

Environmental Science

Systems and Solutions

FOURTH EDITION

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Chapter 11

CONSERVING BIOLOGICAL RESOURCES

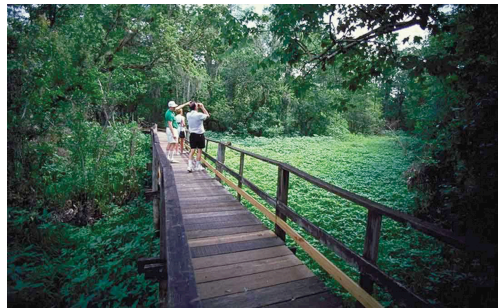
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Environmental Science *Systems and Solutions* FOURTH EDITION

Introduction

- **Biodiversity is “the variety and variability among living organisms and the ecological complexes in which they occur.”**
- **Conservation biology is a new subdiscipline of biology that draws from genetics, ecology, and many other fields to find practical ways of saving species.**

The Corkscrew Swamp Sanctuary in Florida, owned by the National Audubon Society.



Courtesy of South Florida Water Management District

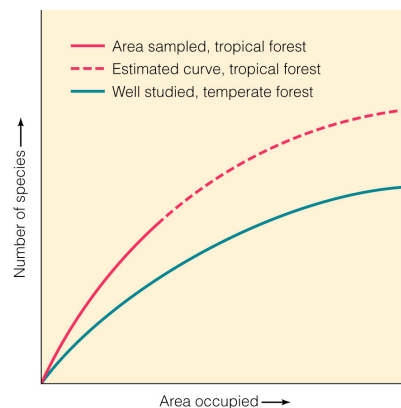
Measuring What's at Risk

- **Biodiversity at its simplest most commonly measures species richness.**
- **Biodiversity varies widely around the planet and over time.**
- **About 1.8 million species have been described.**
- **Not all groups of organisms or parts of the world have been studied equally. The areas with the most species, the tropics, are the least known. (Also the sea)**

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Estimating Numbers of Species

- **Species-area curves predict numbers of organisms in unsampled areas.**
- **Ecological ratios and rainforest insect samples help estimate biodiversity from limited information.**



Species area curves for well-studied temperate forests compared to tropical forests.

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Biodiversity Loss

- **Extinction—the death of a group.**
- **Biological impoverishment is much more common than species extinction.**
 - **Extirpation—A species has died out in a local area. (e.g. CA state animal! (grizzly bear))**
 - **Ecological extinction—A species is too rare to have an impact on its ecosystem.**



Courtesy of National Ocean Service Photo Gallery

Figure 11-01 Florida panther.

Less than 80 panthers, left; only 20 breeding female => almost certain to go extinct. Also Tigers, rhinos, etc.

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Current Biodiversity Loss

Another Mass Extinction?

- **There have been other major mass extinctions throughout history (as determined by the fossil record) and we may be in the midst of another one.(starting with European expansion in 1500's)**
- **Extinction rates of well-studied groups have been increasing rapidly.**
- **Many species now have so few individuals alive that they are probably doomed to extinction.**

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Current Biodiversity Loss

Another Mass Extinction?

- Current extinction rates are hundreds of times higher than the “normal” average extinction rate.
- Table certainly an underestimate:
 - Many extinct before recorded; rate speeding up greatly, but only called extinct if not seen for 50 years, many non-extinct species too depleted to survive

TABLE 11-1 Recorded Extinctions of Vertebrates and Plants, 1600 to 2000

Many additional species have presumably gone extinct without scientists having recorded them. Many more species are now threatened with extinction in the next few years. Except for mammals and birds, most threatened percentages are probably greatly underestimated.

Species	Total Species		Percentage Extinct	Percent Threatened	
	Extinct	Threatened			
Mammals	87	1,130	4,600	1.9	24.6
Birds	131	1,183	9,500	1.4	12.5
Reptiles	22	296	6,300	0.3	4.7
Amphibians	5	146	4,200	0.1	3.5
Fishes	91	750	19,100	0.5	3.9
Plants	90	5,611	250,000	0.04	2.2

Source: Data from International Union for Conservation of Nature and Natural Resources, The World Conservation Union Red List 2000.

Currently 25% of mammals and 13% of birds threatened!
Other plants and animal groups even more at risk

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Current extinction rates

TABLE 11-2 Estimated Rates of Extinction

Estimate	Global Loss per Decade (%)	Method of Estimation
One million species between 1975 and 2000	4	Extrapolation of past exponentially increasing trend
15% to 20% of species between 1980 and 2000	8 to 11	Estimated species-area curve; forest loss based on U.S. government projections
12% of plant species in Western Hemisphere tropics 15% of bird species in Amazon basin	—	Species-area curve
2,000 plant species per year in tropics and subtropics	8	Loss of half the species in area likely to be deforested by 2015
25% of species between 1985 and 2015	9	As above
At least 7% of plant species	7	Half of species lost over next decade in 10 “hot spots” covering 3.5% of forest area
0.2% to 0.3% per year	2–3	Half of rainforest species assumed lost in tropical rainforests to be local endemics and becoming extinct with forest loss
5% to 15% forest species by 2020	2–5	Species-area curve
2% to 8% loss between 1990 and 2015	1–5	Species-area curve; range includes current rate of forest loss and 50% increase

Source: Adapted from Reid WV. “How many species will there be?” Whitmore TC, Sayer JA, eds. *Tropical Deforestation and Species Extinction*. (London, Chapman & Hall, 1992.)

Summary: between 1% and 11% of all species are being lost each decade.
Take average to 5% => 50 species extinct each day; over long times in the past
The extinction rate has been maybe 5 species lost per year (fossil record). Current
Rate implies roughly estimate 1/2 of all current species will be extinct during 21st
century!

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What Causes Biodiversity Loss?

- **Extinction is caused by environmental change.**
- **Species can adapt if the change is not too rapid.**
- **Changes caused by human population growth and technology have been too massive and fast.**

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Four Ways that Humans Cause Population Decline and Species Extinction

Change Physical Environment	Examples
1. Habitat Destruction	Drain swamp, toxic pollution
Change Biological Environment	
2. Introduce new species	New predator
3. Overhunting	Big-game hunting
4. Secondary Extinctions	Loss of food species

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Decline of Tropical Rainforests

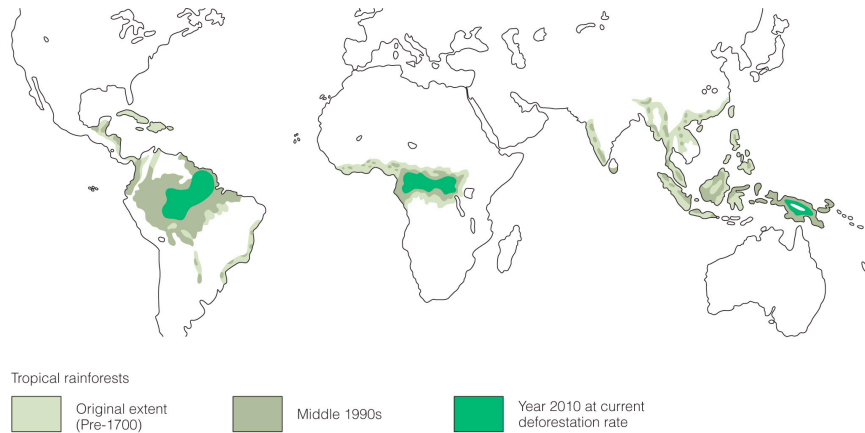


Figure 11-02 Past decline of tropical rainforests and projected decline.

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Habitat Fragmentation Leads to Edge Effect

1. Normal severe situations can kill all member if area is small
2. Pets, etc. penetrate; e.g. a road that occupies only 2% of area can disrupt 50%

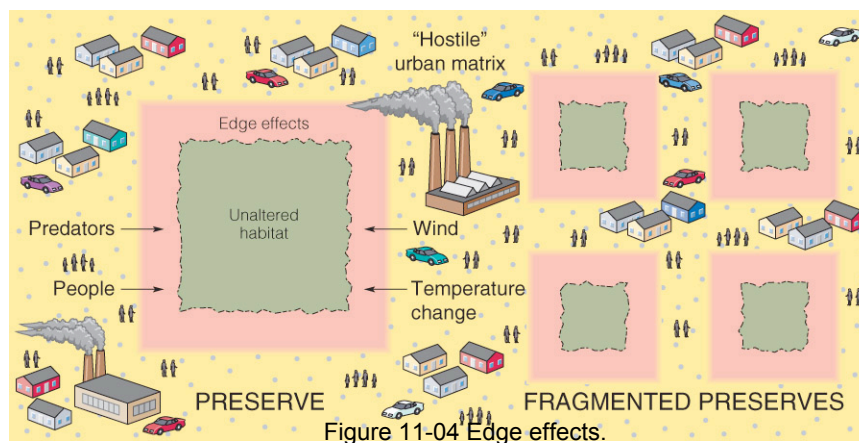


Figure 11-04 Edge effects.

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Figure 11.CS2_01: Encroachment of Gnatcatcher habitat.

Courtesy of Claire Dobert/U.S. Fish and Wildlife Service

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Figure 11.CS2_02: The California gnatcatcher.

© Anthony Mercieca/Photo Researchers, Inc.

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Habitat disruption

- **Most of U.S. natural vegetation is gone**
 - Huge effect on ecosystem (e.g. main problem for songbirds)
- **Farming, deforestation, development in general is primary problem for non-humans**
- **Wetlands (aka swamps and bogs) are very vulnerable since humans don't like them (breeding ground for misquitos and vermin)**
 - Often purposely drained and filled => complete loss of ecosystem
- **Oceans, especially coastal areas and reefs;**
 - ~15% of worlds reefs already dead
 - At current rates another 60% (that's 3/4) will be lost in 20 to 40 years
 - Caused by global warming, runoff from logging, farming, mining, construction, etc. (sediment blocks sunlight, decreases O₂ and smothers reefs)

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Introduced Species

- **Some exotic species can cause devastation of natural ecosystems.**
 - Sometimes done on purpose! (mongoose in hawaii to control rats, kudzu in U.S. South to control erosion)
- **Once the species are introduced, it is hard to get rid of them.**
- **The introduction of exotic species is increasing due to the increased movement of people.**
- **Examples:**
 - English Starling, perhaps most common bird in U.S., introduced in 1900 for Shakespear festival
 - Fire ants, killer bees, gypsy moths,
 - Florida: Giant pythons, african rats (size of dogs) (1/5 of all plants an 1/4 of mammals are now established non-natives)
- **Worse in islands: New Zealand, Hawaii, Guam, etc. (e.g. dogs and cats kill birds)**



Figure 11-CS11_01 Zebra mussels clog pipes.

*Costs were \$100 billion during 1990's
*kudzu smothers many acres and \$1 billion/year spent on removal
*1 fish in Lake Victoria has caused extinction of 35 other species!
(eventually may kill off several 100 more species)

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Courtesy of Peng/GenUSA Agricultural Research Service

Figure 11-05 Old World climbing fern overtaking Cyprus trees in Florida.

Modified by kg © 2007 Jones and Bartlett Publishers

Overhunting is another important mode of extinction

- **People have been overhunting for millennia.**
 - Speculation that woolly mammoths, sabre tooth tigers, giant sloths wiped out by early human hunters!
- **Large animals and plants are often overhunted or consumed more than small organisms.**
 - Elephants, American Bison (aka buffalo) went from many millions to under 1,100 in just a few decades, rhinos, tigers, wolves, shark, bluefin tuna, swordfish, cod, etc. etc. etc.
- **Affects plants too: e.g. silphion in ancient greece used for contraceptive, now extinct...**

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Secondary extinctions



- Secondary extinctions occur when the extinction of one group causes the extinction of another.
 - Famous example is dodo bird. Endemic near Mauritius; 3 foot tall flightless bird. Went extinct in 1600's due to humans.
 - Calavaria tree may go extinct also! Dodo's ate fruit and caused seeds to germinate; loss of dodo meant basically no new trees since the 1600's! (Note this story may be wrong! Other extinct animals may have been necessary, or pigs may be killing young trees. (force fed turkeys now used to help start new trees)

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Minimum Viable Populations

- When a population becomes too small, the species will fall into an extinction vortex.
 - Small populations may have breeding problems.
 - Small populations are more at risk from random environmental fluctuations.
- The minimum viable population (MVP) is the smallest population size needed to stay above the extinction vortex.
- Example, florida panther; most males have deformed testicals, a genetic problem that probably can't be fixed.
- Used to think needed at least 500 animals. Now think it depends on species, but computer models say thousands needed for survival (and survival is only defined as for a few decades)

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Community Degradation

- **Communities and ecosystems are more likely to be disrupted and degraded by human activity than completely destroyed**
 - People tend to focus on individual species, but whole ecosystem is what counts. Cuteness of endangered animal gets money, but may not be as important as the many other species.
- **Ecosystem simplification occurs when the number of species in the ecosystem declines, which can disrupt makeup and infrastructure.**
 - Extreme case is mono-culture (e.g. corn field) where small problem kills everything
- **Lower diversity leads to easier disruption. Indicator species can give warning (e.g. trout dies easily from pollution; fraser fir in smoky mountains easily disrupted; spotted owl is indicator species)**
- **Ecosystem health sometime determined by keystone species.**
 - Example: sea otter near Monterey; Otters go => sea urchins multiply => kelp beds destroyed => entire ecosystem stressed or destroyed.

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Figure 11.08: A sea otter lunches on an urchin.

Courtesy of NOAA

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Stopping Extinctions

- There are both direct and indirect reasons to preserve biodiversity.
- A direct value of a species might be its value when harvested and sold.
- An indirect value of a species might be its intrinsic right to exist, its esthetic value, or its value as part of the ecosystem that provides environmental services.
 - (for instance, purifying water or producing oxygen)
- My reason!
 - Question: What is the most valuable thing on planet Earth? (e.g. to an alien visitor from another planet)
 - Answer: biodiversity and the various ecosystems!
 - Why? The highly complex and non-linear ecosystems took billions (or at least hundreds of million) of years to produce and cannot be regained once lost without waiting again that much time

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Species preservation includes a broad range of techniques

- Habitat protection
- Selection and design of preserves
- Land management incentives
- Legal protection
- Captive breeding and reintroduction

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Figure 11.10: Restored wetland in the prairie pothole region, northern Iowa.

Courtesy of Lynn Betts/USDA /Natural Resources Conservation Service

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Which Species to Save?

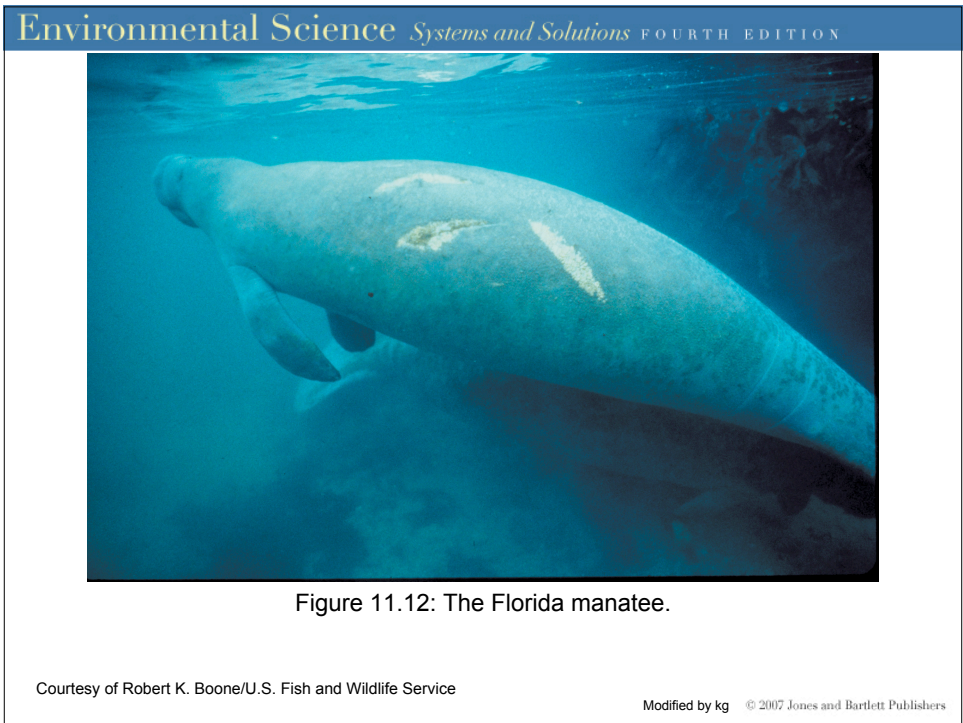
- **The cost of saving all species at risk exceeds current available monetary and human resources.**
- **Triage decisions on which species to assist should not be based on risk of extinction alone.**

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TABLE 11-4 Characteristics of Extinction Susceptibility		
Characteristics	Reason Characteristics Tend to Cause Extinction	Examples
1. Island species	Unable to compete with introduced species	More than half of the native plant species in Hawaii
2. Species with limited habitats or breeding areas	Some species found in only a few ecosystems	Woodland caribou, Everglade crocodile, red-cockaded woodpecker
3. Species that require large territories to survive	Widespread habitat destruction	California condor, blue whale, Bengal tiger, Florida panther
4. Species with low reproductive rates	Many species evolved low reproductive rates because predation was low	Blue whale, California condor, polar bear, rhinoceros, Florida manatee
5. Rare species	Few individuals to replenish population	Tropical insects, rhinoceros
6. Species that are economically valuable or hunted for sport	Hunting pressures by people	Snow leopard, blue whale, elephant, rhinoceros, tiger
7. Predators	Often killed to reduce predation of domestic stock	Grizzly bear, timber wolf, Bengal tiger
8. Species that are susceptible to pollution	Some species are more susceptible than others to industrial pollution	Bald eagle (susceptible to certain pesticides), pelicans
9. Species with inadaptable behaviors	Behaviors promote death in human environments	Manatees swimming close to motorboats

Which species are most at risk?
Which species should be saved?

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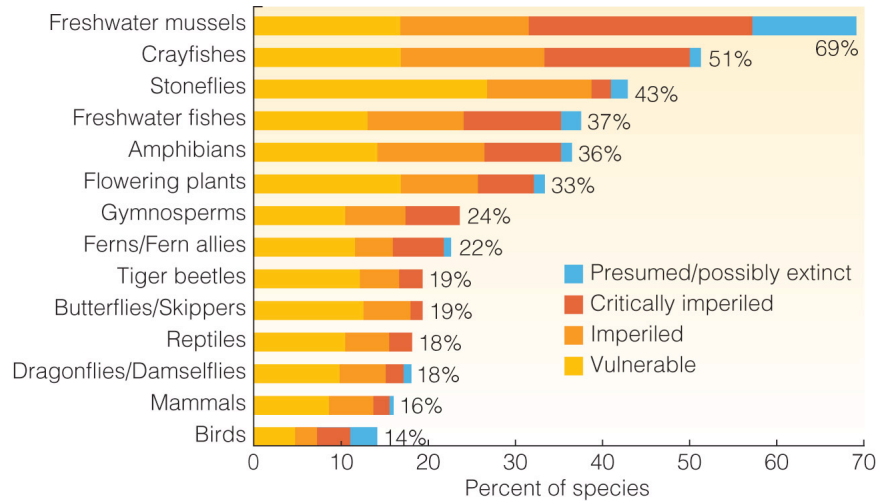


Figure 11.11: Freshwater organisms are among the most imperiled species in North America.

Source: Data from Stein BA, Kutner LA, Adams JS. *Our Precious Heritage: The Status of Biodiversity in the U.S.* (New York: Oxford University Press, 2000), p.102. Modified by kg © 2007 Jones and Bartlett Publishers

Are All Species Equally Important

- Should ecological importance, evolutionary importance, and species charisma play equal roles in our choices?

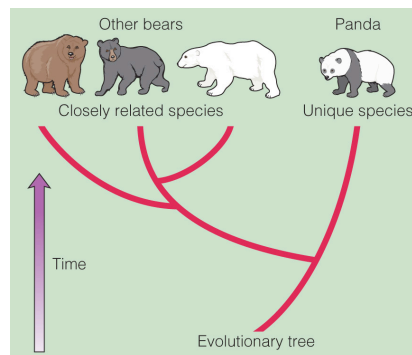


Figure 1113 Unique species have no living closely related species.

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How to Save Species

- **Preservation of the natural environment is the cheapest and most efficient way.**
- **Legal and economic incentives are also necessary and useful.**

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Endangered Species Protection by Law

- **Progress in delisting species protected by the Endangered Species Act is being outpaced by growing numbers of additional endangered species.**
- **The Convention on Trade in Endangered Species (CVITES) has helped reduce illegal trade but smuggling persists.**



Courtesy of John and Karen Helligsoerth, U.S. Fish and Wildlife Service

Figure 11-15a Seized wildlife property.

(a)

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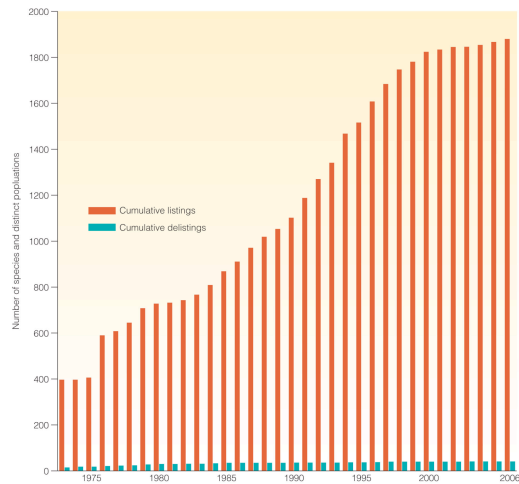


Figure 11-14 The number of species being listed as endangered or threatened is growing faster than the number being delisted.

Source: Data are from U.S. Fish and Wildlife Service, 2006.

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(b)

Figure 11.15b: Seized illegal shipment of Electus Parrots and Cockatoos.

Courtesy of Steve Hillebrand/U.S. Fish and Wildlife Service

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Figure 11.16: Many animals in zoos live in poor conditions.

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Species Recovery

- **Two methods people can use to increase the population size of a threatened species include:**
 - **Captive Breeding**
 - **Reintroduction**



Figure 11-06 The New Zealand kakapo.

© New Zealand Conservation Department, HOVA Photos

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Figure 11.filler: The population of peregrine falcons has recovered.

Courtesy of Craig Koppie/U.S. Fish and Wildlife Service

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(Partial) Success example: Great Bear Rainforest

- **More than 60% of world's temperate rainforest has been logged or developed, and Great Bear has about 1/4 of what is left in the world.**
 - Also about 20% of world's remaining wild salmon spawn there
- **Large scale clearcutting was in progress when large protests, First Nation land claims, many lawsuits, bad publicity for logging companies, and rare (and cute) white "spirit bear" endangering brought about agreement**
 - 1/3 of land off limits to logging and development
 - No clearcutting, only selective, sustainable logging
 - \$120 million for conservation/sustainable projects inside (including oyster farm)



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Sustainable Uses of Biodiversity

- **When people are poor they are more likely to rely on destructive uses of biodiversity to stay alive.**
- **Tourism and sustainable harvesting are methods that can help poor communities and also preserve biodiversity.**