

Integrating Scientific Knowledge for Professional Education in Environmental Management

by

WILLIAM H. MATTHEWS, Ph.D. (M.I.T.)

Arthur D. Little Associate Professor of Environmental Sciences and Engineering, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, U.S.A.; Visiting Faculty Member, Centre d'Etudes Industrielles, Geneva, Switzerland,

&

JOSEPH C. PERKOWSKI

Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, U.S.A.

INTRODUCTION

As concern about environmental problems has increased over the past few years, there has been some corresponding concern about the lack of professional resources available to attack these problems and to prevent their occurrence in the future. Almost every group that has studied this area—whether it was public, private, or governmental—has reached a common conclusion. A statement of this conclusion, which provided the impetus for the study described in this paper, was in the Report of the Secretary-General (1972) on the Action Plan for the 1972 United Nations Conference on the Human Environment, where he observed that it was found for 'virtually every area of environmental concern' that 'there are very few professionals with the training and experience needed to understand and manage multidisciplinary relationships, particularly those involving the common ground shared by scientists and technologists, on the one hand, and the political decision-makers, on the other.'

It has become increasingly clear that the most critical environmental problems of our societies do not correspond neatly to the areas of differentiation and specialization that have been developed to advance knowledge and skills in the dozens of engineering, natural science, and social science disciplines, and in the various professions. It is also apparent that the past and present functions and roles, in the public and private sectors of society, for directing and managing the various activities of Man, are often not very helpful in supporting comprehensive and rational approaches to environmental management.

Thus, a long-term strategy for more effective management of the Earth's environment and resources must include the following three elements: a reorganization and extension of our knowledge in these areas, the development of new functions and roles in the public and private sectors, and the creation of new educational programmes and institutions to meet the critical needs

of a wide variety of persons who analyze environmental problems or who make decisions concerning the environment. There are essentially five major steps required for implementing this strategy: (1) development of a conceptual framework for considering environmental management processes, (2) development of outlines of the substantive bodies of knowledge which are relevant to environmental management, (3) description of the present and needed functions and roles that comprise environmental management, (4) relating the above to one another and deriving criteria for developing new educational programmes, and (5) development of those new programmes.*

The United Nations Environment Programme (UNEP), which was established upon the recommendations of the 1972 U.N. Conference on the Human Environment, has placed a high priority on the implementation of these steps. One of the first project contracts supported by UNEP was with M.I.T.—to begin developing some of the resource materials on which future educational programmes could be based. Collaborative arrangements were made between staff at Massachusetts Institute of Technology (M.I.T.) and the Centre d'Etudes Industrielles (C.E.I., the Center for Education in International Management) in Geneva, Switzerland. Grants were made by the Edna McConnell Clark Foundation, of New York City, to conduct complementary projects designed to produce resource materials and a 'market survey' of the environmental management functions in multinational corporations.

This paper outlines some of the results of the above project. It presents a conceptual approach to professional education in environmental management, a general description of the substantive outlines and bibliographies that were developed for the major subject areas of environmental management, and a report

* A referee has suggested that, between steps 2 and 3, there should be an additional one involving identification of gaps in the available knowledge and encouragement of research in disclosed areas.—Ed.

on some of the work conducted with C.E.I. Neither this paper nor the report which it summarizes is definitive in its treatment of this subject, and nor is either operational in terms of leading directly to educational programmes. The paper and report do, however, represent a first—and essential—step in a complex, iterative process of developing such programmes. The report 'Resource Materials for Environmental Management and Education' (Matthews, in press) presents materials that can be mined by those who already have some idea of the needs of the persons for whom they would prepare educational programmes.

In the course of this project, staff at C.E.I. and M.I.T. have worked together to identify the educational needs of 'environmental managers' in multinational corporations, and have begun work with UNEP to determine how these needs can be identified for policy planners in developing countries. The explanation of these needs is the next step of this process. When that is done, the work to date can be used most effectively to provide a framework and some material for responding to these needs.

ENVIRONMENTAL MANAGEMENT PROCESSES

There are really no formalized comprehensive environmental management procedures (such as those formal and hierarchical structures that exist for managing major enterprises in the public and private sectors of society). There are instead a myriad of individual and collective decisions by persons, groups, and organizations throughout society, that result in impacts—both positive and negative—on environmental resources. Taken together, these decisions, and the interactions among the people involved, constitute a process—a process that in effect results in the management (or mismanagement) of the environmental resources of our society. The study of environmental management thus involves obtaining an understanding of these social and political processes, and also of the natural environmental elements and processes that are affected by societal decision-making in all of its varied forms. Such study encompasses the understanding of all of Nature (the environment) and of all of Man's institutions and means of collective decision-making (management). Full proficiency is not possible in this 'field', because there is not enough collective knowledge, theory, or wisdom, to define or to describe what would have to be mastered.

It should, however, be possible for those with real concern and responsibility for environmental resources to obtain some better understanding than they now have of what would be involved in making these management processes more rational and responsive to environmental criteria (rather than solely to econo-

mics or expediency or other criteria). This project has been directed towards finding ways to provide a somewhat better perspective on the processes of aiding, through the development of suitable educational programmes, those who have proper concern for the environment and responsibility for its future.

Every major decision in environmental management must be made in the broad context of meeting many societal needs. A society cannot simply decide, and get, what kind of environment it wants; it must also decide what it is willing to give up, or to do in addition, so that it can effect the change in the *status quo* which will generally be required to produce a change in the environment. Such decision-making is incredibly difficult under the best of circumstances. It becomes almost intractable in complex, pluralistic and heterogeneous societies where scientific information is incomplete and often speculative.

Environmental management as an operational concept might best be defined as describing the actions of those involved in decision-making, who make a deliberate and systematic attempt to understand how their activities affect the environment and how their concerns about the environment will affect their activities. These persons would strive to make explicit the values involved, the objective information available, and the compromises that would be necessary. They would then attempt to resolve the issues within the relevant public and private decision-making spheres. Such actions are in contrast both to those of people who single-mindedly pursue one set of societal objectives, with no consideration of environmental values, and to those of people who pursue narrowly-defined 'conservation' goals while making no attempt to analyze the major changes that would occur in society as a consequence of radical changes in the *status quo* of human activities and societal development.

Thus, environmental management is a positive concept—not a negative 'halt progress' or 'back to Nature' concept. Some of the key aspects involved are:

- Identification of the values set upon the amenities (economic goods, environmental conditions, and aesthetics) which are regarded as desirable for, or contribute to, Man's individual and social development.
- Identification of the resources that are needed for such development.
- Identification of how meeting some needs and wants will reduce or increase the ability to meet others (as a result of the destruction, degradation, or enhancement, of resources).
- Identification of the 'actors' who have a stake in the conflicts that may arise between meeting needs and protecting resources.
- Resolution of these conflicts.

Fig. 1 presents a very simplified, idealized diagram of the decision-making steps in environmental management processes. The real processes are much more complicated than the figure indicates, and certainly do not follow such an orderly and logical set of steps

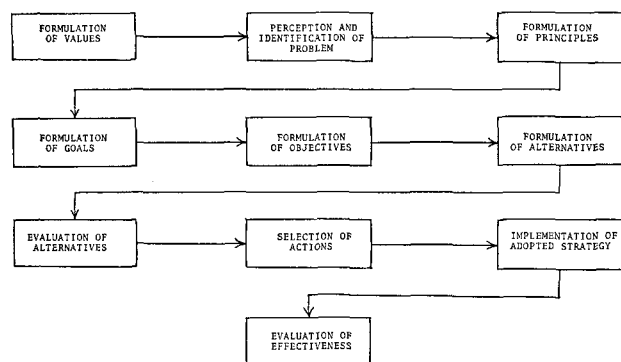


FIG. 1. Major decision-making steps in environmental management processes.

Nor should the reader expect to find them so described in this paper; but the framework is useful for isolating major decision-steps and indicating the educational needs of decision-makers for such steps. The inputs, outputs, and processes of each step will, of course, vary considerably among problem areas and depend upon the types of 'actors' who have the decision-making responsibility. However, the nature of the inputs and outputs, and to some degree the processes, can be generalized, and relevant information can be brought together for educational programmes. Thus it is useful for the environmental manager to have the material which he needs approximately divided into such units as those suggested in Fig. 1.

Each step requires an input of objective and subjective information. While the specifics will vary from case to case, some aspects will remain constant in different contexts. For example, the scientific content involved in water problems is different from that of air but similar for other water problems—especially if the scientific information is sorted into categories such as lakes, rivers, ground-water, and oceans. This categorization will remain relatively constant in any societal context. On the other hand, societal values may be very different between different cultures, but within the same culture the values may be fairly constant—regardless of what physical component of the environment is under consideration.

The types of processes also vary widely. They may be corporate, executive, legislative, judicial, citizen, or other types of processes. It is possible, however, to generalize somewhat if one considers specific decision-making steps; for example, formulation of principles is generally a legislative function, whereas choice of means to implement is generally an executive function.

By considering specific 'actors' or roles, one can also develop some general contexts; for example, politicians play important and similar roles in some steps and a very small part in others.

Perhaps the greatest challenge of professional education in environmental management is to develop the generalizable contexts of knowledge in cultural, decision, and role, categorizations. These must be broad enough to be useful for more than one manager, and be applicable in more than one societal context at more than one step in the process for more than one specific environmental problem. On the other hand, the contexts cannot be so broad that the amount of time and energy required to obtain the needed knowledge and insights would be prohibitive for any given person, or that the coverage would necessarily be so superficial that it would be of little practical value to a manager. (Thus far in our project, we have only been able to take the most preliminary steps in determining the generalizable contexts along the lines of 'actors' and the roles which they play in specific decision-making steps. These determinations are very closely linked to the identification of the needs of the potential clients for educational programmes, and can thus emerge from the type of preliminary survey discussed in the M.I.T. report (Matthews, in press).

BODIES OF KNOWLEDGE

A large part of the M.I.T. investigation has been focused on the development of outlines and bibliographies for the major bodies of knowledge that comprise the 'field' of environmental management. These were based on work done at M.I.T. and on extensive interviews with about one hundred scientists and other professionals in fields ranging from ecology to law. In the present section, a brief description of each of these 'bodies of knowledge' will be given. The pertinent section of the M.I.T. report (Matthews, in press) contains detailed outlines of these, with nearly 1,000 references in all.

The first step in developing these outlines was to determine how best to 'divide' the 'field' of environmental management. After much experimentation and discussion with persons from many disciplines, the following eleven subject-areas were chosen:

- Values and Perceptions
- Ecology
- Environmental Effects
- Environmental Indicators
- Environmental Impact Assessment Methodology
- Modelling
- Monitoring
- Growth and its Implications for the Future

Economics of Externalities Environmental Law Administrative Processes.

Such a division is rather arbitrary, and other sets of subject-areas would also be useful. However, this one seems to provide a reasonable compromise between a list of 'academic' topics and a list of 'operational' or 'decision-oriented' topics. The former consideration is important because one must rely heavily on the academic community for the knowledge that is needed in the various areas; the latter is important because this information must be made relevant to the practising environmental manager.

In all cases the focus has been on functional knowledge—that which would be of use to a manager or planner in understanding the details or the context of some area relevant to his work. It is clear that to master all of these areas one would have to obtain a dozen Ph.Ds and have many years of experience in each of a variety of areas. The challenge of professional education is to extract from these areas only the information that is directly useful for a specific function or role of environmental management.

This requires a fairly explicit set of criteria for selection of relevant material, which in turn requires an extensive survey of the various roles that 'environmental managers' have in the private and public sectors. This 'market survey' of roles and functions is a key element in preparing educational programmes. Using the criteria developed in the market survey, the relevant topics in the outlines of the subject-areas could be selected for each role or function for which programmes were to be designed. The extensive references provided for each area would then be helpful in locating the more detailed material needed for developing the programmes.

The following sections contain a brief description of each subject-area, the approach taken to it, and a general outline of the area. A few of the most useful and general references for these subject-areas are provided at the end of the paper.

Values and Perceptions

The knowledge of people's values and perceptions is a key to planning, if the plan is to be supported by the people. Much emphasis has been placed on technological developments to increase our efficiency in using limited resources, but the question of whether such commitment of resources really corresponds to our needs is often left unasked. In order to formulate a plan which is to be responsive to people's present and future wants, the planner must identify the present values of these wants and inquire how their values will change in the future. At the same time the planner must know what current problems are perceived by the

people, so that he can distribute resources in accordance with their desired priorities.

Every society exhibits a complex and shifting structure of values. This subject-area presents an environmental manager with a spectrum of values which he may face in formulating a plan. If the plan is to address itself to people's future needs, the environmental manager must surmise how present values will change in the future. This subject-area assists the environmental manager to do so by providing information on the basis and development of values. The basic relationship between values and perception is also included in this subject-area. The major topics treated in this area are the following: basis of human values; factors in the development of values; lists of major societal, personal, and institutional, values; and principal variables that shape perception. Sample references of interest are Fishbein (1967) and Proshansky *et al.* (1970).

The primary purpose of this subject-area is to draw the environmental manager's attention, in his planning and decision-making, to the importance of knowing people's values and assessing their capabilities of perception. It is doubtful whether the subject-area alone will enable him to formulate economically-, institutionally-, and politically-feasible plans that will satisfy all wants; but, together with other subject-areas, it will at least bring him closer to attaining that objective.

Ecology

Ecology is the subject that deals with the interrelationships between living organisms (including Man) and their environment. The recent heightened sensitivity of many people to the concept of environmental quality, has stimulated the development of ecology as an important branch of science that is now becoming recognized as widely relevant to everyday human life. In order to comprehend the inherent complexities in this subject-area, it is imperative to adopt a general and integrative approach. This approach is also necessary because ecology has evolved as an integrative science, developing from a variety of disciplines—including biology, geology, physiology, geography, meteorology, and many others. It is this interdisciplinary approach that has particular relevance to environmental management, as the study of ecology involves developing expertise for the purpose of evaluating the utilization of land, air, and water, habitats.

As all human developmental activity takes place in conjunction to some extent with natural systems, it is important to have an adequate understanding of ecological limitations if our development is to be properly managed. Moreover, provision for the rational use of the Earth's resource-base implies consideration of the biological and physical precepts upon which all life functions. To appreciate fully the dynamic processes

which may produce—or act to disturb—stability in the biosphere, it becomes essential to have a fundamental knowledge of the underlying biological mechanisms.

Knowledge of these processes should assist a manager in asking penetrating questions about the ecological phenomena with which he is confronted when performing environmental policy analysis. Some of these questions are: What basic ecological principles underlie environmental dynamics? What are the relations between human activities and their effects on ecosystems? What kinds of responses can we expect from ecosystems when pollutants are introduced? How can planned developments be environmentally efficient? This subject-area highlights consideration of these questions and many others.

The basic principles and concepts of ecology to be treated in this subject-area are physiognomic structure, energy, biochemical cycles, growth and productivity, biological transfers, threshold factors, organization, adaptations to perturbations and stresses, time and space, and resource utilization. The types of ecosystems involved include numerous examples from the entire range of terrestrial, freshwater, marine, and estuarine, 'kingdoms'. Two important works to consider are that of Watt (1973) and a report of the Institute of Ecology (1972) on global ecological issues.

Environmental Effects

This subject-area relates environmental effects to their causes. Associated with any activity is a set of fairly obvious direct or primary effects. However, the influence of the activity does not often terminate with these effects; instead, there is often a succession of derivative, secondary, or indirect, effects which succeed one another like the links of a chain. Complicating the picture of this cause-and-effect relationship is the fact that an effect is generally not the result of one cause alone but of several converging causes. Moreover, any effect may generate a number of direct or indirect effects which will occur at different times and in different places. An environmental manager should not infer from the structure of this subject-area that cause and effect is a one-to-one relationship: a network is a better representation of the interaction and relationship among these effects.

The purpose of singling out this subject-area is to expose an environmental manager to the extreme complexity of the environment. However, even by broadening an environmental manager's perspectives on the spectrum of effects which an activity may have on the environment, this subject-area alone will not actually enable him to contribute effectively to the preservation and enhancement of the environment while at the same time achieving other objectives. After identifying all the probable effects of an activity, an environmental manager must be acquainted with

whatever environmental indicators he can use to measure these effects, be aware of what values he should be particularly concerned with, and be able to assess the total costs and benefits of the activity. Treatment of these topics is provided, respectively, in the subject-areas of Environmental Indicators (next below), Values and Perceptions (*see above*), and Environmental Impact Assessment Methodology (*see below*). It must be emphasized that all our subject-areas are in some way related to one another, and the greatest use can be made of knowledge in each subject-area only if the manager studies them all.

The major topics treated in this outline are water pollution, air pollution, solid wastes, noise, radiation, weather and climate, effects on resources, social and cultural effects, and effects on ecosystems. For each of these areas the activities and residuals that cause the problems are outlined, and the transport and transformation of these residuals in various environmental media are covered. Numerous references are of course available, including, for example, the report of the Study of Critical Environmental Problems (1970), the report of the Study of Man's Impact on Climate (1971), and the National Academy of Sciences (1969) report on resources.

Environmental Indicators

As concern for environmental quality increases, there is a growing awareness among planners, decision-makers, and the general public, that more accurate and objective information on the status and trends of the environment is necessary for improvement of the formulation, implementation, and communication, of environmental policy. An environmental indicator—in the form of a number derived from a collection of statistics which quantitatively summarizes or measures the condition of the physical, ecological, social, economic, or aesthetic, environment—may often provide the kind of information that is required.

This subject-area informs an environmental manager of the significant components in each environment where environmental indicators have been, or should be, formulated to reflect their trends and status. By providing information on who are the potential users of environmental indicators, how environmental indicators can best be made use of, and what the limitations are on the use of these indicators, the subject-area enables the environmental manager to guide himself and others to use indicators discriminately.

The subject-area is related to other subject-areas, and in particular to those of Modelling and Monitoring. The topics covered are the following: needs of, and procedures for, developing indicators; types of indicators; the users, uses, and limitations, of indicators; and indicators currently used or proposed. Inhaber (1974) and Thomas (1972) are two works of interest

in this connection. The principal purpose of the subject-area is to acquaint an environmental manager with a set of potentially effective tools for monitoring the status and trends of the environment, and for evaluating the effectiveness of environmental policy.

Environmental Impact Assessment Methodology

For decades past, the quantifiable costs and benefits—particularly those that could be expressed in terms of dollars—of an activity have dominated its evaluation. Values which could not be quantified or expressed in terms of dollars or other currency were only given superficial treatment, and carried very little weight in decision-making. Environmental quality is one such value; activities were geared to satisfy our immediate material wants. Many industrially advanced countries have had tremendous economic development, but not without a resultant loss of environmental quality. However, the values placed on environmental quality began to grow when the degradation of the environment became increasingly tangible. This growing awareness has gradually pushed planners and decision-makers alike into changing their concept of activity evaluation. Now emerging is a concept that requires all probable impacts of an activity—quantifiable or unquantifiable, direct or indirect—to be evaluated in decision-making.

To make the new concept operative, an environmental manager must be able systematically to identify, predict, and evaluate, the major probable impacts of an activity. This subject-area outlines the procedures which are required to analyze objectively the impacts of an activity, and to evaluate possible alternatives. The procedures outlined can also cause the environmental manager to be aware of precisely what information he needs to select alternatives. Making an objective analysis of all probable impacts, and evaluating alternatives in this sense, are no easy tasks. This subject-area provides the environmental manager with insight into what obstacles may limit either the process of impact analysis or that of alternative evaluation. Although techniques to overcome these obstacles may not be currently available, the environmental manager is at least aware of where the gaps are, and so can focus his efforts on these gaps. In this subject-area, three major steps of environmental management are treated: analysis of proposed projects, formulation of alternatives, and evaluation of alternatives. For each of these steps the effects of values, the obstacles limiting effectiveness, and the relevant techniques and methodologies, are explored. Interested readers are referred to such works as those of Baumgold & Enk (1972) and Dickert & Domeny (1974).

This subject-area is closely related to that of Environmental Effects (*see above*), which broadens the environmental manager's perspectives on the spectrum

of the effects that an activity may have on the environment; it is also related to the subject-area of Environmental Indicators (following the latter above), which acquaints him with a set of potentially effective tools. Together these three subject-areas augment the environmental manager's ability to assess the environmental impacts of an activity, and to select the best choice among alternative courses of action.

Modelling

The process of modelling environmental systems has always, in some form or other, been an important aid to environmental management. In the past, mental models were often cited directly, under the claim of professional experience, in order to justify certain particular assessments or policies. Recently, the technical state-of-the-art has developed rapidly, so that it now includes extensive and complex computer programming techniques which are applied to simulate various environmental parameters on a large scale. The concept of modelling capability as constituting an important tool that assists decision-making is thus quite valid. However, considerable difficulties can arise regarding how one gets specifically involved in the choice of models for a given problem. The well-informed environmental manager should have before him a comprehensive and previously-studied list of criteria relating to the general appropriateness of each existing type of modelling system. He should also be well aware of a number of operational criteria that relate to model performance in general. The approach given in the outline for this subject-area is a first step towards providing a grasp of these issues in a straightforward manner.

Given the recognized usefulness of modelling, it should be understood that some modelling techniques can be flexible enough to be used at almost any level of action. Modelling thus ties in with other subject-areas which have to be considered in professional environmental management. For example, the combined use of modelling for analysis and monitoring for verification of various technical parameters, is one important way to determine the effectiveness of a given administrative control procedure.

The role of modelling is that of a technical tool to be used in conjunction with staff assistants and advisers to the decision-maker. Only when those directly involved with decision-making feel comfortable with these techniques, will they really be used efficiently and purposefully. Thus, the approach of the outline for this subject-area focuses on direct participation in the choice and use of various environmental models. The subject-area treats three major topics: candidates for modelling, models available for use, and appropriateness and operational criteria for judging the first two topics. Sample references include

Hamilton (1969), De Neufville & Marks (1973), and Mar & Newell (1973).

Monitoring

A fundamental responsibility of proper environmental management is the systematic accumulation of information about significant physical and social-system parameters. Adequate monitoring capability can respond to a manager's need for data by providing comprehensive facts in a prompt manner within a tolerable degree of accuracy. Moreover, linkages among various monitoring systems allow decision-making, effected on a broad basis of action, to be executed with confidence in the belief that all critical segments of a given problem have been analyzed and reported.

Results from monitoring systems can provide the key factor in many problem-assessment areas of environmental management, ranging from initial problem definition (e.g. the carrying capacity of a given land-area for extensive industrial development) to continuing post-project analysis (e.g. recording the actual migration of population to a given area after development has been initiated). Knowledge of the manner in which such information can be collected, and the limitations of these collection efforts, gives the environmental manager an initial basis for judgement as to the overall feasibility of assessment for any given undertaking. Another dimension of the utility of monitoring systems is related to the role which these systems perform as part of an overall regulatory mechanism. The existence of certain monitoring techniques and systems may be the principal motivation for the enactment of standard-setting legislation.

It is apparent that monitoring processes can serve a crucial role in providing adequate assessment capability for a given issue. The outline presented for this subject-area is a first step towards providing the environmental manager with both an understanding of the various available systems for the parameters and trends that are of most interest, and a set of criteria for use in choosing a system for a given situation. With these concepts in hand, it is felt that the integration of monitoring efforts with other related tasks will be performed with a better measure of efficiency. Published works that relate to the role of monitoring as a management function include the United States Environmental Protection Agency (1973) discussion of programme usefulness, while an indication of the range of programmes that had so far been developed can be obtained by consulting the monitoring directory of the Smithsonian Institution (1970).

Growth and its Implications for the Future

Development of a comprehensive approach to environmental management concepts in an educational

format requires some exposure to the underlying perspectives of broad-scale social behaviour and trends. In the area of environmental affairs, the processes in which we are most interested are those which describe the past and present physical development modes of society and the various social motivations for these modes. This is because physical development modes provide the setting within which values are established and environmental disruptions are seen to result.

The most common mode of physical development by nation-states in the world today is a growth-mode. This is characterized principally by attempts to expand national industrial and economic bases. Population growth almost always, and naturally, accompanies this economic growth, and presumably fuels a need for further growth. The classical rationale for such expansion is that the quality of life increases as growth continues.

But today the traditional industrial growth-mode is being disturbed by disruptive 'side-effects', and is also being attacked philosophically as not providing an adequate *raison d'être* for daily life. Principal among these 'side-effects' are the environmental implications of further growth, which we must understand in order to manage. At the same time, developing countries must be provided with the means for development that is consistent with an actual, and not falsely perceived, improvement in the quality of life. This subject-area outlines basic parameters that are related to growth, the benefits and hazards of growth, evaluation of adjustment mechanisms, public policy issues, and growth parameters and indicators. The U.S. Congressional hearing on growth (Anon., 1973a), and the publication 'Blueprint for Survival' (Anon., 1973b), are pertinent works.

Economics of Externalities

The issues and problems of environmental management can be very diverse, ranging from almost purely abstract concerns (such as how to define the beauty of a parkland) to extremely sophisticated analytical considerations (such as air transport models for chemical particulate matter). However, in most circumstances the environmental manager will be confronted with problems that have significant dimensions in the economic sphere, as almost any proposal for environmental policy analysis requires the consideration of economic and technical implications.

An understanding of the fundamentals of economic systems is essential for the environmental manager, and such knowledge is a prerequisite to using information in this subject-area. What is often needed, however, is to use such fundamental knowledge within a framework of economic principles related to classical theory, to the theory of welfare economics, and to the various interpretations of the causes of

environmental 'externalities' as they are explained in economic theory. The topics treated in the outline are economic perspectives and principles, technical perspectives of residuals generation, economic analysis procedures, and related important issues. Two works suggested for reading are those of Kneese (1973) and Rothenburg (1970).

Environmental Law

The emerging professional practice of environmental management requires an understanding of the historical perspective of legal norms and of the nature of modern legal approaches to environmental issues and problems. With respect to protecting environmental values, old concepts of common law—including concepts of nuisance, trespass, and negligence—are not sufficient today. Such doctrines were formulated during an expansionary ethos in Western society, and often reflect the view that resources are inexhaustible. The same reasoning could be applied to procedural law; used historically for settling disputes, it makes no provision for guaranteeing rights to a livable environment.

The reason for a subject-area in environmental law emerges from an examination of the functional value of the law to meet societal needs. Law can be considered as a leading means of social regulation that is employed in attempting to formalize social values and mould them into a rational code of principles. Different legal systems have arisen as a result of modifying values and principles. Usually the law not only defines substantive codes of conduct but also delineates the roles of individuals and groups in society who police the prevailing codes.

As a formal system of rules, laws can be enacted on many organizational levels, any or all of which may be in the manager's domain. The manager must be familiar with the substantive content of laws and with the manner in which they specify administrative actions for enforcing precedents, setting standards, and regulating actions. In order to plan the efficient use of resources in legal encounters, it is necessary to examine the broader issues of how laws are formulated in any given political system and what implicit roles are available in seeking legal changes.

It is felt that this particular perspective will provide the environmental manager with a valuable background, because it encompasses issues that are necessary for a comprehensive understanding of the workings of the legal structure in different organizational modes. The areas that are given particular emphasis are values which are used as a basis for law, different legal systems, and controlling activities and actions. Valuable references on the American legal experience are found in publications by the Environmental Law Institute (1974) and Reitz (1972).

Administrative Processes

Environmental management can be considered as a process of discovering, analyzing, and making decisions about, issues and problems concerning Man's impact on the world and its all-too-limited resources. Within the usual societal context, these actions are ascribed to both the individual in his daily life and the social institutions which transform resources into products. The environmental manager should be given instruction on how to operate in an organizational context.

For the purpose of this educational programme, it is necessary to study the functions of administrative organizations from the perspective of environmental control policies and strategies. Such an approach fits well with the other subject-areas that have been developed, as it details a type of actor/role interaction in the policy area that can be supplemented by consideration of other management dimensions. For example, explicitly considering the types of administrative controls which we now have is one way of establishing how the range of monitoring and modelling strategies that are available (taken from development of the monitoring and modelling subject-areas) can be applied to various environmental problems. Also, the economic dimension of environmental control is emphasized through a discussion of the rationale for implementing various controls. The role of environmental indicators, and questions as to the availability and accuracy of relevant data, also need to be considered from the viewpoint of the effectiveness of controls.

In considering environmental policy, any organization is faced with differences in the perception of environmental problems, the degree of commitment to values, and the ordering of policy priorities. An understanding of the available alternatives for control aids us in determining the options that are open to managerial action. This subject-area focuses on the relationship between activities and effects, controls and their effectiveness, and organizations and roles. Two interesting works in this subject-area are those of Siegel (1973) and Caldwell (1974).

DEVELOPING EDUCATIONAL PROGRAMMES

The materials described in this paper are being used to develop a series of educational programmes at C.E.I. for 'environmental coordinators' in multinational corporations and public agencies. The first major seminar in this series was held in Geneva during the last week of January 1975. Forty-two senior professionals and others, from both the public and private sectors of society, attended the sessions which were led by faculty members from C.E.I., M.I.T., and the University of Geneva. The participants were from nineteen different countries and repre-

sented twenty companies and fifteen governmental and international organizations.

Following an intensive week of lectures, discussions, and group work, with role-plays on a specially prepared case-study, the participants indicated in their evaluations that they found the week very beneficial and stimulating, and that most would be prepared to attend additional seminars on related subjects and meanwhile wished to recommend these seminars to colleagues in their own and other industries or agencies. The exchange of experience and information among participants was so productive that twenty-five of them formed an 'Association of Environmental Coordinators' and established a secretariat at C.E.I. to expand membership to other multinational corporations and organizations, to start a newsletter, and to arrange future meetings*.

The present authors have also been involved in developing graduate and undergraduate courses in the School of Engineering at M.I.T., which have used the concepts and materials described in this paper. These courses have been well received and supported by students at M.I.T. and Harvard in engineering science, urban studies, landscape architecture, public health, and law.

The experiences at M.I.T. and C.E.I. suggest that the approach and materials described here can be very useful to professionals and scientists involved in environmental management processes—especially when they are combined with (1) an understanding of the needs and learning styles of the educational 'clients', (2) an innovative approach to creating meaningful educational experiences, and (3) a commitment to integrate all of these in a series of specialist educational programmes.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of Siu Kee So, Frederick A. Curtis, and William F. Martin, in preparing much of the material on major bodies of knowledge that is described in this paper. Maurice F. Strong, Executive Director of UNEP, and Professor Carroll L. Wilson, of M.I.T., played major roles in conceiving and making possible this project. Drs Michael G. Royston and Arie de Koning, of C.E.I., have been invaluable collaborators in this work, and Dr Thomas N. Gladwin, also of C.E.I., has made important contributions to the development of the educational programmes. Financial support for this study has been provided by the United Nations Environment Programme and the Edna McConnell Clark Foundation.

* See the note on page 13 of our Spring issue of this year, and also page 235 of the present issue.—Ed.

SUMMARY

A major challenge in developing programmes for professional education in environmental management is presented by the need to determine how the vast amount of scientific and professional knowledge required for effective environmental management can be efficiently transmitted to prospective or practising 'environmental coordinators' in the private and public sectors of society. This paper describes the work conducted at M.I.T., in collaboration with C.E.I., to provide a conceptual and substantive base for such programmes.

The conceptual framework is based on a simplified model of the decision-making steps in environmental management processes. Such a model can be used for isolating certain types of decisions and roles in different social, cultural, administrative, or political, contexts. When once this has been done, the responsibilities and the educational needs of specific classes of 'environmental managers' can be identified through studies and interviews.

The substantive base for new educational programmes requires the development of outlines and the identification of reference material for the major bodies of knowledge that comprise the 'field' of environmental management. This paper briefly describes the major subject-areas treated in this study: values and perceptions, ecology, environmental effects, environmental indicators, environmental impact assessment methodology, modelling, monitoring, growth and its implications for the future, economics of externalities, environmental law, and administrative processes.

The approach and materials described in this paper are now being used at C.E.I. in the development of educational programmes for practising professionals, and at M.I.T. for graduate and undergraduate students in a variety of disciplines. Thus far, these efforts have been well received and have provided additional information with which to continue designing additional programmes.

References

- ANON. (1973a). *Growth and Its Implications for the Future*. Hearings for the Subcommittee on Fisheries, Wildlife, Conservation, and the Environment, of the Committee on Merchant Marine and Fisheries, United States House of Representatives, Parts 1, 2, and 3. United States Government Printing Office, Washington, D.C.: 2494 pp., illustr.
- ANON. (1973b). Blueprint for survival. *The Ecologist*, 2, pp. 1–44. (Subsequently issued in book form by Tom Stacey, London, England: 173 pp., illustr.)
- BAUMGOLD, M. S. & ENK, G. A. (Eds) (1972). *Toward a Systematic Approach to Environmental Impact Review*. The Institute on Man and Science, Rensselaerville, New York: 59 pp.
- CALDWELL, L. K. (1974). *Environmental Policy, Law, and Administration: A Guide*. School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana: 1200 pp.
- DE NEUFVILLE, R. L.—See NEUFVILLE, R. L. DE.

- DICKERT, T. G. & DOMENY, K. R. (1974). *Environmental Impact Assessment: Guidelines and Commentary*. University Extension Service, University of California, Berkeley, California: 75 pp.
- ENVIRONMENTAL LAW INSTITUTE (1974). *Federal Environmental Law*. West Publishing Company, St Paul, Minnesota: 1602 pp.
- FISHBEIN, M. (Ed.) (1967). *Readings in Attitude Theory and Measurement*. Wiley, New York, N.Y.: xii + 252 pp.
- HAMILTON, H. R. (1969). *Systems Simulation for Regional Analysis: An Application to River-basin Planning*. M.I.T. Press, Cambridge, Massachusetts: xii + 407 pp., illustr.
- INHAKER, H. (1974). *A National Environmental Quality Index for Canada—Technical Edition*. Planning and Finance Service, Environment Canada, Ottawa, Ontario: 220 pp., illustr.
- INSTITUTE OF ECOLOGY (1972). *Man in the Living Environment: Report of the Workshop on Global Ecological Problems*. The Institute of Ecology, Madison, Wisconsin: vi + 267 pp., illustr.
- KNEESE, A. V. (1973). Management science, economics, and environmental science. *Management Science*, **19**, pp.1122–37.
- MAR, B. W. & NEWELL, W. T. (1973). *Assessment of Selected RANN Environmental Modeling Efforts*. University of Washington, Seattle, Washington: 48 pp., illustr.
- MATTHEWS, W. H. (in press). *Resource Materials for Environmental Management and Education*. M.I.T. Press, Cambridge, Massachusetts: (iv + 292 pp. of typescript).
- NATIONAL ACADEMY OF SCIENCES (1969). *Resources and Man*. W. H. Freeman, San Francisco, California: xi + 259 pp., illustr.
- NEUFVILLE, R. L. DE & MARKS, D. H. (Eds) (1973). *Systems Planning and Design*. Prentice-Hall, Englewood Cliffs, New Jersey: x + 438 pp.
- PROSHANSKY, H. M., ITTELSON, W. H. & RIVLIN, L. G. (Eds) (1970). *Environmental Psychology: Man and His Physical Setting*. Holt, Rinehart & Winston, New York, N.Y.: xi + 690 pp., illustr.
- REITZ, A. I. (1972). *Environmental Law*. North American International, Washington, D.C.: xxv + 580 pp., illustr.
- REPORT OF THE SECRETARY-GENERAL (1972). *An Action Plan for the Human Environment*. United Nations Conference on the Human Environment, A/CONF. 48: 43 pp.
- ROTHENBURG, J. R. (1970). The economics of congestion and pollution: an integrated view. *American Economic Review Papers and Proceedings*, **60**, pp. 114–21.
- SIEGEL, G. (Ed.) (1973). *Human Resource Management in Public Organization, A Systems Approach*. University Publishers, Los Angeles, California: vi + 432 pp., illustr.
- SMITHSONIAN INSTITUTION (1970). *National and International Environmental Monitoring Activities: A Directory*. Smithsonian Institution Center for Short-lived Phenomena, Cambridge, Massachusetts: xvi + 292 pp.
- STUDY OF CRITICAL ENVIRONMENTAL PROBLEMS (1970). *Man's Impact on the Global Environment: Assessment and Recommendations for Action*. M.I.T. Press, Cambridge, Massachusetts: xxii + 319 pp.
- STUDY OF MAN'S IMPACT ON CLIMATE (1971). *Inadvertent Climate Modification*. M.I.T. Press, Cambridge, Massachusetts: xxi + 308 pp.
- THOMAS, W. A. (1972). *Indicators of Environmental Quality*. Plenum Press, New York, N.Y.: x + 275 pp.
- UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (1973). *Development of Agency-wide Quality Control Program*. Office of Monitoring Quality Assurance Program, U.S. EPA, Washington, D.C.: 43 pp.
- WATT, K. E. F. (1973). *Principles of Environmental Science*. McGraw-Hill, New York, N.Y.: xiv + 319 pp., illustr.

The Sullom Voe Environmental Advisory Group

The recent discovery of oilfields in the North Sea to the east of Shetland has resulted in plans to bring the oil by undersea pipelines to landfalls in the north of Mainland Shetland, and thence to a terminal development on Calback Ness on the eastern shores of the natural harbour of Sullom Voe. At Sullom Voe, oil storage and handling facilities are to be built from which tankers will be loaded prior to shipment to other parts of the United Kingdom and Europe. This common user facility will be operated by the Sullom Voe Association, a partnership between the Zetland County Council * and the oil companies concerned. Clearly the development of a major oil-port at Sullom Voe, with its associated pipelines and handling and storage of crude oil, raises a number of environmental problems which require expert attention.

Following an approach from the oil companies to the Zetland County Council *, a Sullom Voe Environmental Advisory Group has been established, to advise on all environmental aspects of all stages of the developments—including planning, construction, and operation. Membership of the advisory group is drawn from the Natural Environment Research Council, the Nature Conservancy Council, the Countryside Commission for Scotland, the Universities of Aberdeen and Dundee, the Zetland County Council, and the Shell, Conoco, and British Petroleum Companies.

One of the aims of the Advisory Group is to prepare an environmental impact assessment. This will be linked to

the engineering construction programme, so that the best possible advice will be available when required and in advance of final engineering and operating decisions. To complete this task of assessment the Advisory Group has considerable resources to draw upon from within its membership. However, in a large number of fields, advice and information will be sought from other groups and individuals. Several working groups have been formed to cover specialized aspects such as ornithology and oil-spills contingency planning, fire, and personal safety. Other working groups will be formed as required.

The reports of the Sullom Voe Environmental Advisory Group will be made available to the public, all sources of information being duly acknowledged. It is hoped that this open approach to the environmental discussion of a major development will demonstrate how industry, government departments, research institutes, planning officers, and conservation organizations, can all work together for the common good. The aim is to minimize the environmental impact of an important industrial development through consultation and wise planning.

PETER G. BRACKLEY
Chairman of the Advisory Group
Environmental Control Centre
British Petroleum Company
Britannic House
Moor Lane
London EC2
England.

* Now renamed the Shetland Islands Council.—Ed.