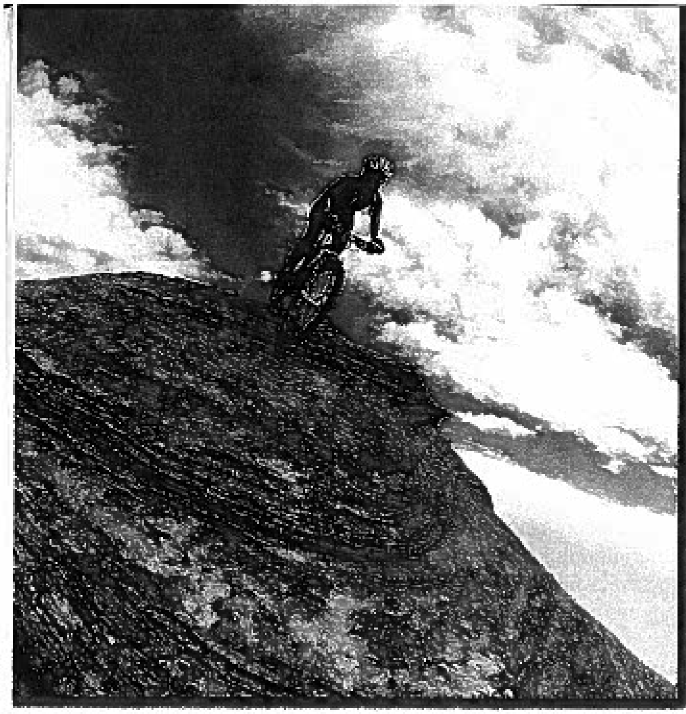


CHAPTER 3

ENVIRONMENTAL RISK: ECONOMICS, ASSESSMENT, AND MANAGEMENT

Many environmental questions are framed by the interrelated concepts of risk and cost. Although mountain biking carries substantial risk, proper training, appropriate behavior, and use of the correct equipment reduce the risk. Similarly, the risk of environmental damage can be lessened by making wise choices.

CHAPTER OUTLINE

OBJECTIVES

After reading this chapter, you should be able to:

- Describe why the analysis of risk has become an important tool in environmental decision making.
- Understand the difference between risk assessment and risk management.
- Describe the issues involved in risk management.
- Understand the difference between true and perceived risks.
- Define what an economic good or service is.
- Understand the relationship between the available supply of a commodity or service and its price.
- Understand how and why cost-benefit analysis is used.
- Understand the concept of sustainable development.
- Understand environmental external costs and the economics of pollution prevention.
- Understand market approaches to solving environmental problems.
- Describe RBCA and Eco-RBCA.
- Understand what is meant by risk tolerance.
- Understand the concept of perceived versus actual risk.

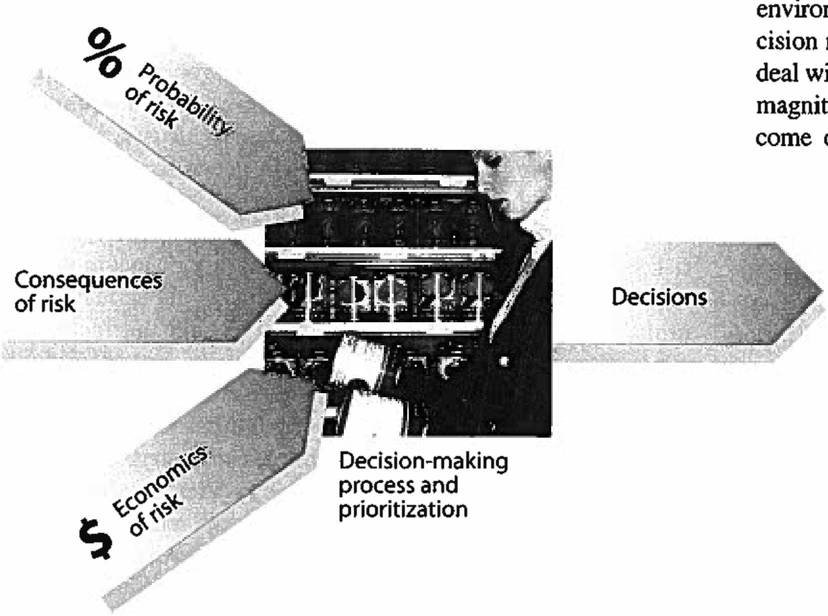
The following additional Case Studies can be found on the book's website at www.mhhe.com/enger12e along with other interesting readings: "ASTM International E2205-02 Standard Guide for Risk-Based Corrective Action (RBCA) for Protection of Ecological Resources," "Great Lakes Fisheries Resources: Who Cares? A Role-Play Exercise," and "Energy Savings Through Light Replacement, Cost-Benefit Analysis."

ƆHARACTERIZING RISK

ƚisk is the probability that a condition or action will lead to an inury, damage, or loss. When we consider any activity or situation hat poses a risk, we generally think about three factors: the probbility of a bad outcome, the consequences of a bad outcome, and ıe cost of dealing with a bad outcome. **Probability** is a matheıatical statement about how likely it is that something will hap·en. Probability is often stated in terms like, "The probability of eveloping a particular illness is 1 in 10,000," or "The likelihood f winning the lottery is 1 in 5 million." It is important to make a istinction between *probability* and *possibility.* When we say omething is *possible,* we are just saying that it could occur. It is very inexact term. *Probability* specifically defines in mathematːal terms how likely it is that a *possible* event will occur.

The *consequences* of a bad outcome resulting from the aceptance of a risk may be minor or catastrophic. For example, amıonia is a common household product. Exposure to ammonia will ɛsult in 100 percent of people reacting with watery eyes and other ymptoms. The probability of an exposure and the probability of n adverse effect are high; however, the consequences are not seere, and there are no lasting effects after the person recovers. 'herefore, we are willing to use ammonia in our homes and accept ıe high probability of an exposure. By contrast, if a large dam 'ere to fail, it would cause extensive property damage and the eaths of thousands of people downstream. Because the conseuences of a failure are great, we insist on very high engineering :andards so that the probability of a failure is extremely low.

One of the consequences of accepting a risk is the *economic ɔst* of dealing with bad outcomes. If people become ill or are inıred, health care costs are likely to be associated with the acceptıce of the risk. If a dam fails and a flood occurs downstream, there will be loss of life and property, which ultimately is converted to an economic cost. The assessment and management of risk involve an understanding of the probability and the consequences of decisions. (See figure 3.1.)



IGURE 3.1 **Decision-Making Process** The assessment, cost, d consequences of risks are all important to the decision-making process.

RISK AND ECONOMICS

Most decisions in life involve an analysis of two factors: risk and cost. We commonly ask such questions as "How likely is it that someone will be hurt?" and "What is the cost of this course of action?" Furthermore, these two factors are often interrelated. When we make economic decisions, we may be risking our hard earned money. Risky decisions that lead to physical harm are often reduced to economic terms when medical care costs or legal fees are incurred. Environmental decision making is no different. Most environmental decisions involve finding a balance between the perceived cost of enduring the risk and the economic cost of eliminating the conditions that pose the risk. If a new air-pollution regulation is proposed to reduce the public's exposure to a chemical that is thought to cause disease in a small percentage of the exposed public, industry will be sure to point out that it will cost a considerable amount of money to put these controls in place and will reduce profitability. Citizens also may point out that their tax money will have to support a larger governmental bureaucracy to ensure that the regulations are followed. On the other side, advocates will point out the new regulations will lead to reduced risk of illness and reduced health care costs for people who live in areas affected by the pollutant.

RISK ASSESSMENT

Environmental **risk assessment** is the use of facts and assumptions to estimate the probability of harm to human health or the environment that may result from particular management decisions. An environmental risk assessment process provides environmental decision makers with an orderly, clearly stated, and consistent way to deal with scientific issues when evaluating whether a risk exists, the magnitude of the risk, and the consequences of the negative outcome of accepting the risk. Voluntary organizations such as the International Standardization Organization (ISO) and ASTM have tried to develop acceptable industry-wide standards for guidance in determining environmental and human health risks based on actual or perceived risks. Many industrial and regulatory agencies have joined in this somewhat difficult exercise.

Calculating the risk to humans of a particular activity, chemical, technology, or policy is difficult, and several tools are used to help clarify the risk. If a situation is well known, scientists use probabilities based on past experience to estimate risks. For example, the risk of developing black lung disease from coal dust in mines is well established, and people can be informed of the risks involved and of actions that can reduce the risk.

There are also environmental risks that do not directly affect human health. If human activities cause the extinction of species, there is a negative environmental impact, although direct human impact may not be obvious. Similarly, unwise policy decisions may lead to the unsustainable harvest of forest products, fish, wildlife, or other resources that will deplete the resource for future generations.

To estimate the risks associated with new technologies or policies for which there is no established history, models must be used. One common method for modeling the risk of chemical exposure to human health is to expose animals to known quantities of a chemical to gain some insight into how dangerous a material or situation may be. However, a rat or rabbit may not react in the same way as a human. Therefore, animal studies are only indicators of human risk.

In other situations, the impact of a new policy initiative may be modeled using computer simulations. For example, in an attempt to understand the risks associated with global climate change, complex computer models of climate have been used to assess the effects resulting from current energy policy, which contributes to climate change. In the final analysis, most risk assessments are statistical statements that are estimates of the probability of negative effects, as in the examples listed in table 3.1. Such estimates typically are modified to ensure that a lack of complete knowledge does not result in an underestimation of the risk. People may be more or less sensitive to the effects of certain chemicals than the laboratory animals studied. Also, people vary in their sensitivity to compounds. Thus, what may present no risk to one person may be a high risk to others. Persons with breathing difficulties are more likely to be adversely affected by high levels of air pollutants than are healthy individuals. In addition, the estimate of human risk is based on extrapolation from animal tests in which high, chronic doses are used. Human exposure is likely to be lower or infrequent.

Because of all these uncertainties, government regulators have decided to err on the side of safety to protect the public health. For example, the decisions to continue registration of pesticides, to list substances as hazardous air pollutants under the Clean Air Act, and to regulate water contaminants under the Safe Drinking Water Act set conditions of use and allowable exposure limits that provide a large margin of safety. Thus, if animal studies show an effect from the presence of a chemical at a certain dose, the allowable dose for humans is set at a lower level. It can be difficult to precisely measure the toxicity of pollutants once they contact or react with air, water, or soils. This leads to debates over the actual risks and to criticism from those who say this approach carries protection to the extreme, usually at the expense of industry. Conversely, others suggest that this method of setting regulations often underestimates the risks to humans of chronic, low-level exposures.

Risk assessment is also being used to help set regulatory priorities and support regulatory action. Those chemicals, technologies, or situations that have the highest potential to cause damage to health or the environment receive attention first, while those perceived as having minor impacts receive less immediate attention. Medical waste is perceived as high-risk, and laws have been enacted to minimize the risk, while the risk associated with the use of fertilizer on lawns is considered minimal and is not regulated.

Many of the most important threats to human health and the environment are highly uncertain. In addition to quantifying risk, a risk assessment process can state the uncertainty associated with alternative approaches to dealing with environmental issues. This can help institutions to determine research priorities and plan in a way that is consistent with scientific and public concern for environmental protection.

TABLE 3.1 Estimates of Selected Environmental Causes of Death

Risk Factor	Approximate Lifetime Risk of Death (per 1000)
Smoking 1–2 packs of cigarettes per day	38–175
Having 200 chest X rays per year	7–30
Driving a motor vehicle	17
Eating one 8-ounce meal per week of Great Lakes salmon with 1984 contaminant levels	11–12
Eating one 8-ounce meal per week of Great Lakes salmon with 1987 contaminant levels	3–6
Breathing air in U.S. urban areas at 1980 contaminant levels	0.1–6
Recreational boating	3.5
Drinking one 12-ounce beer per day	1–2
Recreational hunting	1.5
Complications from insect bites and stings	0.014

Source: Data from Indiana State Department of Health.

Risk Management

Risk management is a decision-making process that involves weighing policy alternatives and selecting the most appropriate regulatory action by integrating the results of risk assessment with engineering data and with social, economic, and political concerns. It is included as part of all good environmental management systems within business and industry. The purpose of risk management is to reduce the probability or magnitude of a negative outcome. This process involves understanding the probability and consequences of the risk and the factors that contribute to increasing or decreasing the risk. For example, automobile accidents are a leading cause of accidental death. Recognizing that the probability is high that a person will be involved in an automobile accident leads to management of the risk so that the consequences of the accident are minimized. Some management activities are designed to reduce the number of accidents. Traffic lights, warning signs, speed limits, and laws against drunk driving are all designed to reduce the number of accidents. Other activities are designed to reduce the trauma to people who are involved in accidents. Air bags, seat

CASE STUDY 3.1

WHAT'S IN A NUMBER?

ʔisk values are often stated as numbers. When the risk concern is can- ɔer, the risk number represents the probability of additional cancer cases ɔccurring. For example, such an estimate for pollutant X might be ex- ɔressed as 1×10^{-6}, or simply 10^{-6}. This number can also be written as).000001, or one in a million—meaning one additional case of cancer pro- ɔcted in a population of 1 million people exposed to a certain level of pol- ɹtant X over their lifetimes. Similarly, 5×10^{-7}, or 0.0000005, or five in *0 million,* indicates a potential risk of five additional cancer cases in a ɔopulation of 10 million people exposed to a certain ɔvel of the pollutant. These numbers signify additional ases above what normally occurs in the general ɔopulation. The normal rate is referred to as the back- round cancer incidence. American Cancer Society tatistics indicate that the background cancer inci- ence in the general population is one in three over a ɛtime. (One-third of the population will develop ɔme form of cancer during their lifetime.)

If the effect associated with pollutant X is a ealth effect other than cancer, such as neurotoxic- y (nerve damage) or birth defects, then numbers re typically given as the levels of exposure below ɦhich no harm is estimated to occur. This often ıkes the form of a reference dose (RfD). A refer- ɿce dose is typically expressed in terms of mil- ɟrams (of pollutant) per kilogram of body weight ɘr day; for example, 0.004 mg/kg/day. A reference ɔse typically has a large uncertainty associated with it. It may be too high or too low by several orders of magnitude (i.e., multiples of 10).

An important point to remember is that numbers by themselves don't tell the whole story. For instance, a cancer risk value of 10^{-6} for the "average exposed person" is not the same thing as a cancer risk of 10^{-6} for a "most exposed individual" (perhaps someone exposed from living or working in a highly contaminated area), even though the numbers are identical. It's important to know the difference. Omitting the qualifier "average" or "most exposed" incompletely describes the risk and could result in an inappropriate assessment of the risk. A numerical estimate is only as good as the quality of the data it is based on. You need to ask yourself the following kinds of questions: What data exist to support the risk assessment? Do the data include human epidemiological as well as animal studies? Do the laboratory studies include data on more than one species? If multiple species were tested, did they all respond similarly to the test substance? Are there pieces of information that you would like to have but do not? What assumptions underlie the risk assessment? What is the overall confidence level in the risk assessment? All of these qualitative considerations are essential when deciding how confident you are that the "numbers" used to characterize a risk are meaningful.

Source: Data from *EPA Journal.*

ɜlts, and car designs that absorb the energy of an impact are ɛamples. A risk management plan includes:

1. Evaluating the scientific information regarding various kinds of risks
2. Deciding how much risk is acceptable
3. Deciding which risks should be given the highest priority
4. Deciding where the greatest benefit would be realized by spending limited funds
5. Deciding how the plan will be enforced and monitored

The process of developing a risk management plan begins ith an evaluation of the scientific evidence that quantifies the agnitude of a risk. The scientific basis can be thought of as a kind problem definition. Science determines that some threat or haz- d exists but does not specify which risks are most important. ith environmental concerns such as hazardous waste, climate ange, ozone depletion, and acid rain, the scientific basis for reg- atory decisions is often controversial. Hazardous substances are sted on animals. Are animal tests appropriate for determining impacts on humans? There is no easy answer to this question. Dealing with climate change, ozone depletion, and acid rain require projecting into the future and estimating the magnitude of future effects. Will the sea level rise? How many additional skin cancers will be caused by depletion of the ozone layer? How many lakes will become acidified? Estimates from equally reputable sources vary widely. Which ones do we believe? For example, it is a fact that dioxin is a highly toxic material known to cause cancer in laboratory animals. It is also very difficult to prove that human exposure to dioxin has led to the development of cancer, although high exposures have resulted in acne in exposed workers.

From a risk management standpoint, whether one is dealing with a site-specific situation or a national standard, the deciding question ultimately is: What degree of risk is acceptable? In general, we are not talking about a "zero risk" standard but rather the concept of **negligible risk:** At what point is there really no significant health or environmental risk? At what point is there an adequate safety margin to protect public health and the environment?

Once the scientific evidence has been evaluated, it is possible to integrate economic and political factors to determine how much risk is acceptable and to prioritize the assignment of economic and personnel resources needed to solve the problems. This is why problem definition is so important. Defining the problem helps to determine the rest of the policy process (making rules, passing laws, or issuing statements) and the appropriate enforcement actions.

Even after a policy has been developed and regulations have been put in place, however, there is often still controversy. For example, some observers believe specific chemicals such as herbicides pose many threats that need to be addressed. Others believe these chemicals pose little threat; instead, they see scare tactics and government regulations as unnecessary attacks on businesses. The commercial logging of forests poses risks of soil erosion and the loss of resident animal species. The timber industry sees these risks as minimal, while many environmentalists consider the risks unacceptable. These and similar disagreements are often serious public-relations problems for both government and business because most of the public have a poor understanding of the risks they accept daily.

Risk Tolerance

Business and industry must have management policies or risk tolerance programs, either formal or understood. Each entity has some level of risk it is willing to accept. In the environmental arena, this can take many forms. Depending upon the situation, policies and/or tolerance for environmental health and safety risks can vary greatly. Generally the more familiar or well understood the issues are, the greater the level of risk that is acceptable. It is the unknown risks that cause problems for most. Questions need to be asked that address the variables encountered: How will the information be processed? What results will be used for making business decisions? Who will perform the tasks and interpret the results? Following an initial review, further inquiry may be necessary. Decisions about the use of property, or the handling of chemical waste, or hazardous substances, can have a material impact on a business.

True and Perceived Risks

Perceptions play a large role in all things environmental. For example, in the recent past, there was a great deal of fear about asbestos in our public schools. There was a public outcry to rid the buildings of this "dangerous, carcinogenic material" immediately to protect our vulnerable children. The perception of many was that our children were at risk. It seemed as if the asbestos would leap off the walls and sicken our children. Simply being near asbestos or in a building that had asbestos-containing material would result in lung cancer and death. This simply was not the case. Asbestos can be dangerous and can cause lung and other cancers as well as asbestosis. However, to become ill with these or other diseases, you must first be exposed. That is, you must receive a regular, chronic dose (over many years). To receive a dose, you must inhale (breathe in) or ingest (swallow) fibers of asbestos. Asbestos is a naturally occurring mineral that comes in several forms, and a person could work in a room mac from solid asbestos and never become ill.

Asbestos does not become a problem unless it is disturbed c removed during renovation or demolition. The worst thing w could have done was to start ripping it out of our schools. The be practice was to leave it in place and encapsulate it with a coatin Simple painting will do in many cases. Only during remov should abatement measures be required. Spraying with water sometimes all that is needed. The perceived risk was much great than the actual risk. Becoming educated about the risks enables u to make better decisions about environmental and human heal issues. This saves time and money, thus maximizing the resourc available to reduce actual risks to ourselves and the environmen

Risk estimates by "experts" and by the "public" on many env ronmental problems differ significantly. Almost every daily activity driving, walking, or working—involves some element of risk. (S table 3.2.) People often overestimate the frequency and seriousne of dramatic, sensational, well-publicized causes of death and unde estimate the risks from more familiar causes that claim lives o by one.

This discrepancy and the reasons for it are extremely importa because the public generally does not trust experts to make importa risk decisions alone. The public generally perceives involuntary risk such as nuclear power plants or nuclear weapons, as greater than vc untary risks, such as drinking alcohol or smoking. In addition, t public perceives newer technologies, such as genetic engineering toxic-waste incinerators, as greater risks than more familiar technol gies, such as automobiles and dams. Many people are afraid of flyi for fear of crashing; however, motor vehicle accidents account for far greater number of deaths—over 40,000 in the United States ea year, compared to less than a thousand from plane crashes.

One of the most profound dilemmas facing decision make and public health scientists is how to address the discrepancy b tween the scientific and public perceptions of environmental risk Numerous studies have shown that in the last 20 years, enviro mental hazards truly affecting health status in the country are n those receiving the highest attention, whether measured by publ

TABLE 3.2 Causes of Accidental Death in the United States, 2007

Cause	Number
Motor vehicle accidents (cars, trucks, buses)	43,620
Falls	16,321
Accidental poisoning	15,100
Unspecified accidents	7,484
Suffocation	6,254
Fires	4,321
Drowning	4,103
Aircraft accidents	1,007
Lightning	48

Source: National Center for Health Statistics.

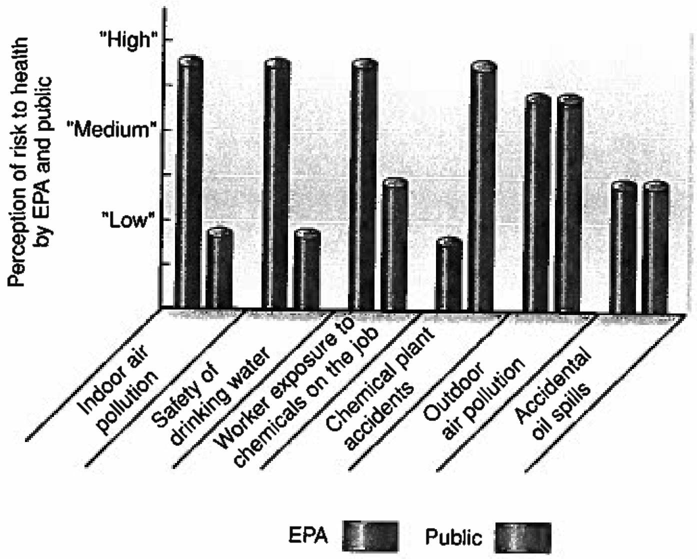


FIGURE 3.2 **Perception of Risk** Professional regulators and the public do not always agree on what risks are.

ɔpinion polls, news coverage, congressional actions, or govern- nent expenditures. (See figure 3.2.)

Indoor air pollution, in its various forms, receives relatively lit- :le attention compared with outdoor sources and yet probably ac- :ounts for as much, if not more, poor health. Hazardous waste lumps, on the other hand, which are difficult to associate with any neasurable ill health, attract much attention and resources. The same :hemicals in the form of common consumer products, such as house- ıold cleaners, pesticides, and fuel (gasoline), account for much more :xposure and ill health and yet raise comparatively little concern rom the public.

Several explanations exist for this difference in perception, the najor ones relating to the fact that the public uses a number of cri- eria other than health risk to establish its concerns. However, this nismatch between real and perceived risks has significant conse- uences. In a world of finite financial resources, when money is sed to reduce risks that have little measurable health impact, there s less to spend on interventions that address more significant risks.

Some researchers argue that the public is frequently misled by ıe politics of public health and environmental safety. This is un- erstandable since many prominent people become involved in uch issues and use their public image to encourage people to look t issues from a particular point of view.

Whatever the issue, it is hard to ignore the will of the people, articularly when sentiments are firmly held and not easily ıanged. A fundamental issue surfaces concerning the proper role f government and other organizations in a democracy when it ɔmes to matters of risk. Should the government focus available :sources and technology where they can have the greatest tangi- :e impact on human and ecological well-being, or should it focus :em on problems about which the public is most upset? What is e proper balance? For example, would adequate prenatal health ure for all pregnant women have a greater effect on the health of ıildren than removing asbestos from all school buildings?

Obviously, there are no clear answers to these questions. Experts and the public, however, are both beginning to realize that they each have something to offer to the debate. Many risk experts who have been accustomed to looking at numbers and probabilities are now conceding that a rationale exists for looking at risk in broader terms. At the same time, the public is being supplied with more data to enable them to make more informed judgments.

Throughout this discussion of risk assessment and management, we have made numerous references to costs and economics. It is not economically possible to eliminate all risk. Sometimes risk identification is all that is possible or required. A risk elimination process can be desirable but not always beneficial. As risk is eliminated, the cost of the product or service increases. Many environmental issues are difficult to evaluate from a purely economic point of view, but economics is one of the tools used to analyze any environmental problem.

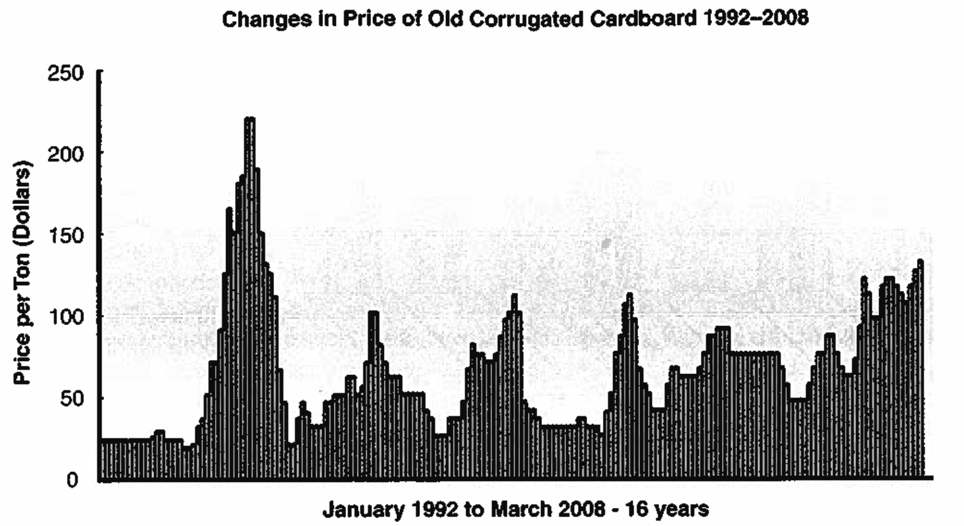
ENVIRONMENTAL ECONOMICS

Economics is the study of how people choose to use resources to produce goods and services and how these goods and services are distributed to the public. In other words, economics is an allocation process that determines the purposes to which resources are put. In many respects, environmental problems are primarily economic problems. While this may be an overstatement, it is not possible to view environmental issues outside the normal economic process that is central to our way of life. Pollution prevention often takes on a purely economic aspect when we look at "waste in, waste out" or mass-balance equations to determine the costs associated with waste. Businesses today cannot simply ignore the economics of environmental considerations. They are sometimes required to maintain environmental management systems even to do business with certain companies or even countries. To appreciate the interplay between environmental issues and economics, it is important to have an understanding of some basic economic concepts.

RESOURCES

Economists look at **resources** as the available supply of something that can be used. Classically, there are three kinds of resources: labor, capital, and land. Labor is commonly referred to as a human resource. Capital is anything that enables the efficient production of goods and services (technology and knowledge are examples). Land can be thought of as the natural resources of the planet. **Natural resources** are structures and processes that humans can use for their own purposes but cannot create. The agricultural productivity of the soil, rivers, minerals, forests, wildlife, and weather (wind, sunlight, rainfall) are all examples of natural resources. The landscape is also a natural resource, as we see in countries with a combination of mountainous terrain and high rainfall that can be used to generate hydroelectric power or in those that have beautiful scenery or biotic resources that foster tourism.

Natural resources are usually categorized as either renewable or nonrenewable. **Renewable resources** can be formed or regenerated by natural processes. Soil, vegetation, animals, air, and water are renewable primarily because they naturally undergo processes that repair, regenerate, or cleanse them when their quality or quantity is reduced. Just because a resource is renewable, however, does not mean that it is inexhaustible. Overuse of renewable resources can result in their irreversible degradation. **Nonrenewable resources** are not replaced by natural processes, or the rate of replacement is so slow as to be ineffective. For example, iron ore, fossil fuels, and mountainous landscapes are nonrenewable on human timescales. Therefore, when nonrenewable resources are used up, they are gone, and a substitute must be found or we must do without.



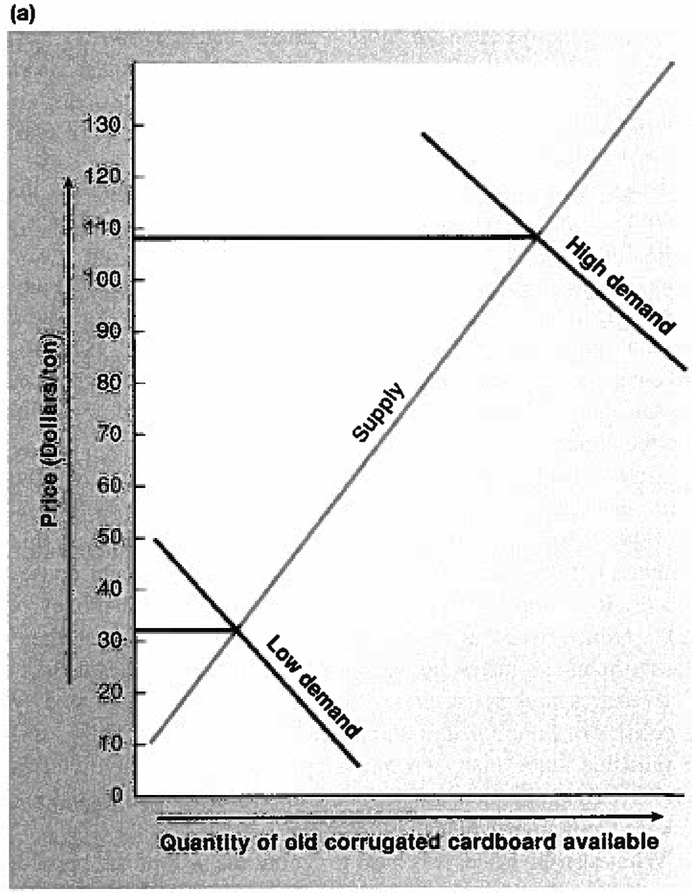
(a)

Supply and Demand

An economic good or service can be defined as anything that is scarce. Scarcity exists whenever the demand for anything exceeds its supply. We live in a world of general scarcity, where resources are limited relative to the desires of humans to consume them. The mechanism by which resources are allocated involves the establishment of a price for a good or service. The price describes how we value goods and services and is set by the relationship among the supply of a good or service and society's demand for it.

The **supply** is the amount of a good or service people are willing to *sell* at a given price. **Demand** is the amount of a good or service that consumers are willing and able to *buy* at a given price. The **price** of a good or service is its monetary value. One of the important mechanisms that determines the price is the relationship between the supply and demand, which is often illustrated with a **supply/demand curve.** For any good or service, there is a constantly shifting relationship among supply, demand, and price. The price of a product or service reflects the strength of the demand for and the availability of the commodity. When demand exceeds supply, the price rises. The increase in price results in a chain of economic events. Price increases cause people to seek alternatives or to decide not to use a product or service, which results in a lower quantity demanded.

For example, prices for recycled paper materials, such as old corrugated cardboard, fluctuate significantly based on their supply and demand. (See figure 3.3.) The supply of old corrugated cardboard does not vary much, because there are well-established recycling programs in place that capture over 70 percent of discarded corrugated cardboard. However, the demand fluctuates significantly depending on several factors. A primary factor that determines demand is the general state of the economy. When the economy is strong, people buy things and those things are typically shipped in corrugated cardboard containers. This results in an increase in demand and an increase in the price cardboard manufacturers are willing to pay for old corrugated cardboard. Conversely, when people are not buying things, less packaging is needed, demand falls, and the price falls as well. A second factor that determines demand is the strength of the export market. When other countries are buying old corrugated cardboard, less is available for



(b)

FIGURE 3.3 Supply and Demand for Old Corrugate Cardboard Graph *a* shows that the price for old corrugated cardboa varies considerably. The supply of old corrugated cardboard is relatively fixe because about 70 percent is captured for recycling. However, the demar varies. Graph *b* shows a typical supply/demand diagram. Demand for o corrugated cardboard is high when the U.S. economy is doing well or expor of old corrugated cardboard are high. Because demand is high the price high. When the U.S. economy is not doing well or exports of old corrugate cardboard are low, the demand falls and so does the price.

Source: (a) Data from USEPA.

Water Connections

Valuing the Removal of the Elwha and Glines Dams

More than half of the major North American rivers have been dammed, diverted, or otherwise controlled. Although the structures provide ıydropower, control floods, supply irrigation, and increase navigation, :hey have changed the hydrological regime—damaging aquatic life, ·ecreational opportunities, and livelihoods of some indigenous peoples. The ecological and economic costs of dams are being increasingly evaluated in comparison to their anticipated benefits, and some have been ·emoved. At least 465 dams have been decommissioned in the United States, with about 100 more planned for removal. There has also been a trend toward river restoration in the United States since 1900, with nost projects directed to enhancing water quality, managing riparian :ones, removing in-stream habitat, allowing fish passage, and stabilizing stream banks.

An environmental impact analysis using CVM (contingent valuaion method) was conducted in the 1990s to explore the removal of the Elwha and Glines dams in the state of Washington. These two 30- and 30-meter-high dams, respectively, are old and block the migration of almon to 110 km of pristine water located in the Olympic National Park. The dams also impact the Lower Elwha Klallam Tribe, which relies on the salmon and the river for its physical, spiritual, and cultural well-being. Dam removal could bring substantial fishing benefits, more than tripling the salmon populations. The cost of removing the dams, especially the sediment build-up, is estimated at about $125 million. Recreational and commercial fishing benefits resulting from dam removal would not be sufficient to cover these costs.

A CVM survey was conducted and yielded a 68 percent response in Washington State, and a 55 percent response for the rest of the United States. Willingness to pay for dam removal ranged from $73 per household for Washington to $68 for the rest of the United States. If every household in Washington State were to pay $73, the cost of the dam removal and river restoration could be covered.

After years of negotiations it has been decided that the dams will be removed, and the Elwha Restoration Project will go forward. This is the biggest dam-removal project in history, and an event of national significance. It is expected that the two dams will be removed in stages over the course of three years, between 2010 and 2013.

ıe domestic market and the price increases. Finally, when the price f old corrugated cardboard approaches $125 per ton, cardboard roducers can buy pulpwood at about the same price and begin to witch from using old corrugated cardboard to pulpwood.

Similarly, food production depends heavily on petroleum for ıe energy to plant, harvest, and transport food crops. In addition, etrochemicals are used to make fertilizer and chemical pestontrol agents. If the demand for energy exceeds the supply, the rice of petroleum increases. As petroleum prices rise, farmers reuce their petroleum use. Perhaps they farm less land or use less ertilizer or pesticide. Because farmers are using less energy, they ill produce less food, so the supply of food decreases. Thus, an ıcrease in petroleum prices results in an increase in food prices. s the prices of certain foods rise, consumers seek less costly ods.

When the supply of a commodity exceeds the demand, producs must lower their prices to get rid of the product, and eventually, me of the producers go out of business. Ironically, this happens farmers when they have a series of good years. Production is gh, prices fall, and some farmers go out of business.

:SSIGNING VALUE TO NATURAL RESOURCES

e assign value to natural resources based on our perception of eir relative scarcity. We are willing to pay for goods or services e value highly and are unwilling to pay for things we think there plenty of. For example, we will readily pay for a warm, safe ace to live but would be offended if someone suggested that we y for the air we breathe.

If a natural resource has always been rare, it is expensive. Pearls d precious metals are expensive because they have always been rare. If the supply of a resource is very large and the demand for it is low, the resource may be thought of as free. Sunlight, oceans, and air are often not even thought of as natural resources because their supply is so large. However, modern technologies have allowed us to exploit natural resources to a much greater extent than our ancestors were able to achieve and resources that were once considered limitless are now rare. For example, in the past, land and its covering of soil was considered a limitless natural resource, but as the population grew and the demand for food, lodging, and transportation increased, we began to realize that land is a finite, nonrenewable resource. The economic value of land is highest in metropolitan areas, where open land is unavailable. Unplanned, unwise, or inappropriate use can result in severe damage to the land and its soil. (See figure 3.4.)

Even renewable resources can be overexploited. If the overexploitation is severe and prolonged, the resource itself may be destroyed. For example, overharvesting of fish, wildlife, or forests can change the natural ecosystem so much that it cannot recover, and a resource that should have been renewable becomes a depleted nonrenewable resource.

Valuing natural resources and evaluating policies where institutions such as markets do not exist, and where there is a lack of individual property rights, pose challenges. Under such uncertainties, and where divergent sets of values exist, the economic value of common resources can be measured by the maximum amount of other goods and services that individuals are willing to give up to obtain a given good or service. Therefore, it is possible to weigh the benefits from an activity such as the construction of a dam against its negative impacts on fishing, livelihoods of nearby communities, and changes to aesthetic values. This method of valuation is called the contingent valuation method (CVM). (See Water Connections box above.)

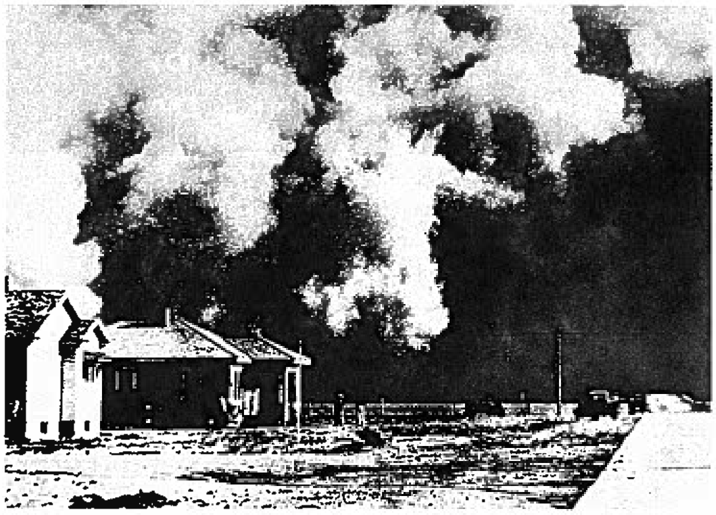


FIGURE 3.4 Mismanagement of a Renewable Resource Although soil is a renewable resource, extensive use can permanently damage it. Many of the world's deserts were formed or extended by unwise use of farmland. This photograph shows a once-productive farm now abandoned to the wind and sand because the soil was mistreated and allowed to erode.

Valuation presents a set of challenges beyond conflicting value systems or lack of existing market institutions. It uses national and local measures to estimate the economic values of tangible and intangible services provided by the environment. Valuation work has been undertaken on areas such as the value of nontimber forest products, forestry, and the health impacts of air pollution and waterborne diseases. However, studies on less tangible but yet important services, such as water purification and the prevention of natural disasters, in addition to recreational, aesthetic, and cultural services, have been hard to get. To get objective monetary estimates of these services remains a challenge. Market data are limited to a small number of services provided by ecosystems. Furthermore, methodologies such as cost-benefit analysis and CVM may raise problems of bias.

Environmental Costs

Air pollution, water pollution, plant and animal extinctions, depletion of a resource, and loss of scenic quality are all examples of the **environmental costs** of resource exploitation. Often environmental costs are difficult to assess, since they are not easily converted to monetary values. This is especially true with the loss of "aesthetics" such as a beautiful scene, relaxing surroundings, or recreational opportunities. These losses are often calculated in "man-hours" spent or lost due to environmental degradation. In addition, since they may not be recognized immediately, environmental costs are often **deferred costs,** which must be paid at a later date. For example, when dams were built on the Colorado River to provide electric power and irrigation water, planners did not anticipate that the changes in the flow of the river would reduce habitat for endangered bird species, lead to the loss of fish species because the water is colder, and result in increased salinity in lower regions of the river. Soil erosion is another example of a deferred cost. The damage done by practices that increase soil erosion may not be felt immediately, but eventually as the amount of damage accumulates, the cost becomes obvious to future generations.

Many of the important environmental problems facing the world today arise because modern production techniques and consumption patterns transfer waste disposal, pollution, and health costs to society. Such expenses, whether they are measured in monetary terms or in diminished environmental quality, are borne by someone other than the individuals who use a resource. They are referred to as **external costs.** For example, when a logging operation removes so many trees from a hillside that runoff from the hillside destroys streams and causes mudslides, the logging operation has transferred a cost to the public. Another example is the thousands of hazardous waste sites produced by industries that have since ceased to exist. The cleanup of these abandoned hazardous waste sites became the responsibility of government and the taxpayers. The entities that created the sites avoided paying for their cleanup. Similarly, when a new shopping complex is built, many additional external costs are paid for by the public and the municipality. Additional roads, police and fire protection, sewer and water services, runoff from parking lots, and pressure to convert the remaining adjacent land to shopping are all external costs typically borne by the taxpayer.

The extraction of mineral resources is a good example of the variety of environmental costs that accompany resource use. All mining operations involve the separation of the valuable mineral from the surrounding rock. The surrounding rock must then be disposed of in some way. These pieces of rock are usually piled on the surface of the Earth, where they are known as mine tailings and present an eyesore. It is difficult to get vegetation to grow on these deposits. Some mine tailings contain materials (such as asbestos, arsenic, lead, and radioactive materials) that can be harmful to humans and other living things.

Many types of mining operations require vast quantities of water for the extraction process. The quality of this water is degraded, so it is unsuitable for drinking, irrigation, or recreation. Since mining disturbs the natural vegetation in an area, water may carry soil particles into streams and cause erosion and siltation. Some mining operations, such as strip mining, rearrange the top layers of the soil, which lessens or eliminates its productivity for a long time. (See figure 3.5.) Strip mining has disturbed approximately 75,000 square kilometers (30,000 square miles) of U.S. land, an area equivalent to the state of Maine.

Probably most environmental costs have both deferred and external aspects. A good example of a problem that is both a deferred and an external cost is the damage caused by the use of high-sulfur coal as an inexpensive way to produce electricity. The sulfur compounds released into the atmosphere resulted in acid rain that caused a decline in the growth of forests and damage to buildings and other structures. The damage accumulated over time so the cost of acid rain was a deferred cost. The cost of the damage was paid for by the public as fewer scenic vistas, by forest products industries with fewer trees to harvest, and by property owners as repair costs for buildings and other structures, so it was an external cost not paid for by the electric utilities directly.

FIGURE 3.5 A Strip-Mining Operation It is easy to see the important impact a mine of this type has on the local environment. Unfortunately, many mining operations are located in areas that are also known for their scenic beauty.

Environmental costs also may include lost opportunities or values because the resource could not be used for another purpose. For example, if houses are built in a forested region, its possible ıse as a natural area for hiking or hunting is lost. Similarly, when and is converted to roads and parking lots, the opportunity is lost o use the land for farming or other purposes.

A primary environmental cost is pollution. **Pollution** is any ıddition of matter or energy that degrades the environment for ıumans and other organisms. When we think about pollution, ıowever, we usually mean something that people produce in arge enough quantities that it interferes with our health or well-ıeing. Two primary factors that affect the amount of damage lone by pollution are the size of the population and the devel-ıpment of technology that "invents" new forms of pollution.

When the human population was small and people lived in a imple manner, the wastes produced were biological and so ilute that they usually did not constitute a pollution problem. 'eople used what was naturally available and did not manufac-ıre many products. Humans, like any other animal, fit into ıeir natural ecosystems. Their waste products were **biodegrad-ble** materials that were broken down into simpler chemicals, uch as water and carbon dioxide, by the action of decomposer rganisms.

Human-initiated pollution became a problem when human opulations became so concentrated that their waste materials ould not be broken down as fast as they were produced. As the opulation increased, people began to congregate and establish illages, towns, and cities. The release of large amounts of noke, biological waste, and trash faster than they could be ab-ɔrbed and dispersed resulted in pollution, which led to un-ealthy living conditions.

Throughout history, humans have sought to improve living conditions and eliminate the misery caused by hunger and disease. In general, we rely on science and technology to improve our quality of life. While technological progress can improve the quality of life, it can also generate new sources of pollution. The development of the steam engine allowed machines to replace animal power and human labor but increased the amount of smoke and other pollutants in the air as well as the need for fuel. The modern chemical industry has produced many extremely valuable synthetic materials (plastics, pesticides, medicines), but it has also produced toxic pollutants.

It is not always easy to agree on what constitutes pollution. To some, the smell of a little wood smoke in the air is pleasant; others do not like the odor. A business may consider advertising signs valuable and necessary; others consider them to be visual pollution. Finally, it is important to recognize that it is impossible to eliminate all the negative effects produced by humans and our economic processes. The difficult question is to determine the levels of pollution that are acceptable. (See figure 3.6.)

As people recognize the significance of environmental costs, these costs are being converted to economic costs as stricter controls on pollution and environmental degradation are enforced. It takes money to clean up polluted water and air or to reclaim land that has been degraded, and the people who cause the damage should not be allowed to defer the cost or escape paying for the necessary cleanup or remediation.

Pollution-control costs include pollution costs and pollution-prevention costs. **Pollution costs** include such things as the private or public expenditures to correct pollution damage once pollution has occurred, the increased health costs because of pollution, and the loss of the use of public resources because of pollution. **Pollution-prevention costs (P2)** are those incurred either in the private sector or by government to prevent, either entirely or partially, the pollution that would otherwise result from some production or consumption activity. The cost incurred by local government to treat its sewage before releasing it into a river is a P2 cost; so is the cost incurred by an electric utility to prevent air pollution by installing new equipment.

Cost-Benefit Analysis

Because resources are limited and there are competing uses for most resources, it is essential that a process be used to help decide the most appropriate use of a scarce resource. **Cost-benefit analysis** is a formal quantitative method of assessing the costs and benefits of competing uses of a resource or solutions to a problem and deciding which is the most effective. It has long been the case in many developed countries that major projects, especially those undertaken by the government, require some form of cost-benefit

Water pollution. This sign indicates it is unsafe to swim in this area because of high levels of bacteria.

Smog. Smog that develops when air pollution is trapped is a serious health hazard.

Smoke. Smoke contains small particles that can cause lung problems.

Solvents. Solvents evaporate and cause localized pollution.

Odors. Feedlots create an odor problem that many people find offensive.

Thermal pollution. Cooling towers release heat into the atmosphere and can cause localized fog.

Visual pollution. Unsightly surroundings are annoying but not hazardous to your health.

Junkyard. This is unsightly but constitutes only a minor safety hazard.

FIGURE 3.6 Examples of Pollution There are many kinds of pollution. Some are major health concerns, whereas others merely annoy.

analysis with respect to environmental impacts and regulations. In the United States, for example, such requirements were established by the National Environmental Policy Act of 1969, which mandates environmental impact statements for major government-supported projects. Increasingly, similar analyses are required for projects supported by national and international lending institutions such as the World Bank.

People use cost-benefit analysis to determine whether a policy generates more social costs than social benefits and, if benefits outweigh costs, how much activity would obtain optimal results. Steps in cost-benefit analysis include:

1. Identification of the project to be evaluated
2. Determination of all impacts, favorable and unfavorable, present and future, on all of society
3. Determination of the value of those impacts, either directly through market values or indirectly through price estimates
4. Calculation of the net benefit, which is the total value of positive impacts less the total value of negative impacts

For example, the cost of reducing the amount of lead in drinking water in the United States to acceptable limits is estimated to be about $125 million a year. The benefits to the nation's health from such a program are estimated at nearly $1 billion per year. Thus, under a cost-benefit analysis, the program is economically sound. Table 3.3 gives examples of the kinds of costs and benefits involved in improving air quality. Although it is not a complete list, the table indicates the kinds of considerations that go into a cost-benefit analysis. Some of these are easy to measure in monetary terms; others are not.

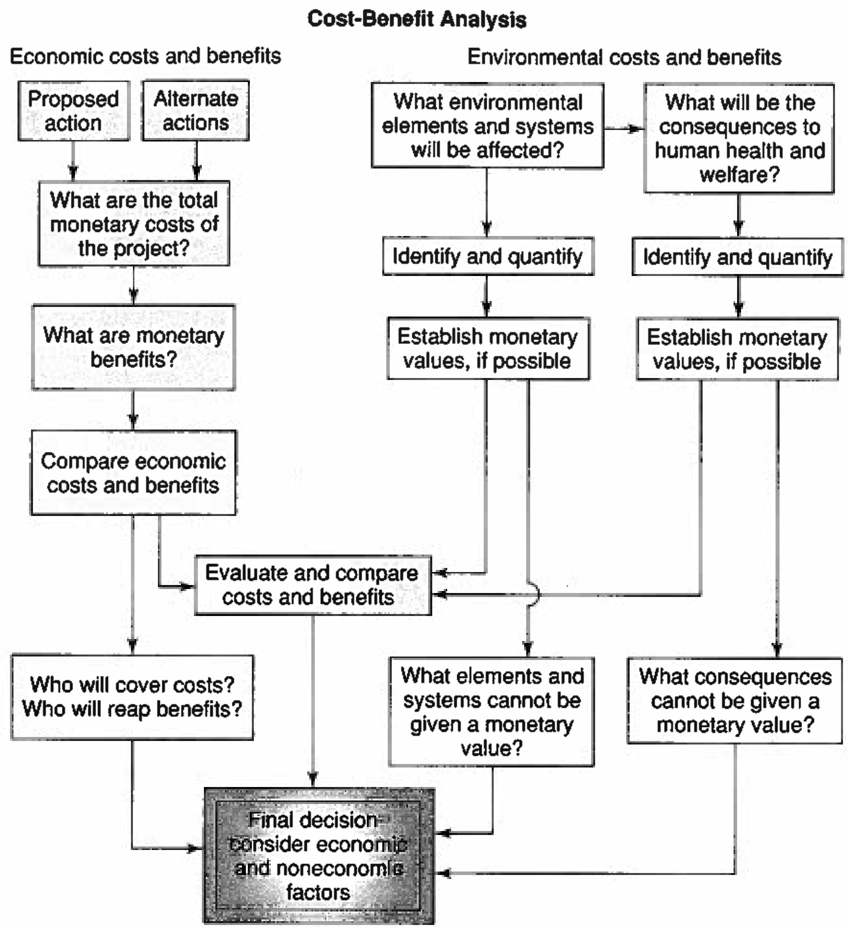
Concerns About the Use of Cost-Benefit Analysis

Critics of cost-benefit analysis often raise the question of whether everything can be analyzed from an economic point of view. Some people argue that if the only measure of value is economic, many simple noneconomic values such as beauty or cleanliness can be justified only if they are given economic value. (See figure 3.7.)

There are clearly benefits to requiring such analysis. Although environmental issues must be considered at some point during project evaluation, efforts to do so are hampered by the difficulty of assigning specific value to environmental resources. In cases of Third World development projects, these already difficult environmental issues are made more difficult by cultural and socioeconomic differences. A less-developed country, for example, may be less inclined to insist on expensive emissions-treatment technology on a project that will provide jobs and economic development because it is unable to afford the treatment technology and it values the jobs very highly.

TABLE 3.3 **Costs and Benefits of Improving Air Quality**

Costs	Benefits
Installation and maintenance of new technology:	Reduced deaths and disease
Scrubbers on smokestacks	Fewer respiratory problems
Automobile emissions control	Reduced plant and animal damage
Redesign of industries and machines	Lower cleaning costs for industry and public
Additional energy costs to industry and public	More clear, sunny days; better visibility
Retraining of employees to use new technology	Less eye irritation
Costs associated with monitoring and enforcement	Fewer odor problems



One particularly compelling critique of cost-benefit analysis is that for analysis to be applied to a specific policy, the analyst must decide which preferences count—that is, which preferences are the most important for cost-benefit analysis. In theory, cost-benefit analysis should count all benefits and costs associated with the policy under review, regardless of who benefits or bears the costs. In practice, however, this is not always done. For example, if a cost is spread thinly over a large population, it may not be recognized as a cost at all. The cost of air pollution in many parts of the world could fall into such a category. Debates over how to count benefits and costs for future generations, inanimate objects such as rivers, and nonhumans, such as endangered species, are also common.

Comparing Economic and Ecological Systems

For most natural scientists, current crises such as biodiversity loss, climate change, and many other environmental problems are symptoms of an imbalance between the socioeconomic system and the natural world. While it is true that humans have always changed the natural world, it is also clear that this imprint is much greater now than anything experienced in the past. One reason for the profound effect of human activity on the natural world is the fact that there are so many of us.

One of the problems associated with matching economic processes with environmental resources is the great differences in the way economic systems and ecological systems function. The loss of biodiversity is an example that illustrates the conflicting frameworks of economics and ecology. Market decisions fail to account for the context of a species or the interconnections between resource quality and ecosystem functions. For example, from an economic point of view, the value of land used for beef production is measured according to its contribution to its economic output (beef). Yet long before economic output and the use value of land decrease, the diversity of grass varieties, microorganisms in the soil, or groundwater quality may be affected by intensive beef production. As long as yields are maintained, these environmental changes go unnoticed by economic measurements and are unimportant to land-use decisions. This does not need to be the case. It should be pointed out that in Zimbabwe and other African nations, some ranchers now earn more money managing native species of

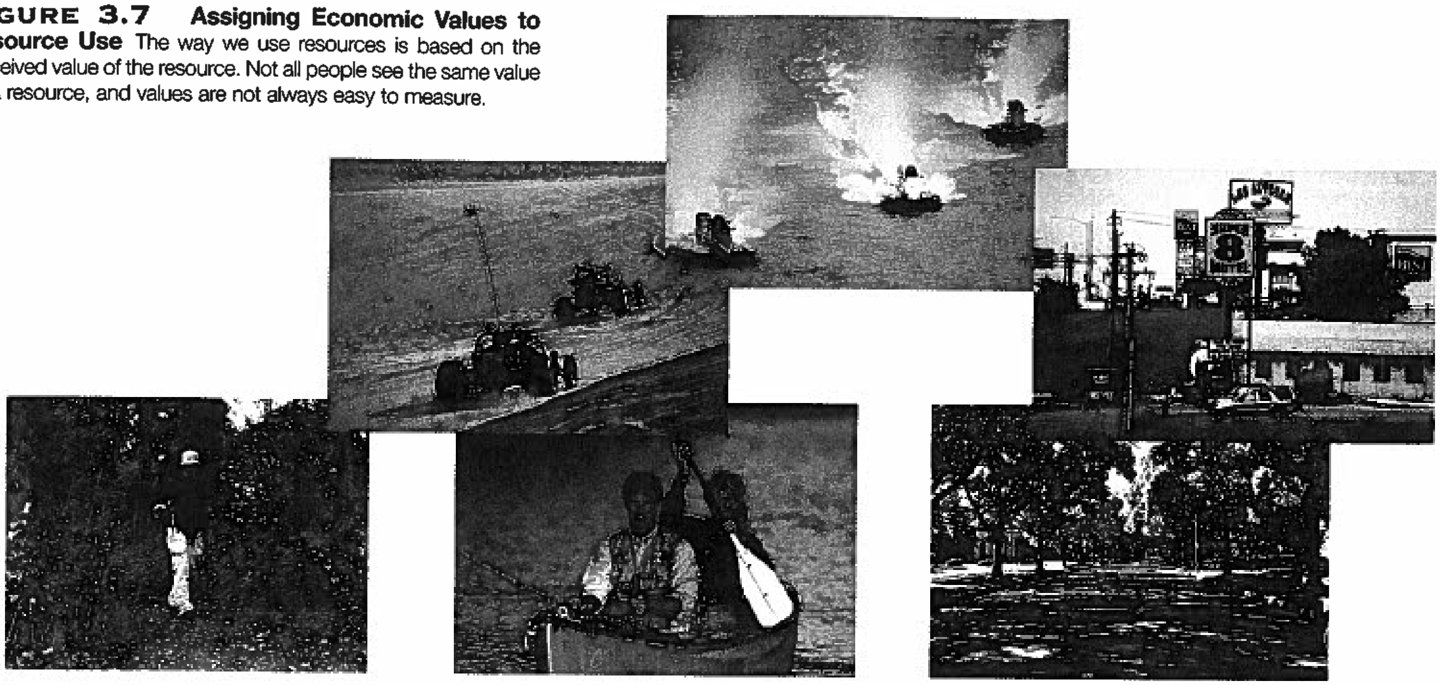


FIGURE 3.7 Assigning Economic Values to Resource Use The way we use resources is based on the perceived value of the resource. Not all people see the same value for a resource, and values are not always easy to measure.

wildlife for ecotourism in a biodiverse landscape than they would from raising cattle in a landscape with reduced biodiversity.

Another obvious difference between economics and ecology is the great difference in the time frame of markets and ecosystems. Many ecosystem processes take place over tens of thousands and even millions of years. The time frame for market decisions is short. It may be as short as minutes for stock trades or as long as a few years for the development and construction of a factory. Where U.S. economic policy is concerned, two- to four-year election cycles are the frame of reference. For investors and dividend earners, performance time frames of three months to one year are the rule.

Space or place is another issue. For ecosystems, place is critical. Take groundwater as an example. Soil quality, hydro geological conditions, regional precipitation rates, plants that live in the region, and losses from evaporation, transpiration, and groundwater flow all contribute to the size and location of groundwater reservoirs. These capacities are not simply transferable from one location to another. For economic activities, place is increasingly irrelevant. Topography, location, and function within a bioregion or local ecological features do not enter into economic calculations except as simple functions of transportation costs or comparative advantage. Production is transferable, and the preferred location is anywhere production costs are the lowest.

Another difference between economics and ecology is that they are measured in different units. The unifying measure of market economics is money. Progress is measured in monetary units that everyone uses and understands to some degree. Ecological systems are measured in physical units such as calories of energy, carbon dioxide absorption, centimeters of rainfall, or parts per million of nitrate contamination. Focusing only on the economic value of resources while ignoring environmental health may mask serious changes in environmental quality or function. (See Case Study on RBCA and protection of ecological resources.)

Common Property Resource Problems—The Tragedy of the Commons

Economists have stated that when everybody shares ownership of a resource, there is a strong tendency to overexploit and misuse that resource. Thus, common public ownership could be better described as effectively having no owner. The problems inherent in common ownership of resources were outlined by biologist Garrett Hardin in a classic essay entitled "The Tragedy of the Commons" (1968). The original "commons" were areas of pastureland in England that were provided free by the king to anyone who wished to graze cattle.

There are no problems on the commons as long as the number of animals is small in relation to the size of the pasture. From the point of view of each herder, however, the optimal strategy is to enlarge his or her herd as much as possible: If my animals do not eat the grass, someone else's will. Thus, the size of each herd grows, and the density of stock increases until the commons becomes overgrazed. The result is that everyone eventually loses as the animals die of starvation. The tragedy is that even though the eventual result should be perfectly clear, no one acts to avert disaster.

The ecosphere is one big commons stocked with air, water, and irreplaceable mineral resources—a "people's pasture," to be used in common, but it is a pasture with very real limits. Each nation attempts to extract as much from the commons as possible without regard to other countries. Furthermore, the United States and other industrial nations consume far more than their fair share of the total world resource harvest each year, much of it imported from less-developed nations.

One clear modern example of this problem involves the overharvest of marine organisms. Since no one owns the oceans, many countries feel they have the right to exploit the fisheries resources present. As in the case of grazing cattle, individuals seek to get as many fish as possible before someone else does. Currently, the UN estimates that nearly all of the marine fisheries of the world are being fished at or above capacity.

Another example of this is the idea of shared fisheries in the Great Lakes region. Commercial fisheries, recreational fishers, Native American tribal fishing, and regulatory agencies in both the United States and Canada have tried for many years to deal with overexploitation of the Great Lakes fishery. Tribal customs and treaties that date back hundreds of years complicate the issue because traditional fishing methods have changed from simple spearing, trapping, and hook-and-line taking to modern gill netting that takes fish indiscriminately.

Invasive and exotic species, pollution, and overfishing are just a few of the issues that must be taken into consideration when dealing with declining fisheries. Fishing regulations and zones were not designed from an ecosystem approach, but rather by political means and sometimes haphazardly with complete disregard for spawning grounds or other important biological realities. These issues have been addressed somewhat in recent years through the Sea Grant program, the International Joint Commission, and other groups.

Finally, common ownership of land resources, such as parks and streets, is the source of other environmental problems. People who litter in public parks do not generally dump trash on their own property. The lack of enforceable property rights to commonly owned resources explains much of what economist John Kenneth Galbraith has termed "public squalor amid private affluence." Common ownership of the ocean makes it inexpensive for ships and oil drilling platforms to use the ocean as a dump for their wastes. (See figure 3.8.)

The tragedy of the commons also operates on an individual level. Most people are aware of air pollution, but they continue to drive their automobiles. Many families claim to need a second or third car. It is not that these people are antisocial; most would be willing to drive smaller or fewer cars if everyone else did, and they could get along with only one small car if public transport were adequate. But people frequently get "locked into" harmful situations, waiting for others to take the first step, and many unwittingly contribute to tragedies of the commons. After all, what harm can be done by the birth of one more child, the careless disposal of one more beer can, or the installation of one more air conditioner?

FIGURE 3.8 The Ocean Is a Common Property Resource ince the oceans of the world are a shared resource that nobody owns, iere is a tendency to use the resource unwisely. Growing populations in oastal areas lead to more marine pollution and destruction of coastal abitats. Many countries use the ocean as a dump for unwanted trash. ome 6.5 million metric tons of litter find their way into the sea each year.

Green Economics

The world has witnessed three economic transformation in the past century: First came the industrial revolution, then the technology revolution, then our modern era of globalization. The world now stands at the threshold of another great change: the age of green economics.

The evidence is all around us, often in unexpected places. Brazil, for example has become one of the biggest players in green economics, drawing 44 percent of its energy needs from renewable fuels. The world average is 13 percent. Much is made of the fact that China is poised to surpass the United States as the world's largest emitter of greenhouse gases. Less well known, however, are its more recent efforts to confront grave environmental problems. China is on track to invest $10 billion in renewable energy—second only to Germany. It has become a world leader in solar and wind power. China has pledged to reduce energy consumption (per unit of gross domestic product) by 20 percent by 2014—not far removed from Europe's commitment to a 20 percent reduction in greenhouse gas emissions by 2020.

Some estimates show that growth in global energy demand could be cut in half over the next 15 years simply by deploying existing technologies yielding a return on investment of 10 percent or more. The Intergovernmental Panel on Climate Change (IPCC) reports such demand cuts in very practical ways, from tougher standards for air conditioners and refrigerators to improved efficiency in industry, building, and transport. It estimates that overcoming serious climate change may cost as little 0.1 percent of global GDP a year over the next three decades.

Growth need not suffer and, in fact, may accelerate. Research by the University of California at Berkeley indicates that the United States could create 300,000 jobs if 20 percent of electricity needs were met by renewable energy. A German firm predicts that more people will be employed in Germany's environmental technology industry than in the auto industry by the end of the next decade. The U.N. Environment Program estimates that global investment in zero greenhouse energy will reach $1.9 trillion by 2020.

USING ECONOMIC TOOLS TO ADDRESS ENVIRONMENTAL ISSUES

The traditional way of dealing with environmental issues is to develop regulations that prohibit certain kinds of behavior. This is often called a "command and control" approach. It has been very

Going Green

Green-Collar Jobs

Everyone knows what blue-collar and white-collar jobs are, but now we have a job of another hue—a green-collar job. It's hard to exactly say what a green-collar job is; however, it has been reported that the green-collar sector is growing in the United States and could include more than 14 million workers by 2017. According to the American Solar Energy Society, there are 8.5 million U.S. jobs that involve Earth-friendly enterprises and renewable energy sources. That figure could grow by 5 million in the next decade. Another study by the Cleantech Network, a venture capital firm for green business, showed that up to half a million new jobs in ecologically responsible trades will develop by 2012. These new jobs will be at every income level and include titles such as:

- Green product designer—designs products that use less energy and raw materials to produce and consume less energy and resources to use.
- Energy rating auditor—performs a comprehensive analysis of a building's energy efficiency.
- Environmental manager—coordinates management of organization's environmental performance to protect and conserve natural resources.
- Biological systems engineer—designs, manages, and develops systems and equipment that produce, package, process, and distribute the world's food and fiber supplies.
- Permaculture specialist—analyzes land use and community building to create a harmonious blend of buildings, plants, animals, soils, and water.

In addition, professionals will find opportunities by adding green to the skill sets, from accountants who can manage corporate carbon emissioi offsets to zookeepers who must maintain environmentally sensitive an ecologically friendly animal habitats.

Part of the growth in green-collar jobs will come from governmer initiatives. In 2007, the U.S. House of Representatives passed the Greei Jobs Act, which provides $125 million annually to train people fc green vocational fields that offer living wages and upward mobility fc low-income communities.

In the private sector, Bank of America launched a $20 billion initia tive to support environmentally sustainable business activity to addres global climate change, and Citigroup plans to commit $50 billion to envi ronmental projects over the next decade. Many companies such as Dov Chemical and DuPont have added Chief Sustainability Officer (CSO) tc their list of top-level executives.

Is there a green-collar job in your future? Listed next are some link to job boards that you may want to look at as you think about your ca reer plans or a career change.

- Ecojobs
- Greenjobs
- Greenbiz

effective at reducing air and water pollution, protecting endangered species, and requiring that environmental concerns be addressed by environmental impact statements. However, there are also tools that use economic incentives to encourage environmental stewardship.

Subsidies

A **subsidy** is a gift from government to individuals or private enterprise to encourage actions considered important to the public interest. Subsidies may include consumer rebates for purchases of environmentally friendly goods, loans for businesses planning to implement environmental products, and other monetary incentives designed to reduce the costs of improving environmental performance.

Governments frequently subsidize agriculture, transportation, space technology, and communication. These gifts, whether loans, favorable tax situations, or direct grants, are all paid for by taxes on the public, so in effect they are an external cost.

When subsidy programs have a clear purpose and are used for short periods to move to new ways of doing business, they can be very useful. Government payments to farmers that encourage them to permanently take highly erodable land from production reduces erosion and the buildup of sediment in local streams. The better water quality benefits fish, and the return of land to more natural vegetation benefits wildlife. Government programs that purchase the fishing boats of fishers who are displaced when fishing quotas are reduced are a form of subsidy to the fishing industry. The cost of government management of federal forests is a subsidy to the forest products industry, which can protect forest resources while ensuring a livelihood for loggers at the same time.

Subsidies are often used inappropriately, however, and when they are, they can lead to economic distortions. One of the effects of a subsidy is to keep the price of a good or service below its true market price. The actual cost of a subsidized good or service is higher than the subsidized market price because subsidy costs must be added to the market price to arrive at the product's true cost. Agricultural subsidies greatly distort the price of food. One common agricultural subsidy is a program that guarantees a price to a farmer for the products produced. If the market price is below the guaranteed price, the government buys the products at the guaranteed price or pays the farmer the difference between the market price and the guaranteed price. On average, U.S. farmers receive about 20 percent of their income from government payments. Other developed countries have programs that support their farmers in similar fashion. In addition, a huge bureaucracy is needed to manage the complex program. One of the unintended outcomes of such subsidies is that farmers are encouraged to produce more on less land. This results in the use of more fertilizer and pesticides that can damage the environment, and typically, there is overproduction of agricultural products.

Once subsidies become a part of the economic fabric of a country, they are very difficult to eliminate. In 1996, the U.S. Congress passed the Freedom to Farm Act, which eliminated many agricultural subsidies and was hailed as the end of agricultural subsidies. It did not work, however, and in 2002, a new federal farm bill abandoned the 1996 goal of reducing farm payments and authorized an 80 percent increase in expenditures.

Conversely, China has successfully reduced its subsidy for coal. In China, subsidy rates for coal declined from an estimated 61 percent in 1985 to 9 percent in 2000. Private mines now account for about half of all production, and some 80 percent of the coal is now sold at international prices. These reforms have had numerous benefits. Energy intensity in China has fallen by about 50 percent since 1980, and the government's total subsidy for fossil fuels fell from about $25 billion in 1990–91 to $9 billion in 2000.

The building of roads and bridges is a major part of the U.S. federal budget. In 2002, over $31 billion was allocated to the building and improvement of roads. This constitutes a subsidy for automobile transportation. Higher taxes on automobile use to cover the cost of building and repairing highways would encourage the use of more energy-efficient public transport.

Liability Protection and Grants for Small Business

On January 11, 2002, President George W. Bush signed an important piece of environmental legislation into law: the Small Business Liability Relief and Brownfield Revitalization Act (SBLRBRA). This law provided incentives for small businesses and other entities to develop so-called **brownfields** (those areas perceived to have environmental liabilities), most of which are in urban areas. Prior to SBLRBRA, brownfield areas were considered too risky to purchase and develop since purchasers could potentially acquire the environmental liabilities associated with the property. Liability protection was provided in Title I and Title II, Subtitle B. In Subtitle A, funding was provided for small businesses and other entities to revitalize these areas. Working together, many states and local industries have used tax incentives and other methods to further encourage development in these previously undesirable or unusable areas.

Businesses must conduct "all appropriate inquiry" into the property prior to acquisition. They must conduct no activities that contribute to the environmental impact, and they must take "due care" while conducting business. They must also utilize "use limitation" criteria—that is, if they say they will build and use a plating operation, they had better do so and not open a day care center where children might be exposed to contaminated soil or groundwater. This program has resulted in many successful projects that have brought business back to where it once was, minimizing impact on the green belts outside urban areas.

Market-Based Instruments

With the growing interest in environmental protection during the past three decades, policy makers are examining new methods to reduce harm to the environment. One area of growing interest is market-based instruments. Market-based instruments provide an alternative to the common command-and-control legislation because they use economic forces and the ingenuity of entrepreneurs to achieve a high degree of environmental protection at a low cost. One of the benefits of market-based instruments is that they can be used to determine fair prices for environmental resources. Because of subsidies and external costs, many environmental resources are under-priced. Instead of inflexible, top down government directives, market-based policies take advantage of price signals and give entrepreneurs the freedom to choose the solution most economically efficient for them. For example, a price can be established for pollution causing activities. Companies are then allowed to decide for themselves how best to achieve the required level of environmental protection. To date, most of these market-based policies have been implemented in developed nations and in some rapidly growing developing nations. In virtually all cases, they have been introduced as supplements to, not substitutes for, traditional government regulations.

Several kinds of market-based instruments are currently in use:

Information programs provide consumers with information about the environmental consequences of purchasing decisions. Information about the environmental consequences of choices make clear to consumers that it is in their personal interest to change their decisions or behaviors. Examples include information tags on electric appliances that inform the public about the energy efficiency of the product, the mileage ratings of various automobiles, and labeling on pesticide products that describes safe use and disposal. Another type of program, such as the Toxic Release Inventory in the United States, discloses information on environmental releases by polluters. This provides corporations with incentives to improve their environmental performance to enhance their public image.

Tradable emissions permits give companies the right to emit specified quantities of pollutants. Companies that emit less than the specified amounts can sell their permits to other firms or "bank" them for future use. Thus, businesses responsible for pollution have an incentive to internalize the external cost they were previously imposing on society: If they clean up their pollution sources, they can realize a profit by selling their permit to pollute. Once a business recognizes the possibility of selling its permit, it sees that reducing pollution can have an economic benefit. The establishment of tradable sulfur dioxide pollution permits for coal-fired power plants has resulted in huge reductions in the amount of sulfur dioxide released.

Emissions fees and taxes provide incentives for environmental improvement by making environmentally damaging activity or products more expensive. Businesses and individuals reduce their level of pollution wherever it is cheaper to reduce the pollution than to pay the charges. Emissions fees can be useful when pollution is coming from many small sources, such as vehicular emissions or agricultural runoff, where direct regulation or trading schemes are impractical. Taxes and fees contribute to government revenue and thus offset some of the indirect costs incurred by government to protect environmental resources.

In China, a pollution tax system is intended to raise revenue for investment in industrial pollution control, help pay for regulatory activities, and encourage enterprises to comply with emission and effluent standards. The system imposes noncompliance fees on discharges that exceed standards and assesses fines and other charges on violations of regulations.

In the Netherlands, an effluent tax on industrial wastewater has been viewed as successful. Especially among larger companies, the tax worked as an incentive to reduce pollution. In a survey of 150 larger companies, about two-thirds said the tax was the main factor in their decision to reduce discharges. As the volume of pollution from industrial sources dropped, rates were increased to cover the fixed costs of sewage water treatment plants. Rising rates are providing a further incentive for more companies to start purifying their sewage water.

Deposit-refund programs place a surcharge on the price of a product that is refunded when the used product is returned for reuse or recycling. Deposit refund schemes have been widely used to encourage recycling. In Japan, deposits are made for the return of bottles. In 2002, the German government imposed a deposit of 0.25 euros on drink cans and disposable glass and plastic (PET) bottles. Eleven states in the United States have similar laws, but so far Congress has been unwilling to pass a national bill.

Performance bonds are fees that are collected to ensure that proper care is taken to protect environmental resources. Some nations—including Indonesia, Malaysia, and Costa Rica—use performance bonds to ensure that reforestation takes place after timber harvesting. The United States also has used this approach to ensure that strip-mined lands are reclaimed. Before a mining permit can be granted, a company must post a performance bond sufficient to cover the cost of reclaiming the site in the event the company does not complete reclamation. The bond is not fully released until all performance standards have been met and full reclamation of the site, including permanent revegetation, is successful—a five-year period in the East and Midwest and 10 years in the arid West. The bond can be partially released as various phases of reclamation are successfully completed.

Although each of these economic incentives can be effective by itself, they also can be used effectively in combination. For example, deposit-refund and tradable emissions programs work better if supported by information programs. Communities that adopted pay-by-the-bag systems of trash disposal had fewer problems if households were given adequate information well in advance. Environmental tax systems can incorporate emissions trading so that taxes can be levied on net emissions after trades.

Life Cycle Analysis and Extended Product Responsibility

Life cycle analysis is the process of assessing the environmental effects associated with the production, use, reuse, and disposal of a product over its entire useful life. Life cycle analysis can help us understand the full cost of new products and their associated technologies.

The various stages in the product chain include raw material acquisition, manufacturing processes, transportation, use by the consumer, and ultimately disposal of the used product. When this approach is used, it is possible to identify changes in product design and process technology that would reduce the ultimate environmental impact of the production, use, and disposal of the product. All factors along the product chain share responsibility for the life cycle environmental impacts of the product, from the upstream impacts inherent in the selection of materials and impacts from the manufacturing process itself to downstream impacts from the use and disposal of the product. (See figure 3.9.)

Because the relationships among industrial processes are complex, life cycle analysis requires an understanding of material flows, resource reuse, and product substitution. Shifting to an approach that considers all resources, products, and waste as an interdependent system will take time, but governments can encourage this kind of thinking by establishing regulations that prevent industries from externalizing their pollution costs and providing economic incentives for those that use life cycle analysis in their product development and planning.

A logical extension of life cycle analysis is extended product responsibility. **Extended product responsibility** is the concept that the producer of a product is responsible for all the negative effects involved in its production, including the ultimate disposal of the product when its useful life is over. The logic behind extended product responsibility is that if manufacturers pay for the post consumer impacts of products, they will design them differently to reduce waste.

Many people identify the German packaging ordinance as one of the first instances of extended product responsibility. Under the

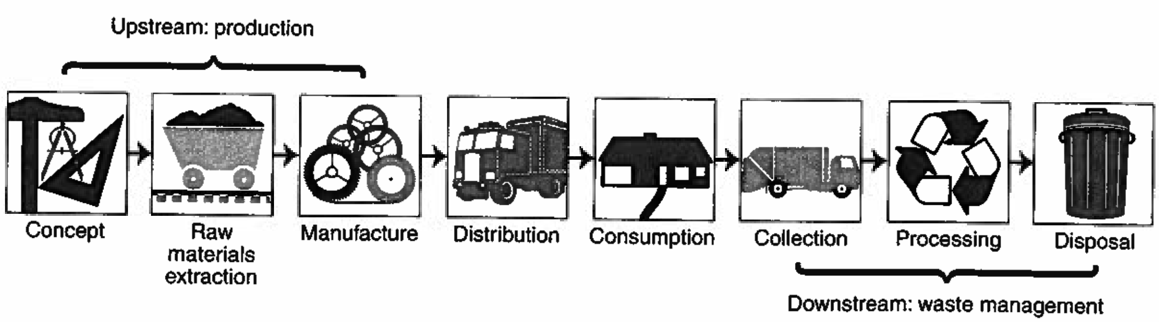


FIGURE 3.9 The Life Cycle of a Typical Product When life cycle analysis is undertaken, it is important to identify all the steps in the process—from obtaining raw materials, through the manufacturing process, to the final disposal of the item.
Source: *Environment*, vol. 39, no. 7, September 1997.

CASE STUDY 3.2

POLLUTION PREVENTION PAYS!

The philosophy of pollution prevention is that pollution should be prevented or reduced at the source whenever feasible. It is increasingly being shown that preventing pollution can cut business costs and thus ncrease profits. Pollution prevention, then, does make cents!

For example, several years ago, 3M's European chemical plant in Belgium switched from a polluting solvent to a safer but more expensive water-based substance to make the adhesive for its Scotch™ Brand Magic™ Tape. The switch was not made to satisfy any environmental law n Belgium or the European Union. 3M managers were complying with company policy to adopt the strictest pollution-control regulations that any of its subsidiaries is subject to—even in countries that have no pollution laws at all. Part of the policy is founded on corporate public relations, a response to growing customer demand for "green" products and environmentally responsible companies. But as many North American multinationals with similar global environmental policies are discovering, cleaning up waste, whether voluntarily or as required by law, can cut costs dramatically. Since 1975, 3M's "Pollution Prevention Pays" program—or 3P—has cut the company's air, water, and waste pollution by nearly 900,000 tons and saved the company almost $900 million. Less waste has meant less spending to comply with pollution control laws. But, in many cases, 3M actually has made money selling wastes it formerly hauled away. And because of recycling prompted by the 3P program, it has saved money by not having to buy as many raw materials.

AT&T followed a similar path. In 1990, it set voluntary goals for the company's 40 manufacturing and 2500 nonmanufacturing sites worldwide. According to its latest estimates, AT&T has (1) reduced toxic air emissions, many caused by solvents used in the manufacture of computer circuit boards, by 73 percent; (2) reduced emissions of chlorofluorocarbons—gases blamed for destroying the ozone layer in the Earth's atmosphere—by 76 percent; and (3) reduced manufacturing waste 39 percent.

Xerox Corporation had focused on recycling materials in its global environment efforts. It provides buyers of its copiers with free United Parcel Service pickup of used copier cartridges, which contain metal-alloy parts that otherwise would wind up in landfills. The cartridges and other parts are now cleaned and used to make new ones. Other recycled Xerox copier parts include power supplies, motors, paper transport systems, printed wiring boards, and metal rollers. In all, 1 million parts per year are remanufactured. The initial design and equipment investment was $10 million. Annual savings total $200 million.

EXAMPLES OF COMMON POLLUTION PREVENTION TECHNIQUES

- Improved process control to use energy and materials more efficiently
- Improved catalysis or reactor design to reduce by-products, increase yield, and save energy in chemical processes
- Alternative processes (e.g., low- or no-chlorine pulping for paper)
- In-process material recovery (e.g., vapor recovery, water reuse, and heavy metals recovery)
- Alternatives to chlorofluorocarbons and other organic solvents
- High-efficiency paint and coating application
- Substitutes for heavy metals and other toxic substances
- Cleaner or alternative fuels and renewable energy
- Energy-efficient motors, lighting, heat exchangers, etc.
- Water conservation
- Improved "housekeeping" and maintenance in industry

German packaging ordinance, consumers, retailers, and packaging manufacturers all share this responsibility, with the financial burden of waste management falling on the retailers and packaging manufacturers. This is thought to be one of the first instances of the concept of "take back," or taking the product back for disposal to the place that made it. This made companies look very hard at how they would manufacture something. The thought was: "This thing is coming back to me someday; how will I recycle/reuse or dispose of it?"

Although no national legislation in the United States mandates extended product responsibility, there are several instances in which manufacturers of specific products have implemented it. When several states passed legislation that required manufacturers of nickel-cadmium batteries to take back the worn-out batteries, manufacturers instituted a national take back program. Kodak has established a program of taking back and recycling single-use cameras. The chemical industry has instituted a program known as Responsible Care®. The concept originated in Canada and has since spread to 46 countries. The primary goals of Responsible Care® are to improve chemical processes and ensure the safe production, transport, use, and disposal of the products of the industry.

Specific benefits of extended product responsibility include:

Cost savings result when manufacturers take back used products because manufacturers recover valuable materials, reuse them, and save money.

Consideration of extended product responsibility has led to companies redesigning products to facilitate disassembly and recycling.

There are more efficient environmental protections, since it is easier to design environmental safety into the product than to try to clean up the problems created by products after they have been dispersed to consumers.

This concept is designated by the U.S. Environmental Protection Agency as Design for Environment (DfE). In other words, prior to going into full production, a product is designed with a consideration of the environmental impacts or aspects that will result from manufacturing it. The company sees the cost-benefit analysis prior to making the product. It can then make rational decisions as to the environmental "liabilities" associated with the manufacture of the product. Production changes, reformulations, source reductions, or complete redesign may be necessary to make the product more environmentally sound, and therefore more cost effective. Some industries have found that the product they designed was a great thing until they examined the environmental costs associated with its manufacture—after they had already gone to full production. This resulted in their product costs being too high to compete in the marketplace (they had to pay for the cost of hazardous waste by-products).

Despite the benefits of extended product responsibility, obstacles remain. These include:

The cost of instituting extended product responsibility programs

The lack of information and tools to assess all impacts of the production, use, and disposal of a product

Difficulty in building relationships among individuals and institutions involved in different stages in the life cycle of a product

Hazardous waste regulations that require hazardous waste permits for collection and disposal of certain products

Antitrust laws that make it difficult for companies to cooperate

Nevertheless, extended product responsibility can be an important tool of industry and policy makers that can lead to less costly and more flexible ways of dealing with the environmental costs of manufacturing and consuming goods.

Green Marketing Principles

Evidence indicates that successful green products have three marketing principles in common: consumer value positioning, calibration of consumer knowledge, and the credibility of product claims.

Consumer Value Positioning

- Design environmental products to perform as well as (or better than) alternatives.
- Promote and deliver the consumer desired value of environmental products and target relevant consumer market segments (such as market health benefits among health-conscious consumers).

Calibration of Consumer Knowledge

- Educate consumers with marketing messages that connect environmental product attributes with desired consumer value (for example, "energy efficiency saves money" or "pesticide free produce is healthier").
- Frame environmental product attributes as "solutions" for consumer needs such as "rechargeable batteries offer longer performance."
- Create engaging and educational Internet sites about environmental products' desired consumer value (for example, Tide Coldwater's interactive site allows visitors to calculate their likely annual money savings based on their laundry habits, utility source (gas or electricity), and zip code location.

Credibility of Product Claims

- Use environmental product and consumer benefit claims that are specific, meaningful, unpretentious, and qualified.
- Obtain product endorsements or eco-certification from reliable third parties, and educate consumers about the meaning behind those endorsements and certifications.
- Encourage consumer evangelism via consumers' social and Internet communication networks with compelling, interesting, and/or entertaining information about environmental products (for example, Tide's "Coldwater Challenge" website includes a map of the United States so visitors can track and watch their personal influence spread when their friends request a free sample).

ECONOMICS AND SUSTAINABLE DEVELOPMENT

Sustainable development has become an important policy priority for the world. The most commonly used definition of the term *sustainable development* is one that originated with the 1987 report, *Our Common Future,* by the World Commission on Environment and Development (known as the Bruntland Commission). It states that "**sustainable development** is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition reflects the dual societal objectives of economic development and environmental stewardship.

However, similar terms such as *sustainable growth* and *sustainable use* have been used interchangeably with *sustainable development,* as if their meanings were the same. They are not. *Sustainable growth* is a contradiction in terms: Nothing physical can grow indefinitely. *Sustainable use* is applicable only to renewable resources: it means using them at rates within their capacity for renewal.

The concept of *sustainability* has gained usage because of increasing concern over the exploitation of natural resources for economic development at the expense of environmental quality. Although disagreement exists as to the precise meaning of the term beyond respect for the quality of life of future generations, most definitions refer to the viability of natural resources and ecosystems over time and to the maintenance of human living standards and economic growth.

In the United States, a biology textbook (*New Essentials of Biology* published in 1911 by the American Book Company) described the "destruction of the forests by waste cutting" and the impact of forests on our economy and the need for replanting of trees after lumbering. It also described how "forests are of much

CAMPUS SUSTAINABILITY INITIATIVE

CAMPUS BUSINESS PARTNERSHIP TO REDUCE GREENHOUSE GAS EMISSIONS

n 2008, Chevron Energy Solutions, a unit of Chevron Corporation, and the ontra Costa Community College District (CCCCD) in Martinez, California nnounced the completion of the first phase of the largest solar power installation ever constructed for an institution of higher learning in North merica. The project is part of a multi-facility energy efficiency and solar proram that is expected to save CCCCD more than $70 million over 25 years.

The state of the art energy infrastructure upgrades—designed, ngineered, and constructed by Chevron Energy Solutions—make CCCD's three college campuses (enrolling more than 58,000 students) nore energy efficient, reliable, and environmentally friendly.

The program includes three types of improvements:

- A 3.2-megawatt solar power generation system comprising photovoltaic panels mounted on 34 parking canopies in six parking lots of the three college campuses
- High-efficiency lighting and energy management systems installed at the three campuses, as well as high-efficiency heating, ventilation, and air conditioning equipment
- High-voltage electrical system replacements on the campuses

The solar installation is expected to generate about 4 million kilowatt hours of power each year, supplying up to half of CCCCD's peak electricity needs. This renewable power will offset the production of about 5.6 million pounds of carbon dioxide emissions annually—equivalent to removing 629 cars from the road or planting 400 hectares of trees.

The $35.2 million project cost is being offset by about $8.5 million in rebates and other incentives administered by Pacific Gas and Electric Company under the State of California's Solar Initiative, Self Generation Incentive Program, and the Community College Partnership Program. The net amount of $26.7 million, supported by California bond funds, will be recovered over time by the annual cost savings achieved as a result of the new systems.

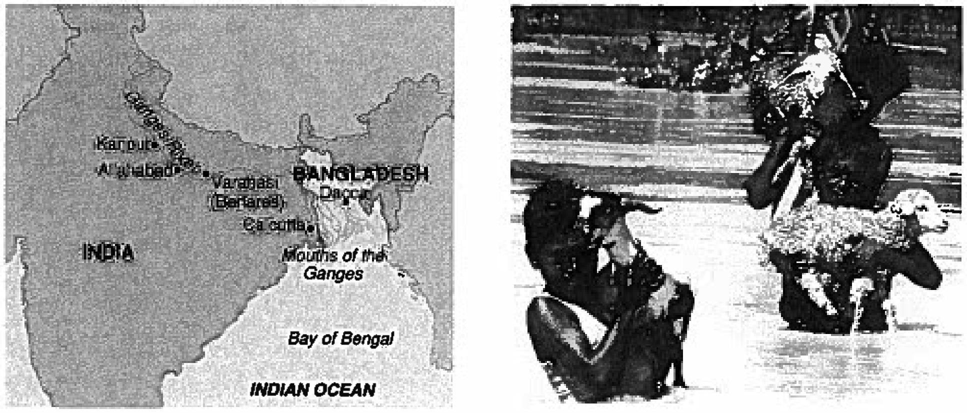
The California Lieutenant Governor commented on the partnership by stating, "Thinking green can no longer be a choice when looking toward the future. Smart businesses and colleges are looking over the horizon, building partnerships, and understanding that the risks and opportunity associated with this critical issue must be part of their overall plan to grow and to be successful in the future."

nportance because they 1. regulate our water supplies 2. prevent rosion 3. change climate 4. are of great commercial importance. Ian is responsible for the destruction of one of this nation's most aluable assets. This is primarily due to wrong and wasteful lumering." The chapter went on to describe the loss of trees as a onetary issue and continually mentioned "waste" from "forest to nished product." Even at that relatively early time it was recogzed that humans may be overharvesting and not maintaining a newable resource. The book suggests that "forests may be artifially planted . . . two seedlings planted for every tree cut is the le followed in Europe." Recognition of a problem is one thing; nplementation of these ideas is another.

A sustainable agricultural system, for example, can be defined one that can indefinitely meet the demands for food and fiber at cially acceptable economic costs and environmental impacts. aylord Nelson, the founder of the first Earth Day, listed five aracteristics that define sustainability:

1. *Renewability:* A community must use renewable resources, such as water, topsoil, and energy sources no faster than they can replace themselves. The rate of consumption of renewable resources cannot exceed the rate of regeneration.
2. *Substitution:* Whenever possible, a community should use renewable resources instead of nonrenewable resources. This can be difficult because of barriers to substitution. To be sustainable, a community has to make the transition before the nonrenewable resources become prohibitively scarce.
3. *Interdependence:* A sustainable community recognizes that it is a part of a larger system and that it cannot be sustainable unless the larger system is also sustainable. A sustainable community does not import resources in a way that impoverishes other communities, nor does it export its wastes in a way that pollutes other communities.
4. *Adaptability:* A sustainable community can absorb shocks and adapt to take advantage of new opportunities. This requires a diversified economy, educated citizens, and a spirit of solidarity. A sustainable community invests in and uses research and development.
5. *Institutional commitment:* A sustainable community adopts laws and political processes that mandate sustainability. Its economic system supports sustainable production and consumption. Its educational systems teach people to value and practice sustainable behavior.

Some people assume that a slowdown of economic growth is needed to prevent further deterioration of the environment. Whether or not a slowdown is necessary provokes sharp differences of opinion. One school of thought argues that economic growth is essential to finance the investments necessary to prevent pollution and to improve the environment by a better allocation of



(a) (b)

FIGURE 3.10 Indian Deforestatic Causes Floods in Bangladesh (a) Becau the Ganges River drains much of India and the cou try of Bangladesh is at the mouth of the river, defc estation and poor land use in India can result (b) devastating floods in Bangladesh.

resources. Another school of thought, which is also progrowth, stresses the great potential of science and technology to solve problems and promotes technological advances as the way to solve environmental problems. Neither of these schools of thought sees any need for fundamental changes in the nature and foundation of economic policy. Environmental issues are viewed mainly as a matter of setting priorities in the allocation of resources.

A newer school of economic thought believes that economic and environmental well-being are mutually reinforcing goals that must be pursued simultaneously if either one is to be reached. Economic growth will create its own ruin if it continues to undermine the healthy functioning of Earth's natural systems or to exhaust natural resources. It is also true that healthy economies are most likely to provide the necessary financial investments to support environmental protection. For this reason, one of the principal objectives of environmental policy must be to ensure a decent standard of living for all. The solution, at least in the broad scope, would be for a society to manage its economic growth in such a way as to do no irreparable damage to its environment.

If sustainable development is to become feasible, it will be necessary to transform our approach to economic policy. Historically, rapid exploitation of resources has provided only short-term economic growth, and the environmental consequences in some cases have been incurable. For example, 40 years ago, forests covered 30 percent of Ethiopia. Today, forests cover only 1 percent, and deserts are expanding. Trees once covered one-half of India; today, only 14 percent of the land is in forests. As the Indian trees and topsoil disappear, the citizens of Bangladesh drown in India's runoff. (See figure 3.10.) One of the steps necessary to move economies toward sustainable development is to change the definition of gross national product (GNP) to include environmental improvement or decline.

Sustainable development is a worthy goal, but many changes are needed for the concept to be viable. One of these involves the transfer of modern, environmentally sound technology to developing nations. Tan Sri Razali, former chairman of the UN Commission on Sustainable Development, has stated that this transfer is the "key global action to sustainable development." Another major obstacle to sustainable development in many countries is a social structure that gives most of the nation's wealth to a tiny minority of its people. It h been said that a person who is worrying about his or her next meal not going to listen to lectures on protecting the environment. Wh seem like some of the worst environmental outrages to residents in tl Northern Hemisphere—cutting rainforests to make charcoal for sa as cooking fuel, for example—are often committed by people wl have no other source of income.

The disparities that mark individual countries are also reflect in the planet as a whole. Most of the wealth is concentrated in tl Northern Hemisphere. From the Southern Hemisphere's point view, it is the rich world's growing consumption patterns—big car refrigerators, and climate-controlled shopping malls—that are tl problem. The problem for the long term is that people in develo ing countries now want those consumer items that make life in tl industrial world so comfortable—and these items use large amoun of energy and raw materials for their production and use. If the sta dard of living in China and India were to rise to that of Germany the United States, the environmental impact on the planet would l significant.

Sustainable development requires choices based on value To make intelligent choices, the public must have informatic about the way economic decisions affect the environment. A. V Clausen, in his final address as president of the World Ban noted the

> increasing awareness that environmental precautions are essential for continued economic development over the long run. Conservation, in its broadest sense, is not a luxury for people rich enough to vacation in scenic parks. It is not just motherhood issue. Rather, the goal of economic growth itse dictates a serious and abiding concern for resource management.

High-income developed nations with high educational level such as the United States, Japan, and much of Europe, are in position to promote sustainable development. They have the re sources to invest in research and the technologies to impleme research findings. Some believe that the world should not impo environmental protection standards on poorer nations without al helping them to move into the economic mainstream.

ECONOMICS, ENVIRONMENT, AND DEVELOPING NATIONS

As previously mentioned, the Earth's "natural capital," on which humankind depends for food, security, medicines, and machines, includes both nonrenewable resources such as minerals, oil, and mountains and renewable resources such as soil, sunlight, and biological diversity. Many countries in the developing world have resources that they wish to develop in order to improve the economic conditions of their inhabitants. To pay for development projects, many economically poor nations are forced to borrow money from banks in the developed world.

The debt they have incurred is a perverse incentive to overexploit their resources. Because they have borrowed money and creditors expect repayment of the debt, many countries must divert a major part of their gross domestic product to debt payment. In 2001, the debt in the developing nations had risen to over US $1900 billion, a figure equal to about half their collective gross national product. The burden of external debt is so great that many developing nations feel forced to overexploit their natural resources rather than manage them sustainably. The debt burdens have led to investments in programs absolutely necessary for immediate survival and in projects with safe, short-term returns. Environmental impacts are often neglected because severely indebted countries feel they cannot afford to pay attention to environmental costs until other problems are resolved. These "other problems" include the reality that simple day-to-day survival issues take precedence over environmental protection. This held true for the United States as it first struggled to survive in its formative years. All countries go through different phases during their development, and they often must work toward the time when they can literally afford to worry about the environment. Nevertheless, often environmental impacts cause international problems.

One new method of helping manage a nation's debt crisis is referred to as debt-for-nature exchange. **Debt-for-nature exchanges** are an innovative mechanism for addressing the debt issue while encouraging investment in conservation and sustainable development. Three players are involved in debt-for-nature exchanges: the debtor nation, the creditor, and a third party interested in conservation initiatives. The exchange works as follows:

1. The conservation organization buys the debt from the creditor at a discount.
2. Although the creditor receives only partial payment of the initial loan, some return is better than a total loss.
3. The debtor country has the debt removed and is relieved of the huge burden of paying interest on the debt.
4. In exchange, the conservation organization requires the debtor country to spend money on appropriate conservation and sustainable development projects.

Debt-for-nature exchanges originated in 1987, when a nonprofit organization, Conservation International, bought $650,000 of Bolivia's foreign debt in exchange for Bolivia's promise to establish a national park. By 2005, at least 16 debtor countries—in the Caribbean, Africa, Eastern Europe, and Latin America—had made similar deals with official and nongovernmental organizations. By 2005, nearly US $160 million of debt around the world had been purchased at a cost of some US $35 million, but the debtor countries spent the equivalent of US $78 million. This money was used to establish biosphere reserves and national parks, develop watershed protection programs, build inventories of endangered species, and develop environmental education.

The primary goal of debt-for-nature exchanges has not been debt reduction but the funding of natural-resource management investment. The contribution made by exchanges could increase, as in the case of the Dominican Republic, where 10 percent of the country's outstanding foreign commercial debt is to be redeemed by exchanges. Although eliminating the debt crisis alone is no guarantee of investment in environmentally sound projects, instruments such as debt-for-nature exchanges can, on a small scale, reduce the mismanagement of natural resources and encourage sustainable development.

Attitudes of banks in the industrialized nations also seem to be changing. For example, the World Bank, which lends money for Third World development projects, has long been criticized by environmental groups for backing large, ecologically unsound programs, such as a cattle-raising project in Botswana that led to overgrazing. During the past few years, however, the World Bank has been factoring environmental concerns into its programs. One product of this new approach is an environmental action plan for Madagascar. The 20-year plan, which has been drawn up jointly with the World Wildlife Fund, is aimed at heightening public awareness of environmental issues, setting up and managing protected areas, and encouraging sustainable development.

Another problem associated with resource exploitation in developing countries is the short-term exploitation of a country's resources by foreign corporations. Because poor countries do not have the financial means to develop their natural resources themselves, they often contract with corporations to do the development. Many of these corporations have no long-term commitment to the project and withdraw as soon as the project becomes unprofitable. For example, many forest resources have been logged with no interest in sustaining the resource. Companies are involved for the short-term economic gain and have little interest in the long-term economic needs of the people of the country.

ISSUES & ANALYSIS

The Economics and Risks of Mercury Contamination

Mercury is a chemical element that is used in many industrial processes and products. Since it is a liquid metal, it is used in many kinds of electrical applications. Common uses of mercury include fluorescent lightbulbs, mercury vapor lights, electrical tilt switches, and certain kinds of small batteries. It also is alloyed with silver and other metals to produce fillings in teeth. Elemental mercury by itself is poisonous, but so few people have direct access to elemental mercury that it constitutes a minor risk. Certain bacteria, however, are able to convert elemental mercury to methylmercury, which can be easily taken up by living things and stored in the body.

Some of the mercury available for conversion to methylmercury is from natural rock. Thus, some parts of the world naturally have high mercury levels compared to others. A common human-generated source of mercury is the combustion of coal in electric power plants and similar facilities. The mercury is released into the air and distributed over the landscape downwind from the power plant.

Contamination with methylmercury is a particular problem in aquatic food chains where fish at higher trophic levels accumulate high quantities of methylmercury in their tissues. Fish are an important source of omega-3 fatty acids that are associated with reductions in heart disease. If fish are declared unfit for human consumption because of methylmercury levels, there is a major economic impact on the people who catch and process fish. There can also be an increased health risk if people switc to eating other foods that do not have omega-3 fatty acids. One study ‹ the risks and benefits of Alaskan natives eating fish determined that tl risk to health from ingesting small amounts of methyl mercury in fish w: less than the risk associated with changing to a diet that included oth‹ sources of protein.

In 2000, under the Clinton administration, the EPA announced that would require reductions in the amount of mercury released from co fired power plants. This would require expensive additions to pow‹ plants to capture the mercury so that it was not released into the a mosphere. The power industry protested that changes would be too e: pensive, and the program was never initiated. In December 2003, und‹ the George W. Bush administration, the EPA announced a mercury emi sion trading proposal to deal with the problem. Under this proposal, co fired power plants will be issued permits to release specific amounts ‹ mercury. If they do not release much mercury, they can sell their perm to other power plants that are not able to reduce the amount of mercu‹ they release. Proponents point out that a similar emissions trading pr‹ gram for sulfur dioxide resulted in major reductions in sulfur dioxide r‹ lease. Critics of the mercury emissions program say that the program is concession to the power industry.

- Should power companies be able to buy rights to pollute?
- Should all pollution be prevented regardless of the cost, or shou risk assessment and economic analysis be a part of the decisio making process?

SUMMARY

Risk is the probability that a condition or action will lead to an injury, damage, or loss. Risk assessment is the use of facts and assumptions to estimate the probability of harm to human health or the environment that may result from exposures to pollutants or toxic agents. While it is difficult to calculate risks, risk assessment is used in risk management, which analyzes the risk factors in decision making. The politics of risk management focus on the adequacy of scientific evidence, which is often open to divergent interpretations. In assessing risk, people often overestimate new and unfamiliar risks while underestimating familiar ones.

To a large degree, environmental problems can be viewed as economic problems that revolve around decisions about how to use resources. Many environmental costs are deferred (paid at a later date) or external (paid by someone other than the entity that causes the problem). Pollution is a good example of both a deferred and an external cost. Cost-benefit analysis is concerned with whether a policy generates more social benefits than social costs. Criticism of cost-benefit analysis is based on the question of whether everything has an economic value. It has been argued that if economic thinking dominates society, then noneconomic values, such as beauty, can survive only if a monetary value is assigned to them. There is a strong tendency to overexploit and misuse resources that are shared by all. This concept was developed by Garrett Hardin in his essay, "The Tragedy of tl Commons."

Economic policies and concepts, such as supply and deman and subsidies, play important roles in environmental decisic making. The balance between the amount of a good or servic available for purchase and the demand for that commodity dete mines the price. Subsidies are gifts from government to encourag desired behaviors. Recently, several kinds of market-based aj proaches have been developed to deal with the economic costs ‹ environmental problems. These approaches include informatic programs, tradable emissions, emissions fees, deposit refund pr‹ grams, and performance bond programs. The goal of all the: mechanisms is to introduce a profit motive for institutions and iı dividuals to use resources wisely.

A newer school of economic thought is referred to as sustaiı able development. Sustainable development has been defined as a‹ tions that address the needs of the present without compromising tł ability of future generations to meet their own needs. Sustainab development requires choices based on values. Economic concep are also being applied to the debt-laden developing countries. Or such approach is the debt-for-nature exchange. This program, whic involves transferring loan payments for land that is later turned inı parks and wildlife preserves, is gaining popularity.

THINKING GREEN

1. If you smoke, quit! If you do not smoke, help a friend who does smoke to quit.
2. Research the "green marketing" claims for several products that you use.
3. Work on sustainability projects in your college.
4. Develop a cost-benefit analysis for a local issue.
5. Buy products that come in a container that is reusable or that requires a deposit.

WHAT'S YOUR TAKE?

lercury contamination of our lakes, streams, oceans, soil, and groundater is an ongoing issue. Because of surface water contamination, many ate and federal agencies have issued health advisories to limit the nounts of certain fish and shellfish that people eat. If you like to eat fish or shellfish, would you limit your consumption based on warnings from state or federal health agencies? Develop an argument for or against consuming fish that potentially contain mercury.

REVIEW QUESTIONS

l. How is risk assessment used in environmental decision making?
2. What is incorporated in a cost-benefit analysis?
3. What are some of the concerns about the use of cost-benefit analysis in environmental decision making?
4. What concerns are associated with sustainable development?
5. What are some examples of external environmental costs?
6. Define what is meant by pollution-prevention costs.
7. Define the problem of common property resource ownership. Provide some examples.
8. Describe the concept of debt-for-nature exchanges.
9. Give examples of subsidies, market-based instruments, and life cycle analysis.
10. What kinds of risks are willingly accepted by people?
11. Give examples of renewable and nonrenewable resources.
12. Why are environmental costs often deferred costs?
13. What is meant by "take back"?
14. Why would a small business be interested in SBLRBRA?
15. Why do some companies have different levels of risk tolerance?
16. What does Eco-RBCA have to do with ecological assessment and cleanup?
17. Why is the perception of risk so important to how we look at environmental health and safety issues?
18. How could DfE have an effect on our environment?
19. What impact could governments have on sustainability of natural resources through political means?

CRITICAL THINKING QUESTIONS

1. If you were a regulatory official, what kind of information would you require to make a decision about whether a certain chemical was "safe" or not? What level of risk would you deem acceptable for society? For yourself and your family?
2. Why do you suppose some carcinogenic agents, such as those in cigarettes, are so difficult to regulate?
3. Imagine you were assessing the risk of a new chemical plant being built along the Mississippi River in Louisiana. Identify some of the risks that you would want to assess. What kinds of data would you need to assess whether or not the risk was acceptable? Do you think that some risks are harder to quantify than others? Why?
4. Granting polluting industries or countries the right to buy and sell emissions permits is a controversial idea. Some argue that the market is the best way to limit pollution. Others argue that trade in permits allows polluting industries to continue to pollute and concentrates that pollution. What do you think?
5. Imagine you are an independent economist who is conducting a cost-benefit analysis of a hydroelectric project. What might be the costs of this project? The benefits? How would you quantify the costs of the project? The benefits? What kinds of costs and benefits might be hard to quantify or might be too tangential to the project to figure into the official estimates?
6. Do you think environmentalists should or should not stretch traditional cost-benefit analysis to include how development affects the environment? What are the benefits to this? The risks?
7. Looking at your own life, what kinds of risks do you take? What kinds are you unwilling to take? What criteria do you use to make a decision about acceptable and unacceptable risk?
8. Is current worldwide growth and development sustainable? If there were less growth, what would be the effect on developing countries? How could we achieve a just distribution of resources and still limit growth?

9. Should our policies reflect an interest in preserving resources for future generations? If so, what level of resources should be preserved? What would you be willing to do without in order to save for the future?
10. If you owned a small business in the United States and were looking to expand your business within your home state, would you consider purchasing a contaminated piece of property in a downtown or urban area? Why or why not? Would you be concerned about the environmental liabilities associated with it? Would you be worried about the health and safety of your workers if you located there? Why? What might be your concerns, or how could you find out? Would you conduct an environmental assessme prior to applying for financing the purchase and constructio Knowing what you know now, what type of risk tolerance do y have concerning your finances, your workers' health and safe and the environment?
11. If you were developing a new product ("super" sprocket), and fou that you had to use chrome plating in the manufacturing proce how might you utilize DfE concepts in the development stage of d sign? What types of questions might you ask the production eng neer? What type of P2 techniques might you employ? Would y consider "take back" at your facility? Why or why not?