CHAPTER ONE

Environmental Assessment in Engineering and Planning

Environmental assessment is the process of assessing, or measuring, the change or consequence to environmental factors when making *plans*, such as those for an engineering construction project, or *decisions*, such as deciding whether to go forward with a new, tax-funded project. The art and science of contemporary environmental assessment began with the enactment of the National Environmental Policy Act on January 1, 1970. Methodologies and procedures were developed for responding to the requirements of the act, and techniques and considerations continue to evolve as these processes mature.

Environmental considerations were largely ignored for almost 200 years in the development of the United States. Only in the last third of the twentieth century did environmental factors begin to play a significant role in the speed and direction of national progress. These factors have brought about a fresh concern and recognition of the dependence that we, as human beings, have on the long-term viability of the environment for sustaining life. The "ethic" of conservation of resources has also grown as concern for the environment has grown, because much of our environmental quality is itself a nonrenewable resource.

Human development, especially in the late twentieth and early twenty-first centuries, has made an intrusion into the overall ecological balance required to maintain the Earth as a habitable place. We recognize this fact through our concern for the environment, but in most developed countries people depend on and are reluctant to give up the profligate consumption of resources that characterizes their way of life. Thus, it is incumbent upon the human species to examine its past actions and to attune future actions to ensuring the long-term viability of Earth as our home. The development of environmental impact analysis, or assessments, is a logical first step in this process. Environmental analysis provides an opportunity for us to consider in our decision making the effects of actions that would not otherwise be accounted for in the normal market exchange of goods and services. Any adverse effects to the environment that are disclosed in the assessment process then need to be weighed against any social, economic, and other advantages that might be derived from a given proposed action. The art and science of identifying and quantifying the potential social or economic *benefits* from a proposed action has become finely tuned. We now understand that an equally clear exposition of associated *problems* is equally deserving of careful study and consideration.

Blind adherence to the theory and practice of a pure economic exchange for decision making has possible long-term adverse consequences for the planet Earth. However, some aspects of life cannot be accurately represented as monetary values. Economic guidelines for decision making are adequate as long as the effects of societal activities are insignificant when compared to the long-term suitability of the planet as a place to reside. This type of trade-off is essential and is one that will always be made, but we must remain aware that sacrificing long-term viability for short-term expediency is less than a bad solution; it is no solution.

As long as there have been human societies, people have manipulated their environments to address their needs for food, shelter, damage control, aesthetics, or sport. Pre-historic people hunted the woolly mammoth to extinction; the classical societies of ancient Greece and the Mediterranean permanently removed forests for building materials, fuel, and to increase areas for cultivation; the mediaeval hunters of central Europe extirpated lions from their prior northern range; early Central America civilizations built large sports arenas; exotic plants have been moved around the world to grace new gardens (sometimes becoming noxious weeds); and settlers to the United States imported pheasants, oryx, and other nonnative species. With the increase in human population and the rise of industrial societies, we have developed the ability to generate large-scale changes, sometimes with disastrous consequences. In the last century, the serious environmental problems that surfaced following the collapse of the totalitarian regimes of Eastern Europe are vivid examples of unintended, and extreme, adverse impacts to both the native environment and human health.

As *glasnost* opened the previously closed Eastern European and Soviet countries to the West during the late 1980s, it also revealed a region suffering extreme environmental degradation. In previous decades, the area had focused on centrally planned industrial development with disregard for the environmental consequences of this development. Industrialization had been the foremost priority, and production targets were to be met to the exclusion of other goals. Industries had been heavily subsidized by the government, particularly for energy and natural resource needs, and allotments of resources and budgets had been made based on past use and expenditures. Although some countries may have had stringent environmental regulations on their books, these regulations were not enforced. Pollution fines levied by the government were small and easily paid with government subsidies. With the presence of production targets and subsidies and the absence of open markets and a realistic price structure, industries had no incentive to conserve resources, avoid pollution fines, or invest in efficient production technologies.

As a result, environmental conditions were seriously degraded; air pollution, water pollution, hazardous wastes, and extensive impairment of agricultural land and forests were at extreme levels and among the highest in the world. Air in the region was polluted by exceptionally high levels of sulfur dioxide due to dependence on coal burning for energy, few pollution controls, and extremely inefficient use of energy (Schultz & Crockett, 1990). Rivers, lakes, and seashores were heavily polluted by industrial waste discharge and agricultural runoff; 95 percent of Polish rivers were so badly polluted that their water could not be used directly, even for industrial purposes, because it was corrosive (Hallstrom, 1999).

Indiscriminate dumping of hazardous wastes and the use of substandard landfills contaminated groundwater sources in the region. In addition, the withdrawal of the Soviet Union from previously occupied territories left behind substantial environmental degradation; 6 percent of Czechoslovakian territories were damaged by toxic wastes, oil, and lead (Renner, 1991). In some instances there was so much spilled fuel available in the soil that private individuals could dig productive oil wells (Carter & Turnock, 1997). The Chernobyl accident of 1986 released 1000 times the radioactivity of the 1979 Three Mile Island accident near Harrisburg, Pennsylvania, and the radiation from Chernobyl was widely dispersed over the northern hemisphere (Flavin, 1987). Inappropriate agricultural practices in Eastern Europe eroded soils, and industrial pollution contaminated large land areas. For example, in the late twentieth century the land around Glubokoe (Hlybokaye), a nonferrous metallurgical center in northern Belarus, had 22 times the permitted level of lead, 10 times the permitted level of cobalt, and 100 times the permitted level of zinc (French, 1990b). An average of 77 percent of Polish and Czech forests showed signs of acid rain damage, most likely as a result of huge amounts of highly toxic dust released into the atmosphere throughout Bulgaria, Romania, Hungary, and Poland from industrial smelter releases and brown coal combustion (Hallstrom, 1999). The cost of pollution to human health was seen in lower life expectancies, higher infant mortality, and higher incidence of respiratory diseases, cancers, birth defects, and other illnesses.

But this is not the only cost of environmental degradation in the region; without a base of functioning water, land, and air resources, industrial productivity and growth have been hampered. The decline in forestry, falling crop yields, damage to historic buildings due to acid deposition, and corrosion of pipes by polluted water are a few examples of real costs incurred by industrialization without separate regard for environmental consequences. The issues of economic growth (prosperity), poverty, and environmental protection are intertwined in a perplexing way. Lasting economic growth is based on managing natural resources in a sustainable manner. Poverty is both a cause and an effect of environmental problems. Sustainable economic growth provides the means to address world poverty and the means to solve environmental questions. Industrialization and economic development are essential to provide basic amenities of life and to sustain and improve our standard of living. The challenge is how to determine a direction and level of development that is not focused merely on what is most expedient for the present, but that will benefit future generations as well as provide for the immediate needs of society.

During the past few decades, the business world has become increasingly aware that sustainable development and production can indeed be good for business. With the passage of the Pollution Prevention Act of 1990 (42 U.S.C. §13101 et seq.), pollution prevention was declared to be the nation's primary pollution control strategy, and a hierarchical system for pollution management was developed—with source reduction at the top of the hierarchy followed by recycling, treatment, and disposal. Increased support for pollution prevention practices has allowed industry to realize that waste reduction, recycling, conservation, and pollution control can also be tied to lower production costs. Furthermore, a public image as an environmentally responsible company can be essential in gaining community acceptance, attracting top employees, and securing the trust of investors. This "corporate environmentalism"—as it has been termed by Edgar S. Woolard, Jr., the former chairman and CEO of DuPont—when coupled with the managerial skills and productive capacity commanded by business, appropriately places corporations in a position of leadership in moving toward sustainable use of Earth's resources ("Agenda for the 21st Century," 1990).

1.1 WHAT IS ENVIRONMENTAL ASSESSMENT?

In order to incorporate environmental considerations into a decision or a decision-making process, it is necessary to develop a comprehensive understanding of the possible and probable consequences of a proposed action. However, prior to this development, a clear definition of the environment must be constructed.

The word "environment" means many different things to different people. To some, the word conjures up thoughts of woodland scenes with fresh, clean air and pristine waters. To others, it means a pleasant suburban neighborhood or a quiet campus. Still others relate environment to ecology and think of plant–animal interrelationships, food chains, threatened species, and other recently recognized issues.

In current usage, the term *environment* means a combination of all these concepts plus many more. It includes not only the categories of air, water, plants, and animals, but also other natural and human-modified features that make up our surroundings. Beauty, as well as environmental values, is very much in the "eye of the beholder." Thus, transportation systems, land-use characteristics, community structure, and economic stability all have one thing in common with carbon monoxide levels, dissolved solids in water, and natural land vegetation—they are all characteristics of the human environment. Our environment also includes aesthetic, historic, cultural, economic, and social aspects. In other words, the environment is made up of a combination of our natural and physical surroundings and the relationship of people with these surroundings. Thus, in environmental assessment, all these elements are to be considered. The ultimate selection of what is "really important" in any one case is very much an art, or at least a refined judgment, based in part on social and political views as well as technical or engineering considerations. Approaches that firmly lay down rigid rules in this area will prove to be too inflexible. We seek to develop a feeling for what ought to be emphasized, as well as pointing out ways in which each situation is different.

Environmental assessment implies the determination of the environmental consequences, or impact, of proposed projects or activities. In this context, *impact* means change—whether positive or negative—from a desirability standpoint. An environmental assessment is therefore a study of the possible or probable changes in the various socioeconomic and biophysical characteristics of the human environment that may result from a proposed or impending action. Of course, some proposed actions will result in no significant change for one aspect or another of the environment. In these cases, the impact is one of "no effect." Some proposed actions may also have no *change*, but the present status may be environmentally unacceptable or trending downward; the result would be continued degradation of the environment. In practice, the terms *environmental effects* and *consequences* are generally interchangeable with *impacts*, especially since the latter has come to have solely negative connotations in many circles. Remember, of course, that some proposed projects and actions may well have many, or even mostly, positive effects in many sectors of the environment. Environmental assessment should not be an adversarial activity.

In order to perform the assessment, it is first necessary to develop a complete understanding and clear definition of the *proposed action*. What is to be done?

Where? What kinds of materials, labor, and/or resources are involved? Are there different ways to accomplish the original purpose? It is often very difficult to obtain a clear description of these factors, especially at early stages of planning. The project planners may not have a clear idea themselves, or the project design may continue to evolve as the assessment is performed.

Second, it is necessary to gain a complete understanding of the *affected environment*. What is the nature of the biophysical and/or socioeconomic characteristics that may be changed by the action? What is the boundary of the work site? How widely might some effects be felt? Within a mile radius? As far as the next state? All may be possible.

Third, it is necessary to envision the implementation of the proposed action into that environmental setting and to determine the *possible impacts* on the environmental characteristics, quantifying these changes whenever possible. An interdisciplinary analysis of these effects is required to ensure that a comprehensive and broad perspective is applied.

Fourth, it is necessary to *report the results* of the study in a manner such that the analysis of probable environmental consequences of the proposed action may be used in the decision-making process. For federal government agencies, this process has been extensively codified. For state government agencies or other entities, the documentation process may vary widely.

The exact procedures to be followed to accomplish each environmental assessment are by no means simple or straightforward. This is due primarily to the fact that many and varied projects are proposed for equally numerous and varied environmental settings. Each combination results in a unique cause–condition–effect relationship, and each combination must be studied individually in order to accomplish a comprehensive analysis. For the project manager, selecting which aspects of a particular environment to emphasize, and which effects to elucidate, is a highly skilled decision-making process. It is potentially as difficult as developing the plan for the project itself. Generalized procedures have been developed for conducting an analysis in the manner indicated by the four steps outlined earlier—1) define proposed action, 2) define affected environment, 3) determine possible impacts, and 4) report the results. These procedures are explained in subsequent chapters of this book.

1.2 ENGINEERING AND PLANNING ISSUES

In the United States, the spirit of the several environmental laws, past and present, is stated in the National Environmental Policy Act (NEPA, Public Law 91-190; see Appendix A for the full text): "It is the continuing policy of the Federal Government . . . to use all practicable means and measures . . . to create and maintain conditions under which man and nature can exist in productive harmony." NEPA provides the underlying premise that the United States will preserve and protect our environment "in harmony" with human activities. NEPA is at heart a planning document. It provides that proposed federal actions must be well defined; that the reasons for taking the action must be disclosed; that reasonable alternative approaches must be identified; and that considerations such as environmental impacts, social and economic concerns, and aesthetics must be considered as appropriate alongside such traditional engineering considerations as cost, scope, and schedule. The well qualified engineer should be able to determine how to apply the phrase "in harmony" and how to integrate environmental assessment and protection concerns into a completed project.

A *policy* defines intent, or "what" will be done, and provides general guidelines; a *procedure* defines the measures that will be undertaken to carry out the policy, or "how" it will be done. While NEPA provides underlying national policy, it is perhaps best known for its procedural requirements that govern how the national policy will be implemented. Congress specifically included *action-forcing provisions* in NEPA to ensure that individual agencies would carry out the policy as intended. These provisions, framed as regulatory procedures, form the basis of environmental assessment (40 CFR 1500–1509; see Appendix D). NEPA and its implementing regulations apply to federally funded actions. Many states and local governments have followed suit and have put into place similar requirements for projects funded by state or local grants, taxes, or other entities. Note that any federal funding contribution is enough to trigger the need for NEPA consideration. Cost-shared projects often fall here, even if all the planning and engineering are done locally. A particularly difficult area is when the only federal role is the granting of a permit or license. Numerous such projects have been required to undergo NEPA assessment procedures. For the engineer, environmental assessments provide a means to consider and weigh environmental factors when planning and designing projects.

Engineering project planning may be done in many ways. Engineering standards often rely on the "plan-do-check-act cycle," a four-step model for carrying out change developed early in the twentieth century and applied broadly to business process quality improvement in the 1950s by W. E. Deming (sometimes called "the Deming cycle") (American Society for Quality, n.d.; Deming, 1986). Since the early 1990s, some corporations have developed similar engineering quality-improvement methodologies that use five steps: define, measure, analyze, improve, and control; other similar concepts include Six Sigma associated with quality control in manufacturing (a process in which 99.99966% of products are statistically predicted to be defect free).

In addition to planning requirements and environmental considerations, some types of engineering projects are heavily regulated in other ways besides environmental requirements, such as highway projects regulated by transportation criteria and design standards (see http://www.fhwa.dot.gov/resources/legsregs/), nuclear power plants regulated by the Nuclear Regulatory Commission (see http://www.nrc.gov/reactors/operator-licensing.html), chemical plants regulated by the Occupational Safety and Health Administration (see http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910), or hospitals regulated by various health and safety criteria. However, these other regulatory concerns do not preclude environmental assessment or take precedence over NEPA. Environmental assessment documentation may provide a convenient path to include other regulatory considerations, thus ensuring that project documents are internally consistent and all relevant factors are discussed. Of course, NEPA does not require that alternatives that are inconsistent with other laws or regulations be analyzed, although it may be of some value to the design team or the public to understand why such alternatives might be dismissed from further consideration.

Some federal agencies lump "environment" in with "human health and safety," with mixed results. For example, in the last decade of the twentieth century the U.S. Department of Energy (DOE) espoused a philosophy called Integrated Safety Management (ISM), targeted on reducing or eliminating industrial accidents at its several laboratories and plants (U.S. Department of Energy Office of Health, Safety and Security, 2011). ISM is intended to protect workers, the public, and the environment through identifying hazards associated with work processes and then to apply "tailored" controls to mitigate adverse effects from those work processes. Although initially lacking reference to "environment," the definition of ISM was modified to cover environmental protection as well as health and safety. On the surface, ISM appears to be a means to achieve environmental protection, but under ISM environmental protection appears secondary to "safety": the DOE's ISM implementing guidance defines "safety" as a synonym for "environment, safety, and health" and does not make reference to environmental protection (Department of Energy Order Doe O 450.2, April 25, 2011). ISM can be a complementary process when used to implement the controls indicated through NEPA reviews. However, the potential problem for environmental stewardship arises when ISM or a similar safety program is applied *instead* of the NEPA process, which both short-circuits the environmental review process and fails to meet the letter or spirit of the law (Webb & Doerr, 2002).

Of special interest to the engineer is the question of "how?" How is a policy or program going to be carried out? How are the assumptions underlying an environmental analysis going to factor into analysis parameters and design plans? How are the ensuing mitigation measures, adopted to ameliorate adverse impacts, going to be carried forward? How are project plans, funding requests, product specifications, or construction documents going to be developed or modified to take into account the results of environmental analysis and NEPA–related mitigation measures?

Engineering disciplines generally make use of some type of formal *project management* process to plan, organize, and carry out workflow. Although there are many variations, all project management systems include the following: a project definition (project description, objectives, and what is to be built); project activities (a detailed list of project activities); project schedules (a detailed timeframe for all activities and their interdependence); a defined endpoint (when the job will be finished); and some number of formal measurement points, or "milestones," to help ensure that work stays on track, on schedule, and within allocated budgets. Of interest to the engineer and project manager is how environmental assessment considerations will be parsed into the project management plan. Even something as seemingly benign as the name of the project may be an issue. For example, in the 1980s a U.S. Department of Defense project entitled "Improving Troop Mobility" was actually a proposal to construct a 10,000-foot runway on an installation. While the original title did not suggest a need for NEPA consideration, the actual project plans surely did.

It is important to time the NEPA review so that it is conducted when it will do the most good. If the NEPA analysis is done "too late," useful alternatives may be foreclosed without proper consideration. A common failure when deciding the location of a new facility, for example, is to perform NEPA analyses too late - after the construction site has been selected using other criteria. Projects must still be flexible enough to meaningfully incorporate analysis of alternative courses of action and to apply the results of any mitigation measures that were developed through the NEPA review and incorporated into the Record of Decision (ROD) or other decision documents. On the other hand, if the NEPA review is conducted before a project is adequately defined and before sufficient project details are available to determine probable consequences to the environment, then NEPA may have been applied "too early."

Conducting a NEPA review is often thought to unnecessarily delay a project; however, project planners must factor in appropriate time (and costs) of preparing environmental documentation and determine ways to expedite the review if time is truly of the essence. Additionally, the assumptions used for the NEPA analysis must bear resemblance to the assumptions used for the engineering design and for any other permits required. For example, if an engineering design calls for three cooling units to manage process airflow, and the air quality permit covers four units to provide redundancy, it is not useful for the NEPA review to be based on installation and operation of only one unit as this may lead to a review that either understates the total impact or concludes that more units must be installed to mitigate adverse impacts related to heat release.

After the environmental review is completed, the project manager or engineer must determine how to apply or implement mitigation and monitoring measures. In some cases, mitigation may consist simply of long-term monitoring by an outside party, such as keeping track of wildlife movements by the local or state forester. In some cases, the project design may remain basically unchanged but the location may need to be altered, such as moving a building location a few hundred yards to avoid an archaeological site. In some cases, the project may be built as planned but operation of the facility may be modified, such as limiting use of external lights during wildlife breeding seasons or limiting the use of specific hazardous materials to agreed-upon amounts. In some cases the project or facility must undergo major revision to accommodate environmental concerns or mitigation measures or be abandoned if the decisionmaker deems the environmental cost too great.

"Environmental monitoring" (or "NEPA monitoring") refers to checking an activity or facility over time to see if the consequences that were projected to occur did in fact occur, if they were higher or lower than anticipated, and if mitigation measures have been effective. For example, if a coastal project was thought to potentially affect endangered sea turtle nesting sites, and seasonal mitigation measures regarding nighttime lighting were put into place, were critical habitat areas actually affected? Did the restrictions on nighttime lighting result in a sufficiently darkened area? More importantly, were the promises of reducing nighttime lighting during the nesting season actually carried out? Did the turtles continue to use the area? Was a change in wildlife use (up or down) attributable to operation of the facility? Monitoring may also uncover unintended, unanalyzed consequences that may need to be addressed at a later time, or may disclose that the project "as built" did not conform to the project analyzed. This is especially evident if "field changes" were put into place during construction, for example to correct for survey or measurement errors, to use an alternative building material when the specified product was not available, or to address conditions that were previously not known to exist such as intermittent seasonal flooding.

Failure to meaningfully monitor the post-project consequences is one of the most egregious and most common omissions in the total process.

The engineer must always be cognizant of the fact that no matter how skillful the project design was, how meaningful the environmental analysis was, or how diligently the mitigation measures were developed, the final determination of environmental consequences rests with how the project is implemented and operated throughout its lifecycle.

1.3 WHY ENVIRONMENTAL ASSESSMENT IS NEEDED

The necessity for preparing an environmental assessment may vary with individual projects or proposed actions. For many actions, there is a legal basis for requiring such an analysis. By law (NEPA), major federal actions require environmental impact assessment. Occasionally, Congress may require preparation of environmental documentation as a condition of passing legislation for a particular project, even though other laws and regulations may not normally require it. For other types of projects, the environmental analysis may be undertaken simply for incorporation of environmental considerations into planning and design, recognizing the merit of such amenities on an economic, aesthetic, or otherwise desirable basis. Good professional practice or agency policy may require this analysis even if law or regulation does not. The incorporation of environmental considerations in business practices is an extremely important aspect of environmental assessment.

In the United States, enactment of the NEPA, on January 1, 1970, mandated that federal agencies assess the environmental impact of actions "which may have an impact on man's environment" (NEPA, Title I, Sec 102[2][A]). Other state or local governments and some other nations have enacted legislation patterned after NEPA requiring environmental assessment of major actions within their jurisdictions. Chapter 3 further discusses NEPA, and Chapter 4 describes the content and format of documents such as the Environmental Impact Statement (EIS) and the Environmental Assessment (EA).

1.4 WHO PREPARES ENVIRONMENTAL ASSESSMENT AND PLANNING DOCUMENTS?

Within the federal government, the *responsible official* of the federal agency that is proposing the action is required to generate environmental documents and is called the *proponent* of the action. The preparation of these documents, naturally, requires input by a multidisciplinary team of engineers, scientists, and others representing disciplines related to the major potential environmental impacts. Section 102(2)(A) of NEPA requires that a "systematic and interdisciplinary approach" be used in preparing environmental documentation.

Frequently, more than one federal agency is involved in a project due to:

1. Sharing of project leadership
2. Joint funding of projects
3. Functional interdependence

In such cases, one federal agency must be designated as the "lead agency" and, consequently, the proponent of the project or action. The other agencies are termed "cooperating agencies."

At times, private industry may be undertaking major resource development projects (e.g., offshore oil exploration), and the federal agency is merely issuing a permit, license, lease, or other entitlement for use. The question becomes: "Who should prepare the required EA or EIS?" In such a case, the federal agency issuing the permit or other entitlement normally relies on the applicant to submit much of the environmental information needed for documentation and analysis. The applicant may be required to submit an essentially complete study. The agency should assist the applicant by outlining the types of information required. Many federal agencies, however, require that the EA or EIS be prepared by the federal agency itself, with project input (but not the assessment of potential consequences) generated by the permit applicant. In all cases, the agency granting the permit must make an independent evaluation of the environmental issues involved and must take full responsibility for the scope and content of the environmental documentation prepared.

As a result of NEPA-mandated environmental assessment, a number of separate documents may be required at different phases of the effort. Some examples are: Notice of Intent, Scoping Summary, Environmental Assessment, Finding of No Significant Impact, Environmental Impact Statement, and Record of Decision. The role of each of these documents in the assessment process is described in Chapter 4.

Table 1.1 and Figure 1.1 provide a summary of EISs filed by selected agencies between 1998 and 2008. In practice, there are many more filed documents than major proposed actions. Each action requires at least a draft and a final EIS, and many have one or more supplements in later years as well. Some draft EISs never result in an action. The 10-year total of documents filed thus may represent less than half as many "major actions." Table 1.2 and Figure 1.2 detail the total EISs filed by executive departments during the years 1998 to 2008.

Table 1.1 Total EISs filed by selected agencies for the years 1998–2008

	Year											
Federal Agencies	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
Forest Service	110	87	115	119	112	189	174	153	144	139	124	1466
Federal Highway Administration	89	85	67	89	96	84	89	77	66	79	64	885
U.S. Army Corps of Engineers	72	52	55	42	61	44	48	48	56	40	42	560
Bureau of Land Management	38	38	30	24	33	47	33	43	42	52	48	428
Department of Energy	20	33	20	36	47	39	31	33	42	53	36	390
National Park Service	37	36	35	31	22	41	35	43	34	26	25	365
National Oceanic & Atmospheric Administration	26	18	11	16	19	24	32	28	23	23	36	256
Fish and Wildlife Service	3	13	18	7	13	8	14	15	15	16	13	135
U.S. Navy	20	20	10	9	9	6	5	4	1	8	24	116
U.S. Army	20	10	3	11	8	5	8	4	9	20	7	105
Federal Aviation Administration	6	17	9	16	9	3	9	13	4	6	10	102
U.S. Air Force	8	10	10	6	4	5	5	3	8	3	6	68
General Services Administration	4	4	7	7	7	2	4	3	5	8	2	53
Environmental Protection Agency	7	1	1	7	3	6	10	4	2	0	1	42

(http://ceq.hss.doe.gov/nepa/nepanet.htm)

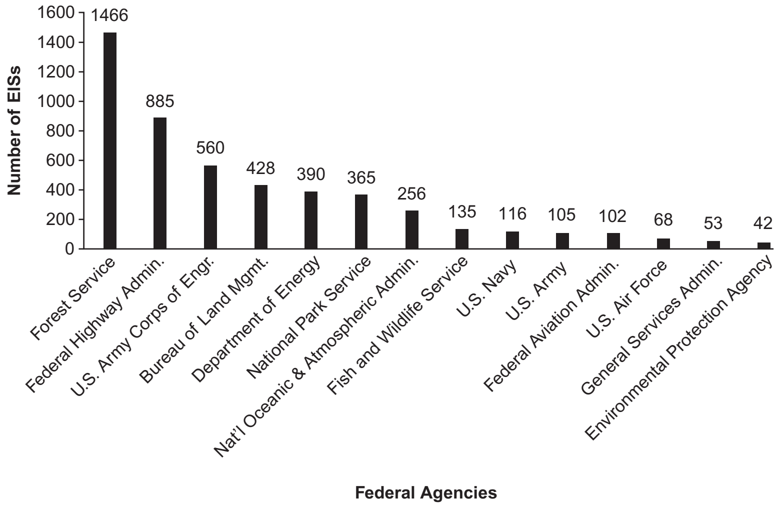

Figure 1.1 ***Total EISs filed by selected agencies for the years 1998–2008.*** *(http://ceq.hss.doe.gov/nepa/nepanet.htm)*

1.5 INTEGRATING ART, SCIENCE, STRATEGY, AND MANAGEMENT ISSUES

Environmental assessment, like most other complex processes, has elements that represent rigorous scientific endeavor. Some examples might be the analysis of soil or water samples or the design of a plan to acquire these samples. The selection of instrumentation to measure soil loss or air quality is equally complex, with numerous references, formulas, and guidelines from handbooks and rulebooks from regulatory agencies. A skillful project manager will be knowledgeable about the basic principles of a dozen or more sciences, from civil engineering through biology, or will seek the advice of people trained in these areas.

Another skill is the art of knowing when, if ever, aspects such as soil nutrients, water, air quality, lichen productivity, or aesthetic effects will be relevant and will require examination. This can be taught only to a degree. Through use of real-life examples, we hope to illustrate many ways in which judgment may be developed in this area. This area of analysis is an *art*, and there are few hard-and-fast rules. One must learn what has been proven desirable in practice, just as one must be aware of what has been considered inadequate. What are the elements of a good artistic composition? One

Table 1.2 Total EISs filed by executive departments for the years 1998–2008

	Year											
Executive Departments	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
Department of Agriculture	119	95	119	125	128	200	179	157	157	148	128	1555
Department of the Interior	96	110	111	82	93	113	111	126	117	117	121	1197
Department of Transportation	108	116	94	120	123	108	116	104	86	97	104	1176
Department of Defense	123	95	80	69	83	60	69	60	75	74	79	867
Department of Energy	20	33	20	21	47	39	31	33	42	53	36	375
Department of Commerce	28	20	11	17	20	24	32	28	23	23	36	262
Department of Justice	11	9	9	14	4	9	4	2	2	3	2	69
Department of Homeland Security	1	0	1	1	1	3	7	4	10	5	8	41
Department of Housing & Urban Development	0	1	3	3	1	1	5	5	2	5	0	26
Department of State	1	0	2	0	0	3	2	0	0	4	3	15
Department of Health & Human Services	0	0	0	0	0	4	4	4	0	0	1	13
Department of Veteran Affairs	0	0	0	0	0	0	0	0	1	1	0	2
Department of Labor	0	0	0	0	0	0	0	0	0	0	0	0
Department of Treasury	0	0	0	0	0	0	0	0	0	0	0	0

(http://ceq.hss.doe.gov/nepa/nepanet.htm)

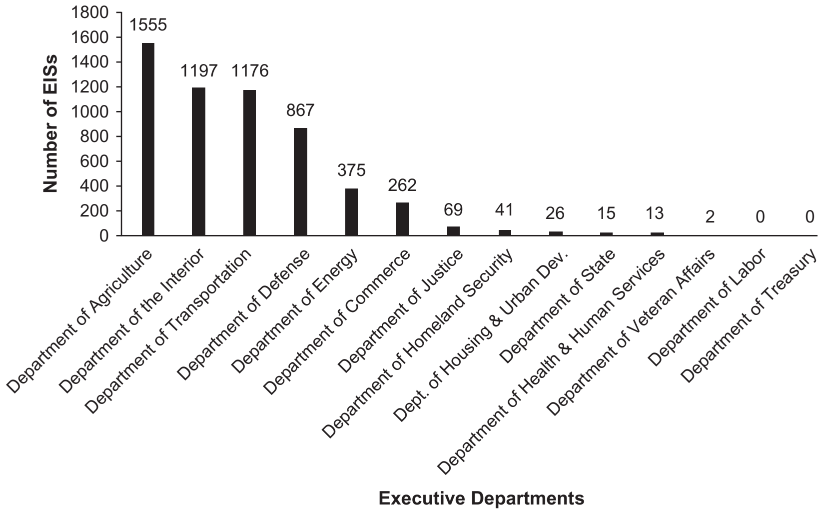

Figure 1.2 ***Total EISs filed by executive departments for the years 1998–2008.*** *(http://ceq.hss.doe.gov/nepa/nepanet.htm)*

may learn a few rules, but that in itself is insufficient to generate meaningful, adequate environmental analyses. We will present those rules, but the practitioner must rely on experience, both personal and that gained through extensive study in relevant areas.

1.6 DISCUSSION AND STUDY QUESTIONS

1. Consider the history of the United States. In the past 300 years, what were the significant federal actions taken with respect to conservation and environmental preservation? Who were the individuals most responsible for these actions and what were their motives? What contemporary federal agencies resulted from some of these actions? How have the roles of these agencies changed with time?
2. Many tribes and bands of native peoples occupied this country before Spanish occupation in the late fifteenth century. How did these people manipulate the environment? What were the intended and unintended consequences of these activities? Do any of the practices survive today, and what have been the results? What were the changes brought about by the Spanish and other early colonists? How do those changes vary regionally, from the Hawaiian Islands and South Pacific territories, to Alaska, to the Southwest, to the Caribbean territories, to the Northeast?

3. Discuss the tradeoffs between economic development and environmental concerns. How do factors such as inflation, economic conditions, political power, and international concerns affect our environmental "conscience"?
4. Define the term *environment*. Distinguish between 1) the natural and the built environment, and 2) the biophysical and the socioeconomic environment. Describe how these environments may be affected by human activities. Are the effects negative or positive? What kinds of tradeoffs may become significant? Is it likely that all these types of considerations would enter into the decision-making process unless mandated by law?
5. How does *interdisciplinary* differ from *multidisciplinary*? Is it possible to thoroughly and adequately evaluate the environmental consequences without utilizing an interdisciplinary approach? Why or why not?
6. What is the most effective way to integrate environmental protection mitigation measures into construction project documentation: Plans? Design drawings? Specifications? Permits? Construction contracts?