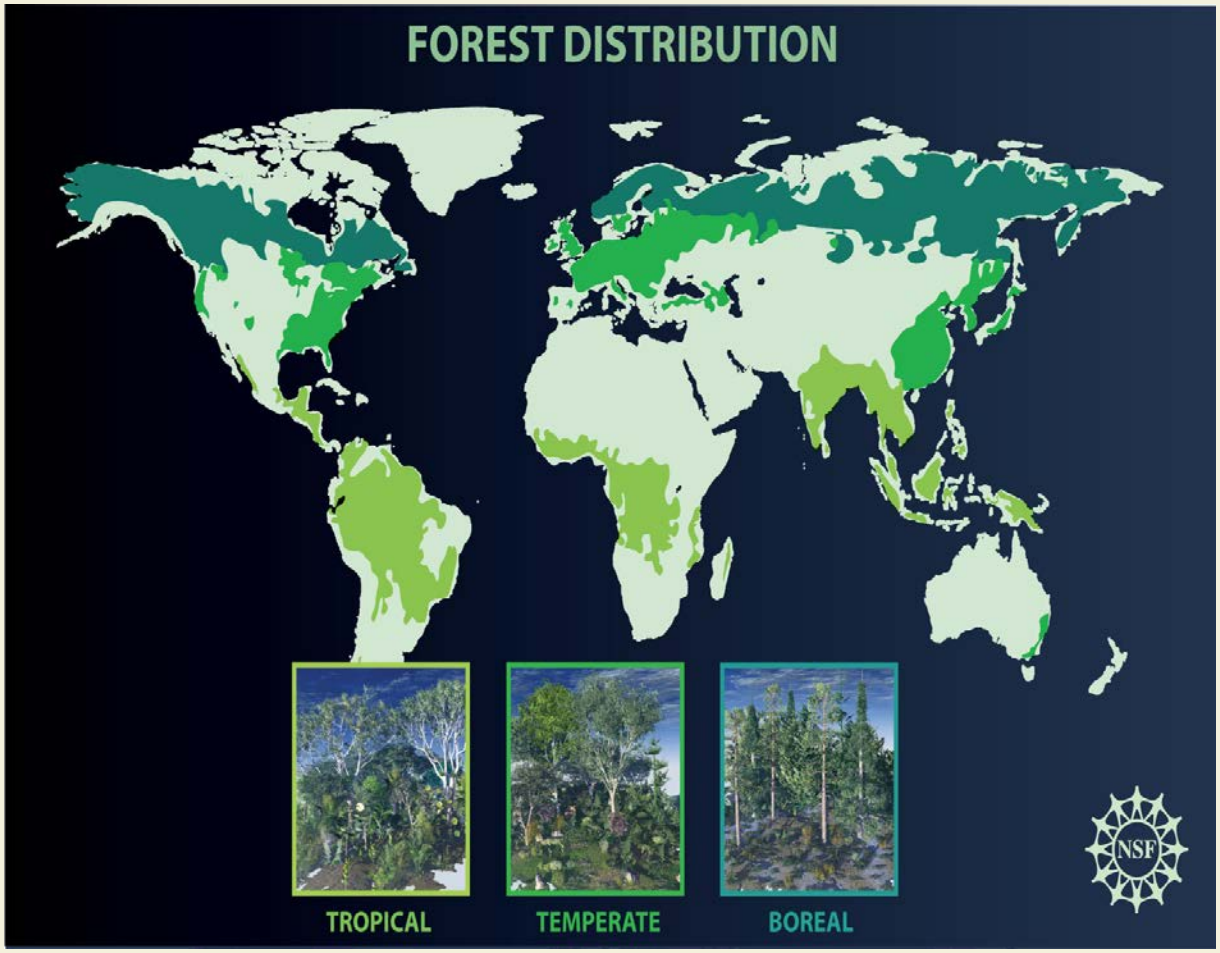
# Chapter 10

# Sustaining Terrestrial Biodiversity: The Ecosystem Approach



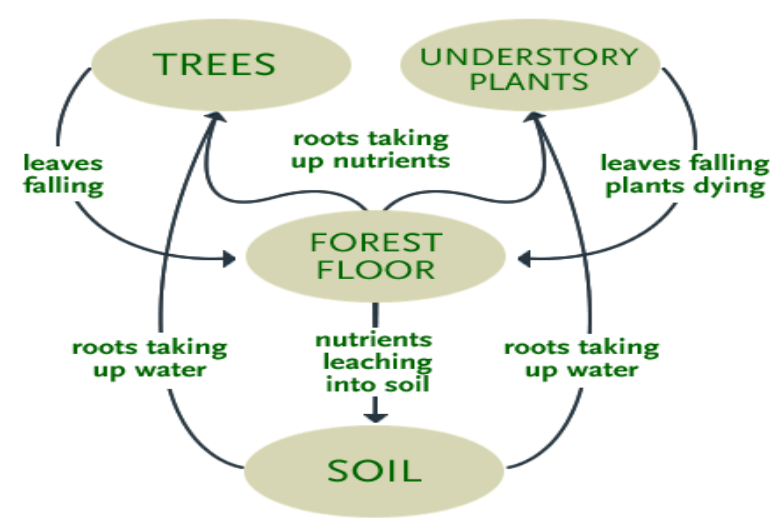

***There is no solution, I assure you, to save Earth's biodiversity other than preservation of natural environments in reserves to maintain wild populations sustainably.***
***- Edward O. Wilson***

# Individuals Matter: Wangari Maathari and Kenya's Green Belt Movement

- **First backyard nursery began in 1977**
  - **Self-help group of women in Kenya**
  - **Success of tree planting**
  - **50,000 members planted 40 million trees**
  - **Women are paid for each tree that survives**
  - **Slows soil erosion**
  - **Shade and beauty**
  - **Combats global warming**

- **Nobel Peace Prize: 2004**

# 10-1 What Are the Major Threats to Forest Ecosystems?




***Concept 10-1A*** *Forest ecosystems provide ecological services far greater in value than the value of raw materials obtained from forests.*

***Concept 10-1B*** *Unsustainable cutting and burning of forests, along with diseases and insects, all made worse by projected climate change, are the chief threats to forest ecosystems.*

# Forests Vary in Their Make-Up, Age, and Origins

**Old-growth or primary forest (36%)**

- **Uncut, or not disturbed for several hundred years**
- **Reservoirs of biodiversity (ecological niche)**

**Second-growth forest (60%)**

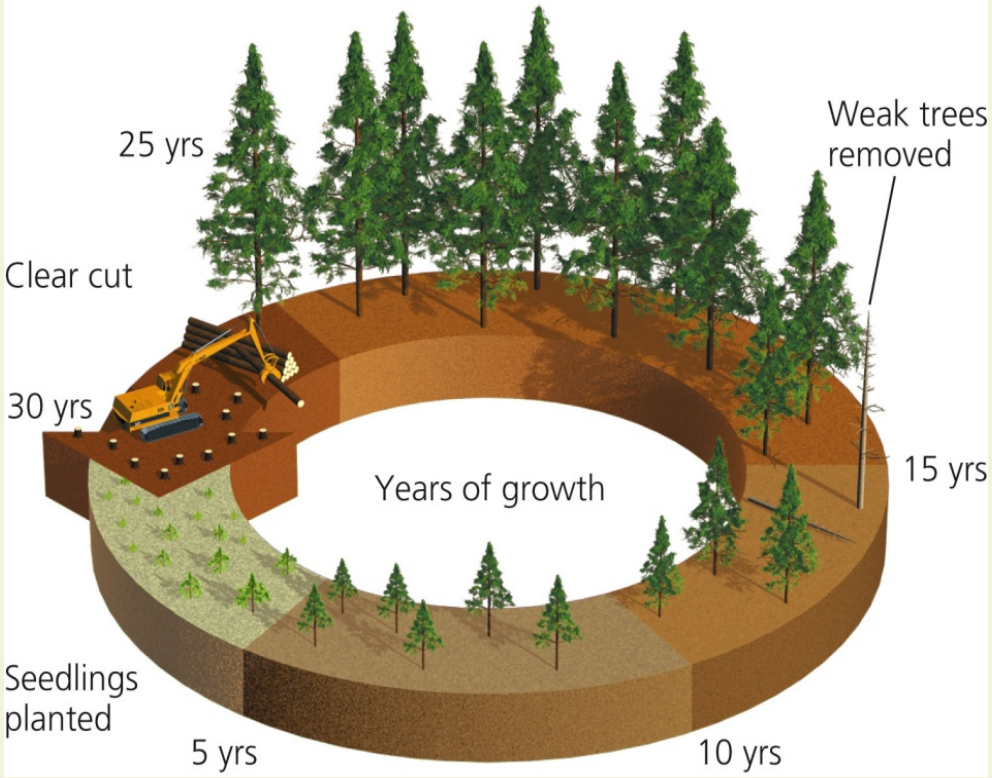
- **Secondary ecological succession**

**Tree plantation, (tree farm, commercial forest) (4%)**

- **May supply most industrial wood in the future**
- **1 or 2 species of same age**
  - ➢ **Violate sustainability & biodiversity**
  - ➢ **Depletion of nutrients from topsoil**

**An Old-Growth Forest**

# Rotation Cycle of Cutting and Regrowth of a Monoculture Tree Plantation




**What are two ways in which this process can degrade an ecosystem?**

Fig. 10-3, p. 219

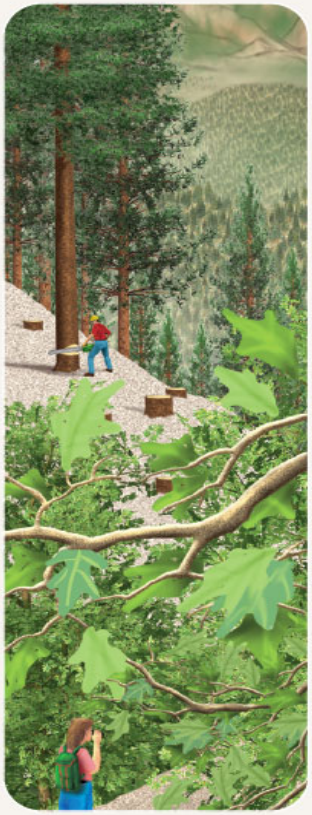
# Natural Capital: Major Ecological and Economic Services Provided by Forests

## Natural Capital

### Forests

**Ecological Services**

- Support energy flow and chemical cycling
- Reduce soil erosion
- Absorb and release water
- Purify water and air
- Influence local and regional climate
- Store atmospheric carbon
- Provide numerous wildlife habitats



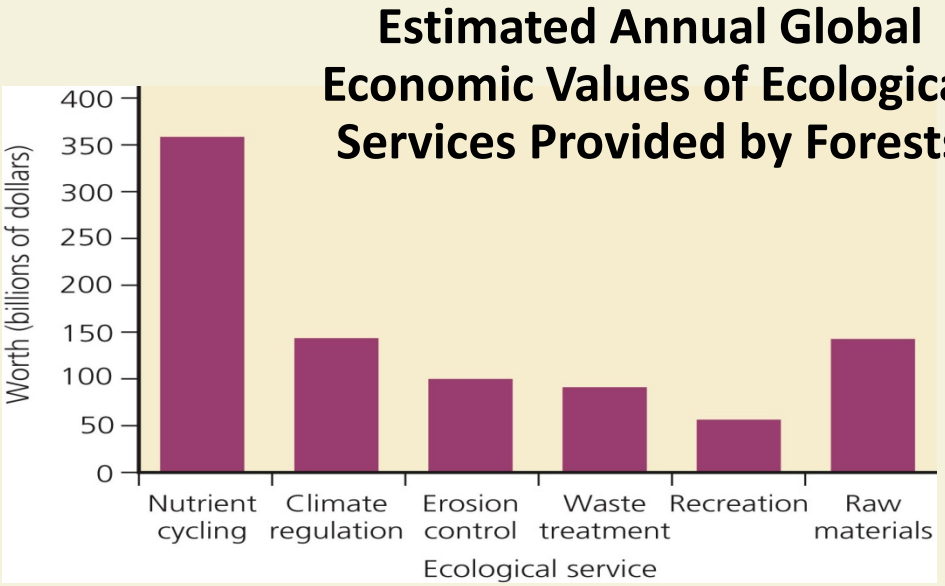
**Economic Services**

- Fuelwood
- Lumber
- Pulp to make paper
- Mining
- Livestock grazing
- Recreation
- Jobs

Fig. 10-4, p. 220

# Science Focus: Putting a Price Tag on Nature's Ecological Services

- Forests valued for ecological services




- $4.7 trillion per year

# Unsustainable Logging
# Major Threat to Forest Ecosystems

- **Increased erosion**
- **Sediment runoff into waterways**
- **Habitat fragmentation**
- **Loss of biodiversity**
- **Invasion by**
  - **Nonnative pests**
  - **Disease**
  - **Wildlife species**

# Natural Capital Degradation: Building Roads into Previously Inaccessible Forests

**Building roads into previously inaccessible forests is the first step to harvesting timber, but it also paves the way to fragmentation, destruction, and degradation of forest ecosystems.**

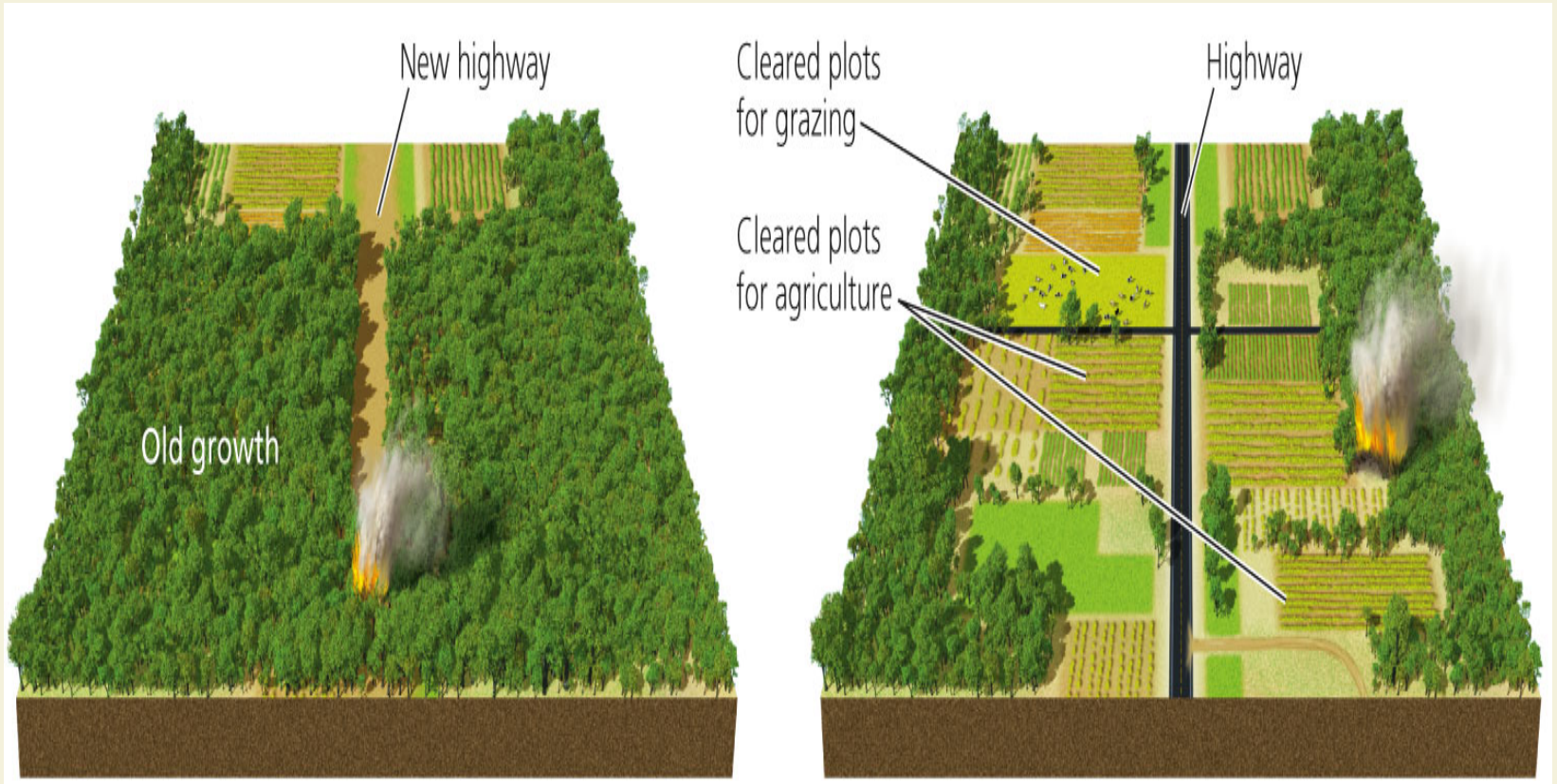
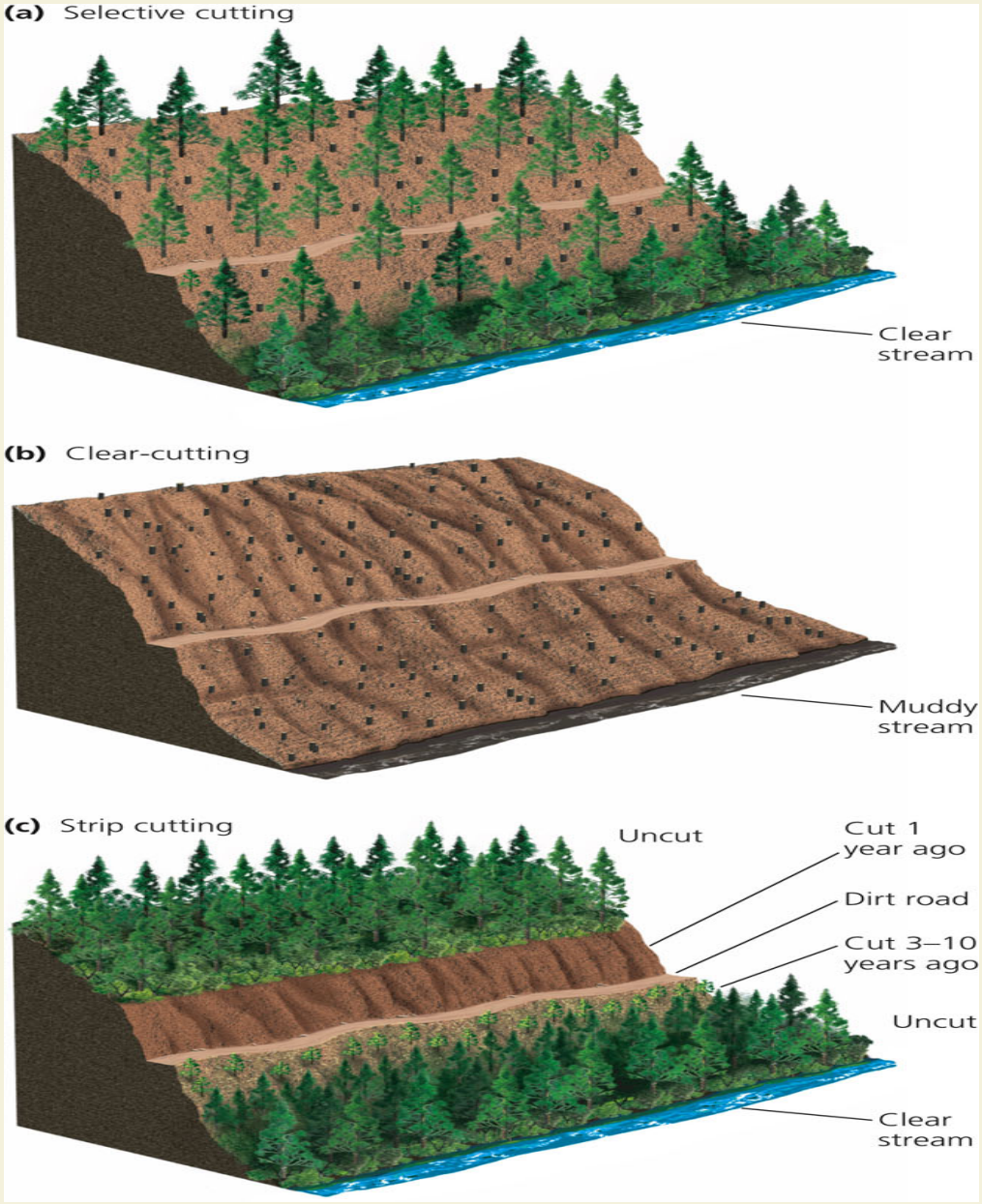



Fig. 10-5, p. 221

# Major Tree Harvesting Methods




**Selective cutting:**

- **Intermediate-aged or mature trees are cut singly or in small groups**

**Clear-cutting:**

- **Removal of all trees from an area**
- **Most efficient for logging operation to harvest trees**
- **Environmental costs**

**Strip cutting:**

- **Clear-cutting a strip of trees along the contour of the land**

# Illegal, Uncontrolled, & Unsustainable Logging

- Over 70 countries
- Africa & SE. Asia
- 70 -80% Indonesia logging
- Global trade in timber & wood
  - China: imports more tropical rain forest timber than any other nation

Clear-Cut Logging in Washington State

Fig. 10-7, p. 222

# Trade-offs: Advantages and Disadvantages of Clear-Cutting Forests

## Trade-Offs

### Clear-Cutting Forests

| Advantages | | Disadvantages |
|---|---|---|
| Higher timber yields |  | Reduces biodiversity |
| Maximum profits in shortest time | | Destroys and fragments wildlife habitats |
| Can reforest with fast-growing trees |  | Increases water pollution, flooding, and erosion on steep slopes |
| Good for tree species needing full or moderate sunlight | | Eliminates most recreational value |

Fig. 10-8, p. 223

# FIRE
# Threaten Forest Ecosystems

**Surface fires**

- **Usually burn leaf litter and undergrowth**
- **May provide food in the form of vegetation that sprouts after fire**

**Crown fires**

- **Extremely hot: burns whole trees**
- **Kill wildlife**
- **Increase soil erosion**

# Insects, and Climate Change Threaten Forest Ecosystems

**Introduction of foreign diseases and insects**

- **Accidental**
- **Deliberate**

**Global warming**

- **Rising temperatures**
- **Trees more susceptible to diseases and pests**
- **Drier forests: more fires**
- **More greenhouse gases**


**Figure 10, Supplement 8**

# We Have Cut Down Almost Half of the World's Forests

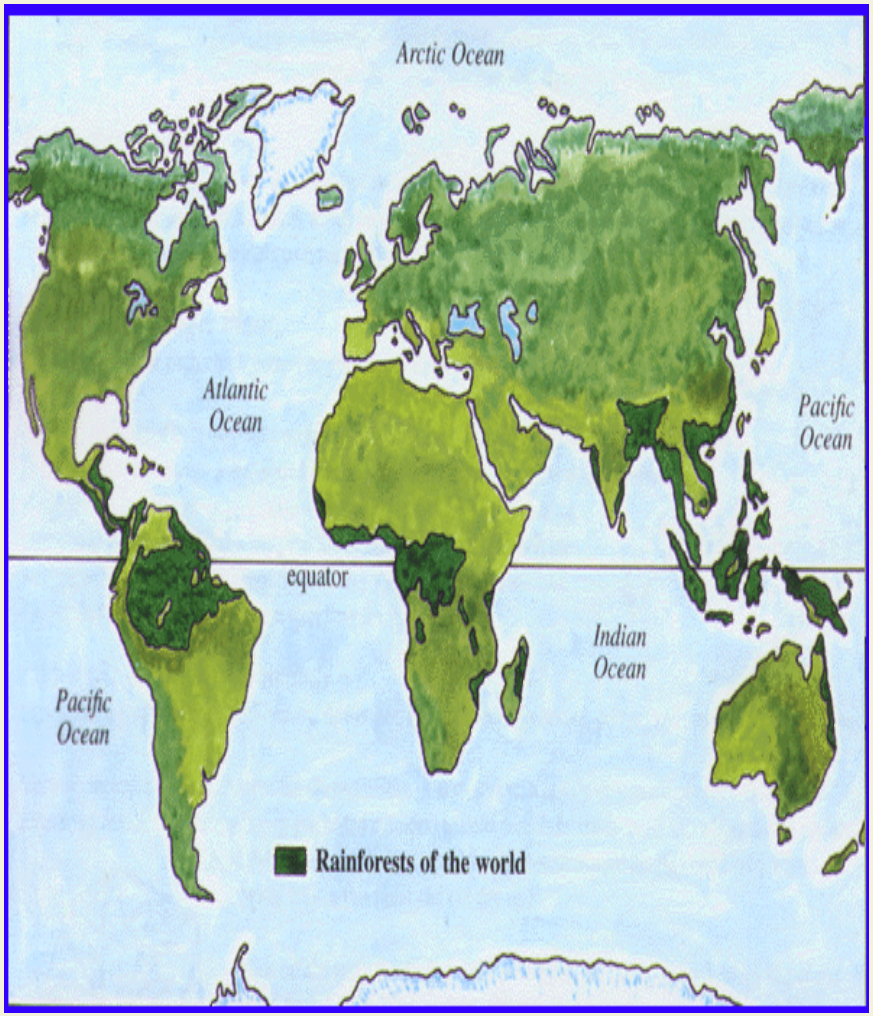
## Deforestation

- **Tropical forests**
  - **Especially in Latin America, Indonesia, and Africa**
  - **Main reason for 8,000 tree species are threatened with extinction (10% of the world rate)**
- **Boreal forests**
  - **Especially in Alaska, Canada, Scandinavia, and Russia**

**☺ Net total forest cover has stayed the same or increased in U.S. and a few other countries between 2000 and 2007**

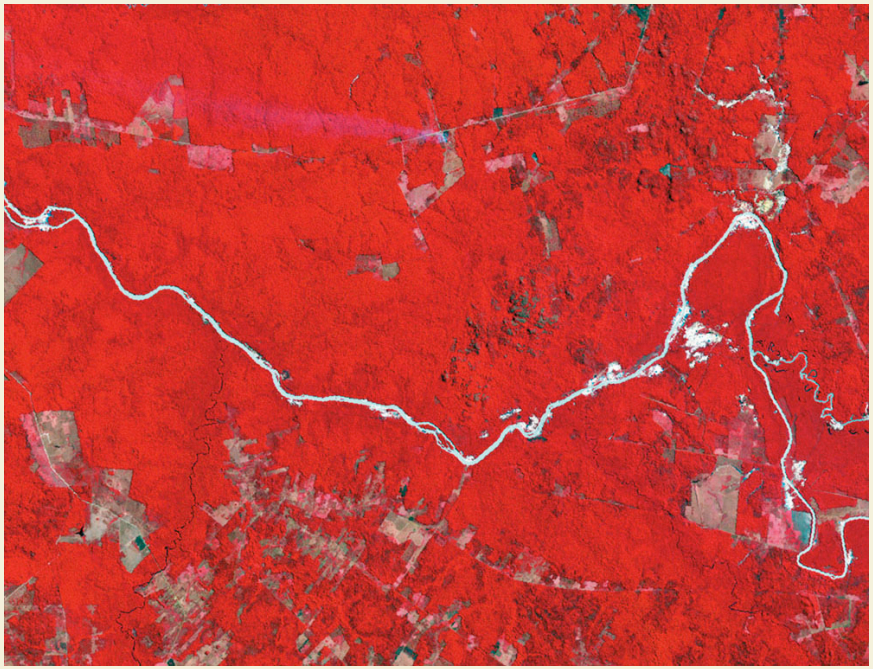
**Extreme Tropical Deforestation in Thailand**

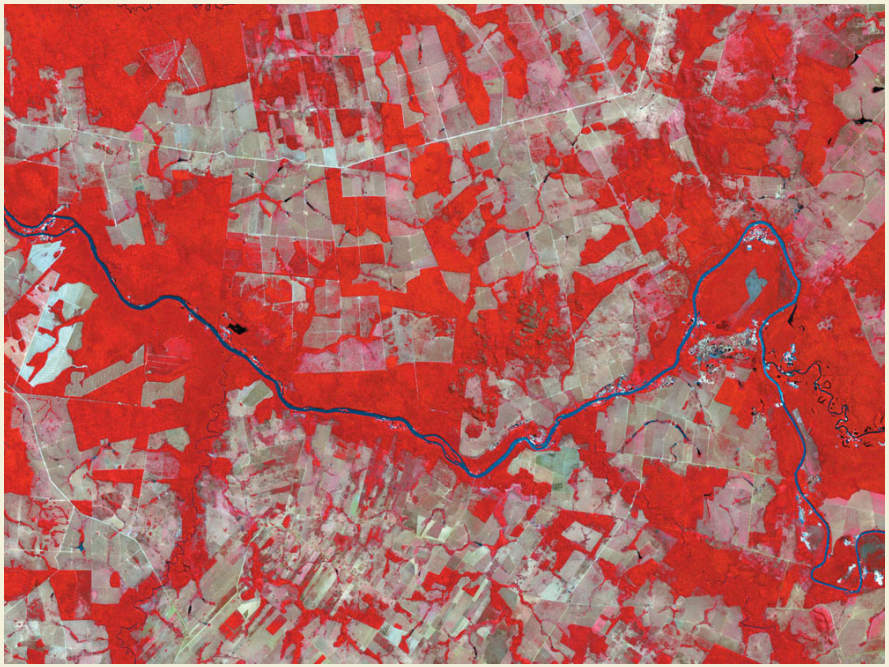
# Tropical Forests Disappearing Rapidly




- **Majority of loss since 1950**
- **Africa, Southeast Asia, South America**
- **98% will be gone by 2022**
- **Role of deforestation in species' extinction**
- **Secondary forest can grow back in 15-20 years**

# Harmful Environmental Effects of Deforestation Brazil 1992-2006



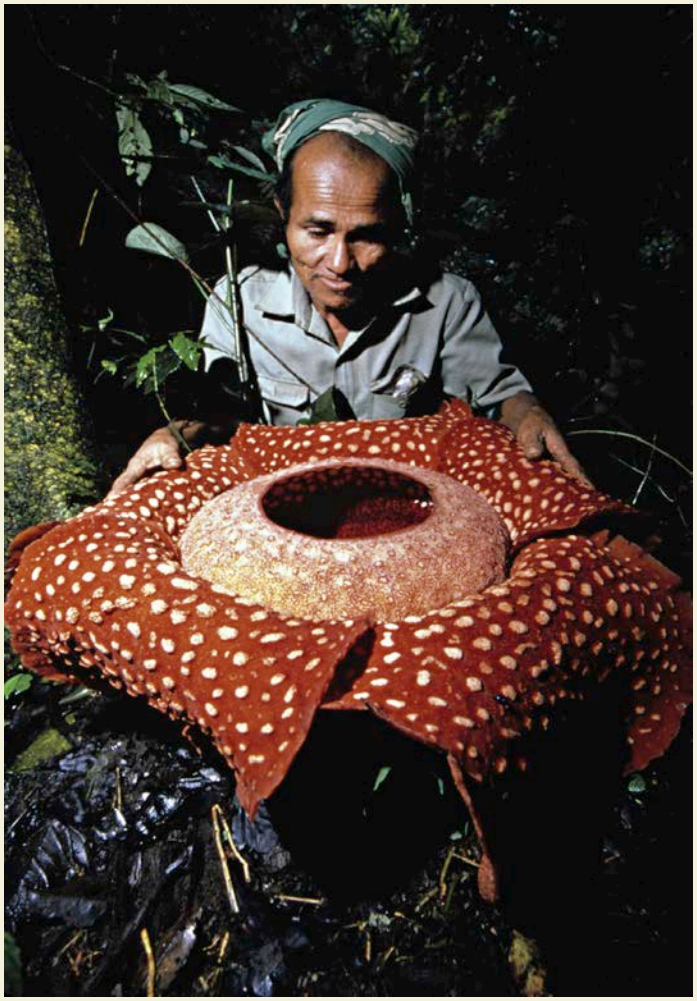


- **More than 30% of world's remaining tropical rain forests**
- **1% in 1970 up to 20% in 2008**
- **2009 scientist (Laurence) forest are growing back**
  - ➢ **"one bulldozer does more damage than 1,000 farmers with machete"**

**Fig. 10-12, p. 226**

# Species Diversity in Tropical Forests

***White Ukari***



***Flesh Flower (Rafflesia)***

**Fig. 10-13, p. 227**

# Causes of Tropical Deforestation Are Varied and Complex

- **Population growth**
- **Poverty of subsistence farmers**
- **Ranching**
- **Lumber**
- **Plantation farms: palm oil**

**<u>Degradation of Tropical Forest</u>**

- **Begins with building of roads**
- **Many forests burned**
- **Can tilt tropical forest to tropical savanna**

**Vary in different tropical areas**

- **<u>Amazon & S. America:</u> cattle grazing & soybean plantations**
- **<u>SE. Asia:</u> plantations of palm oil**
- **<u>Africa:</u> small scale farming & wood for fuel**

# Major Causes of the Destruction and Degradation of Tropical Forests

## Natural Capital Degradation

### Major Causes of the Destruction and Degradation of Tropical Forests

**Underlying Causes**

- Not valuing ecological services
- Crop and timber exports
- Government policies
- Poverty
- Population growth

**Direct Causes**

- Roads
- Fires
- Settler farming
- Cash crops
- Cattle ranching
- Logging
- Tree plantations

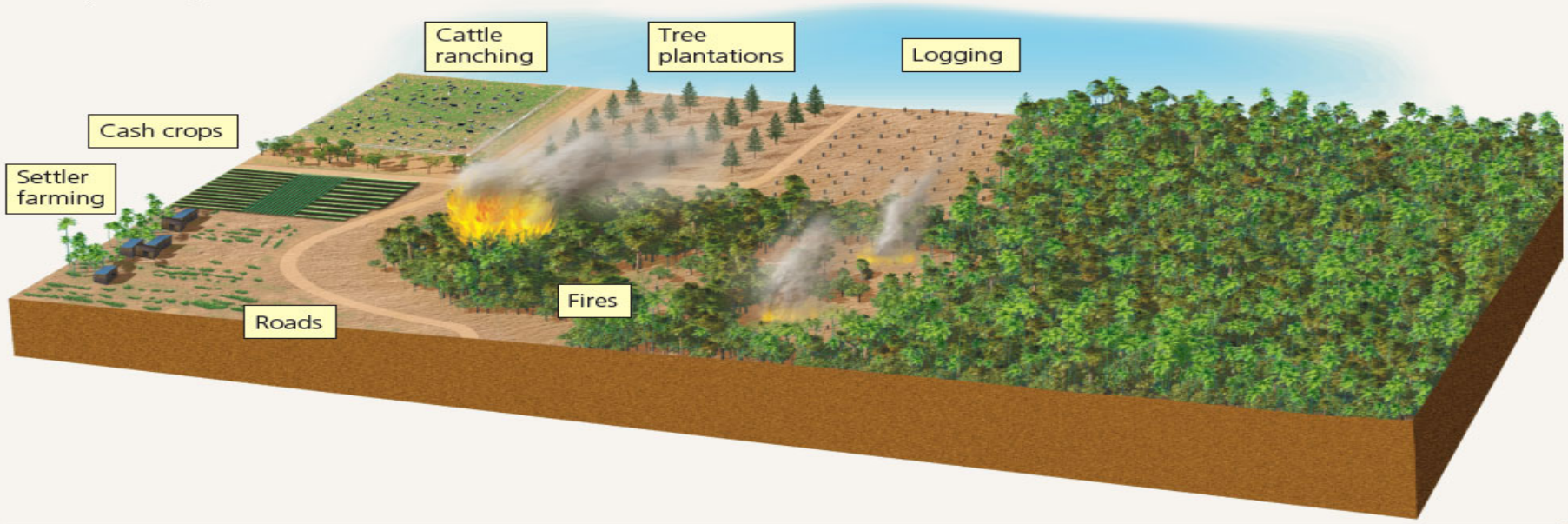


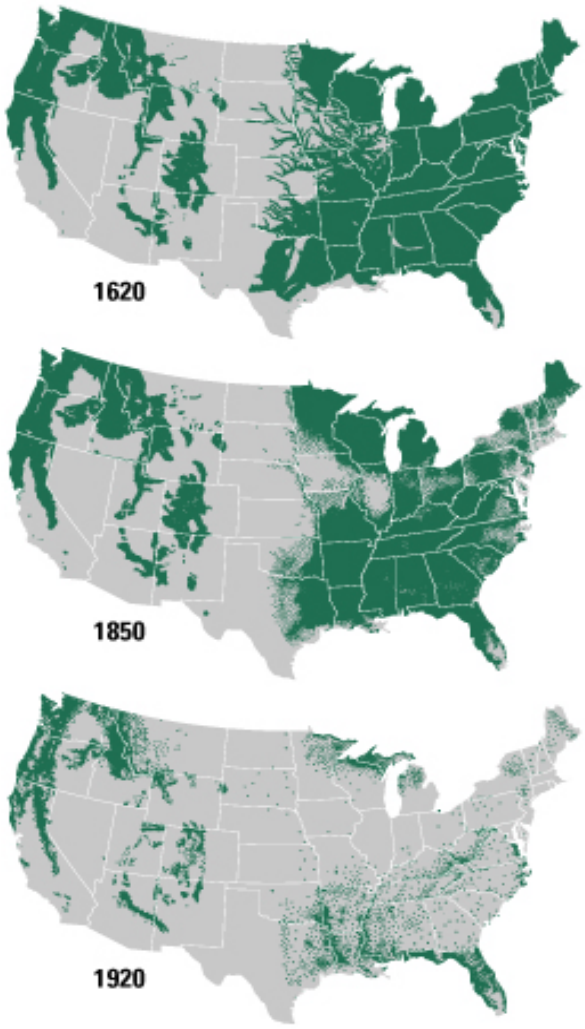

Fig. 10-14, p. 228

# Natural Capital Degradation: Large Areas of Brazil's Amazon Basin Are Burned

Fig. 10-15, p. 228

# Case Study: Many Cleared Forests in the United States Have Grown Back

- **Forests of the eastern United States decimated between 1620 and 1920**
- **Grown back naturally through secondary ecological succession in the eastern states**
- **Biologically simplified tree plantations reduce biodiversity and deplete nutrients from soil**



# VIDEO: FOREST OF THE TREES

# *10-2 How Should We Manage and Sustain Forests?*

***Concept 10-2*** *We can sustain forests by emphasizing the economic value of their ecological services, removing government subsidies that hasten their destruction, protecting old-growth forests, harvesting trees no faster than they are replenished, and planting trees.*

# Solution: Sustainable Forestry


Fig. 10-16, p. 230

# Science Focus: Certifying Sustainably Grown Timber


**Collins Pine**

- **Owns and manages protective timberland**

**Forest Stewardship Council**

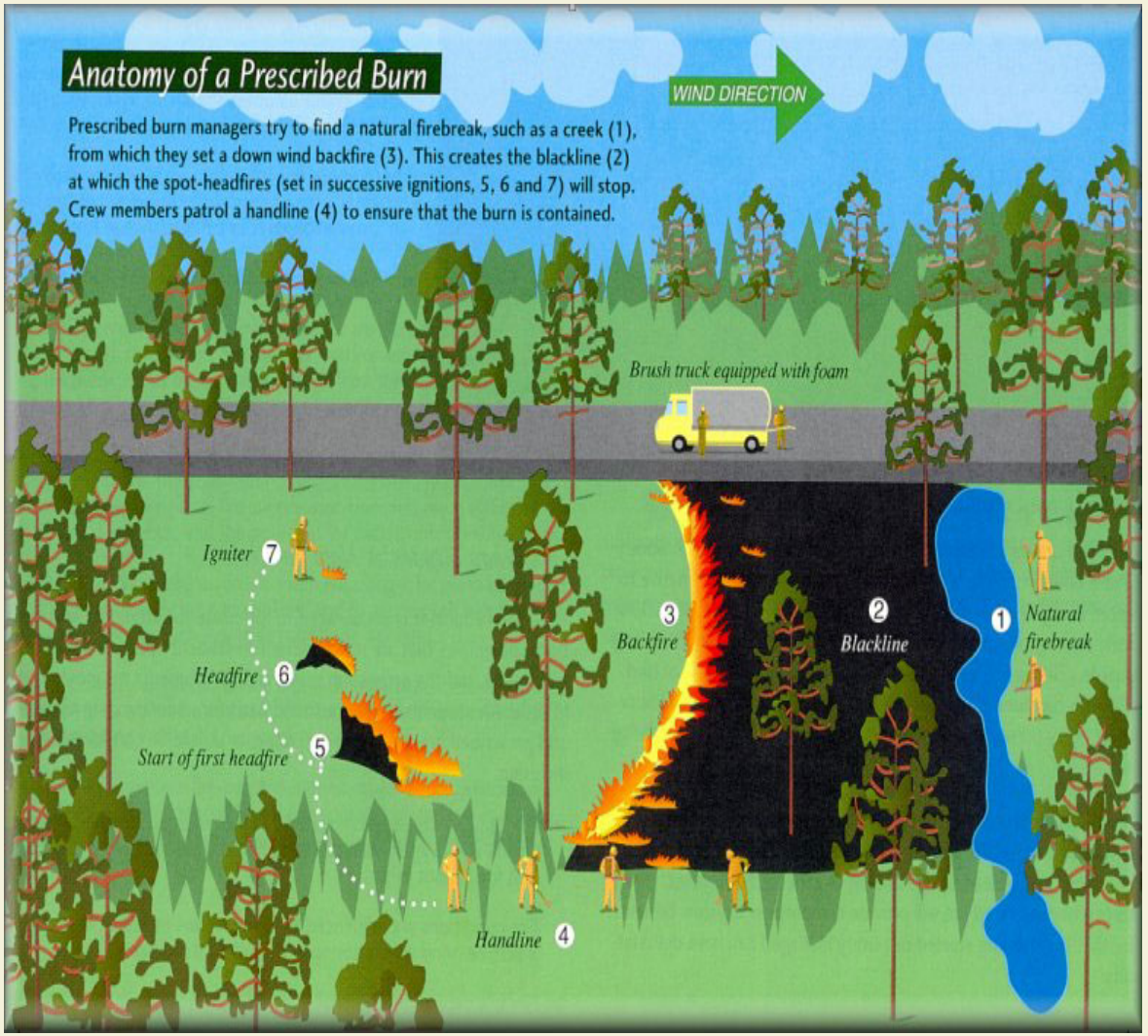
- **Nonprofit**
- **Developed list of environmentally sound practices**
- **Certifies timber and products**
- **2009: 5% of world's forest have certified to FSC standards**
- **Also certifies manufacturers of wood products**

# Improving the Management of Forest Fires: Smokey Bear Education

- **US Forest Service**
- **Pros:**
  - **saved lives**
  - **prevented $$ in loss of trees, wildlife & Human structure**
- **Cons:**
  - **convinced public that ALL fires are bad and should be prevented or put out**
  - **Can lead to increases in crown fires**

# Improving the Management of Forest Fires: Prescribed Fires

- **careful planning & monitoring**
- **set small contained surface fires to remove flammable small trees and underbrush**



# Improving the Management of Forest Fires: Other Strategies


- **Allow fires on public lands to burn**
  - **Removes flammable underbrush & smaller trees**
- **Protect structures in fire-prone areas**
  - **Eliminate use of flammable construction materials**
  - **Thinning a zone of 60 m (200 ft) around fire prone areas**
- **Thin forests in fire-prone areas**
  - **Clear away small fire-prone trees & underbrush under environmental controls**
  - **☹ can leave behind slash (highly flammable debris)**

# We Can Reduce the Demand for Harvested Trees

- **Improve the efficiency of wood use**
  - **60% of U.S. wood use is wasted**
  - **Construction materials, excess packaging, overuse of junk mail, inadequate paper recycling, failure to reuse**

- **Make tree-free paper**
  - **Kenaf or Hemp**
  - **Yield more paper pulp per area of land**
  - **Require less pesticides & herbicides**

# Case Study: Deforestation and the Fuelwood Crisis

- **One half of world wood harvest is for fuel**

- **Possible solutions**
  - **Establish small plantations of fast-growing fuelwood trees and shrubs**
  - **Burn wood more efficiently**
  - **Solar or wind-generated electricity**
  - **Burn garden waste**

# Mangrove Forest in Haiti Chopped Down for Fuelwood

Fig. 10-18, p. 232

# Governments and Individuals Can Act to Reduce Tropical Deforestation

- **Reduce fuelwood demand**
- **Practice small-scale sustainable agriculture and forestry in tropical forest**
- **Government protection**
- **Debt-for-nature swaps/conservation concessions**
- **Plant trees**
- **Buy certified lumber and wood products**

# Solutions: Sustaining Tropical Forests

## Solutions

### Sustaining Tropical Forests

**Prevention**

Protect the most diverse and endangered areas

Educate settlers about sustainable agriculture and forestry

Subsidize only sustainable forest use

Protect forests through debt-for-nature swaps and conservation concessions

Certify sustainably grown timber

Reduce poverty

Slow population growth


**Restoration**

Encourage regrowth through secondary succession

Rehabilitate degraded areas

Concentrate farming and ranching in already-cleared areas

Fig. 10-19, p. 233

# *10-3 How Should We Manage and Sustain Grasslands?*

***Concept 10-3*** *We can sustain the productivity of grasslands by controlling the number and distribution of grazing livestock, and by restoring degraded grasslands.*

# Grasslands: Ecological Services

- **Soil formation**
- **Erosion control**
- **Chemical cycling**
- **Storage of atmospheric $CO_2$ in biomass**
- **Maintenance of biodiversity**

# Rangelands and Pastures

## Rangelands

- **Unfenced grasslands in temperate and tropical climates that provide forage for animals**

## Pastures

- **Managed grasslands and fences meadows used for grazing livestock**

# Some Rangelands are Overgrazed

**Overgrazing of rangelands**

- Reduces grass cover
- Leads to erosion of soil by water and wind
- Soil becomes compacted
- Enhances invasion of plant species that cattle won't eat

**Malapi Borderlands**

- Arizona-New Mexico border
- Management success story

# We Can Manage Rangelands More Sustainably (1)

- Rotational grazing

- Suppress growth of invasive species
  - Herbicides
  - Mechanical removal
  - Controlled burning
  - Controlled short-term trampling

# We Can Manage Rangelands More Sustainably (2)

- Replant barren areas
- Apply fertilizer
- Reduce soil erosion

# Natural Capital Restoration: San Pedro River in Arizona

Fig. 10-21, p. 235

# Case Study: Grazing and Urban Development the American West

- American southwest population surge since 1980
- Land trust groups: conservation easements
- Reduce the harmful environmental impact of herds
  - Rotate cattle away from riparian areas
  - Use less fertilizers and pesticides
  - Operate ranch more economically and sustainably

# *10-4 How Should We Manage and Sustain Parks and Natural Reserves?*

***Concept 10-4***

*Sustaining biodiversity will require more effective protection of existing parks and nature reserves, as well as the protection of much more of the earth's remaining undisturbed land area.*

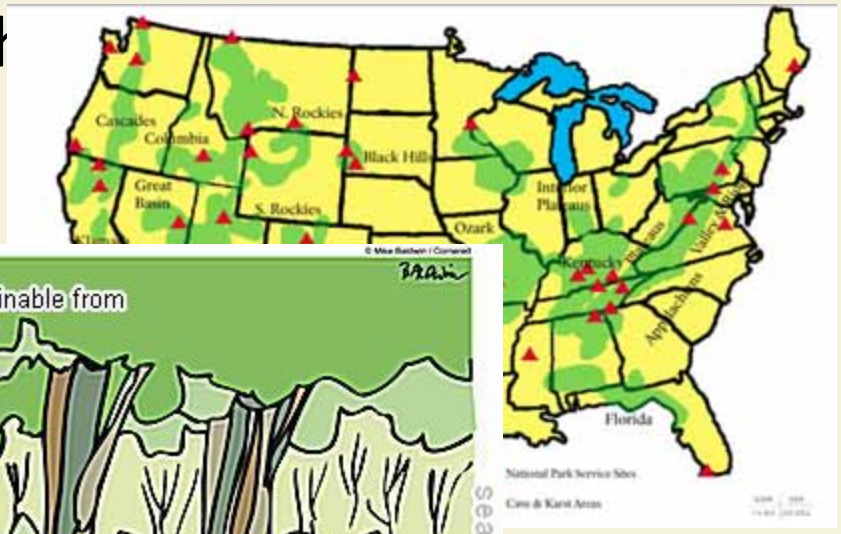
# National Parks Face Many Environmental Threats

- Worldwide: 1100 major national parks

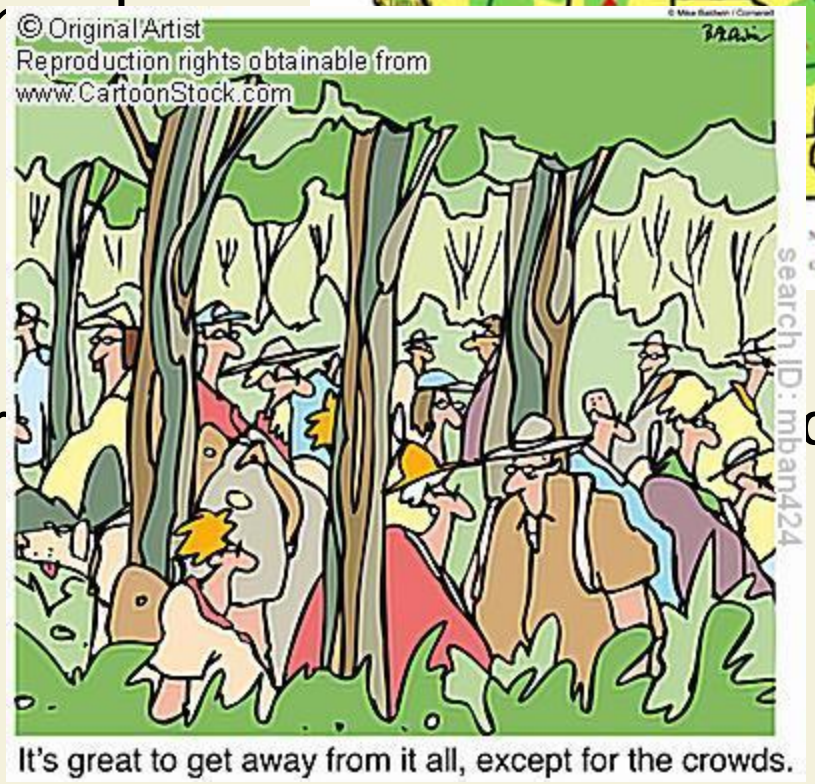
- Parks in developing countries
  - Greatest biodiversity
  - 1% protected agains
    - Illegal animal poac
    - Illegal logging and

# Case Study: Stresses on U.S. Public Parks (1)

- 58 Major national parks in th




- Biggest problem m
  - Noise
  - Congestion
  - Pollution
  - Damage or destr dlife



# Case Study: Stresses on U.S. Public Parks (2)

- Damage from nonnative species
  - Boars and mountain goats
  - Introduced plants, insects, worms
- Native species sometimes killed or removed
- Threatened islands of biodiversity
  - Air pollution
- Need billions in trail and infrastructure repairs

# Grand Teton National Park

Fig. 10-22, p. 237

# Natural Capital Degradation: Damage From Off-Road Vehicles

Fig. 10-23, p. 237

# Solutions: National Parks


**Fig. 10-24, p. 239**

# Science Focus: Reintroducing the Gray Wolf to Yellowstone National Park

- Keystone species
- 1995: reintroduced; 2009: 116 wolves in park

- Prey on elk and push them to a higher elevation
  - Regrowth of aspen, cottonwoods, and willows
  - More beaver dams, more wetlands, more aspens

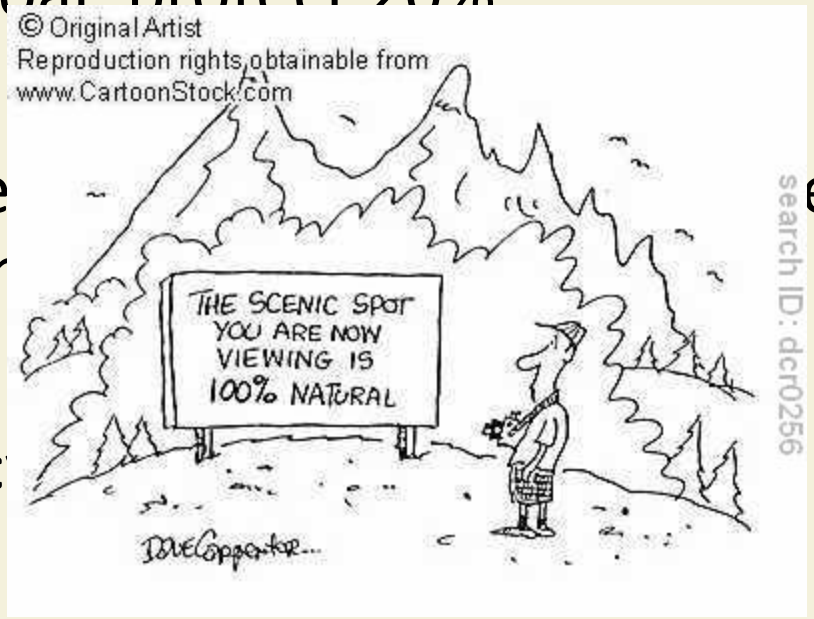
- Reduced the number of coyotes
  - Fewer attacks on cattle
  - More smaller mammals

# Natural Capital Restoration: Gray Wolf

Fig. 10-B, p. 238

# Nature Reserves Occupy Only a Small Part of the Earth's Land

- Currently less than 13% is protected
- Conservationists' goal: protect 20%
- Cooperation betwe e groups and concerr
- Nature Conservanc
- Land trust groups



# Silver Creek Nature Conservancy Preserve near Sun Valley, Idaho

Fig. 10-25, p. 240

# Designing and Connecting Nature Reserves

- Large versus small reserves
- The buffer zone concept
  - United Nations: 553 biosphere reserves in 107 countries
- Habitat corridors between isolated reserves
  - Advantages
  - Disadvantages

# Case Study: Costa Rica—A Global Conservation Leader

- 1963–1983: cleared much of the forest
- 1986–2006: forests grew from 26% to 51%
  - Goal: net carbon dioxide emissions to zero by 2021
- ¼ of land in nature reserves and natural parks – global leader
- Earns $1 billion per year in tourism

# Solutions: Costa Rica: Parks and Reserves—Eight Megareserves

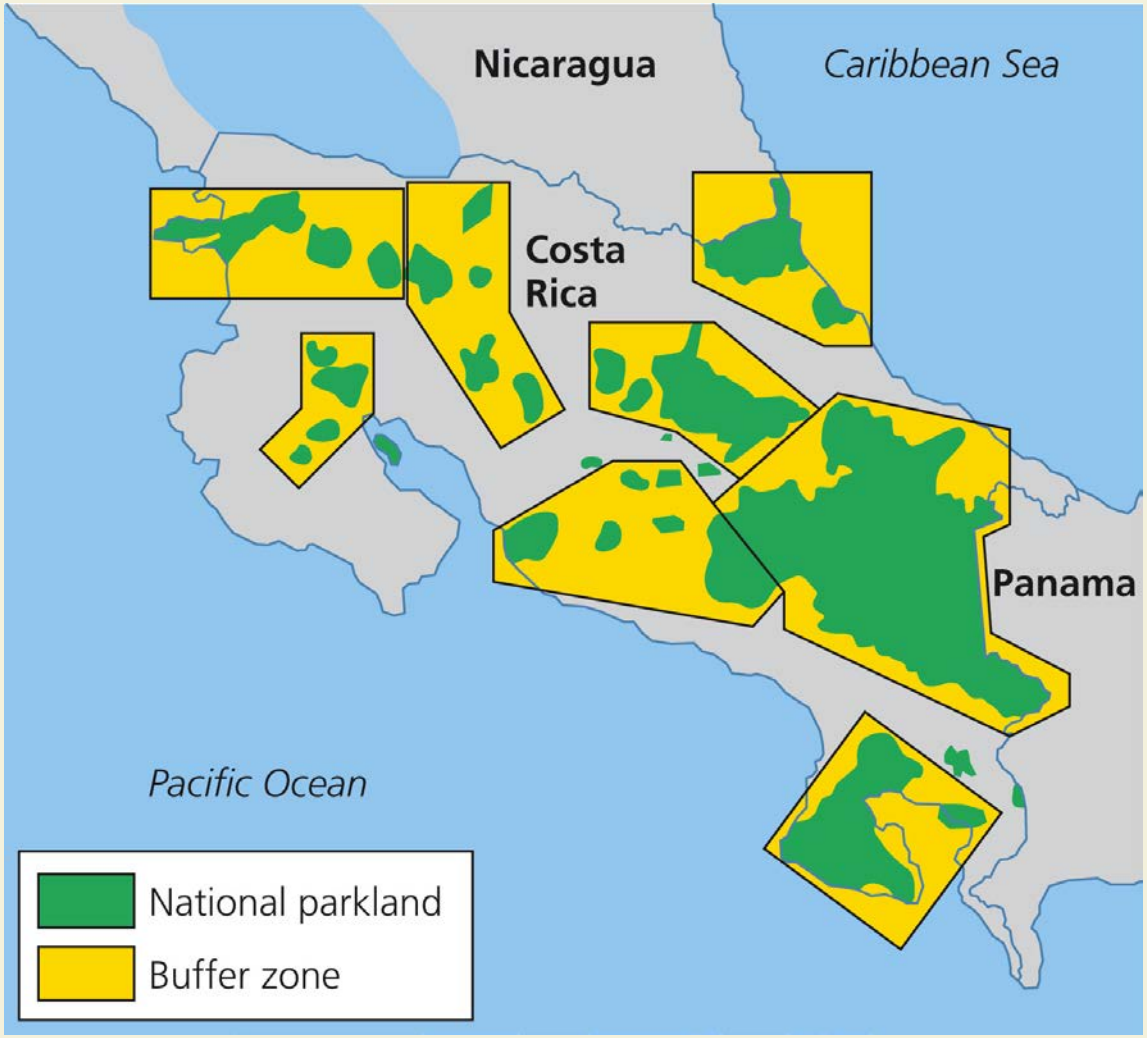



Fig. 10-26, p. 241

# Protecting Wilderness Is an Important Way to Preserve Biodiversity

- Wilderness
  - Land officially designated as having no serious disturbance from human activities
  - Wilderness Act of 1964

- Controversial…

# Case Study: Controversy over Wilderness Protection in the United States

- Wilderness Act of 1964
  - Protect undeveloped lands
  - 2% of lower 48 protected, mostly in West
  - 10-fold increase from 1970 to 2010
- 2009
  - 2 million more acres get wilderness protection
  - 50% increase in length of wild and scenic rivers

# *10-5 What is the Ecosystem Approach to Sustaining Biodiversity?*

- ***Concept 10-5*** *We can help sustain biodiversity by identifying and protecting severely threatened areas (biodiversity hotspots), restoring damaged ecosystems (using restoration ecology), and sharing with other species much of the land we dominate (using reconciliation ecology).*

# We Can Use a Four-Point Strategy to Protect Ecosystems

1. Map global ecosystems; identify species
2. Locate and protect most endangered ecosystems and species
3. Restore degraded ecosystems
4. Development must be biodiversity-friendly

- Are new laws needed?

# Protecting Global Biodiversity Hot Spots Is an Urgent Priority

- 34 **biodiversity hot spots** rich in plant species
  - 2% of earth's surface, but 50% of flowering plant species and 42% of terrestrial vertebrates
  - 1.2 billion people

- Drawbacks of this approach
  - May not be rich in animal diversity
  - People may be displaced and/or lose access to important resources

# Endangered Natural Capital: 34 Biodiversity Hotspots

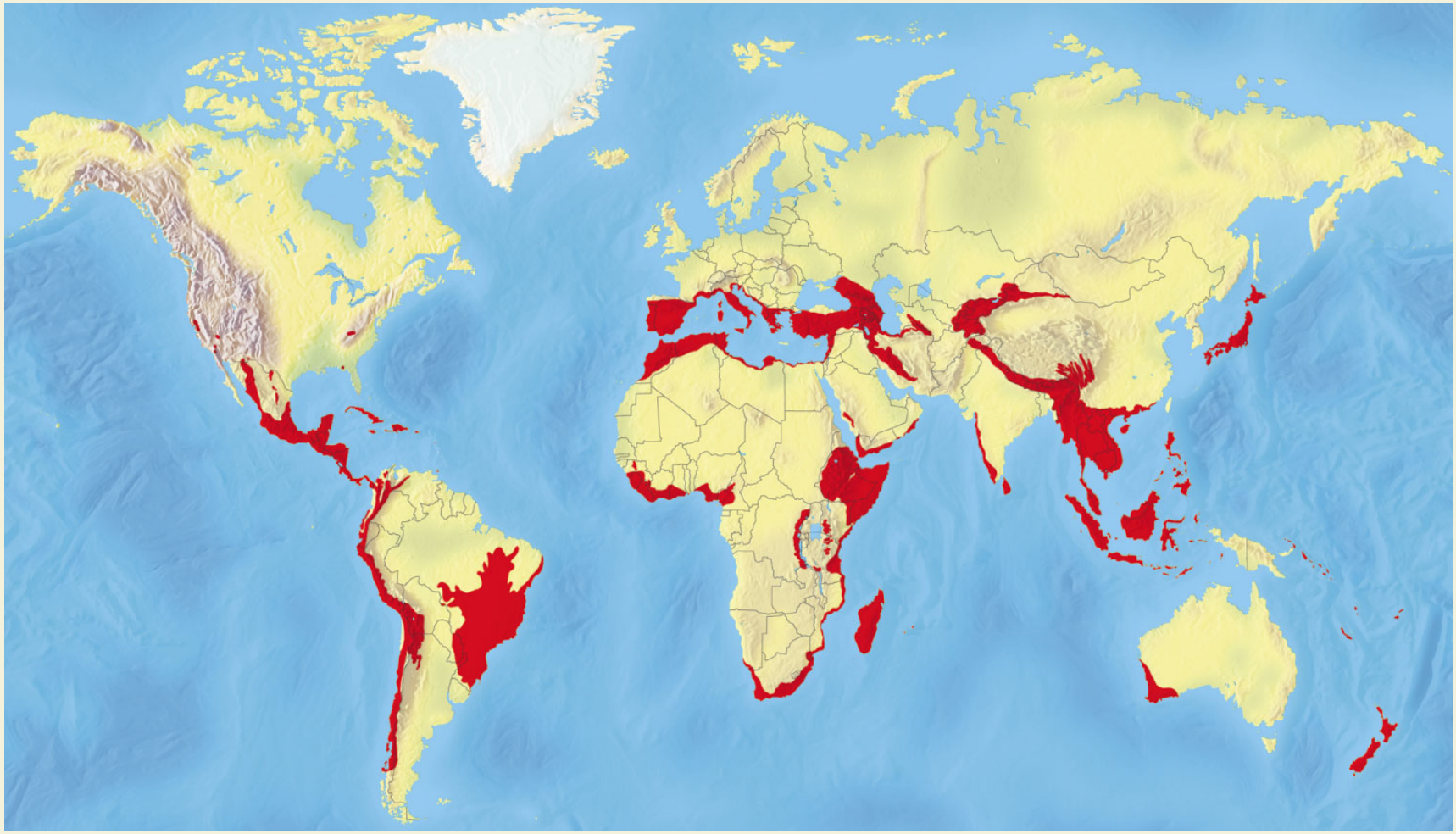


Fig. 10-27, p. 243

# Endangered Natural Capital: Biodiversity Hotspots in the U.S.

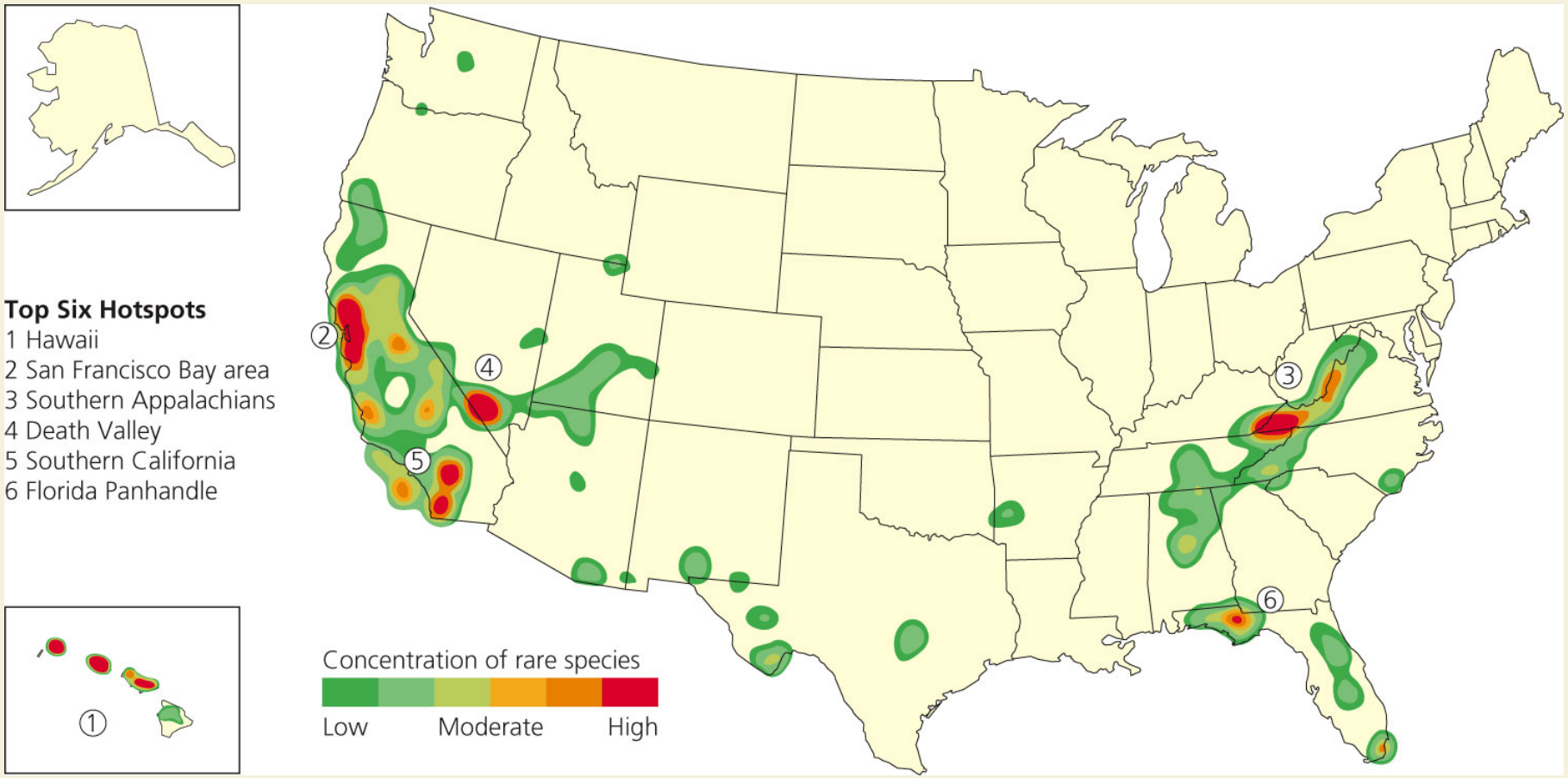



**Figure 27, Supplement 8**

# Protecting Ecosystem Services Is Also an Urgent Priority

- U.N. Millennium Ecosystem Assessment: 2005
  - Identify key ecosystem services
  - Human activities degrade or overuse 60% of the earth's natural services

- Identify highly stressed life raft ecosystems
  - High poverty levels
  - Ecosystem services degraded
  - Foster cooperation among residents, government and scientists to protect people and biodiversity

# We Can Rehabilitate and Restore Ecosystems That We Have Damaged (1)

- Study how natural ecosystems recover
  1. Restoration
  2. Rehabilitation
  3. Replacement
  4. Creating artificial ecosystems

# We Can Rehabilitate and Restore Ecosystems That We Have Damaged (2)

- How to carry out most forms of ecological restoration and rehabilitation
  1. Identify what caused the degradation
  2. Stop the abuse
  3. Reintroduce species, if possible
  4. Protect from further degradation

# Science Focus: Ecological Restoration of a Tropical Dry Forest in Costa Rica

- Guanacaste National Park restoration project
  - Relinked to adjacent rain forest
  - Bring in cattle and horses – aid in seed dispersal
  - Local residents – actively involved

# Will Restoration Encourage Further Destruction?

- Preventing ecosystem damage is cheaper than restoration

- About 5% of the earth's land is preserved from the effects of human activities

# We Can Share Areas We Dominate With Other Species

- **Reconciliation ecology**
  - Invent and maintain habitats for species diversity where people live, work, and play

- Community-based conservation
  - Belize and the black howler monkeys
  - Protect vital insect pollinators

# Case Study: The Blackfoot Challenge—Reconciliation Ecology in Action

- 1970s: Blackfoot River Valley in Montana threatened by
  - Poor mining, logging, and grazing practices
  - Water and air pollution
  - Unsustainable commercial and residential development

- Community meetings led to
  - Weed-pulling parties
  - Nesting structures for waterfowl
  - Developed sustainable grazing systems

# What Can You Do? Sustaining Terrestrial Biodiversity

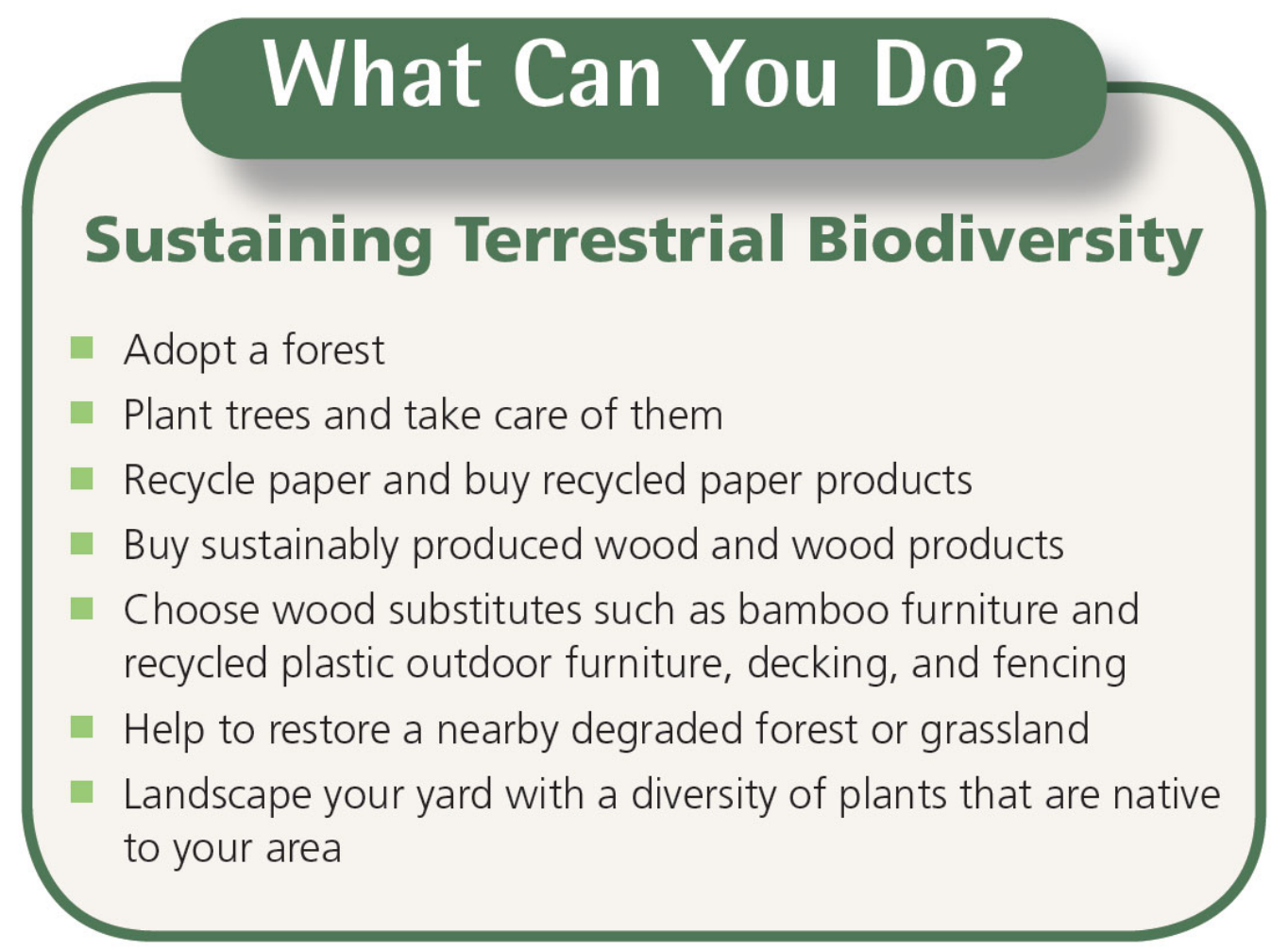



Fig. 10-28, p. 247

# Three Big Ideas

1. The economic values of the important ecological services provided by the world's ecosystems are far greater than the value of the raw materials obtained from those systems.

2. We can manage forests, grasslands, parks, and nature preserves more effectively by protecting more land, preventing over-use of these areas, and using renewable resources provided by them no faster than such resources can be replenished by natural processes.

# Three Big Ideas

3. We can sustain terrestrial biodiversity by protecting severely threatened areas, protecting remaining undisturbed areas, restoring damaged ecosystems, and sharing with other species much of the land we dominate.