habitat for several species of birds, including: Brewer's sparrow, sage sparrow, and sage-grouse
    - **Solution? IPM: Herbicide & Mechanical Removal**


Characteristics of Ecosystems Vulnerable to Invader Species
• Climate similar to habitat of invader
• Absence of predators on invading species
• Early successional systems
• Low diversity of native species
• Absence of fire
• Disturbed by human activities
Characteristics of Successful Invader Species
• High reproductive rate, short generation time (r-selected species)
• Pioneer species
• Long lived
• High dispersal rate
• Release growth-inhibiting chemicals into soil
• Generalists
• High genetic variability