ENVIRONMENTAL DECISION-MAKING

From the *Technology and Environmental Decision-Making* Series

ATEEC

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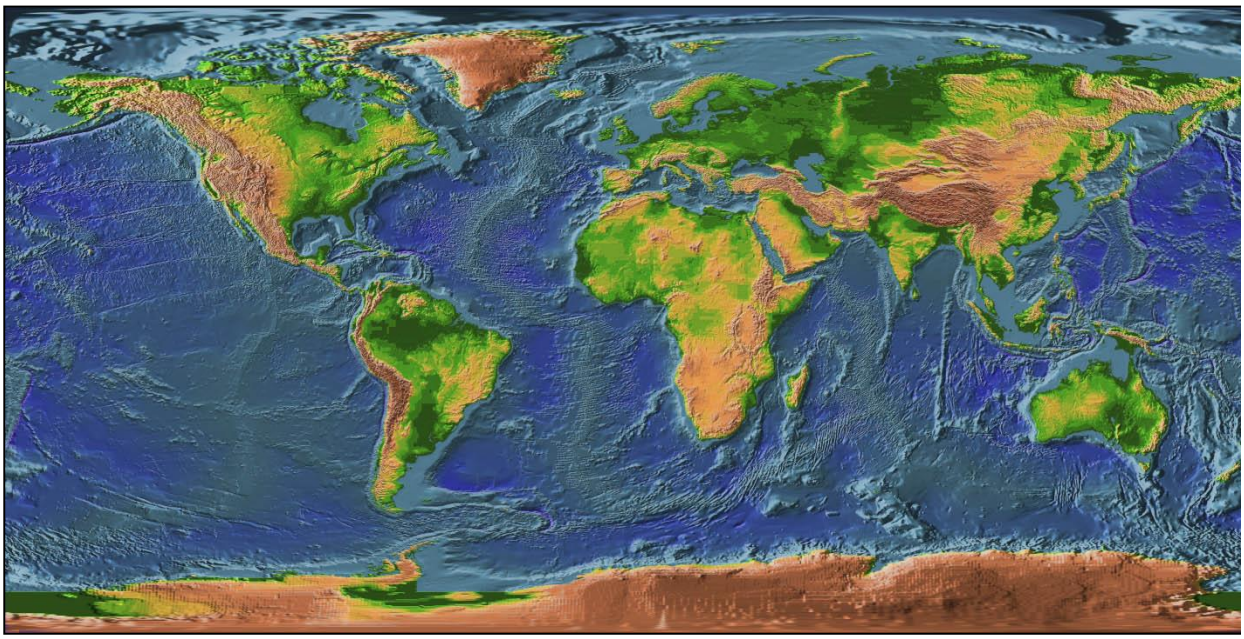
Environmental Decision-Making



A topographic view of the Earth. Credit: NASA

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Introduction

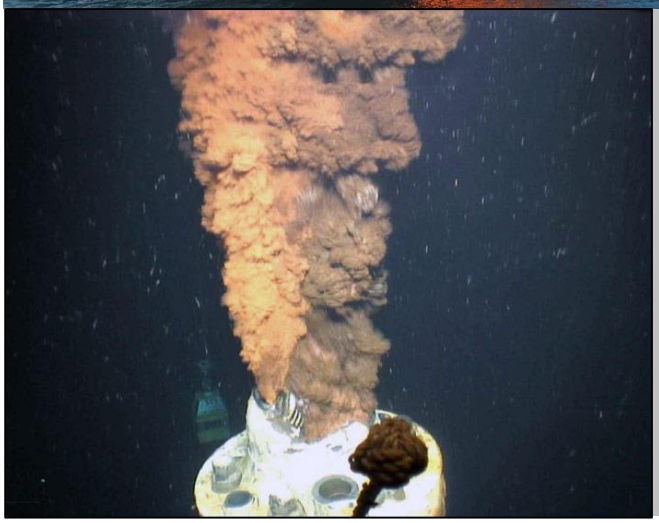
Environmental decision-making—it sounds complicated. It sounds like something that should be left to the experts. And environmental issues can be complicated. But environmental decision-making in a society shares some of the key processes that individuals use to make shared decisions on a daily basis. If we compare the societal decision-making process to that of a family, the issue becomes a much more manageable concept.

Members of Congress and those they are entrusted to serve. Credits (clockwise): White House, U.S. Census Bureau, Walter Bratton, U.S. Census Bureau

Picture a typical family problem—a 16-year-old gets his driver's license and his parents have told him that he will need to pay for his own gas and car insurance. Until now, his weekly allowance from household chores has been adequate for his expenses. He decides to get a part-time job to pay for the extra expense of driving a car, and his parents approve—a fairly straightforward problem, decision, and resolution.

More often, however, solutions are not this simple. What may at first seem like a straightforward decision can be affected by variables that complicate the matter considerably. Imagine the same basic problem, this time with added factors. In this family, one parent works second shift and the other parent takes frequent business trips. The 16-year-old boy has the responsibility of watching a 10-year-old sibling most evenings, and a part-time job would require that he work in the evenings. In this instance, there are more people involved in the problem—more stakeholders. The solution in this case is less obvious and will need to respond to the concerns of all stakeholders.

Public decision-making about environmental management tends to involve many stakeholders and complicated, often unexpected, challenges. In the case of an oil spill, such as the April 20, 2010 Deepwater Horizon oil spill in the Gulf of Mexico, it seemed relatively simple to determine that the spill must be cleaned up and that the responsibility for doing so lies with whomever caused the oil to be spilled. Yet a closer look reveals far more complexity. A spill of this type and magnitude had never occurred before, so the crucial immediate problem was how to stop the oil and gas from escaping the well. There continues to be controversy over how intense the cleanup should be—sometimes the cleaning does more environmental harm, and is more costly, than leaving the oil to the forces of nature. The assignment of responsibility was also complex—was it British Petroleum, owner of the Macondo oil well, that should be held accountable? Transocean Horizon, the drilling contractor and owner of the oil rig? Halliburton, the company that maintained/repaired the well? Initially all denied responsibility, and eventually all shared in the economic responsibility.



Deepwater Horizon oil spill.
Credits: Upper, Wikipedia ; lower USGS

In a slightly different scenario, if an area of the ocean becomes contaminated through nonpoint sources of human activity, both the identification of the problem and its remediation are likely to be complicated.

Many of the decision-making processes that confront society are complex and shaped by a multitude of scientific and social factors. Science, technology, economics, politics, public opinion, and cultural values all play a role in the decision-making process. Yet environmental

decision-making involves at least three particularly challenging twists. When society makes decisions about the environment, those decisions affect:

- resources that many communities hold in common,
- determining value of non-monetary aspects of a resource, and
- the range of possibilities that will be available to generations to come.

Environmental technicians, most often on the front lines of the day-to-day environmental compliance efforts, find it necessary to solve problems and participate in decision-making on a regular basis. This module provides instructors with a technician's overview of the factors involved in environmental decision-making, allowing the instructor to teach contextually, placing technical decisions in the real world of overall environmental concerns. It may sometimes be frustrating to see situations in which an advanced technological solution is not implemented to solve a problem. At these times, it is helpful to understand that technology may not be the best or only solution, when put into the context of other factors.

Society has responded to the complexity of environmental decision-making by developing a variety of structures, approaches, and tools to help make the process of decision-making more manageable, as well as to help make the resulting decisions more effective and durable. Whether the challenge they face is personal or potentially global, decision-makers should make use of as many available resources as possible and take all relevant factors into account to determine the most appropriate and effective course of action.

Module Purpose

"Environmental Decision-Making" is an instructor resource for exploring many factors that go into decisions on environmental issues, especially by government bodies, and for examining how environmental decisions are developed within a range of contexts, particularly in the United States government. Though national government decisions are the centerpiece of this module, these resources will inform views of other governmental processes and even decisions made in the private sector, including corporations.

Using the other learning modules in the *Technology and Environmental Decision-Making* series as case studies, this core module illustrates the multidisciplinary nature of environmental problems and problem solving. The goal is to help instructors of environmental technology, natural science, social science, and other disciplines understand the social, economic, and political contexts as well as the scientific and technological dimensions of environmental issues. This understanding will, in turn, be passed onto their students to help them cope with the policy process and need for multidisciplinary teamwork they will encounter when faced with tough environmental problems.

Links to the other three modules in this series highlight the ***scope*** of environmental decision-making, from the local to the international level. At the same time, they also provide a sense of the ***breadth*** of the issues, from a specific, identified ground water contaminant to the multiple challenges of global climate change. Links to relevant websites provide instructors with additional information and resources. The module also features suggestions for class activities to increase student understanding.

Module Organization

In attempting to explain environmental decision-making, this module first looks at the pluralistic nature of U.S. society and the corresponding design of its decision-making structure. Examining the structures and processes in greater depth, the module then identifies the decision-makers and the influences they encounter. Finally, it provides information on the decision-making approaches and tools available to help practitioners with key components of the decision-making process. "Environmental Decision-Making" is directly applicable to the case studies contained in the other three learning modules in the *Technology and Environmental Decision-Making* series.

Examples and links to additional information are provided to enhance the learning experience, as are the additional resources and activities in the Aids to Understanding section.

Decision-Making in a Diverse Society

The U.S. has been described variously as a "melting pot" or a "mosaic" of people with different backgrounds and interests. The roots of this nation are fundamentally pluralistic, meaning that a basic value of our democratic government is to respect and cultivate the coexistence of a variety of groups. The melting pot metaphor has generally been used to describe the racial and ethnic makeup of our country. However, it also accurately describes the wide variety of needs, concerns, and interests that differ with every individual. Depending on factors such as location, income, profession, age, family status, race, and personal history, citizens will have widely divergent views on many issues, including those that affect the environment.

Pluralism

"The group is the primary working unit for the system. The system works through the push and pull of many groups that seek to advance their interests by using their resources to maximum advantage. Assumes that power and resources are widely dispersed (although not necessarily evenly distributed). Assumes that consensus on basic democratic norms is necessary to control conflict and permit harmonious resolution of differences."

Robert Reich,
former U.S. Secretary of Labor

Many times technology specialists wonder why simple technical solutions are not quickly implemented to solve environmental problems. But technology affects different people in different ways. When faced with issues that affect a society's common interest, such as the environment, decision-makers must account for differences in values or priorities even when implementing a relatively straightforward technical approach.

The challenge of making environmental decisions in a diverse society is to find a timely solution that balances the concerns and views of conflicting interests. In a pluralistic and democratic society, participants in public decision-making analyze the concerns of all parties and try to resolve conflicts through a process of discussion and compromise that is open and fair. In general, this may be the ideal goal, though it may not be the goal of all of the stakeholders involved in the process all of the time.

Within the context of diverse social values and priorities, an optimal decision-making process in such a society is one that systematically includes all stakeholders and is informed by current science and technological developments.

Clash of Values and Interests

Clashing Views

"As with all social issues, those on opposite sides of environmental disputes have conflicting personal values. On some level, almost everyone would admit to being concerned about threats to the environment. However, enormous differences exist in individual perceptions about the seriousness of some environmental threats, their origins, their relative importance, and what to do about them. In most instances, very different conclusions, drawn from the same basic scientific evidence, can be expressed on these issues."

Theodore D. Goldfarb

Environmental decision-makers may strive to examine all the facts, analyze the available solutions, and then make the best decision possible. However, even the most optimal solutions do not always satisfy all parties. Many public disputes, including those concerning the environment, involve conflicts of closely held, contrasting values and interests among the stakeholders.

The personal values and interests held by stakeholders in environmental decision-making processes affect how they participate as individuals as well as how they align themselves with various groups that are also active in the process. Depending on priorities, a group's interests can be related to many things, including:

- economic interests
- political and economic power
- quality of life (high, middle, low, desire to change) gender, ethnicity, age, family structure
- community values, religious and social norms
- history

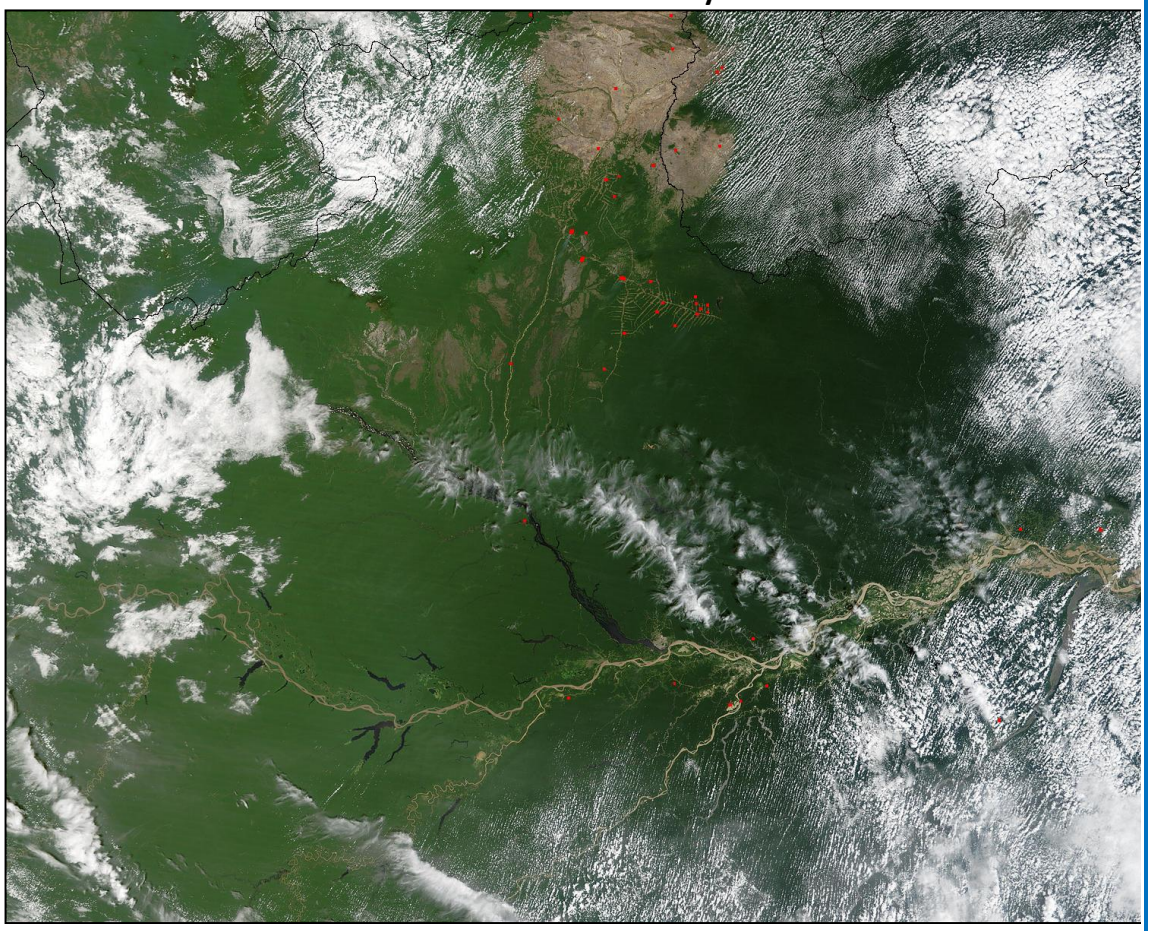
When one group's interests and values differ from those held by other groups, conflict often results. Each group's beliefs are strongly held, and compromise can seem elusive. This is one reason why many environmental disputes result in legal action.

Thoughts from 1787—
Conflicting Interests and Values

"…the most common and durable source of factions [i.e., divisiveness] has been the various and unequal distribution of property. Those who hold and those who are without property have ever formed distinct interests in society… A landed interest, a manufacturing interest, a mercantile interest, a moneyed interest, with many lesser interests, grow up of necessity in civilized nations, and divide them into different classes, actuated by different sentiments and views. The regulation of these various and interfering interests forms the principal task of modern legislation, and involves the spirit of party and faction in the necessary and ordinary operations of the government."

James Madison,
The Federalist Papers, 1787

Global Interests vs. **Community** Interests

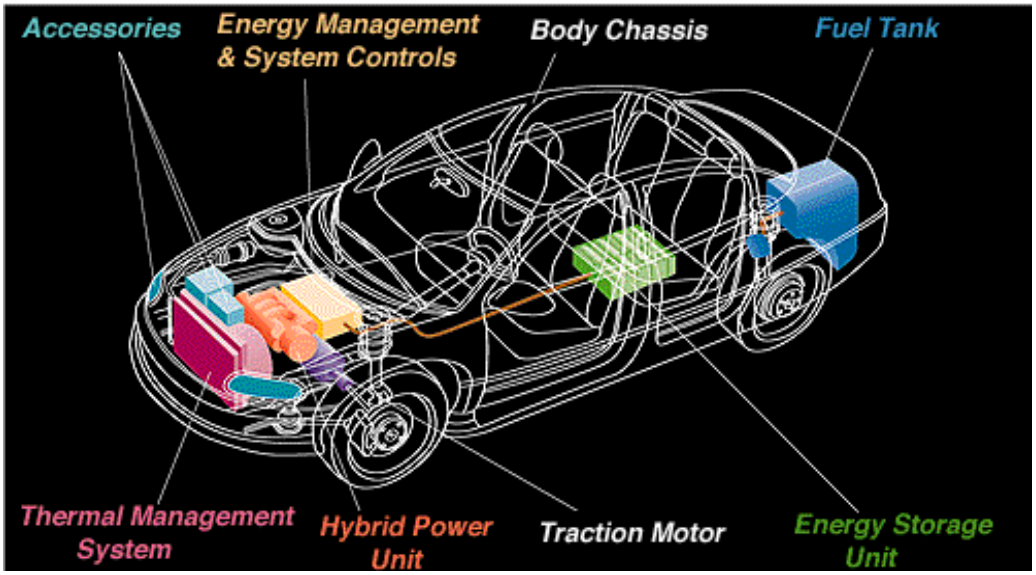


Brazil's Amazon River Basin. Credit: NASA

The issue of deforestation in the Amazon Rainforest is a longstanding example of a conflict of interests and values. From the perspective of many scientists and environmentalists around the world, the rapid and unmanaged removal of trees in South American rainforests is having an adverse affect on biodiversity and the global climate; the global community has a strong interest in reducing deforestation. From the perspective of South American developing nations and their local communities, the change in forest land use (e.g., food and biofuel crops, cattle grazing) is crucial to the development of their countries; they have a strong interest in continuing to utilize their countries' natural resources to increase their people's standards of living. **Each side feels that they have a legitimate and pressing interest.** No definitive compromise between interests has yet been reached in this case at a global level; many efforts to address the issue are active at the local level, with varying degrees of success. This particular dispute is just one of a multitude of conflicting issues at play in the context of Amazonian rainforests.

For more details on the complexities of this issue, refer to the Amazon Conservation Team website, a non-profit organization that works in partnership with indigenous people of tropical America in conserving the biodiversity of the Amazon Rainforest as well as the culture and land of its indigenous people.

National Interests vs. **Individual** Interests



Components of a hybrid-electric vehicle
Credit: U.S. DOE Office of Transportation Technologies

With energy crises looming every few decades and the ever-present air pollution in large U.S. cities, the issue of fuel-efficient and less polluting transportation technology has become increasingly important. Few dispute the view that the U.S. has become too dependent on foreign oil for its fossil fuel needs and would benefit from finding alternative sources. But another aspect of this issue also involves decision-making on a personal level. One of the main barriers to making a sound environmental decision involves the necessity for individuals and groups to examine their values and priorities and to make potentially hard decisions that can contribute to behavioral and cultural change.

Technology Is Not the Only Answer

Many pressing environmental problems can be improved, even resolved, through the application of technology solutions. So why haven't the problems been solved, once and for all? The answer is that technology alone does not always resolve conflicting values and interests.

For example, technology is available to increase the fuel efficiency of automobiles, yet that technology has not been fully deployed. Much has been made of the American "love affair with the car," and it is true that Americans like the mobility cars afford them as well as the enjoyment they get from driving. Drivers are reluctant to give up size and power, along with perceived safety, and automobile manufacturers hesitate to invest millions of dollars in retooling production lines to produce cars that drivers may not want. The underlying problem is not a technological inability to fix the problem, but rather the conflict of values and interests raised by the:

- the clash between individuals' preferences for mobility
- the interests of the automobile industry
- the economics of conversion to an alternative technology
- the harm vehicles cause the environment

Mix of Voices

A pluralistic society by definition is made up of people and groups with widely ranging priorities, concerns, needs, and capabilities. The same is true of the stakeholders—people or groups who are particularly involved in or concerned about a particular topic—associated with an issue. In environmental decision-making, key stakeholders include:

- government entities
- private citizens
- business and industry
- scientific community (including both natural and social)
- non-governmental organizations (NGOs), such as environmental and cultural not-for-profit groups

The question of whether to bring the voices of future generations and non-humans into environmental decision-making—not to mention how to bring them in—is a subject of considerable debate. In ethics, these "indirect stakeholder" issues are known as "intergenerational equity" and legal "standing" for non-human entities.

In addition to these direct stakeholders, there are those whose interests are at stake, but cannot participate in the process:

- future generations
- non-human entities (such as wildlife and ecosystems)

Each of these groups has a stake in the decisions that are made regarding the environment. Each group brings its own priorities and influences to the decision-making process.

For a contextual teaching and learning activity on public participation in environmental decision-making, refer to the Town Meeting in Aids to Understanding.

How People and Groups Make Their Voices Heard

Democratic decision-making requires the participation of the public to ensure that decisions are responsive to the range of public concerns, fair, and sufficiently durable. Yet the scope and scale of many environmental decisions make it a significant challenge to get broad public participation.

The U.S. government has responded to that challenge over the last century with a range of reform efforts that have rendered government actions more transparent to the public through public documents and open hearings. Many of these efforts coincided with the development of environmental policy, and were integrated into environmental law.

Reforms to make public participation processes more open have been facilitated by the introduction of the Internet. USA.gov provides a useful website for obtaining public information. For environmental issues, the U.S. Environmental Protection Agency website is one of the best places to start, with a comprehensive site map, index, search engine, and links to other government and non-government environmental resources.

Many government documents, especially proposed laws and regulations, must be published for the general public and are usually posted online. Public libraries also offer access to thousands of printed and electronic public documents related to environmental issues. Even if a government document is not published, the average citizen has a right to view it.

Public Participation in Rulemaking

Federal eRulemaking portal—A collection of links, gathered from the Federal Register, of rulemaking resources throughout the federal government. Most of these sites offer Federal Register documents and other regulatory information, and some let you submit comments online.

Laws that govern the creation of regulations, including so-called "sunshine laws" (because they require government process to be done in the "light of day" for public viewing) require that policies be developed through an open process. The Freedom of Information Act (FOIA)[1] allows any citizen to file a request to see any non-confidential internal government document. These requests are routinely filed for a variety of reasons, though more controversial requests may be contested in court.

The National Environmental Policy Act (NEPA)[2] mandates opportunities for public input in the environmental decision-making process. Public hearings and other venues typically used to fulfill NEPA requirements offer citizens opportunities to air their concerns, opinions, and

information about problems and proposed policies. Many of these hearings are listed on government websites.

NEPA has played a crucial role in getting more citizen input into government environmental decision-making processes. However, its success in making public deliberation truly participatory—and thus truly democratic—has been limited. Citizens and citizen groups have expressed concerns that public hearings are held too late in government agency decision-making processes for people to have any real influence over the choices that are made. Citizen knowledge, often based on long years of local experience, is not always respected in the data gathering and analysis that support government decisions. In addition, while public hearings allow voices to be heard, they do not allow citizens to talk *with each other* and thus come to new understandings together. Rather, public hearings and public comment periods often seem to form a sort of conduit of input into an otherwise closed government process.

"Collaborative Approaches to Environmental Decision-Making" provides an overview of twelve case studies of collaborative decision-making involving the engagement of diverse stakeholders.

In response to these limitations, local initiatives have taken root across the country. Many of these initiatives feature decentralized decision-making and particularly active engagement of diverse interests. Decision-making that is more collaborative and closer to the ground is better informed by a wider range of data, more innovative, more flexible, and better able to cope with complexity. Public participation in collaborative decision-making begins with how problems are defined, includes the determination of what data are needed and how that data should be gathered and analyzed, and informs the range of options that are considered, as well as the ultimate decision of what course of action to pursue. See Decision-Making Approaches and Resources in this module for a more detailed discussion of collaborative decision-making.

While information access and participation in the process are the rights of each U.S. citizen, it should be noted that not everyone has the capacity to participate equally in all processes, nor does everyone have equal influence. Lack of knowledge about the issue or the process may prevent some stakeholders from participating. For example, those without Internet access or computer skills may have difficulty finding necessary information.

Additionally, participation does not ensure influence. While each of us has the legal right to be heard, what we say may not have the same impact as what someone else says. Wealth, education, knowledge, history, power, and position often play a role in who listens to whom. NEPA and the trend toward collaborative approaches have helped to better engage all stakeholders in environmental issues, but the fundamental diversity of our society means that power and influence are dynamic and changing forces in public decision-making.

Forums for Individual Participation

Individual citizens have several opportunities for input in the decision-making process. These include:

- voting
- campaign contributions
- participation in public hearings/meetings and providing written or oral feedback during public comment periods
- creation and participation in local collaborative initiatives and partnerships (such as ongoing meetings and discussion)
- membership in civic organizations and interest groups
- communication with legislators (e.g., town meetings, office visits, correspondence)
- communication with media (including Internet)

Forums for Group Participation

The U.S. government also allows for the voices of various groups and organizations to be heard. Many institutions, not just individuals, often provide input into the policymaking process, including:

- business and industry
- scientific professional societies
- non-governmental organizations (NGOs) (usually represents either a group of citizens organizing grassroots activities, an association of scientific experts on a specific topic, or a coalition of industry representatives)

Business and industry often express their interests and values via industry associations, one type of NGO. These can be not-for-profit organizations with close ties to for-profit companies, such as Edison Electric Institute and the Oil Manufacturers' Association.

Group forums for decision-making input include:

- facilitation of voter participation (e.g., voter registration, organizing rides to the polls)
- lobbying voters (e.g., direct political advertisements)
- campaign contributions (including political action committees (PACs))
- participation in public hearings, open meetings, social media platforms, and public comment periods
- communication with legislators (e.g., lobbying)
- communication with media (e.g., internet, press conferences)

Lobbying, a specific example of a forum for group participation, is a key element of U.S. political decision-making. Lobbyists employ varying strategies and tactics depending on the issues, their interests, and the likely receptivity of potential audiences to their messages. For example, lobbyists who wish to limit regulation form relationships with individual legislators (federal and state congressman and senators) who favor limited government rules, since the legislative branch has the power to easily eliminate bodies of regulation. On the other hand, lobbyists invested in existing regulation may target regulators (federal and state agencies) to assure that laws are effectively implemented and enforced.

Credit: U.S. EPA

Lobbying from a variety of NGOs (including the agricultural industry and environmental groups) has played a major role in the decision-making process concerning the solution to the issue of hypoxia in the northern Gulf of Mexico. The "Nonpoint Source Water Contamination" module within this *Technology and Environmental Decision-Making* learning module series provides more background on the scientific and practical complexities of this issue.

Environmental Justice

As with most human enterprises, the process of environmental decision-making in a pluralistic system seldom works perfectly. Some of the concerns are the lack of capacity to participate in public forums, unequal influence in the decision-making process, and NIMBY (Not In My Back Yard). These issues are all part of a growing recognition of and concern about environmental justice. Environmental justice advocates attempt to show the disproportionate influence of certain groups in the process of environmental decision-making and the potential negative impacts on less influential groups.

NIMBY is an acronym for Not In My Back Yard and can be used to describe one of the challenges to many environmental issues, such as siting hazardous waste disposal areas. These disposal sites are chosen through an elaborate public process. While many people in a given area might agree with the need for disposal of such waste, some are unwilling to accept a disposal site near their area. Perceptions—whether founded or unfounded—of a potential health risk sometimes trigger this type of opposition. Health, community, social, and economic values conflict with the need for safe disposal of hazardous wastes.

A discussion of environmental decision-making would not be complete without addressing this issue of environmental justice, but it is too complex an issue to be adequately handled in a few paragraphs. The following links will be helpful for more in-depth study of the issue:

- Environmental Justice[3] from the U.S. EPA
- Federal Interagency Working Group on Environmental Justice, lead by the Council on Environmental Quality[4]
- Harvard University's Working Group on Environmental Justice[5]
- Environmental Health and Justice by the Pacific Institute[6]
- Environmental Justice Resources from the Deep South Center for Environmental Justice at Xavier University of Louisiana[7]
- Environmental Justice Case Studies from the University of Michigan's Environmental Justice Program[8]

Aids to Understanding provides resources and activities.

The Environmental Justice and Climate Change (EJCC) Initiative is a particularly interesting example of an advocacy group focused on the intersection of social and environmental justice. Environmental justice movements are often concerned primarily with local issues; in contrast, the EJCC Initiative is focused on a global problem—climate change. The EJCC Initiative supports energy efficiency, renewable energy, and conservation policies while seeking equitable measures to protect and assist the communities most affected by climate change.

Government Decision-Making Structure

The U.S. government was initially designed, and continues to evolve, to foster and guide pluralism. As fundamental to U.S. society as the rights of individuals is the principle that individuals have the right to form and affiliate with groups to organize their contributions and shape policies that affect their groups' interests. Diverse and often openly competing groups and interests are hallmarks of a pluralistic society. Government structures in the U.S. are explicitly designed to facilitate and balance input from many groups and to provide a system for developing policy that best meets the needs of the public.

First page of the original Constitution of the United States of America.

All three branches of U.S. government are involved in environmental decision-making—legislative, executive, and judicial. Each has a different role, operates in different ways, and is influenced in different ways. It may be helpful to view an organizational chart[9] showing the government's structure while reviewing the following material.

This separation of powers is a fundamental characteristic of democratic government, ensuring that the system has the advantage of checks and balances and reducing the ability of one branch to overpower others. However, a disadvantage of decentralization is the tendency for fragmentation. With different divisions of different branches and agencies looking at different aspects of a problem, individual findings may not be communicated to all others working on the problem. In fact, each group may be unaware that another group is working on the same problem.

For details on the structure of U.S. government, refer to the U.S. Federal Government website.[10]

Legislative Branch—Enacting the Law

The U.S. Congress is responsible for passing laws, many of which have a direct impact on the ways humans interact with the environment. Most often, Congressional **legislation** provides a detailed explanation of the law and its intent, and then provides for the development of the detailed rules (i.e., **regulations**) by a specific government entity (e.g., the Environmental Protection Agency, the Occupational Safety and Health Administration).

Legislation sometimes runs the risk of unintended consequences. The following are two examples of legislation that created unexpected problems.

Unintended Environmental Consequences Due to
Unanticipated Human Actions

Aerial view of a hazy Mexico City. Credit: UCAR

In the 1990s, as part of an attempt to resolve the problem of air pollution in Mexico City, municipal officials decided that a reduction of vehicles on the road each day would result in a corresponding reduction of air pollution in the city. Lawmakers enacted the "Hoy No Circula" (HNC) policy, which allowed citizens to drive their vehicles only on odd- or even-numbered days, based on license plate numbers.

The intention of the HNC was to lower the levels of vehicle emissions; but in fact, emissions levels increased. Further investigation showed that many Mexico Citians were circumventing the policy by purchasing a second car with a license plate that allowed them to drive on "off" days. These second vehicles were often older, higher-emitting vehicles that contributed to Mexico City air pollution.

For details on an air pollution study of Mexico City, recommended mitigation policies, and the driving restrictions policy, refer to *Air Quality in the Mexico Megacity: An Integrated Assessment*[11] and "The Effect of Driving Restrictions on Air Quality in Mexico City."

Another classic case of legislation with unintended consequences was illustrated by U.S. policy decisions concerning the gasoline additive methyl-tertiary butyl ether (MTBE).

Unintended Environmental Consequences Due to
Unanticipated Chemical Reaction

Credit: UCAR

In the 1990 Clean Air Act Amendments, Congress mandated the use of oxygenates in gasoline to reduce air pollution from vehicle emissions. To comply with this requirement, refineries increased the amount of MTBE in gasoline. But the lack of a **holistic** approach to risk assessment resulted in unforeseen problems in the wake of this implementation. When added to gasoline and stored in underground tanks, MTBE leaked from the storage tanks and contaminated the surrounding ground water reservoirs. Legislation created to fix one problem, in turn created an equally serious problem.

Impact of Legislation

Legislation related to environmental decision-making has had a major impact on the policymaking process. Federal statutes now hold the government accountable to the people through the public participation process, and individual citizens now have some legal standing to file suits related to environmental laws. For environmental issues, the National Environmental Policy Act (NEPA)[12] has had the effect of requiring public involvement in the environmental decision-making process. Other federal laws provide individual citizens with the right to sue.

Influences on Legislation

As members of Congress deliberate matters related to environmental policy, many factors influence the debate. Lobbyists from industry, environmental organizations, and other groups with interest in the issue will submit data and arguments for their position and against another, in hopes that they may win legislative support for their view. Scientists are often asked to testify before Congress to provide information about and understanding of the complex issues related to the decision at hand. Individual citizens also present their cases to their elected representatives. Legislators must decide to whom they will listen and what arguments are most persuasive.

Another factor legislators must consider is their own authority. This is especially significant when dealing with international environmental issues. The sovereignty of nations limits the ability of the global community to act collectively. There is no single mandatory enforcement entity for all nations for collective international action. This leaves implementation of and compliance with international environmental agreements to be executed through each nation's legislators.

International Environmental Decision-Making—Ozone Depletion and Climate Change

Over the last few decades, climate change and depletion of the ozone layer have been widely believed to be the world's largest environmental problems. The two problems have many similarities. Both involve global risks created by diverse nations, and both seem to be best handled through international agreements. The Montreal Protocol (which went into effect in 1989) is an international treaty designed to protect the ozone layer by phasing out the production of specific greenhouse gases (GHGs) that are responsible for ozone depletion. The Kyoto Protocol (which went into effect in 2005) is an international treaty as well, designed to mitigate climate change through reduction of CO_2 emissions, another GHG. The outcomes of international decision-making on these two issues have thus far been very different.

Many nations have seen it as being in their economic interest to participate in the Montreal Protocol and to cut ozone-depleting chemical use. By 2009, 197 countries had ratified the agreement. As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Averaged over the globe, ozone in the period 1996-2009 is about four percent lower than before 1980, as documented in the 2010 UN Environment Programme's report on the assessment of ozone depletion. Climate projections indicate that the ozone layer will return to 1980 levels around the middle of this century. Due to its widespread adoption and implementation, The Montreal Protocol has been touted as a model of successful international cooperation.

In stark contrast to The Montreal Protocol's efficacy, The Kyoto Protocol is not faring as well with its goal of climate change mitigation through reduction of CO_2 emissions. This is mainly due to continued perceptions that the treaty's commitment to a reduction in carbon emissions (CO_2) is NOT in some countries' economic interests, and that climate change is a natural cycle and therefore remedial action is unnecessary.

Addressing climate change mitigation is proving much more difficult than ozone mitigation. Leading industrialized nations such as the U.S., Canada, China, India, Japan, and Russia are using their sovereignty to opt out of global agreements such as the Kyoto Protocol, thereby limiting the effectiveness of such international initiatives. This is a particularly polarizing debate in the U.S., a highly carbon dependent society. A variety of stakeholders are trying to reach consensus and determine the cost-benefit analysis of CO_2 reduction, and just where U.S. "interests," or priorities, lie with this issue.

Read more at

- United Nations Montreal Protocol website, "Ozone: All there is between you and UV"
- World Bank's Montreal Protocol
- United Nations Framework Convention on Climate Change, "Kyoto Protocol"
- Social Science Research Network, "Montreal vs. Kyoto: A Tale of Two Protocols"

The "Climate Change" module within this *Technology and Environmental Decision-Making* learning module series provides more background on the scientific and practical complexities of the climate change issue and The Kyoto Protocol.

Executive Branch—Enforcing the Law

The executive branch is comprised of institutions, such as the Department of the Interior[13] or the Environmental Protection Agency[14] created to ensure implementation of the laws enacted by the legislative branch. As part of the implementation task, these bodies also establish many of the specific regulations for these laws, particularly within the environmental arena. And because these institutions oversee the implementation and enforcement of the laws, they also play a key role in the policymaking process.

The organization of the executive branch dramatically influences how decisions are made. The Department of Agriculture[15] and the Department of the Interior[16] are examples of government entities that are obviously involved directly with environmental issues. But environmental issues affect a wide range of interests, most often cutting across departmental boundaries. Thus, decision-making authority on environmental issues is spread throughout many departments and agencies.

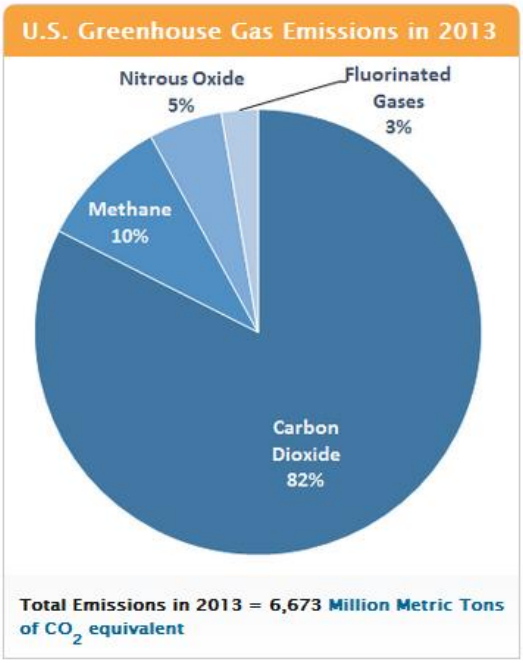
Influences on Executive Branch

As with the legislative decision-making process, many people and groups have input into the decisions made by government agencies. Bureaucrats often rely on scientists to provide information and to interpret data about complex environmental issues. Lobbyists from a variety of organizations—industry, health organizations, environmental groups, other non-governmental organizations—advocate for their groups' interests.

Judicial Branch—Interpreting the Law

As U.S. environmental policy has evolved over time, the U.S. judicial system has become increasingly important in establishing precedents in environmental decision-making. In the 1970s, following the enactment of legislation such as NEPA, interpretations and decisions by the courts enabled environmental interests to use litigation effectively to bring pressure on Congress, administrative agencies, and regulated parties. More recently, other concerned parties, such as industry, have also turned to the courts, seeking relief from environmental regulations.

Using **Judicial** Process to Leverage **Regulatory** and **Legislative** Processes



Credit: U.S. EPA

In 2006, because the U.S. Congress refused to approve or even consider climate control legislation (e.g., carbon tax, cap-and-trade), a group of state Attorneys General (AG) led by Martha Coakley (AG, Massachusetts) sued the U.S. Environmental Protection Agency (EPA) to declare that greenhouse gases (GHGs), specifically CO_2, are criterion pollutants under the Clean Air Act of 1970 (amended 1990, section 202(a)(1)). The U.S. Supreme Court found for the plaintiffs in *Massachusetts, et al.* v. *Environmental Protection Agency, et al*. (2007). The decision stated that GHGs were declared criterion pollutants, and thus the EPA is not only authorized but is mandated to establish emission limits. On the basis of this judicial finding and the authority of previous legislation, regulations such as reduced Corporate Average Fuel Economy (CAFE) standards and power plant emission limits are currently being implemented.

For details on this case, see "An Inconvenient Decision: *Massachusetts et al.* vs. *Environmental Protection Agency*."[17]

The number of environmental cases has grown tremendously in recent years. The disparity of viewpoints concerning how to interpret key facets of environmental problems often forces disputes into the courts. Judicial rulings set precedents that are important in determining future policy. The role of the judicial branch in environmental decision-making is to:

- interpret the law and decide disputes over differing interpretations
- ensure implementation of law by government agencies
- adjudicate claims of criminal environmental violations
- enforce proper administrative procedures in the implementation of other laws

Challenges in Deciding Environmental Cases

The judicial system faces difficult challenges with environmental court cases. Judges and juries are often asked to determine liability, reparation, and remediation for an environmental problem in the face of real uncertainty, not only about who caused the problem but also the scientific nature of the problem itself.

Research into environmental problems is ongoing and the interpretation of data can change over time as additional data is gathered and analyzed. This can also result in a change in the interpretation of the cause of a problem.

In addition to scientific uncertainty, there are other limitations on the role of science in determining environmental policy outcomes—narrowing scientific uncertainty is essential, but not sufficient. Reducing economic uncertainty is also essential. In the meantime, while disputes continue and are taken to the courts, in many cases courts must make determinations of highly technical and scientific issues—and there is considerable concern that judges do not have the technical and scientific training necessary to make these decisions. To address this concern, outside experts are sometimes appointed to act on behalf of the court to evaluate scientific data.

Ultimately, the basic challenge faced by judges and juries in environmental decision-making is identical to that in any decision-making arena—that of interpreting and deciding between conflicting values and interests. As discussed in the first section of this module, many different positions and values exist alongside each other in the U.S. When these views are deeply held and when they clash with the equally deeply held priorities of another group, the debate often results in legal action.

Aids to Understanding provides resources and activities.

Decision-Making Approaches and Tools

Within the framework established by government structures, citizens, groups, organizations, businesses, and government staff work to thoroughly understand environmental issues, assess available options, decide on courses of action, and implement and evaluate those decisions. Every instance of environmental problem solving is unique in its own way, depending on the particular combination of stakeholders, environmental factors, and social and environmental history. Similarly, every response to environmental problems is also distinctive, depending upon how parties to the decision-making process choose to approach their challenge, and on the corresponding tools they use to address it.

To illustrate the dynamic nature of the decision-making process, refer to the Town Meeting activity in the Aids to Understanding section of this module.

Society responds to environmental problems with a range of decision-making *approaches* (ways of thinking about and organizing responses to a particular situation) and *tools* (specific techniques or strategies for accomplishing certain tasks). Three examples of environmental decision-making approaches —information-focused, adaptive, and community-oriented—are described in this module. Environmental decision-making *tools* discussed here include the Environmental Impact Statements (EIS) required by NEPA, risk analysis, skills in cross-boundary collaboration, and several types of monitoring. Familiarity with several examples of approaches and tools lends flexibility to decision-making participants (such as citizens, groups, and government agencies) and contributors (such as technicians, consultants, and analysts). Examples of different tools are found on the EPA's Scientific Tools to Support Sustainable Decision Making Web page.[18] The capacity to adapt one's inputs into public decision-making processes according to the history and status of a particular situation is key to ensuring that those inputs will be effective.

Decision-makers use many tools to analyze impacts to humans and the environment. While providing a brief overview of other tools, this module focuses on risk assessment because it is used in many environmental technology training programs. Other approaches are equally effective, and it is important for decision-makers to use all the tools available to them to make the best, most informed decisions possible.

It is also important for technicians to be familiar with as many tools as possible, both so that they can use whichever tool is most helpful for a given situation and so that they can more fully understand and appreciate ongoing decision-making processes that they contribute to and observe.

An Information-Focused Approach

One way to confront an environmental issue is to use a systematic process, similar to the scientific method, to gather and analyze information needed for decision-making. The following are the steps in such a model of a public decision-making process:

Information-Focused Example of Public Decision-Making Process Model*	
Step	**Substeps**
• Identify the problem.	
• Gather data.	Determine goals and values. Characterize the environment. Characterize the economic, social, and political setting. Characterize the legal and regulatory setting.
• Integrate information.	
• Analyze the data (and determine likely cause).	
• Identify, assess, refine, and narrow down options.	
• Identify potential solution.	
• Develop an action plan.	Write a draft plan. Elicit feedback from stakeholders. Incorporate feedback. Submit plan for approval by applicable governing body.
• Implement the plan.	
• Evaluate the outcome and adapt as necessary.	

*Adapted from the National Center for Environmental Decision-Making Research, "Information Gathering and Analysis Tools."

Refer to Organizational Process Models of Decision-Making for a summary of analytic models of decision-making.

The utility of this approach is its straightforward identification of critical components of decision-making and the information they require. Each step is important, and merits the attention and involvement of key stakeholders and decision-makers. However, it is important to remember that engaging in a real-world decision-making process is seldom as straightforward and sequential as a step-by-step presentation of the model suggests. Some stakeholders in a particular environmental problem may begin gathering data before others have fully agreed on the nature of the problem; data gathering can also cause stakeholders to realize that the problem has been misdiagnosed, or that an entirely new problem exists as well. Thus, depending on which decision-making participants are involved and what information is available to them, even a systematic, information-focused approach to decision-making may jump around from step to step within the above model.

In addition, the decision-making process rarely comes to an end, if the evaluation and adaptation step is effective. Changing environmental and social conditions and changing scientific knowledge mean that environmental decisions may require periodic revisiting. Incomplete follow-up with evaluation and adaptation can lead to problems such as unforeseen or unintended consequences that are difficult to address, or policy failure in which the decisions that are made cannot be implemented. Evaluation and adaptation can thus transform the information-focused model from a list of steps into a cycle. (See more under "An Adaptive Management Approach.")

For examples of real-world decision-making processes, refer to the case studies in the other modules of this series.

An Adaptive Management Approach

For a graphic depiction of the adaptive management approach, see "Adaptive Management Area Network Objectives" from the USDA Forest Service.

One way to understand adaptive management is to see it as the transformation of the step-by-step approach described above into a cycle, where monitoring and evaluation explicitly lead back to problem identification. This cyclical approach ensures that ongoing environmental management is informed by new information, and that decisions are revisited if necessary. In essence, adaptive management treats environmental management as a deliberate experiment. Decisions that are made should ensure that actions taken are documented and their effects are monitored, so that both participants and interested observers can learn from the evolving situation.

Some versions of adaptive management also emphasize that for data-gathering to be as complete as possible, the local knowledge and experience of affected communities must be incorporated. In order for this information to be included in environmental decision-making and management, government agency staff and scientists must forge productive working relationships with local communities.

> The mantra of adaptive management is "policies are experiments; learn from them."
>
> Kai N. Lee, author of Humans in the Landscape

One implication of working within an adaptive management framework is that mistakes are viewed as opportunities for learning. This is different from more traditional approaches to management, in which mistakes are viewed as a waste of resources and time. Adaptive management acknowledges that not all mistakes are avoidable, and in fact some "mistakes" during decision-making and management may turn out to provide important new knowledge and opportunities.

Collaborative, Deliberative Approaches

In general, approaches to environmental decision-making that emphasize collaboration and deliberation seek to ensure that the "public participation" mandated by statutes such as NEPA meets two basic qualifications: that opportunities for stakeholder involvement are embedded throughout the decision-making process, and that they offer real opportunities for informing decisions and actions. These approaches gained momentum when citizens became frustrated that some parts of government decision-making appeared open to their input, while others seemed closed or already decided.

> Action—on climate, species loss, inequity, and other sustainability crises—is being driven by local, people's, women's, and grassroots movements around the world, often in opposition to the agendas pursued by governments and big corporations.
>
> State of the World 2015, The Worldwatch Institute.

Taking a collaborative approach requires that environmental decision-making processes operate locally, in order to effectively include the knowledge and experience of people who have lived with the problem and will have to live with decisions made. In addition, collaborative approaches emphasize an ongoing process where people with different interests develop the ability to work together, and continue to do so, over a period of time. In addition to ensuring that the most current scientific and technical information is gathered, collaborative processes focus on the people involved in decision-making. In essence, collaborative approaches operate on the assumption that a decision (and its implementation and monitoring) will be most effective if government, business, interest groups, and citizen stakeholders work together.

Environmental Decision-Making Tools

Many resources are available to help participants in environmental decision-making processes as they implement effective decisions. Some of these resources are skills, such as careful listening, while others provide specific guidelines to follow, such as the environmental impact statement (EIS).

Tools for the major components of environmental decision-making—public participation, information gathering, analysis, implementation, and monitoring—are discussed below. Some tools are typically used in the context of an information-focused decision-making process, others in the context of a collaborative approach. Yet any may prove useful in a given situation, regardless of whether the overall process emphasizes one approach over another.

Tools for Public Participation

From their different standpoints, government and citizens have distinctive, yet related roles in fostering effective participation in environmental decision-making. Government agencies, officials, and staff have the responsibility and authority to manage resources in the public's interest; it is thus also the government's responsibility to create sufficient and appropriate opportunities for stakeholder participation in decision-making. Citizens seeking to engage in these opportunities have the challenge of balancing pursuit of their own needs and interests with recognition of situational constraints as well as the needs and interests of other stakeholders. Refer to the "Public Participation Guide: Internet Resources on Public Participation."[19]

Technical specialists have the important responsibility of providing current information at various points in the decision-making process, as well as providing informed responses to questions or uncertainties. It is important to note that information is not neutral: the way in which technical specialists make their contributions to public decision-making is equally as important as the nature (accuracy, timeliness, completeness, etc.) of the information itself. Technical specialists who are aware of the tools for effective participation that are available for both government and citizens will have a toolbox that can help them make sure that they provide information in a way that is responsive to the concerns of these two major information constituencies.

Five Guidelines Important to Collaborative Environmental Decision-Making[20]

These suggestions can help government staff work in a more collaborative fashion and can also be used to enhance the effectiveness of public participation in any environmental decision-making process.

1. *Help* … employees imagine the possibilities of collaboration in carrying out important work, building necessary relationships, and generating better decisions.
    - convey images in many ways
    - provide opportunities for participants to tell their own stories
    - capitalize on existing meeting and conference opportunities
    - spark the attention and ideas of those beyond agency walls
2. *Enable* … employees to develop and use collaborative arrangements by such means as enhancing employee capabilities and providing resources and flexibility to those who are already motivated to collaborate.
    - train individuals and teams
    - enhance workforce composition
    - provide resources
    - increase flexibility
    - create formal links with other agencies
3. *Encourage* … employees to experiment with collaborative approaches to resource management by influencing the attitudes of staff and supervisors and providing incentives to employees and groups outside the agency to be involved in collaborative initiatives.
    - influence perceptions and attitudes
    - provide incentives
4. *Evaluate*… the effectiveness of differing approaches to promoting and undertaking collaborative arrangements in the agency and how they might be modified.
5. *Be committed* to the process and follow through with your agency's agreements and responsibilities.
    - use consistent measures in employee performance evaluation
    - maintain continuity within agency collaborative relationships
    - follow through with your commitments
    - believe in the potential of collaboration

Tools for Information-Gathering

NEPA Process

NEPA was the first of the modern federal environmental statutes. For more information on NEPA, see the Council on Environmental Quality's NEPA.gov website at https://ceq.doe.gov/.

One of the most important methods used to gather data for public environmental issues is through the National Environmental Policy Act (NEPA),[21] enacted in 1969 and signed into law in 1970. NEPA was the first of the modern federal environmental statutes, setting the stage for laws dealing with specific environmental issues, such as the Clean Water Act[22] and the Clean Air Act.[23] Revisions to NEPA have been made through internal evaluation, public participation, and Council on Environmental Quality (CEQ) review through 2011, and are likely to continue as improvements are considered.[24] The main thrust of this relatively brief statute is simply to establish national environmental policies and goals for the country and create the CEQ to report directly to the President of the United States.

NEPA is not a regulatory statute, i.e., it does not impose pollution control requirements. Rather, NEPA is an information statute, requiring the federal government to prepare and publish information about the environmental effects of and alternatives to actions that the government may take. NEPA is premised on the assumption that it is more effective to be *proactive* (and prevent environmental problems before they occur) rather than *reactive* to problems (after they are created). By providing information to decision-makers and the public prior to initiation of actions, NEPA's intention is to improve the quality of final decisions—hence NEPA's nickname as the "stop-and-think" legislation.

One of the most important provisions of NEPA for disseminating information about planned actions is the requirement that a federal agency prepare a detailed statement, known as an Environmental Impact Statement (EIS), when it proposes to take any "major federal action significantly affecting the quality of the human environment." This seemingly simple requirement has triggered far-reaching and sometimes controversial consequences as a tool to ensure that environmental impact is a major consideration in all governmental decision-making.

Environmental Impact Statement (EIS) Process

Yucca Mountain, Proposed Nuclear Waste Repository. Credit: USGS

One prominent example of the EIS process is the Yucca Mountain Project, for which extensive research has been conducted and which includes public participation in the process of siting a nuclear waste repository in Nevada. A study of the site began in 1978 and the project has spawned much public debate. The EIS process was finalized in 2006, but the facility has not yet been built. Controversy over the environmental impact of the project continues to this day.

The Final Environmental Impact Statement (FEIS) is available online at the Department of Energy's website at http://energy.gov/nepa/downloads/eis-0250-final-environmental-impact-statement. Basic background information and a timeline of government NEPA-related actions on the project can be found in *A Reporters Guide to Yucca Mountain* and at YuccaMountain.org.

Because many proposed actions of state and local governments are dependent at least in part on federal funding, the stop-and-think requirement of NEPA often affects actions beyond those that are primarily federal. Many state governments have adopted their own NEPA-type legislation. Thus NEPA or similar state laws affect the many projects in the private sector that are tied directly or indirectly to government projects or approvals.

Three levels of analysis in the NEPA environmental impact process determine whether or not an undertaking could significantly affect the environment. These three levels include:

1) Categorical Exclusion (CE)
2) Environmental Assessment (EA) or a Finding of No Significant Impact (FONSI)
3) Environmental Impact Statement (EIS)

Categorical Exclusion (CE)

At the first level, an action can be categorically excluded from the analysis requirement if it meets certain criteria previously determined as having no significant impact on the environment. A number of agencies have developed individual lists of actions that are normally categorically excluded from environmental evaluation under their NEPA regulations. If those criteria are not met, the agency prepares an EA.

For examples of CEs, refer to the Region 8 NEPA Compliance Document Index on the U.S. EPA website.[25]

Environmental Assessment (EA)

At the second level, an agency prepares a written EA to determine whether or not an undertaking would significantly affect the environment. Generally, an EA explains the need for a proposed action, the alternatives considered, and the environmental impacts of each alternative. It must also identify agencies and persons consulted in preparing the EA.

"Environmental impact assessment should not come after the drawing up of a business proposition or the proposal of a particular policy, plan, or programme. It should be part of the process from the beginning, and be carried out in a way which is interdisciplinary, transparent, and free of all economic or political pressure. It should be linked to a study of working conditions and possible effects on people's physical and mental health, on the local economy and on public safety … A consensus should be reached between the different stakeholders, who can offer a variety of approaches, solutions, and alternatives."

Pope Francis, Encyclical Letter "Laudato Si'," 2015

If assessors determine that the action won't impact the environment significantly, the agency issues a FONSI, which can address measures that will be taken to reduce potentially significant impacts. If the EA determines that the environmental consequences of a proposed federal undertaking may be significant, an EIS must be prepared.

For examples of EAs, refer to the EPA's Environmental Assessment Publications.[26]

Environmental Impact Statement (EIS)

An EIS is a more detailed evaluation of a proposed action and alternatives to that action. The public, other federal agencies, and interested outside parties may provide input into the preparation of an EIS and may comment on the draft EIS.

If an agency anticipates that an undertaking may significantly impact the environment, or if a project is environmentally controversial, a federal agency may choose to prepare an EIS without first preparing an EA.

After a final EIS is prepared, the agency makes a decision on whether to proceed with the action. At this time, the agency is required to publish the Record of Decision (ROD), including a description of how the findings of the EIS were incorporated in the decision-making process.

For examples of EISs, refer to Environmental Impact Statement (EIS) Database[27] from the EPA.

Tools for Analysis and Assessment

Analyzing Risk

Definitions of key concepts of risk analysis vary somewhat within the field, but for the purposes of a basic understanding of risk analysis in relation to environmental issues, some broad definitions of the basic terms can be established. The following general definitions from the National Council for Science and the Environment will be used in this section.

How one risk analyst defines terms

"**Risk**" is the probability of occurrence of a particular adverse effect on human health or the environment as a result of exposure to a "hazard," which may be a hazardous chemical in the environment, a natural hazard, or a hazardous technology.

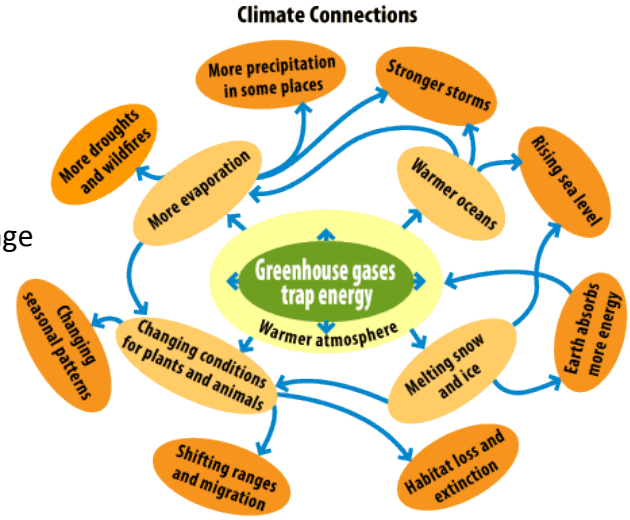
"**Risk assessment**" refers to a formal or informal procedure producing a quantitative estimate of environmental risk. For example, risk assessment is often used to estimate the expected rate of illness or death in a population exposed to a hazardous chemical.

"**Risk analysis**" is used more broadly to include quantitative and qualitative evaluation of all relevant attributes of environmental hazards, risks, adverse effects, events, and conditions that lead to or modify adverse effects, and populations or environments that influence or experience adverse effects.

"**Risk management**" is the process of deciding what should be done about a hazard, the population exposed, or adverse effects, implementing the decision, and evaluating the results. It also refers to decision-making at the program or agency level, for example, deciding which hazards should be managed and in what order.

"**Comparative (or relative) risk analysis**" and "**cost-benefit analysis**" (or assessment) are aids to risk management.

Scientific Uncertainty



Credit: U.S. EPA

Scientific uncertainty is a major factor in risk analysis. Climate change and global warming are current and well-known examples of environmental issues that have involved ongoing scientific uncertainty. In the 1990s, scientific opinion of the validity of climate change shifted dramatically in a single decade. In large part, this was due to a disagreement in the scientific community based on what constituted the best available science at the time. It involved methodology, i.e., how much data over what length of time is sufficient to warrant remediative action (which could have far-reaching economic and social repercussions) versus the consequences of failure to take immediate action (which could have equally far-reaching economic and social repercussions, in addition to potentially irreversible environmental damage).

With further study and advances in research and technology in the 21st century, the scientific debate concerning the effects of human activity on climate change has been largely resolved. There is widespread consensus in the scientific community that anthropogenically-accelerated climate change is occurring. According to the AAAS, "Based on the evidence, about 97% of climate scientists agree that human-caused climate change is happening."[28]

A report published by the National Research Council (NRC), Understanding Risk: Informing Decisions in a Democratic Society, states "the NRC committee responsible for this report supports the importance of bringing the best science to bear in analyzing risks, while emphasizing that the science currently available for conducting risk assessments is often incomplete, imprecise, and laden with debatable assumptions and that conflicts among the values and interests of the affected publics are common in risk assessment and risk management."

A report by the National Academy of Sciences asserts that, "Climate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems."[29]

According to the 2014 Fifth Assessment Report from the International Panel on Climate Change (IPCC), "Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane, and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century."[30]

Despite the overwhelming scientific consensus that human activities have increased the rate of climate change, there does continue to be disagreement and discussion about the political, economic, and social ramifications of making decisions based on the existing climate change science.

The "Climate Change" module within this *Technology and Environmental Decision-Making* learning module series provides more background on the scientific and practical complexities of this issue.

Risk Assessment

Risk assessment has become an important analytical tool in environmental decision-making. Basically, it involves the identification of potential adverse effects to humans or ecosystems resulting from exposure to environmental hazards. Risk assessment is used to help determine if these adverse effects are great enough to require increased management or regulation.

The fact that exposure to many potential hazards can occur simultaneously and in varying

degrees makes the risk assessment process complex. Risk assessment employs a systematic evaluation process to determine if a hazard exists and what potential risk it might pose. Observed effects, estimations, and extrapolations are all used to establish estimates, identify uncertainties, and support planning and decision-making.[31]

Risk assessment is frequently used in developing regulations to protect the public from exposure to toxic contaminants. Risk assessment also helps analyze ecosystems and such issues as stratospheric ozone depletion and global climate change. Because of gaps in risk assessment data sets, efforts to compare and rank environmental risk will always rely on professional judgment.[32]

Human Health Risk Assessment

For information on risk assessment of human health, refer to the "Point Source Water Contamination" module within this *Technology and Environmental Decision-Making* learning module series.

Ecological Risk Assessment

Ecological risk assessment evaluates ecological effects caused by human activities, such as the draining of wetlands or the release of chemicals. It is used to support many types of management actions, including management and regulation of hazardous waste sites, industrial chemicals, pesticides, and the effects on watersheds or other ecosystems, which may be affected by multiple chemical and nonchemical stresses.[33]

Ecological risk assessment includes three major phases:

- problem formulation
- analysis
- risk characterization[34]

Problem formulation is a planning and scoping process that establishes the goals, breadth, and focus of the risk assessment. Its end product is a conceptual model that identifies the environmental values to be protected (the assessment endpoint), the data needed, and the analyses to be used.[35]

The **analysis** phase develops profiles of environmental exposure and the stressor effects. The exposure profile characterizes the ecosystems in which the stressor may occur as well as the plants and animals that may be exposed. It also describes the magnitude and spatial and temporal patterns of exposure. The ecological effects profile summarizes data on the effects of the stressor and relates them to the assessment endpoints.[36]

Risk characterization integrates the exposure and effects profiles. Risks can be estimated using a variety of techniques, including comparing individual exposure and effects values, comparing the distributions of exposure and effects, or using simulation models. Risk can be expressed as a qualitative or quantitative estimate, depending on available data. In this step, the assessor also:

- describes the risks in terms of the assessment endpoint
- discusses the ecological significance of the effects
- summarizes overall confidence in the assessment
- discusses the results with the risk manager[37]

Ecological risk assessment also interacts with activities integral to, but separate from, the risk assessment process. For example, discussions between the risk assessor and risk manager are important. At the initiation of the risk assessment, the risk manager can help ensure that the risk assessment will ultimately provide information that is relevant to making decisions on the issues under consideration, while the risk assessor can ensure that the risk assessment addresses all relevant ecological concerns.[38]

A major component of effective risk assessment is the interaction among risk assessors, risk managers, and interested parties at the beginning (planning and problem formulation) and end (risk characterization) of the risk assessment process. In problem formulation, the complementary roles of each determine the scope and boundaries of the assessment, selecting ecological entities that will be the focus of the assessment and ensuring that the production of the assessment will support environmental decision-making. The interface among risk assessors, risk managers, and interested parties is critical for ensuring that the results of an assessment can be used to support a management decision.[39]

For additional coverage of risk assessment and related issues (such as scoping, generation of alternatives, impact identification and analysis, mitigation, decision-making, and post-decision analysis), refer to "Human Health Risk Assessment."[40]

For further details on ecological risk assessment and habitat evaluation, refer to "Guidance, Tools, and Applications"[41] and "Damage Assessment and Restoration Plans."[42]

Risk Management

Once a risk has been identified, risk management is the part of the decision-making process by which an action or a policy is developed. The process integrates risk assessment with technical, political, social, and economic issues to develop risk reduction and prevention strategies.[43]

When possible, risk management must take into account the uncertainties associated with various assumptions and judgments made in each step of the risk assessment process. The risk assessment should describe the uncertainties so that a risk manager may factor them into the decision-making process. Of course, not all uncertainties are known, which constitutes the inherent difficulty of the risk analysis process.[44]

Cost-Benefit Analysis

As with all public policies, environmental decision-making must include economic considerations. In a cost-benefit analysis of environmental issues, three main points of information must be gathered and analyzed:

- What are the relative costs and benefits of proposed policies?
- Who will pay these costs?
- How much are the stakeholders willing to pay to achieve the desired goals?

Because these points directly involve the values and interests of the stakeholders, the cost-benefit analysis of the risk management process is complex. The difficulty is increased when decision-making involves the value of resources that are not privately owned, such as the air, water, or biodiversity.

For further details on cost-benefit analysis and environmental economics, refer to the National Center for Environmental Economics[45] and its Environmental Economics Course Materials.[46]

Comparative Risk Assessment

Comparative risk assessment has been an aspect of risk analysis since the late 1980s. Two principal forms of comparative risk assessment help develop risk rankings and priorities to place various kinds of hazards on an ordered scale from small to large.[47]

- **Specific risk comparison** refers to side-by-side evaluation of the risk (on an absolute or relative basis) associated with exposures of a few substances, products, or activities. Such comparisons may involve similar risk agents (e.g., the comparative cancer risks of two chemically similar pesticides) or widely different agents (the cancer risk from a particular pesticide compared with the risk of death or injury from automobile travel).[48]

- **Programmatic comparative risk assessment** attempts to make macro-level comparisons among many widely differing types of risks, usually to provide information for setting regulatory and budgetary priorities for hazard reduction. In this kind of comparison, risk rankings are based on either which hazards pose the greatest threat or on the amount of risk that can be avoided with available technologies and resources.[49]

Risk Communication

Risk communication covers a range of activities directed at increasing public knowledge of risk issues and participation in risk management. This includes, for example, warning labels that provide consumer education about existing hazards, development of publicly accessible databases characterizing hazardous circumstances, and public hearings on risk management issues. Risk communication is viewed as a dialogue among stakeholders—risk experts, policymakers, and affected segments of the public.[50]

Alternatives Assessment

Some scholars criticize risk assessment as an overly restrictive approach to analyzing available options for environmental decision-making. One such scholar, Mary O'Brien, defines risk assessment as "the process of estimating damages that may be occurring, or that may occur if an activity is undertaken." O'Brien argues that "it is not acceptable to harm people [or non-humans] when there are reasonable alternatives," and that "nobody is able to define for someone else what damage is 'acceptable.'" She suggests adopting "alternatives assessment" in which "pros and cons of a [. . .] range of options" are thoroughly considered in a process that "include[s] the public whenever they might be harmed by activities considered in the assessment." Alternatives assessment includes reviewing a wide range of options along with potential adverse and beneficial effects of each option.[51]

Tools for Implementation

Regulatory Methods

A number of different methods are used to implement federal environmental pollution policies. Each of the following approaches has its strengths and weaknesses, and each approach is used to some extent in federal environmental decision-making and regulation.

In his "Civic Environmentalism" essay, public administration scholar DeWitt John claims that a primarily federal regulatory approach to implementation has difficulty reckoning with the increasing technical, social, and ecological complexity of emerging environmental problems. He argues that states and communities should be more involved with environmental policy, and that "in some cases, [they] will organize on their own to protect the environment, without being forced to do so by the federal government." John calls for a "civic environmentalism" in which state and local activity is encouraged and facilitated, rather than mandated, by federal agencies. In sum, civic environmentalism is "a bottom-up approach to environmental protection."[52]

Command and Control

Currently, federal environmental regulation often employs a "command and control" method, where the laws specify the amount of pollutants a facility may emit or the type of emissions control equipment it must use. Two primary approaches are used to determining how much emissions control will be required.

- **Technology-Based**. A technology-based regulation is a standard or limitation that requires as much emissions control as can be achieved with existing technology. Technology-based regulations use an assessment of the type of available control technologies and their costs. In most cases, technology-based regulations are set without considering the effect of the emissions on the environment.

- **Environmental Quality-Based.** Environmental quality-based regulations are intended to ensure that a certain level of environmental quality is achieved. This may include consideration of the impact of emissions on human health, environmental ecosystems, or both. The National Ambient Air Quality Standards under the Clean Air Act are examples of environmental quality-based standards, and individual limits on air emissions are set to ensure that these standards are not violated.

Market Incentives

Some regulatory techniques use the market economy to control emission of pollutants. These techniques provide economic incentives to reduce pollution by the emitting sources. They allow individual facilities, rather than the government, to make decisions about how they control their own emissions.

- **Marketable Pollution Rights (Cap-and-Trade).** A cap-and-trade system attempts to use market forces to control emissions. With this approach, the regulatory agency:
    - establishes a given level of allowable emission of pollutants (cap)
    - allocates to industrial facilities the right to emit pollutants at a level that will achieve the established allowable level
    - allows facilities to buy and sell their allocated right to emit (trade)

  For example, one facility reduces its emissions to a level below its allocated right. It then sells its right to emit equal to this reduction to a second facility. The second facility buys the right if it can do so more cheaply than its cost of actually reducing emissions. The main purpose here is to achieve a desired level of emissions at the lowest cost.

- **Subsidies.** In some cases, the government encourages control of emissions by providing an economic subsidy to those who do control their emissions. For example, in the past, up to 75 percent of the cost of building municipal sewage treatment plants was paid by the government. In many cases, tax deductions are also provided for certain expenditures for emissions control equipment.

- **Effluent Fees.** Taxes or other fees could be imposed based on the amount of pollution produced by an industry. The more an industry pollutes, the more taxes or fees it pays. Effluent fees have not been widely used in the U.S.

Information Disclosure

The requirement to develop and publish environmental information is also intended to improve environmental quality. The informational approach does not require that any specific level of emissions control be achieved or that the information result in specific control measures. The act of compiling the information and its public disclosure are the intended catalysts for voluntary emissions control by individual companies, in order to avoid negative public, political, or economic results.

- **Reporting.** Industrial facilities can be required to provide public information about the types and amounts of pollutants they emit. The Emergency Planning and Community Right-to-Know Act requires such reporting.

- **Study/Planning.** In some cases, statutes require persons to study and report on the environmental effects of proposed activities. The requirement that the federal government prepare EISs under NEPA is an example of this approach.

Litigation

In addition to establishing regulations, federal legislation can also give citizens the right to sue in cases of harm to individuals, groups, and the environment. Beginning with the Clean Air Act of 1970, Congress created what is commonly known as a "citizen suit" provision, which allows individuals to file suit to compel compliance with the Act if the federal or state government fails to do so. Almost every major environmental statute contains this provision. (See the following table for examples from Cornell University Law School.)

Legislation with Citizen Suit Provision	
Legislation	**Title & Section**
Clean Air Act	42 U.S.C. § 7604
Clean Water Act	33 U.S.C. § 1365
Superfund	42 U.S.C. § 9659
Emergency Planning & Community Right-to-Know Act	42 U.S.C. § 11046
Resource Conservation and Recovery Act	42 U.S.C. § 6972
Safe Drinking Water Act	42 U.S.C. § 300j-8
Toxic Substances Control Act	15 U.S.C. § 2619

Tools for Monitoring and Evaluation

Whether environmental decision-making is viewed as following a series of steps (as in the traditional analytic approach) or as an ongoing evolution (as in adaptive management and collaborative approaches), monitoring the effects of decisions is an important responsibility of the decision-making community.

Broadly, three types of monitoring are used to help evaluate environmental management. **Implementation or compliance monitoring** assesses whether or not planned activities took place. **Effectiveness monitoring** judges how well the planned activities achieved intended results. **Validation monitoring** identifies additional information required to further support or disprove measured effects.

When, in addition to ecological, scientific and technical factors, social factors are being monitored and evaluated, consultant Su Rolle, who has been closely involved with the long-standing Applegate Partnership in California, recommends using the following "measures of progress for collaboration"[53] to assess "the ability of a collaborative group to:"

- meet its mission and achieve outcomes
- be sustained
- understand the community
- be inclusive and diverse, reflect the community
- create a forum for diverse ideas and shared learning
- increase community capacity
- increase cooperation across organizational, administrative, and jurisdictional boundaries
- stimulate innovation, new ways of doing business
- facilitate changes in policy, laws, and programs

Aids to Understanding provides resources and activities.

Summary

As any parent raising a child can attest, it would be nice to have a manual of rules to follow. But just like parents, decision-makers are not provided with a full set of hard and fast rules or procedures. Making decisions about the environment involves a dynamic mix of technical innovation, science, economics, politics, and social interaction.

A technological solution to a problem may take many years to develop and implement; the social process that is intertwined with technical innovation is just as complex. Many people throughout the process—from manufacturers to environmental organizations, government workers to scientists, lobbyists to individual citizens—have deeply held views about their own interests and values, and about the environment and the extent to which it should be protected. These values and interests, as well as the scientific uncertainty in many areas related to cause and effect of environmental problems, are just as important as technological breakthroughs in moving society from recognizing a problem to making a decision about it to ultimately improving human health and environmental quality.

Understanding the social implications of environmental decision-making gives students insight into the dynamics that shape how environmental problems are addressed and what resources are available to assist in the effort. This insight, combined with their technical knowledge, also will help them identify critical points in the process and respond to them appropriately as environmental professionals.

Aids to Understanding

Resources

These online course syllabi and printed textbook resources offer additional information about **environmental policy**:

- "Environmental Policy and Economics," MIT OpenCourseWare (OCW) syllabus. Course textbook is:
  - *Environmental Economics* by Charles Kolstad, Oxford University Press, 2010.
- "Environmental Policy," University of Massachusetts syllabus. Course textbooks are:
  - *Environmental Policy: New Directions for the Twenty-First Century* by (Eds.) Norman J. Vig & Michael E. Kraft, SAGE, 2012.
  - *Debating the Earth: The Environmental Politics Reader* by (Eds.) John S. Dryzek & David Schlosbert, Oxford University Press, 2005.
- "Fundamentals of Environmental Economics and Policy," Harvard University syllabus. Course textbook is:
  - *Markets and the Environment* by Nathaniel Keohane and Sheila Olmstead, Island Press, 2007.
- "Environmental and Natural Resource Policy," University of Tennessee-Knoxville syllabus. Course textbook is:
  - "Environmental Economics and Policy" by Tom Tietenberg and Lynne Lewis, Prentice Hall, 2009.

Many resources provide information on **decision-making process and tools**. These websites provide a sampling:

- "Handling Scientific and Technical Information in Contentious Public Issues: Tools and Techniques for Extension Educators" from North Carolina State University[54]
- "The Adaptive Decision-making Process as a Tool for Integrated Natural Resource Management: Focus, Attitudes, and Approach" from Conservation Ecology[55]
- "Environmental Policy Tools: A User's Guide" from the U.S. Congress Office of Technology Assessment[56]
- "Managing Uncertainty in Environmental Decisions" from the American Chemical Society[57]
- "Public Participation in Environmental Decision-Making and the Federal Advisory Committee Act" from Resources for the Future[58]

For some specific resources on **adaptive management**, see:

- Some useful definitions of adaptive management, plus a diagram that summarizes the concept, are provided by the government of British Columbia.[59]
- The Sierra Nevada Forest Plan Amendment provides a current example of how adaptive management is being implemented in the U.S. Forest Service. Their website provides an overview of the decision-making context[60] with information on how adaptive management has been incorporated into the planning process, and an update on the evolving role of adaptive management in this case. [61]

For some specific additional resources on **collaborative, deliberative approaches**, see:

- *Collaborative Environmental Decision-Making: A Power Sharing Process that Achieves Results Through Dialogue* from Virginia Tech[62]
- "Measures of Progress for Collaboration: Case Study of the Applegate Partnership" from the U.S. Forest Service[63]
- *Negotiation and Collaborative Problem Solving: Working Effectively on Tough Community Issues* from North Carolina State University[64]
- *Making Collaboration Work: Lessons from Innovation in Natural Resource Management* by Julia Wondelleck and Steven Yaffee[65]
- *The Deliberative Practitioner: Encouraging Participatory Planning Processes* by John Forester[66]

Several websites provide good background information about **risk analysis and assessment**, including:

- Environmental Assessment Publications. From the U.S. EPA[67]
- "Risk Management Guide" from the U.S. Department of Energy[68]
- "The Role of Risk Analysis and Risk Management in Environmental Protection" from the Library of Congress, Congressional Research Service[69]
- "Science and Decisions: Advancing Risk Assessment" from the National Research Council[70]

Several sites have information specific to **ecological risk assessment and valuation**, including:

- "Guidance for Conducting RCRA Ecological Risk Assessments" from the Ohio EPA[71]
- The EPA's "Ecological Risk Assessment"[72] and "Natural Resource Damages: A Primer."[73]

For information on the **economics of environmental decision-making**, especially cost-benefit analysis and valuation, visit these sites:

- Benefit-Cost Analysis from the U.S. EPA[74]
- "Assessing Preferences for Environmental Decisions with Long-Term Consequences" from the U.S.EPA/NSF STAR Partnership for Environmental Research.[75]
- "Environmental Decision Making and Economics." From the U.S. EPA STAR Partnership for Environmental Research.[76]
- "Economics and Cost Analysis Support" resources from the U.S. EPA[77]

Activities

Activity: Perceptions of Environmental Decision-Making

Assign students the task of researching and bringing to class newspaper articles on current environmental issues. To get a sense of students' perceptions regarding environmental decision-making, select one or two of the issues in the newspaper articles. Facilitate a class discussion on the topic(s) and ask the following questions:

- Do you make environmental decisions?
- Who are the key players/stakeholders in the decision-making process and what are their roles?
- What information and expertise do you need to make a sound environmental decision?
- Can good decisions be made with limited information?
- Can bad decisions be made even if you have a substantial amount of information?
- How do priorities, values, and preferences factor into decision-making?
- What role do scientific facts play in decision-making?
- What is your role as a citizen or as a member of the workforce?
- Who determines the need for environmental laws and regulations?
- How can policymakers become aware of new scientific information as it becomes available?
- What should policymakers do when new scientific data is available on issues they have already made decisions on?
- Is there a way to facilitate this "updating" process?

Activity: Exploring Decision-Making Forums

Assign students to research and participate in (or observe) one or more of the participatory forums in their local community. (Examples are listed in the Forums for Individual Participation or Forums for Group Participation sections in this module.)

Students should describe the participatory forum they chose and evaluate its effectiveness based on the following social goals or outcomes:

- public information and education
- public values in decision-making
- quality of decisions
- confidence in institutions (e.g., government)
- conflict resolution among competing interests
- cost-effectiveness

Ask students to recommend, based on their findings, ways to improve the participatory process. Students could also select and apply one or more of the participatory methods to one of the case studies from the other modules in the *Technology and Environmental Decision-Making* modules, recommending ways to improve public involvement.

Activity: Attend a Local Decision-Making Meeting

Assign students to attend and observe a decision-making meeting in their local community. Select a meeting (e.g., city council, county board, zoning commission) that will have an agenda item relating in some way to an environmental issue. Students should describe the meeting in general, how the environmental issue was addressed, who the stakeholders were, and the stakeholders' viewpoints. (Stakeholder examples are listed in the Mix of Voices section in this module.)

Students should also evaluate the effectiveness of the meeting based on the same outcomes outlined in the previous activity.

Activity: Town Meeting Role Play

This activity, excerpted from ATEEC's "Brownfields in a Box"[78] multimedia instructional material, is provided as part of this module. It presents a town meeting to discuss a Brownfield site, a property that has been or is perceived to be environmentally contaminated. Students act out the roles of stakeholders and decision-makers. This simulated Brownfield site is in the town of "Anyplace, USA" and is used for the environmental decision-making scenario. Any environmental issue affecting any town could be adapted for discussion.

The activity generates discussion and planning for redevelopment of a Brownfield site and gives the student an insight into participatory environmental decision-making. (It can be modified slightly to generate discussion for any type of strategic planning.) Instructional strategies, scenarios, and stakeholder roles are provided in the activity.

Activity: Risk Characterization

University of North Carolina provides learning activities concerning Superfund sites at the website "Identifying Risks at a Superfund Site."[79]


Social
Behavioral
Equitable
Sustainable
Environmental
Viable
Economical

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