Environmental Economics

Volume 1: The Essentials

Inside the guide:

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Chapter 1: Introduction to Environmental & Resource Economics

Environmental economics is the subset of economics that is concerned with the efficient allocation of environmental resources. The environment provides both a direct value as well as raw material intended for economic activity, thus making the environment and the economy interdependent. For that reason, the way in which the economy is managed has an impact on the environment which, in turn, affects both welfare and the performance of the economy.

One of the best known critics of traditional economic thinking about the environment is **Herman Daly**. In his first book, ***Steady-State Economics***, Daly suggested that "enough is best," arguing that economic growth leads to environmental degradation and inequalities in wealth. He asserted that the economy is a subset of our environment, which is finite. Therefore his notion of a steady-state economy is one in which there is an optimal level of population and economic activity which leads to sustainability. Daly calls for a qualitative improvement in people's lives – development – without perpetual growth. Today, many of his ideas are associated with the concept of **sustainable development**.

By the late 1970s, the late economist **Julian Simon** began countering arguments against economic growth. His keystone work was ***The Ultimate Resource***, published in 1981 and updated in 1996 as ***The Ultimate Resource 2***, in which he concludes there is no reason why welfare should not continue to improve and that increasing population contributes to that improvement in the long run. His theory was that population growth and increased income puts pressure on resource supplies; this increases prices, which provides both opportunity and incentive for innovation; eventually the innovations are so successful that prices end up below what they were before the resource shortages occurred. In Simon's view, a key factor in economic growth is the human capacity for creating new ideas and contributing to the knowledge base. Therefore, the more people who can be trained to help solve arising problems, the faster obstacles are removed, and the greater the economic condition for current and future generations.

Environmental economics takes into consideration issues such as the conservation and valuation of natural resources, pollution control, waste management and recycling, and the efficient creation of emission standards. Economics is an important tool for making decisions about the use, conservation, and protection of natural resources because it provides information

about choices people make, the costs and benefits of various proposed measures, and the likely outcome of environmental and other policies. Since resources – whether human, natural, or monetary – are not infinite, these public policies are most effective when they achieve the maximum possible benefit in the most efficient way. Therefore, one job of policymakers is to understand how resources can be utilized most efficiently in order to accomplish the desired goals by weighing the costs of various alternatives to their potential benefits.

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In competitive markets, information exists about how much consumers value a particular good because we know how much they are willing to pay. When natural resources are involved in the production of that particular good, there may be other factors – scarcity issues, the generation of pollution – that are not included in its production cost. In these instances, scarcity issues or pollution become **externalities**, costs that are external to the market price of the product. If these full costs were included, the cost of the good may be higher than the value placed on it by the consumer.

A classic example of an externality is discussed in **Garrett Hardin's *Tragedy of the Commons***, which occurs in connection to public commons or resources – areas that are open and accessible to all, such as the seas or the atmosphere. Hardin observed that individuals will use the commons more than if they had to pay to use them, leading to overuse and possibly to increased degradation.

There are three general schools of thought associated with reducing or eliminating environmental externalities. Most **welfare economists** believe that the existence of externalities is sufficient justification for government intervention, typically involving taxes and often referred to as **Pigovian taxes** after economist Arthur Pigou (1877-1959) who developed the concept of economic externalities. **Market economists** tend to advocate the use of incentives to reduce environmental externalities, rather than command-and-control approaches, because incentives allow flexibility in responding to problems rather than forcing a singular approach on all individuals. **Free-market economists** focus on eliminating obstacles that prevent the market from functioning freely, which they believe would lead to an optimal level of environmental protection and resource use. The key objective of environmental

economics is to identify those particular tools or policy alternatives that will move the market toward the most efficient allocation of natural resources.

Recommended Resources

Center for the Advancement of the Steady State Economy
www.steadystate.org
The Center for the Advancement of the Steady State Economy is a nonprofit organization that educates citizens and policy makers on the fundamental conflict between economic growth and environmental protection, economic sustainability, national security, and international stability through its promotion of a steady state economy as a sustainable alternative to economic growth.

Political Economy Research Center
www.perc.org
The Political Economy Research Center is dedicated to original research that brings market principles to resolving environmental problems. The site has an extensive publications list and an environmental education section that touches on a variety of subject areas that relate to both economics and the environment.

Protecting Ecosystem Services: Science, Economics, and Law
eprints.law.duke.edu/archive/00001071/01/20_Stan._Envtl._L._J._309_(2001).pdf
This paper is the result of a workshop that took place in December 2000 when a group of 30 scientists, conservationists, economists, lawyers, and policymakers came together at Stanford University to discuss ways to market ecosystem services.

Chapter 2: The Law of Diminishing Returns

The "**law of diminishing returns**" is one of the best-known principles outside the field of economics. It was first developed in 1767 by the French economist **Turgot** in relation to agricultural production, but it is most often associated with **Thomas Malthus** and **David Ricardo**. They believed that human population would eventually outpace the production of food since land was an integral factor in limited supply. In order to increase production to feed the population, farmers would have to use less fertile land and/or increase production intensity on land currently under production. In both cases, there would be diminishing returns.

The law of diminishing returns – which is related to the concept of marginal return or **marginal benefit** – states that if one factor of production is increased while the others remain constant, the marginal benefits will decline and, after a certain point, overall production will also decline. While initially there may be an increase in production as more of the variable factor is used, eventually it will suffer diminishing returns as more and more of the variable factor is applied to the same level of fixed factors, increasing the costs in order to get the same output. Diminishing returns reflect the point in which the marginal benefit begins to decline for a given production process. For example, the table below sets the following conditions on a farm producing corn:

Number of Workers	Corn Produced	Marginal Benefit
1	10	10
2	25	15
3	45	20
4	60	15
5	70	10
6	60	-10

It is with three workers that the farm production is most efficient because the marginal benefit is at its highest. Beyond this point, the farm begins to experience diminishing returns and, at the level of 6 workers, the farm actually begins to see decreasing returns as production levels decline, even though costs continue to increase. In this example, the number of workers changed, while the land used, seeds planted, water consumed, and any other inputs remained the same. If more than one input were to change, the production results would vary and the law of diminishing returns may not apply if all of the inputs could be

increased. If this case were to lead to increased production at lower average costs, **economies of scale** would be realized.

The concept of diminishing returns is as important for individuals and society as it is for businesses because it can have far-reaching effects on a wide variety of things, including the environment. This principle – although first thought to apply only to agriculture – is now widely accepted as an economic law that underlies all productive endeavors, including resource use and the cleanup of pollution.

The theory was effectively applied by **Garrett Hardin** in his 1968 article on the tragedy of the commons in which he looked at many common property resources, such as air, water, and forests, and described their use as being subject to diminishing returns. It is in this case that individuals acting in their own self-interest may "overuse" a resource because they do not take into consideration the impact it will have on a larger, societal scale. It can also be expanded to include limitations on our common resources. The services that fixed natural resources are able to provide – for example, in acting as natural filtration systems – will begin to diminish as contaminants and pollutants in the environment continue to increase. It is externalities such as these that can lead to the depletion of our resources and/or create other environmental problems.

However, the point at which diminishing returns can be illustrated is often very difficult to pinpoint because it varies with improved production techniques and other factors. In agriculture, for example, the debate about adequate supply remains unclear due to the uneven distribution of population and agricultural production around the globe and improvement in agricultural technology over time.

The challenge – whether it be local, regional, national, or global – is how best to manage the problem of declining resource-to-people ratios that could lead to a reduced standard of living. Widely used solutions for internalizing potential externalities include **taxes**, **subsidies**, and **quotas**. Often, there are attempts to find "bigger picture" solutions that focus on what many see as the primary causes, namely population growth and resource scarcity. Reducing population growth, along with increased technological innovation, may slow the growth in resource use and possibly offset the impact of diminishing returns. These potential benefits are a key reason why population growth and technological innovation are most often used in analyzing sustainable development possibilities.

Recommended Resources

The Origin of the Law of Diminishing Returns
socserv2.socsci.mcmaster.ca/~econ/ugcm/3ll3/cannan/cannan003.html
This article, by early 20th century economist Edwin Cannan, is part of an archive collection of significant texts in the history of economic thought.

Diminishing Returns
william-king.www.drexel.edu/top/Prin/txt/MPCh/firm6.html
Dr. Roger A. McCain, professor of economics at Drexel University, explains diminishing returns on his website and provides an in-depth look at related key concepts.

Law of Diminishing Returns
www.auburn.edu/~johnspm/gloss/diminishing_returns_law_of
Dr. Paul M. Johnson of Auburn University, provides a thorough definition of the law of diminishing returns, using garden and factory examples to illustrate his point.

VIEWPOINTS

Diminishing Returns: World Fisheries Under Pressure
pubs.wri.org/pubs_content_text.cfm?ContentID=1390
This article, by the World Resources Institute, shows the problems fisheries have been experiencing over the past fifty years as catch rates decline.

Thoughts on Long-Term Energy Supplies: Scientists and the Silent Lie
fire.pppl.gov/energy_population_pt_0704.pdf
Retired physics professor Albert Bartlett, a modern-day Malthusian, frequently lectures on "Arithmetic, Population and Energy." This article was published in *Physics Today*, July 2004.

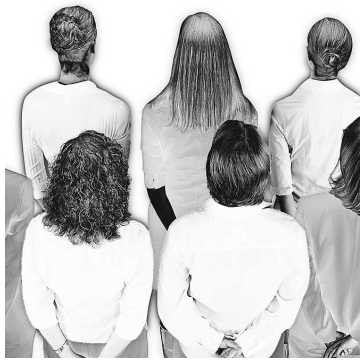
Long-Term Energy Solutions: The Truth Behind the Silent Lie
www.physicstoday.org/vol-57/iss-11/p12.html
These letters to the editor in the November 2004 edition of *Physics Today* are in response to Albert Bartlett's July 2004 article.

Chapter 3: Carrying Capacity

Changes in population can have a variety of economic, ecological, and social implications. One population issue is that of **carrying capacity** – the number of individuals an ecosystem can support without having any negative effects. It also includes a limit of resources and pollution levels that can be maintained without experiencing high levels of change. If carrying capacity is exceeded, living organisms must adapt to new levels of consumption or find alternative resources. Carrying capacity can be affected by the size of the human population, consumption of resources, and the level of pollution and environmental degradation that results. Carrying capacity, however, need not be fixed and can be expanded through good management and the development of new resource-saving technologies.

The relationship between carrying capacity and population growth has long been controversial. One of the original arguments appeared in 1798 by English economist **Thomas Malthus** who stated that continued population growth would cause over-consumption of resources. Malthus further argued that population was likely to grow at an **exponential rate** while food supplies would increase at an **arithmetic rate**, not keeping up with the exponential population growth. Malthus believed that an ever increasing population would continually strain society's ability to provide for itself and, as a result, mankind would be doomed to forever live in poverty.

Over a century later, American economist **Julian Simon** countered Malthus' arguments, asserting that an increase in population would improve the environment rather than degrade it. He believed human intellect to be the most valuable renewable natural resource that would continue to find innovative solutions to any problems that might arise – environmental, economical, or otherwise. Simon was also one of the founders of **free-market environmentalism**, finding that a free market, together with appropriate property rights, was the best tool in order to preserve both the health and sustainability of the environment.



Throughout the late 1960s and 1970s, the controversy over the effect that an increasing population has on the Earth's

limited resources reemerged. **Garrett Hardin** and **Paul Ehrlich**, both authors on overpopulation, believed that human population had already exceeded the carrying capacity. Hardin is best known for his paper ***The Tragedy of the Commons***, in which he argues that overpopulation of any species will deplete shared natural resources. Ehrlich, who wrote ***The Population Bomb*** in 1968, predicted a population explosion accompanied by increasing famine and starvation. Although his prediction did not come true – in fact, in 1970 there was a slight decline in the population growth rate – he was correct in pointing out that, with the exception of solar energy, the Earth is a closed system with limited natural resources.

The standard of living in a region can help to alter an area's carrying capacity. Areas with a higher standard of living tend to have a reduced carrying capacity compared to areas with a lower standard of living due to the access to and demand for more resources. Nevertheless, the environmental **Kuznets Curve** – an observed phenomenon – suggests that beyond some point, increased income and environmental improvement often goes hand-in-hand. While population growth rates have stabilized and, in fact, are declining in many developed nations, consumption of resources and the generation of pollution and waste continue to grow. The effect this has on an ecosystem is called an "**ecological footprint**," which can be used to measure and manage the use of resources throughout an economy. It is also widely used as an indicator of environmental sustainability.

Carrying capacity often serves as the basis for sustainable development policies that attempt to balance the needs of today against the resources that will be needed in the future. The **1995 World Summit on Social Development** defined sustainability as 'the framework to achieve a higher quality of life for all people in which economic development, social development, and environmental protection are interdependent and mutually beneficial components'. The **2002 World Summit** furthered the process by identifying three key objectives of sustainable development: eradicating poverty, protecting natural resources, and changing unsustainable production and consumption patterns.

While the exact value of the human carrying capacity is uncertain and continues to be under debate, there has been evidence of the strain that both overpopulation and over-consumption has placed on some societies and the environment. Economists, ecologists, and policy analysts continue to study global consumption patterns to determine what the human carrying capacity is and what steps can be taken to ensure it is not exceeded. In the meantime, actions to reduce the strain and ensure natural resource recovery for the future will depend on an increase of sustainable development policies worldwide.

Recommended Resources

Linking Population and Development
www.unfpa.org/pds/index.htm
The United Nations Population Fund explores the links between population, poverty, and development. Their website includes information on population trends, urbanization, and environmental sustainability.

Human Carrying Capacity of Earth
www.ilea.org/leaf/richard2002.html
The Institute for Lifecycle Environmental Assessment explains carrying capacity and its related components. The distinction between social and biophysical carrying capacity, as well as the roles that land area, food production, and energy play, are also discussed.

VIEWPOINTS

Tragedy of the Commons
www.sciencemag.org/cgi/content/full/162/3859/1243
Full text of Garrett Hardin's famous 1968 *Science* magazine essay.

Ethical Implications of Carrying Capacity
dieoff.org/page96.htm
Garrett Hardin's 1977 essay on the importance of carrying capacity is closely related to his famous concept of the tragedy of the commons.

Population, Sustainability, and Earth's Carrying Capacity
dieoff.org/page112.htm
In 1992, Paul Ehrlich and Gretchen Daily published this article addressing population patterns at the time and what could be done to create more sustainable patterns.

Chapter 4: Sustainable Development

Over the past few decades, many definitions of **sustainable development** have been suggested and debated, resulting in a concept that has become broad and somewhat vague. In recognition of the need for a clearer understanding of sustainable development, the United Nation's World Commission on Environment and Development commissioned a study on the subject by what is now known as the **Brundtland Commission**. The resulting report, ***Our Common Future*** (1987), defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," which has become the accepted standard definition. The report also identified three components to sustainable development: economic growth, environmental protection, and social equity, and suggested that all three can be achieved by gradually changing the ways in which we develop and use technologies.

Although sustainable development is a widely accepted goal by many governmental and non-governmental agencies, concerns about what it means in practice have often been raised. One point of contention is over the role of economic development in fostering sustainable development. Some argue that economic growth is the best way to help developing countries conserve their natural resources, while others argue that any economic growth is unsustainable because we already consume too much.

The United Nations attempted to reconcile these views in 1992 by convening the first **Earth Summit** in Rio de Janeiro. It was here that the international community first agreed on a comprehensive strategy to address development and environmental challenges through a global partnership. The framework for this partnership was **Agenda 21**, which covered the key aspects of sustainability – economic development, environmental protection, social justice, and democratic and effective governance.

The second Earth Summit, held in Johannesburg in 2002, was an attempt by the UN to review the progress of the expectations raised in Rio and to reaffirm the commitment of world leaders in continuing to pursue actions towards sustainable development. The **Report of the World Summit on Sustainable Development** outlined the challenges to, and commitments of, the international community in attaining these goals. The summit leaders also developed a plan of implementation, which included means of eradicating poverty, changing unsustainable patterns of consumption, and protecting biodiversity and natural resources.

INDICATORS

Economic:
- Gross domestic product
- Trade balance
- Intensity of energy use

Social:
- Poverty rate
- Life expectancy
- Literacy rate

Environmental:
- Greenhouse gas emissions
- Percent of forested land
- Water quality

Institutional:
- R&D expenditures
- International cooperation
- Disaster preparedness

Since sustainable development goes well beyond economic issues, linking the economy, environment, and society, no comprehensive economic theory related to sustainable development exists. However, progress toward sustainable development is often measured by a variety of indicators, which can be used at the local, regional, national or international level. The primary components are economic performance, social equity, environmental measures, and institutional capacity. Examples of indicators within each component are located in the box to the left. Within the economic performance component, the indicators selected under economic structure are well-known and commonly used measures at the national and international levels. They reflect important issues of economic performance, trade, and financial status. Consumption and production patterns are also represented within the economic performance component, providing additional coverage of material consumption, energy use, waste generation and management, and transportation.

For many nations, the ability of the economy to meet basic needs allows them to focus more on environmental issues. Historically, the general public is not willing to place a high priority on protecting the environment when there is concern about achieving a certain level of welfare or economic goals. For example, when the economy was doing well in the United States in the late 1980s, there was an increased awareness about the environment. However, as the economic conditions began to decline in the early 1990s, people became more concerned about their own well-being and less concerned with the environment.

The study of economics has always emphasized the relative scarcity of resources, whether they are natural, capital, or human, thereby placing constraints on what we can have and affecting the choices and decisions made by individuals or by society. Sustainable development encompasses the view that a healthy environment is essential to support a thriving economy. Therefore, decisions should be made taking into account both the present and future value of our resources in order to achieve continued economic development without a decline of the environment.

Recommended Resources

Agenda 21
www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm
The U.N. Department of Economic and Social Affairs, Division of Sustainable Development offers the complete text of Agenda 21.

Report of the World Summit on Sustainable Development
www.world-tourism.org/sustainable/wssd/final-report.pdf
The full text of the official report from the second Earth Summit, held in Johannesburg in 2002.

United Nations Educational, Scientific and Cultural Organization: Education for Sustainable Development
portal.unesco.org/education/en/ev.php-URL_ID=27234&URL_DO=DO_TOPIC&URL_SECTION=201.html
In 2002, the United Nations General Assembly adopted the "Decade for Sustainable Development (2005-2014)" with UNESCO acting as the lead agency. This site features information on a variety of themes related to sustainable development and provides a clearinghouse for information briefs, news, and demonstration projects.

International Institute for Sustainable Development
www.iisd.org
The International Institute for Sustainable Development is a research organization that contributes to sustainable development – the integration of environmental stewardship, economic development and the well-being of all people, not just for today but for generations to come – by advancing policy recommendations on international trade and investment, economic policy, climate change, and natural resources management.

Chapter 5: How Markets Work – Supply and Demand

Two basic terms that are used most often by economists are ***supply*** and ***demand***. How much of something that is available - the supply - and how much of something people want - the demand - are what makes a working market. Markets have existed since early in history when people bartered and made exchanges for food, trinkets, and other goods.

The market is the way in which an economic activity is organized between buyers and sellers through their behavior and interaction with one another. Buyers, as a group, determine the overall demand for a particular product at various prices while sellers, as a group, determine the supply of a particular product at various prices.

The interaction of buyers and sellers in the market helps to determine the market price, thereby allocating scarce goods and services efficiently. The price is taken into account when deciding how much of something to consume, and also how much to produce. The relationship between price and quantity demanded is so universal that it is called the ***law of demand***. This law states that with all else equal, when the price of a good rises, the quantity demanded falls - and when the price falls, the quantity demanded rises. The ***law of supply*** is just the opposite: the higher the price, the higher the quantity supplied - and the lower the price, less quantity is supplied.

A key function of the market is to find the **equilibrium price** when supply and demand are in balance. At this price, the goods supplied are equal to what is being demanded thereby bringing about the most efficient allocation of the goods. An efficient allocation of goods in a market is one in which no one can be made better off unless someone else is made worse off.

There are influences other than price, however, that often play a role in keeping the market from being truly efficient and at equilibrium. On the demand side, income can clearly play a significant role. As income rises, people will buy more of some goods or even begin to purchase higher quality - or more expensive - goods. The price of related goods can also alter demand. If the price of one cereal increases, for example, demand will likely switch to a similar cereal - which would be considered a substitute good. If the goods are considered to be complimentary - or are typically used together - a decrease in the price of one of the goods will increase the demand for another. An example of complimentary goods would be cars and gasoline where the price of gasoline

depends partly on the number of cars. Personal tastes and expectations of the future also influence individual demands as does the number of buyers (an increase in buyers vying for a specific number of goods will increase the demand and likely increase the overall purchase price).

Variables that Influence Buyers (Demand)	Variables that Influence Sellers (Supply)
• Price • Income • Prices of related goods • Tastes • Expectations • Number of Buyers	• Price • Input prices • Technology • Expectations • Number of sellers

On the supply side, both expectations and the number of sellers can influence the number of goods produced. In addition, the cost of producing the good - or the input prices - as well as the level of technology used to turn the inputs into goods greatly influence the final price and quantity supplied.

Although most economic analyses focus on finding the market equilibrium, there exist a number of other **market forms**. When it comes to the utilization of natural resources or other environmental quality amenities, it is often difficult to find the equilibrium through mere market pricing since they are not true market goods. Efficiency would require maximizing current costs and benefits of using or extracting natural resources while also taking into consideration future costs and benefits, as well as the intrinsic and existence value of the resources. When the market fails to allocate the resources efficiently, market failure can occur. One example of this is the creation of **externalities**. Often, this occurs when clear property rights are absent, as with air and some water resources. Sometimes the government intervenes in an attempt to promote efficiency and bring the market back into equilibrium. Market options can include economic incentives and disincentives, or the establishment of property rights.

Recommended Resources

Price Theory, Lecture 2: Supply and Demand
www.csun.edu/~dgw61315/PTlect2y.pdf
Glen Whitman, an Associate Professor of Economics at California State

University, Northridge, shares his lecture notes on principles of supply and demand, constructing the market, and various types of competition.

Supply and Demand
en.wikipedia.org/wiki/Supply_and_demand
An excellent summary hosted by Wikipedia, the free encyclopedia.

Microeconomic Laws of Supply and Demand
mason.gmu.edu/~tlidderd/104/ch3Lect.html
Tancred Lidderdale's microeconomic resource hosted by George Mason University.

Chapter 6: Externalities

Externalities are unintentional side effects of an activity affecting people other than those directly involved in the activity. A negative externality is one that creates side effects that could be harmful to either the general public directly or through the environment. An example would be a factory that pollutes as a result of its production process. This pollution may pose health risks for nearby residents or degrade the quality of the air or water. Either way, the owner of the factory does not directly pay the additional cost to address any health issues or to help maintain the cleanliness of the air or water. In some cases, however, the harmed parties can use legal measures to receive compensation for damages.

A positive externality, on the other hand, is an unpaid benefit that extends beyond those directly initiating the activity. One example would be a neighborhood resident who creates a private garden, the aesthetic beauty of which benefits other people in the community. Also, when a group voluntarily chooses to create a benefit, such as a community park, others may benefit without contributing to the project. Any individuals or groups that gain additional benefits without contributing are known as "**free riders**".

Traditionally, both negative and positive externalities are considered to be forms of market failure - when a free market does not allocate resources efficiently. **Arthur Pigou**, a British economist best known for his work in welfare economics, argued that the existence of externalities justified government intervention through legislation or regulation. Pigou supported taxes to discourage activities that created harmful effects and subsidies for those creating benefits to further encourage those activities. These are now known as **Pigovian taxes and subsidies**.

Many economists believe that placing Pigovian taxes on pollution is a much more efficient way of dealing with pollution as an externality than government-imposed regulatory standards. Taxes leave the decision of how to deal with pollution to individual sources by assessing a fee or "tax" on the amount of pollution that is generated. Therefore, in theory, a source that is looking to maximize its profit will reduce, or control, their pollution emissions whenever it is cheaper to do so.

Other economists believe that the most efficient solution to externalities is to include them in the cost for those engaged in the activity. Thus, the externality is "internalized." Under this framework externalities are not necessarily market failures, which weaken the case for government intervention. Many externalities

(pollution, free rider benefits) can be internalized through the creation of well-defined **property rights**. Through much of his work, economist **Ronald Coase** showed that taxes and subsidies were typically not necessary as long as the parties involved could strike a voluntary bargain. According to **Coase's theorem,** it does not matter who has ownership, so long as property rights exist and free trade is possible.

Two methods of controlling negative externalities loosely related to property rights include **cap and trade** and **individual transferable quotas** (ITQs). The cap and trade approach sets a maximum amount of emissions for a group of sources over a specific time period. The various sources are then given emissions allowances which can be traded, bought or sold, or banked for future use, but - over the course of the specified period of time - overall emissions will not exceed the amount of the cap and may even decline. Therefore, individual sources, or facilities, can determine their level of production and/or the application of pollution reduction technologies or the purchase of additional allowances.

Individual transferable quotas are a market-based solution that is often used to manage fisheries. Regulators first determine a total annual catch that will preserve the health of the ecosystem, and then it is divided into individual quotas to prevent over-fishing. Each ITQ allows for a certain amount of fish to be caught in any given year. ITQs are transferable, which allows fishing vessel owners to buy and sell their quotas depending on how much they want to catch. The ITQ program also tries to create a commercial fishing industry that is more stable and profitable.

The options for dealing with externalities - positive or negative - are numerous, and often depend on the type of externality. The key is to identify the particular tool or policy alternative that will best move the market toward the most efficient allocation of resources.

Recommended Resources

Law & Economics, Lecture 2: Externalities
www.csun.edu/~dgw61315/L&Elect2.pdf
Glen Whitman, an Associate Professor of Economics at California State University, Northridge, shares his lecture notes on principles of both macroeconomics and microeconomics including discussions on division of

labor, opportunity costs, diminishing returns and the components of market equilibrium.

Environmental Externalities in Electric Power Markets
tonto.eia.doe.gov/FTPROOT/features/rea1.pdf
This article by John Carlin, an industry analyst at the Energy Information Administration, discusses environmental externalities associated with electric power markets, such as acid rain, ozone and climate change. Also discussed are incentive-based measures, such as emissions fees and systems of marketable emissions allowances as a means of regulating externalities.

Socioeconomics of Individual Transferable Quotas and Community-Based Fishery Management
www.findarticles.com/p/articles/mi_qa4046/is_200410/ai_n9470006/print An October 2004 *Agricultural and Resource Economics Review* article by Parzival Copes, Professor Emeritus, Institute of Fisheries Analysis, Simon Fraser University, and Anthony Charles, Professor, Management Science and Environmental Studies, Saint Mary's University. The article was written as part of a project to provide fishery participants and coastal communities in Atlantic Canada with a socioeconomic assessment of fishery management approaches.

Chapter 7: Net Present Value

Economists focus much of their analyses on a marketplace where supply and demand are based on the perceptions of present value and scarcity. However, when going beyond the simplicity of the short-term, particularly when costs and benefits occur at different points in time, it is important to utilize **discounting** to undertake longer-term analyses. Discounting adjusts costs and benefits to a common point in time. This approach can be useful in helping to determine how best to utilize many of our non-renewable natural resources.

Net present value (NPV) is a calculation used to estimate the value – or net benefit – over the lifetime of a particular project, often longer-term investments, such as building a new town hall or installing energy efficient appliances. NPV allows decision makers to compare various alternatives on a similar time scale by converting all options to current dollar figures. A project is deemed acceptable if the net present value is positive over the expected lifetime of the project.

The formula for NPV requires knowing the likely amount of time (*t*, usually in years) that cash will be invested in the project, the total length of time of the project (*N*, in the same unit of time as *t*), the interest rate (*i*), and the cash flow at that specific point in time (cash inflow – cash outflow, *C*).

$$\mathrm{NPV} = \sum_{t=0}^{N} \frac{C_t}{(1+i)^t}$$

For example, take a business that is considering changing their lighting from traditional incandescent bulbs to fluorescents. The initial investment to change the lights themselves would be $40,000. After the initial investment, it is expected to cost $2,000 to operate the lighting system but will also yield $15,000 in savings each year; thus, there is a yearly cash flow of $13,000 every year after the initial investment. For simplicity, assume a discount rate of 10% and an assumption that the lighting system will be utilized over a 5 year time period. This scenario would have the following NPV calculations:

t = 0 NPV = (-40,000)/(1 + .10) 0 = -40,000.00
t = 1 NPV = (13,000)/(1.10) 1 = 11,818.18
t = 2 NPV = (13,000)/(1.10) 2 = 10,743.80
t = 3 NPV = (13,000)/(1.10) 3 = 9,767.09

t = 4 NPV = (13,000)/(1.10) 4 = 8,879.17
t = 5 NPV = (13,000)/(1.10) 5 = 8,071.98

Based on the information above, the total net present value over the lifetime of the project would be $9,280.22.

Once the net present value is calculated, various alternatives can be compared and/or choices can be made. Any proposal with a NPV < 0 should be dismissed because it means that a project will likely lose money or not create enough benefit. The clear choice is a project whose NPV > 0 or, if there are several alternatives with positive NPVs, the choice would be the alternative with the higher NPV. With most societal choices, the **opportunity costs** are also considered when making decisions. Net present value provides one way to minimize **foregone opportunities** and identify the best possible options.

This particular example assumes that the interest rate does not change over time. Longer periods of time will often require separate calculations for each year in order to adjust for anticipated changes in the interest rate. When **discounting** is used it takes into account the fact that benefits in the future are not expected to be worth as much as in the present time. For example, $10 today may only be worth $9, $5, or even $1 in 2025. The rationale behind using a discount rate is two-fold: all things being equal, (1) individuals prefer to benefit now rather than later and (2) they tend to be risk averse, uncertain of what will occur in the future.

Net present value calculations can also help account for **depreciation**. Over time most assets depreciate, or lose value. Companies or individuals must be able to calculate a rate that includes depreciation for account balancing and tax purposes, as well to help predict replacement times for the asset in question. NPV and depreciation calculations are extremely valuable in the world of economics; they tell us what projects and businesses are better investments and what outcomes we may expect in the future.

However, while depreciation rates can be reliably estimated for most physical items, such as computer equipment or buildings, their application to natural resources and other environmental issues is more uncertain. Natural resources do not necessarily lose value over time. Thus, in most cases natural resources should not be depreciated when calculating resource NPVs. Also, since there is uncertainty about the future and external effects exist, it is much easier to predict what a company can do and what the reaction will be in the structured world of business than to accurately assess, say, the value of a forest to a local economy in future years.

Despite how helpful calculating NPV can be, using it to assess projects related to the environment will continue to be controversial. **Ecosystem valuation** is a complex process that does not always result in the assignment of accurate values to natural resources. And, while the use of discounting may make sense for money – being not as valuable in the future as it is today – it may be more difficult to use in assessing natural resources. Since many natural resources often increase in value, this type of evaluation method would need to recognize increased future resource values and/or that of other environmental services.

Recommended Resources

Cost Analysis for Pollution Prevention
www.kbeap.org/Resources/p2costanalysis.pdf
The Washington State Department of Ecology emphasizes the importance of using net present value calculation in the economic analysis of pollution prevention measures.

Discounting in the Long Term
llr.lls.edu/volumes/v35-issue1/bazelon.pdf
Authors Bazelon and Smetters discuss the use of discounting in making public policy choices in this Loyola of Los Angeles *Law Review* article.

An Eye on the Future
iis-db.stanford.edu/pubs/20078/Discounting.pdf
A straightforward *Nature* article by Lawrence Goulder and Robert Stavins explaining the process of discounting future values in an environmental policy context.

Making a Compelling Energy Efficiency/Pollution Prevention Case to Business
www.aceee.org/p2/primer.htm
The American Council for an Energy Efficient Economy makes the case why energy efficiency and pollution prevention can be valuable investments for business. Included are explanations on how to calculate costs and benefits, as well as net present value.

VIEWPOINTS

Choice and Discounting
www.findarticles.com/p/articles/mi_m1076/is_n2_v39/ai_19279716

A March 1997 article in *Environment* magazine looks at using present value and cost-benefit analysis in environmental decision making. Author Kerry Smith, supports using present value, but acknowledges that no method is perfect.

Nature is More Than a Commodity
www.sustainabilityinstitute.org/dhm_archive/index.php?display_article=vn408commodityed
Donella Meadows, of Dartmouth College, writes about ecosystem valuation and using net present value to determine the worth of natural resources. Her view is that the current methods of valuation are not adequate, frequently discrediting the true value of our environment.

Chapter 8: Ecosystem Valuation

Valuation can be a useful tool that aids in evaluating different options that a natural resource manager might face. Because our ecological resources and services are so varied in their composition, it is often difficult to examine them on the same level. However, after they are assigned a value, an environmental resource or service can then be compared to any other item with a respective value. **Ecosystem valuation** is the process by which policymakers assign a value – monetary or otherwise – to environmental resources or to the outputs and/or services provided by those resources. For example, a mountain forest may provide environmental services by preventing downstream flooding.

Environmental resources and/or services are particularly hard to quantify due to their intangible benefits and multiple value options. It is almost impossible to attach a specific value to some of the experiences we have in nature, such as viewing a beautiful sunset. Problems also exist when a resource can be used for multiple purposes, such as a tree – the wood is valued differently if it is used for flood control versus if it is used for building a house. The quantity of a resource must also be taken into consideration because value can change depending how much of a resource is available. An example of this might be in preventing the first “unit” of pollution if we have a pristine air environment. Preventing the first unit of pollution is not valued very highly because the environment can easily recover. However, if the pollution continues until the air is becoming toxic to its surroundings; the value of preserving clean air by preventing additional pollution is going to be increasingly valued.

Within economics, value is generally defined as the amount of alternate goods a person is willing to give up in order to get one “additional unit” of the good in question. An individual's preference for certain goods may either be stated or revealed. In the case of stated preferences, the amount of money a person is willing to pay for a good determines the value because that money could otherwise be used to purchase other goods. However, value may also be determined by simply ranking the alternatives according to the amount of benefit each will produce. Revealed preferences can be measured by examining a person's behavior when it is not possible to use **market pricing**.

There are typically two ways to assign value to environmental resources and services – **use** and **non-use** – and there are approaches to measuring environmental benefits based on these defined values. When environmental resources or services are being used, it is easier to observe the price consumers are willing to pay for the conservation or preservation of those resources. Market or **opportunity cost pricing** can be used when there are tangible products to measure, such as the amount of fish caught in a lake. Replacement cost can also be used, calculated based on any expenses incurred to reverse environmental damage. **Hedonic pricing** will measure the effect that negative environmental qualities have on the price of related market goods. When evaluating non-use value, **contingent valuation** is employed through the use of surveys that attempt to assess an individual's willingness to pay for a resource that they do not consume.

A **cost-benefit analysis** requires the quantification of possible impacts of a proposed project. The impacts could be physical or monetary, but both must be calculated and included since a financial analysis that requires assigning dollar values to every resource evaluated is also performed. The process of environmental resource or service valuation provides a way to compare alternative proposals, but it is not without problems. All valuation techniques encompass a great deal of uncertainty: flaws can exist in the methods of assigning value accurately due to a wide number of variables and it is difficult to compartmentalize and measure environmental and natural resources and/or services within an ecosystem that functions as an interconnected web.

In summary, **ecosystem valuation** is a complex process by which economists attempt to assign a value to natural resources or to the ecological outputs and/or services provided by those resources. Although challenging, it allows policymakers to make decisions based on specific comparisons, typically monetary, rather than some other arbitrary basis. In recent years, the government has placed increasing emphasis on cost-effective laws and projects. Therefore, establishing a common measure by which to evaluate alternatives is essential.

Recommended Resources

EcosystemValuation.org
www.ecosystemvaluation.org/index.html
Professors Dennis King from the University of Maryland and Marisa Mazzotta from the University of Rhode Island provide this website for non-economists

with clear, non-technical explanations of ecosystem valuation concepts, methods, and applications.

Environmental Valuation
www.csc.noaa.gov/coastal/economics/envvaluation.htm
The National Oceanic and Atmospheric Administration provides a thorough explanation of how we determine the value of our environmental resources.

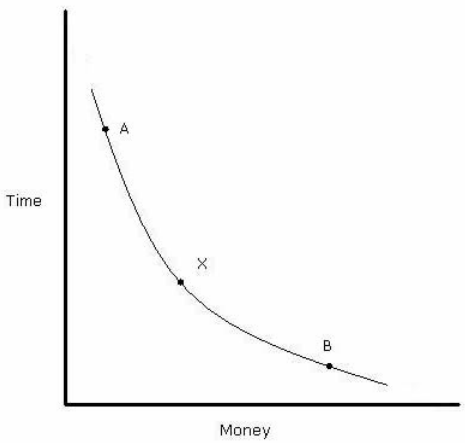
Ecosystem Valuation
en.wikipedia.org/wiki/Ecosystem_valuation
An excellent summary hosted by Wikipedia, the free encyclopedia.

Ecological Benefits Assessment Strategic Plan
yosemite.epa.gov/ee/epa/eed.nsf/webpages/EcologBenefitsPlan.html
The Environmental Protection Agency developed this strategic plan to identify the ecological benefits of environmental policy. The webpage gives an overview of the plan and provides access to a copy of the plan and related resources.

Chapter 9: Trade-offs

As we make everyday choices – how much time to spend working or studying, what to spend our money on – we are experiencing what in economics are called **trade-offs** and **opportunity costs**. A trade-off is when we choose one option in favor of another and the opportunity cost is what is sacrificed in order to get something. Whether we realize it or not, we are constantly evaluating the costs and benefits of each decision we make; therefore, it can also be said that we are performing our own **cost-benefit analysis** each time we make a choice.

As decisions are made – either individually or as a society – we constantly make trade-offs in order to get more of one thing by giving up another. The saying "time is money" illustrates this point. If we 'consume' more free time, we are left with less money due to the fact that we are not earning money from using the time to work. The opposite is true as well; if we want more money, we must put in more work hours to get it; therefore there is less free time available. When we consider time and money, and graph the combinations for where one has no preference of one over the other, we come up with an **indifference curve**, such as the one below.



On the graph, X is the point where we have an even balance of time and money; yet an indifference curve is such that one is equally satisfied at any point along the curve. Therefore, we could move to point A, where we would have a lot more time but less money, or we could move to point B, with a lot more money but less time, and we would be equally satisfied. The slope of the indifference curve is based on the **marginal utility** of each decision; each successive move towards an axis comes at a higher price. For example, at point B we require more money for each unit of time than we do at point X because our time is more valuable since we have less of it. Therefore, we will begin to experience diminishing marginal utility.

The economy and the environment are inextricably linked. Whether one is looking at daily life or natural resources and other environmental issues, because

resources are scarce, choices have to be made about how to use them. The basic fact is that resources used to meet one choice or alternative cannot be used to meet another. Just like how we value regular goods, the **valuation** of natural resources and the environment is based on how we value their services and, for services that are consumed directly, that value is based on our utility and willingness to pay for a certain amount of the services.

The decision about how to allocate resources relating to the environment has an impact on all sectors of our economy, primarily because of the complex relationship between utilizing natural resources and economic output. Many times, the cost of utilizing these resources and/or services include **direct costs** as well as **opportunity costs** and **external costs**, which are not traded in markets or assessed directly in monetary terms. For example, when trees are cut for such uses as housing and furniture, some of the direct costs will include the cost of machinery and labor during cutting, processing, and manufacturing. The opportunity costs relating to this use would be the opportunities foregone by the machinery and labor that could not be used elsewhere, since it was occupied cutting trees. The external costs are the loss of environmental benefits that are no longer realized which may include a loss in watershed management services, species protection, and CO_2 reduction.

Many agree that in most cases the market is the best way to determine the allocation of resources. The demand for various products and the availability of natural resources – along with a number of other factors, including preferences, the number of buyers and sellers, pricing, alternative choices, etc – is expected to lead to an efficient result of actual supply and demand. However, markets can fail to account for the full cost of a natural resource and/or services, which will prevent it from achieving an efficient allocation of the resource, leading to **externalities**.

To reduce the potential for market failures and their resulting externalities, planners and policymakers attempt to identify a course of action that generates the greatest societal benefits. Much of this is done by using a mix of policy and strategies, including regulation, taxes, permits, access restrictions, etc. It is finding the appropriate balance between utilizing our natural resources and meeting the demands of society that will allow us to continue to expand our economy while sustaining our natural resources and the environment.

Recommended Resources

Full Cost Accounting in Environmental Decision-Making
edis.ifas.ufl.edu/FE310
David W. Carter, Larry Perruso, and Donna J. Lee from the University of Florida write about how governments, businesses, and individuals make decisions that should take into consideration all of the trade-offs when calculating the most efficient and economic choice.

Engineering Trade-Offs
www.epa.gov/nrmrl/std/sab/eto/eto_concept.htm
The Environmental Protection Agency established a program to assist decision-makers in evaluating the various trade-offs when making choices. They include consideration for environmental impacts, effectiveness, efficiency, and people affected.

Opportunity Cost
www.netmba.com/econ/micro/cost/opportunity/
This website clearly explains the concept of opportunity cost, providing examples and applications to clarify understanding.

VIEWPOINTS

Environment-Economy Trade-Offs and Forest Environmentalism
http://egj.lib.uidaho.edu/egj18/hand1.html
Carl Hand and Ginger Macheski from Valdosta State University examine how the public views forest management in this 2003 article from the *Electronic Green Journal*. The authors asked participants to weigh the importance of conservation versus the economy, and found that most people wanted both aspects considered, with slightly more emphasis on the environment.

Chapter 10: Marginal Costs and Benefits

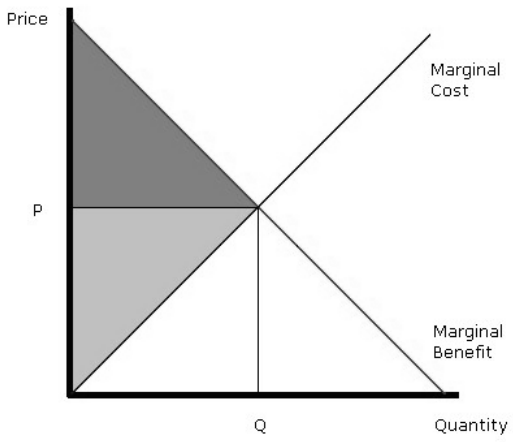
Marginal costs and benefits are essential information for economists, businesses, and consumers. Even if we do not realize it, we all make decisions based on our marginal evaluations of the alternatives. In other words, "what does it cost to produce one more unit?" or "what will be the benefit of acquiring one more unit?"

When necessary, individual and social marginal cost and benefit curves can be drawn separately in order to understand different effects that a given action or policy might have. In the case of pollution, the social cost is generally higher than the individual cost due to **externalities**. However, as a whole, an economic system is considered efficient at the point where marginal benefit and marginal cost intersect, or are equal. Similar to the production of goods and services, we can utilize the same information in order to analyze pollution abatement – in terms of the *production* or *reduction* of pollution – within the market. In order to assess environmental improvement, we must take cost into consideration. The cost of these improvements is often thought of as the direct cost of any action taken in order to improve the environment.

Marginal cost measures the change in cost over the change in quantity. For example, if a company is producing 10 units at $100 total cost, and steps up production to 11 units at $120 total cost, the marginal cost is $20 since only the last unit of production is measured in order to calculate marginal cost. Mathematically speaking, it is the **derivative** of the total cost. Marginal cost is an important measurement because it accounts for increasing or decreasing costs of production, which allows a company to evaluate how much they actually pay to 'produce' one more unit.

Marginal cost will normally initially decrease through a short range, but increase as more is produced. Therefore the marginal cost curve is typically thought of as upward sloping. The marginal cost curve can represent a wide range of activities that can reduce the effects of environmental externalities, like pollution. The key point is that most environmental improvements are not free; resources must be expended in order for improvement to occur. For example, take an environment that has been polluted – while the initial *unit* of cleanup may be cheap, it becomes more and more expensive as additional cleanup is done. If cleanup is undertaken to point "Q", the total cost of the cleanup is P*Q the white and light gray areas on the graph below.

Marginal benefit is similar to marginal cost in that it is a measurement of the change in benefits over the change in quantity. While marginal cost is measured on the producer's end, marginal benefit is looked at from the consumer's



perspective – in this sense it can be thought of as the demand curve for environmental improvement. The marginal benefit curve represents the tradeoff between environmental improvement and other things we could do with the resources needed to gain the improvement.

Again take an environment that has been polluted, the first unit of this pollution that is cleaned up has a very high benefit value to consumers of the environment. Each additional unit that is cleaned up is valued at a somewhat lower level than each previous one because the overall pollution level continues to decrease. Once the pollution is reduced below a certain point, the marginal benefit of additional pollution control measures will be negligible because the environment itself is able to absorb a low level of pollution. Taking a look at the graph above, the total consumer benefit that is represented as the dark grey area, the net benefit is greatest when the quantity – "Q" – reaches the marginal benefit curve. We could increase total benefit by adding pollution controls beyond Q, but only with marginal costs (MC) greater than marginal benefits (MB), so it is no longer efficient to further increase the benefits.

Oftentimes, benefits are more difficult to measure because they are not always monetary. In cases such as these the measurement may involve utilizing revealed preferences, through a survey or another mechanism, in order to discover the maximum price consumers are willing to pay for a particular quantity of a good. An *average* benefit is used when considering society as a whole because each individual's willingness to pay is different.

Marginal costs and benefits are a vital part of economics because they help to provide the relevant measurement of costs and benefits at a certain level of production and consumption. If measured marginal costs and benefits are provided, it is much easier to calculate the ideal price and quantity. It is where the two intersect that will always be the most economically efficient point of production and consumption.

When considering environmental issues, the efficient point at which marginal costs and marginal benefits are equal is an important economic concept because it captures the essence of tradeoffs. Often, environmental improvement concerns often revolve around whether we are above or below this point –

whether any additional environmental improvement can provide more benefit than it will cost; this becomes an essential component in **cost-benefit analysis**.

Recommended Resources

Efficiency and Markets
www.ingrimayne.com/econ/optional/effic/EfficiencyMark.html
A good summary and part of Economics Professor Robert Schenk's (Saint Joseph's College) online textbook for introductory Economics. Also see: "The Maximization Principle" [*ingrimayne.com/econ/LogicOfChoice/MaximPrin.html*].

Marginal Analysis
sorrel.humboldt.edu/~economic/econ104/marginal/
Tim Yeager of Humboldt State University includes this excellent introduction (including PowerPoint slides) to marginal costs and benefits in his Contemporary Topics in Economics course.

VIEWPOINTS

Pareto Optimality, External Benefits and Public Goods: A Subjectivist Approach
www.mises.org/journals/jls/4_1/4_1_6.pdf
Barry Brownstein of the University of Baltimore makes the case that arguments regarding external benefits and public goods are generally incorrect since they fail to consider all of the costs involved in deciding whether the public sector should subsidize or provide the goods in question.

Chapter 11: Cost Benefit Analysis

Cost-benefit analysis (CBA) is an analytical way for society to make decisions about complicated issues such as education, health care, transportation, or the environment. Like most personal decisions, it involves a comparison of the costs of an action compared with considerations of the benefits of that action. However, for public policy it is formalized and quantitative. For instance, a public policy can be evaluated by calculating and weighing the benefits against the costs, once all factors have been given a common unit of measurement. When policymakers have to choose among various alternatives, they require a tool that will allow them to distinguish between the options. Decision makers can then choose the policy with the largest surplus, or overall net benefits. In recent years, for example, the U.S. government is increasingly seeking more cost-effective policies in order to balance the budgets. While the overall concept of CBA is simple, the steps taken to evaluate each benefit and cost can become quite complicated.

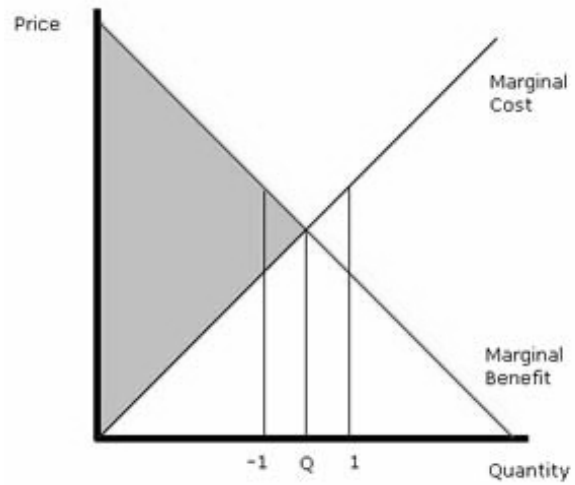
The most important component of a CBA is the **base situation** – or what would happen if no changes were made. All other decisions are compared to this base situation. The first step is to identify the relevant time period: when would the costs and benefits be realized? Once the base and relevant time period are established, benefits and costs can be calculated in terms of human well being. In this case, a benefit is defined as anything that increases human well-being, and a cost is anything that decreases it. These definitions and their respective calculations tend to provoke controversy due to the use of **valuation** and **discounting**, which involves applying a mathematical formula to determine the present value of future benefits and costs. For example, a dollar today will not be worth the same amount in 50 years, its value will have decreased due to inflation. Also, today's dollar could be put to other uses (**foregone opportunities**) which can decrease its net future value in the chosen use. Discounting takes the values of costs and benefits in the future and "discounts" them by the value of the foregone opportunities, or makes them smaller, to account for their inevitable change in value.

Measuring the benefits of a policy can involve anything from additional income, to an increased quality of life, or even to a cleaner environment; costs may consist of forgone opportunities, internal and external costs, and externalities. However, in measuring costs, it is important not to confuse **externalities** with **secondary effects**: externalities result in real output changes whereas secondary effects do not. An example of this would be electricity generation - the externality would be pollution while the secondary effect would be the increased

cost of doing business when the price of electricity rises. The pollution actually generates new costs, such as the need to scrub sulfur dioxide from smokestacks. The increased business costs are simply a reflection of the fluctuation in the price of electricity which is already calculated as a cost. In order to avoid double-counting, only true externalities can be included in a CBA.

After all benefits and costs have been given a common unit of measurement, options can be evaluated. The ideal situation will result in **Pareto improvement**: some are made better-off while no one is made less well off. But, since the ideal outcome is rare, CBA is based on a 'potential' Pareto improvement and economic efficiency. A potential Pareto improvement is where the possibility exists for compensation to those who are less well off, whether or not it actually happens.

A final result of a CBA should be where **marginal benefits** and **marginal costs** of a proposed project are equal. In the graph below, this is at point Q. The surplus is illustrated by the shaded area in the graph. At the equilibrium, the surplus is greatest, making it the best possible solution. If the quantity were to increase to point 1, the marginal costs would exceed the marginal benefits, meaning it would not economically efficient. If the quantity were to decrease to point -1, some of the surplus would be lost, which would also indicate inefficiency. CBA aims to achieve point Q, where marginal benefit and marginal cost are equal in order to maximize economic efficiency.



The uncertainty of these forecasts can create a fundamental problem when policymakers rely entirely on CBA to make a decision. Critics argue that cost-benefits analysis does not include equity considerations. Ecological valuation and discounting are other controversial aspects of CBA because there are many different values that certain natural resources could assume, and the discount rate chosen will have significant implications for the resulting analysis. These arguments are perhaps the best illustration of why CBA can best be used when combined with other forms of analysis.

Recommended Resources

An Introduction to Cost-Benefit Analysis
www2.sjsu.edu/faculty/watkins/cba.htm
Thayer Watkins, a professor of economics at San Jose State University, has put together this comprehensive site about cost-benefit analysis which explains the key concepts using a thorough example.

Cost-Benefit Analysis and Environmental Decision-Making
sunsite.utk.edu/ncedr/tools/othertools/costbenefit/overview.htm
The National Center for Environmental Decision-making Research outlines the key aspects of cost-benefit analysis, including the rationale behind it, some technical considerations, and further information.

VIEWPOINTS

Priceless Benefits, Costly Mistakes: What's Wrong with Cost-Benefit Analysis
www.paecon.net/PAEReview/issue25/Ackerman25.htm
Frank Ackerman of Tufts University, critiques the economic theory of cost-benefit analysis, primarily as it relates to current conservative politics.

Chapter 12: Environmental Impact Analysis

> **"To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation…"**
>
> ***~ National Environmental Policy Act (1969)***

An **environmental impact analysis** is typically conducted to assess the potential impact a proposed development project will have on the natural and social environment. This may include an assessment of both the short- and long-term effects on the physical environment, such as air, water and/or noise pollution; as well as effects on local services, living and health standards, and aesthetics.

In enacting the **National Environmental Policy Act (NEPA) of 1969**, Congress required all agencies of the Federal government to give equal consideration to environmental consequences as well as to economic motivations and technological feasibility when making a decision that could affect the quality of the human and natural environment. NEPA also established the **Council on Environmental Quality** within the Executive Office of the President to ensure that federal agencies would meet their obligations under the Act.

One provision of the law requires that an **Environmental Impact Statement** (EIS) be written for major federal actions and made available to all, including to the general public. An EIS must include: the environmental impacts of a proposed action; unavoidable adverse environmental impacts; alternatives – including no action; the relationship between short-term uses of the environment and maintenance of long-term ecological productivity; irreversible and irretrievable commitments of resources; and secondary/cumulative effects of implementing the proposed action. Now, most state and local governments also require that environmental impact analyses be conducted prior to any major development projects.

Environmental impact analyses are often challenging because they call for making projections with incomplete information. Methods of assessing the impacts typically include both objective and subjective information making it difficult to quantify. Therefore, the methods are frequently seen as complex and, oftentimes, controversial. Despite being a requirement for many development projects, the function of an environmental impact statement is merely

procedural. There is no specific legal force of action if information stemming from an environmental impact analysis confirms that a particular project may harm the environment. As a result, it is often left up to the courts to rule on whether risks to the environment are overstated or not.

Although **environmental impact analysis** often raises more questions than it answers as it examines the various links between social, economic, technological, and ecological factors involved in a potential development project, it also provides a practical and interesting approach to the understanding and appreciation of the many complexities and uncertainties involved with these interrelationships.

Recommended Resources

Council for Environmental Quality: NEPANet
ceq.eh.doe.gov/nepa/nepanet.htm
This site contains the full text of the National Environmental Policy Act, guidelines for preparing an environmental impact statement, and reports on NEPA's effectiveness.

Community Guide to Development Impact Analysis
www.lic.wisc.edu/shapingdane/facilitation/all_resources/impacts/analysis_environmental.htm
This guide, developed by Mary Edwards, an Assistant Professor at the University of Wisconsin – Madison, includes a chapter on environmental impact analysis. Edwards provides a good overview of the topic, as well as general guidelines and steps to follow in conducting an environmental impact assessment.

The Global Development Research Center
www.gdrc.org/uem/eia/impactassess.html
The Center carries out initiatives in education, research, and practice in the spheres of environment, urban, community, economy and information. They offer a variety of documents and information repositories on environmental impact assessment.

Chapter 13: Regulatory Policy vs. Economic Incentives

> **“Command-and-control is comforting to politicians and people: governments know what they are asking for, people know what they are getting, companies know what they are supposed to deliver; the only people who do not like it are economists.”**
>
> ***~ The Economist, September 2, 1989***

Environmental regulation in the United States has traditionally relied on **command-and-control** policies in which regulators – typically the government – set standards or limits and apply them uniformly to a broad category of sources. There are three types of command-and-control mechanisms that regulators can choose to implement: ambient, emissions, or technology standards.

An **ambient standard** sets the amount of a pollutant that can be present within a specific environment. An example of this would be when a regulator sets a limit on ground level ozone [parts per million or “ppm”] allowable within a city's limits. This is also an example of an indirect regulation because although emissions from individual sources are being restricted, the ambient level is what the standard is attempting to control. **Emissions standards** are much more common as they seek to limit the amount of emissions released by a firm, industry, or area. It differs from an ambient standard because its use does not determine the ambient level of a pollutant in the environment; rather, it attempts to reduce the overall amount of a pollutant released on a firm-by-firm basis. Finally, regulators can choose to implement a **technology-based standard** which would force polluters to use a particular pollution control technology that they deem reasonably cost-effective, such as installing scrubbers on smokestacks.

It is believed by many that the primary advantage of using command-and-control mechanisms is that they provide a clear outcome. It is also comparatively simple to monitor compliance since regulators only have to make sure that the standard has been met. Therefore, it is possible that an emissions reduction goal can be reached; if not, the violators will pay a fine.

However, command-and-control mechanisms have several drawbacks. One key element is information uncertainty. It is not only very costly for regulators to gather necessary information, they often have to collect it from the sources that

they are regulating, creating the possibility for inaccurate or dishonest reporting. Another significant concern is that polluters have very little choice about how to meet the standard since some standards are strictly dictated by the regulators. Therefore, there is no incentive for the sources to research new and creative ways to further reduce their own pollution emissions. However, in the case of emission standards, sources are often able to decide how they can best meet the standard. Finally, since command-and-control mechanisms are uniformly applied across broad categories of sources, it is unlikely that it can be the most cost-effective way to decrease pollution levels or emissions. Because the **marginal costs** for limiting pollution will vary among the sources, it also essentially guarantees that equity will not be achieved. Under this scenario, polluters are not charged for the marginal cost of pollution that they continue to emit; only for the pollution they abate, which is economically inefficient.

Economic incentives – which have been debated by economists for decades – have only recently begun to play a larger role in both national and international environmental policy. As regulators seek to meet increasingly costly environmental quality goals, they have begun to look at incentives as a more flexible, lower cost alternative. It is expected that the regulatory system can be made more effective by promoting environmentally efficient choices with less government interference. Incentive-based policies aim to encourage polluters to find innovative, low-cost ways to reduce their environmental emissions by offering rewards or by doling out punishments in the form of taxes or fees, marketable permits, or liability.

Taxes or fees charge the polluter a certain amount per unit of pollution, the value of which is determined by the regulator. **Marketable permits** allow companies to pollute at a level that is marginally cost-effective. It allows them to buy additional permits as needed if they fail to meet their targets internally, and to sell excess permits if they exceed their internal pollution reduction targets. **Liability** involves establishing a precautionary level that allows for the greatest benefit to society, and holding firms to that standard if a problem arises. While more flexible than true established standards, it puts the burden on the firm to take certain levels of precaution with respect to environmental issues or to be held accountable for any negative results.

Incentives have several advantages, including allowing the source to play a role in determining the most cost-effective way to reduce their emissions and, thereby, in meeting their marginal costs. All three types of incentives attempt to maintain the "**equimarginal principle**," or when the marginal control costs are equal across all sources. This creates an efficient or "least cost" overall solution. Also, when compared to command and control mechanisms, the regulator requires less information under an incentive program since there is greater motivation for polluters to devise their own innovative solutions.

Therefore, the regulator does not need to know how cost-effective various control options will be, or what the cost is at any particular installation, because the source will be held accountable for all of their actions and will pay both pollution control costs and damage costs.

Although many may be in favor of using economic instruments – when it comes to taxes – the affected sources are often in opposition. These affected groups begin to perceive economic policy instruments as imposing higher costs than command-and-control regulations. Taxes also present political obstacles since no industry likes to see increased taxes, and politicians do not want to lose support by passing legislation that includes more taxes. Of additional concern is the view of added complexity as regulators attempt to address pollution issues across diverse areas and/or industries. However, pollution taxes are sometimes desired by companies if they are applied to all since the equal taxation is viewed to be 'fair.'

In the case of environmental policy, politicians are primarily concerned that something be done and less interested in the specific choice or design of the policies. Oftentimes, economic incentives have to be approved by a political system where the bargaining processes become important, and the issues to be sorted out between officials, experts, and the affected parties become more technical and legal in nature. However, while **command-and-control regulation** is still common, more and more legislation is beginning to use **market mechanisms**, or a combination of command-and-control along with market mechanisms, in order to best meet the demands of the environmental issues at hand.

Recommended Resources

Economic Incentives for Pollution Control
yosemite.epa.gov/ee/epa/eed.nsf/webpages/EconomicIncentivesPollutionControl.html
A variety of reports from EPA's National Center for Environmental Economics examine the interest and use of economic incentive mechanisms for environmental management over the past 20 years in both the U.S. and abroad.

The Economics of Pollution Control at the Local and Global Levels
www.globalchange.umich.edu/globalchange2/current/lectures/pollution_control/pollution_control.html
This lecture, part of the University of Michigan Program in the Environment's

Global Change Curriculum, offers an introduction to environmental economics and pollution control and mechanisms for reduction, including at the global level. Definitions and additional suggested readings are also included.

Pollution Controls
www.econlib.org/LIBRARY/Enc/PollutionControls.html
The Library of Economics and Liberty 's Concise Encyclopedia of Economics contains a thorough article by Robert Crandall of the Brookings Institution that describes economic aspects of pollution control, including command-and-control and incentive-based policies.

Regional Clean Air Incentives Market (RECLAIM)
www.aqmd.gov/reclaim/reclaim.html
This project, implemented in California in 1994, utilizes tradable emissions permits as an innovative approach to air quality regulation.

VIEWPOINTS

Rescuing Environmentalism
www.economist.com/opinion/displayStory.cfm?story_id=3888006
This article appeared in the April 2005 *Economist* in response to the publication of *The Death of Environmentalism*, a book which criticizes the current state of the "green" movement and encourages environmentalists to become more politically viable. The article agrees with the book's prognosis and offers solutions which focus on utilizing markets.

Appendix: Resources for the Classroom

Basic Economics

CyberEconomics: An Analysis of Unintended Consequences
www.ingrimayne.com/econ/mainmenu.htm
A comprehensive website on basic economics created by Robert Schenk, Professor of Economics at Saint Joseph's College in Indiana.

Essential Principles of Economics: A Hypermedia Text
william-king.www.drexel.edu/top/prin/txt/EcoToC.html
Roger A. McCain, Professor of Economics at Drexel University, compiled information in this website based on his lecture notes. He includes principles of both macroeconomics and microeconomics including discussions on division of labor, opportunity costs, diminishing returns and the components of market equilibrium.

Resources for Economists
www.rfe.org/
Bill Goffe, Dept. of Economics, SUNY Oswego, runs this comprehensive list of more than 2,000 online resources of interest to practicing economists and journalists, teachers, students, and other members of the public interested in learning more about economics. Sponsored by the American Economics Association.

Introduction to Economic Models of Natural Resource Utilization
www.agecon.lsu.edu/WebClasses/AGEC3503/WebUnit1/Web%20Unit%201-1.htm
Richard Kazmierczak, Jr., an Associate Professor at Louisiana State University, compiled this information based on his class in Natural Resource Economics.

National Council on Economic Education
www.ncee.net
The National Council on Economic Education (NCEE) is a nationwide network promoting economic literacy. Their mission is to help students develop the real-life skills they need to succeed: to be able to think and choose responsibly as consumers, savers, investors, citizens, members of the workforce, and effective participants in a global economy.

EconEdLink: K-12 Economics Resources
www.econedlink.org
A site created and maintained by the National Council on Economic Education to provide free classroom tested, economic lesson materials for K-12 teachers and their students. The site contains a library of lessons searchable by title, grade, standard, lesson type, or economic concept.

Foundation for Teaching Economics
www.fte.org
The Foundation for Teaching Economics is a nonprofit organization providing leadership in economic education to educators and to young people selected for their leadership potential.

EcEdWeb
ecedweb.unomaha.edu/home.cfm
The University of Nebraska at Omaha's Center for Economic Education hosts this site to provide economic education resources in all forms and at all levels and allows for searching by grade level, standard, classroom lesson, web project, economic concept, or support resource. They also provide a useful quiz on basic economic concepts.

Environmental & Resource Economics

Tragedy of the Commons Teaching Activity
www.enviroliteracy.org/article.php/1160.html
This lesson deals with the idea of common property - such as air, water, and biodiversity. The activity was created by an experienced team of AP environmental science educators, with help from the College Board, and is a part of the Environmental Literacy Council collection of *AP Environmental Science Labs and Activities*. [Grades 9-12].

Popcorn Economics
ecedweb.unomaha.edu/lessons/popcorn.htm
This EcEdWeb lesson addresses the concepts of scarcity and natural and capital resources. The activity asks students to be subjected to scarcity and then relate it to their own experiences and other real-world circumstances. [Grades 6-8]

I Don't Want Much, I Just Want More: Allocation
www.econedlink.org/lessons/index.cfm?lesson=EM532&page=teacher
This EconEdLink lesson addresses the concepts of competition, productivity, and scarcity. Students examine different methods for allocating resources, taking note of the cost and benefits associated with each method. [Grades 9-12]

Diminishing Returns

Finding Energy Resources
www.beloit.edu/~SEPM/Geology_and_the_enviro/Energy_game.html
Crafted by Earth Science professor, DeWayne Backus, this lesson teaches students about scarcity and energy resources. By dividing into teams and looking for and collecting beads representing energy resources, students learn how their value increases as the resources become scarce. [Grades 5-8]

Production and Costs
ecedweb.unomaha.edu/entrepreneur/lesson9.pdf
This lesson from the University of Nebraska at Omaha "Entrepreneurs" module allows students to learn about diminishing returns in the production process. A hands-on activity makes the concepts concrete by demonstrating how production factors influence output. [Grades 8-12]

Spraying Strawberries
fte.org/teachers/programs/efl/lessons/tues/efltue2.htm
In this Foundation for Teaching Economics exercise, students learn about marginal costs and benefits and diminishing returns as they take on the role of a farmer who must make decisions regarding hiring additional employees and pesticide use.

The Tennis Ball Game
www.bized.co.uk/educators/16-19/economics/firms/lesson/dimreturns.htm
High school students, with a good grasp of economic concepts, will find this activity useful in learning about diminishing returns. In addition to physical activity, the students will calculate labor costs versus benefits and marginal costs. A final discussion will consider efficiency, salaries, fixed and variable costs, as well as average and marginal costs.

Carrying Capacity

Population Education
www.populationeducation.org/
The Population Connection's website contains lesson plans for teachers and activities and resources for students who wish to learn more about population-related issues.

Journey to Planet Earth
www.pbs.org/journeytoplanetearth/
Videos and lessons from PBS explain urban planning and pollution problems

caused by increasing population in "Urban Explosion" and "Land of Plenty, Land of Want." Not all lessons require the video. [Grades 6 and up]

Linking Population, Health, & the Environment
www.prb.org/Educators/LessonPlans/2005/LinkingPopulationHealthand Environment.aspx
The Population Reference Bureau provides this lesson plan exploring how people can alter the environment through the use of natural resources and the production of wastes. Students also take a look at the connection between human health and the environment. [Grades 9-10]

Sustainable Development

Teaching and Learning for a Sustainable Future
www.unesco.org/education/tlsf/
This multimedia teacher education program published by UNESCO contains 100 hours of professional development for use in pre-service teacher courses as well as the in-service education of teachers, curriculum developers, and education policy makers.

DEPweb
www.worldbank.org/depweb/
The World Bank's Development Education Program (DEP) designs mainly high school level, classroom-ready, teaching and learning materials on social, economic, and environmental issues of sustainable development.

ESD Toolkit: Drain or Sustain?
www.esdtoolkit.org/concept_intro/drain1.htm
This lesson, adapted from "Greed vs. Need" in the *Project Learning Tree: Pre-K-8 Activity Guide*, introduces students to the concept of sustainable development. [Grades K-8]

The Economics of Income Which 'Wood' You Choose?
www.econedlink.org/lessons/index.cfm?lesson=NN140&page=teacher
This EconEdLink activity looks at the principle of sustainable economic growth that depends on the implementation of a long term vision of a nation's resources (natural, human, technological, etc.) as inputs for producing outputs as efficiently as possible. [Grades 9-12]

Is It Sustainable?
facingthefuture.org/Members/documents/6.Is.it.Sustainable.pdf
Facing the Future is an organization that helps teachers engage students on

global issues. This lesson helps students define and discuss sustainability and its 3 key components: the economy, the environment, and society. [Grades 7-12]

Supply and Demand: How Markets Work

To Market To Market
www.econedlink.org/lessons/index.cfm?lesson=EM357&page=teacher
This EconEdLink lesson has students become consumers and producers by taking turns buying and selling things in a classroom-created market. Students will establish prices for items and observe what happens during the sale. [Grades K-5]

Fill'er Up Please: A Lesson in Supply and Demand
www.econedlink.org/lessons/index.cfm?lesson=EM394&page=teacher
This EconEdLink activity provides students with an opportunity to learn about gas prices and how prices in general affect both consumer demand and producer supply. [Grades 6-8]

The Economics Classroom: Workshop 2 - Why Markets Work
www.learner.org/channel/workshops/economics/support/econclass_wk2.pdf
This workshop, a collaborative effort by Pacific Street Films and the National Council on Economic Education, includes a market simulation and exercise, "A Classroom Market for Crude Oil" to illustrate key concepts of the market. Special emphasis is given to the interplay of supply and demand. [Grades 9-12]

Externalities

Externalities, Property Rights and Pollution
fte.org/teachers/programs/efl/lessons/lesson6.htm
The Foundation for Teaching Economics, whose objective is to improve economic education, presents this lesson introducing the topic of externalities to the classroom. It includes national content standards, lesson objectives, and ideas for discussion. [Grades 6-12]

New Sense, Inc. vs. Fish Till U Drop, or Coase vs. Pigou
www.econedlink.org/lessons/index.cfm?lesson=EM582&page=teacher
This EconEdLink lesson uses an engaging open-ended role play situation to explore the question of "Which economic approach is the most efficient and fair to resolve utility issues surrounding the use of common or public property?" [Grades 9-12]

Net Present Value

Calculating Present Value
www.moneyinstructor.com/lesson/presentvalue.asp
Instructors are provided with a lesson outline to teach the concept of present value. Students then complete a worksheet to test their knowledge of the subject. [Grades 9-12]

Speculation and Bubbles in an Asset Market
www.people.virginia.edu/~cah2k/bubbletr.pdf
In this classroom activity, students learn about trading assets and discounting by actually placing bids and taking asks. They can also earn money from dividends and capital gains. A classroom discussion helps clarify the exercise, emphasizing the role of discounting. [Grades 11-Undergraduate].

Ecosystem Valuation

Ecosystem Services - Water Purification
www.sciencenetlinks.com/lessons.cfm?DocID=275
This MarcoPolo Education Foundation's Science NetLinks lesson shows students how ecosystems provide essential services by using water purification as an example. [Grades 6-8]

There is Something in the Water
www.econedlink.org/lessons/index.cfm?lesson=EM308&page=teacher
This EconEdLink lesson will teach middle school students to analyze and debate the tradeoffs and discuss the economic factors involved in making decisions about draining wetlands versus protecting them to retain their value as a natural resource. [Grades 6-8]

The Economics of Income: Which 'Wood' You Choose
www.econedlink.org/lessons/index.cfm?lesson=NN140&page=teacher
This EconEdLink activity looks at the principle of sustainable economic growth that depends on the implementation of a long term vision of a nation's resources (natural, human, technological, etc.) as inputs for producing outputs as efficiently as possible. [Grades 9-12]

Trade-offs

Energy Trade-Offs
www.earth.uni.edu/EECP/mid/mod5_ss.html
Part of an Energy Education Curriculum Project developed at the University of

Northern Iowa, this activity has students learn about energy trade-offs by taking on roles of various countries. Students work to trade their resources among the various countries and finish with a discussion about the reality underlying the activity. [Grades 6-8]

It's a Matter of Power
www.econedlink.org/lessons/index.cfm?lesson=EM341&page=teacher In
Students get the chance to make decisions as to whether Kaiser Aluminum should continue to produce aluminum or switch to selling electricity. Students will learn about trade-offs and opportunity costs as they read about and examine various options. [Grades 9-12]

Using Maps to Evaluate Environmental Trade-Offs
archive.orr.noaa.gov/esi/exercise/index.html
Students learn about environmentally sensitive coastal areas and the decisions that must be made to protect them in the case of an oil spill. [Grades 6-12]

Marginal Costs and Benefits

Cost Benefit Analysis: The Three Gorges Dam
www.econedlink.org/lessons/index.cfm?lesson=EM347&page=teacher
This middle school lesson allows students to evaluate the costs/benefits of the Three Gorges Dam project on the Yangtze River in China by encouraging students to look at a complex issue from differing viewpoints. [Grades 6-8]

Market Failures and Government Regulation: Is the Cure Worse than the Disease?
www.econedlink.org/lessons/index.cfm?lesson=EM40&page=teacher
This lesson for high school students takes a look at economic efficiency, and how it is about much more than simply producing goods at the lowest possible cost. [Grades 9-12]

Lesson 3: The Marginal Cost Curve
daphne.palomar.edu/jose/sabbatical/Webpages/lesson_3.htm
This lesson, developed by Jose Estaban an Economics Professor at Palomar College in San Marcos, California, allows students to construct and visually understand the concept of marginal cost. [Grades 9-Undergraduate]

Cost Benefit Analysis

There is Something in the Water
www.econedlink.org/lessons/index.cfm?lesson=EM308&page=teacher

In this lesson, middle school students learn about cost-benefit analysis by applying economics to decisions regarding wetlands. Students consider the development of wetlands, debate important factors involved, and then decide what course of action to take. [Grades 6-8]

It's a Matter of Power
www.econedlink.org/lessons/index.cfm?lesson=EM341&page=teacher
In this lesson, students apply cost-benefit analysis to a company's decision to switch from aluminum production to electric sales. Specific concepts include trade-offs, profit maximization, and opportunity costs. [Grades 9-12]

Environmental Impact Analysis

Extreme Oil: Exploring the History of Oil
www.pbs.org/wnet/extremeoil/teachers/lp1.html
In this PBS lesson based on the series *EXTREME OIL*, students examine the role oil has played in human history and the repercussions of oil use on society and the environment. Students brainstorm a list of oil's current uses, explore how the function of oil has changed over time, then complete an in-depth analysis of oil's current and historic applications (does not require video). Finally, through the use of the broadcast series *EXTREME OIL*, students examine the environmental impact of the oil industry, and decide whether or not they support an expansion of oil drilling operations into the Arctic National Wildlife Refuge. [Grades 9-12]

Regulatory Policy vs. Economic Incentives

Guess Who's Coming to Dinner
www.econedlink.org/lessons/index.cfm?lesson=EM522&page=teacher
This EconEdLink lesson introduces regulation and information as tools used by government to promote fair competition and complete information in a market economy. [Grades 6-12]

What's the Problem with Digital TV?
www.econedlink.org/lessons/index.cfm?lesson=EM189&page=teacher
This EconEdLink lesson introduces the mandate for digital TV transmission, considers the implications the mandate will have for the environment (negative externalities), and evaluates possible solutions. [Grades 6-12]

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