



Biodiversity and Its Threats

- Cunningham & Cunningham (2017): Chapter 5
- World Wildlife Fund (WWF)



Lecture Outline

- **Biodiversity**
- **How many species** are there?
- **Biodiversity Hot Spots**
- How do we **benefit** from diversity?
- **Threats** to Biodiversity
- **Protecting** biodiversity

What is Biodiversity?

Biodiversity

= Biological Diversity (the variety of living things)

Three kinds of biodiversity

- 1. Genetic diversity**
- 2. Species diversity**
- 3. Ecological diversity**

1. Genetic Diversity

The variety of versions of the same **genes** within individual species.

- *Higher genetic diversity (more types of the same gene)*
 - Populations can better **adapt to changing environment**
 - Higher chance that **at least some individuals** of the species can adapt to environmental changes
 - Higher chance for the species to **reproduce and continue the population**



2. Species Diversity

The number of different kinds of organisms within individual communities or ecosystems.

3. Ecological Diversity

The **richness** and **complexity** of a biological community, including the number of

- **Niches**
- **Trophic levels**
- **Ecological processes** that capture energy, sustain food webs, and recycle materials

How Many Species are There?

- **Identified: ~1.5 million**
 - **~70%: Invertebrates** (animals without backbones/vertebrae)
 - Examples: **Insects**, sponges, clams, worms
- **Estimation: 3-50 million**

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TABLE 5.1 | Estimated Number of Species

CLASS	NUMBER DESCRIBED	NOT YET EVALUATED ¹	PERCENTAGE THREATENED ²
Mammals	5,491	0%	21%
Birds	9,998	0%	12%
Reptiles	9,084	82%	28%
Amphibians	6,433	2%	30%
Fishes	31,300	86%	32%
Insects	1,000,000	100%	27%
Mollusks	85,000	97%	45%
Crustaceans	47,000	96%	35%
Other invertebrates	173,250	99%	30%
Mosses	16,236	99%	86%
Ferns and allies	12,000	98%	66%
Gymnosperms	1,021	11%	35%
Flowering plants	281,821	96%	73%
Fungi, lichens, protists	51,563	100%	50%

¹Evaluated by IUCN for threatened status.

²Number of species as a percentage of those evaluated. Includes IUCN categories critically endangered, endangered, or vulnerable.

SOURCE: IUCN Red List, 2012.

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Biodiversity Hot Spots—Rich and Threatened

Biodiversity Hot Spot is a region that meets **both** of the following criteria

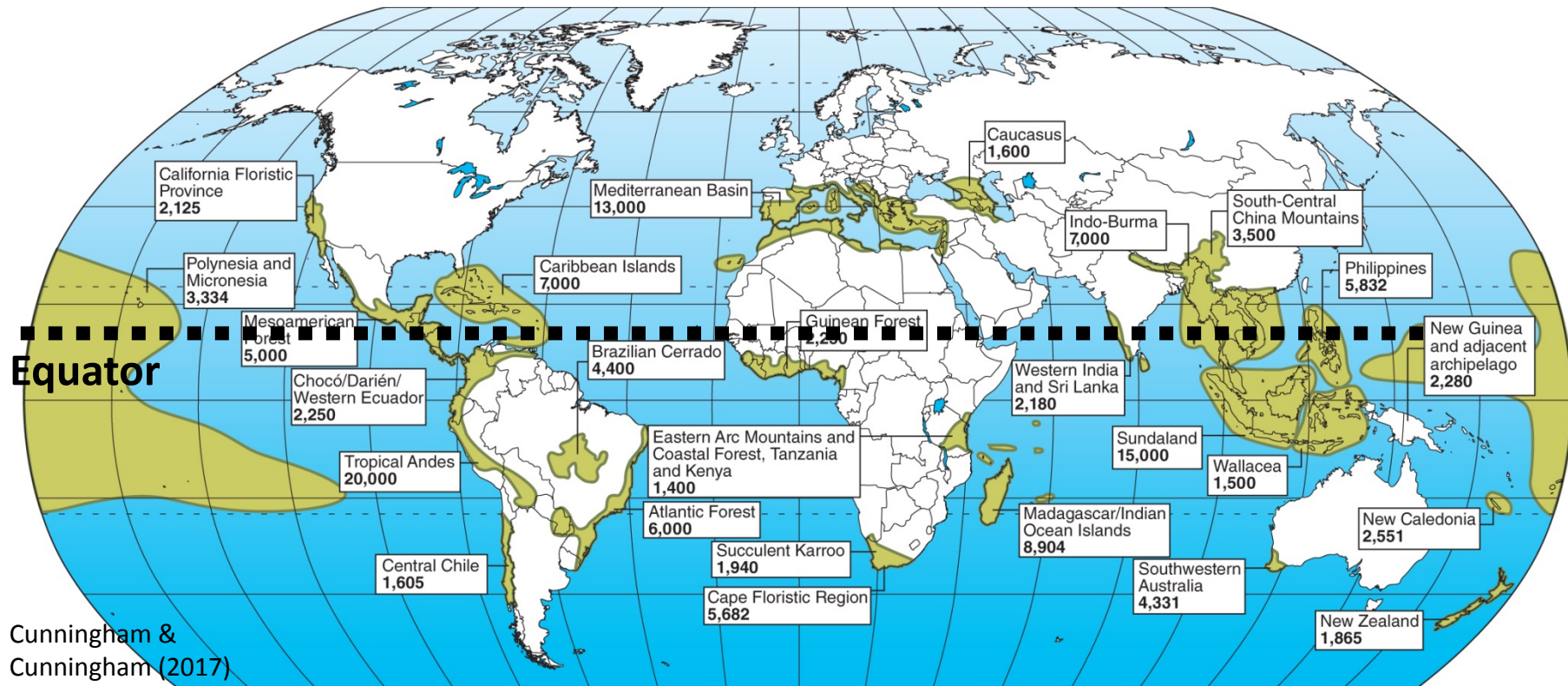
1. Contains **$\geq 1,500$ species of vascular plants as endemics**
2. Has **lost $\geq 70\%$ of its original natural vegetation**

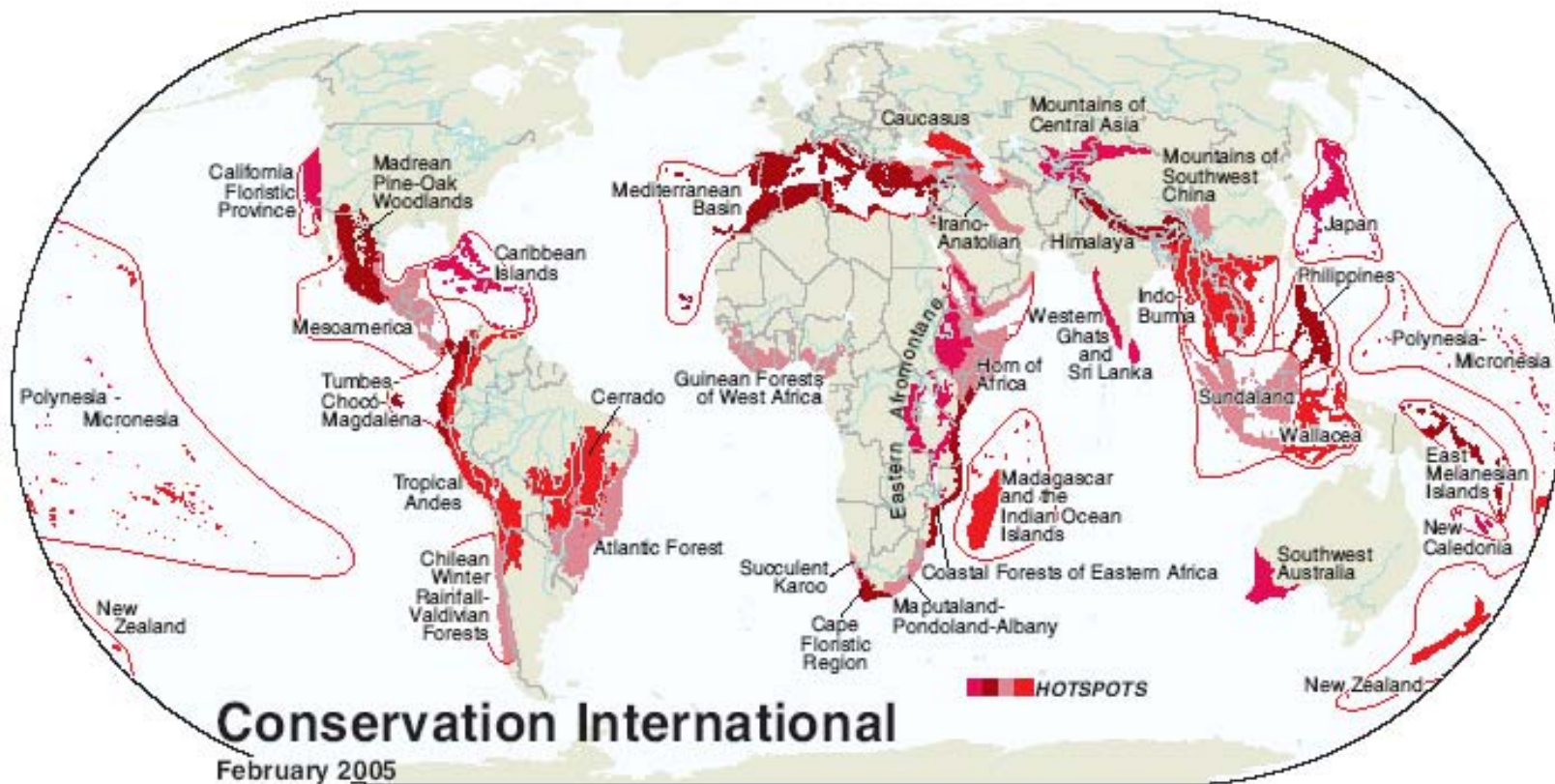
Biodiversity Hot Spots (cont)

Most of the world's biodiversity are **near the equator**, especially **tropical rainforests** and **coral reefs**.

North America and Europe: 10% - 15% only

Biodiversity hotspots. Numbers represent **estimated endemic (locally unique) species**. (Data from Conservation International)





Current record: 35 biodiversity hot spots
(1988: 10 hot spots)

Mountains of Southwest China

Dramatic variations in **climate** and **topography**

→ A wide range of **habitats** and **endemic species**

- >30% of China's plants
- ~50% of China's birds and mammals
 - **Giant panda**

Biodiversity Hot Spots (cont)

- Lots of species are **endemic** to the 35 hot spots
 - >50% of world's plant species
 - >40% of world's terrestrial vertebrate species
- Occupy **2.3%** of the Earth's land surface
 - Once covered 15.7%!



How Do We Benefit from Diversity?

1. **Food**
2. **Drugs and Medicines**
3. **Aesthetic and Cultural Benefits**
4. **Ecological Benefits**

1. Food

Wild plants and animals

- **Food sources**
- Source of genetic material to **improve domestic (agricultural) crop**

2. Drugs and Medicines

- >1/2 of all prescriptions contain some **natural products**
- **Pharmaceutical products** from developing world **plants, animals, and microorganisms**:
>US\$30 billion per year

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TABLE 5.2 | Some Natural Medicinal Products

PRODUCT	SOURCE	USE
Penicillin	Fungus	Antibiotic
Bacitracin	Bacterium	Antibiotic
Tetracycline	Bacterium	Antibiotic
Erythromycin	Bacterium	Antibiotic
Digitalis	Foxglove	Heart stimulant
Quinine	Chincona bark	Malaria treatment
Diosgenin	Mexican yam	Birth-control drug
Cortisone	Mexican yam	Anti-inflammation treatment
Cytarabine	Sponge	Leukemia cure
Vinblastine, vincristine	Periwinkle plant	Anticancer drugs
Reserpine	Rauwolfia	Hypertension drug
Bee venom	Bee	Arthritis relief
Allantoin	Blowfly larva	Wound healer
Morphine	Poppy	Analgesic

3. Aesthetic and Cultural Benefits

a) Nature-based activities

- Photography, hunting, fishing, diving, camping, hiking, wildlife watching
- Physical exercise
- Psychological and emotionally restorative

b) Religious

c) Moral/ Ethical value

d) Existence value

- Just the idea that wildlife exists has value

e) Economically important



4. Ecological Benefits

- a) **Soil** formation
- b) **Air** and **water** purification
- c) **Pest** control
- d) Detoxification and decomposition of **wastes**
- e) **Climate** stabilization
- f) Prevention and mitigation of **natural disasters**

4a) Soil Formation

Activities of **microorganisms** and **animals**

(bacteria, algae, fungi, mites, millipedes and worms)

- i. Condition **soils**
- ii. Break down **organic matter**
- iii. Release **essential nutrients** to plants

4b) Air and Water Purification

i. Maintenance of air quality

Example: Plants

- Regulate **air composition**
- Recycle **oxygen**
- Filter **harmful particles** resulting from industrial activities

ii. Maintenance of water quality

Example: Trees and forest soils

- **Purify water** as it flows through forest ecosystems
- **Prevent harmful siltation** of rivers and reservoirs that may arise from erosion and landslides

4c) Pest Control

Biodiversity: *Natural* pesticides

- ~ 99% of potential crop pests are controlled by other organisms such as insects, birds, fungi
- Pests can develop **resistance** to chemical pesticides

4d) Detoxification and Decomposition of Wastes

- **Organic waste** $\xrightarrow{\text{Decomposition by organisms}}$ **Simple inorganic chemicals**
- **Industrial wastes** $\xrightarrow{\text{Detoxification and decomposition by organisms}}$ **Simple inorganic chemicals**
(e.g. detergents, oils, acids, paper)
- **Simple inorganic chemicals** in soil = Plants **nutrients**
- Some plants **remove harmful substances** from groundwater

4e) Climate Stabilization

- i. Plant tissues and other organic materials: **Carbon storage**
 - Reduce **carbon dioxide** in air
- ii. Rainforests: **Release moisture** into atmosphere (regular rainstorms)
 - Reduce **water loss** from the region, control **surface temperature**
- iii. Forests: **Insulators** and **windbreaks**
 - Reduce impacts of **freezing temperatures** in cold climates

4f) Prevention and Mitigation of Natural Disasters

- i. **Forests and grasslands: Binding action of roots**
 - Protect landscapes against **erosion, nutrient loss, landslides**
- ii. **Floodplain forests and wetlands**
 - **Absorb excess water**
 - **Reduce flood damage**
- iii. **Certain coastal ecosystems (salt marshes, mangrove forests, etc)**
 - **Prevent erosion** of coastlines



Threats to Biodiversity

What is Extinction?

Elimination of a species.

- A **normal** process of the natural world
- Background extinction rate (no human impact)
 - ~**One** species **per decade**
- Extinction rate over the past century (with human impacts)
 - **Thousands** of species, subspecies, and varieties **per year**

Natural Causes of Extinction

- Fossil record: >99% of all species that ever existed are now **extinct**
- **Mass Extinctions** occur periodically

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Table 5.3 | Mass Extinctions

Historic Period	Time (Before Present)	Percent of Species Extinct
Ordovician	444 million	85
Devonian	370 million	83
Permian	250 million	95
Triassic	210 million	80
Cretaceous	65 million	76
Quaternary	Present	33–66

Source: Data from W. W. Gibbs, 2001. "On the termination of species." *Scientific American* 285(5): 40–49.



Human-Caused Reductions in Biodiversity

- 1. Habitat Destruction (Habitat Loss)**
- 2. Invasive Species**
- 3. Pollution**
- 4. Population of Humans**
- 5. Overharvesting**

1. Habitat Destruction (Habitat Loss)

Habitat destruction (loss) is the *major* threat for many species.

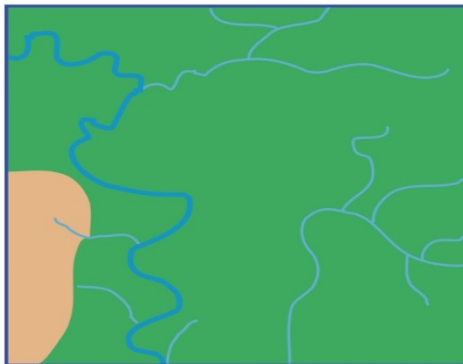
Examples

- **Deforestation** → >1/2 world forest areas already lost
- **Grassland** → **Cropland**
- **Mining**
- **Dam-building**
- Indiscriminate **fishing** methods
(e.g. bottom trawling: dragging a large net *along the sea bottom* behind a commercial fishing boat)

Habitat Fragmentation

Fragmentation reduces habitat to *small, isolated* patches.

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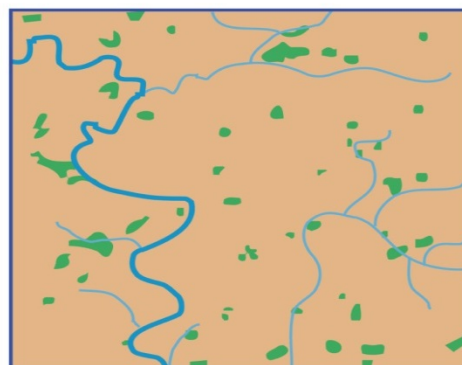
1831



1882



1902



1950

Decrease in wooded area of Cadiz Township in southern Wisconsin during **European settlement**. Green areas represent the amount of land in forest each year.



Impacts of Habitat Fragmentation

- **Loss of biodiversity**
- Some species need **large territories** to survive
- **Edge effects**
 - **Microclimatic changes** (light, temperature, and wind)

Impacts of Habitat Fragmentation (cont)

- **Decrease** in the amount of **interior habitat**
 - Some species (e.g. some **forest interior birds**) **reproduce successfully only in deep forest** far from edges and human settlement
- **Predators** and **invasive species** spread quickly into new areas following fragment edges
- Populations divided into **isolated groups vulnerable to catastrophic events** (e.g. storms, diseases)

2. Invasive Species

Other names: Alien, exotic, non-native, non-indigenous, unwanted, disruptive, pests

Organisms that thrive in new territory where they are free of predators, diseases, or resource limitations that may have controlled their populations in their native habitat.

- **Intentional or accidental** dispersal by human activities

2. Invasive Species (cont)

All forms of life evolve in **close interaction with their environment**

- Example: Species develop mechanisms to protect themselves from predators

→ **Native species have no defences** against new (invasive) species.

3. Pollution

- Some types of pollution: Visible, relatively easy to deal with
- Many other types: Much less obvious
 - **Impacts may not become apparent until high concentrations** of toxic chemicals have **built up in soil or living tissue**
- Pollutants: **No boundaries**

4. Population

- Beginning of 19th century: 1 billion
- Now: 7.4 billion
 - Rapid increase in exploitation of natural resources
 - **Unsustainable use**

5. Overharvesting

Taking more individuals than reproduction can replace.

Unsustainable logging

- >1/2 of the Earth's forests destroyed
- Worldwide, every minute
 - ~26 hectares of forest lost



Predator and Pest Control

Many animal populations are regarded as dangerous to humans or livestock

→ Greatly reduced or killed



Commercial Products and Live Specimens

Wildlife smuggling: Very profitable

- **Animal parts:** Medicines, food
- **Plants:** Medicines, horticulture
- **Live animals:** Pet trade

News Clip: 'Hong Kong Takes the World Closer to Ending Ivory's Bloody Trade'

South China Morning Post (24 January 2014)

Hong Kong's Endangered Species Advisory Committee has agreed unanimously to incinerate most of the city's stockpile of confiscated ivory, which, at an estimated 30 tonnes, is one of the largest in the world.

Hong Kong's role as an epicentre of the booming ivory trade makes the decision truly extraordinary. It's an encouraging sign that Africa's elephants, which are being poached by the tens of thousands each year, may soon have more campaigners and protectors working for their survival than ivory consumers and poachers working against it.

News Clip (cont)

One of the best protections for Africa's elephants is a non-existent market for ivory

Hong Kong is a major destination and transit hub for trafficked ivory. In recent years, its busy ports have witnessed some of the largest seizures of illegal ivory, as elephant tusks concealed in hidden compartments or underneath other products in shipping containers flow to Hong Kong's shores from Nigeria, Togo, Tanzania and other countries. In spite of these seizures, for every shipment of illicit ivory that is caught, many more go undetected by officials, destined for the region's many carving factories before their contents end up displayed in shop windows and living rooms.

The Environmental Investigation Agency estimates that up to 90 per cent of ivory in China is illegal...

Protecting Biodiversity

Examples

- Hunting and Fishing Laws
- U.S. Endangered Species Act (ESA)
- Recovery Plans
- Habitat Protection
- Convention on Biological Diversity
- IUCN Red List Program
- Convention on International Trade in Endangered Species (CITES)



Case Study (1): Giant Pandas

- **Population and Distribution**
- **Characteristics**
- **Diet**
- **Threats**
- **Conservation**

Giant Pandas—Population and Distribution

- ~1,864 in the wild
- Found *only* in China (endemic)
 - Southwest China (Gansu, Shaanxi, and Sichuan Provinces) to the east of the Tibetan plateau
- Temperate broadleaf and mixed forests



Giant Pandas—Characteristics

- **Biologically unique**

- Belong to the **bear family**
- Have the **digestive system of a carnivore**, but adapted to a **vegetarian** diet (mainly **bamboo**)
- Cannot easily break down cellulose in bamboo
→ Must eat **huge amounts** to meet energy requirements

- **Poor breeders**

- Life span: ~20 years in the wild, up to 30 in captivity

Giant Pandas—Diet

Bamboo: Flowers every 30 to 120 years, depending on species.

All the bamboo plants of a species in one area **flower** at the same time, then **die-off**

→ Pandas must find **another species** of bamboo to eat

Giant Pandas—Diet (cont)

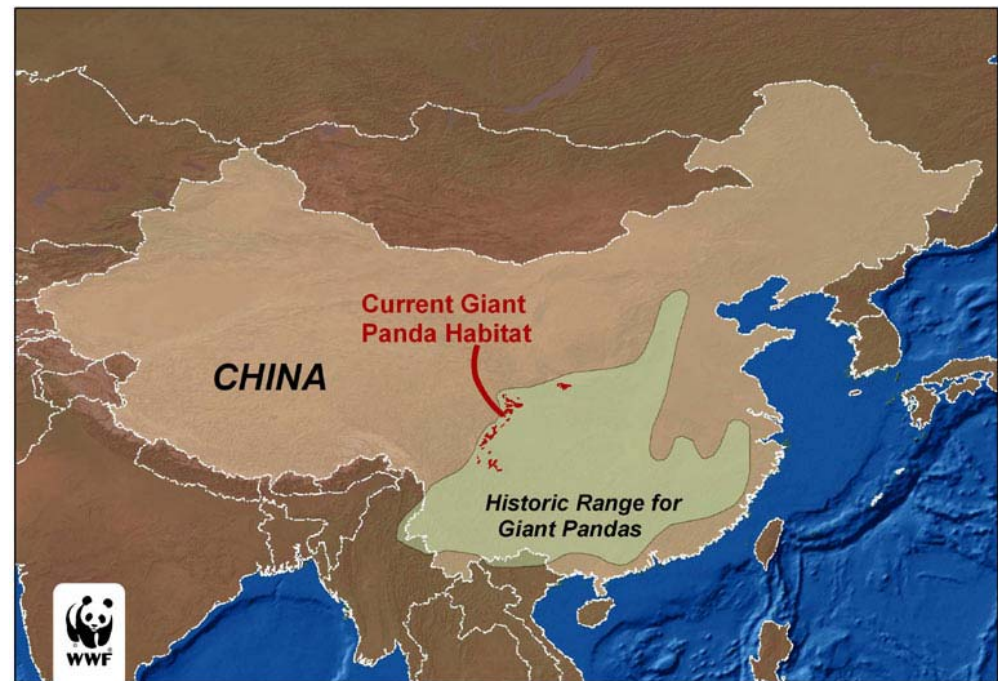
In most cases, ≥ 2 **species** of bamboo in a panda habitat.

- When 1 species of bamboo is in short supply
 - Pandas **switch to other species**, or
 - **Expand their home range** to areas where bamboo has not flowered

Threats to Giant Pandas

a) Habitat fragmentation and loss (*greatest threats*)

- **Deforestation** for agriculture, timber, fuel wood



While giant pandas once roamed much of southern China, they are now confined to isolated patches on six mountain ranges

Threats to Giant Pandas (cont)

b) Inbreeding

- **Less adaptability** to environmental changes
- **Reduced resistance** to disease

c) Poaching (= illegal killing)

- Pelt

Threats to Giant Pandas (cont)

d) **Accidentally trapped and killed**

- People trapping other animals in the panda habitat

e) **Habitat degradation**

- Collect **fuel wood** and **timber** for building homes
- Collect **wild plants and animals**
 - Traditional medicines, food

Giant Pandas

—Conservation Work by Mainland Government

Giant panda: A national treasure in China

- a) Legal protection
- b) Banned logging
- c) Nature reserves
- d) Captive breeding (Wolong Nature Reserve and Captive Breeding Center)
- e) New panda reserves and forested 'corridors' (collaboration with WWF)
- f) National Panda Survey



Case Study (2):

Japan's Drive Fisheries of Dolphins



Summary

- What is **Biodiversity**?
- **Three kinds** of Biodiversity
 1. **Genetic** Diversity
 2. **Species** Diversity
 3. **Ecological** Diversity
- **How many species** are there?
- **Biodiversity Hot Spots**
- How do we **benefit** from diversity?
- **Threats** to Biodiversity

Summary (cont)

- What is **extinction**?
- **Causes** of extinction
 - **Natural** causes
 - **Human-related** causes
- **Protecting biodiversity**
 - Case Study (1): **Giant Pandas**
 - Case Study (2): **Japan's Drive Fisheries of Dolphins**