Environmental Science, 15e
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8

Sustaining Biodiversity: Saving Species and Ecosystem Services

Core Case Study: Honeybees

- Honeybees provide one of the most important ecosystem services: pollination

- European honeybees are used by farmers almost exclusively in the U.S. for pollinating crops

  – This dependence on one species is a violation of the principle of sustainability

Where Have All the Honeybees Gone?

- Since 2006 the honeybees have been in massive decline
  - This is called colony collapse disorder (CCD)
- Extinction of species is one of the most long-lasting environmental threats
- What can we learn from their collapse?
- What might happen to food supplies if the European honeybee continues to decline?

European Honeybee Sipping Nectar From a Flower

Darlyne A. Murawski/National Geographic Creative

8.1 What Role Do Humans Play in the Loss of Species and Ecosystem Services?

- As the human population has grown exponentially, the rate of species extinction has also increased many-fold

- By the end of the 21st century, the extinction rate is predicted to be 10,000 times higher than before human exponential growth began

Extinctions Are Natural but Sometimes They Increase Sharply

- Species that can no longer be found on earth have suffered biological extinction

- Mass extinction: the extinction of many species in a relatively short period of geologic time

  – Geological history and fossils show that the earth has had five mass extinctions

  – After each mass extinction, biodiversity returned and often was higher than before

    - Recovery took millions of years

Scientists Use Background Extinction Rates To Study Populations

- Current annual rate of species extinction is between 100 and 1,000 times the background extinction rate

  – At today's rates (100 to 1,000 times that background rate) we are losing between 1,000 and 10,000 species per year – 2 to 27 species per day

  – During the next 100 years, the background extinction rate is estimated to rise to at least 10,000 times its current rate

Background Extinction Rate Projections

- The expected 21st century dramatic rise in the background rate of extinction:

  - Will be a result of habitat loss and degradation, climate change, ocean acidification, and the impact of human activity

- In the past:

  - As humans moved across the earth, environments were destroyed, habitats were degraded, and ever larger ecological footprints were created

Species Extinctions Rates in the 21st Century

- What do these extinction rates indicate?
  - 25-50% of the world's roughly 2 million identified species, as well as, millions of unidentified species, could become extinct by the end of the 21st century
    - This will potentially be the sixth mass extinction
  - We need to save species (especially keystone species) in order to reduce the human impact on biodiversity and ecosystem services

Projected Extinction Rates May Be Too Low

- Extinction rates in biodiversity hotspots are much higher than the global average
  - The rapidly growing human population increases per capita use of resources, which sharply increases harmful environmental impacts

- We are creating a speciation crisis
  - Limits to long term recover of biodiversity may result as there too few places for new species to evolve

Endangered Natural Capital: Four Critically Endangered Species

a. **Mexican gray wolf:** About 42 in the forests of Arizona and New Mexico
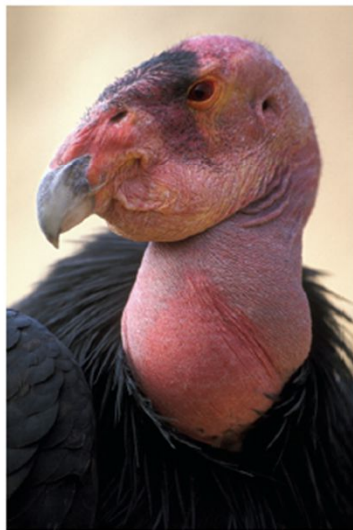
b. **California condor:** 226 in the southwestern United States (up from 9 in 1986)

c. **Whooping crane:** 437 in North America

d. **Sumatran tiger:** No more than 500 on the Indonesian island of Sumatra

Endangered and Threatened Species Are Ecological Smoke Alarms

- Species heading towards biological extinction are classified as either:
  - Endangered: so few individual survivors that it could soon become extinct
  - Threatened: enough individuals to survive in the short term, but not long term
- Some species actually have characteristics that contribute to their chances of becoming extinct (low reproductive rate, rare, narrow distribution)

8.2 Why Should We Try To Sustain Wild Species and Their Ecosystem Services?

- Recovering from large-scale extinctions can take millions of years

- Many people think species have a right to exist, even if they are harmful or not useful to humans

All Species Provide Ecosystem Services

- The orangutan, a significant member of tropical forests, may soon disappear:
  - Their forest habitats are being cleared, they bear young every 8 years, and live animals are being smuggled out of the wild for up to $10,000 each
- Why should we work to prevent these kinds of extinction possibilities?
  - When one species goes extinct, this can affect many other populations

Why Should We Work To Prevent Extinction Possibilities?

- We depend on ecosystem services for food, fuel, and lumber

- Many species contribute to economic services (discovery of medicinal drugs)

  "…eliminating species that make up an essential part of the world's biodiversity is like burning millions of books that we have never read…"

- Sharp reductions in biodiversity result in the reduction of speciation

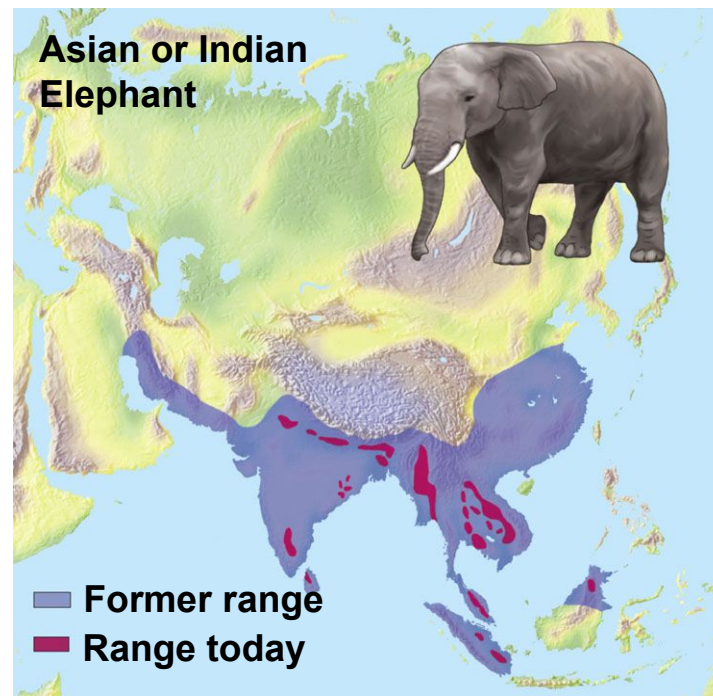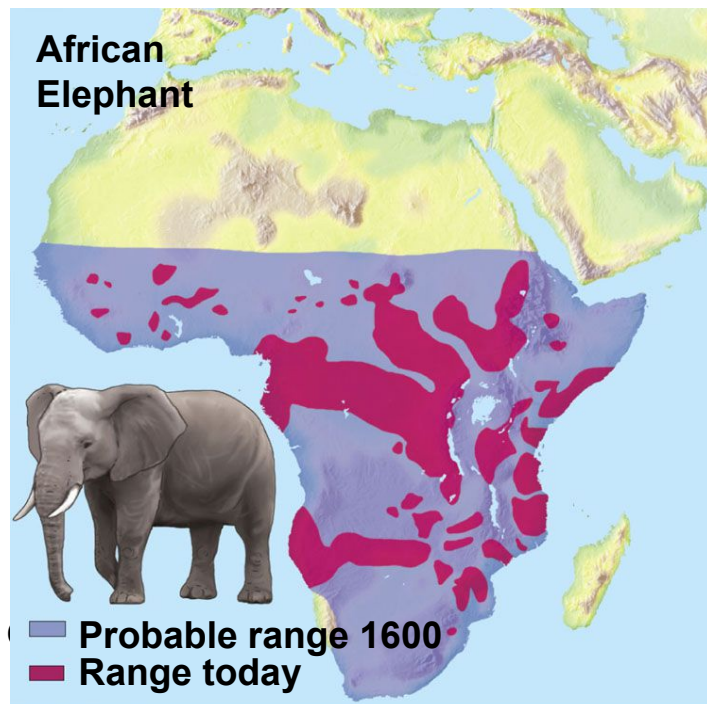# 8.3 How Do Humans Accelerate Species Extinction and Their Ecosystem Services?
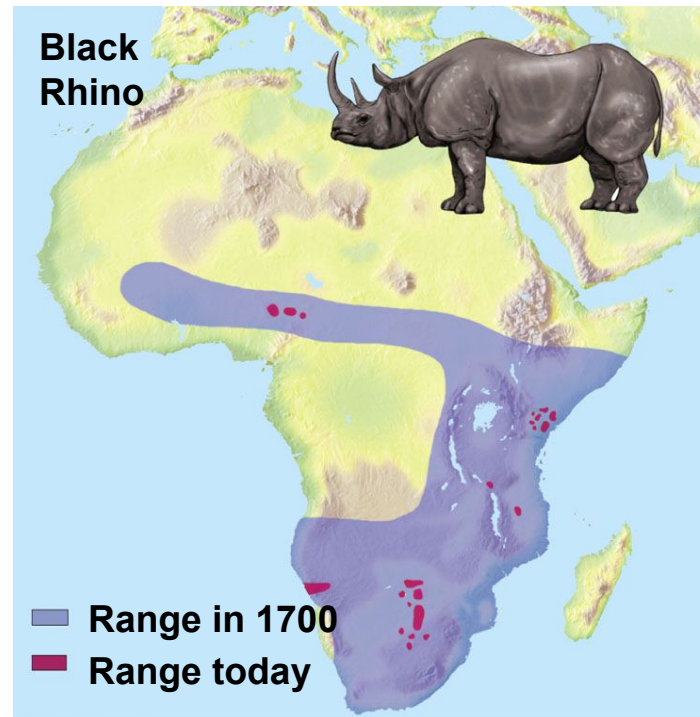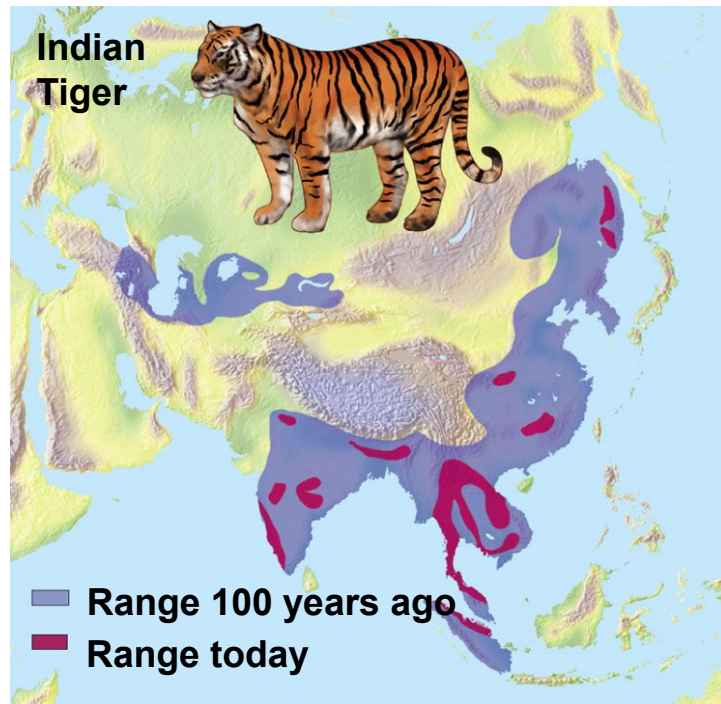
- There are many threats to both species and ecosystem services

Loss of Habitat Is the Single Greatest Threat to Species: Remember HIPPCO
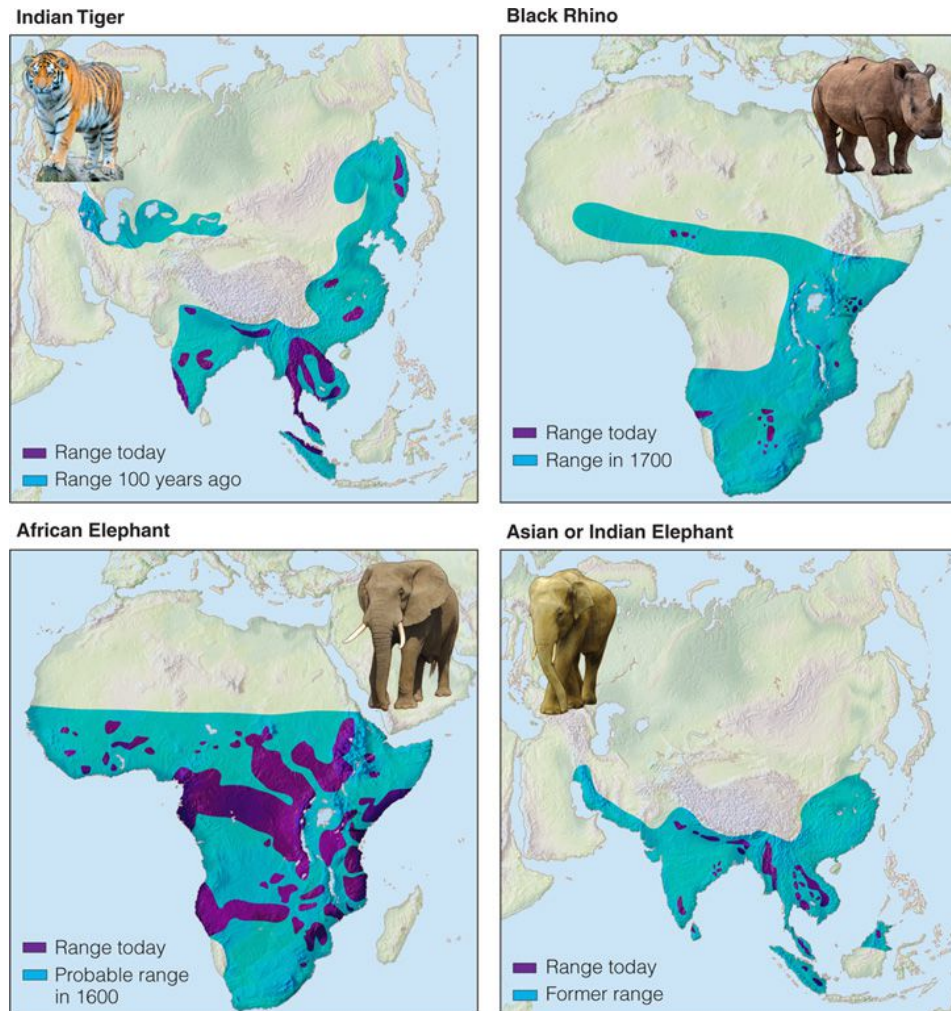
- **HIPPCO**:
  - **H**abitat destruction, degradation, and fragmentation (greatest threat to species)
  - **I**nvasive (nonnative species)
  - **P**opulation growth and increasing use of resources
  - **P**ollution
  - **C**limate change
  - **O**verexploitation

Habitat Fragmentation

- With no where else to go, island species (often endemic) are vulnerable to extinction and ecosystem degradation

- Habitat islands: formed by habitat fragmentation – occur when intact habitats are divided into smaller patches by roads, logging, crop fields, and urbanization
  - Species migration routes can be affected, making them vulnerable to predators, storms and fires

Indian Tiger

Range 100 years ago
Range today

Black Rhino

Range in 1700
Range today

African Elephant

Probable range 1600
Range today

Asian or Indian Elephant

Former range
Range today

Stepped Art

Natural Capital Degradation: Maps Showing Habitat Loss and Fragmentation

Indian Tiger
- Range today
- Range 100 years ago

Black Rhino
- Range today
- Range in 1700

African Elephant
- Range today
- Probable range in 1600

Asian or Indian Elephant
- Range today
- Former range

Compiled by the authors using data from International Union for Conservation of Nature and World Wildlife Fund.

We Have Moved Disruptive Species Into Some Ecosystems

- Intentional or accidental introduction of species:
  - 98% of U.S. food supply is provided by intentionally introduced nonnative species
    - Helps to control pests
    - Without facing natural predators and competitors, nonnative species can crowd out native species
  - Whether deliberately or accidentally introduced, nonnative species can be both ecologically and economically harmful

Harmful Effects of Nonnative Species

- At present, about 40% of U.S. species are listed as endangered – 95% of which are endangered because of nonnative species

- Examples of troublesome bioinvaders:
  - Argentinean fire ants (accidental)
  - Burmese and African pythons (both intentional and accidental)
  - Kudzu plant (intentional)
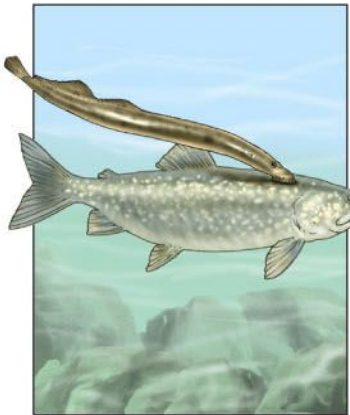 - Zebra mussels (accidental)

Deliberately Introduced Species
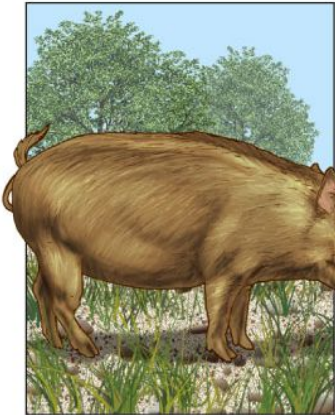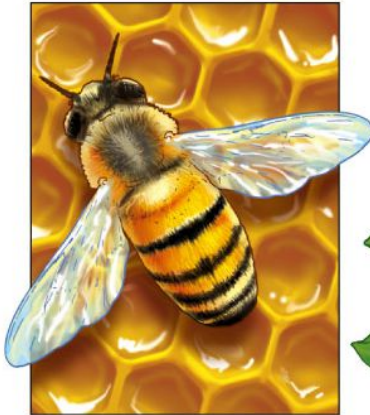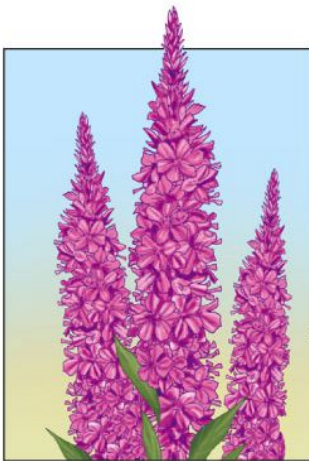
Purple loosestrife African honeybee ("Killer Bee") Water hyacinth Japanese beetle European wild boar (Feral pig)

Fig. 8-7a, p. 159

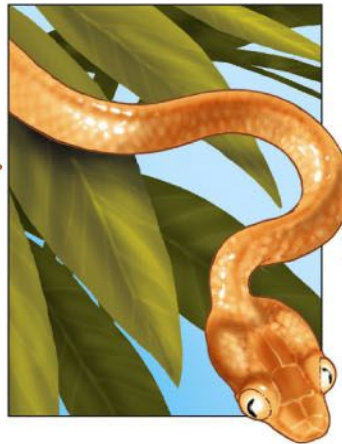# Accidentally Introduced Species

Sea lamprey (attached to lake trout) Argentina fire ant Brown tree snake Formosan termite Zebra mussel

Fig. 8-7b, p. 159

Deliberately and Accidentally Introduced Species

Deliberately Introduced Species

Purple loosestrife

African honeybee ("Killer bee")

Kudzu

Nutria

European wild boar (Feral pig)

Accidentally Introduced Species

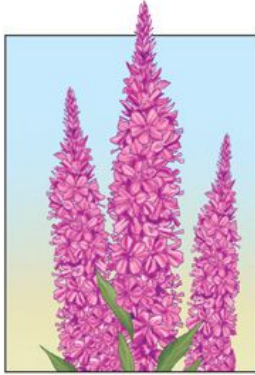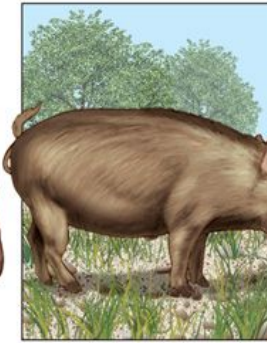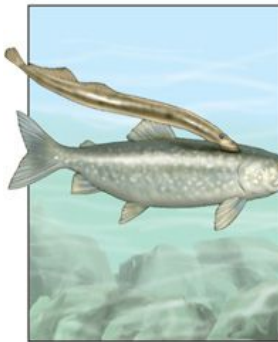Sea lamprey (attached to lake trout)

Argentina fire ant

Burmese python

Formosan termite

Zebra mussel

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Prevention Is the Best Way to Reduce Threats From Invasive Species

- Once nonnative species become established it is almost impossible to remove them

- Preventing their introduction is the best way to limit threats of nonnative species

  - Funding research to identify bioinvader characteristics useful for controlling species

  - Use satellite observations and ground surveys to develop models predicting dispersal patterns and harmful effects

How Can We Limit the Harmful Impacts of Nonnative Species?

- Establish international treaties banning transfer of species from country to country

- Increase inspection on imported goods

- Educate the public about the harmful effects of releasing nonnative species into environments near where they live

Contributions to Species Extinction

- Population growth, overuse of resources, and climate change

- Exponential growth of the human footprint

- Pesticide pollution (DDT)

  – Washing into hydrologic systems has a damaging effect on terrestrial and aquatic species

  – Pesticides kill more than 67 million birds and 6-14 million fish each year – and threaten 20% of endangered species

Further Contributions to Species Extinction

- Climate change is also a serious threat to species – ¼ to ½ of terrestrial animals and plants may be driven to extinction by the end of the century

- Illegal killing (poaching), capturing, and selling of species threatens biodiversity
  - Many species are killed for their parts or are captured live to be sold for large profits (yet about 2/3 of these live species die in transit)

Loss of Species Due to Overhunting

- Some African species are threatened with extinction due to the rising demand for bushmeat -- to feed growing human populations and provide exotic foods for restaurants

- Eating of bushmeat has also spread fatal diseases (HIV/AIDS and Ebola)

8.4 How Can We Sustain Wild Species and the Ecosystem Services They Provide?

- Enact and enforce national environmental laws and international treatises

- Create wildlife sanctuaries

International Treaties and National Laws Can Help Protect Species

- 1975 Convention on International Trade in Endangered Species (CITES) – treaty signed by 178 countries bans hunting, capturing, and selling of threatened and endangered species
  - Enforcement varies from country to country
  - Countries can exempt themselves from a particular species
  - Much of the hunting takes place in countries that did not sign the treaty

More International Treaties and National Laws

- Convention on Biological Diversity (CBD) Treaty was signed by 193 countries
  - As of 2012, the U.S. had not signed it
- CBD commits to reducing biodiversity loss and sharing the world's genetic resources
  - Including efforts to control/prevent the spread of invader species
  - Focuses on ecosystems, not individual species

Wildlife Refuges Can Help Protect Species

- We can establish wildlife refuges and other protected areas
  - The National Wildlife Refuge System was established by President Theodore Roosevelt and by 2013 there were more than 560 refuges in the system
    - Wetlands are protected in ¾ of these refuges and this protects waterfowl migration
    - At least ¼ of all US endangered and threatened species have habitats in these wildlife refuges

The First U.S. Federal Wildlife Refuge at Pelican Island, Florida

Chuck Wagner/Shutterstock.com

George Gentry/U.S. Fish and Wildlife Service

Negative Aspects of U.S. Wildlife Refuge System

- Unfortunately, activities harmful to wildlife (mining, oil drilling, use of off-road vehicles) occur in nearly 60% of these wildlife refuges

Seed Banks, Botanical Gardens, and Wildlife Farms

- All of these can help protect species:
    - Plant genetic information is preserved in climate controlled seed banks (Svalbard Global Seed Vault in the arctic)

    - Botanical gardens help – but only 3% of the world's plants are preserved in these gardens

    - Some farms raise endangered species for sale which takes some of the ecological pressure off the endangered species

Zoos and Aquariums Protect Some Species

- Some endangered species are being preserved in zoos and aquariums using:
  - Egg pulling (removing eggs from the wild to be hatched in the zoo)
  - Captive breeding (some wild species are collected and breed in zoos)
  - Other techniques: artificial insemination, embryo transfer, use of incubators and cross fostering

Captive Breeding and Genetic Variation

- The major issue is genetic variation
  - Scientists estimate that 10,000 or more endangered individuals of a species are needed to maintain the species' capacity for biological evolution
    - Zoos do not have the space or money to maintain these kinds of populations

- Aquariums are display places for education, but cannot serve as gene banks

Efforts To Protect Species Raise Difficult Questions

- Should the focus be to protect species, or to protect ecosystems and the services they provide?

- How do we allocate limited resources between these two ideas?

- How do we decide which species to protect – the most threatened or those that are keystone species?

Limitations of Financial and Human Resources Raise Additional Questions

- More challenging questions:
  - Is it more important to focus on protecting species humans find appealing or on species of ecological importance?
  - How do we determine which habitats are most in need of protection?
  - How do we allocate limited resources among biodiversity hotspots?
- We can help by not buying products made from threatened or endangered species

Additional Case Study: The Asian Carp Invasion

- In the 1970s, the Asian carp was brought to the U.S. to be used in fish farms in Arkansas and Mississippi to keep the plankton under control in the fish ponds
  - Storm-induced flooding of the fish farms resulted in the accidental release of the Asian carp into the Mississippi River water system
  - This carp is considered the most invasive species in the U.S.

Additional Case Study: The Asian Carp Invasion

- The Asian Carp outcompetes natural species for both food and habitat, cannot be caught by rod fishing, and currently has limited economic value in the U.S. food market
  - How are scientists trying to control the spread of these fish to other ecosystems?
  - If not controlled, where will the Asian carp invade next?
  - Would you eat Asian Carp?

The Asian Carp and the Three Big Ideas

- The Asian carp is degrading native fish habitats and nutritional sources in Mississippi River waterways

- We should avoid contributing to wild species extinction by preventing the invasion of nonnative species

- In spite of the many laws, treaties, and establishment of wildlife sanctuaries, accidental invasions still occur