

# ENVIRONMENT

*THE SCIENCE BEHIND THE STORIES*

Jay Withgott • Scott Brennan

## Ch 11

### Biodiversity and Conservation Biology

Part 2: Environmental Issues  
and the Search for Solutions

PowerPoint® Slides prepared by  
Jay Withgott and Heidi Marcum



**Third Edition**

# Biodiversity encompasses several levels

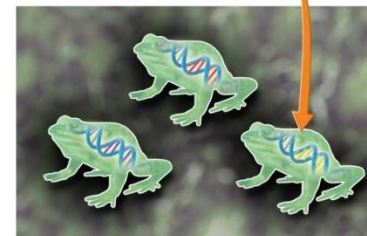
- Humans are reducing Earth's diversity of life
- **Biodiversity** – sum total of all organisms in an area
  - Split into three specific levels:
    - Species diversity
    - Genetic diversity
    - Ecosystem diversity



Ecosystem diversity



Species diversity

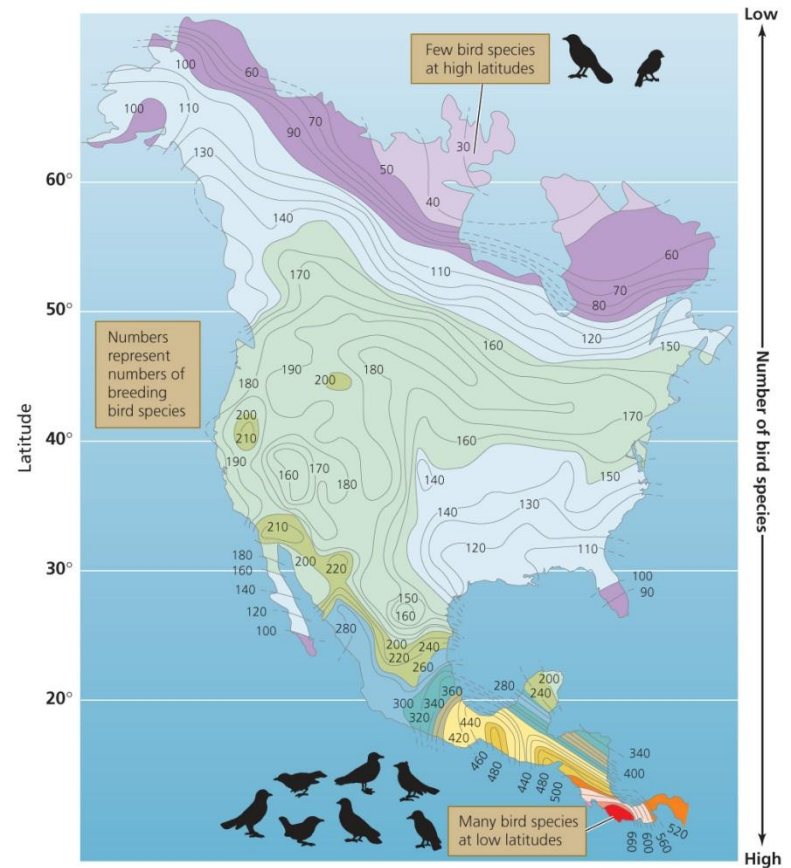


Genetic diversity

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# Biodiversity is unevenly distributed

- Living things are distributed unevenly across Earth
- **Latitudinal gradient** = species richness increases towards the equator
  - Climate stability, high plant productivity, and no glaciation
  - Diverse habitats increase species diversity

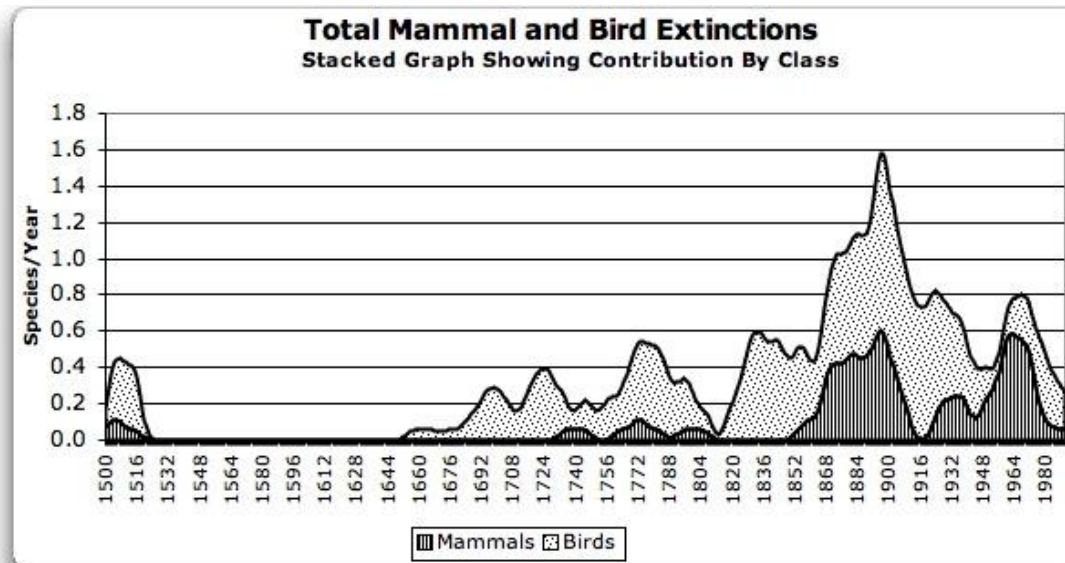


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*Canada has 30 - 100 species of breeding birds, while Costa Rica has more than 600 species*

# Biodiversity losses and species extinction

- **Extinction** = occurs when the last member of a species dies and the species ceases to exist
- **Extirpation** = the disappearance of a particular population from a given area, but not globally
  - Can lead to extinction

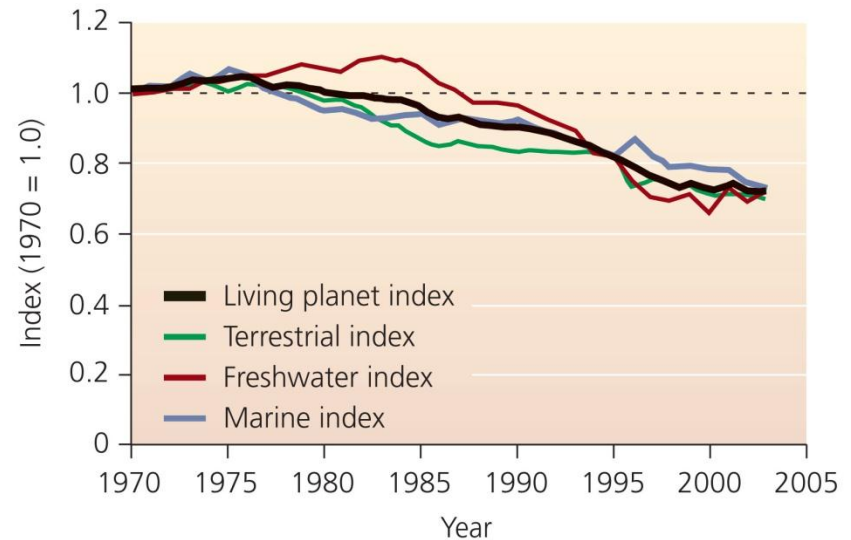


# Current extinction rates are higher than normal

- **The Red List** = an updated list of species facing high risks of extinctions
  - 23% of mammal species
  - 12% of bird species
  - 31 - 86% of all other species
- Since 1970, 58 fish species, 9 bird species, and 1 mammal species has gone extinct
  - In the U.S., in the last 500 years, 236 animal and 17 plant species are confirmed extinct
  - Actual numbers are undoubtedly higher

# Biodiversity loss is more than extinction

- Decreasing numbers are accompanied by smaller species' geographic ranges
- Genetic, ecosystem, and species diversity are being lost.
- The Living Planet Index summarizes trends in populations
  - Between 1970 and 2003, the Index fell by 30%



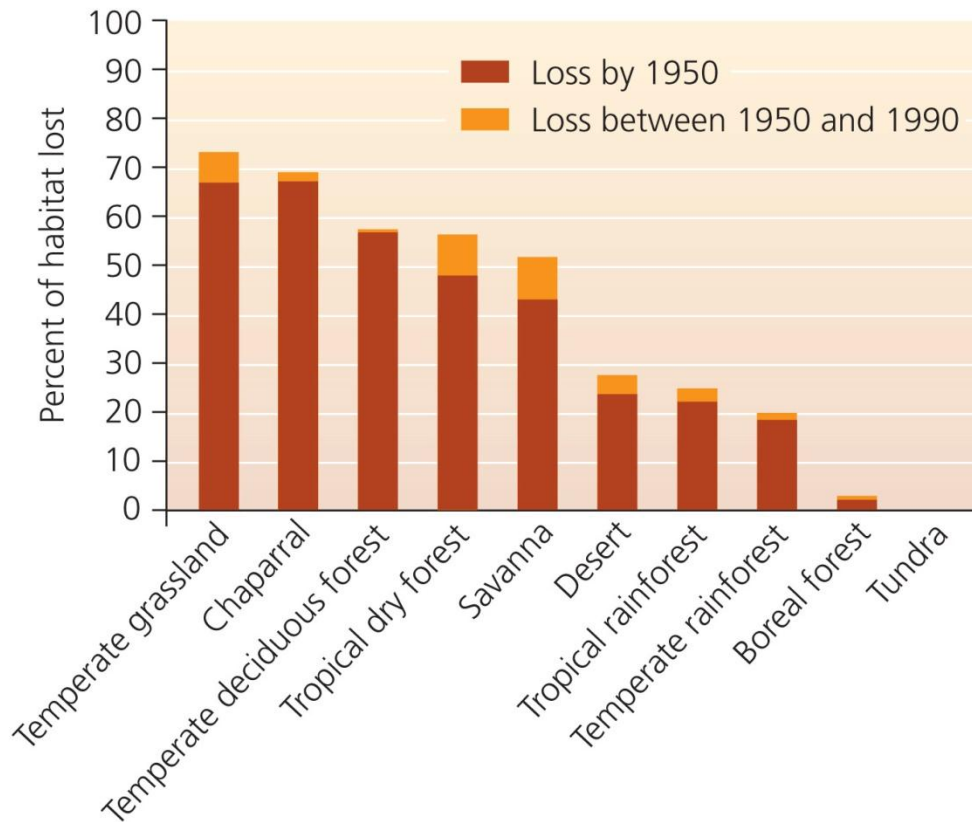
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# Habitat alteration causes biodiversity loss

- The greatest cause of biodiversity loss
  - Farming simplifies communities
  - Grazing modifies the grassland structure and species composition
  - Clearing forests removes resources organisms need
  - Hydroelectric dams turn rivers into reservoirs upstream
  - Urbanization and suburban sprawl reduce natural communities
  - A few species (i.e., pigeons, rats) benefit from changing habitats



# Habitat alteration has occurred in every biome






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*Particularly in tropical rainforests, savannas, and tropical dry forests*



# Invasive species cause biodiversity loss

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

Invasive Species			
Species	Native to...	Invasive in...	Effects
Gypsy moth <i>(Lymantria dispar)</i> 	Eurasia	Northeastern United States	In the 1860s, a scientist introduced the gypsy moth to Massachusetts in the mistaken belief that it might be bred with others to produce a commercial-quality silk. The gypsy moth failed to start a silk industry, and instead spread through the northeastern United States and beyond, where its outbreaks defoliate trees over large regions every few years.
European starling <i>(Sturnus vulgaris)</i> 	Europe	North America	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 the new continent. It only took 75 years for the birds to spread to the Pacific coast, Alaska, and Mexico, becoming one of the most abundant birds on the continent. Starlings are thought to outcompete native birds for nest sites.
Indian mongoose <i>(Herpestes auropunctatus)</i> 	Southeast Asia	Hawaii	Rats that had invaded the Hawaiian islands from ships in the 17th century were damaging sugarcane fields, so in 1883 the Indian mongoose was introduced to control rat populations. Unfortunately, the rats were active at night and the mongooses fed during the day, so the plan didn't work. Instead mongooses began preying on native species like ground-nesting seabirds and the now-endangered Nene or Hawaiian goose ( <i>Branta sandvicensis</i> ).

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# Pollution causes biodiversity loss

- Harms organisms in many ways
  - Air pollution degrades forest ecosystems
  - Water pollution adversely affects fish and amphibians
  - Agricultural runoff harms terrestrial and aquatic species
  - The effects of oil and chemical spills on wildlife are dramatic and well known
- The damage to wildlife and ecosystems caused by pollution can be severe
  - But it tends to be less than the damage caused by habitat alteration or invasive species

# Overharvesting causes biodiversity loss

- Vulnerable species are large, few in number, long-lived, and have few young (K-selected species)
  - The Siberian tiger is hunted without rules and regulations
  - The early 1990s saw increased poaching because of powerful economic incentives
  - Many other species affected: Atlantic gray whale, sharks, gorillas



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

# Climate change causes biodiversity loss

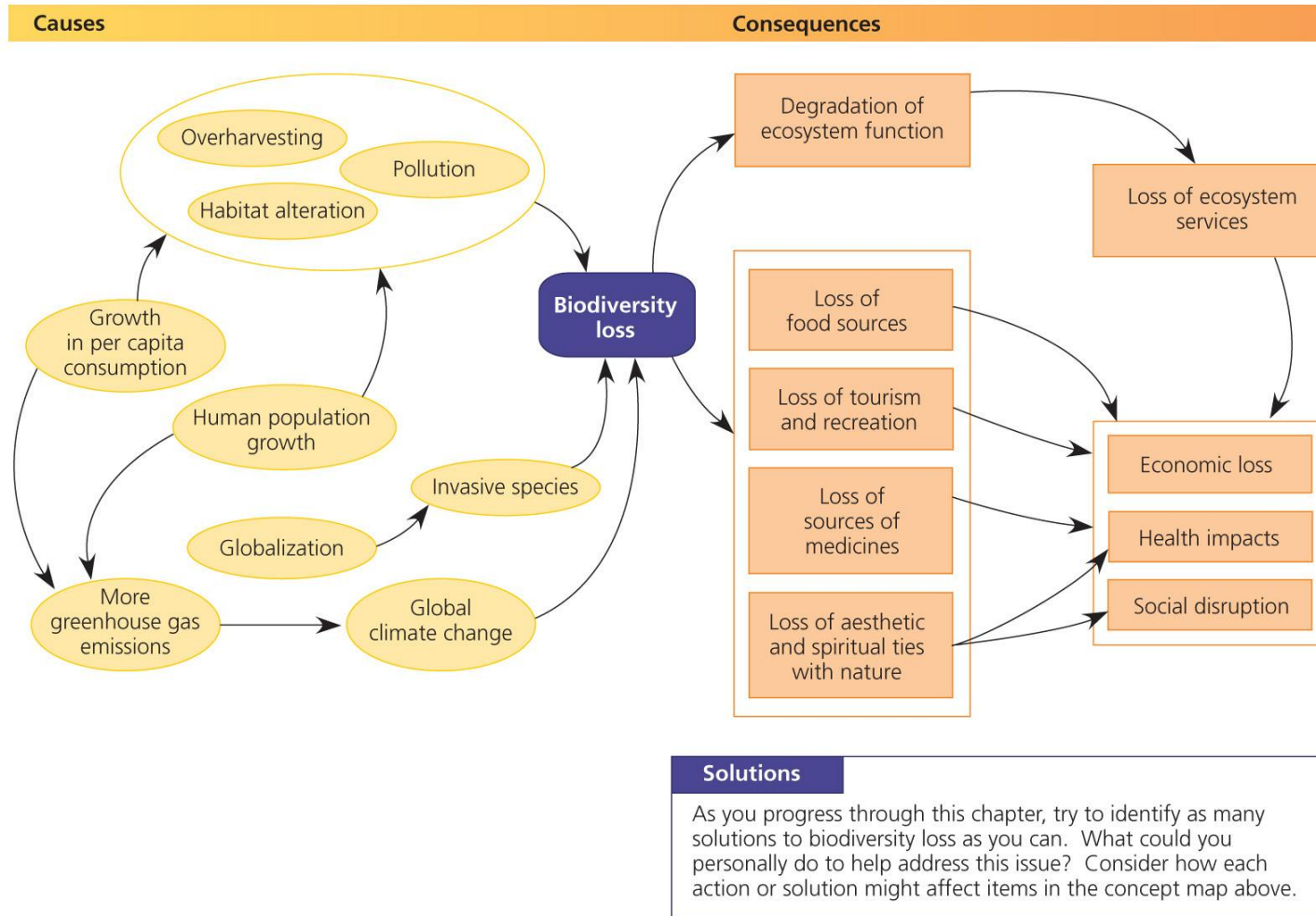
- Emissions of greenhouse gases warms temperatures
  - Modifies global weather patterns and increases the frequency of extreme weather events
  - Increases stress on populations and forces organisms to shift their geographic ranges
- Most animals and plants will not be able to cope



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*The polar bear is being considered for the endangered species list*

# Biodiversity loss has a variety of causes



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# Biodiversity provides free ecosystem services

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








*The annual value of just 17 ecosystem services = \$16 - 54 trillion per year*

# Biodiversity enhances food security

- 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 and have the ability to grow back year after year without being replanted
- New potential food crops are waiting to be used
  - Serendipity berry produces a sweetener 3,000 times sweeter than sugar

# Organisms provide drugs and medicines

- Each year pharmaceutical products owing their origin to wild species generate up to \$150 billion in sales
  - The rosy periwinkle produces compounds that treat Hodgkin's disease and leukemia

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

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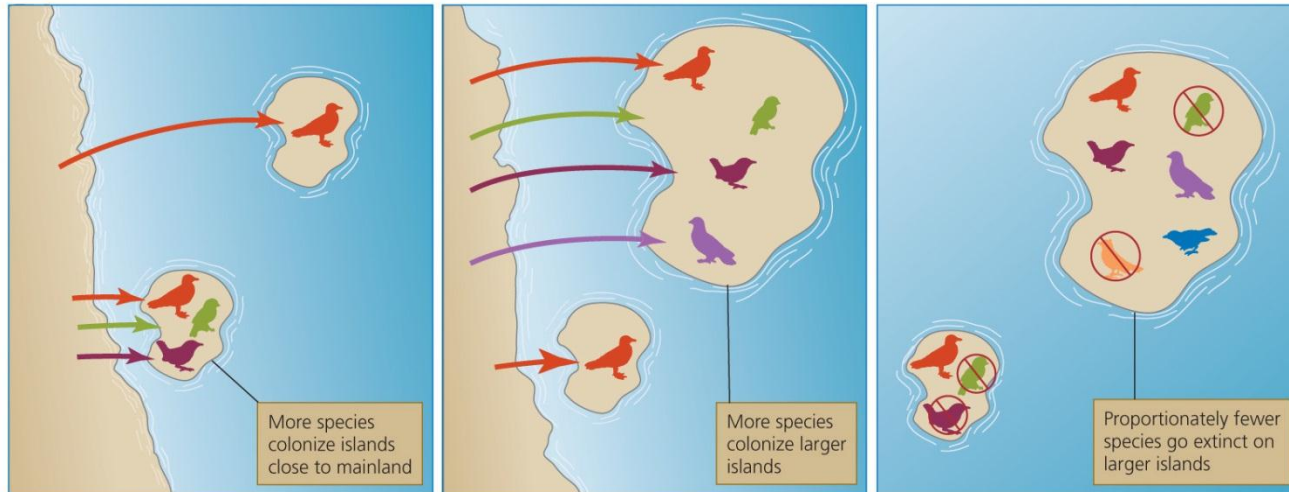


# Biodiversity generates economic benefits

- People like to experience protected natural areas, creating economic opportunities for residents, particularly in developing countries
  - Costa Rica: rainforests
  - Australia: Great Barrier Reef
  - Belize: reefs, caves, and rainforests
- A powerful incentive to preserve natural areas and reduce impacts on the landscape and on native species
- But, too many visitors to natural areas can degrade the outdoor experience and disturb wildlife

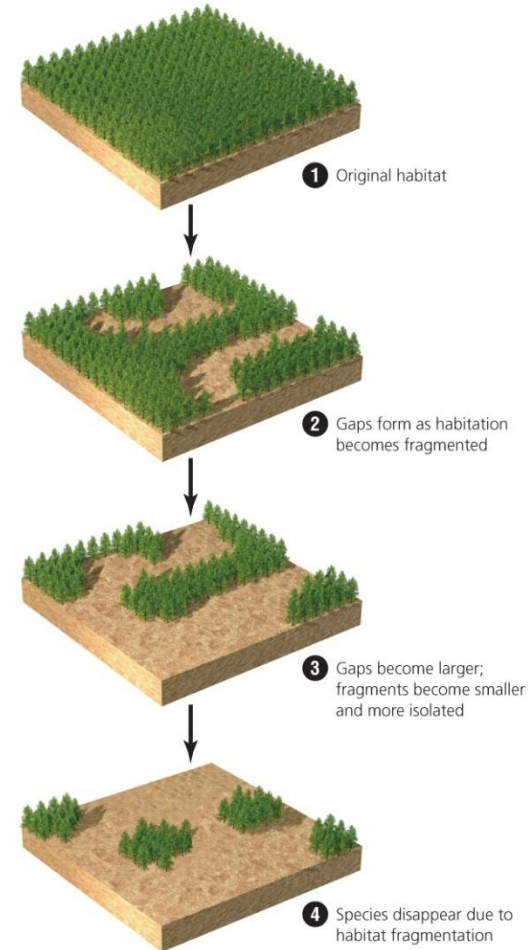
# Island biogeography

- **Equilibrium theory of island biogeography** = explains how species come to be distributed among oceanic and habitat islands
  - Explains how the number of species on an island results from an equilibrium between immigration and extirpation
  - Predicts an island's species richness based on the island's size and distance from the mainland
    - Fewer species colonize an island far from the mainland
    - Large islands have higher immigration rates
    - Large islands have lower extinction rates



# Small “islands” of forest rapidly lose species

- Forests are fragmented by roads and logging
- Small forest fragments lose diversity fastest
  - Starting with large species
- Fragmentation is one of the prime threats to biodiversity



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# Should conservation focus on endangered species?

- **Endangered Species Act (1973) (ESA)** = forbids the government and private citizens from taking actions that destroy endangered species or their habitats
  - To prevent extinction
  - Stabilize declining populations
  - Enable populations to recover
- As of 2007, the U.S. had 1,312 species listed as endangered or threatened

# Other countries have their own version of the ESA

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

# Protecting biodiversity

- **Captive breeding** – individuals are bred and raised with the intent of reintroducing them into the wild
  - Zoos and botanical gardens
- Some reintroductions are controversial
  - Ranchers opposed the reintroduction of wolves to Yellowstone National Park
  - Some habitat is so fragmented, a species cannot survive
- **Cloning** – a technique to create more individuals and save species from extinction
  - Most biologists agree that these efforts are not adequate to recreate the lost biodiversity



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# Umbrella species

- Conservation biologists use particular species as tools to conserve communities and ecosystems
  - Protecting the habitat of these **umbrella species** helps protect less-charismatic animals that would not have generated public interest
- **Flagship species** – large and charismatic species used as spearheads for biodiversity conservation
  - The World Wildlife Fund's panda bear
- Some organizations are moving beyond the single species approach to focus on whole landscapes

# 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





# 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 human impact



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# 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*



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# Innovative economic strategies

- **Debt-for-nature swap** = a conservation organization pays off a portion of a developing country's international debt
  - In exchange for a promise by the country to set aside reserves
  - Fund environmental education, and
  - Better manage protected areas
- **Conservation concession** = conservation organizations pay nations to conserve, and not sell, resources