# Environmental Science, 15e

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# Environmental Problems, Their Causes, and Sustainability

# Core Case Study: The Greening of American Campuses

- Colleges across the United States are taking sustainability seriously
  - Green building designs and reuse
  - Environmental science curriculums
- What does the term sustainability mean to you?
- How does your campus community approach sustainability?

# Sustainability Defined

- The ability of ecosystems and human cultural systems to survive, flourish, and adapt together to constantly changing environments over long periods of time

# 1.1 What Are Some Principles of Sustainability?

- Life on the earth:
  - Has been sustained for billions of years by solar energy, biodiversity, and chemical cycling
  - Depends on energy from the sun and natural capital provided by the earth
  - Can been preserved by shifting towards full-cost pricing and win-win solutions

# Environmental Science Is a Study of Our Interactions With the World

- What is the environment?
  - Everything around us, living and nonliving
- Ecosystem:
  - Group of organisms in a defined geographic area (terrestrial or marine) that interact with each other and their environment
- Environmentalism:
  - A social movement dedicated to sustaining the earth's life-support system

# What Are the Goals of Environmental Science?

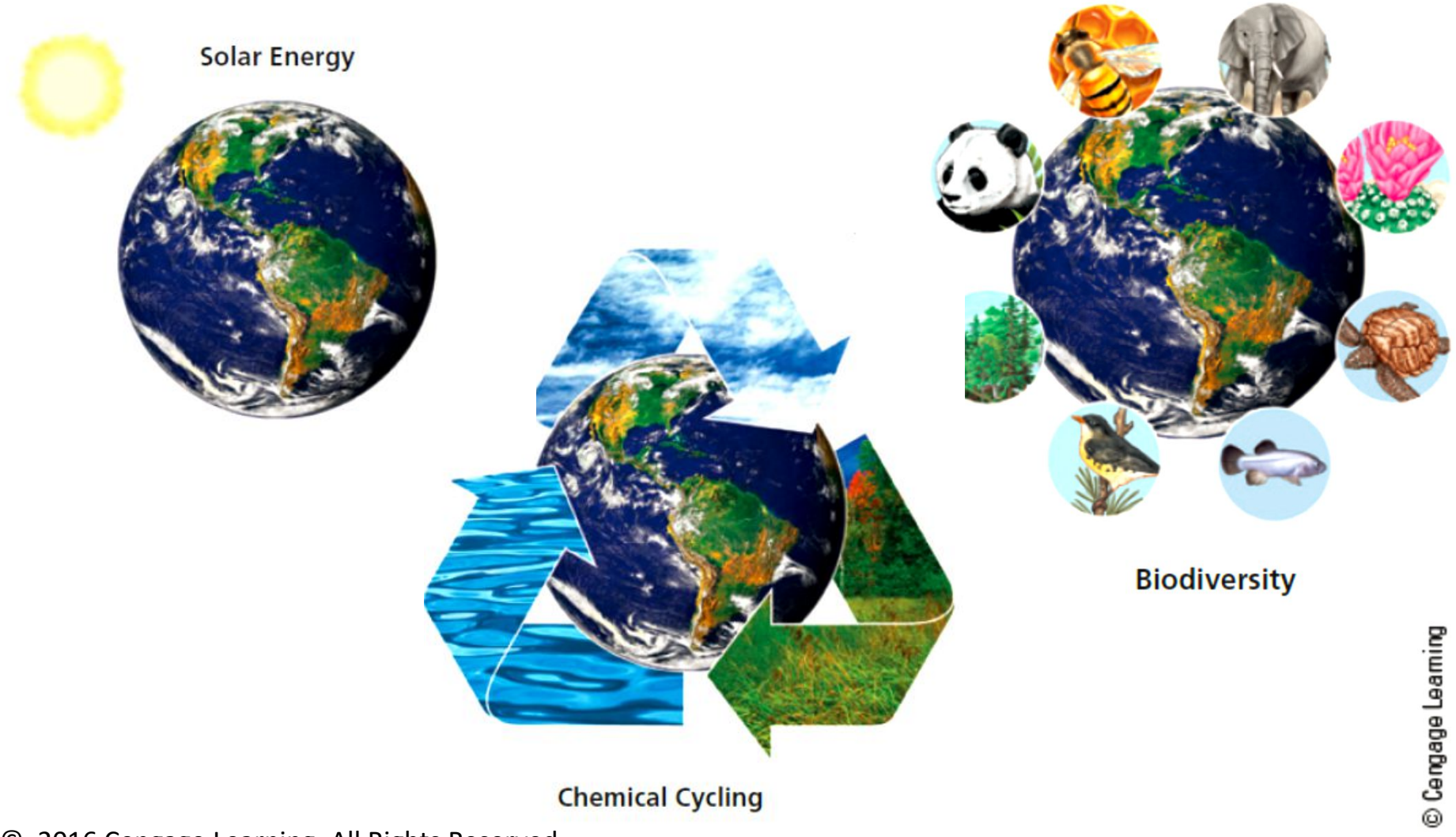
- To learn how life on the earth has survived and thrived
- To understand how we interact with the environment
- To find ways to deal with environmental problems and live more sustainably

# Three Scientific Principles of Sustainability

- Dependence on solar energy
  - Supplies nutrients, directly and indirectly
- Biodiversity
  - Provides ecosystem services and adaptability
- Chemical/nutrient cycling
  - In nature, waste = useful resources

**Interdependence, not independence, is what sustains life**

# Lessons From Nature



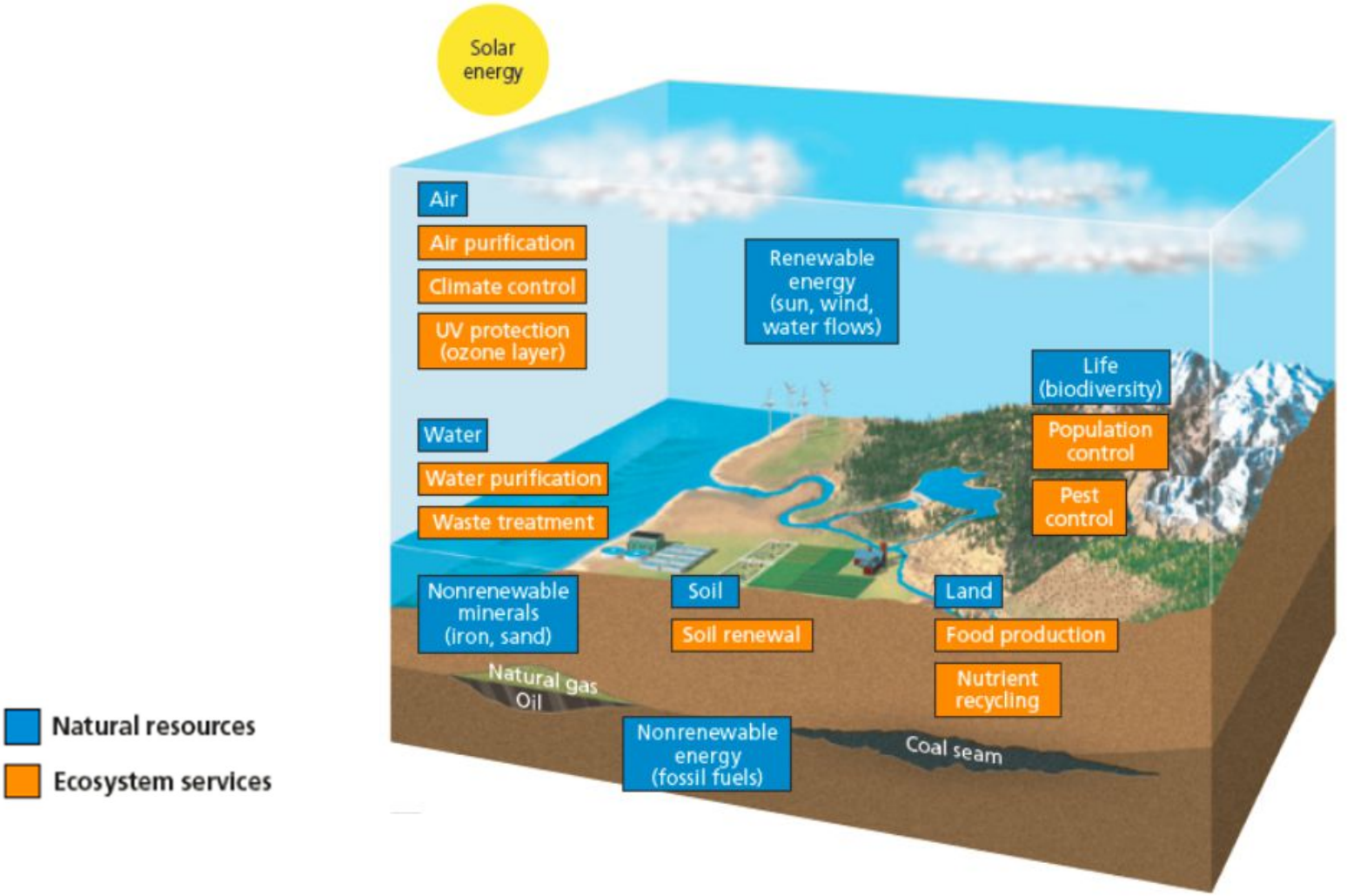
# Sustainability Has Certain Key Components

- Natural capital
  - Natural resources
  - Ecosystem services
- How do humans degrade natural capital?
  - By using renewable resources faster than nature can restore them
  - By overloading natural resources with pollution and waste

# Sustainability Solutions

- Solutions cross disciplines
  - Scientific versus economic and political solutions
- There are trade-offs and compromises
  - Corporate subsidies can encourage sustainability
  - Daily individual and local contributions matter

# Natural Capital = Natural Resources + Ecosystem Services



# Other Principles of Sustainability from the Social Sciences

- Full-cost pricing (economics)
- Win-win situations (political science)
- A responsibility to future generations (ethics)

# What is a Resource?

- A resource is anything we obtain from the environment
  - Can be readily available for use
  - Or – can require technology to acquire
- Sustainable solutions for resource use
  - Reduce
  - Reuse
  - Recycle

# Resources Are Inexhaustible, Renewable, and Nonrenewable

- Inexhaustible resources
  - Perpetually available and expected to last
- Renewable resources
  - Replenished by natural processes within their sustainable yield
- Nonrenewable/exhaustible resources
  - Available in fixed quantities that can be renewed, but only through long-term geologic processes

# Countries Differ in Resource Use and Environmental Impact

- Industrialized countries
  - 17% of world's population (United States, Canada, Western Europe)
- Developing countries
  - 83% of world's population
    - Middle income, moderately developed countries (China, India, Brazil)
    - Low income, least developed countries (Nigeria, Bangladesh, Haiti)

# 1.2 How Are Our Ecological Footprints Affecting the Earth?

- Over time, growth of ecological footprints depletes and degrades earth's natural capital (natural resources and ecosystem services)
  - Environmental degradation
- Is there any good news?

## Natural Capital Degradation

### Degradation of Normally Renewable Natural Resources

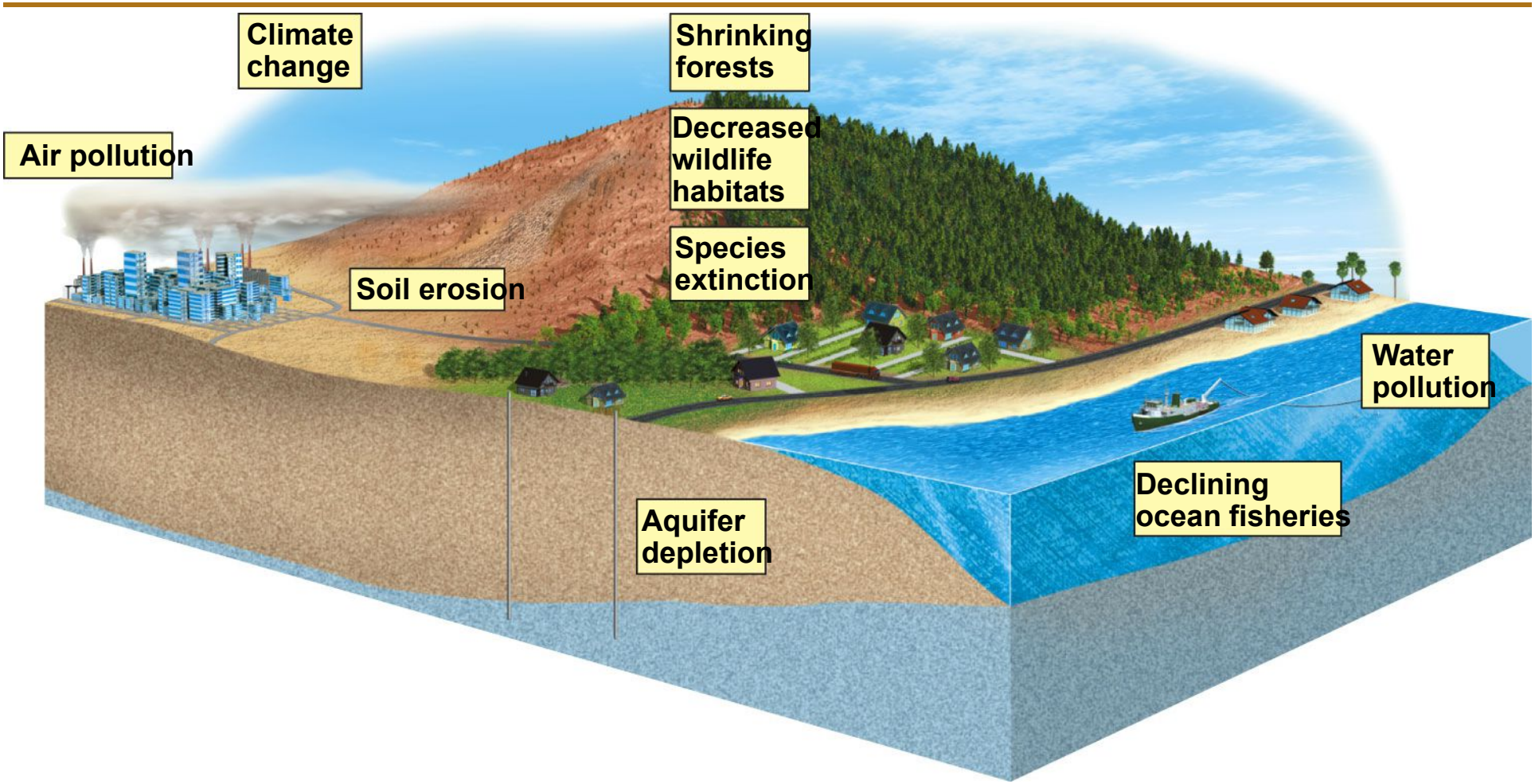
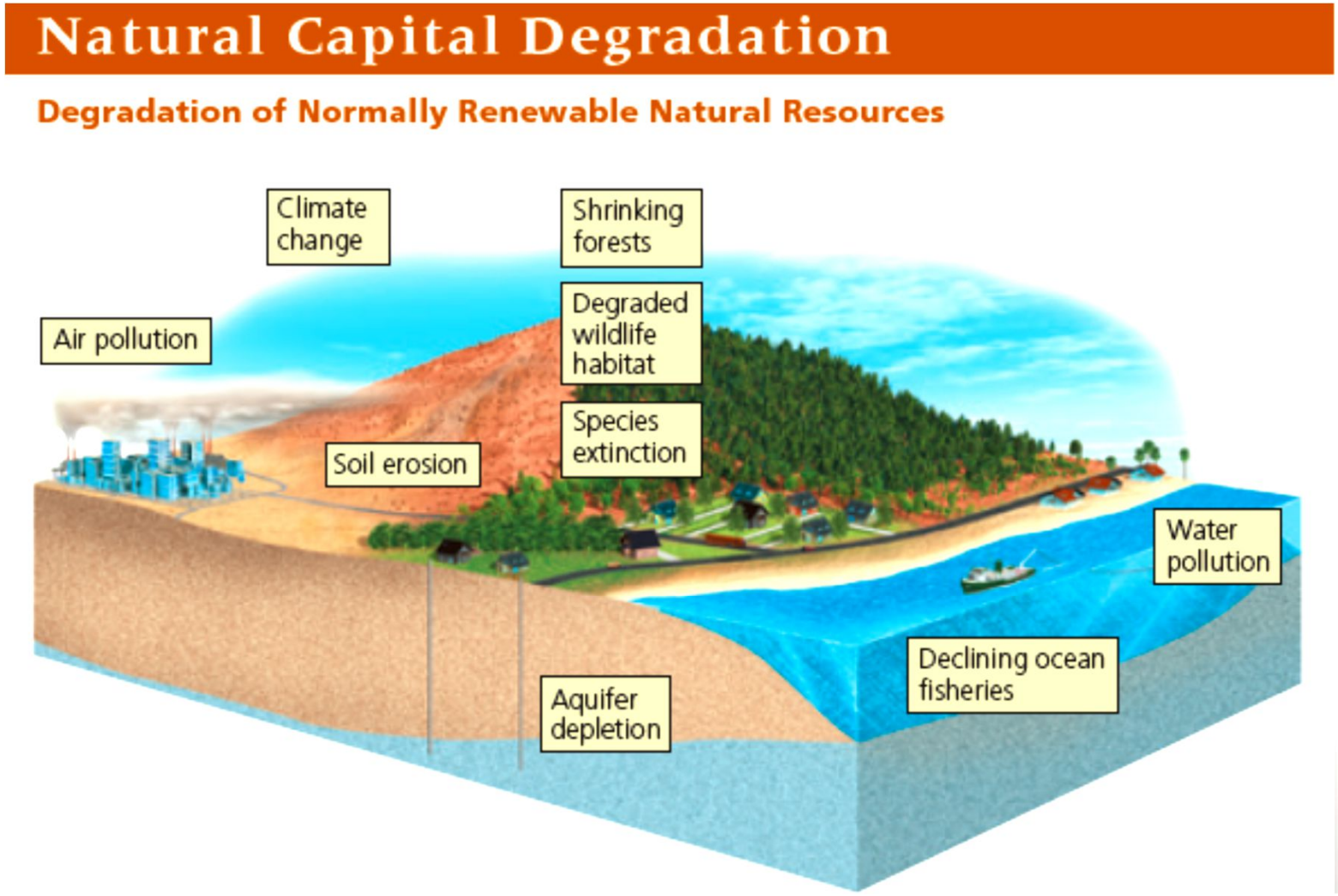





Fig. 1-5

# We Are Living Unsustainably



# Pollution Comes From a Number of Sources

- Pollution: contamination of the environment by polluting substances (pollutants) such as chemicals, noise, and heat
  - Naturally occurring (volcanoes)
  - Contributed by humans (burning of fossil fuels)

# Point Sources

- Single, identifiable origins (e.g., smokestacks)

# Nonpoint Sources

- Dispersed and difficult to identify sources (e.g., pesticides, trash in streams)

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# How Are We Dealing With Pollution?

- Pollution cleanup (post-production)
  - Cleanup: dilution/reduction of pollutants
- Pollution prevention (before pollution occurs)
  - Reduces or eliminates the production of pollutants

# We Are Degrading Commonly Shared Renewable Resources

- The tragedy of the commons
  - Cumulative degradation due to the overuse of:
    - Open access, renewable resources (atmosphere, open ocean, fish)
    - Shared resources (grasslands, forests, streams)
  - The individual (incorrectly) believes that:
    - "The little bit that I use or pollute is not enough to matter, and anyway, it's a renewable resource"

# What is an Ecological Footprint?

- An ecological footprint
  - The amount of land and water needed to supply a population or geographic area with renewable resources, as well as the ability to absorb/recycle wastes and pollution produced by resource usage
- The growth of ecological footprints
  - Leads to degradation of natural capital
  - Results in the creation of pollution and waste

# Our Ecological Footprints Are Growing

- An ecological deficit:
  - Occurs when the ecological footprint is larger than the biological capacity to replenish resources and absorb wastes/pollution
- In an ecological deficit, people are living unsustainably
  - This creates adverse environmental impacts, which can be mitigated by upcycling

# IPAT Is Another Environmental Impact Model

- In the early 1970s, a new environmental model called the IPAT model was developed to determine the environmental impact of human activities

$$\text{Impact } (I) = \text{Population } (P) \times \text{Affluence } (A) \times \text{Technology } (T)$$

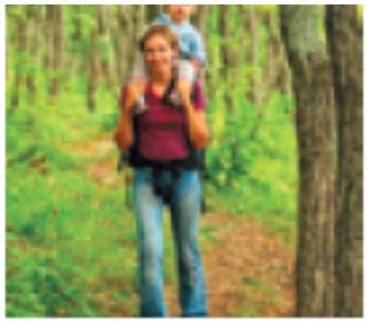
# 1.3 Why Do We Have Environmental Problems?

Population growth

Unsustainable resource use

Poverty

Excluding environmental costs from market prices



Increasing isolation from nature

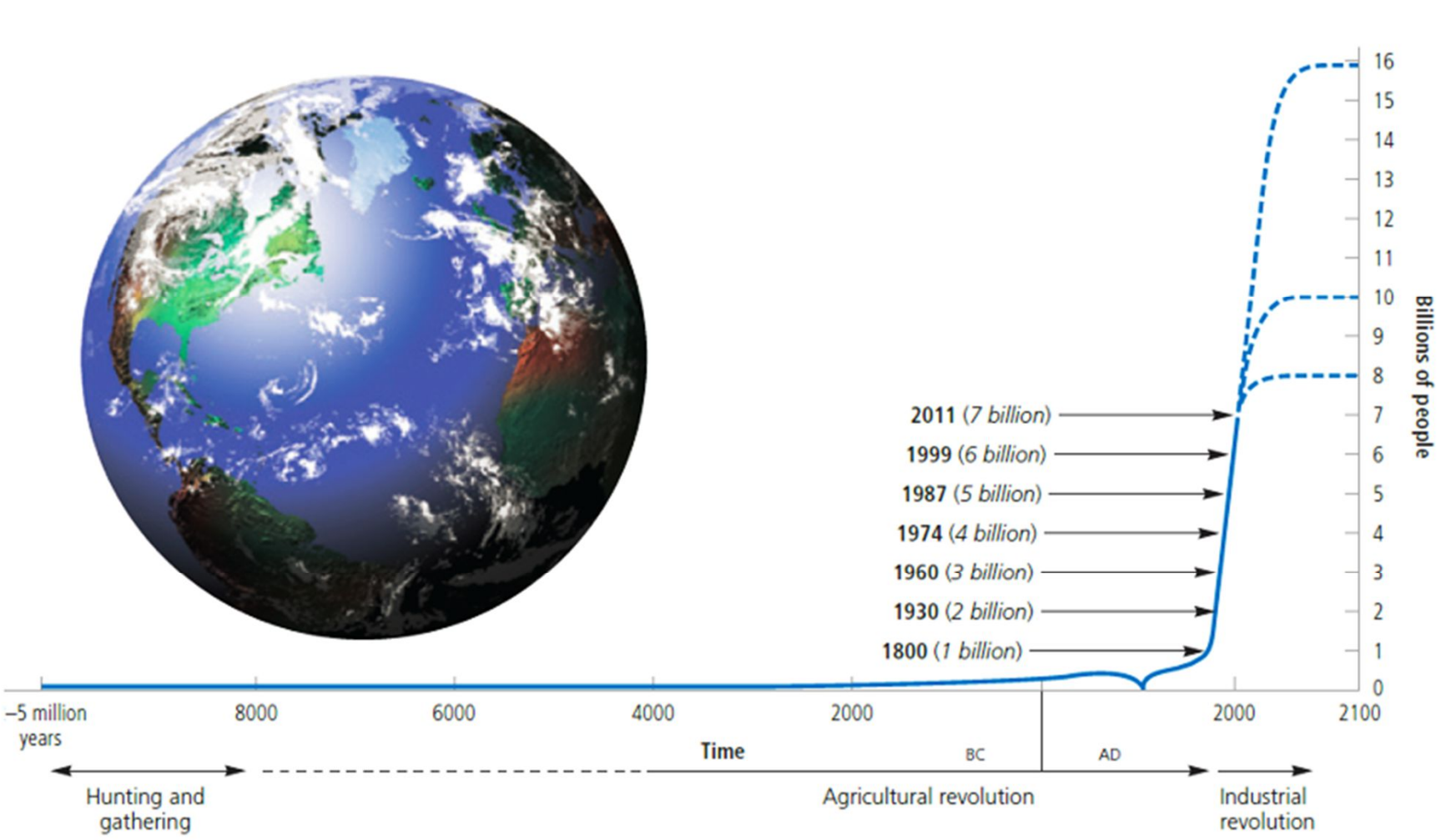
# Our Environmental Worldview

- For each of these causes, what are two environmental problems that result?
- Our own worldview determines whether we live sustainably or unsustainably

# The Human Population Is Growing at a Rapid Rate

- Unchecked population/ecological footprint growth results in natural capital degradation
- Can we slow down this degradation by reducing the rate of population growth?

# Exponential Growth




Compiled by the authors using data from the World Bank, United Nations, and Population Reference Bureau. Photo: NASA.

# Affluence Has Harmful Environmental Effects

- High levels of consumption and waste of resources
- More air pollution, water pollution, and land degradation
- Acquisition of resources without regard for the environmental effects of their consumption

# Affluence Has Beneficial Environmental Effects

- Better education
- Scientific research
- Technological solutions resulting in improvements in environmental quality (e.g., safe drinking water)

# Poverty Can Have Harmful Environmental and Health Effects

- Harmful effects
  - Short term requirements for survival can lead to degraded forests, topsoil, grasslands, fisheries, and wildlife populations
- Health effects
  - Malnutrition, limited access to sanitation/clean drinking water, outdoor and indoor air pollution

# Prices of Goods/Services Rarely Include Their Harmful Environmental/Health Costs

- Consumers are unaware of the damage caused by their consumption
- Current government subsidies often increase environmental degradation
  - To live sustainably, government subsidies must become beneficial to the environment by:
    - Taxing pollution and waste
    - Shifting from environmentally harmful to environmentally beneficial subsidies

# We Are Increasingly Isolated From Nature

- More than half the world's population lives in urban environments technological isolated from nature
- We are unaware of:
  - The origins of our food, water and other goods
  - The pollution and waste generated by the production of these goods and services

# What is Your Environmental Worldview?

- Each individual has his or her own environmental worldview
  - A set of assumptions and values reflecting how one thinks the world works and what one's role in it should be

# People Have Different Views About Environmental Problems/Solutions

- Three major types of world views:
  - Human-centered
    - Planetary management world view
    - Stewardship world view
  - Life-centered
  - Earth-centered

# The Rise of Environmental Conservation and Protection in the United States

- The preservationist school (John Muir)
  - Leave wilderness areas on some public lands untouched
- The conservationist school (Theodore Roosevelt, Gifford Pinchot)
  - Manage all public lands wisely and scientifically, primarily to provide resources for people

# 1.4 What Is an Environmentally Sustainable Society?

- In order to live sustainably, one must live off the natural resources without depleting or degrading the natural capital that supplies these natural resources

# We Must Protect Our Natural Capital and Live Off of Its Income

- Earth's natural capital provides natural income
  - Renewable resources such as plants, animals, soil, and clean water and air
- By living only on the natural income and not depleting the natural capital, society moves from an unsustainable lifestyle to a sustainable one

# A More Sustainable Future Is Possible

- Given enough time, most degraded environments can recover – but many will take hundreds and even thousands of years to recover
  - Time is our most scarce resource
  - However, 5-10% of a population that changes can make a difference
  - Changes can occur in a shorter time than previously thought

# Additional Case Study: An Eco-City – Tianjin, China

- Tianjin, China is a real-life entirely sustainable community developed on non-arable land located in an area facing a water shortage in one of the fastest growing regions of China
  - How does Tianjin reduce, reuse, and recycle its resources?
  - Do you think you could live in this city? Why or why not?

# Tiajin and the Three Big Ideas

- Create a more sustainable future
  - Use natural capital and natural resources
  - Reduce, reuse, and recycle
- Utilize full-cost pricing
  - Be aware of ecological footprints – and address cleanup and prevention
- Find win-win solutions
  - Apply these solutions to other societies