Lesson Overview

6.4 Meeting Ecological Challenges
THINK ABOUT IT

Every year, the EPA awards up to ten President’s Environmental Youth Awards. Past winners all came up with ideas that protect the environment while satisfying both present and future needs.

These kinds of ideas and leadership are what will help us chart a new course for the future.
Ecological Footprints

How does the average ecological footprint in America compare to the world’s average?
Ecological Footprints

How does the average ecological footprint in America compare to the world’s average?

According to one data set, the average American has an ecological footprint over four times larger than the global average.
Ecological Footprint

Ecologists refer to the human impact on the biosphere using a concept called the ecological footprint.

The ecological footprint describes the total area of functioning land and water ecosystems needed both to provide the resources an individual or population uses and to absorb the wastes that individual or population generates.
Ecological Footprints

Ecological footprints take into account the need to provide resources such as energy, food, water, and shelter, and to absorb such wastes as sewage and greenhouse gases.

Ecologists use footprint calculations to estimate the biosphere’s carrying capacity for humans.
Calculating actual numbers for ecological footprints is complicated. The concept is so new that there is no universally accepted way to calculate footprint size.

In addition, footprints give only a “snapshot” of the situation at a particular point in time.
Comparing Footprints

Although calculating absolute footprints is difficult, ecological footprints can be useful for making *comparisons* among different populations.

The per person use of resources in America is almost twice that in England, more than twice that in Japan, and almost six times that in China, as shown on the map on the following slide.
This world map shows each country in proportion to its ecological footprint.
Ecology in Action

How can ecology guide us toward a sustainable future?
Ecology in Action

How can ecology guide us toward a sustainable future?

By (1) recognizing a problem in the environment, (2) researching that problem to determine its cause, and then (3) using scientific understanding to change our behavior, we can have a positive impact on the global environment.
Ecology in Action

The future of the biosphere depends on our ecological footprints, global population growth, and technological development.

Ecological research, properly collected, analyzed, and applied, can help us make decisions that will produce profoundly positive effects on the human condition.
Case Study #1: Atmospheric Ozone

Between 20 and 50 kilometers above Earth’s surface, the atmosphere contains a relatively high concentration of ozone called the ozone layer.

Ozone at ground level is a pollutant, but the natural ozone layer absorbs harmful ultraviolet (UV) radiation from sunlight. By absorbing UV light, the ozone layer serves as a global sunscreen.
Recognizing a Problem: “Hole” in the Ozone Layer

Beginning in the 1970s, satellite data revealed that the ozone concentration over Antarctica was dropping during the southern winter. An area of lower ozone concentration is commonly called an ozone hole.
Recognizing a Problem: “Hole” in the Ozone Layer

For several years after the ozone hole was first discovered, it grew larger and lasted longer each year. These images show the progression from 1981 to 1999. The darker blue color in the later image indicates that the ozone layer had thinned since 1981.
Researching the Cause: CFCs

In 1974 a research team demonstrated that gases called chlorofluorocarbons (CFCs) could damage the ozone layer.

CFCs were once widely used as propellants in aerosol cans; as coolant in refrigerators, freezers, and air conditioners; and in the production of plastic foams.
Changing Behavior: Regulation of CFCs

Once the research on CFCs was published and accepted by the scientific community, the rest was up to policymakers.

Following recommendations of ozone researchers, 191 countries signed a major agreement, the Montreal Protocol, which banned most uses of CFCs.
Changing Behavior: Regulation of CFCs

Ozone-destroying halogens from CFCs have been steadily decreasing since about 1994, evidence that the CFC ban has had positive long-term effects.

Current data predict that although the ozone hole will continue to fluctuate in size from year to year, it should disappear for good around the middle of this century.
Case Study #2: North Atlantic Fisheries

From 1950 to 1997, the annual world seafood catch grew from 19 million tons to more than 90 million tons.

Recent dramatic declines in commercial fish populations have proved that the fish supply is not an endless, renewable resource.
Recognizing a Problem: More Work, Fewer Fish

From the 1950s through the 1970s, larger boats and high-tech fish-finding equipment made the fishing effort both more intense and more efficient.

Catches rose for a time but then began falling and continued to fall despite the most intense fishing effort in history.

The total mass of cod caught has decreased significantly since the 1980s because of the sharp decrease of cod biomass in the ocean.
Researching the Cause: Overfishing

Fishery ecologists gathered data including age structure and growth rates. Analysis of these data showed that fish populations were shrinking.

Ecologists determined that recent declines in fish catches were the result of overfishing. Fish were being caught faster than they could be replaced by reproduction.
Changing Behavior: Regulation of Fisheries

The U.S. National Marine Fisheries Service created guidelines for commercial fishing. The guidelines specified how many fish of what size could be caught in U.S. waters.

In 1996, the Sustainable Fisheries Act closed certain areas to fishing until stocks recover. Other areas are closed seasonally to allow fish to breed and spawn.
Changing Behavior: Regulation of Fisheries

Aquaculture—the farming of aquatic animals—offers a good alternative to commercial fishing with limited environmental damage if properly managed.
Overall, progress in restoring fish populations has been slow.

Huge fleets from other countries continue to fish the ocean waters outside U.S. territorial waters.

Some are reluctant to accept conservation efforts because regulations that protect fish populations for the future cause job and income losses today.

The challenge is to come up with sustainable practices that ensure the long-term health of fisheries with minimal short-term impact on the fishing industry.
Case Study #3: Climate Change

Intergovernmental Panel On Climate Change (IPCC) reports contain data and analyses that have been agreed upon and accepted by 2500 climate scientists from around the world and the governments participating in the study.
Weather and Climate

**Weather** is the day-to-day condition of Earth’s atmosphere.

**Climate** refers to average conditions over long periods and is defined by year-after-year patterns of temperature and precipitation.

Climate is rarely uniform even within a region. Environmental conditions can vary over small distances, creating *microclimates*.

For example, in the Northern Hemisphere, south-facing sides of trees and buildings receive more sunlight, and are often warmer and drier, than north-facing sides. These differences can be very important to many organisms.
Recognizing a Problem: Global Warming

The IPCC report that global temperatures are rising. This increase in average temperature is called global warming.

Winds and ocean currents, which are driven by differences in temperature across the biosphere, shape climate. The IPCC report discusses climate change—changes in patterns of temperature, rainfall, and other physical environmental factors that can result from global warming.

There is much physical and biological evidence that has contributed to our current understanding of the climate change issue.
Physical Evidence

Eleven of the twelve years between 1995 and 2006 were among the warmest years since temperature recording began in 1850.

Between 1906 and 2005, Earth’s average global temperature rose 0.74° C. The largest changes are occurring in and near the Arctic Circle.
Physical Evidence

Change in Global Land-Surface Air Temperature, 1850–2005
Physical Evidence

*Sea level has risen since 1961 at a rate of 1.8 mm each year.*

This increase is caused by warmer water expanding and by melting glaciers, ice caps, and polar ice sheets. Satellite data confirm that arctic sea ice, glaciers, and snow cover are decreasing.
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Meeting Ecological Challenges

Physical Evidence: Changes in Sea Ice and Changes in Sea Level

![Graph showing change in mean global sea ice from 1953 to 2007.](image)

![Graph showing change in global sea level from 1870 to 2005.](image)
Biological Evidence

Each organism’s range is determined by factors like temperature, humidity, and rainfall. If those conditions change, the organisms can be affected.

For example, if temperature rises, organisms would usually move toward cooler places away from the equator and from warm lowlands to cooler, higher altitudes.

In addition, plant flowering and animal breeding are often cued by seasonal changes. If warming is occurring, these organisms should respond as though spring begins earlier.
Biological Evidence

Data from 75 studies covering 1700 species of plants and animals confirms that many species and communities are responding as though they are experiencing rising temperatures.

Yellow-bellied marmots, for example, are coming out of hibernation more than a month earlier than they used to.
Researchers had to determine whether current warming is part of a natural cycle or whether it is caused by human activity or by astronomical and geological changes.

The IPCC report documents that concentrations of carbon dioxide and several other greenhouse gases have increased significantly over the last 200 years. Several kinds of data suggest this increase is due to the burning of fossil fuels, combined with the cutting and burning of forests worldwide. These activities add carbon dioxide to the atmosphere faster than the carbon cycle removes it.

Most climate scientists worldwide agree that this added carbon dioxide is strengthening the natural greenhouse effect, causing the biosphere to retain more heat.
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Researching the Cause: Models and Questions

Greenhouse Gas Concentration Through 2005

Greenhouse Gas Emissions by Sector, 2004:
- Agriculture: 13.5%
- Waste Management: 2.8%
- Energy Supply: 25.9%
- Forestry: 17.4%
- Industry: 19.4%
- Residential and Commercial Buildings: 7.9%
- Transportation: 13.1%
How Much Change?

Researchers use computer models to predict how much warming is expected. The models are complex and involve assumptions about climate and human activities. For these reasons, predictions are open to debate.

The IPCC reports the result of six different models, which predict that average global temperatures will rise by the end of the twenty-first century from just under 2°C to as much as 6.4°C higher than they were in the year 2000.
Possible Effects of Climate Change

Some climate changes are likely to threaten ecosystems ranging from tundra and northern forests to coral reefs and the Amazon rain forest.

Sea levels may rise enough to flood some coastal ecosystems and human communities.

Some models suggest that parts of North America may experience more droughts during the summer growing season.
Changing Behavior: The Challenges Ahead

Scientists have been saying for more than two decades that the world needs to recognize the importance of climate change and take steps to minimize further warming.

The changes in behavior needed to cut back on greenhouse gas emissions will be major and will require input from economics and many other fields beyond biology.

Some changes will rely on new technology for renewable energy and more efficient energy use. We have begun to see the emergence of electric cars, recycled products, and green buildings.
Nations of the world have begun holding international climate summits, at which they attempt to work out agreements to protect the atmosphere and climate.