

## **CHAPTER 9**

### **Sustaining Biodiversity: The Species Approach**

# 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 estimated to be between 100 to 1,000 times higher than typical background rate of .0001%; may rise to 10,000 times the background rate by the end of the century or 1% per year. This amounts to 10,000 species gone extinct per year for every 1 million wild species living on Earth; this would be roughly  $\frac{1}{4}$  of the world's plant and animal species.



# Human Role in increasing Extinction Rates

**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; plus species ranges are overlapping, this may result in convergent evolution (2 species become 1), which will further reduce the number of species.

# Three Levels of Extinction & Mass Extinction

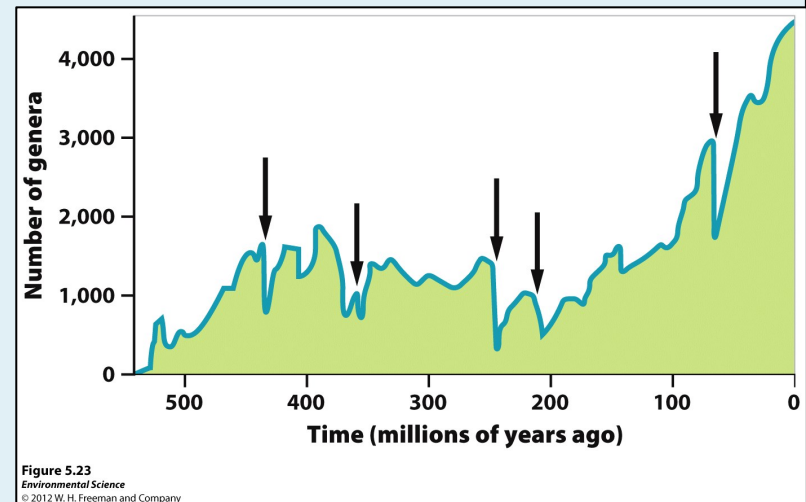
**Local Extinction:** not found in parts of range/area it once inhabited but is found other places

**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 Big Five Mass Extinctions

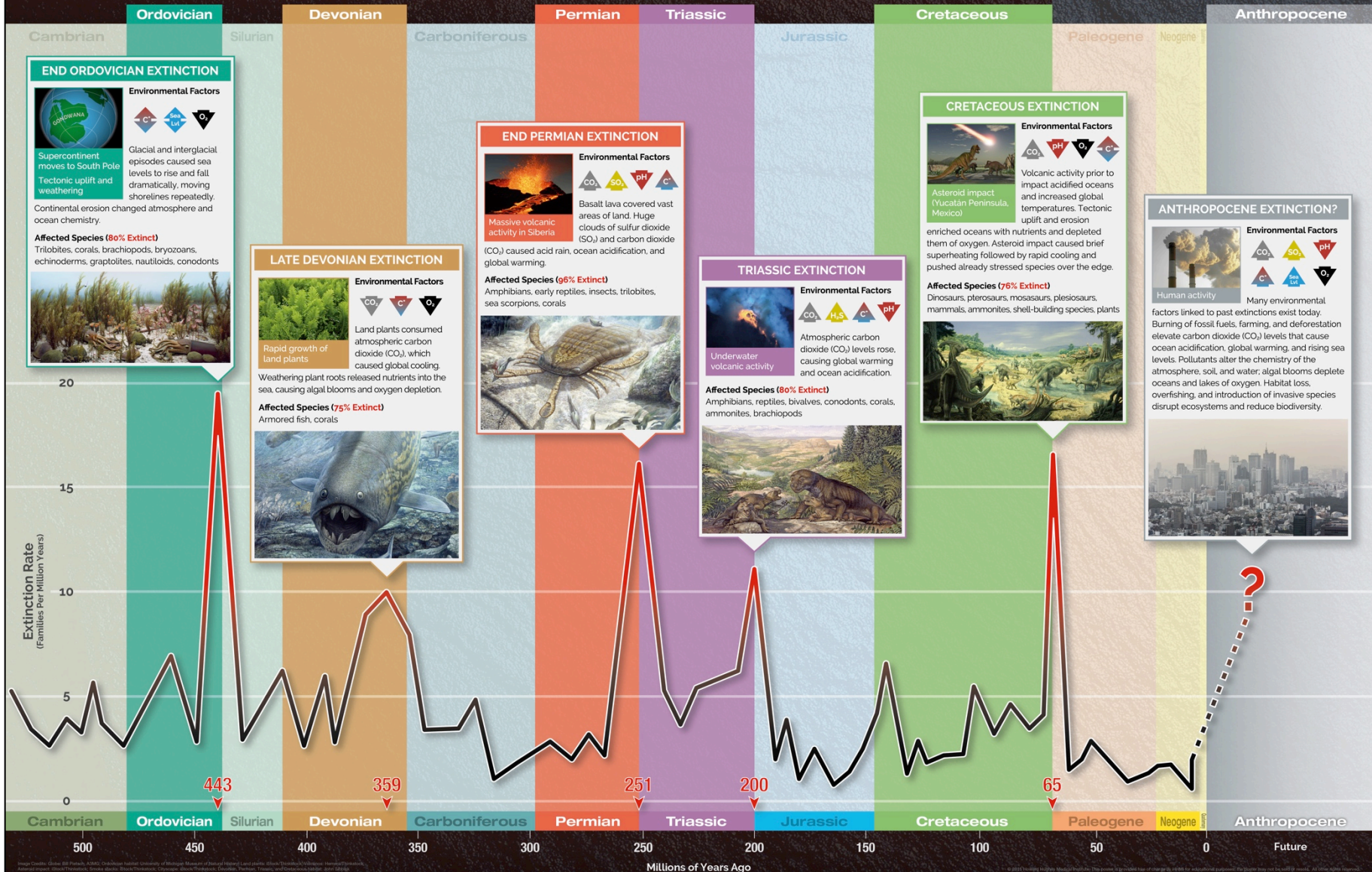
Extinction is a normal part of the evolutionary process and most species that have ever existed are not living today. The normal loss of species through time is generally balanced by the rise of new species. Mass extinctions, however, disrupt this balance—representing times when many more species go extinct than are replaced by new ones.

Scientists have found evidence of five mass extinction events during Earth's history. What caused these "Big Five" extinction events? And are we about to enter a sixth mass extinction?

The graph shows estimated rates of extinction plotted over geologic time. The fossil record reveals that these rates fluctuate around a generally low level, but peak at certain points in Earth's history, indicating mass extinction events.

## The Sixth Mass Extinction?

A large number of current ecological threats have moved extinction rates above normal levels and potentially put numerous species on the path to extinction. If left unchecked, some scientists predict that within a few human generations, the sixth mass extinction will become inevitable.





# Paths to Extinction

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

**Threatened species:** still abundant in natural range but many populations showing a decline (e.g. 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

## Endangered Species



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.

# Characteristics of Species That Are Prone to Ecological and Biological Extinction

## Characteristic

## Examples

Low reproductive rate



Blue whale, giant panda, rhinoceros

Specialized niche



Blue whale, giant panda, Everglades kite

Narrow distribution



Elephant seal, desert pupfish

Feeds at high trophic level



Bengal tiger, bald eagle, grizzly bear

Fixed migratory patterns



Blue whale, whooping crane, sea turtle

Rare



African violet, some orchids

Commercially valuable



Snow leopard, tiger, elephant, rhinoceros, rare plants and birds

Large territories



California condor, grizzly bear, Florida panther

## Percentage of Various Species Threatened with Premature Extinction



**Plants**

**70%**



**Fishes**

**34% (37% of freshwater species)**



**Amphibians**

**30%**



**Reptiles**

**28%**



**Mammals**

**21%**



**Birds**

**12%**

# Protecting Endangered & Threatened Species

## **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 and NMFS prepare plans & designate habitat to help each species recover; conservation action plan (CAP)

# Protecting Endangered & Threatened Species

## **CITES: Convention on International Trade in Endangered Species**

1975; 175 countries. The International Union for Conservation of Nature (IUCN) is the world's main authority on the conservation status of species. IUCN Red List (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.

## **Convention on Biological Diversity (BCD); 1993**

- United Nations Environment Program (UNEP)
- Focuses on ecosystems
- Ratified by 190 countries (not the U.S.)

## **The Convention has three main goals:**

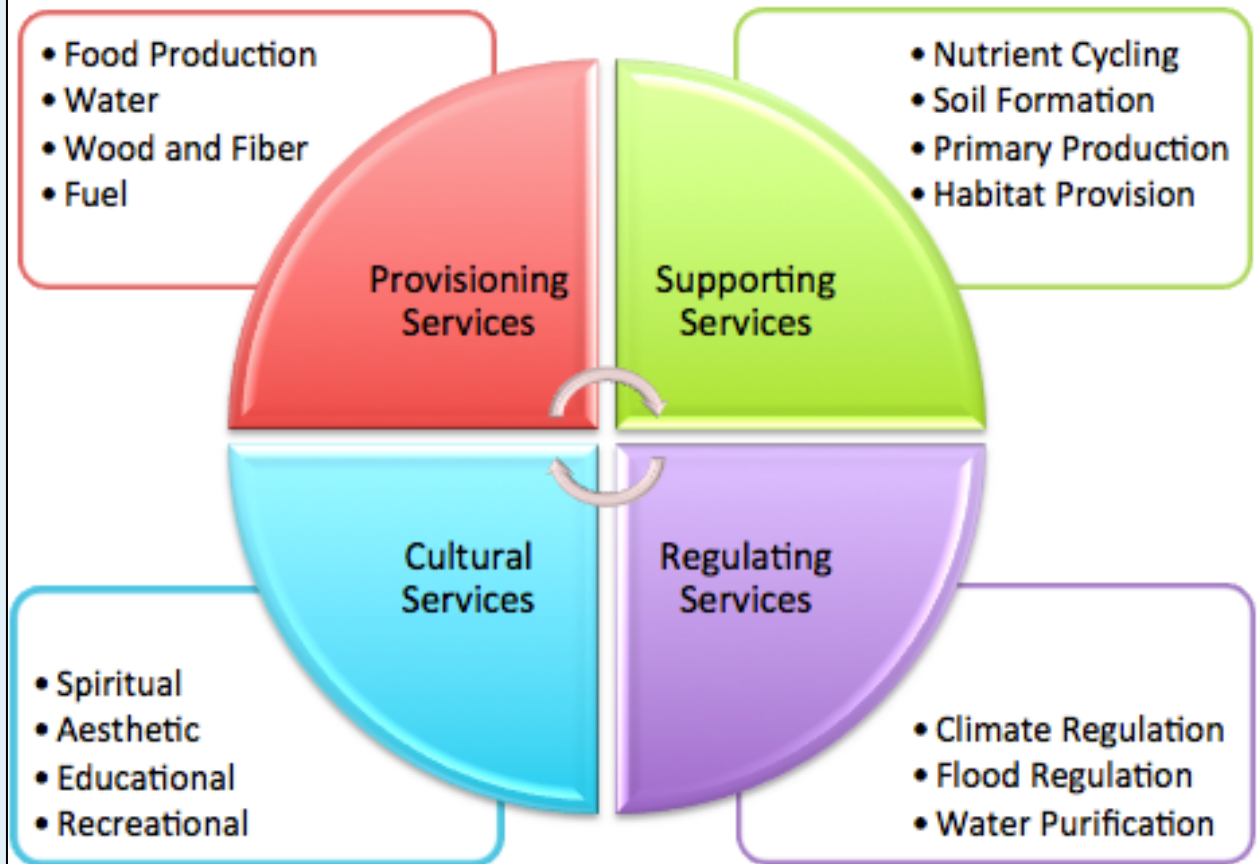
1. conservation of biological diversity (or biodiversity);
2. sustainable use of its components; and
3. fair and equitable sharing of benefits arising from genetic resources.



# Species Are a Vital Part of the Earth's Natural Capital

## Ecosystem Services

- Provisioning
- Regulating
- Cultural
- Supporting



Source: Millenium Ecosystem Assessment, 2005.

# Species Are a Vital Part of the Earth's Natural Capital

## 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

# Species Are a Vital Part of the Earth's Natural Capital

## 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

# Species Are a Vital Part of the Earth's Natural Capital

## BIODIVERSITY ECOSERVICES

Living Planet and Human Well-Being



**PROVISIONING**  
Food



**PROVISIONING**  
Raw Materials



**REGULATING**  
Natural Disasters



**REGULATING**  
Pollination



**CULTURE**  
Tourism



**PROVISIONING**  
Fresh Water



**PROVISIONING**  
Medicinal Resources



**REGULATING**  
Waste-Water Treatment



**REGULATING**  
Biological Control



**CULTURE**  
Recreation and Health



**REGULATING**  
Local Climate



**REGULATING**  
Carbon Storage



**REGULATING**  
Erosion and Fertility



**HABITAT**  
Species and Ecosystems



**HABITAT**  
Genetic Diversity



**CULTURE**  
Spiritual Experience

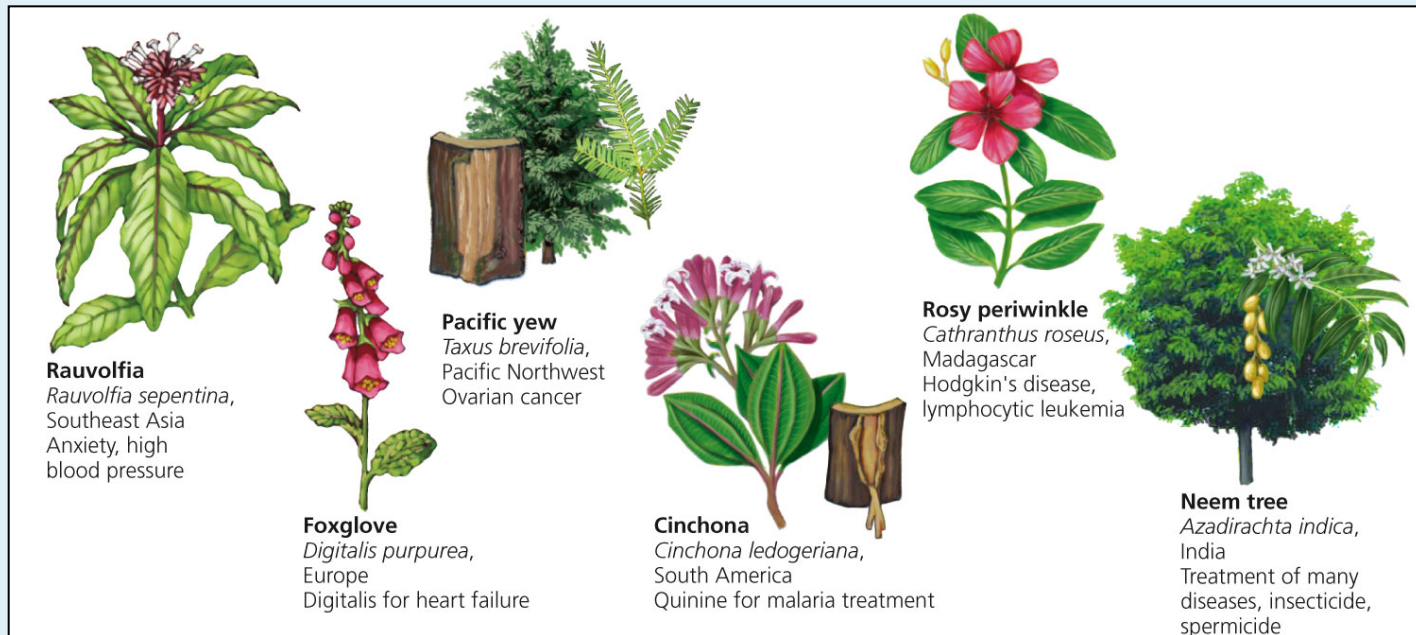


**CULTURE**  
Aesthetic Appreciation

Icons: Jan Sasse / TEEB  
Design: Globaia

## 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





# Natural Capital Degradation & Species at the Brink of Extinction



## Endangered Orangutans in a Tropical Forest

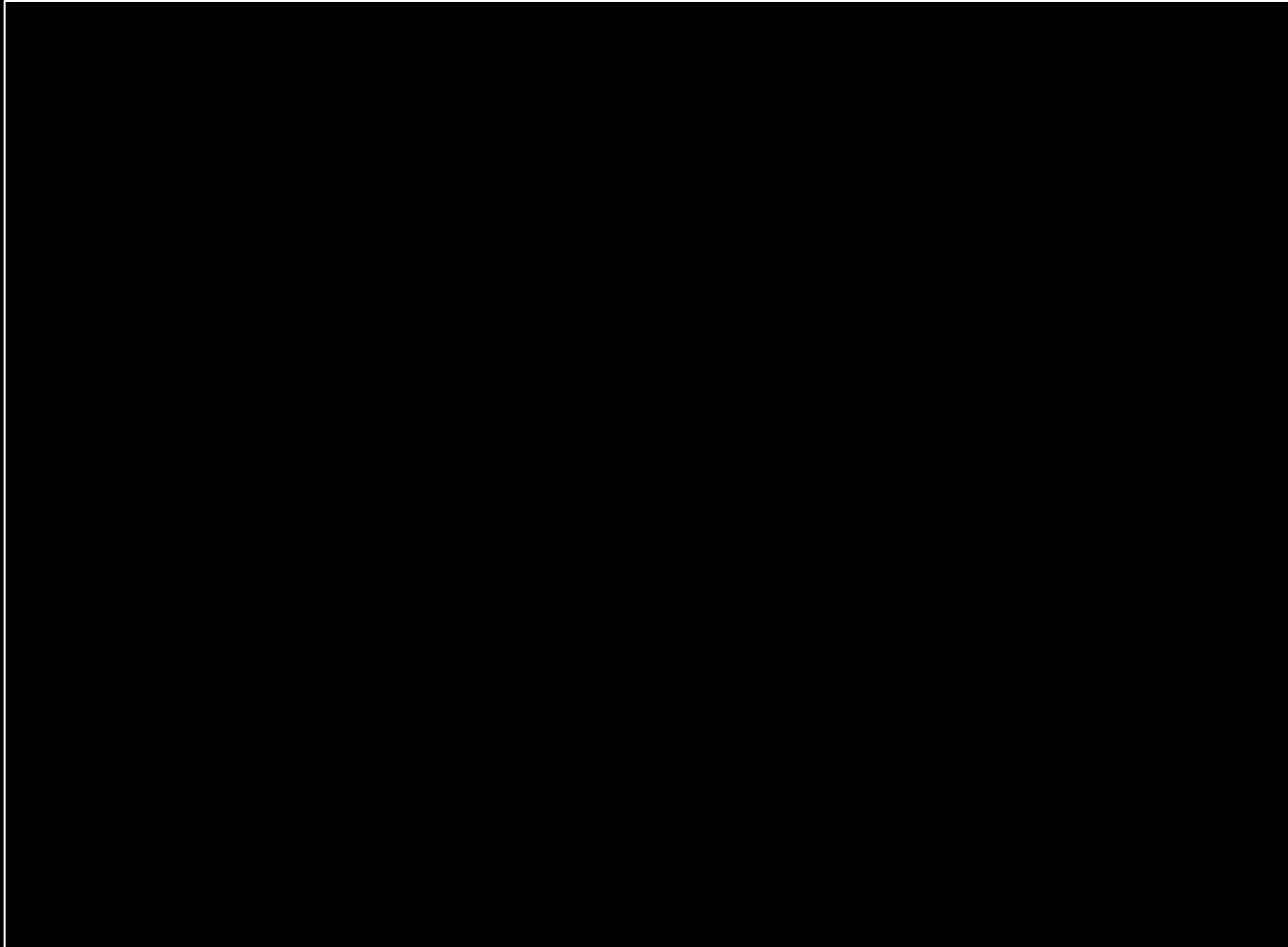
Endangered due to habitat loss: rapidly disappearing tropical forest. 1900: 315,000 & 2016: <56,000  
Illegal smuggling & Clearing of tropical forest for palm oil plantations.



## Hyacinth macaw

Species of parrot; Endangered due to popularity; removed from the wild & sold as pets (sometimes illegally)

# How to Save an Endangered Species- Video Clip



# Loss of Habitat Is the Single Greatest Threat to Species: Remember **HIPPCO**

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



# Habitat Destruction, Degradation, & Fragmentation

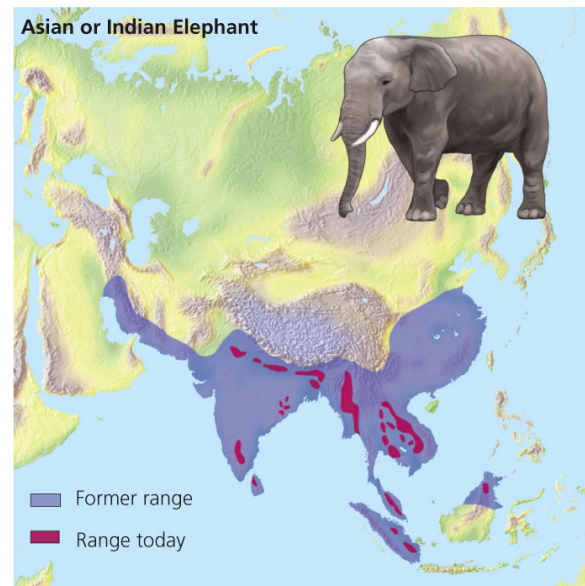
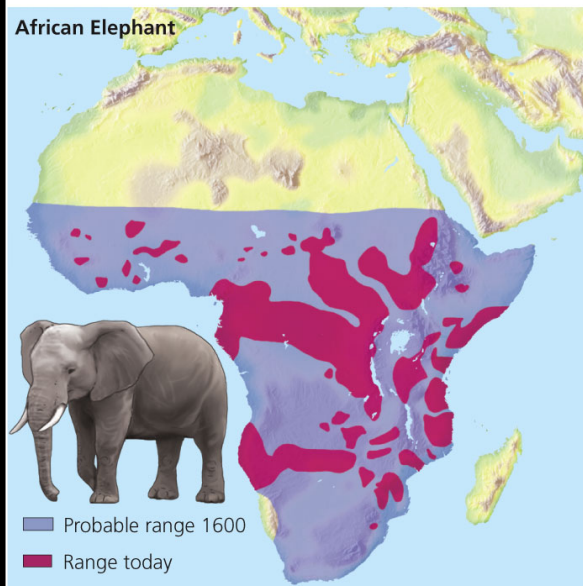
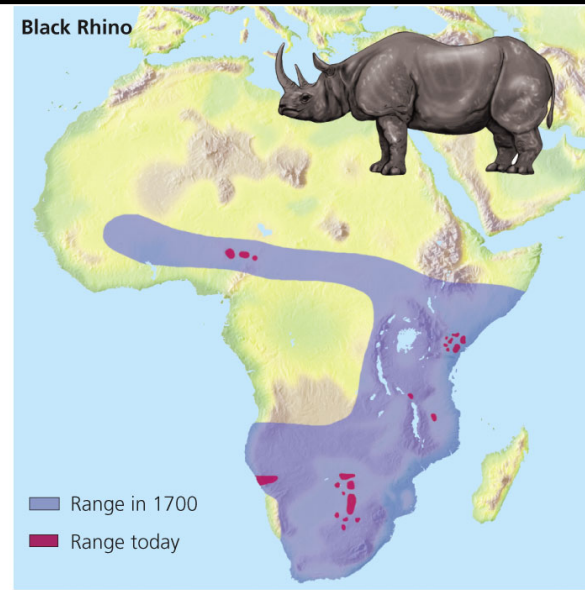
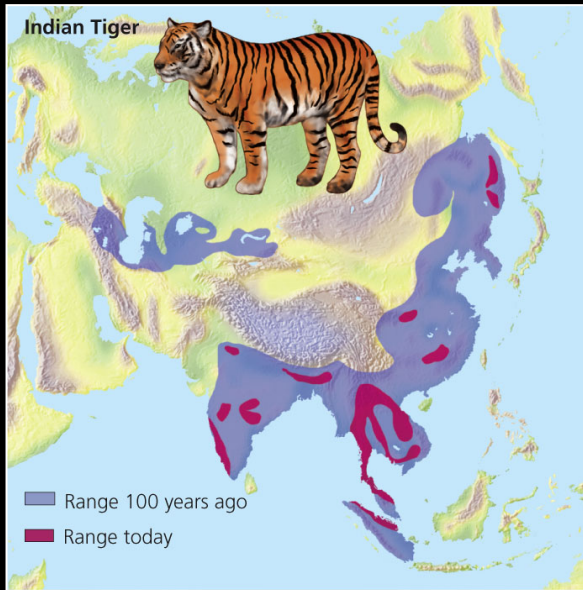
## Habitat fragmentation

- 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



# Habitat Destruction, Degradation, & Fragmentation

## *Reduction in the Ranges of Four Wildlife Species*





# Habitat Destruction, Degradation, & Fragmentation

## Natural Capital Degradation

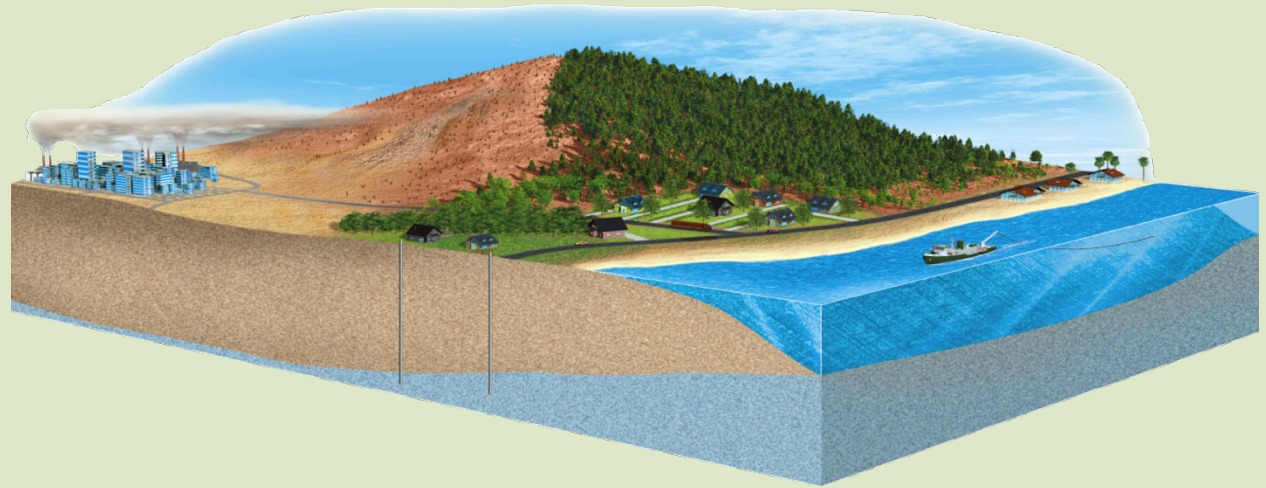
### Causes of Depletion and Extinction of Wild Species

#### Underlying Causes

- Population growth
- Rising resource use
- Undervaluing natural capital
- Poverty

#### Direct Causes

- |                                         |                  |                                             |
|-----------------------------------------|------------------|---------------------------------------------|
| • Habitat loss                          | • Pollution      | • Commercial hunting and poaching           |
| • Habitat degradation and fragmentation | • Climate change | • Sale of exotic pets and decorative plants |
| • Introduction of nonnative species     | • Overfishing    | • Predator and pest control                 |



## Protecting Habitat for the Amur Tiger in the Russian Far East- Video Clip

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## Remember HIPPCO

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

# Invasive Species- Video Clip

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# 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 environmental 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

Most species introductions are beneficial

- Food
- Shelter
- Medicine
- Aesthetic enjoyment

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 man.

- 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.



## Some Deliberately Introduced Species Can Disrupt Ecosystems

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.

# 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)

# Some Deliberately Introduced Species Can Disrupt Ecosystems

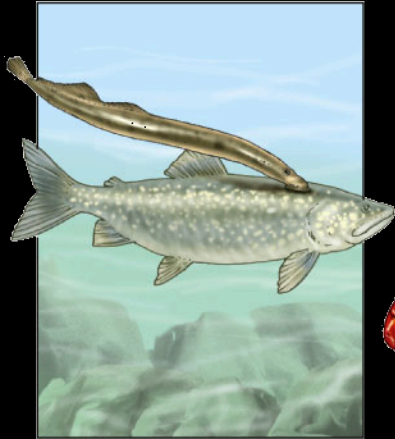
## The Kudzu Vine: A deliberately introduced invasive species

- 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.*





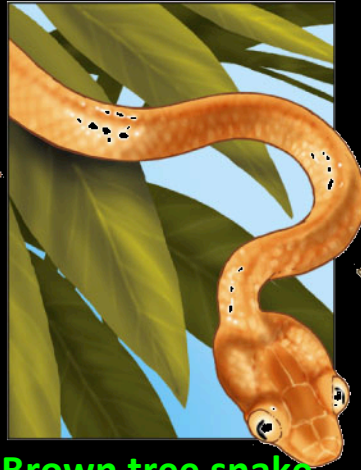
# Harmful Accidentally Introduced Species



Sea lamprey  
(attached to lake  
trout)



Argentina fire ant



Brown tree snake



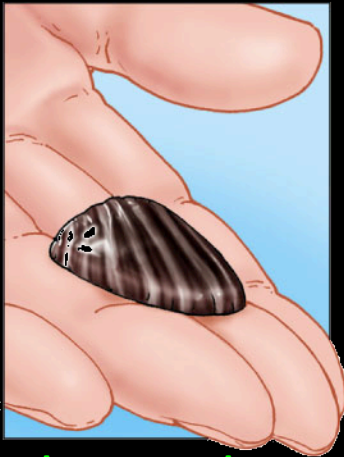
Eurasian ruffe



Common pigeon  
(Rock dove)



Formosan termite



Zebra mussel



Asian long-horned  
beetle



Asian tiger  
mosquito

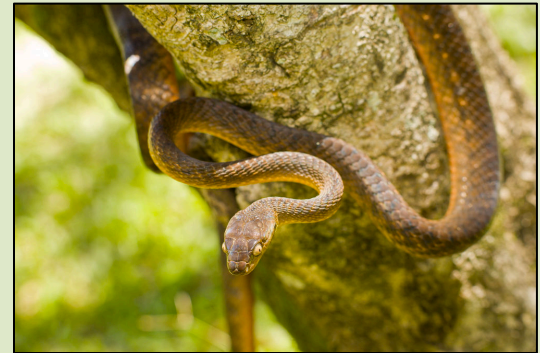


Gypsy moth  
larvae

# Some Accidentally Introduced Species Can Also Disrupt Ecosystems

## 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.





### **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

# Invasive Species

## 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

### What Can You Do?

#### 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 the contents of an aquarium into waterways, wetlands, or storm drains.
- When camping, use wood found near your campsite instead of bringing firewood from somewhere else.
- Do not dump unused bait into waterways.
- After dogs visit woods or the water, brush them 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 for home.

## Remember HIPPCO

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



# Pollution

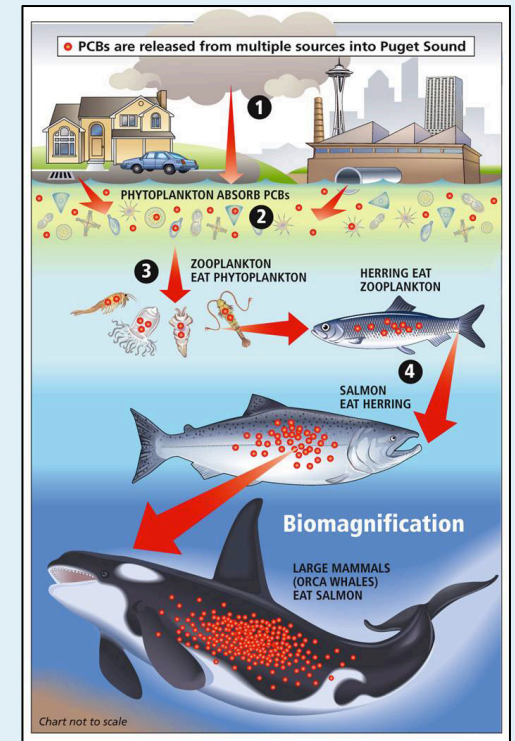
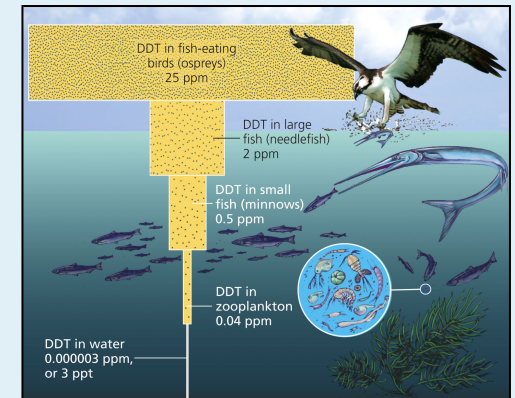
## Bioaccumulation

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 a substances such as POP's in a food chain, not an organism. Tends to impact organisms at higher trophic levels the most.

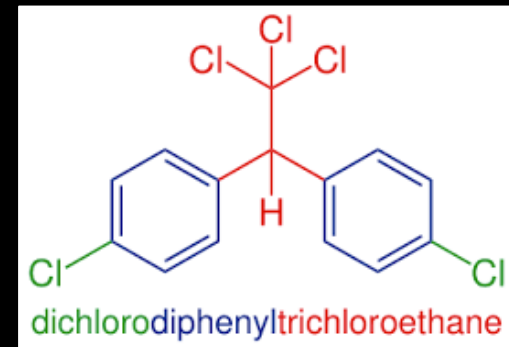
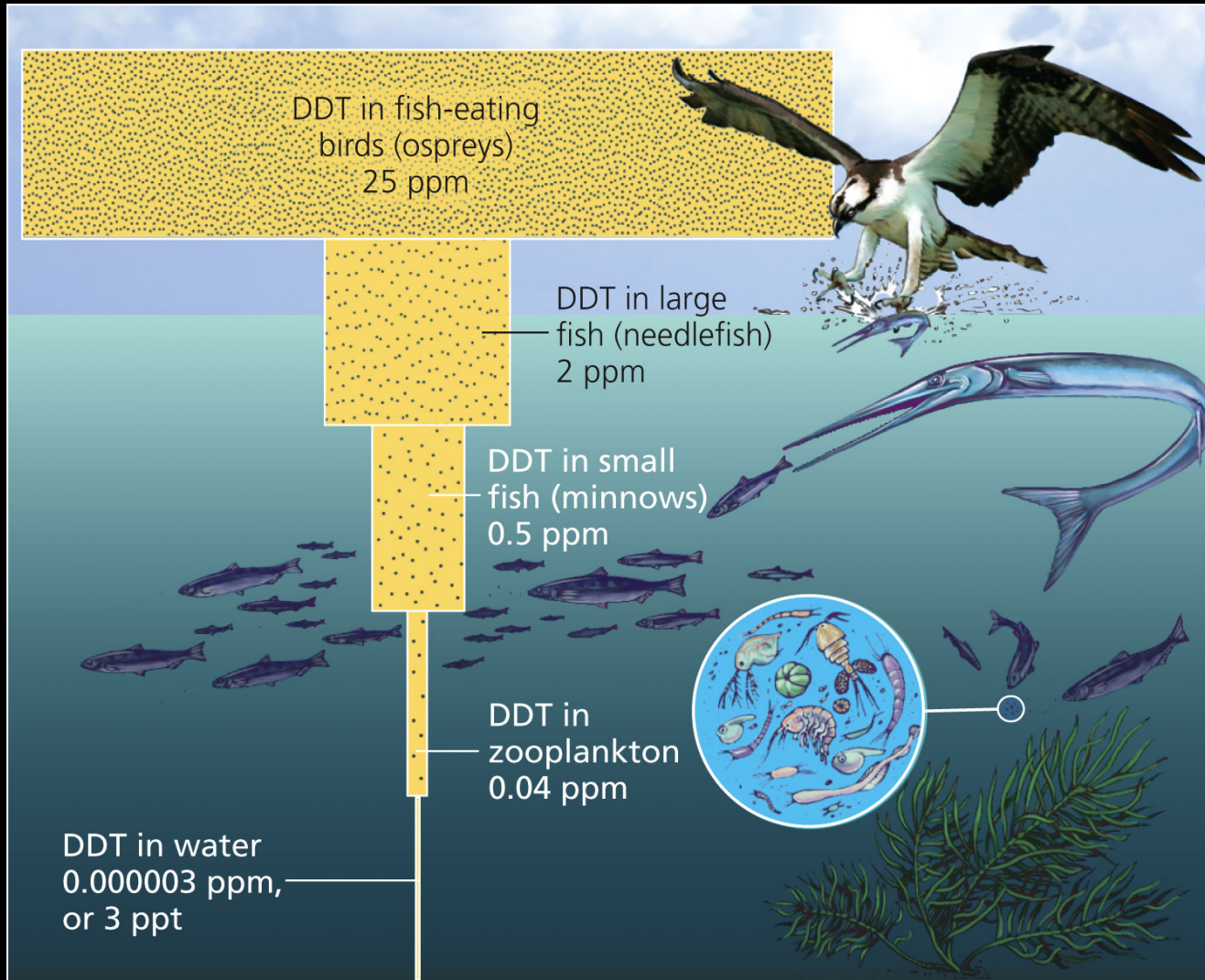


# Pollution: organic compounds also create pollution and disrupt life.

- Organic compounds- Persistent Organic Compounds (POP)

Chlorinated Hydrocarbons- DDT pesticide

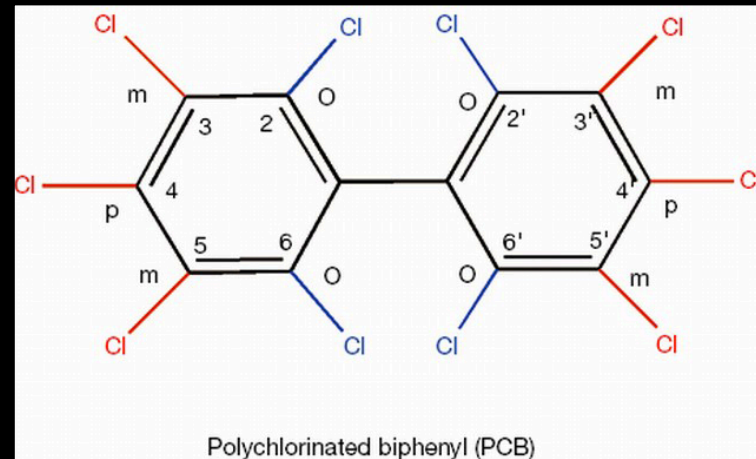
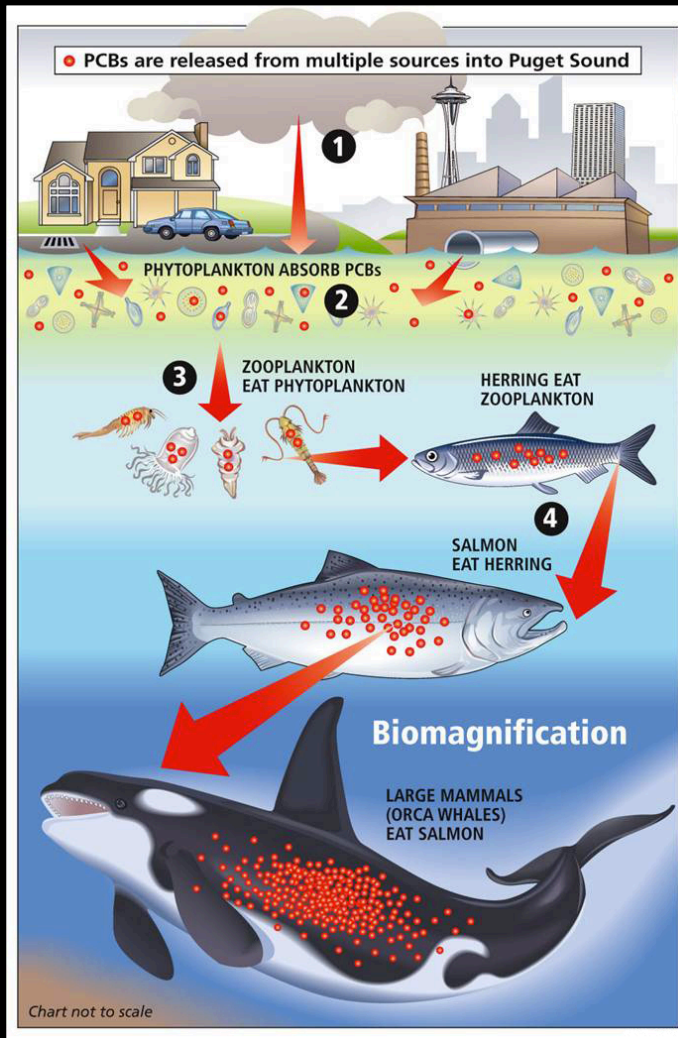
DDT: Banned in the U.S. in 1972

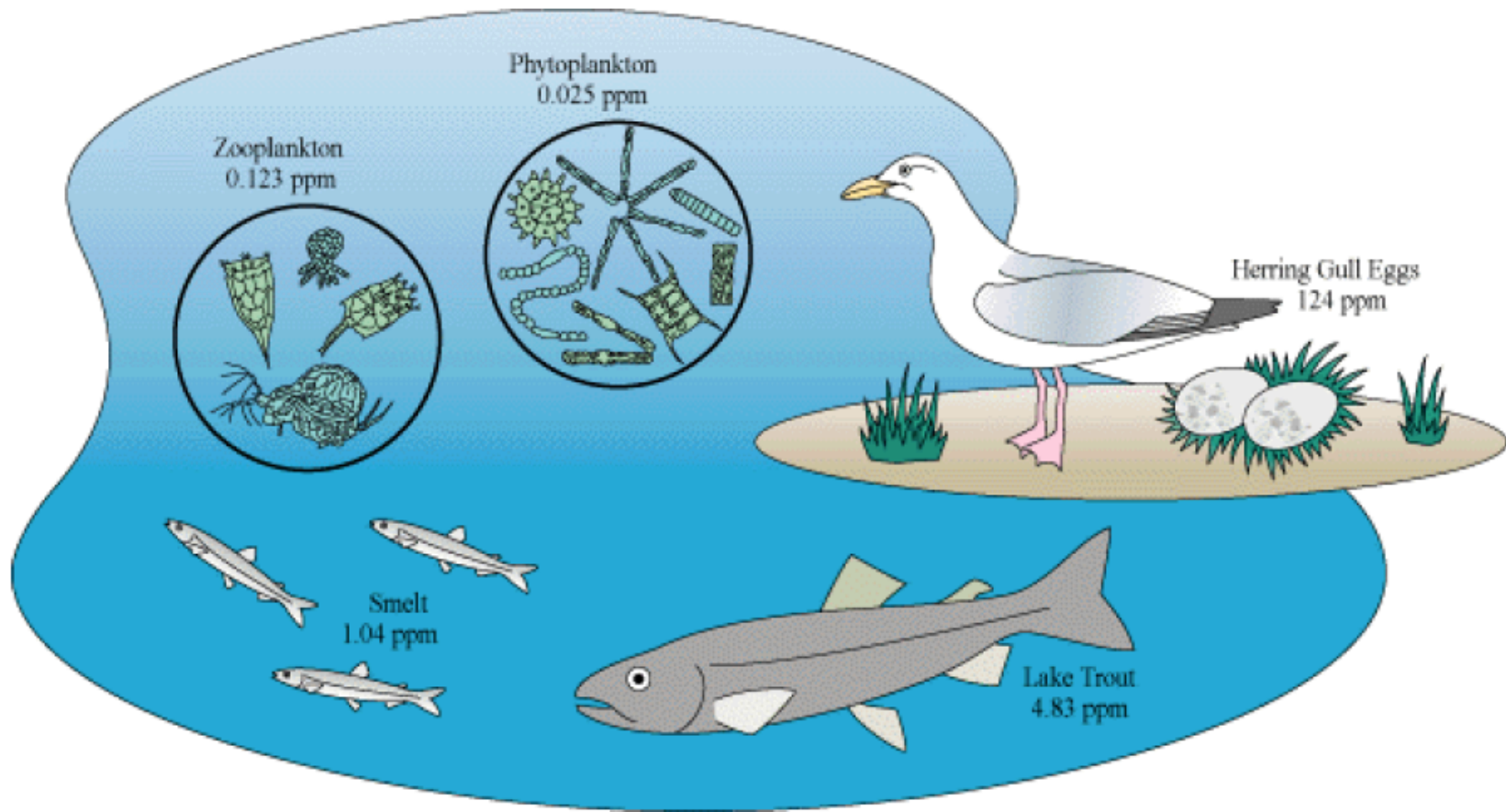




# Pollution: organic compounds also create pollution and disrupt life.

- Organic compounds- Persistent Organic Compounds (POP)  
Chlorinated Hydrocarbons- Polychlorinated Biphenyl's e.g. PCBs  
Uses: industrial lubricant & electrical and building materials

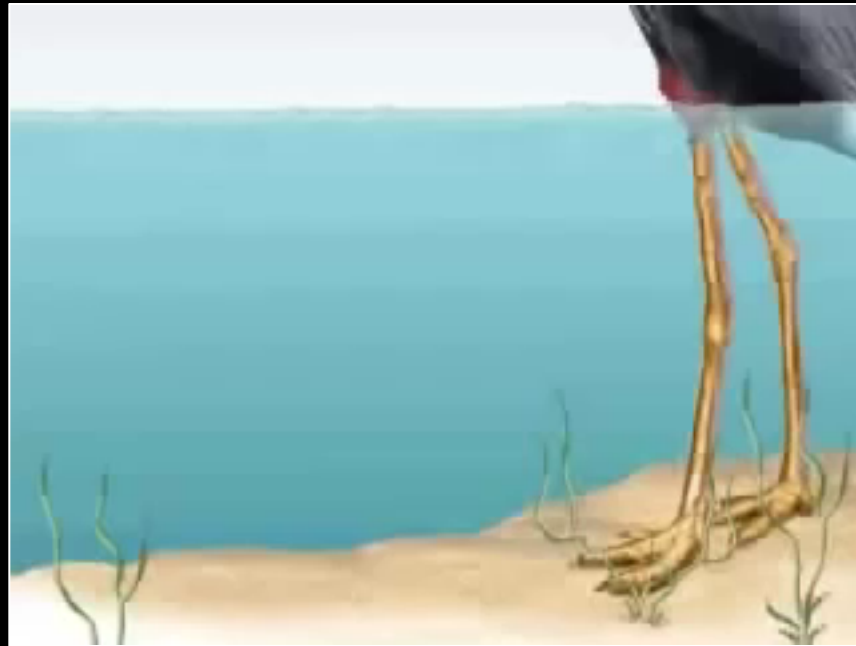




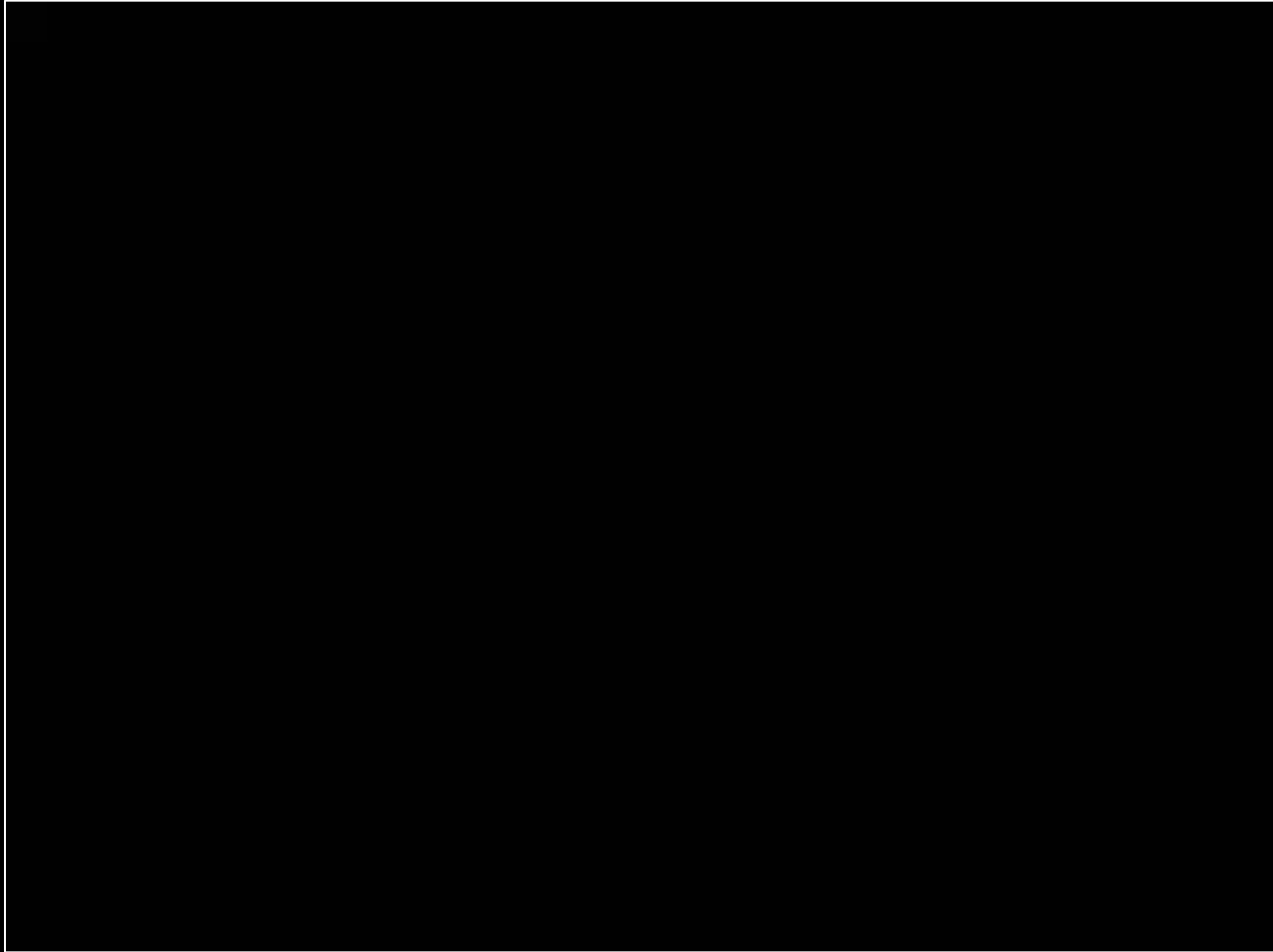
**Persistent Organic Chemicals such as PCBs bioaccumulate. This diagram shows the degree of concentration in each level of the Great Lakes aquatic food chain for PCBs (in parts per million, ppm). The highest levels are reached in the eggs of fish-eating birds such as herring gulls.**



# Bioaccumulation & Biomagnification- Video Clip



# Bioaccumulation & Biomagnification- Video Clip



# Pollution

## 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, or CCD, is a phenomenon in which honeybees inexplicably 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 that are raised and managed by beekeepers.
- Everything from apples and cherries to broccoli, pumpkins, and almonds depends on honeybees.

## Remember HIPPCO

- **H**abitat destruction, degradation, and fragmentation
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- **P**opulation and resource use growth
- **P**ollution
- **C**limate change
- **O**verexploitation



# 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*



Mountain Gorilla in Rwanda



White Rhinoceros  
Killed by a Poacher

# Overexploitation

- 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 inaccessible 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.



## Remember **HIPPCO**

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# Overexploitation

In the forested depths of eastern Congo lies Virunga National Park, one of the most bio-diverse places on Earth and home to the planet's last remaining mountain gorillas.

Park rangers protect this UNESCO world heritage site from militia, poachers and dark forces struggling to control Congo's natural resources.





## Remember HIPPCO

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# 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 Arctic 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



Polar Bear with Seal Prey; Svalbard, Norway



This map shows the 19 subpopulations of polar bears across the Arctic.

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# 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
  - Eat the birds
- Seabirds caught and drown in fishing equipment
- Migrating birds fly into power lines, communication towers, skyscrapers
- Other threats
  - Oil spills
  - Pesticides
  - Herbicides
  - Ingestion of toxic lead shotgun pellets
- Birds Environmental indicators; e.g. → **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.



# 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 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; 1997 30,000 people in India died of rabies deaths; more than half of the world total that year.



Diclofenac-tainted carcasses caused an unprecedented decline in vulture numbers

# Protecting Endangered Species

## Gene Banks, Botanical Gardens, and Wildlife Farms

- Gene or seed banks
  - Preserve genetic material of endangered plants
- 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

## 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.
- Status: critically endangered; slow to reproduce; captive breeding program; Pop. increased from 22 in 1987 to 410 in 2016.
- Threats habitat loss, degradation, & fragmentation. Urban development; loss of food supply as land use shifts.
- Primary cause of death lead poisoning from lead pellets in carcasses left over from hunting.
- Power lines & wind turbines; a serious threat.



# Whooping Crane

- N. America's tallest bird
- Status: endangered
- Traditional range: gulf states to N. Canada
- Habitat loss and hunting drastically reduced the whooping crane population.
- The species declined to around 20 birds in the 1940s.
- Captive breeding, wetland management, teaching young cranes how to migrate; increased population to about 600 (2016).



# California Condor- Video Clip

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# Whooping Crane- Video Clip



# Wildlife Refuges

1903 President Theodore Roosevelt established the first U.S. Federal wildlife refuge at Pelican Island, Florida to help protect birds like the brown pelican.

**Mission:** *to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the U.S.*

## Wildlife refuges

- Birding, hunting, fishing, hiking, and photography
- $\frac{3}{4}$  are wetland sanctuaries vital for protecting migrating waterfowl
- Abandoned military lands are now being used;  
→ Rocky Mountain Arsenal National Wildlife Refuge



Pelican Island National  
Wildlife Refuge



# Private Land

## Encouraging Private Land Owners

- *Habitat Conservation Plans*: allow landowners/developers to destroy habitat if they do something in exchange, i.e. relocate species or buying habitat elsewhere
- *Safe Harbor Agreement*: Landowners get financial and technical assistance to restore, improve or maintain habitat
- *Habitat Corridors*: a strip of land that aids in the movement of species between disconnected areas of their natural habitat.

