6

Resource Utilization

According to the AP topic outline for environmental science, about 10–15 percent of the questions you'll see on the exam will ask about subjects we'll review in this chapter. Let's take a step back and review the fundamental themes of this chapter. First of all, a "**resource**" is strictly defined as "an available supply that can be drawn on as needed." That's easy enough to understand, but what resources are we talking about? Well, all of the earth's resources that humans rely on to live—namely the land, water, and the things that grow from them. As we'll see in this chapter, humans use the land and water for countless reasons.

We will begin our discussion with a description of the resources of the world—including what happens if people don't get enough resources, and who has too few. We'll then go through the resources gleaned from agriculture, forests, oceans, and mining. We'll end with a (short!) discussion of the economics behind our resource use. Let's begin!

SHARE AND SHARE ALIKE?

When people talk about managing common property resources such as air, water, and land, a paper published in *Science* magazine by Garret Hardin in 1958, called "The Tragedy of the Commons," often comes to mind. In this paper, Hardin referenced a parable from the 1880s in which a piece of open land, a commons, was to be used collectively by the townspeople for grazing their cattle. Each townsperson who used the land continued to add one cow or ox at a time until the common was overgrazed. Hardin quite eloquently says, "Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."

This parable serves as a foundation for modern conservation. **Conservation** is the management or regulation of a resource so that its use does not exceed the capacity of the resource to regenerate itself. This is different from **preservation,** which is the maintenance of a species or ecosystem in order to ensure their perpetuation, with no concern as to their potential monetary value.

In this chapter, we'll continue to show how human economics often influences how we interact with Earth's resources. Ecosystems (both biotic and abiotic) are often referred to as **natural resources.** When we describe something as a *resource,* we are essentially putting an economic value on it; therefore, natural resources are described in terms of their value as **ecosystem capital.**

Some Terms Used to Describe Resources

Let's start by discussing the two main types of resources.

- **Renewable resources** are resources such as plants and animals. These resources can be regenerated quickly.
- **Nonrenewable resources** are things like minerals, fossil fuels, and soil. Nonrenewable resources are typically formed by very slow geologic processes, so we consider them incapable of being regenerated within the realm of human existence.

There are a couple more terms you should know before we dive into our review of the major resources available to humans on Earth; these are consumption and production. The **consumption** of natural resources refers to the day-to-day use of environmental resources such as food, clothing, and housing. On the other hand, **production** refers to the use of environmental resources for profit. An example of this might be a fisherman who sells his fish in a market. Got those terms? Let's move on.

AGRICULTURE

How do resources relate to your dinner? Well, 77 percent of the world's food comes from croplands, 16 percent comes from grazing lands, and 7 percent of the world's food comes from ocean resources. Despite the importance of our crops, and although the population of the United States has increased significantly, fewer people than ever in the history of the United States now farm the land. Why is this? The short answer is that it has a lot to do with increasing urbanization (as we mentioned in the last chapter) and industrialization. Now that machines are readily available to work the land and harvest crops, farms have become more like factories—currently only 15 percent of the entire workforce of the United States produces the food to feed the entire county—and for exporting. Farms in the United States today are quite a bit larger than farms of the past; the average farm is 400 acres, while in the early twentieth century the average farm size was about 100 acres.

The use of machinery in farming has allowed a farmer to work more land and do so more efficiently; however, one of the drawbacks of the machinery is the amount of fossil fuel needed to power it. As the cost of fuel rises, the cost of food will also rise.

This rise in agricultural productivity can be tied to the new pesticides and fertilizers, expanded irrigation, and the development of new high-yield seed types. However, it has also resulted in a significant decrease in the genetic variability of crop plants and led to huge problems in erosion.

Traditional Agriculture and the Green Revolution

Throughout most of history, agriculture all over the world was such that each family grew crops for themselves, and families primarily relied on animal and human labor to plant and harvest crops. This process is called **traditional subsistence agriculture,** and it provides enough food for one family's survival. Traditional subsistence agriculture is still practiced in developing nations, and is currently practiced by about 42 percent of the world's population.

Another component of traditional agriculture that's still practiced in many developing countries today is a method called **slash and burn;** this practice actually dates back to early man. In slash and burn, an area of vegetation is cut down and burned before being planted with crops. Then because soils in these developing countries are generally poor, the farmer must leave the area after a relatively short time and find another location to clear. This practice severely reduces the amount of available forest; it is a significant contributor to deforestation.

The **Green Revolution** is generally thought of as the time after the Industrial Revolution when farming became mechanized and crop yields in industrialized nations boomed. Do not confuse the Green Revolution, which is about farming, with the Green movement, which is about conservation.

Fertilizers and Pesticides

One factor that contributed to the Green Revolution was an increase in the use of fertilizers and pesticides. Interestingly, when the non-native settlers (the first white settlers) planted their first corn crops, certain tribes of Native Americans taught them to plant a fish along with the corn seed; the fish acted as a natural fertilizer for the crops. As you can see, manures and other organic materials have been used as fertilizers by farmers for many years. However, the development of inorganic (chemical) fertilizers brought about the huge increases in farm production seen during the Green Revolution. It's estimated that if chemical fertilizers were suddenly no longer used, then the total output of food in the world would drop about 40 percent!

Of course, there are downsides to the widespread use of chemical fertilizers, and these include the following: the reduction of organic matter and oxygen in soil; the fact that these fertilizers require large amounts of energy to produce, transport, and supply; and the fact that once they are washed into watersheds, they are dangerous pollutants.

Similarly, the increased use of pesticides in the Green Revolution has significantly reduced the number of crops lost to insects, fungi, and other pests, but these chemicals have also had an effect on ecosystems in and surrounding farms. It's estimated that the average insect pesticide will only be useful for 5–10 years before its target pest evolves to become immune to its effects; therefore, new pesticides must constantly be developed. However, even with this constant development, crop loss due to pests has not decreased since 1970, although the used of pesticides has tripled!

Because the use of pesticides is so prevalent in the United States, Congress passed the *Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)* in 1947 and amended it in 1972. This law requires the EPA to approve the use of all pesticides in the United States. You will need to know this for the exam!

Irrigation

As we've mentioned, another major contributor to the increased crop yields seen in the Green Revolution was advanced irrigation techniques, which allowed crops to be planted in areas that normally would not have enough precipitation to sustain them. However, repeated irrigation can cause serious problems, including a significant buildup of salts on the soil's surface that make the land unusable for crops. To combat this **salinization** of the land, farmers have begun flooding fields with massive amounts of water in order to move the salt deeper into the soil. The drawback to this, however, is that the large amounts of water can waterlog plant roots, which will kill the crops. This process also causes the water table of the region to rise.

Genetically Engineered Plants

The third and last significant contributor to the Green Revolution was the introduction of genetically engineered plants. When genetically engineered plants were first introduced to the public, they were met with hostility and fear. This is in part because many people feared the eventual creation of hybrid humans and other genetic abominations.

Arguably, one of the most important developments in the genetic modification of plants has been the creation of golden rice, which contains vitamin A and iron. The introduction of this rice addresses two of the serious health problems that are seen in developing nations: Vitamin A deficiency, which can result in blindness and other serious health problems; and iron deficiency, which leads to anemia. This is just one example of the potentially multitudinous uses of genetic engineering in solving global hunger problems!

So far, the only empirical problem that has arisen as a result of the introduction of genetically engineered plants has been that pollen from these plants can spread, and hybrids between genetically engineered and non-genetically engineered plants can arise. This is a concern for some, since it may result in a loss of certain indigenous plant strains, such as the blue corn of Mexico.

Genetically engineered plants enable us to develop foods with higher nutritional value, and they also have the potential to enable us to decrease the amount of pesticides we use. For example, one particular strain of cotton has been genetically modified in such a way that it produces a pesticide in its leaves—but only at times when the insect population is a problem. Some other potential benefits of genetically engineered plants include producing their own nitrogen (which is often hard for plants to derive from the soil) or tolerating higher levels of salt in the soil. As you know, this latter development would allow plants to grow in areas where over-irrigation previously rendered the soil unusable.

Monotonous Monoculture

Believe it or not, three grains provide more than half of the total calories that are consumed worldwide! These three crops are rice, wheat, and corn, and the phenomenal increase in the yield of these crops was a result of genetic engineering. Genetic engineers discovered a way to cause plants to divert more of their photosynthetic products (called **photosynthate**) to becoming grain biomass rather than plant body biomass.

It's estimated that, of the roughly 30,000 plant species that could possibly be used for food, only 10,000 have been used historically, with any regularity. Today 90 percent of the caloric intake worldwide is supplied by just fourteen plant species and eight terrestrial animal species! In other words, today's agriculture represents a major reduction in agricultural biodiversity.

On a smaller scale, much of the farming that occurs today is characterized by **monoculture.** In monoculture, just one type of plant is planted in a large area. As we discussed earlier, this has proved to be an unwise practice for numerous reasons. **Plantation farming,** which is practiced mainly in tropical developing nations, is a type of industrialized agriculture in which a monoculture cash crop such as bananas, coffee, or vegetables, is grown and then exported to developed nations.

Soil Degradation

Have you ever read *The Grapes of Wrath* by John Steinbeck? Well, the story in this book took place in the 1930s, when droughts in the Great Plains reduced the area to a giant Dust Bowl. Although the drought was the major cause of the Dust Bowl, farming practices used at that time also contributed to the destruction of the land.

In an effort to address the Dust Bowl and other agricultural problems, the United States Soil and Conservation Service (today it's called the National Resources Conservation Service) was established, and it passed the Soil Conservation Act in 1935. Conservation districts were set up by the Service and these franchises provided education to farmers.

Today, farmers can protect soil from degradation in numerous ways. The practice of **contour plowing,** in which rows of crops are plowed across the hillside, prevents the erosion that can occur when rows are cut up and down on a slope. **Terracing** also aids in preventing soil erosion on steep slopes. Terraces are flat platforms that are cut into the hillside to provide a level planting surface; this reduces the soil runoff from the slope. Additionally, **no till methods** are quite beneficial; in no-till agriculture, farmers plant seeds without using a plow to turn the soil. Soil loses most of it carbon content during plowing, which releases carbon dioxide gas into the atmosphere. (And as you know, increased levels of CO_2 in the atmosphere have been associated with global climate change!)

Finally, **crop rotation** can provide soils with nutrients when legumes are part of the cycle of crops in an area. An alternate to crop rotation is **intercropping** (also called **strip cropping**), which is the practice of planting bands of different crops across a hillside. This type of planting can also prevent some erosion by creating an extensive network of roots. As you might be aware, plant roots hold the soil in place and reduce or prevent soil erosion.

The Livestock Business

Perhaps not surprisingly, the introduction of all these new agricultural techniques has significantly affected the livestock business, and this brings us full circle to the concept of the Tragedy of the Commons. As long as the grazing area is sufficient for the number of animals, livestock grazing is a sustainable practice. If, however, grass is consumed by animals at a faster rate than it can re-grow, land is considered **overgrazed.** Overgrazing is harmful to the soil because it leads to erosion and soil compaction. One solution to the problem of overgrazing is similar to crop rotation—animals can be rotated from site to site. Another solution involves the overall control of herd numbers.

Various tracts of public lands are available for use as rangeland, and cooperation between government agents, environmentalists, and ranchers can help avoid problems of overgrazing on these lands.

Another problem that arises from the large number of grazing animals worldwide is the large amount of animal waste produced. Instead of this waste being used as a natural fertilizer, it has instead

become the most widespread source of water pollution in the United States. Grazing animals also consume 70 percent of the total grain crop consumed in the United States, making them expensive food stuff.

FOREST RESOURCES

Many environmentalists are concerned about the deforestation that is taking place in North America. It is interesting to note that the number of trees growing in North America is approximately the same as 100 years ago, but only 5% of the original forests are left. The numbers are approximately the same because of the number of trees growing in national parks and tree plantations. What does this mean? It means that most of the trees in North America are young, and that most forests have been harvested and replanted, and have undergone significant upheaval.

DEFORESTATION

Deforestation, or the removal of trees for agricultural purposes or purposes of exportation, is a major issue for conservationists and environmentalists. Worldwide, industrialized countries have a higher demand for wood and less deforestation, while developing countries exhibit a smaller demand for wood, but more deforestation. This can be partly explained by the fact that the deforestation that occurs in developing countries primarily takes place because land is being cleared for pastures and farms. Industrialized countries can also import lumber from developing countries.

Nearly all of the deforestation that takes place in North America is done in order to create space for homes and agricultural plots. In sites where deforestation is occurring, the impact on resident ecosystems is significant. Take, for instance, Canada's Vancouver Island. On this island, whole mountainsides have been stripped bare of the centuries-old forests that once existed. While the lumber industry tries to offset this destruction by planting new trees, the saplings, which won't be harvestable for another 80 years, are no substitute for forests of 300-foot giant redwoods. Remember how we talked about ecological succession in Chapter 5? Where do you think all of the plants and animals that relied upon this forest ecosystem (which was a climax community) went to live?

Despite the moral questionability of this habitat destruction, the lumber industry will not be asked to leave Vancouver Island. This is because it's the island's most important source of income. Fifty cents of every dollar the island earns comes from lumbering—this number easily beats the island's income from tourism, which is the runner-up.

Another environmentally negative by-product of deforestation is seen in countries with tropical forests. In these forests, when trees are removed and farms are placed in the cleared land, the already-poor soil is further degraded and the area can only support crops for a short time. Usually, once the soil will no longer support a crop, the land will be used for grazing, but the soil becomes more and more depleted over time until it has no use for humans.

The negative repercussions of clearing tropical rainforests—the losses in biodiversity, and the erosion and depletion of nutrients in the soil—seem to outweigh the economic gains in many people's opinions. However, for those who would like to take a stand by refusing to purchase wood from tropical rainforests, it is often difficult to determine which wood products come from tropical rainforests and which come from sustainable forests. Various organizations, such as the nonprofit group the Forest Stewardship Council, have developed certifying procedures based on standards that will encourage only the use of the wood from sustainable forests.

How Can We Use Forests Sustainably?

There are three major types of forests, and woods are categorized based on the age and structure of their trees. An **old growth forest** is one that has never been cut; these forests have not been seriously disturbed for several hundred years. Not surprisingly, the controversies that revolve around the issue of deforestation are primarily centered on instances in which deforestation is occurring in old growth forests. As we mentioned in the last section, old growth forests contain incredible biodiversity, with myriad habitats and highly evolved, intricate niches for a multitude of organisms. **Second growth forests** are areas where cutting has occurred and a new, younger forest has arisen naturally. About 95 percent of the world's forests are naturally occurring, and the remaining forests are known as **plantations** or **tree farms.** Plantations are planted and managed tracts of trees of the same age (because they were planted by humans at the same time) that are harvested for commercial use.

It makes sense that those in the forestry business would be concerned about finding a way to promote sustainable forestry, because without forests they have no way of perpetuating their income. From an economic viewpoint, the forest must be managed to continually supply humans' need for wood. The management of forest plantations for the purpose of harvesting timber is called **silviculture.** This relatively modern field has a basic tenet to create a sustainable yield; to do this humans must harvest only as many trees as they can replace through planting. There are two basic management plans that attempt to uphold this tenet.

- **Clear-cutting** is the removal of all of the trees in an area. This is typically done in areas that support fast growing trees, such as pines. Obviously this is the most efficient way for humans to harvest the trees, but it has major impacts on the habitat, as in our previous example of Vancouver Island.
- **Selective cutting** is the removal of select trees in an area. This leaves the majority of the habitat in place and has less of an impact on the ecosystem. This type of **uneven-aged management** is more common in areas with trees that take longer to grow, or if the forester is only interested in one or more specific types of trees that grow in the area. Another type of uneven-aged management occurs in **shelter-wood cutting**. For **shelter-wood cutting,** mature trees are cut over a period of time (usually 10–20 years); this leaves some mature trees in place to reseed the forest.

In the case of **agroforestry,** trees and crops are planted together. This creates a mutualistic symbiotic relationship between the trees and crops—the trees create habitats for animals that prey upon the pests that harm crops, and their roots also stabilize and enrich the soil.

National Forest Policy

The federal government owns about 35% of all land in the United States. The need to preserve some of the land was recognized by President Lincoln who established the world's first National Park in Yosemite California. In 1916 the *National Park System* was created in part to manage and preserve forests and grasslands. Today, in addition to the National Park System there are several ways the federal government controls forested land: *Wilderness Preservation Areas* are open only for recreational activities with no logging permitted. The *National Forest System, Natural Resource Lands,* and *National Wildlife Refuges* are the other groups of federally controlled lands that allow logging with a permit.

You should be aware of two important laws that relate to our federal government's policies on preserving public lands; these are shown below, on page 114.

Date	Name of Law	What It Does
1964	Wilderness Act	Established a review of road-free areas of 5,000 acres or more and islands within the National Wildlife Refuges or the National Park System for inclusion in the National Preservation System. This act restricted activities in these areas.
1968	Wild and Scenic Rivers Act	Established a National Wild and Scenic Rivers System for the protection of rivers with important scenic, recreational, fish and wildlife, and other values.

One more point about managing treed areas: Recent times have seen an increase in the number of greenbelts, nationally. **Greenbelts** are open or forested areas built at the outer edge of a city. Since no one is permitted to build in them, they can increase the quality of life for people living nearby. They also border cities, putting limits on their growth. Sometimes satellite towns are built outside the greenbelt and interconnected with the city by highways and mass transportation methods; in this way, we can add green spaces in urban areas.

Natural Events (That Create Problems for Humans) in Forests

Certain tree diseases and the existence of pests in trees are two natural problems in forested areas. These can create problems for humans (in addition to the trees) because oftentimes they affect the quality of the food and the number of trees that are available for use. Humans manage these natural events in many different ways: by removing infected trees; by removing select trees or planting them sparsely to provide adequate spacing between them; by using chemical and natural pest controls; by carefully inspecting imported trees and tree products; and by developing pest- and disease-resistant species of trees through genetic engineering.

Forest fires are another natural occurrence. There are three major types of fires that occur in forests, and you should be familiar with them for the test.

- **Surface fires** typically burn only the forests' underbrush and do little damage to mature trees. These fires actually serve to protect the forest from more harmful fires by removing underbrush and dead materials that would burn quickly and at high temperatures, escalating more severe fires.
- **Crown fires** may start on the ground or in the canopies of forests that have not experienced recent surface fires. They spread quickly and are characterized by high temperatures because they consume underbrush and dead material on the forest floor. These fires are a huge threat to wildlife, human life, and property.
- **Ground fires** are smoldering fires that take place in bogs or swamps and can burn underground for days or weeks. Originating from surface fires, ground fires are difficult to detect and extinguish.

One final note about forest fires: Most people believe that forest fires are a bad thing despite the fact that they are part of the natural life of a forest. Some trees and plants even need fire in order for their seeds to germinate. The U.S. Forest Service started an advertising campaign to warn people about the ravages of fires and soon adopted "Smokey the Bear" to help get the message out. This policy reduced the amount of fires but it also created conditions for more destructive fires. Under

natural conditions, fires burn every few years and consume the fuel (dry leaves, needles, and wood) on the forest floor. However, if there are fewer fires, the amount of fuel can build up to very high levels. When this large amount of fuel ignites, the fires are much hotter and the flames much larger, causing more damage than if the fuel supplies were low. One way to solve the fuel buildup issue is to implement "controlled burns." These are small fires started when the conditions are just right and which lower the amounts of fuel. This practice is quite controversial.

Have you got all that information about forests? Let's move on to another vast resource that exists on Earth—our oceans.

OCEAN RESOURCES

The term **fishery** is used in several ways, but its main definition is: The industry or occupation devoted to the catching, processing, or selling of fish, shellfish, or other aquatic animals. In the economic sense, a fishery is the sum of all activities on a given marine resource.

Worldwide, about one billion people depend on fish as their main source of food, and about one million people are currently employed in the fishing industry. Incredibly, about 125 million tons of fish are harvested each year—approximately 75 percent of this total amount is consumed as food by humans, and the other 25 percent is used for other purposes.

For many years, nations were subject to what is known as the 12-mile limit—this limited each nation's territorial waters to just 12 miles from shore. However, in the late 1960s, the depletion of a number of offshore fisheries inspired the United Nations to host a series of international conferences to address the problems of fish scarcity. At this time, the depletion of marine fisheries began to be compared to the Tragedy of the Commons and it was nicknamed the Tragedy of Free Access. The result of this conference was that nations were authorized to extend their limits of jurisdiction to 200 miles from shore.

Today, fishermen must go farther and farther out to sea to catch fish, and need to rely on more sophisticated methods for finding them. Sonar mapping, thermal sensing, and satellite navigation are just a few of the advances that have aided fisherman as fish become scarcer and harder to locate.

By-Catch and Overfishing

Most of the fish that are harvested worldwide come from **capture fisheries;** they are caught in the wild and not raised in captivity for consumption. Some of the techniques that have been developed in order to improve fishing yields are creating problems that relate to overfishing. One of these problems is known as by-catch. **By-catch** refers to any other species of fish, mammals, or birds that are caught that are not the target fish. Some fishing methods that result in by-catch are the use of **driftnets,** which float through the water and indiscriminately catch everything in their path; **long lining,** which is the use of long lines that have baited hooks and will be taken by numerous aquatic organisms; and **bottom trawling,** in which the ocean floor is literally scraped by heavy nets that smash everything in their path, including whole marine mountains known as seamounts. Some advances that have been made in the fishing industry in an attempt to mitigate the problems of by-catch are: restrictions on the use of driftnets, the installation of ribbons on bait hooks that scare away birds and prevent them from being caught, and bans on bottom trawling.

How Many Fish Are Left?

It has recently been reported that about 47–50 percent of the major fish stocks of the world are fully exploited. Close to another 20 percent of the stocks are nearly overexploited, and about 10 percent are depleted; and this is mostly due to overfishing.

One partial solution to the problem of overfishing is **aquaculture,** which is the raising of fish and other aquatic species in captivity for harvest. In general, the fish that are raised in captivity are those with the highest economic value—for example, salmon and shrimp. Various different methods are used in aquaculture—some fish are raised totally in captivity and then harvested, while others (like salmon) are initially hatched in captivity, but then released into the wild and captured later. Some saltwater aquaculture is performed in shallow coastal areas; though this is generally for the raising of seaplants and mollusks.

While aquaculture, also known as **fish farming,** does help to meet worldwide demands for fish, it is not a panacea for all of our fishery problems. One concern about aquaculture is the possibility of the accidental release of farmed fish into the wild, which has the potential to introduce new diseases to ocean fish and contaminate the native gene pool. Another problem lies in the fact that many fish that are raised in captivity are carnivorous and are fed captured wild fish, which defeats the purpose of the attempt to kill fewer wild fish!

Most of the public outcry about the endangered animals of the sea has centered on two groups: the dolphins and the whales. Dolphins are a high-profile by-catch, and as you may have noticed, many cans of tuna now advertise as having been caught using "dolphin safe" nets. The slogan "Save the Dolphins" has been frequently employed by international marine conservation groups. However, that slogan is impossible to obey unless humans work to save the natural *habitat* of these creatures, first.

The International Whaling Commission (1974) regulates whaling. Recent policies implemented by the IWC allow the capture of a certain number of whales annually—by Norway for human consumption and by Japan for scientific use. It has recently come to light, however, that Japan has been eating the whales it catches, and they have stated that their rationale is that whales eat too many fish that could instead be caught by humans. Another industry that has recently been criticized for damaging whales' ecosystems is the tourism industry—whale watching tours are said to disrupt whale migration patterns and cause the whales undue stress.

Two Endangered Aquatic Ecosystems

As we've reviewed in earlier chapters, coral reefs are structures found in warm, shallow tropical waters that represent diverse and ecologically crucial ecosystems. Coral reefs are created by small marine animals (called **cnidarians**), which are involved in symbiotic relationships with photosynthetic algae called **zooxanthellae.** Reefs provide local populations with a great variety of seafood, and are also important recreational areas for humans.

In many areas of the world, exploitation has led to severe and irreversible damages to these reefs. One example of such irreversible coral damage is coral bleaching. In coral bleaching, higher-than-usual water temperatures cause the death of the zooxanthellae, and this in turn causes the death of the coral reef. While some bleaching is normal, high water temperatures can be caused by weather fluctuations such as El Niño, and since this is a periodic event, coral bleaching is an ongoing concern.

Another threatened aquatic ecosystem is the mangrove swamp. Mangrove swamps are coastal wetlands found in tropical and subtropical regions, and they are threatened by activities such as shrimp aquaculture and the degradation of the Western coastlines. Mangroves are characterized by trees, shrubs, and other plants that can grow in brackish tidal waters, and are often located in estuaries, which as you learned earlier, are areas where freshwater meets salt water. In North America, mangrove swamps are found from the southern tip of Florida along the entire Gulf Coast to Texas; Florida's southwest coast supports one of the largest mangrove swamps in the world.

A huge diversity of animals is found in mangrove swamps. Because these estuarine swamps are constantly replenished with nutrients transported by freshwater runoff from the land, they support a bursting population of bacteria, other decomposers, and filter feeders. These ecosystems also sustain

billions of worms, protozoa, barnacles, oysters, and other invertebrates, which in turn feed fish and shrimp, which support wading birds, pelicans, and in the United States, the endangered crocodile.

The importance of mangrove swamps has been well established. They function as nurseries for shrimp and recreational fisheries, exporters of organic matter to adjacent coastal food chains, and enormous sources of valuable nutrients. Their physical stability also helps to prevent shoreline erosion, shielding inland areas from severe damage during hurricanes and tidal waves.

Along with the Whaling Commission, there are many laws and regulations pertaining to preserving ocean resources. A few that the College Board is likely to ask about are

Date	Name of Legislation	What It Did
1965	Anadromous Fish Conservation Act	Protected fish that live in the sea but grow up and breed in fresh water
1976	Magnuson Fishery Conservation and Management Act	Governed the conservation and management of ocean fishing
1972	Marine Mammal Protection Act	Established a federal responsibility to conserve marine mammals
1973	Endangered Species Act	Provided broad protection for species of fish, wildlife, and plants that are listed as threatened or endangered in the U.S. or elsewhere

Finally, there are some international agreements.

Date	Name of Legislation	What It Did
1982	The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea	Set out the principles for the conservation and management of certain types of fish
1975	CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora)	An international agreement between governments that ensured that international trade in specimens of wild animals and plants do not threaten their survival

We're done with our discussion of resources from the sea. Let's move on to talking about resources that come from underground.

MINING

Mining is the excavation of earth for the purpose of extracting ore or minerals. We can divide mineral resources into two main groups by how they're used. **Metallic minerals** are mined for their metals (for example, zinc), which can be extracted through smelting and used for various purposes. **Nonmetallic minerals** are mined to be used in their natural state—nothing is extracted from them. Examples of nonmetallic minerals are salt and precious gems. Here's one more term you should know for the exam, if you don't already: A **mineral deposit** is an area in which a particular mineral is concentrated. An **ore** is a rock or mineral from which a valuable substance can be extracted at a profit.

The cost of extracting minerals depends on numerous factors, including the location and size of the mineral deposit. Additionally, the impetus for mining certain deposits more than others is often purely based on the value of the mineral resource. Understandably, the higher the value of the resource, the more money and effort will be put into mining it.

Environmental concerns about mining do not center on the depletion of mineral resources from the Earth's surface. Instead, they revolve around the damage that is done during the extraction process. The extraction of a mineral from Earth generally disrupts the ecosystem and scars the land. Sometimes the extraction leaves pollutants that were associated with the mineral ore underground or the machinery used to extract it. One example of this is the deposition of iron pyrite and sulfur in the mining of coal. The acid forms as water seeps through mines and carries off sulfur-containing compounds. The chemical conversion of sulfur-bearing minerals occurs through a combination of biological (bacterial) and inorganic chemical reactions; and the result is the buildup of extremely acidic compounds in the soil surrounding the deposit. These compounds create acid mine drainage that can severely harm local stream ecosystems. In mining processes, waste material is called **gangue,** and piles of gangues are called **tailings.**

One of the most controversial types of mining is **strip mining,** which involves stripping the surface layer of soil and rock (and anything growing on that surface layer) in order to expose a seam of mineral ore. This type of mining is only practical when the ore is relatively close to the surface, which is why it's used mainly for coal mining. This is the least expensive—and least dangerous—method of mining for coal. However, because strip mining requires removing massive amounts of top soil, it has a much greater impact on the surrounding environment than underground mining. The most extreme form of strip mining, Mountaintop removal, transforms the summits of mountains and destroys ecosystems. This method is mostly associated with coal mining in the Appalachian Mountains. With shaft mining, vertical tunnels are built to access and then excavate minerals that are underground and otherwise unreachable.

Another environmental drawback to mining is that the refinement of these minerals often requires extensive energy input. For example, it takes approximately 15.7 kW of electricity to produce one kilogram of pure aluminum from its ore. On the other hand, recycling aluminum requires only 5 percent of the energy that's required to smelt it, and generates only 5 percent of the greenhouse gases. Recycle those soda cans!

After minerals have been extracted from their ore, they may be used in their rough form or further processed. Aluminum, for example, must be further refined after it is mined. Coal is an exception. After mining, it is transported to a power plant and burned in its original state. Sometimes two metals are combined to form a product; this is the case with stainless steel, which is a combination of iron and either nickel or chromium, and regular steel, which is 95.5 percent iron and 0.5 percent carbon. Because of the energy expended in mining and extraction, the steel industry is responsible for much of the air pollution that exists today!

Fortunately, air, land and water harmed by mining can be reclaimed through mine restoration projects. In 1977, Congress passed the Surface Mining Control and Reclamation Act (SMCRA), which created one program to help coal mines manage pollutants and another to guide the reclamation of abandoned mines.

Mineral Production

The following table shows you the production (in thousands of metric tons) of some non-fuel mineral resources. While you will not have to memorize the amounts for the exam, you can appreciate how much is produced. Remember that these high production rates lead to the eventual depletion of these resources. Also, be ready to describe the impact of mining and mineral production on the environment.

Mineral	2004 Production (Thousands of metric tons)
Bauxite (aluminum ore)	159,000
Copper	14,600
Iron ore	1,340,000
Phosphate rock (for fertilizer)	141,000
Zinc	9,600,000

As you can see from the chart, demand for mineral resources is very high. The increased demand for manufactured goods means that we need to extract more and more raw materials from the Earth. The chart below, from the U.S. Geological Service, shows the number of years of supply for five selected mineral ores. For the exam, you should be aware of the need to use mineral resources in a sustainable manner.

Mineral	Years of Supply
Bauxite (aluminum ore)	152
Copper	32
Iron Ore	105
Nickel	41
Zinc	22

Finally, there are several laws that govern mining in the United States. The first two laws deal with exploration and mining of minerals. The last two laws deal with the pollution and waste that result from mining.

Date	Name of Legislation	What It Did
1872	Mining Act	Governed prospecting and mining of minerals on publicly owned land
1920	Mineral Leasing Act	Permitted the Bureau of Land Management to grant leases for development of deposits of coal, phosphate, potash, sodium, sulphur, and other leasable minerals on public domain lands
1980	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)	Regulated damage done by mining
1976	Resource Conservation and Recovery Acts (RCRA)	Regulated some mineral processing wastes
1977	Surface Mining Control And Reclamation Act	Established a program for regulating surface coal mining and reclamation activities. It established mandatory standards for these activities on state and federal lands, including a requirement that adverse impacts on fish, wildlife, and related environmental values be minimized.

ECONOMICS AND RESOURCE UTILIZATION

The study of how people use limited resources to satisfy their wants and needs is called economics. As you can imagine, some of those needs are tangible (food and shelter are two examples) while others are intangible (the beauty of a forest and clean air are two examples). A resource can have both tangible and intangible properties.

A forest has value for supplying jobs and wood (tangible) as well as for its beauty and ability to remove CO_2 from the air (intangible). When private citizens, governments, and corporations make a decision on how to use the forest, they must weigh the benefits (more jobs or lumber) against the cost of cutting down the trees (less recreation space, the loss of biodiversity, or decrease in CO_2 removal). This process is called **cost-benefit analysis**. It may be easy to assign a monetary value to the tangible properties (like the amount of lumber in the forest), but how do you assign a monetary value to the intangible properties (like the beauty of a forest)? While cost-benefit analysis helps make decisions on how to use resources, you can see that the process is very difficult, and it can lead to different estimates by different groups.

Economists also want to figure out the cost of each step in a process. From our forest example, what is the cost to the economy of adding one more acre to the forest; or what is the benefit to us if we add one more acre to the forest? The additional costs are termed **marginal costs**; the added benefits are called **marginal benefits**. It is important to remember that resources are not free and unlimited. Some resources must be expended in order for us to use them. While we may benefit from more acres to hike in, the lumber company will suffer from not having as many trees to cut. In other words, marginal benefits and costs help us understand tradeoffs. By preserving a forest, we trade more hiking space with less profit for local economies.

As we use resources there are often unwanted or unanticipated consequences of our using those resources or **externalities**. These can be positive, when the result is good, and negative when the result is bad for the environment. Consider buying a television, for example. When you buy the television there are costs—you pay for the labor, raw materials and electricity to run it. After you buy the television, the dealer uses some of that money to pay employees to clean up litter on a highway. That cleanup benefits everyone (positive externalities), even those who did not buy the television. On the other hand, there are also negative externalities. If you watch a lot of television, you use a lot of electricity. That electricity is generated by burning coal, and that causes acid rain. The damage done by the acid rain harms everyone—a negative externality.

One final thing to remember: the use of economics (cost-benefit analysis, marginal costs and benefits, and externalities) to make choices dealing with environmental issues is morally neutral. These economic factors do not say anything about the ethics or fairness of those choices. There are situations in which we make decisions not based on the best balance between marginal costs and benefits, but on what is best for everyone. Take water pollution, for example. If a toxic chemical "X" is in a stream, there is a cost to clean it up. We make the decision to clean up most of chemical "X," even if the marginal costs exceed the marginal benefits because removing chemical "X" will keep all of the people healthy.

We're done discussing resources. As we've alluded to many times, as populations increase, more pressure is placed on Earth's natural resources, and along with this comes the need for humans to find ways to develop those natural resources for direct human use. With this in mind, let's move on to the next chapter and review energy resources and consumption.

KEY TERMS

Here are your key terms for Chapter 6. Know what you should do with them? No, don't skip them! Learn them!

Resources
- renewable resources
- nonrenewable resources
- consumption
- production

Agriculture
- subsistence agriculture
- slash and burn agriculture
- Green Revolution
- salinization
- monoculture
- plantation farming
- overgrazing

Forestry
- old growth forest
- second growth forest
- silviculture
- clear-cutting
- selective cutting
- shelter-wood cutting
- agroforestry
- surface, crown, ground fires

Oceans
- fishery
- driftnets
- long lining
- bottom trawling
- aquaculture
- fish farming
- coral bleaching

Mining
- ore
- metallic and nonmetallic minerals
- gangue
- tailings
- strip mining
- mountaintop removal
- shaft mining
- restoration

Economics
- cost-benefit analysis
- marginal costs and benefits
- externalities

CHAPTER 6 QUIZ

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case.

1. Which of the following correctly describes the process of smelting?

   (A) Separating the desired metal from other elements in the ore
   (B) Cleaning up drainage from mines
   (C) Detoxifying harmful chemicals
   (D) Removing ore from underground mines
   (E) Making gasoline

2. In a very polluted river it costs $3 per kilogram to remove the first 80% of the pollution. It costs $25 per kilogram to remove the last 20% of the pollutant. This phenomenon is correctly referred to as:

   (A) cost-benefit analysis
   (B) external costs
   (C) marginal costs
   (D) marginal benefit
   (E) externalities

3. Which of the following correctly describes the process of clear-cutting?

   (A) Some mature trees are left to provide shade for younger trees.
   (B) Only trees with commercial value are cut down.
   (C) A few mature trees are left to reseed the land after cutting.
   (D) All the commercially usable trees in an area are cut down.
   (E) Trees are planted between rows of other crops.

4. Repeated irrigation can cause which of the following?

   (A) Salinization
   (B) Waterlogging
   (C) Desertification
   (D) Succession
   (E) Leeching of minerals from the soil

5. All of the following are problems created by the deforestation of rainforests EXCEPT

   (A) increased erosion
   (B) loss of biodiversity in the area
   (C) changes in local rainfall levels
   (D) an increase in the availability of grazing land
   (E) loss of soil fertility

6. Greenbelts are useful to

   (A) slow the process of urban growth
   (B) get more crops out of farmland
   (C) maintain borders around a person's home property
   (D) prevent erosion
   (E) hide unwanted objects from people's view

7. Which of the following government agencies is responsible for the management of federal rangeland?

   (A) The U.S. Park Service
   (B) The U.S. Bureau of Mines
   (C) The Bureau of Land Management
   (D) The Environmental Protection Agency
   (E) The U.S. Commerce Department

8. Which of the following is NOT a renewable resource?

   (A) Air
   (B) Soil
   (C) Copper ore
   (D) Water
   (E) Biodiversity

9. Nations have overfished international waters and have depleted many commercially important fish species. This is a good example of which of the following?

   (A) International agreements
   (B) The Tragedy of the Commons
   (C) The Rule of 70
   (D) Trade barriers
   (E) Sustainability

10. Which of the following best describes industrialized agriculture?

    (A) Consumes large amounts of fossil fuels, pesticides, and water
    (B) Uses human labor and draft animals to grow crops
    (C) Rows of crop plants are interspersed with rows of trees
    (D) Uses little water or fossil fuels; relies on human labor
    (E) Crops are grown on small plots of land

11. The international trade in endangered species is regulated by which of the following?

    (A) The Endangered Species Act
    (B) Marine Mammal Protection Act
    (C) The National Environmental Policy Act
    (D) RCRA
    (E) CITES

12. Which of the following are problems that have emerged with the overuse of pesticides?

I. Better crop yield
II. Pesticide-resistant pests
III. Improved human health

(A) I only
(B) II only
(C) III only
(D) I and III only
(E) I, II, and III

13. Which of the following is true concerning the use of National Parks?

(A) They can be used for cutting timber as well as recreation.
(B) They can be used for mining as well as recreation.
(C) They can be used only for camping, fishing, and boating.
(D) They can be used for conservation of natural habitat as well as livestock grazing.
(E) They can be used for military activities and the development of natural gas reserves.

14. The acid most commonly found in mine drainage is

(A) carbonic acid
(B) sulfuric acid
(C) hydrochloric acid
(D) acetic acid
(E) citric acid

15. The World Trade Organization strives to

(A) protect endangered species on land
(B) regulate the global fishing industry
(C) move toward the globalization of all the nations
(D) establish rules for the free flow of economic goods and services between countries
(E) decrease competition for goods among nations

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement. A choice may be used once, more than once, or not at all in each set.

Questions 16-19 refer to the various methods used to catch fish.

(A) drift net
(B) long-line fishing
(C) aquaculture
(D) bottom trawling

16. A weighted net is dragged across the sea floor

17. Marine organisms are raised in a bay or confined area

18. This is dragged through the water indiscriminately to catch everything in its path

19. Bated hooks attached to lines are dropped off the side and then reeled back onboard

Free-Response Question

1. The irrigation of farmland is vital to the production of the world's food supply. In China, 87 percent of the water withdrawn is used for irrigation. In the United States, this figure approaches 41 percent. Most of the water is applied to the land in a process called gravity irrigation, in which the water is simply allowed to flow, via the force of gravity, into the fields.

   (a) Describe one positive and one negative impact of gravity irrigation.

   (b) Describe one alternative to gravity irrigation. Give one positive and one negative effect of that practice.

   (c) Massive irrigation programs can also impact underground water supplies. Describe one negative impact that irrigation might have on those supplies.

   (d) Dams are often used to create irrigation water reservoirs. Describe two positive and two negative impacts that a large dam would have on the immediate area around it.

ANSWERS AND EXPLANATIONS

Multiple-Choice Answers

1. **A** Smelting is a process that separates a desired ore from other materials in mined ore. It is usually accomplished by heating the ore and ladling off the desired molten element.

2. **C** (A), cost-benefit analysis, is the comparison of the benefit of an action relative to the costs of that action. (B), external costs, are the costs that occur after someone purchases something. For example, after you buy a car, the cost of gasoline is an external cost. (D), marginal benefits, are the tradeoff between how much we gain by buying forest land (for example) or using the money to do some other beneficial activity. (E), externalities, are accidental side effects of something we do that affects other people. So, if you drive a car the pollutants you produce can cause acid rain that kills trees in a forest. That is a negative externality. (C), marginal costs, are the costs of each step in a process. Thus, (C) is the correct answer.

3. **D** Clear-cutting is the removal of all trees from an area at the same time. Selective cutting is the removal of select trees in an area; this leaves the majority of the habitat in place and has less of an impact on the ecosystem. This type of uneven-aged management is more common in areas with trees that take longer to grow, or when the forester is only interested in one or more specific types of trees that grow in the area. Another type of uneven-aged management occurs in shelter-wood cutting. In shelter-wood cutting, mature trees are cut over a period of time (usually 10–20 years); this leaves mature trees, which can reseed the forest, in place.

4. **A** Repeated irrigation can cause serious problems, including a significant buildup of salts on the soil's surface, which makes the land unusable for crops; this condition is known as salinization.

5. **D** One of the major motivations for cutting down rainforests is to increase the amount of grazing land for cattle and other farm animals. All of the other options are problems associated with deforestation, but (D) benefits humans.

6. **A** Greenbelts are used in urban planning in order to increase green space and control the growth of cities. They are open or forested areas built at the outer edge of a city. Because no growth is permitted in them, they can increase the quality of life for people living near them. Sometimes satellite towns are built outside the greenbelt and connected to the city by highways and mass transportation methods.

7. **C** The Bureau of Land Management is responsible for the management of federal rangeland.

8. **C** The amount of copper ore in the Earth is limited. It is considered a nonrenewable resource. (A), (B), (D), and (E) are considered to be renewable because a renewable resource is one that will be available as long as humans use it in a sustainable manner.

9. **B** In the Tragedy of the Commons, a common resource is used by many people and then becomes depleted as these people do not regulate their consumption of the resource. Some sources say that 75 percent of the world's 200 commercially usable fish are either overfished or are being fished at their maximum sustainable yield.

10. **A** Traditional industrialized agriculture consumes large amounts of energy and other resources. When all aspects are considered (growing crops, processing, and transportation), 17 percent of the U.S.'s total commercial energy use goes into food production. Typically, for every unit of food energy eaten, it takes ten units of fossil fuel energy to prepare and deliver the food.

11. **E** CITES is the international law that regulates the international trade in endangered species of both plants and animals. This is the correct answer. (A) deals with species only in the United States. (B) is another United States law that deals with marine mammals. (C) is a law that set how the United States will deal with environmental issues. (D), the Resource Conservation and Recovery Act (RCRA), deals with problems created by underground petroleum tanks.

12. **B** Pesticide resistance is the only answer choice that represents a problem that results from the use of pesticides. Because pesticides have been used in large amounts, some species of pests have evolved traits that allow them to resist the action of pesticides.

13. **C** The uses of National Parks are restricted to camping, fishing, and boating. Motor vehicles are permitted, but only in designated areas. (D) and (E) describe the permitted uses of National Wildlife Refuge land, and (A) and (B) both describe acceptable uses of National Forest lands.

14. **B** Sulfuric acid forms as water seeps through mines and carries off sulfur containing compounds. The chemical conversion of sulfur-bearing minerals occurs through a combination of biological (bacterial) and inorganic chemical reactions.

15. **D** In 1995, most of the world's nations formed the WTO to establish ground rules for international commerce.

16. **D** A bottom net is pulled along by one or more boats.

17. **C** Fish pens or oysters raised on wodden racks are a good example of aquaculture.

18. **A** Drift nets are not towed or dragged. They float freely for up to six months before they're reeled in.

19. **B** The hooked line can be more than a mile long and is generally dragged behind a boat.

Free-Response Answer

1. Use the checklists below to determine if your responses were correct. We will use checklists like these when there are many different ways that you could have answered the question. However, remember that your answers should be in paragraph format!

(a) Aspects include

Positive aspects	Negative aspects
Low cost to implement this way of watering	Lots of water lost to evaporation
Little technology and training necessary	Not all areas well-adapted to this technique
Low cost to maintain this way of watering	Delivers more water than plants need
	Water distribution is uneven
	Promotes weed growth along with crops

(2 points maximum—1 point for a correct positive aspect and 1 point for a negative aspect)

(b) Alternatives include

- Lining canals (Positive: reduces water lost to infiltration; Negative: expensive to do and uses resources)
- Leveling fields (Positive: water flows where needed; Negative: very expensive to level fields)
- Irrigate at night (Positive: avoids evaporation; Negative: requires careful planning and training)
- Irrigate only when necessary (Positive: less waste; Negative: difficult to time)
- Use drip irrigation (Positive: water drops right to roots; Negative: uses resources of plastic)
- Center pivot: (Positive: low waste as water is sprayed directly on to plants; Negative: equipment is very costly and runs on fossil fuels)

(3 points maximum—1 point for identifying process, 1 point for correct positive impact, and 1 point for correct negative impact)

(c) Possible negative impacts are

- saltwater intrusion: as the aquifer diminishes, nearby ocean water can migrate underground
- diminished water for domestic or industrial use
- subsidence: as water is withdrawn, the soil settles and sinkholes can develop; these can damage buildings and destroy ecosystems

(2 points maximum—1 point for naming impact and 1 point for explanation)

(d) Some positive and negative effects are

Positive effects	Negative effects
Production of low-cost electricity	Costly to build
Reservoirs used for many recreational activities	Negative impact on local ecology
Provides flood control	Prevents silt recharging of floodplain
Irrigation water can be controlled	Decrease in fish migration and spawning
Durable	Great danger if breached

(3 points maximum out of 4 possible—1 point for each positive and negative impact)