ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT
Current Progress and Prospects for the Approach

SUMMARY REPORT
of the First Policy Seminar
18-21 June 1979

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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
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PREFACE

This publication summarizes the first IIASA Policy Seminar, held in Laxenburg from 18-21 June 1979. The Seminar focussed on an approach to adaptive environmental assessment and management developed at IIASA and the University of British Columbia, Canada. During the past several years, the approach has been tested, implemented, and evaluated by a variety of government and industrial groups. The Seminar drew together senior administrators involved in these implementation experiments, with the goal of analysing successes and failures of the approach, and determining priorities for its future improvement and promulgation. This publication consists of the short summary report prepared by the Seminar, and unedited copies of the background papers which individual participants had been asked to prepare.

CONTENTS

Objectives of the Seminar 2
Presentations 4
Discussion Groups 8
Summary of Conclusions 13
Appendix A: Agenda 15
Appendix B: Participants 17
Appendix C: Papers Submitted 19

OBJECTIVES OF THE SEMINAR

An approach to adaptive environmental assessment and management has been developed at IIASA and at the University of British Columbia by an international team of ecologists and environmental resource managers led by C.S. Holling. More than 30 real environmental problems ranging from tourist development in the Austrian Alps to fishery management in Canada have been analyzed during the development of the approach, which was recently described in a book entitled "Adaptive Environmental Assessment and Management" (J. Wiley & Sons, 1978). The project was co-sponsored by IIASA and The United Nations Environmental Program (UNEP).

During the past several years, the approach has been tested, implemented, and evaluated by several other groups. The seminar drew together key people involved in these new programs.

The first IIASA policy seminar had two aims:

- To consider the extent to which adaptive environment assessment and management has been implemented effectively and the extent to which it has failed.
- To consider the extent to which the approach might be used in the future to improve environmental management.

How the Approach Works

To implement the adaptive approach, the design and management of environmental systems are adjusted as necessary to take account of changes in the state of those systems and in the demands made upon them. The approach provides a basis first for designing and choosing management actions and then for forecasting, monitoring,

and evaluating the results of these actions as they unfold. This enables the people involved to adapt their behavior as their understanding of the system grows and the environment changes.

The approach starts with a meeting of a small group, usually led by someone from the environmental management agency or department confronted with the problem. The group includes individuals who are experienced in the adaptive method. The goal is to define the issues and to set bounds on the questions to be answered. The meeting is followed (or paralleled) by the selection of a project leader, a core team to provide continuity, and potential participants for a series of workshops. In selecting participants, it is unnecessary, and even undesirable, to have a consensus of views. The adaptive approach is meant to resolve conflicts, so the participants should reflect a wide range of attitudes. Initially the workshops allow relatively free interaction between representatives of all groups believed capable of contributing to the solution of a management problem.

The approach explicitly rejects the expensive and time-consuming procedure of "measuring everything". It encourages participants to limit data needs by identifying and concentrating on key linkages between factors. Set in quantitative terms, these factors are converted into one or more mathematical models. Needs for new data and for precise definition of relationships between components of the system are likely to emerge, leading to a research phase and then to subsequent workshops.

The whole process must be continually evaluated, and feedback must be sent to the environmental management organization involved.

The approach leads to a set of alternative policies (including the alternative of not proceeding with development) for evaluation and selection by the appropriate authority. The design of a monitoring framework and provision for continuing evaluation and adjustment by management are essential to the approach. Later workshops can play a significant role in this continuing evaluation process.

The process as briefly outlined above may take a full year to complete.

PRESENTATIONS

The seminar focussed on experience with implimentation of the adaptive approach in Canadian forest and fishery management and in the United States Fish and Wildlife Service. It also considered the results of broader evaluations carried out in a United States industrial corporation and in the context of environmental policy design in the United Kingdom. The discussion was based on the following papers:

- Implementation of adaptive approaches in provincial and federal forestry agencies: G. Baskerville (Canada)
- A salmonid enhancement program: A. Wood (Canada)
- Implementing adaptive environmental assessment in an operating agency: A. Hirsch, A.K. Andrews, and J.E. Roelle (USA)
- Adaptive environmental management: an industrial viewpoint, S. Dempsey (USA)
- Changes and challenges in environmental management: M.W. Holdgate (UK)

The arguments presented in the papers and the discussion that followed their presentation are summarized below. (Texts of the papers are in Appendix C.)

Forestry Management, Canada

The adaptive approach has proved successful in enhancing communication between the forest products industry, the government forest management service and environmental scientists. Improved forest management has resulted. In the discussion, much attention focussed on the organizational barriers that may slow down or stop the introduction of new methods in any organization. The barriers may be accentuated by attitudes. It was stressed that any method of this kind has to be accepted by individual users if it is to spread.

Discussion also examined how far adaptive assessment and management could accomodate public participation (a theme returned to later in the meeting). In general, the approach has undoubtedly increased the efficiency of data gathering and helped to ensure that no important issues are overlooked. It has also ensured that problems are stated in a language understood by the different participating professions.

Salmonid Enhancement, Canada

The Canadian salmonid management program benefits from a continuing experience with adaptive assessment and management procedures. The procedures were introduced in two organizations, one an existing agency and the other a new agency focusing on salmonid enhancement. In the established agency, the approach was introduced

into operations without an explicit policy commitment. Implementation and acceptance in this agency have taken more than two years. In the new agency, there was a policy commitment to adaptive assessment at the start. As a consequence, implementation in the new agency has been quicker, easier, and more widespread.

Development of both these programs is implemented sequentially so that the knowledge acquired in the initial phases can be used to adapt later phases to changing needs and opportunities. The program design is now being used as an example by other Canadian agencies.

The essential attributes of the core team were discussed, and additional specific workshop benefits were identified. These include: establishment of a framework for dialog, forced organization and evaluation of data, and the presentation of conflicting points of view in a context of overall reality and in a common language.

A Federal Environmental Agency, USA

Experience in the United States Fish and Wildlife Service has established that the IIASA techniques are of special value at the practical level in developing wildlife management strategies and in evaluating the likely impact of development on habitats and populations. Experience also shows that to be most effective, the procedure has to be started while alternative decision options remain open. Furthermore, all groups with relevant interest must be included in the discussions from the start.

A central group must hold the exercise together throughout, guide its operations, and plan them. This group has special

responsibility for developing and testing the mathematical models associated with the analysis and for handling the computer programming. In discussion, the essential need for clear communication with the people who actually manage the resource was again stressed.

The Broader Evaluations

The presentations and discussions based on the broader evaluations also confirmed the value of the approach, but they indicated that some questions remain open. Experience in an environmentally aware industry in the United States suggested that the adaptive assessment approach was attractive partly because industry was used to working adaptively, and partly because the approach appeared efficient and offered a way out of the wastefulness of lengthy checklists and attempts to measure everything.

It helped to state all the assumptions of the very different interests in an environmental system and to define data necessary for testing those assumptions. This allowed more open discussion, greater shared acceptance of the inevitable uncertainties and risks in the management system chosen, and greater flexibility in the control strategies. The approach could help focus debate by ensuring that the basic facts about the system were separated from contention over alternative options for management.

Criteria for Greater Acceptance

It was argued that the adaptive approach would not be widely accepted unless programs applying it do the following:

- Establish common language between scientists, developers, and regulatory authorities.
- Identify the significant interactions within environmental systems and evaluate the effects that changes in use and management will have on them.
- Define inevitable uncertainties.
- Check the accuracy of predictions in time for management procedures to be altered if necessary.
- Provide clear advantages in time, effort, cost, and benefits over other types of management programs.

In discussion, it was agreed that the issue of use in different legal and administrative systems was crucial. Improved ability to predict the likely outcome of management decisions was important, as was the ability to identify remaining uncertainties.

Generally the methods would be studied and tested by practical environment managers rather than directly by senior administrators, so the main thrust of communication might need to be with the managers. They could serve as interpreters for the administrators.

DISCUSSION GROUPS

Three major themes emerged from the presentations:

- Whether the approach can provide for the public involvement that is increasingly sought in many countries.
- How to create an institutional and administrative setting where the approach can be used most efficiently.

- How to transfer the methodology to the users and ensure its effective application.

The seminar divided into small groups to discuss these themes.

Public Involvement

The first group concluded that in many circumstances there is a substantial demand for meaningful public participation in environmental policy design and management. Public inputs may be expected not only in the planning stages of a development program, but also throughout the program's implementation and subsequent operation. These inputs may be conflicting, and may change rapidly both in response to and independent of development experience. In short, public participation is another form of the unexpected that environmental policy design and management must control.

The adaptive approach has seldom been used directly to address public participation demands, but it seems suited to this purpose. It has been designed to cope with the uncertainties of scientific and engineering considerations, and with the conflicting views that even these technical considerations invariably bring to the development and design debate. The successes of the approach in the scientific-engineering realm should therefore be translatable into a relatively effective means of dealing with public participation.

Public participation often provides new information, and it can provide a rapid form of feedback on the efficiency of implemented programs. Monitoring public attitudes, and considering them in the process of development review and revision may therefore constitute a powerful tool of adaptive management, whether legally mandated or not.

The group noted that public attitudes are often diverse and fickle, that public demands often exceed what any management system could provide, and that public participation can be costly. All these were considered issues for continuing exploration.

Finally, the discussion emphasized that the workshop procedures reviewed in this seminar are only one of the many possible precedures for incorporating public participation in an adaptive management process. The workshops as presently practiced can accomodate only a limited number of participants, and further exploration of alternative or complementary procedures would be desirable.

A Setting for the Approach

There are numerous potential obstacles to the adoption of adaptive assessment and management procedures. These may be legal --the approach may not satisfy specifications laid down by statute. Or, obstacles may arise from the incompatibility of procedures and established administrative processes, or because the approach was developed in other economic and social settings. But human attitudes are often the chief barrier in the adoption of a new technique, and caution may be needed until the limits of the approach have been further explored.

Adaptive assessment and management should be broadly attractive, because it can improve environmental planning and management by offering these advantages:

- Proper account of the dynamics of environmental systems.
- Better prediction (partly because it can make uncertainty explicit).

- o Balancing of a wide range of scientific, economic and social variables (including public attitudes).
- o Feedback through monitoring development and management (and provision for making any necessary adjustment).
- o More economical and rapid action.

All these advantages have strong theoretical attraction to national policy makers. But they alone will not overcome institutional reluctance to change. The only way for adaptive assessment and management to gain acceptance is through successful application. And its successes to potential new users--chiefly the managers of environmental resources and those responsible for development control.

Case studies are useful to show how adaptive assessment and management has worked elsewhere. But illustration of how it can be adapted to new circumstances is essential. When practical environmental managers can see that the approach offers a real prospect of help with their particular problems, they will be most likely to test it. If satisfied, they will influence wider national or regional administrative organizations to incorporate it as one of the tools of environmental resource planning and management. The managers can also best help national scientific organizations (academies, universities, agencies, or consultancies) in determining how the need for trained personnel can be met.

Applying the Approach

The crucial issue for the whole seminar proved to be how to transfer the methodology successfully from the group developing the

approach to potential new users whose problems and organizational constraints might be very different. This was the issue discussed in the third group. The group's conclusions were as follows:

- A first prerequisite is a clear and precise summary of the method and experience to date, which neither oversells the approach nor makes false claims on its behalf. This document should be aimed principally at senior administrators and managers. Its production should be a top priority.
- The existing book, Adaptive Environmental Assessment and Management, provides a broad overview of concepts, procedures, and methods. Also needed (in addition to the summary statement) is a methodological handbook that clearly explains how to apply the necessary procedures and methods to potential users.
- In addition to improved documentation, many of the participants thought that without personal contact between those experienced in the approach and those coming to it new, misunderstandings and failures would occur. Two remedies were discussed. The first involved the engagement of an institution with experience of the method as a consultant to those wishing to apply the approach. But only about five institutions have the necessary expertise, and they are substantially committed to their own mission and activities. The second alternative was to develop special training courses of some months duration, associated with an experienced group or run at some central point such as IIASA. Again, limitations of organizational capability were recognized, as was a preference that the necessary training evolve

in a variety of settings to reflect the individual needs of various potential users.

- The seminar concluded that all the ways discussed for transferring adaptive assessment and management methodology were likely to be used to some degree, and that for all of them a clear summary document and a methodological handbook were essential prerequisites, as supplements to the IIASA book already available.

SUMMARY OF CONCLUSIONS

The main conclusions and proposals concerning the adaptive management approach were these:

- The technique has proved its value in a wide range of environmental contexts, but the bounds of its applicability are not yet clear. They require further exploration. For example: means of providing public participation.
- IIASA should retain an interest in the development of the methodology and its transfer to users, working in association with other appropriate organizations. In addition, it should seriously consider playing an active brokerage role.
- It is important that the broad overview provided by the existing book on the subject be supplemented by a summary statement. IIASA should develop an active dissemination plan that elicits comments and response from policymakers and senior administrators.
- IIASA should also facilitate the preparation of a methodological handbook for users.

The main conclusions and proposals concerning the role of IIASA in providing policy seminars took note of IIASA's wishes to devote more effort to the practical application of its results, as expressed by R. Levien in his introductory remarks.

The seminar indicated the potential value of meetings devoted to the examination of how an approach developed at the Institute can be adopted by those concerned with national environmental policies. But the policy seminar also noted that this technology transfer cannot solely--or even largely--be achieved by meetings. The value of meetings is in their identification of the best means of transfer--which in the present case is likely to involve publications (including a methodological handbook), contact between those with knowledge of the approach and potential users, and training. National Member Organizations need to be provided with lucid summaries of IIASA results in a form suitable for internal dissemination within their countries.

But the seminar confirmed that for best results, the potential and means for application of a research program should be considered when the program is planned. More should be done to select the users who are targets for the work at its outset and to develop ways of reaching them throughout its progress. The more the research program of IIASA is designed to concentrate on global or universal environmental problems of real significance to its national member organizations, the easier the process of transfer is likely to be.

APPENDIX A: AGENDA

Monday, 18 June 1979

8.30 - 9.15	Registration (Conference Secretariat - First Floor)
9.15 - 12.30	Introduction - Roger Levien, Director, IIASA
	Adaptive Environmental Assessment and Management - C.S. Holling, IIASA
	Changes and Challenges in the United Kingdom and Developing Countries - Martin Holdgate, UK
	Discussant: Allan Hirsch
14.00 - 17.30	Implementation of Adaptive Approaches in Provincial and Federal Forestry Agencies - Gordon Baskerville, Canada
	Discussant: Stanley Dempsey
	Evaluation from an Industrial Perspective - Stanley Dempsey, USA
	Discussant: Gordon Baskerville
17.30	Departure for Heuriger in Baden

Tuesday, 19 June

9.00	Implementing Adaptive Approaches in Operating Resource Management Agencies - Allan Hirsch, USA
	Discussant: Martin Holdgate

General Review

Three working groups will be established to explore the experience within other nations, leading to a synthesis review, evaluation and recommendations.

Wednesday, 20 June

9.00 - 12.30	Working groups continue leading to summary statements from each by mid-morning
14.00 - 17.30	Drafting Committee meets to develop an executive statement
	Other participants are invited to attend a talk given by Prof. Donella Meadows (see enclosed announcement) and/or contact members of the staff (see Ms Ursula Reiter, Vistor's Service, Schloss Reception)

Thursday, 21 June

9.00 - 12.30	Plenary session to summarize and discuss executive statement
	Concluding evaluation

APPENDIX B: PARTICIPANTS

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C.S. HOLLING

Hugh MISER

APPENDIX C: PAPERS SUBMITTED

Baskerville G. (Canada), Implementation of Adaptive Approaches in Provincial and Federal Forestry Agencies.

Wood A. (Canada), A Salmonid Enhancement Program.

Hirsch A., A.K. Andrews, J.E. Roelle (USA), Implementing Adaptive Environmental Assessment in an Operating Agency.

Dempsey S. (USA), Adaptive Environmental Management: An Industrial Viewpoint.

Holdgate M.W. (UK), Changes and Challenges in Environmental Management.

IMPLEMENTATION OF ADAPTIVE APPROACHES IN PROVINCIAL AND FEDERAL FORESTRY AGENCIES

G. Baskerville

Department of Forest Resources
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A PAPER PRESENTED AT THE "ENVIRONMENTAL POLICY SEMINAR", INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS, LAXENBURG, AUSTRIA.
JUNE 18-20, 1979.

Page

INTRODUCTION 1

BACKGROUND 3

THE RESOURCE 3

THE BUDWORM 3

STRUCTURE OF THE DECISION ENVIRONMENT 4

EVOLUTION OF THE MANAGEMENT PROBLEM 6

DEVELOPMENT OF ADAPTIVE MANAGEMENT TOOLS 8

LEVEL OF IMPLEMENTATION ACHIEVED 10

PROBLEMS IN IMPLEMENTATION 14

ADAPTIVE MANAGEMENT IS A PHILOSOPHY 14

ONLY THE MANAGER CAN MANAGE 16

GETTING/GIVING "THE ANSWER" 17

REALITY/CREDIBILITY 20

THE INFORMATION PROBLEM 25

FEAR OF EVALUATION 27

INSTITUTIONAL RESISTANCE 29

RESISTANCE IN SCIENTISTS 36

RESISTANCE IN SOCIETY 38

BOUNDARY SPANNING 40

CONCLUSION 41

IMPLEMENTATION OF ADAPTIVE APPROACHES IN PROVINCIAL AND FEDERAL FORESTRY AGENCIES

G. Baskerville[1)]

INTRODUCTION

The basic principles of managing renewable resources are straight forward. The rate of renewal and the rate of exploitation must be controlled in such a way that they balance over time. Despite this apparent simplicity, renewable resource management appears to have generated more "failures" than "successes". Indeed, from a survey of the non-scientific media, one might conclude that there have been no successes! There are problems of over-exploitation with respect to whale, fish, ducks, deer and trees in various parts of the world. In most, if not all, of these cases, thoughtful examination, of the more scientific media, indicates that the technology to permit "better" management already exists. The problem turns more on how to implement the existing technology operationally, than on the creation of new technology.

This paper reports on experience gained in working towards the implementation, of some rather sophisticated tools for planning and policy formulation, in a major insect/forest management problem. The tools were designed by a group of scientists from several institutions in Canada, the United States and Europe. The implementation setting, is in governmental agencies responsible for management of the insect/forest system in the

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province of New Brunswick, in eastern Canada. Implementation of adaptive management in this context has encountered many problems. While each such problem seemed entirely unique as it was faced, in retrospect it appears that they were, for the most part, generic problems, common to many natural resource planning situations. For this reason, the analysis of implementing adaptive management in the insect/forest system, which follows, is cast in terms of some of these generic problems. You will see that these generic problems relate far more to people, than to elegant technology. None of the problems are insurmountable, except perhaps in situations where there is refusal to recognize their existence.

The views presented here are highly personal, and because I was one of the players they are not unbiased. I accept a share of the warmth of the successes, and I also accept a share of the blame for the failures. The situation that we have addressed is immensely complex. There were many people involved. The development of the adaptive policy tools took place over a four-year period, but this was done on the basis of research and management programs that had extended over more than a quarter of a century. There is both good news, and bad news, in what I have to say. Many will feel that I have concentrated on all of the things that went wrong, and our inability to initiate change at the pace we desired. My concentration on the hangups is to focus your attention on the need to deal with certain classes of problems and not to assign blame.

BACKGROUND

Before attempting to analyse the degree of success in implementing adaptive management in the budworm/forest case, some background on the problem, the development of the tools for adaptive management, and on our approach to implementation, is necessary.

THE RESOURCE

Some 85% of the land area in the province of New Brunswick is covered by forest - a total of some 6,000,000 ha. A major portion of this forest is comprised of the softwood species, red spruce, white spruce, black spruce, and balsam fir. These softwood species constitute the primary resource base for the major industry in the province. The industry is currently made up of ten pulp and paper mills, a half dozen large sawmills, and a number of small sawmills. While the forests of the province do not produce particularly large trees, the land is productive and is readily accessible. The forest-based industries have thrived in this situation, having approximately doubled their capacity in the last quarter century.

THE BUDWORM

The spruce budworm is an insect defoliator that feeds on the leaves of the balsam fir and spruces. Persistent defoliation by the budworm, which tends to feed on newer foliage, results in the death of trees. During periods of epidemic budworm populations, this defoliation, and consequent mortality, can extend over large areas of forest. The loss of mature forests to budworm-caused mortality poses a serious threat to the forest-based industry, since

both the budworm, and the industry, "feed" on the same softwood species.

The budworm is a natural inhabitant of this forest, and has periodically erupted to epidemic proportions, at least over the past several hundred years. The outbreaks normally lasted six to ten years, with an interval of some thirty to sixty years between outbreaks. In the interval between outbreaks, budworm was not an economic pest. However, during an outbreak, the infestation can reach damaging levels over areas in excess of one hundred million ha. Thus the six million ha of forest in New Brunswick, is a relatively small proportion of the total forest in eastern North America that can be at risk. Further, because this insect pest is highly mobile in its adult state, it is not possible to manage the pest in any one political jurisdiction as if it were disconnected from the outside world.

STRUCTURE OF THE DECISION ENVIRONMENT

In natural resource management, the decision making structure is usually rather complex. The complexity of the present situation represents one of the major difficulties in dealing with the protection of the forest, and therefore the industry based upon it, from the depredations of the spruce budworm.

Approximately one-half of the forest area in the province is unalienated land, and is managed by a department of the provincial government (Dept. of Natural Resources) on behalf of the people. About one-quarter of the forest area is freehold land in large blocks, held by major international pulp and paper companies. The remaining one-quarter is owned by some fifty to sixty thousand individual owners, mostly farmers. Policy with respect to protection from the spruce budworm is influenced by: the provincial

Department of Natural Resources, four other departments of the provincial government, some fifty companies in the pulp and paper and the sawmilling business, and by a large number of small woodlot owners. Super-imposed on this, is the influence of eight agencies of the federal government, which play various roles in economic development and environmental protection. When one adds, to this already cumbersome situation, a variety of special interest groups ranging from, marketing boards for the products from small woodlots, to environmental protection groups, the situation is indeed complex.

In general, it is the responsibility of the provincial government, as represented by the Minister of the Department of Natural Resources (an elected official) to promulgate forest policy. In doing so, he must be cognizant of the roles of other provincial departments, of the federal government involvement and, since he is a politician, he must be sensitive to a wide variety of social factors. The wide range of roles, with associated responsibilities and authorities, that have evolved with respect to forest resource management, have lent great inertia to the policy-making and decision-making mechanisms. To oversimplify the problem, we can identify three main roles for our purposes. The provincial government through its Department of Natural Resources has the general responsibility for forest management, including policy decisions with respect to industrial capacity, and for standards for maintaining the renewability of the resource. As part of the provincial responsibility in this latter respect, there is legislation designating responsibility for protection of the forest from fire and insects to the Department of Natural Resources. With respect to the spruce budworm, this responsibility is exercised through a company, Forest Protection Limited, comprised of the provincial government and the major forest industries. The

third role is that of research. Because of the immense scale of spruce budworm outbreaks, the mobility of the insect, and the complex nature of the budworm/forest interaction, this role was given to the Canadian Forestry Service, a research agency of the federal government. While the discussion which follows will relate primarily to these three organizations, this is for convenience of presentation. The myriad constituencies involved in the budworm/forest problem all influenced what evolved.

EVOLUTION OF THE MANAGEMENT PROBLEM

When it became apparent in the late 1940's and early 1950's that another spruce budworm outbreak was imminent, in New Brunswick it was deemed necessary to protect the forest to permit the maintenance, and expansion, of the forest-based industry. Forest Protection Limited was formed for this purpose. Since 1953, this company has prevented extensive mortality in the softwood forest of the province by the use of aerial spraying of insecticides. The plan was to prevent mortality of whole stands until the outbreak subsided. Since previous outbreaks had lasted only from six to ten years, this was viewed as a short-term endeavour. In the fullness of time, it has become apparent that, maintenance of a live forest, from which to feed the forest-based industry, simultaneously maintains a live forest to feed outbreak levels of budworm populations. That is, the infestation has been more or less sustained, from 1952 to the present. The intensity of the outbreak has varied, both spatially and temporally, during that time, as has the need, and extent, of protective action. The continued program of protection has become increasingly costly, and has also become the target of intense environmentalist opposition.

At the outset, the three roles, management, research, and protection, were clearly understood, if not well-defined. However, as the problem persisted, the authorities and responsibilities with respect to these three roles have become blurred, and a substantial degree of territorial confusion has developed. Since the problem was complex, and viewed to be short term, the research agency (Canadian Forestry Service) adopted a key role in assembling information on the insect, its impact on the forest, and in developing measures to be taken to protect the forest. Since the problem was viewed to be short term, it seemed unnecessary for the province to acquire the scientific expertise necessary to understand the complex budworm/forest system and its management. Now, the agencies responsible for management and protection of the resource find themselves unduly dependent on the research agency in carrying out their operational roles. Further, the research agency has evolved so that a major portion of its scientific budget is devoted to an operational role, in which their authority and responsibility is purely historical. On the part of the provincial government, there is resentment of the Federal intrusion into the provincial role, and sufficient discontent, with respect to the effectiveness of the budworm research program, that the province has begun to support research on its own. As the problem persisted and acquired a high public profile, the roles of the provincial, federal, and private agencies have at times been antagonistic. Each agency has engaged the issue from the point-of-view of its limited responsibilities and authorities, and interagency confrontation has become common.

Since 1953, the provincial government has commissioned three major studies of "Forestry". These studies had the task of rationalizing the management of the forest resource, and of the forest-based industry. Despite

the overwhelming presence of the budworm problem, none of these studies paid more than lip service to budworm/forest management. In fact, the studies primarily addressed the form and structure of the forest-based industry, and provided very little in the way of analysis or guidance with respect to management of the resource itself. In short, while the infrastructure of the forest-based industry and the forests of the province have been studied extensively, there has been little change in terms of on-the-ground management.

DEVELOPMENT OF ADAPTIVE MANAGEMENT TOOLS

The budworm/forest system is a classic resource management problem in need of an adaptive approach. That is, it is impossible to resolve the situation by conventional experimentation. The spatial and temporal scales of the dynamics in the system prevent this. The problem has evolved as we have worked on it. It is still evolving, as is our perception of it. In 1974, a group from the University of British Columbia came to the Canadian Forestry Service, in New Brunswick, to run a workshop with scientists from the Service, aimed at constructing a budworm/forest model. The objective was to assemble the results of the massive Canadian Forestry Service budworm research program, that had continued for some thirty years, into a comprehensive and logically consistent form. We believed that such an exercise would lead to a clearer understanding of the research problems involved in this complex system. At the same time, we recognized that consideration of the forest dynamics, and of forest management decisions, had not been consistently addressed in the research program. Therefore, the team that worked on the model, included representatives from the provincial Department of Natural Resources from the outset.

The mechanics of construction of the model, and the philosophy of its use, were in the hands of scientists from the University of British Columbia. The budworm and forest scientists in New Brunswick, participated as biological scientists who provided information to design consultants. It was natural, therefore, that refinement of the model took place mainly at the University of British Columbia. This early work led to feedback with respect to the design of research programs. At this point, the main aim in the use of the model was as an aid in improvement of research strategy. Its use as an aid to the decision-maker in understanding his system was of somewhat less importance.

When IIASA took an interest in the budworm model, and the budworm/forest management problem that is described, the program developed rapidly in a somewhat different direction. The emphasis switched from guiding research, to that of policy design and the analysis of decisions. In short, the priority for development and use of the tool, switched to aiding the decision maker, rather than aiding the researcher. It was during the latter stages of the IIASA/U.B.C. involvement that the notion of "adaptive management" emerged. That is, in this case study, we were already well along when the significance of the concept of adaptive management became clear, and implementing adaptive management, as such, was not a goal from the outset.

In 1976, just as the intensive IIASA/U.B.C. involvement was peaking, the provincial government decided it needed a major analysis of the budworm/forest problem. Since they did not possess the technical expertise to use the budworm model, and its attendant policy and decision tools, they asked me to lead a Task-Force which would do this analysis. The Task-Force was set up independent of the provincial government, but operating from offices of the Department of Natural Resources. The report of the task force (Baskerville,

1976) demonstrated the use of the policy analysis tools developed by the IIASA/U.B.C. groups, giving several examples of possible policies. Each example gave a fifty year forecast of the development of the budworm/forest, and of the forest-based industry, in terms of a number of indicators.

LEVEL OF IMPLEMENTATION ACHIEVED

The total effort in terms of scientific manpower and dollars that were devoted to this exercise are not known, but it was substantial. There was at least fifteen man-years, from some dozen scientists, in the development of the model and policy tools. This does not include the scientific base, of over one hundred man-years, upon which the policy analysis team based their work. Thus, we have a substantial application of scientific talent, to a major natural resource problem, that extends over a large area, and towards which a substantial amount of managerial energy is devoted. In scientific terms, the exercise was an unquestionable success. However, this exercise was, or at least became, addressed directly to a very real problem, and the assessment presented here will be in terms of on-the-ground change accomplished with respect to the management system and the resource itself. As an academic exercise in the field of adaptive policy design, we have been successful, but we have failed to come close to our expectations, in terms of modifying the approaches taken to management of the budworm/forest system.

The provincial budworm/forest management agency has not adapted its budworm/forest policy. While that agency has increased its dollar and man-power committments to the problem, these efforts are largely directed towards improving the efficiency of the existing policy. The current policy is not an

explicit one and consequently is not well understood. The provincial agency has not designated any portion of a man-year towards policy design with respect to budworm/forest management. All three agencies, management, protection, and research, are still gathering information on the budworm/forest system much as they did in the mid 1950's. Decisions with respect to what and where to spray, are still made in much the same way as in the mid 1950's. The period of our study coincided with a marked rise in public antagonism towards the policy of crop protection with chemical insecticides, and this has led to a very defensive reaction on the part of all three agencies. They appear to be unable to use the rather powerful policy tools which are available to them in a positive way. They rather fear that these tools will be used against them.

The research agency has not adapted its research program by use of the tools provided. Difficulties in getting the research mechanism to respond to feedback still persist. The agency is essentially carrying out the same sort of research that it did in the mid 1950's, but with fewer people committed to the program. There has been no qualitative change in the approach to research, although the policy analysis strongly indicates such change. The research agency does not have the capability to use the budworm model and the associated policy design tools to help the provincial agency. No one in the research agency has used the policy design tools, and there has been little interest shown within that agency in developing these tools. Perhaps half a dozen scientists in the research agency could give an adequate description of the model, and about the same number could identify the difference between a state-dependent and a time-dependent model.

The most frustrating feature, if not the most damming, with respect to implementation, has been the tendency for our work to be used in defense of

the status quo. We have been unsuccessful in getting the manager to use the available tools in exploring his policy options. Instead, we have done the exploring for the manager. This attitude of the management, and of the research agencies of "having it done", and our willingness to participate in this way, has been devastating to implementation. To a considerable extent, the sophisticated policy and decision tools have been used to bolster the preferences of policy makers and decision makers, rather than as protocols for deliberately evaluating alternative schemes. The tools we developed are used only occasionally by the management agencies and by the research agencies, and then primarily in defense of the status quo.

As institutional bodies, the provincial management and protection agencies and the federal research agency are barely aware of the policy tools they are not using. These agencies still act as if they knew how the past got from then to now. They are largely unaware of the inadequacies of their historical data on system performance, and appear to plan on the basis of the assumption that the future will repeat the past. Despite the emphasis on interactions in our study, and in our implementation attempts, there is still a strong tendency in all three agencies to treat the budworm/forest issue in parts.

There have been positive elements in our attempts at implementation. Our work demonstrated a need to study the forest part of the problem more intensively than had been done in the past. Particularly, our work demonstrated a need for comprehensive analysis of forest growth, and wood supply to existing mills, quite apart from the influence of budworm. Such a study was initiated and carried out, with personnel hired by the provincial government agency, and I have some optimism that this is leading to a more adaptive approach to

management of the forest. The management agency has committed about one-and-one-half man-years to this project, annually in each of the past three years.

The Federal research agency has engaged in an extensive attempt to design an adaptive research program for the budworm/forest system. This has resulted in four scientists, who participated in this analysis, gaining an understanding of the application of adaptive management, particularly with respect to research.

Perhaps the brightest part of the implementation picture, is that there are now people in the management and research agencies who understand, and positively advance, the concepts associated with adaptive management. To be sure, their numbers are small, perhaps half a dozen in each agency, but, as you will see in what follows, I believe that in-house understanding is the only approach to the implementation of adaptive management. In this we have a beginning.

There are many lessons to be learned from this extensive and intensive attempt to implement adaptive management in a complex natural resource management problem. I am convinced that these lessons have application beyond this particular problem. The difficulties that we encountered are common to forest management analyses throughout Canada. The message is that, it is not possible to implement an adaptive approach to resource management as one final step in a developmental series. To be effective, implementation must begin when the technique development begins, and it must be carried on, from the outset, inside the agencies that are intended to manage adaptively. What follows emphasizes the problems we encountered in implementation. These are presented as a preventative guide to certain generic problems. The

substantial positive results of our work are not emphasized here, but are reported extensively elsewhere (Holling, 1979).

PROBLEMS IN IMPLEMENTATION

In retrospect, it is clear that the difficulties associated with the implementation of adaptive management were primarily of a social-psychological nature. That is, the problems were not of a technological nature, but rather centred on people and institutions. I have chosen, therefore, to present my review of these problems in a manner similar to that of Michael (1973). It is interesting to wonder how different things might have been, had I read the Michael treatise before, rather than after, our implementation program. On the other hand, perhaps without the experience of our attempt, his analysis of the problems of initiating adaptive (social) planning would not ring so true.

ADAPTIVE MANAGEMENT IS A PHILOSOPHY

The concept of adaptive management is based on three premises. First, we must strongly influence present actions by sophisticated conjecture about the future, with respect to a wide range of indicators of system performance. Second, as we move from the present to the future, we must have a system for scanning the environment in which decisions are taken, for feedback on system performance. Thirdly, our goals must serve as regulators of development, rather than as rigid end points. Adaptive management is, thus, a philosophy, with operational implications about learning how to act in the present, in the light of continuously revised anticipations about the future. It is important

that adaptive management be considered, and be developed as, a philosophy, rather than as another neat technological innovation. The techniques of implementing a technological innovation (eg. a new diode) can be straight forward. On the other hand, acquiring a philosophy, and learning to live that philosophy, are by no means straight forward, and require substantially different approaches than learning to use the latest invention. Michael (1973) gives an extensive analysis of the problems of implementing long range social planning. I find his basic requirements for changing toward long range social planning, perfect analogues for the requirements for changing toward adaptive management of natural resource systems. These requirements are: " .... that people working in organizations, and in the social and natural environments linked to them, find it rewarding to learn how to do at least these six things:

1) Live with and acknowledge great uncertainty.

2) Embrace error.

3) Seek and accept the ethical responsibility and conflict-laden interpersonal circumstance that attend goal-setting.

4) Evaluate the present in the light of anticipated futures, and commit themselves to actions in the present intended to respond to such long-range anticipations.

5) Live with the role stress and forego the satisfactions of stable, on-the-job, social group relationships.

6) Be open to changes in committments and direction, as suggested by changes in the conjectured pictures of the future and by evaluations of on-going activities."

It seems clear to me that the requirements for adaptive social planning, as specified by Michael, apply equally to adaptive resource management, and they indicate a fundamental change in philosophy of approach to management.

As such, one must believe that there will be a learning period before these requirements are met. It is therefore not possible to "implement" adaptive management in any simplistic sense. Adaptive management will not be implemented, from the "outside", by a group of scientists, but rather it will be learned, and then lived (implemented if you will) in the management of the system by the policy/decision makers. Before examining the problems of initiating the learning of an adaptive philosophy, one further quotation from Michael (1973) is relevant here:

> "Now or within the foreseeable future, long range social planning (read adaptive management) does not seem possible unless there are radical changes in the structure of organizations and in the norms that guide and sustain the behaviour of the people who work in them and who in turn sustain those structures".

ONLY THE MANAGER CAN MANAGE

Only the manager can manage adaptively. Implementation must therefore reach the manager in that he must acquire, and live, the philosophy of adaptive management. This may seem like stating the obvious. However, scientists working in the area of policy analysis, and decision making, do not show much recognition of the learning process that must go on with the manager. Most of their writings implicitly assume that the competent manager will simply "use" their tools.

Adaptive management is an acquired skill on the part of the manager. Only he can practise it, and he can only learn by actually doing it. Curiously, most managers we worked with, believe they already manage adaptively. That is, this is not a new concept, it is the doing of it, which is new. To achieve implementation of adaptive management, the policy and decision

scientists will have to both, nurture the philosophy of adaptive management amongst the managers, and teach the managers the technical components. In this respect, our most powerful approach is through highly interactive workshops. These must be substantial in nature, and, at least initially, they must quite literally force an interaction of the manager and the scientist. Initiating the learning process will take several workshops, carefully spaced in time. Although we used workshops extensively, we permitted too passive a participation by the learners. We did not adequately nurture the philosophy of adaptive management as it evolved in our work. Indeed, our emphasis, particularly at first, was on constructing the model, and instructing the scientists and managers with respect to the technical specifications of the tools. We addressed the context in which these tools were to be used only peripherally.

In retrospect, it is clear that we changed our approach rather dramatically over the four-year period. We began with a presentation of tools, which we felt could assist the manager, and we evolved to a comprehensive philosophy of resource management. We did not adequately carry the participants in our various workshops through this evolution. The major task in the implementation of adaptive management, is gaining sufficient committment from the managers for them to learn the approach. Without such committment to a learning process, they will never acquire sufficient understanding to use the concept effectively.

GETTING/GIVING THE ANSWER

In providing assistance to the policy/decision maker, the scientist must tred a careful path. If the scientist fails to present a comprehensive

answer, and he leaves the usual array of scientific bits and pieces in an assortment of journals, the policy/decision maker will be resentful. On the other hand, if the answer is presented as "the appropriate" solution the policy/decision maker will be resentful because the scientist has preempted his role.

We recognized early in this exercise that involvement of the management agency was essential, if we were to provide a tenative answer, which assisted the manager, without preempting his role. Indeed, we had participation of people from the provincial management agency from the first day, of the first workshop, onwards. In review, we can see that the level of managerial participation we generated was far too low. The important point here, is that in adaptive management the "planner" and the "doer" are the same person. For the scientist to assist, it is, therefore, critical to get an understanding of the context in which the policy/decision maker sees his problem. Viewing the problem from his perspective, and presenting the analysis in terms of performance indicators that are familiar to him, is of extreme importance. Extensive discussions certainly help, but only active participation by the policy/decision makers, will reveal the indicators they use to evaluate performance of the system in response to past decisions, and the ones they would like to use to compare possible results of alternative future decisions.

It is not possible to over-emphasize the importance of involving the policy/decision makers intimately, from the outset in the development of an adaptive management scheme. If they are to learn the philosophy, they must have continued exposure to it, and must come to regard the techniques that are developed as their own. Two examples will serve to illustrate these

problems. The senior administration of the federal research agency engaged in the development of an adaptive strategy of budworm/forest research, with virtually no discussion of the concept of adaptive strategy, and apparently, little understanding of its meaning. We are nearing the completion of this exercise and it has become apparent that some in the senior administration wanted "the questions" for research identified, so they could then direct research appropriately. They wanted a firm statement of research needs which could be used as a fixed goal for "orderly" research. That is, they wished to be told "the answer", and they would use it. This is the antithisis of adaptive management.

The second example relates to optimal policies, and I would suggest that the greatest of caution be exercised with respect to using the word optimal in the presence of policy/decision makers. In one period of our evolution in policy design, we engaged in rather extensive optimization explorations. Several of these optimal policies were displayed in various ways to policy/decision makers. In every case, either immediate or delayed, the reaction was negative. The notion of optimality has meaning only within the context of certain weighted parameters of response. The policy/decision makers were not long in asking what objective function we had used, although they didn't use that term, and immediately pointing out to us, that this was not an adequate objective function. In every case, either the constraints to operation we imposed in order to achieve optimization, or the objective function we used, were unacceptable to the policy/decision maker. This in itself is not a problem, except that because certain model outcomes were "good", the policy decision maker can become angered by the appearance that he is not using the "best" approach to his problem when he knows the "best" is nonsense.

In our case, a report in the New York Times, based on an innocent press release from IIASA in Vienna, caused a major turbulent excursion in the implementation process in New Brunswick! The report in the Times said that scientists in Europe had discovered how to manage the budworm/forest system without spraying insecticides - an optimal policy. A new Brunswick newspaper with an environmentalist flavour, attacked the government rather loudly on the grounds that, "spraying is unnecessary" and "how come the Europeans can figure this out and our scientists can't?". Of course, the "optional" policy, was not a possible policy, in the operational real world. Nevertheless, valuable policy/decision maker energy was diverted, from learning about adaptive management. This cost our implementations program, both because of the time consumed unproductively (counter-productively), and because it reduced our credibility with the policy/decision makers. The incident was trivial perhaps, but as a result, there is still lurking suspicion in the minds of some policy decision/makers about our idea of reality, and there is still a rather large body of the public who believe we could stop spraying this year, and accomplish protection by adopting a fixed policy (unspecified) of forest management.

In adaptive management "the answer" does not exist. It is a mistake to imply that it does, since this causes resentment over role preemption, and is counter to the learning process.

REALITY/CREDIBILITY

High credibility of the policy design team with the manager is of paramount importance in the introduction of adaptive management. To achieve, and maintain, such credibility it is necessary for the scientist to get close

to the managers understanding of his problem, and express the scientific analysis in terms understandable to the manager. The policy/decision maker knows that his problem is variable, in both space and time. He knows this, even if he is attempting to implement a policy which assumes otherwise! To be credible with the policy/decision maker, it is important that the scientist approach the problem in the same spatial and temporal context as the manager. If the spatial and temporal scales chosen for analysis, are not also those of the manager, or if the model analysis implies system control techniques which are not available in the real world, credibility is impossible to achieve.

All natural resource decisions involve an attempt to anticipate the future. Although the policy/decision maker often does not realize that he made such a forecast, in order to make a decision, he is acutely aware of the impossibility of predicting the future. By far the biggest problem we encountered in this area was the issue of assumptions. A surprisingly large number of operational managers seem to believe, that if they did not state an assumption, then they hadn't made one. In most cases this meant that their decision was based on the assumption, that the future would repeat the past, which in a dynamic system with evolving interventions, is perhaps the most dangerous of all assumptions. Attempts to explain the dynamic model, that was central to the implementation of adaptive management, often resulted in comments like "look at all those assumptions! - we don't make any". By using an explicit model, the assumptions are given a rather high profile, and are easily identifiable. A major part of the learning process for the policy decision makers, therefore, is to gain an appreciation of the degree to which their intuitive projections are dependent on unstated assumptions, many of which they would not accept. Thus, if the output from a model for a given

policy does not agree with the managers' view of reality, they simply reject the model as wrong. There are definitive indicators which show when the policy/decision maker has achieved the necessary level of learning, to begin using the adaptive process effectively. For example, in the forest productivity analysis model, we use only assumptions stated explicitly, by each user, at the start of each run. If the model output does not agree with his view of reality, the learning manager will explore to see which of his assumptions caused the counter-intuitive outcome. Having done this, he will reevaluate these assumptions, and if necessary restate them, and rerun the policy. If he cannot identify relationships which he feels need modificaiton, then be begins to question his view of reality. It is astounding how often this "reality" turns out to be unsubstantiated. At this point, such a policy/decision maker is learning about the model, about the dynamics of the system he is attempting to manage, and about his information needs, and how they relate to his view of reality in the system. Since the forest productivity model is very simple, many users have reached this level, and found themselves evaluating assumptions that were implicit in their intuitive forecasts. Through this, the use of the model as a forecasting tool, has established credibility with these people. In the case of the budworm policy design tool, the model is sufficiently complex that we have not succeeded in getting a single scientist, let along a policy/decision maker, to this level of understanding. I believe this is the explanation of the policy/decision makers willingness to stick with a mid 1950's approach to "getting on with the job" (without assumptions!) rather than attempt to design alternative policies with the simplified, but still complex, world of the model.

In introducing the policy/decision maker to the dynamic model as an aid in forecasting, it is essential to strike a balance with respect to credibility/reality. Some managers we worked with, simply rejected the use of all dynamic models as so much assumption. They continue with their persistency approach to problem solving. The teaching/learning procedure to be adopted by the policy scientist in this case is relatively straight forward. At the other extreme, we encountered those policy/decision makers who see the model as a way to get "the answer", or "a number", and they really believe that the model is predicting the future. These men are dangerous. To the extent that no model can be an accurate predictor of a dynamic system with evolving interventions, these men may very well use the policy tool to systemically wreak havoc in the resource to be managed. Somewhere between these two extremes, lies a balanced skepticism. Here, the policy/decision maker accepts the model as a more comprehensive tool for combining, interactively, a large number of assumptions, which he knows he must make, but he also recognizes that the model is incomplete, and is therefore a foil for his intellect, rather than a deliverer of truth and light. To reach this level, the policy/design maker needs persistent and thoughtful contact with the policy design scientist.

The essence of adaptive management is its recognition of dynamics in the system that is being managed. To manage adaptively, requires a knowledge of system dynamics, rather than just description of the outcome of these dynamics, and this will always pose serious learning problems. Real adaptive management operates in real time, and is directly tied to the manager himself. That is, the manager himself must aquire an understanding of system dynamics. There is a curious inverse relationship here. If a person's

domain of knowledge, with respect to system dynamics, is very small, then the interface with that infinite domain of ignorance, is also very small. In this situation, it is possible to have strong beliefs, and take firm decisive action in an unquestioning manner. The results of getting on with the job in this manner are seldom acceptable. As Bok's law states, "if you think education is expensive, try ignorance". However, as a person expands his domain of knowledge with respect to system dynamics, the interface with the outside domain of ignorance also expands. Thus, the more one learns about the dynamics of a system the more one comes to realize how limited is our understanding. As this realization of limitation dawns, it is difficult to prevent the counter-reaction of the, "it's so complex, we can't do anything", variety. Here again careful attention to the learning process is essential.

In attempting to implement adaptive management, or in writing about implementation, it is difficult to avoid inventing reality. Reality is different things to different people, depending on their perspectives, and the indicators that they react to. Policy design scientists have shown a rather strong predilection to inventing their own notion of reality, in terms of what adaptive policies are, and what they can do to the real world. A good part of the absence of change in the policy/decision makers, and in the system they are managing, results from the fact that, our policy studies are not adequately related to reality as the policy/decision maker percieves it. The policy/decision makers that we worked with are acutely aware that all approaches to budworm forest management, other than the one they are actually using, are hypothetical. If these people are to be sensitized to the alternative policies, therefore, it is essential that the policy, and the tools for accomplishing that policy, be presented to the manager in a way

that is consistent with his view of reality in the budworm forest system. This does not mean that his view of reality is necessarily correct - only that we must start from that base. Perhaps another quote from Michael (1973) will make the point here:

> "Ironically, appreciation of the need to cope with social turbulence has produced not only the beginnings of a technology intended to do so, but also a technology which on every hand brings to would be planners information that emphasizes that things are much more complicated, interlocked, and seemingly intractable and unpredictable than they had appreciated when these evolving means were available for probing societal processes; this information emphasizes the pathetic limits of our theory and methods for understanding for what is going on "out there", for coping with societal turbulence".

THE INFORMATION PROBLEM

Adaptive management uses information differently than does conventional fixed policy management. In our analyses with respect to the budworm forest system, with respect to forest productivity, and with respect to budworm research program, it became apparent that different information was required from that which was currently gathered, and that different information handling systems were required. The essence here, is the need for detecting differences between what is happening in the system, and what was intended to happen in the system. For adaptive management, the data gathering and handling system must, 1) provide an up-to-date description of the system state, 2) identify where change in the system is being stimulated, and 3) record how the system changes over time. All this, in addition to basic information on the dynamic processes within the system itself. It is difficult to over-emphasize the importance of a good record of past performance, as this facilitates long term evaluation. It should also be clear, that the level of

adaptivity that can be achieved with any policy, will be in proportion to the speed of reaction of the information feedback loop.

Without exception, we encountered strong resistence to change in the information gathering and handling systems. Even where there was explicit recognition, by the policy/decision maker, that the information being gathered, or the form in which it was presented, was inadequate to the purpose of management, there was resistence to change because this would "spoil the historical record". For example, the study of forest productivity indicated major inadequacies in the forest inventory as an aid for management decisions. It was clear that the information gathered did not permit knowledgeable decisions about control of forest productivity. Despite this, the modifications in the data gathered, and data handling, that were made, were of the nature of minor tinkering, where a major overhaul was needed. The difficulty appears to stem from the problem of credibility discussed in the previous section, and the institutional comfortability of the "steady as she goes" form of management. Only those few policy/decision makers who have worked interactively with the forest productivity model, and been forced to evaluate their own assumptions, have come to the realization that the information available on the forest is not adequate, and that the inadequacies are not being addressed by tinkering changes. Some progress has been made in this respect, but as Michael (1973) suggested, the vital notion of a "management information system" is beginning its test period in isolation from most of the operational management part of the provincial government.

When an organization adapts its information system, so that the feedback loops from the system being managed are more direct, and carry more information on system performance, they inevitably introduce turbulence to

the management operation. This turbulence means that the managers must learn to live with information overloads, and with confusion about what their job actually is. To emphasize this latter point, it is suprising how frequently acquisition of information is regarded as simply a job within a management organization. The notion of adaptive management, with its attendent needs for different information, and systematic interpretation of that information, results in a cascade of task and job redefinition within the management organization.

FEAR OF EVALUATON

All participants in the implementation of adaptive management exhibited fear (avoidance) of evaluation at some time or other. A feature common to all steps of the process, from the policy design scientist, to the on-the-ground implementation, is the absence of rigorous evaluation. That is, while there is universal lip service to evaluation, there is seldom a mechanism in place which rigorously evaluates, and causes appropriate adaptation. Adaptive management will not succeed in such an environment.

There are many examples of the arms-length approach to evaluation. Those of us in the policy design part of the exercise, have shown almost infinite capacity to rationalize our inability to achieve implementation. The problem is more serious, in my opinion, the closer one comes to on-the-ground management. It seems inevitable, that studies of alternative futures, such as those basic to adaptive management, will raise questions about the long term utility of present activities. Our reward systems all operate on the basis of "doing things right" and the implication here is one of changing the standards of what is right. Thus, an adaptive management

plan must include procedures intended to accomplish the plan, and to provide for a systematic evaluation, and adaptivity, of the plan and the means used to accomplish it, and it must do this in such a way that the institutional reward system enforces adaptivity.

The fear of evaluation stems from the basic fear that such an evaluation might show the programs are not working. Yet this information is precisely what is needed. In budworm/forest management, there has been much more attention paid to agonizing over past mistakes (or arguing whether they were mistakes) than to evaluating alternative policies for the future. Arguments about past performance are broadly counter-productive, in that they focus attention in precisely the wrong direction, in terms of time, and in that they greatly enhance organizational territoriality. A major point to establish in the philosophy of adaptive management, is therefore, that evaluation is not carried out to demonstrate inadquacies of past performance, but rather, evaluation is used to permit the policy/decision maker to design better approaches to the future. That is, while evaluation must necessarily be carried out with respect to past events, it should be interpreted primarily in terms of future events. Overcoming the resistence to evaluation is a major limitation to adaptive management, and the longer an organization persists with an approach of disjointed incrementalism, the more difficult it will be to undertake real evaluation, and to become adaptive.

When the presentation of an alternative policy includes an evaluation of the existing policy, it is incredible how quickly subsequent discussion centers on a defense of the status quo. For example, there has been no real evaluation, by the management agency, of the spray rule used for the past twenty six years in this case study. There have been many defenses of the rule,

but no systematic evaluation, which would lead to an improved approach to the future. Thus, in the spring of every year, New Brunswick faces a veritable deluge of misinformation in the media, stating emphatically that the policy does (or does not) work. It seems incredible that, after twenty six years, there are still arguements about whether or not the policy of crop protection with insecticides prolongs the outbreak! A seriously debilitating feature of these arguments, is that, the continued use of a disjointed incrementalism approach to the problem, and the continual defense that this approach requires, engages the energies, of the very people, who are needed to introduce adaptive management.

INSTITUTIONAL RESISTENCE

Institutional resistence to change is not unique to the implementation of adaptive management in the budworm/forest system. Indeed, one must concede at the outset that a certain amount of internal inertia is essential to prevent policy from vascillating like a floppy weather vane. However, institutional resistence to policy change, and specifically to change in the sense of adaptive management, is a major impediment to the implementation of adaptive policies. The institutions of our society have an incredible preoccupation with stability-oriented management. The institutions are designed, and the reward systems within them function, in a manner that promotes acceptance of the "steady as she goes" approach. In this environment, the notion of "going adaptive", is counter to all the rules of conventional bureaucracy. In the organizational structures with which we were concerned, the reward system functions in direct opposition to the notion of adaptive management. There was great willingness on the part of policy/decision makers to discuss our

approaches to the management problem, and to listen to our proposals. Problems appeared only when these people were required to change (that is adapt) their actions and decisions.

The most common manifestation of institutional resistence was the "yes that's good stuff" syndrome. If the policy/decision maker has not learned the philosophy of adaptive management, he is inclined to greet the vigorous stimulator (policy design scientist) with considerable warmth, and with the use of many appreciative words. Questions about the approach are characteristically superficial, since neither participant in the discussion wishes to be offensive. In initiating the learning process with these people, the policy design scientists must face the reality of the organizational structure within which the policy/decision maker operates, and he must adapt the learning process to that environment. Many writers on the subject of organizational structure have pointed out that these structures evolve to serve the organization, rather than to serve the purpose of the organization. For example, the provincial management agency in the present case, has several man-years committed to a unit entitled Policy and Planning. In the policy context that we are discussing, in this workshop, this unit does not engage in any policy or planning. Its activities are centred on control of the current budget. Its members will acknowledge the need for policy analysis, and for long range planning, but they will immediately follow this acknowledgement, with a statement that the preeminent role of their unit is to ensure best use of currently available resources as determined by the internal structure of the agency.

In his incisive analysis of institutional resistence, Michael (1973)

argues that adaptive management requires a change in organizational structure. The agencies with which we were involved, all have engaged in organizational redesign, or are doing so now. However, in all cases, this redesign is a reallocation of the existing manpower, and consequently of the existing philosophies of resource management, to a different set of boxes in a box and line diagram. Their redesign characteristics, meet the criteria for prevention of change outlined in Michael (1973) and Cantley (1973). Redesign which does not address structuring the organization to enhance the management of the resource, will only strengthen resistence to adaptive management. Organizational redesign which does not intentionally introduce the capability to handle turbulence, in the sense described by Michael (1973) and Cantley (1973) will not suffice. Paradoxically, those involved in the redesign of organizational structures have "ideal" goals, and such redesigns are normally carried out for the very purpose of enhancing effectiveness in management of the resource, however, the internal reward pressures and manpower constraints invariably prevent the development of mechanisms for dealing with turbulence.

A second major institutional impediment to the implementation of adaptive management is the occurrence of gaps in the administrative structure. These gaps are of at least two kinds. There are those between two members of a bureaucracy, which occur because the defined jobs of the two individuals do not interface precisely (because they fail to touch, or because they overlap). The second form of gap, occurs when there is an element of the bureaucratic system which either does not, or will not, understand the need to learn with respect to adaptive management. In our experience, both kinds are sufficiently common, that it is not safe for the policy design scientist to assume that concepts, which he introduces to a management agency, will pass through the formal

structure of that agency. In fact, the more valid assumption is, that such concepts do not move at all internally. This means that the issue of where to enter in an organization when attempting to introduce adaptive management is important. The "right" people will vary with each organization. However, in the sense that the policy design scientist is the stimulator he must establish contact with, both the initiators at the operational level, and with the legitimizers at the senior level from the outset. In our experience, there is relatively little resistence to initiating the learning process for adaptive management at the very lowest level of operational initiators. These people are frequently recent graduates, who are able to accept technological innovation, and show a willingness to attempt to invoke these innovations. Similarly, the most senior administrators did not exhibit significant resistence to adaptive policies. In fact, these people will usually state that the essence of their job is adaptibility. They are normally supportive of techniques which systematize adaptivity, and therefore enhance their performance as a policy/decision maker. Difficulty, in initiating the learning process for adaptive management, more characteristically occurred in the middle level of operational initiators. These people often have a view of technology that is frozen, at the level of time of their graduation, and they have become conditioned to be very responsive to the internal reward system of the organization. They may express a willingness to discuss innovation, but they seldom are willing to initiate the turbulence associated with real application of innovations. Initiating the learning process here must recognize both these factors, the absence of an appreciation of modern technology, and the responsiveness to the internal reward system. Senior management is quite often unaware of such hangups in the middle levels of

their organizations. Operating "around" a middle management layer, that is acting as a filter against adaptive approaches, is a tempting short run expedient that is disastrous in the long run. The learning process must be initiated in these people. A convenient mechanism, in this respect, is to have senior management legitimize the activity by committing an amount of manpower and resources to the project, so that the middle management recognizes that this "change" is acceptable in the organizational structure.

To operate adaptively, it is necessary for a management agency to treat all current policy as hypothesis. That is, they state, and invoke, a policy, and then sense performance by gathering information from the environment, which in turn permits them to test, and as necessary adapt, the "hypothetical" policy. Unfortunately, in most agencies, it is so difficult to get a firm statement of policy, that once one arises, there is a tendency to inscribe it in stone. The reward systems in most organizations enhances such rigidity. Clearly, a key effort in initiating the learning process, must be directed towards helping the manager discover that his policy can evolve systematically, as distinct from either remaining rigidly fixed, or wandering aimlessly in an ad hoc fashion. We found a major problem here, in that our approach emphasized the development of an array of policy options, which the policy/decision maker would systematically review. By contrast, the conventional approach to policy (disjointed incrementalism) emphasizes two (trivial) alternatives normally stated as "do" or "don't". The learning process with respect to an adaptive philosophy must progress some distance, for the policy/decision maker to give up the "simple" decision between two "simple" alternatives. The most common form in which we encountered this resistence was a reaction of the policy/decision maker that, "when the crunch comes we

know what works, and will use it with no nonsense". That is, when the pressure is on, and a decision must be made, they know that insecticides have worked, and hence there is a tendency to play down the need to get a better way. An example of this centres on the use of an early-intervention spray rule in the application of insecticides. All of our analyses have indicated that a spray rule that causes the application of insecticides early in the defoliation sequence, as opposed to near the end when the trees approach death (as has been used operationally) is a "better" rule in many ways. This early-intervention reduces the amount of insecticide used over time, maintains the forest in a healthier state, and maintains more options for the manager, should he be constrained in the use of insecticides. This early-intervention rule proved to be exceedingly robust to a wide array of assumptions in the budworm/forest model. Ernest discussion of the early-intervention spray rule, with the provincial management agency and the protection agency, led to an explicit conclusion, on their part, to adopt the early-intervention rule as a policy. Since the rule is the antithesis of the one currently used, considerable effort went into the design of a transition rule from the late-to early-intervention. By the time a tentative spray program based on this transition rule could be presented to the protection agency (four weeks) it had become apparent that the total dollars available for the current year spray program was fixed at a level below that required for the transition rule. The agency thus designed yet another ad hoc application of the old spray rule, without even appearing to recognize the inconsistency of this action with the policy statement they had made previously.

One form of institutional resistance has been oversold - in my

opinion. There is, in our society, strong belief that senior executives should not be exposed to detail. Most attempts to initiate the learning process, with those who would make policies or decisions adaptively, are met with the "executive summary please" syndrome. Such executive summaries are inevitably over simplified and because they are so abstracted from the real world, they will lack reality in the eyes of the reader. They are consequently easy to poke holes in, and the net result most frequently is a loss of credibility for the approach, rather than an enhancement. I believe our experience shows that senior executives are willing to engage in a substantial learning process, if it is addressed to them.

A most pernicious form of institutional resistence to adaptive management is bureaucratic territoriality. This is an immense problem which has been addressed by many writers (eg. Chambers, 1979). I can only say that, those who would initiate the learning process for adaptive management, prepare themselves to deal with the territoriality problems that emerge amongst the many agencies necessarily involved in a natural resource problem. In this case study, despite the fact that several agencies possess terms of reference which contain the common goal of improved management of the resource, it is common for the interaction amongst these agencies to be at least as much antagonistic, as it is cooperative. One example should serve my point here. When the sequence of transfer processes in the development of the adaptive policy tools reached the Canadian Forestry Service, the next step was to engage in the transfer of the model, and its attendant policy design tools, to the provincial management agency. However, at this point senior management in the research agency became concerned that sufficient recognition be given to the

"contribution" of the service, and determined that transfer could occur only within their terms. The proponents of this notion stated an explicit proprietary interest in the model and the policy design tools, and expressed great concern that this ownership be recognized. Their motives were to insure that, in the total picture, a major scientific contribution of their unit was given adequate recognition. The result of their intervention in this manner, was a breakdown in communications between the research agency and the management agency with respect to the budworm/forest policy design tool, and no progress toward implementation for almost two years, at a period in the process when rapid communication and response was most essential. The problem was overcome partly, by a turnover in staff and partly by a very circuitous approach to implementation. Ironically, the failure of the Canadian Forestry Service to actively advance the use of the tools, has resulted in the exact opposite of the intended effect. The tools are widely known as the "Holling Model" or "U.B.C. Model", seldom, if ever, recognizing the Canadian Forestry Service role, because the visible action all came from outside that Service.

RESISTENCE IN SCIENTISTS

Perhaps because I was a member of the scientific team, I found resistence to the concept of adaptive management in the scientific community difficult to acknowledge, and finally, even more difficult to accept. Resistence amongst scientists takes several forms, but the most important one, is their inability to grasp the "nowness" that is associated with decision making. Scientists are so dedicated to the notions of precision and the need for scientific understanding, that they are distinctly unwilling to

provide the manager with interim (adaptive) guidance. Classically, the scientific response, to the need for specific information about system dynamics, is to tell the manager to come back in ten years, after a study has been conducted. By refusing to give their best scientific judgement, on system structure and function, the scientists seem unaware that, by default, they have shifted this responsibility for analysis of system dynamics to the manager. That is, some forecast of the future must, and will, be made, and if the scientist refuses to use his capabilities the manager must use his, however limited. This, of course, means that scientists have largely opted-out of participation in adaptive management. The basis of adaptive management is application of the best available current information to the system, with adaptation, as system performance indicates, and as improved research permits. The scientific cop-out inevitably causes antagonism, because the manager is acutely aware of his limitations in making forecasts that involve scientific understanding, and the scientist is only too willing to point out inadequacies in the managers' forecast, even if he is unwilling to make one himself. The learning process for scientists in this respect must involve sufficient association with managers, that the scientist begins to understand the nature of the environment in which decisions are made, and the fact that decisions must be made.

The nature of the scientific method is so closely related to adaptive management one would assume that scientists would readily grasp this approach. While they may apply it in their individual work, they show resistence to an adaptive approach, in the context of the team research situation which is common in resource management problems. The situation here, is analogous to that of the policy/decision makers who are willing to discuss

the notion of an adaptive approach, but are unable, or unwilling, to carry it through. Scientists are willing to discuss the needs for budworm/forest research in a comprehensive manner, and seem to recognize a need for an adaptive approach to overall research design. However, when it becomes apparent that an individual scientist must adapt his approach to research, in order to fit the overall needs, the resistence is frequently overwhelming. I have hopes that when an adaptive research strategy is available, within which each scientist can see his role, this resistance will dwindle.

Most scientists view of resource management is totally unrelated to reality as perceived by the manager. Typically, the scientist views some "no risk" situation, at some distant time in the future, when research has provided all the necessary information, whereas the manager is continually faced with a high risk situation in which he must make decisions now.

RESISTENCE IN SOCIETY

For adaptive management to be implemented successfully in natural resources, there will have to be a substantial improvement in the understanding of resource dynamics in society at large. By and large, society prevents policy change by placing great emphasis on a "firm committment" from it's policy makers. Society rewards firmness in this respect, and has little tolerance for adaptations. This is a particularly sensitive issue for policy/decision makers who are responsible directly to society. Further, the mass media in our society have contributed in a major way to the evolution of an understanding (or lack thereof) of system dynamics which leads to notions of simple solutions. It sometimes seems that all issues, no matter how complex, must be reducible to the fifty second time frame used in a television newsclip. In our case,

the effect of this lack of public understanding has been the wide dispersal of a multiplicity of simple solutions to the budworm/forest management problem, all of which are unworkable. The initiation of the learning process with respect to society must concentrate on gaining acceptance that natural resource management problems are complex, and that meaningful solutions will also be complex.

Pressure groups have taken on a major role in our society. Small dedicated groups can bring, via the media, disproportionate pressure on the policy/decision maker. In the budworm/forest management problem that we have looked at, such pressure has been a major contributor to the persistence of a disjointed incrementalism approach to the problem. These groups capitalize on what might be termed "media ecology", which is more closely related to a Utopian wishful thinking than to any science you may be familiar with. Although not all groups are irresponsible, they uniformly contribute to the polarization of agencies (bureaucratic territoriality), to the disjointed incrementalism approach to the problem, and quite frequently are counter-productive to their own aims. One such group, which took a very responsible approach to reviewing the Task-Force report, were particularly interested in one alternative to spraying. As it happened, I knew that the management agency had discontinued work in that particular area, precisely because of fear of adverse publicity from this and other environmentalist groups who did not understand its complexity. The group were stunned that this could happen.

The goal of education in society with respect to adaptive management must be to generate an attitude which allows the manager to adapt. While society must have constraints on its natural resource managers, it must somehow gain the confidence it needs to give the managers' freedom to adapt

to the certain future as it unfolds.

BOUNDARY SPANNING

The concept of boundary spanning is central to the issue of implementing adaptive management, and is indeed the real subject of this paper. I draw attention to it here more in summary than in substance. It should be clear, from what I have said above, that I do not believe that simply making the concept of adaptive management, and the tools for adaptive management available, is an adequate approach to implementation. There must be an active boundary spanner group, dedicated to initiating the learning process with respect to adaptive management. This most major of tasks will require incredible dedication, both because it requires some understanding of the scientist environment and the managerial environment, and also because it necessarily becomes laden with interpersonal conflict. Once again, I would like to quote Michael (1973) since, having been there, I find his description very apt:

> "The spanner is in one way or another a carrier of information between systems of activity, and as carrier he is both an information feedback system and an information-generating system. He is often a feedback vehicle for information generated in consequence of his interventions to get information. As a human he will be fallible in what he observes and reports; and activities he initiates for the purposes of generating information may not turn out to be the ones he intended. He is thus especially vulnerable to error, and because of ambivalence toward him, his messages will often be ignored, repressed, rejected, or distorted. Inevitably, the boundary spanner function will be ambiguous, conflict laden, and ambivalently performed and responded to, and thus precarious. Boundary spanners will often be distrusted and resented by all parties they span between."

CONCLUSION

The foregoing has reviewed certain difficulties that arose with respect to the implementation of adaptive management in the budworm/forest system. Because I was deeply involved it is necessarily a personal review, and others may well interpret events differently. The scientific part of the exercise was successful. The team succeeded in building a comprehensive model that was consistent with the data available on budworm/forest dynamics. The use of this model with other policy design tools permitted discovery, and evaluation, of a range of possible policies for dealing with management of the budworm/forest system. The program that achieved this, also contributed substantially to the development of the concept of adaptive management in natural resource systems. If we judge success to be, the use of the available tools to illustrate the possibilities of adaptive management in the budworm/forest system, then report of the Task-Force could be used to justify a claim to success. On the other hand, if we are to judge success to be, change in the environment in which policies and decisions are framed, and in change on-the-ground, then the degree of our success has been limited to the initiation of the learning process in a small cadre of people in each of the organizations that share the responsibility for managing the resource. Despite the difficulties enumerated in the previous sections, I consider this a reasonable degree of success. Perhaps this is rationalizing, however, it seems that our initial expectations with regard to implementation were naive. Although we strove to give recognition of the "people problems" involved in such a transfer of technology, our approach was still much more oriented to the technology, than to the people, and consequently our methods as boundary spanners were inadequate.

The implementation of a concept such as adaptive management is quite different from that associated with the transfer of technology, of say a new diode. I conclude that with respect to the implementation of a concept, such as adaptive management, that it cannot be treated as a separate step which comes at the end. To be explicit, if implementation is treated as a step in a transfer process, it is already defeated. We attempted to lead the management agencies into the philosophy of adaptive management in a manner that would permit them to discover it for themselves. With sufficient dedication of time and manpower, this is a "best" method. It seems clear, however, that much time must be devoted to teaching, so that the policy/decision maker can begin to see that he is not really doing what he believes he is doing, that is, managing adaptively. For adaptive management, implementation must start with the first glint in the eye of the systems analyst. It is true that we had participation of the management agency from the outset, however, in retrospect this appears to have been only tokenism. Real implementation, will require firm committment of substantial portions of manpower by the legitimizers in the management agency, and a firm committment on the part of the scientist, to work with these people while they learn the philosophy of adaptive management.

Attempts to implement adaptive management should focus on the people involved, rather than on the technology involved. If you would implement adaptive planning, you must understand at the outset that you will create substantial difficulties for yourself, and others, by requiring you and others to adjust and adapt. In establishing an atmosphere conducive to such interpersonal adaptation, it is essential to keep all of the processes, including the mysteries of the model itself, as visible as possible.

Implementation is not an impersonal technical problem. It is a highly interpersonal and stress-filled exercise. I would suggest that, initiating the learning process leading towards implementation should centre on intelligent use of the counter-intuitive results that come from the analysis of model output. Addressing this issue directly, enhances the learning process, and increases credibility simultaneously.

Since most managers believe they already manage adaptively, it is essential that they learn the philosophy well enough to actually operate adaptively, as opposed to simply using the appropriate words. In this context, it should be clear that changing over to adaptive management cannot be done quickly. Those of us who wish to stimulate advancement towards an adaptive approach to resource management, must recognize the need for a phased change over. Promoting a sudden change to adaptive management is not a realistic goal. It is realistic, however, to initiate the evolution towards adaptive management.

In implementing an adaptive approach to resource management the formidable resistences to its introduction must be recognized. These resistences are formidable because they are supported by conventional, and widely embedded, societal norms that people subscribe to, and because they set the bases for reward and punishment. The examples of resistence that I have used are specific to our situation. However, I am convinced that these are classes of problems, and they are not unique. I have seen them in every other natural resource situation with which I have any familiarity. More particularly, they exist most prominently in those places where the agencies, and people involved, insist that they don't have such problems.

The concept of an adaptive approach to management is sound. The

problems associated with its introduction are not insurmountable, unless we refuse to recognize them. In precisely the nature of the philosophy of adaptive management, this paper is an attempt to close the information loop, and advance the cause of adaptive planning. It contains messages from the environment. These messages are addressed to the policy scientist, the biological scientist, and to the policy/decision makers. I hope these messages will not be seen as criticism of past performance. To progress, the messages must be viewed as information which will enhance our ability to plan adaptively for the uncertain future.

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EXPERIENCE IN IMPLEMENTING ADAPTIVE MANAGEMENT AND ASSESSMENT

by

F.E.A. WOOD

SALMONID ENHANCEMENT PROGRAM

CANADA DEPARTMENT OF FISHERIES AND OCEANS

The Canadian fisheries agency has experience with adaptive management and adaptive assessments in the salmon management and enhancement fields.

1. Salmon Management Experience

The process started with workshops in 1974 on Skeena River salmon management and has continued to the present. A number of key problem areas including stock relationships and fleet dynamics dimensions have been identified, and analysed. A number of optional strategies and tactics were identified and evaluated. All this work was done at the tactical/operational level only. There was no serious commitment from the strategic level of the organization until 1978. As a result of that commitment, the public and client groups were involved in the process of evaluation of management alternatives. A change in the management approach was initiated. Then, for other reasons, the strategic (and most of the tactical) level staff involved were lost in an organizational change later in 1978.

An area of exploration in fisheries management of special note is what we call adaptive management. This is the strategy of consciously managing stocks to generate information on required population parameters in an optimal pattern. The results to date suggest that at low risk we may be able to achieve as much as 25% increase in production by improved management.

We are again working toward acceptance by both these staff levels.

2. Salmon Enhancement Experience

The planning of this program was initiated in 1975. From the beginning the strategic level staff was committed to the adaptive philosophy. The staff group was small and carefully selected. Implementation was easy and quick. The program proposal was formally adopted by the policy level in 1977.

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This program is adaptive in a number of ways. It doesn't have a rigid plan; rather, it is responsive to opportunities and problems as they develop. Where possible, enhancement facilities are built in phases so that the knowledge acquired from the early phases can be used to adapt later phases. Similarly, projects are sequenced to optimize knowledge feed forward for the same reason.

3. Implementations Options/Recommendations

The technical aspects of implementing adaptive management are relatively easy, albeit important. The workshops, data assembly and analyses, and policy analyses only cost money and staff time. It is implementing the strategies and tactics identified which may be difficult.

My experience suggests:

(a) The process may elicit numerous bureaucratic survival responses. The key problems are people problems.

(b) Support and commitment at the strategic level of the organization is very important. Trying to work up through the organization is a slow, costly, and frustrating experience. Because of this, the use of "converts" to "infiltrate" an organization may be a questionable strategy.

(c) New ideas have a definite gestation period for acceptance. Forcing the ideas during this period may be counter productive. It is better just to nurture them.

(d) The larger the group affected, and the greater the difference between present and proposed tactics, the more difficult it will be to get implementation.

(e) Sometimes "outsiders" or perceived competitors,when involved in the workshop process, may catalyze rapid progress.

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(f) The staff training benefits of the program can be lost when staff return to the normal non-receptive or antagonistic working environment.

(g) Communication with other agencies suggests that a "crisis" situation may serve to catalyze implementation of even major changes, such as adaptive management.

4. Core Group Attributes

If the adaptive process is to be implemented effectively, the capabilities of the core group are of vital importance.

If the process is to have depth and breadth without a lot of redundant development work there is definite need for creative members who are not "risk averse". If they are intuitive, it will help the process considerably.

To compliment this capability, people who can bridge the gap between the creative component and workshop participants are essential. They must serve as interpreters and communicators, and bring the process back to reality if it drifts too far away. It helps if the core group members have complimentary and diverse experience.

It is essential that the core group is seen to be interested in the subject and hopefully that its interest will be infectious. The core group must be able to energize the workshop. The workshop leader must be perceptive of peoples' behaviour if he is to keep control of the workshop and make it work.

In my opinion, such a team of people will require much experience and development to be able to emulate the capability of the U.B.C. group.

If, as in our case, implementation is not seen to progress at least a little, frustration and disheartenment may influence or overwelm the core group or the entire workshop group. Because of this, it is important to have a chance of success before the process is initiated.

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5. Benefits of Workshop Process

The general purpose of the workshop process is to create a simulation model which, in the process of creating it and using results in "new" knowledge of relationships, permits/assists/forces the compromise of initially divergent assumptions, attitudes, and positions in a form of non-static optimization. The process helps to identify and clarify options and explore alternate strategies and tactics, adapting a composite of them to a dynamic optimum.

There are a number of other benefits to be derived from the workshop process. It creates a framework for dialogue and a common language. The organization and evaluation of data before they enter the model are key benefits. Our required data were not easily accessible or rationally organized. The traditional wisdom and dogmas may be challenged when all are taken together rather than individually. The workshop process injects an overall reality to the target subject.

I am convinced that there are significant benefits to be achieved from the adaptive process. There are potential pitfalls in implementation but these may be outweighed by the considerable benefits satellite to the process. The philosophy of adaptive management is especially valuable in this age of growing complexity.

Implementing Adaptive Environmental Assessment in an Operating Agency

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In February 1978, approximately 25 scientists and managers from the United States Fish and Wildlife Service (FWS) participated in a week-long workshop on adaptive environmental assessment at the University of British Columbia (UBC). That workshop marked the beginning of a continuing cooperative effort between our staff and Dr. C. S. Holling and his associates through which we have been applying adaptive assessment methods to issues of concern to our agency. Our objective has been to build a capability to apply the approach, as outlined in the IIASA-sponsored book, "Adaptive Environmental Assessment and Management," to various management problems faced by FWS. This paper will discuss the results of our experience to date and possible implications for wider operational use of adaptive environmental assessment.

Organizational Background

Role of the Fish and Wildlife Service

FWS is a component of the Department of the Interior, which is the principal natural resource management agency of the U.S. government. FWS is responsible for a diverse range of activities relating to its mission to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the people. In general, these activities can be characterized as:

1. Those where the Service has a direct responsibility for resource management, often exercised in concert with State governments, with which responsibility for fish and wildlife management is shared under the U.S. Federal system.

2. Those where the Service's role is one of providing environmental review and comment on the developmental or regulatory actions of other government agencies.

Examples of responsibilities in the first category are: management of migratory bird populations, control of predatory and nuisance animal populations, protection of threatened and endangered species, and development and restoration of anadromous fish populations. These responsibilities are exercised through a variety of programs, including management of 34 million

acres of lands in the National Wildlife Refuge system, maintenance of a hatchery system for the stocking and development of fish populations, provision of financial and technical assistance to State government fish and wildlife agencies, establishment of regulations relating to population harvest, conduct of law enforcement activities, and management of a large and diversified research effort.

With respect to the second category, FWS has an increasingly important role in environmental protection, particularly as it relates to the impact of other governmental programs on fish and wildlife resources. Under various Federal laws, the Service comments upon the effects of such diverse activities as river basin development, highway construction, extraction of energy and mineral resources, operation of electric power generating facilities, and many others. Comments take the form of recommendations concerning potential impacts on fish and wildlife resources to the Federal resource development agency or the Federal regulatory agency licensing the activity. The Service sometimes recommends against initiation of projects and in other cases recommends measures for preventing or mitigating environmental damage in connection with project development.

The Service's recommendations do not have the force of regulation and have frequently been overridden. However, in recent years, particularly since the advent of the environmental movement and the National Environmental Policy Act, these recommendations have had increasing influence, frequently projecting the Service into areas of intense political controversy. For example, currently the Service's recommendations have deferred construction of two oil refineries on the Atlantic coast.

In addition, the Service has been making major efforts to move from a reactive posture of commenting after project alternatives have been developed toward a position of participation in initial stages of planning as a means of minimizing conflicts and securing more effective environmental protection.

Role of the Office of Biological Services

The increasing number and complexity of major development projects to be addressed under the Service's environmental review function and the desire to move away from a reactive posture has required that the agency improve the basic data and analytical tools available to address these issues. Much of the damage to fish and wildlife resources stemming from land, water, and energy developments could have been avoided or mitigated if projects had been planned with greater consideration for environmental values and if conservation recommendations had been better justified, documented, and understood. The need to demonstrate to decisionmakers the values of particular habitats and to show that alternative cost-effective plans could preserve such values, has become particularly apparent.

In short, the operational components of the Service need to be strengthened and provided with the means of becoming more effective and efficient participants in the resource development planning process. To address this need, FWS established an Office of Biological Services (OBS) in 1974. The Office was given a high priority to accomplish the following mission:

1. To strengthen the FWS in its role as a primary national source of information on fish and wildlife resources, especially in respect to environmental impact assessment.

2. To gather, analyze, and present information that would aid decisionmakers in the identification and resolution of ecological problems associated with major land and water use changes.

3. To provide better ecological information and evaluation for Department of the Interior resource management programs, such as those relating to energy development.

The Office has developed a broad strategy for dealing with the major environmental problems it has under study.

1. The first element of this strategy is to describe and analyze selected regions and ecosystems under stress from resource development. In a number of regions that are of important ecological concern, various approaches are being used to characterize the ecosystems. For some areas the emphasis has been on assembling and interpreting an already extensive information base, which had not been pulled together previously. For other areas, where there is a lack of relevant data, extensive field studies are conducted.

2. The second element is to identify impacts on fish and wildlife resulting from various classes of development. This involves not only focussing on primary impacts, such as the immediate effects of strip mining; it also involves an effort to identify and describe secondary impacts, such as those stemming from related industrial development and population growth.

3. The third element involves establishing a capability for examining alternatives, mitigation methods, and management strategies aimed at minimizing environmental damage. Better ways to contribute to the resource planning and development process are being sought to ensure that ecological issues are made known to resource planners and managers as early as possible.

4. The fourth element of the strategy involves implementing information transfer techniques and procedures so that ecological findings can be more effectively used in decisionmaking. This requires the conversion of research results into readily usable formats, development of manuals and handbooks, presentation of workshops and training courses, and development of effective information storage and retrieval mechanisms.

5. Finally, OBS seeks institutional means to strengthen FWS participation in the planning and decisionmaking process. This involves fostering coordination between operational elements of the Service and other agencies involved in resource development.

In summary, the role of OBS is to develop better information and techniques for assessing the impacts of a variety of developmental activities on fish

and wildlife resources, and to transfer that information and those techniques to users in a manner ensuring their inclusion in the decisionmaking process.

Potential for Application of Adaptive Environmental Assessment

Our role in fostering improved methods for evaluating the impacts of development activities on fish and wildlife resources led us to explore the work of Dr. Holling and his associates at UBC on adaptive environmental assessment. We first became aware of the process through the work of a staff member, Dr. Jack Gross, who was a participant in the project leading to the publication of "Adaptive Environmental Assessment and Management" and, subsequently, through participation at a workshop convened at IIASA in 1977 to critique a draft of the book. Let us say from the outset that, without such direct involvement, it is highly unlikely that we would have undertaken the commitment to this effort that will be described below.

The adaptive environmental assessment approach appeared to us to have many merits in relation to the needs and issues we had encountered in the work of OBS. We saw the method as an attempt to address some of the principal shortcomings and limitations of environmental impact assessment as currently practiced:

1. An assumption that impacts occur as a black and white, either/or situation--with a failure to recognize the dynamic nature of ecosystems and their resiliency characteristics.

2. An over-reliance on predictive capability, and therefore a failure to build in adequate monitoring and adaptive policies to reflect the shortcomings of prediction.

3. A tendency to want to make one-time, one-shot decisions, as contrasted with a flexible, adaptive approach in which provisions are made for policy adjustments based on subsequent experience.

4. A reactive approach to environmental assessment, rather than one of integrating environmental considerations into resource planning and management from the outset, resulting in unnecessary polarization of environmental protection and resource development interests.

5. A tendency toward large, expensive state-of-the-system surveys resulting in the preparation of ineffective impact assessment documents that fail to address critical decision issues.

Although we had attemped to confront many of these problems in the work of OBS, we had identified some important limitations in our program. Among the most important of these were administrative separation of the staff that designed and managed our studies from the policy/decisionmakers. This made it quite difficult to define information requirements with reference to decisionmaking needs. In addition, individually conducted studies tended to diverge from the salient questions, to develop excessive detail, and to provide no way to test alternative policies. Further, it has been quite difficult to integrate individual studies to provide a comprehensive interdisciplinary view.

As we saw it, some of the key features of the adaptive environmental assessment approach could help address these shortcomings in effective resource development planning and in design of meaningful environmental assessments. The approach included systematic means of:

1. Inclusion and coordination of key individuals and interest groups in the initial stages of development planning.

2. Integration of information, and analysis and design of policy alternatives through the application of systems analysis and simulation modeling techniques.

3. Design of adaptive policies that incorporate and benefit from uncertainty concerning the behavior of ecosystems under stress.

4. Design of monitoring programs that can provide early recognition of system changes in areas where uncertainties exist.

Based on these conclusions, it was decided to commit a substantial effort to see whether we could apply adaptive environmental assessment in a practical way to problem solving within our agency.

Cooperative Program with University of British Columbia

We entered into an agreement with Dr. Holling and his group at the UBC Institute of Animal Resource Ecology to pursue transfer of the adaptive environmental assessment capability to FWS. We began with an exploratory workshop in which about 25 carefully selected FWS personnel were exposed to the method through lectures and simulated problem solving. The response was enthusiastic.

We subsequently concluded that the best approach to implementation would be to establish and train a small group which would serve as the nucleus for a FWS workshop staff. This staff would address various problems using the adaptive assessment method. The remainder of this paper deals largely with our experiences in developing the capability to run these modeling workshops in cooperation with operational personnel elsewhere in FWS or in other organizations.

The workshop staff currently consists of an aquatic biologist, a terrestrial ecologist, an urban planner, and an economist. We are presently recruiting one or two additional members. The group is associated with a much larger interdisciplinary team within OBS upon which it can call for additional assistance.

Although the workshop staff was comprised of carefully selected specialists with ecological and quantitative skills, it was clear that an intensive training effort would be required before it could apply the modeling workshop aspects of the adaptive assessment approach. This training is being accomplished through the actual conduct of workshops in which the staff is shadowed and assisted by experienced personnel from UBC. Several such workshops have now been conducted as will be described below. In addition, an intensive two-week training workshop for FWS personnel has been conducted at UBC.

Our plan is to fully train this group to become self-sufficient within about two years. In addition, as it was not considered feasible to dedicate a significant block of manpower and financial resources solely to a two-year training exercise, we felt that we also had to show some practical results during this period.

Following the establishment of this workshop staff, we applied the workshop approach to a variety of problems. It has been used in small in-house exploratory sessions at which we evaluated the feasibility of applying the adaptive assessment method, as well as in more experimental exercises in a UBC training setting, and in full-scale workshops in a real-world setting. These problems have addressed issues primarily related to FWS in-house management responsibilities--such as examination of alternative management schemes for individual National Wildlife Refuges, and issues involving the FWS environmental review functions. Our success and effectiveness have varied.

Case Studies

We have been able to carry three of these issues to the point of conducting full-scale workshop exercises, and we will describe each of these in greater detail. We will not attempt to describe the adaptive assessment approach itself, as our assumption is that Seminar participants will have received this information from other presentations.

Charles M. Russell Wildlife Refuge Planning

The Charles M. Russell Wildlife Refuge surrounds a large reservoir, constructed and operated by the U.S. Army Corps of Engineers, on the Missouri River in the western United States. Until 1975 the refuge was jointly managed by FWS and another Department of the Interior agency, the Bureau of Land Management. At that time Congress directed that FWS assume complete management responsibility and the courts directed that FWS prepare an environmental impact statement (EIS) assessing the effects of its management program. The Service placed a five-man team on the refuge and charged it with preparing the EIS and a subsequent refuge master plan. Personnel on the refuge planning team represented expertise in fishery and wildlife biology, outdoor recreation planning, range conservation, and soil science.

Development of an EIS and refuge master plan was selected as a case study for an adaptive environmental assessment workshop in 1978. The workshop had four objectives:

1. To assist the refuge planning team in identifying issues, impacts, and important variables.

2. To assist the refuge planning team in establishing research priorities.

3. To expose a broad spectrum of fish and wildlife personnel to adaptive assessment philosophies and techniques so that they might evaluate the process as a planning tool.

4. To provide the FWS workshop staff with experience in conducting a workshop.

A meeting to define more closely the physical, temporal, and biological bounds of the problem was held prior to the workshop and was attended by the entire FWS workshop staff and the leader of the refuge planning team. The format of the meeting mimicked the first two days of an adaptive assessment workshop and the result was a completed interaction matrix such as would be used to guide submodel construction. The workshop staff then used the time remaining before the workshop to further develop the conceptual submodels and, in some cases, to begin translating the concepts into computer code.

The workshop was held in facilities provided by the Institute of Animal Resource Ecology at UBC. Participants from the FWS, other than the workshop staff and the refuge planning team, represented a variety of offices and programs. In addition there were representatives from the U.S. Army Corps of Engineers and the Montana State Department of Fish and Game.

Although an operational dynamic simulation model was produced during the course of the workshop and objectives 1. and 4. were met, the workshop staff was relatively unsuccessful in accomplishing objectives 2. and 3. Many decisions concerning research priorities had been made by the Service before the workshop, and, to some extent, the refuge planning team was assembled with expertise to address those research needs. The model produced during the workshop simply was not powerful or credible enough to change firmly established directions. Had the workshop been held earlier in the planning process, a model of similar power and credibility might have had greater influence.

Furthermore, the workshop did not persuasively demonstrate the value of the adaptive assessment process. The workshop staff failed to convince the participants that they had a significant input into the structure of the model. This resulted from relative inflexibility of the workshop staff in including input from the participants during the first two days of the workshop. Generally, the complaint was, "Why did I come and spend a week of my time since you had already constructed the model?" This impression persisted in some of the participants, in spite of the fact that the submodels did reflect their understanding and insights into system structure and function. While important issues, impacts, and variables in the model exhibited counter-intuitive behavior, indicating need for change in research priorities, FWS personnel were not convinced of the value of the process.

In addition to the basic experience gained from running a workshop, the workshop staff learned two very important lessons from this exercise. First, workshops should be carefully directed toward decisions that still remain open. Thus, greater care is needed in selection of problems to be addressed, with particular attention to identifying which decisions might be influenced. Second, participants must be able to develop a commitment to the model that is produced at the workshop. Although it is necessary to hold a detailed scoping meeting prior to the workshop and although a "shadow model" should be constructed as a back-up in case the participants have trouble conceptualizing the system, this back-up model must remain invisible.

Truckee-Carson River Quality Assessment

In August 1978, the U.S. Geological Survey's (USGS) Nevada District Office was charged with conducting a river quality assessment on the Truckee and Carson River systems. These two rivers, which originate in western U.S. mountains, terminate in sinks in the Great Basin and are connected by an irrigation diversion canal.

Original USGS objectives for the assessment were:

1. To identify the most significant resource management problems affecting, or affected by, water quality in the two basins.

2. To analyze existing information and collect additional data as required, to rationally assess these problems.

3. To communicate the results to responsible planners, managers, and the general public in an effective and timely manner.

The emphasis of the assessment process was to focus the research effort on components of the river systems most relevant to planning and management problems and to develop practical tools for predicting the most probable impacts of alternative management actions on the river systems. The Nevada District Office of the USGS was given 2½ years to complete the assessment.

One of the members of the USGS staff had been trained in the adaptive assessment process at UBC, and he suggested that his agency test this procedure on the proposed assessment. Since the FWS was in the process of applying the technique, the two agencies entered into a cooperative agreement to conduct jointly an adaptive assessment workshop as a means of focussing the Truckee-Carson river quality assessment. Back-up support was again provided by personnel from UBC. The following specific workshop objectives were formulated:

1. To develop a group perception of water resources problems in the area by having scientists, managers, and affected publics communicate in common terms.

2. To rank the pertinent water resources problems in order of importance to management.

3. To set practical bounds for consideration of potential management responses to those problems.

4. To indicate areas of critical needs for more information on the resources.

5. To establish effective and continuing communication between workshop participants.

6. To provide additional experience for the FWS staff in conducting workshops.

7. To evaluate the applicability of the adaptive assessment process to USGS objectives.

Members of the FWS workshop staff and the USGS river quality assessment team met approximately six weeks before the full-scale workshop to discuss the scope of the assessment. Results of the meeting were a general understanding of the system bounds, system operation, and probable important variables, and a list of potential participants. Because of the experience at the Charles M. Russell workshop, no further modeling was done. However, the workshop staff did review background material and arranged to have a synopsis prepared of the legal considerations pertaining to the Truckee-Carson system.

The USGS assessment team judged that the subsequent workshop held in Reno, Nevada, was very successful. In a letter sent to the FWS workshop staff, the assessment leader stated that ". . . enthusiastic response we are receiving from the local participants . . . our personal goals for the workshop with respect to defining the study objectives and establishing rapport between the Assessment team and local managers were more than fulfilled. The additional goal of bettering communications at the working levels between the conflicting factions of water management was achieved beyond our highest expectations."

Several factors contributed importantly to the success of this workshop. First, the USGS assessment team did an excellent job of laying the groundwork for the exercise. Participants representing all of the interested factions (including 23 Federal, State, municipal, and private interest groups) were carefully chosen and advised of what to expect at the workshop and what kinds of supporting data and other materials to bring. Second, the USGS assessment team leader had an excellent general appreciation and understanding of the adaptive assessment approach. He was therefore able to assume a leadership role at the workshop. This allowed the FWS team to perform a true staff support function. Third, a working simulation model, in which the participants took "pride of authorship," was produced. This was due, in large part, to very competent support from the UBC back-up personnel, and to a longer than usual programming period (three days). And finally, the USGS assessment team took particular care to have the participants assist in setting priorities, evaluating the workshop, and suggesting model refinements as the workshop was brought to a close.

In addition, several other important points were reinforced during the course of the workshop. First, it became apparent that the thought put into a back-up model, especially those parts that are almost certain to be included in the final model (e.g. the flow routing and water availability submodels in the Truckee-Carson exercise), greatly enhances the probability of a successful workshop. Again, this back-up model must remain invisible to the participants.

Second, we also learned something about the technical problems of conducting a workshop remote from UBC's computer support. The utility of a technically competent computer systems specialist was very graphically demonstrated, both in setting up complex remote communications with the computer, and in isolating subtle errors that occasionally result from such long-distance data transfers (e.g., incorrectly transmitted bits).

Third, we had tended to plan workshops not only as problem-solving exercises, but also as opportunities for exposing a wide range of individuals to

adaptive assessment. However, it became clear that individuals without a personal stake in the issue being addressed have little place in a workshop, unless they attend strictly as observers. Such persons, if allowed to participate, often are inclined to be critical of trivial issues and may divert the group into unproductive discussions.

Finally, the Truckee-Carson exercise taught us something else about the role and makeup of the workshop staff. It demonstrated the necessity for a non-programming workshop staff member to work with the participants in building scenarios and attempting to predict qualitative responses of the model to these scenarios. Programmers are simply too busy to perform this scenario-building function. An additional individual is necessary in order to avoid a very slack period for the participants. This individual need not be a programmer, but must be sufficiently familiar with the model being constructed to ensure that the participants develop policy scenarios to which the model will be responsive. It also became apparent that to have productive subgroup meetings, the programmer must provide structure according to his ideas of submodel design. Without this structure, subgroup meetings tend to be much too diverse and general to contribute greatly to a working submodel.

California Central Valley Water Management

The Sacramento and San Joaquin Rivers are the primary inputs to San Francisco Bay on the west coast of the United States, draining the entire Central Valley of the State of California. In 1977 FWS formed a California Water Policy Center to focus on complex problems of water allocation throughout California, with emphasis on the Central Valley Project of the Bureau of Reclamation (a Federal water resource development agency) and on associated State and private water developments. In February 1978, the director of the California Water Policy Center requested that the FWS workshop staff address Central Valley problems with the following objectives:

1. To assist FWS and the California Department of Fish and Game in developing common perceptions of fish and wildlife problems related to water resource management in the Central Valley.

2. To assist those agencies in establishing priorities for information needs for fish and wildlife management.

3. To evaluate the applicability of the adaptive assessment technique to problems as complex and diverse as management of fish and wildlife resources in the Central Valley.

During the scoping meeting held in March 1978, key staff from the FWS California Water Policy Center and the California Department of Fish and Game met to discuss the background of water development in the Central Valley and the proposals for future water projects that would impact fish and wildlife resources. The result of this discussion was the decision to address the entire Sacramento-San Joaquin system (excluding the estuary into which the system discharges) despite large differences in quality and quantity of data available for the two river systems. A decision was also made to restrict attendance at the April 1978, workshop to FWS and California

Department of Fish and Game personnel. This overruled attempts by the workshop staff to indicate that such a narrowly focussed group would fail to provide the perspective necessary for the best possible workshop. Personnel from UBC again participated as back-up staff and a hydrologist from the California Water Policy Center joined the workshop staff as a subgroup leader and programmer.

The workshop was successful in that the broad objectives were accomplished. Most of the participants had a reasonably good understanding of the dynamics of the species within their respective fields of specialization, and in the case of the fisheries personnel, had already constructed good empirical models. However, the dynamic simulation model produced at the workshop afforded them their first opportunity to examine interactions between fish, wildlife, and water within the entire Central Valley system. During the summary at the conclusion of the workshop most of the participants indicated that new thinking and effort needed to be directed toward aquiring information on causative or limiting factors controlling the populations they were interested in managing. They also indicated a need for some mechanism to support their request that the water development agencies address system-wide effects of proposed water development and management projects.

Participation in this effort demonstrated to the workshop staff that while the adaptive assessment process can be used to address general perspectives and information needs for highly complex systems, followup technical workshops will be needed to develop the submodels to the point where specific research or data priorities can be established. The loss of the broader perspective that could have been provided by inclusion of all interest groups was recognized by the participants early in the workshop. The workshop staff also learned the importance of further developing their programming skills so that submodels can be operational early enough during the week to allow the subgroup members to examine and criticize them. This became apparent because one of the fish submodels was ready early in the workshop while the other was not operating until close to the workshop's end. The participants who had the opportunity to become familiar with the submodel that was operating earlier were much more comfortable with the information needs suggested by the output from that submodel. Finally, it became even more apparent that subgroup leaders must be able to find the proper middle ground between blind acceptance of participant input and an actual leadership role in subgroup modeling. The ability to effectively extract key information and functional relationships from the voluminous amounts of irrelevant information that is usually available is both difficult and crucial.

Results

To date results of the effort to develop an adaptive assessment capability within FWS may be summarized as follows:

1. We have developed a small workshop staff that is now partially capable of designing and conducting workshops on a wide variety of environmental issues of concern to FWS. Considerable support from UBC is still required, but it is estimated that the staff will be able to function independently as it gains additional experience and personnel during

the coming year. The workshop staff has learned a great deal concerning the necessity of precise planning, the importance of rapid programming, and the need for subgroup leaders to take a more active role in directing and challenging the participants in their conceptualization of problems.

2. Software for utilizing the various models developed by UBC has been transferred to computers in two universities in the United States, where FWS has ready access on a time shared basis.

3. A significant number of personnel within FWS (and to a lesser extent within cooperating natural resource agencies such as the USGS, the Bureau of Land Management, and State fish and wildlife agencies) have been exposed to the adaptive assessment approach and its problem solving potential. Some of these individuals have worked in concert with the workshop staff on workshop exercises of direct concern to them. In addition, among others who have not been directly active as participants in workshop activities, we have already discerned an impact in thinking and approach to problem solving as a result of exposure to adaptive assessment concepts.

4. We have analyzed three major resource development problems using adaptive assessment workshops, two of which can be described as at least moderately successful. Both the Truckee-Carson and California Water Management exercises contributed substantially to better communication among the participants, to a better understanding of the behavior of the overall resource system, and to the setting of research and data-gathering priorities. The Charles M. Russell exercise failed to influence the refuge planning process materially, due to inexperience on the part of the workshop staff and because we entered the planning process too late.

Next Steps

Future progress in applying adaptive environmental assessment within FWS is dependent upon two principal thrusts. The first of these involves improving our capability to apply the method; the second involves establishing credibility with the user community of managers within the agency, and thus developing a clientele.

With respect to the first of these thrusts, we must continue to upgrade the expertise of our workshop staff through recruitment, training, and experience gained in conduct of additional workshops. There are also opportunities for further evolving some of the technical aspects of the adaptive assessment method. For example, we will be pursuing ways of utilizing the adaptive assessment approach to apply spatially oriented models developed within FWS, and currently in use by the agency. If these models also can be married with the primarily process and time related models used by the UBC group, an even more powerful analytical tool could emerge.

In addition to strengthening the workshop staff, we expect to see small satellite nodes of capability develop in various parts of our agency's operational structure. Usually, this will involve one or more individuals

who have been exposed to adaptive assessment through participation in a workshop or training exercise. These individuals, by providing a direct link with operations, can play an important role in gaining the institutional credibility so necessary to develop a clientele.

The other element necessary to achieve credibility will be demonstrated success in using adaptive assessment to solve problems of significant management concern to the agency. Thus far, only a modest measure of success has been achieved in this regard. We would hope to be able to move beyond the current problem scoping phase, in which the principal outcome has been to describe system functions and identify needs and priorities for additional studies and data. We are still a long way from having carried a case forward into the stage of actually displaying management alternatives, monitoring programs, and subsequent adaptive responses which would represent achievement of the full potential outlined in "Adaptive Environmental Assessment and Management."

The best way to assure credibility wth agency line managers would be to accomplish a successful demonstration of adaptive environmental assessment to provide management alternatives for a problem important to FWS. This is our dilemma. We are having difficulty in getting managers to experiment with adaptive assessment in the absence of such a clear-cut demonstration. Thus we may have to continue to work by increments to minimize the perceived risks and to develop credibility and clientele. It may be some time before we have the opportunity to apply the method in all its stages, as has been done in the case of spruce budworm control in eastern Canada.

In addition to our primary effort of applying the method to issues of direct concern to FWS, we expect to begin work on applications of adaptive environmental assessment to developing countries. The Agency for International Development (AID) is an agency of the U.S. Department of State which funds development programs and projects within developing nations. Under recent National Environmental Policy Act procedures, development projects funded by AID must include environmental assessments. AID is sponsoring training programs aimed at both its own staff and the staffs of its foreign cooperators to increase capability to conduct environmental assessments. As part of this effort, FWS and AID are in the process of developing a cooperative agreement to include training in adaptive environmental assessment. It is planned to initiate this effort in the fall of 1979.

This approach would be very similar to the one followed in the initial FWS efforts. The initial agreement would provide for FWS, with UBC support, to conduct two workshops for the staff of AID cooperating nations. The first of these would be a broad exploratory workshop designed to expose a variety of individuals to adaptive environmental assessment concepts. The second workshop would focus on a specific case study, probably in Latin America. The ultimate objective would be to determine the feasibility of transferring a full-scope capability in adaptive environmental assessment to a developing nation.

Summary and Conclusions

Our experience to date strongly reinforces our view that the concepts and procedures outlined in "Adaptive Environmental Assessment and Management" have the potential of providing more realistic approaches to environmental management. At the same time, a number of questions still remain.

1. The first of these is the difficulty in conveying to decisionmakers just what the approach is all about. We do not believe that the book, its synopsis, or some of the excellent audio-visual materials produced by UBC have yet accomplished this. Actual participation in a workshop exercise seems to be required to get a full understanding of the approach.

   We have found that a significant investment of money and manpower is required to develop an operational capability to fully apply the concepts of adaptive environmental assessment. In the case of FWS, a happy coincidence of the OBS mission and staff involvement in the development of the adaptive methods persuaded us to make that investment. However, if the technique is to be transferred more widely, more direct and concise means of explaining it must be found.

2. As a closely related matter, clear explanatory materials are needed to convince clients to utilize the approach once a workshop staff capability exists. This remains a sticking point in FWS. We see many situations where the applications and benefits appear even more promising than for the case studies already tested, but where we have not had the means of persuading pragmatic operational managers to participants. All the difficulties typically associated with technology transfer are involved, and in this case are compounded by a fear of losing control of the outcomes in a high risk, public setting. The traditional EIS approach may be widely recognized as inadequate, but it is a known quantity.

3. Further, we wonder whether some aspects of adaptive environmental assessment continue to be more of an art than a science. Dr. Holling has spoken of the "gray eminence" required to orchestrate and lead real-world workshop exercises. A highly trained workshop staff can only provide support. It is clear that group dynamics skills are essential and in each situation it may be difficult to find the gray eminence who can assume the leadership role.

4. Our experience also leads us to conclude that a fairly intensive training effort is required to develop a workshop staff capability. In our relationship with UBC, we continue to be dependent upon moral and technical support--we have not yet cut the apron strings. As already indicated, many of the concepts outlined in the book can impact thinking. To apply them requires training. We have been fortunate in having the direct assistance of UBC in training our staff. Despite highly motivated and well qualified FWS personnel, our effort would have foundered without this support. But we must ask, if the method is to be utilized more widely, who will train the others?

5. There are many elements of the adaptive assessment process that, even standing alone, can contribute somewhat to problem solving. The "looking outward matrix," in which the primary information transfers between system subparts are identified, can be readily undertaken as a separate effort. For example, recent Council on Environmental Quality regulations governing environmental impact assessment under the National Environmental Policy Act state: "There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process shall be termed scoping." The adaptive assessment process would lend itself to such scoping exercises, even if it went no further. In recognition that some will approach adaptive assessment on a partial basis, we need to consider explanatory materials that will facilitate implementation of discrete portions of the system.

6. In summary, we remain firmly convinced that adaptive environmental assessment has the potential for more realistic environmental management than many traditional approaches. More effective means of explaining the approach to managers and decisionmakers must be found, however, if they are to be persuaded to make the necessary investment in staff and financial capabilities and to submit meaningful management issues for analysis and resolution. In addition, special training of already well qualified personnel is needed to enable them to function effectively in organizing and conducting the modeling workshops that are a central feature of the adaptive approach. If wide application of the techniques outlined in the book is to be facilitated, institutional means will have to be found through which personnel can be trained and developed on a continuing basis.

ADAPTIVE ENVIRONMENTAL MANAGEMENT: AN INDUSTRIAL VIEWPOINT

BY
STANLEY DEMPSEY

INTRODUCTION

This is my second visit to Laxenburg. I was here in June of last year, accompanied by Lord Solly Zuckerman. That visit was prompted by a suggestion made several years ago by Dr. Beatrice E. Willard of the United States, who was then serving on the President's Council on Environmental Quality. Dr. Willard had visited Laxenburg and was excited about the work going on here. She felt that some of the work being done would be of particular interest to industrialists and encouraged me to visit IIASA. Lord Zuckerman, who has, in recent years, worked with issues involving mining and the environment, and who is a consultant to my firm, was helpful in arranging my visit. Dr. Levien was a most generous host and I was given a very thorough briefing on IIASA, and on several of the environmentally-oriented projects then in progress.

I did not expect to return so soon to IIASA and, more particularly, I did not expect to be put to work. However, I am very happy that Dr. Levien and Dr. Holling have asked me to speak at this Environmental Policy Seminar and to participate in its work. I am very enthusiastic about the Adaptive Environmental Management approach that Dr. Holling and his colleagues have developed, and about IIASA's efforts to bring that approach to the attention of the environmental policy and decision-making world. I hope that my remarks today will contribute effectively to those efforts.

WHY INDUSTRY IS INTERESTED IN ADAPTIVE ENVIRONMENTAL MANAGEMENT AND POLICY DESIGN

A bit of background on my firm and its experience with environmental management may help place my remarks into their proper perspective, and give you a better understanding why I am so interested in promoting the adoption of the Adaptive Environmental Management approach.

AMAX is a widely diversified, international, natural resource development firm headquartered in the United States. Our operations include:

- Two of the world's largest producing molybdenum mines, which are in the Colorado Rocky Mountains, and molybdenum conversion facilities in the United States and Europe;

- Copper, lead and zinc mines, concentrators and refineries in the United States and Canada;

- We have an interest in a firm that is an integrated producer of aluminum and aluminum products;

- We are the United States' third largest producer of steam coal with several mines in the Illinois Basin and Wyoming;

- We have wide-ranging interests in specialty metals, forest products, and agricultural chemicals, both in the United States and abroad;

- We have an interest in a large open pit iron ore mine in Western Australia;

- We engage in exploration world-wide for a variety of minerals.

AMAX's interest in environmental management goes back many years. We were pioneers in controlling sulfur dioxide emissions from copper smelters. During the 1940's and 1950's our coal company learned to reclaim and farm lands disturbed by mining.

During the 1960's managers in our molybdenum business began to learn about ecology and public participation in project decision-making. In late 1966 AMAX determined that it was feasible to mine the Henderson molybdenum ore body in the Colorado Rockies. A program called the "Experiment in Ecology" was organized by the Climax Molybdenum division of AMAX and the Colorado Open Space Coordinating Council (a private citizen environmental protection organization) in early 1967 - three years before passage of the National Environmental Policy Act (NEPA) and long before Earth Day, 1970. By bringing together people with widely divergent viewpoints and philosophies on environmental issues and setting them to work on a practical problem - the design of the Henderson Project near Empire, Colorado - the "Experiment" became a real-life example of effective environmental problem-solving. Mine planners displayed mining concepts, and citizen environmental activists made suggestions for environmental protection. Some of the earliest baseline studies and environmental impact assessments made in connection with an industrial project in the United States were made as a result of the give and take process developed by the "Experiment." And the mine was built without litigation and delay.

Roger Hansen, who was a leader of the Colorado Open Space Coordinating Council at the time, and a key participant in the program, later stated of the experiment:

> "The 'Experiment' reminds us that the revolution for a quality environment has been occurring in three phases, (1) the attention-getting phase to create environmental awareness; (2) the institutional arrangements phase in which laws, regulations, and organizations are fashioned to deal with environmental problems, and (3) the harmonizing phase in which the vicissitudes of human aspirations and human values systems are called upon to strike some sort of balance between economic needs and environmental imperatives."

The "Experiment" involved attention-getting and creation of a new institutional arrangement, but quickly leaped ahead into the harmonizing phase, achieving success in effectively blending environmental interests into a major industrial project. The "Experiment" gained international attention but was probably ahead of its time.

The late 1960's and early 1970's are better known for Phase 1 and 2 activities, with Earth Day attention-getting, and the United Nation's Conference on the Human Environment

at Stockholm and the passage of the National Environmental Policy Act in the United States receiving credit for pushing development of national and international environmental protection strategies. The years since have been characterized by the development of extensive environmental regulatory schemes, including an incredibly complicated set of requirements and procedures under NEPA and the Clean Air Act in the United States.

We have had little of Phase 3 harmonization of late, although I must say that the Adaptive Environmental Management approach revives my hope that Phase 3 is just around the corner.

Stimulated by our experience with the Experiment in Ecology and a growing awareness that environmental issues were commanding greater public attention, AMAX began organizing to deal with environmental issues in 1970. I was appointed by our Chairman to head a corporate-wide environmental committee. The committee became a corporate staff department in 1973, and in 1977 we formed a subsidiary firm to deal with all aspects of environmental activity.

AMAX's chairman participated at the Stockholm conference as a non-governmental organization observer, and by 1972 we were beginning to deal with the environmental impact

statement requirements of NEPA. Our experience with the "Experiment in Ecology" gave us an excellent background for understanding what was happening, but I must admit that we were surprised by the rapidness and forcefulness with which the impact statement process was thrust upon the United States.

In early 1973 AMAX was involved in the development of what is now the Belle Ayr open pit coal mine in northeastern Wyoming. When our mine plan was submitted for approval to the regional office of the U.S. Geological Service, it was determined that the preparation of an Environmental Impact Statement was required. At that point, our corporate environmental staff moved quickly to develop the necessary environmental assessment skills. Although many of the principles and techniques we had used to arrive at environmentally acceptable solutions on the Henderson project were applicable to Belle Ayr, we were now confronted with a more rigid framework within which to operate.

The effort required to prepare basic information that was submitted for the Belle Ayr EIS involved two professionals, full-time, for one year and two part-time staff for an additional 2 years. We estimate the overall cost of that effort in the range of $300,000.

During the mid-1970's we proposed construction of a major aluminum plant in Oregon. We met determined citizen opposition and a classic environmental conflict developed. We were forced to move to another site in Oregon, and were eventually stopped by protracted NEPA litigation triggered by the move of our electrical power contract. We were caught up in an impact statement that covered power generation on a regional basis, and the matter is still not resolved.

We are currently involved in environmental assessment work on several projects around the world. By comparison, and to show generally what has happened to the environmental assessment process, we are planning to spend roughly $2 million, from the period August 1978 to July 1980, for an Environmental Impact Statement on a proposed phosphate mining development in the southeast United States. On another project - a molybdenum mine on an Indian reservation in the State of Washington - we have spent a quarter of a million dollars in six months on the environmental scoping process alone; we estimate the EIS will cost roughly $1.7 million; and total environmental expenditures will range from $2.5 to 3 million over a 3 to 4 year period.

These projects are roughly of the same magnitude as the Belle Ayr project in terms of capital commitment for engineering and construction. However, the costs of environmental aspects have been escalating at an alarming rate.

Adding further to overall pre-construction environmental costs and delays for projects in the United States is the extensive prevention of significant deterioration of existing air quality review now required for most new plants or expansions. In some cases a year's ambient air monitoring and extensive modelling are required. Although sometimes warranted, there are many places where more straightforward approaches would be adequate.

The point I wish to make is that I'm not sure that we are making any better environmental decisions as a result of all this. We are now being pushed by EIS and PSD requirements to keep two sets of books, one for legal compliance and one for environmental design and management. We have learned that environmental assessment is good business. We really want to take ecological principles into account in project design, but our data collection for those purposes is practical and to the point, whereas the work for an EIS may be much more elaborate just to satisfy politicians who want to defer decisions, or to meet the demands of regulators who really don't know what to ask for and err on the side of measuring everything.

Which brings me to the theme of this seminar; a theme that Dr. Holling stated in his introductory remarks. The message is that present environmental assessment practice is flawed, that "the emphasis on environmental protection is not only inhibiting economic development, it is subverting environmental concerns as well."

It is not an overstatement to say that, at times, a project developer's preoccupation with EIS legal compliance interferes with his ability to do good environmental planning and management. A project environmental officer is under incredible pressure to meet EIS deadlines. He devotes himself first to EIS work, and second to the tougher tasks of trying to analyze environmental data, determine significance of relationships between various environmental components, and develop facilities environmental design criteria.

Hoping to find a better approach to environmental assessment and management, I have been pushing our environmental staff to develop systems approaches to their work, and have searched all over the world for people with new ideas in the environmental field. We have done an extensive study of the Town and Country Planning Acts in the United Kingdom, and how they accommodate mineral development. We are working with residuals management concepts to try to develop more thoughtful approaches to control of process

emissions. We have explored integration of ecological principles and design concepts to achieve in industrial facilities visual harmony with plant surroundings, less ecosystem disturbance, and lower cost reclamation. We have explored with Dr. Thomas Gladwin at New York University and Dr. Michael Royston at Center for International Environment in Geneva analysis and management of environmental conflict, including attempts to model these dynamic systems. We are developing our own ideas about appropriate growth management intervention in locations where major industrial projects are imposed upon small towns. Finally, we have placed great emphasis upon better approaches to environmental assessment and the design of our overall environmental plan for major projects. It is this last area, dealing with environmental assessment and management, that has attracted us to pursue the adaptive approach and to try to make it work for our projects.

In 1977 a study of the adequacy of current environmental assessment practices was conducted by the Institute of Ecology. I believe their summary findings are worthy of repeating, particularly as they closely parallel the findings of the IIASA project. They state:

> "We believe that two fundamental substantive questions stand out as having inadequate treatment in any of the guidelines we have examined, and as

being basic to the coherent and adequate implementation of the law's (NEPA's) purposes. These issues are first, the definition of the appropriate scope, elements, and systemic relationships making up the 'human environment'; and second, the identification of meaningful thresholds for determining 'significant' effects upon the quality of the human environment."

The work of the IIASA project on Adaptive Environmental Management has gone a long way towards addressing these two issues.

INDUSTRIAL EXPERIENCE WITH ADAPTIVE ENVIRONMENTAL MANAGEMENT

Turning now to the specifics of my discussion, I will describe my firm's current goals with respect to environmental assessment and management, what we have done up to now, what difficulties we have encountered, why I think we are encountering these difficulties, and offer some ideas about overcoming the difficulties. I will close with some comments on the significance of adaptive environmental assessment and management in developing countries.

Goals of Industry with Respect to Environmental Assessment and Management

Industrial organizations such as my firm have at least four specific goals with respect to Environmental Assessment and Management. These goals are:

1. To learn how a proposed development will impact natural and man-made systems, and how those systems will impact the development, so that planners can avoid undue risks to the project and the environment.

2. To assure that a proposed facility can meet legally mandated environmental protection requirements.

3. To develop a case for changing or removing unreasonable regulatory constraints upon industrial activity, or to support positions which we wish to advance in public policy making forums.

4. To reduce the cost of environmental assessment and management so that we do not waste resources.

The first goal is stated rather too succinctly. What I really mean is that we need environmental assessments, that we use them in designing, constructing, operating and finally reclaming industrial facilities. We now do environmental assessments for all projects, and would keep doing so even if NEPA were repealed. We presently do such assessments in many nations, even when they are not required by law. We want our assessments to be accurate because we expect to use the results in designing and operating of facilities. Thus, we are interested in developing better assessment techniques.

Obviously, we do environmental assessments where they are required by law, and we use assessment techniques to assure ourselves that a facility we construct will be able to meet all applicable environmental laws.

We are also doing intensive environmental assessment work in cases where we feel that regulations are overly restrictive upon our activities, or are not effective to achieve the desired environmental result. If we can demonstrate that a particular industrial process is not unduly impacting the environment, or that a particular regulation is ineffective, we can secure changes in the regulatory scheme. Detailed assessments are more persuasive than rhetoric.

Finally, we are trying to learn how to accomplish environmental protection at the lowest possible cost. Better assessments, and particularly better understanding of ecosystem changes caused by industrial processes is the key to better siting and design decisions, and to cost effective environmental management during operations. I am convinced that cost of reclaiming disturbed lands can be reduced if we understand more about how natural systems work. We need to understand how plant succession works before we try to speed it up in revegetation programs.

Experience With Adaptive Environmental Management

In describing what we in AMAX have done to date to utilize adaptive environmental management approaches, and in analyzing the difficulties we have encountered, I want to refer to several of the themes which are emphasized in Adaptive Environmental Assessment and Management and in Adaptive Policy Design. I have reordered and restated these themes to make them fit my needs, placing emphasis first upon assessment, and then upon management.

These themes are:

Assessment

1. Learning how things work is more important than making a census of what things are there. Good assessment depends upon measuring the right things and identifying the key relationships.

Management

2. The need for early introduction and integration of environmental concerns into project planning.

3. Project developers should reduce uncertainty as much as possible, but must ultimately make a decision and move along with the work, correcting mistakes as they go.

4. Continuous monitoring and assessment during project construction and operation permits management to intervene effectively when necessary.

I would like to expand somewhat on each of these themes in light of my particular experience.

Theme 1

Prediction of impact is not based upon accumulation of masses of facts but upon understanding of key interrelations. Computer simulation modelling can help in the task.

Dr. Holling and his colleagues have accurately pointed out that new project planning has been thrust into a "study everything" mode. So-called "baseline" studies have assumed greater importance than actual, systematic evaluation of potential impacts or of feasible siting or process alternatives. The major result of this is, in most cases, a massive collection of disjointed facts which have little real usefulness. Compilers of lists of species are rewarded by the system, and project developers who fail to count something do so at their peril.

The shortcomings of this approach have been widely discussed and there is now general agreement among industrial developers, environmental professionals, and citizen activists that reform is required. The Institute of Ecology study, which I mentioned earlier, identified the key problems. In 1977 President Carter issued an Executive Order directing the Council on Environmental Quality to re-evaluate their guidelines and publish regulations which would make the environmental review process more useful to decision-makers. That reevaluation has been accomplished and CEQ has issued recently revised guidelines.

Specifically, the new CEQ guidelines call for an open-planning "scoping" process early in the assessment period to define critical concerns and determine which relationships are important. They endorse a workshop approach of the type recommended in the Adaptive Management approach.

With this change in the legal framework of environmental assessment, project developers should now be able to focus their attention on environmental matters that count. We in AMAX are trying to do exactly this, and I would like to briefly relate two case examples.

AMAX is currently conducting environmental studies on a proposed phosphate mine in Central Florida. From the

beginning of the project, it was clear that groundwater and surface water studies would be required. At first, it looked as though these studies could drag out the assessment period interminably, and be more a source of confusion than a way to reduce uncertainty. But intelligent scoping took place, and regulatory authorities and project planners focused attention on issues of real significance.

Early in the project, the impact of extracting large quantities of fresh water from the Floridian sole-source aquifer was identified as a critical concern. It was originally determined that 16 1/2 million gallons of water per day would have to be pumped from the aquifer to meet process water requirements. This was found to be unacceptable by the state water board authorities as they were fearful the drinking water supply would be depleted.

AMAX process engineers, hydrologists and other specialists set about an intensive evaluation of the problem. By redesigning certain segments of the process we were able to increase water recycling and reduce our water requirements to 12.7 million gallons per day. Additionally we conducted extensive test pumping and mathematical modelling studies and were able to prove that the amount of water extracted would not adversely affect the drinking water supply. We were issued the permit by the water board authorities.

The effort cost us roughly $2 million, however, I feel the money was well spent, as it was spent on resolving the critical issue, and not dribbled away on insignificant data gathering efforts of limited practical application.

At another location -- in Western Australia -- we are trying to understand why there is a die-off of mangroves near a port through which we ship iron ore. We have learned about the biological value of mangroves, and are sensitive to the need for their protection on environmental grounds. But our principal concern is economic.

The mangroves in question protect the headlands adjacent to the ship channel and port. We fear that loss of the mangroves in this area will lead to greater erosion and that, in turn, we will be faced with much greater maintenance dredging costs. Leading experts in mangrove ecology have not yet agreed what the critical factors are. They have apparently dismissed blowing iron ore dust as the culprit, and are now focusing attention on variations in salinity. However, once we understand the cause of the trouble, we will focus our efforts on protecting the necessary elements rather than attempting to solve the problem by randomly throwing large sums of money and effort at all possible elements of the system.

Once critical relationships have been defined, tools such as computer simulation modelling can be put to use. We

at AMAX have traditionally used such techniques in geological and economic applications and are most interested in testing their usefulness in our environmental assessment work.

Theme 2

Environmental concerns should be introduced at the very beginning of the development design and integrated as equal partners with economic and social considerations. Workshops assist in facilitating communications exchange among the affected parties.

Early introduction of environmental concerns is a concept which may be intuitive to project planners and managers who must necessarily analyze issues from several viewpoints. I can assure you however, that it comes more slowly to traditional functional specialists - engineers, biologists, economists - who are trained to view a problem from their particular perspective. AMAX is not unique in finding it sometimes difficult to sell the concept of total project integration.

Some of the techniques we have used internally to promote systematic integration of environmental concerns in project planning are: conducting workshops on environmental assessment and management; distributing an internal environmental newsletter throughout the corporation; and conducting environmental audits of changes or improvements

to existing facilities and of new project proposals through a capital expenditure review process.

Additionally we have begun to develop organizational structures, on new projects, which lend themselves to greater integration of information. On all of our major new projects, AMAX Environmental Services, Inc., a subsidiary of AMAX, plays a large role in initial project planning. We have started to move away from traditional hierarchical organizations and are using matrix-type management structures on several projects. We feel that this provides for better information distribution and processing, greater diversity of thinking, more creativity, and more freedom of action by project participants.

The ultimate result, we hope, will be a greater integration of all project systems prior to commitments being made to a particular site, concept or design.

Aside from these internal efforts at greater communication, we have been opening up our planning process to the public as a way to bring about more thorough consideration of environmental and social factors. For example, on a molybdenum development project in Colorado we released information on several alternative tailing disposal sites under study prior to acquiring any of the privately owned

land. This generated considerable public input and allowed us to evaluate our plans in light of new information.

These steps towards greater systems integration have not been easy or without risk. Practicing open planning is more easily said than done from both an internal and an external perspective. Internally it requires a constant dedication and effort to convince project personnel that these concepts pay off in the long run. Engineers traditionally feel that biologists are too theoretical and are obstacles to accomplishing practical engineering goals. Biologists feel that engineers are too production-oriented and insensitive to ecological interactions. Engineers and biologists agree, however, that they can handle the public better than project lawyers and public relations specialists, and are often very nervous about releasing information. Disagreements over open planning can demoralize project personnel, decreasing ability of an organization to do good planning and good communicating. A systems planning and management approach can go a long way towards opening up lines of communication and understanding.

From an external affairs viewpoint, the open planning process likewise presents risks. There are pitfalls in either premature or delayed involvement of outside parties. Publically releasing data or preliminary plans before a

company has prepared itself internally can result in unnecessary adverse reaction. On the other hand, delaying the integration of public input can result in company plans which are too inflexible to adapt to external attitudes. A company's openness likewise, can be turned back on them by pressure groups. Information - the presence of an endangered species habitat, for example - which was meant for use in evaluating project plans, could well be utilized by project opponents to bring a halt to further planning through emotional outcries.

I think, however, that we can, and will, overcome these problems. We can continue to work towards developing internal organizations which are responsive to the ideas of project integration. The use of workshops and matrix-type project teams are proving that they are more able to adapt to the inevitable bumps one encounters in the course of a typical project. And I think that when the public, as well as special interest groups, see that a firm such as ours is indeed making sincere efforts at integrating all concerns, they will be more willing to play an active, productive role as opposed to an adversary one.

Theme 3

The key to adaptive management is flexibility and the ability to plan in the face of uncertainty. We should not attempt to design all uncertainty out of a project, but should allow for the ability to absorb small failures, and adjust accordingly.

On the subject of risk, Peter Drucker, the well known business author, states:

> "To try to eliminate risk in business enterprise is futile. Risk is inherent in the commitment of present resources to future expectations. Indeed, economic progress can be defined as the ability to take greater risks. The attempt to eliminate risks, even the attempt to minimize them, can only make them irrational and unbearable. It can only result in that greatest risk of all: rigidity."

Industry and business have long recognized the validity of the concept. Developers in my industry carry out sophisticated engineering studies and even test mining, concentrating and smelting in pilot plants, in order to reduce uncertainty about the feasibility of a project. But risk is never entirely eliminated. At some point the studying and testing ends and a decision must be made. The developer takes the studies and tests into account, but must finally rely on his intuition, experience and judgement for the final decision.

Perhaps the best example of the adaptive management approach that I can think of comes from my company's experience with its Henderson molybdenum mine development in

Colorado. The ore body is several thousand feet below the surface of the earth. To mine the ore we planned to undercut a column of ore, inducing a caving action when support for that column is removed. The competency of the ore and the naturally occurring stresses in the mountain govern the "cavability" of the ore. Our mine planners used every conceivable mining engineering technique to determine "cavability." They reduced uncertainty considerably, but in the end, the decision was made by men who had experience with the caving method in other mines, and who relied on their own judgement of the situation. Their decision also took into account a certain self-confidence in their ability to adapt to a problem caving situation -- a feeling that they could manage their way through and force the caving activity to occur if it did not occur as planned.

Just as we accepted the mining risks at Henderson, we are prepared to handle new challenges in the environmental management field. We do not have all the answers yet, we cannot demonstrate successful reclamation in every case where it has been attempted, but we have the basic skills necessary to manage our way through problems and to eventually handle most of the environmental problems associated with large scale development.

With the coming of the "environmental era" the misconception that man's industrial activities always damage the environment became popular. This resulted in what Dr. Holling terms "catatonia" - i.e. "Don't do ANYTHING until we know more." It was felt that if we studied everything, for long enough, we could eliminate the uncertainty from our decision-making; that we could achieve "zero risk" environmentally.

This attitude has created significant problems for industry. It results in government policies which attempt to eliminate the environmental risks by simply not making decisions. Severe restrictions of mineral exploration and development on "Wilderness Area" lands in the United States "pending further study" is one example. The lack of a clearly defined U.S. coal leasing policy for public lands stands out as another. Since 1971 when a moratorium was declared on the issuance of coal leases on federal lands, we have seen the passing of one administration, three major court cases, several proposed policies, numerous studies and impact statements - and the United States government is still "studying" the problem. The symptoms of Catatonia can be seen on individual development proposals as well as far-reaching policies. The names Kaiparowits, Seabrook and Colstrip immediately come to mind. I'm certain we could all relate examples of proposals which have met this fate by being buried under volumes of impact assessments.

But what can we; as rational scientists, businessmen, and policy makers; do to deal more effectively with this problem. I think that requisite to any plan of action we have to admit that there is no such thing as zero risk. That leaves the major question - "what degree of risk are we willing to accept, what degree of certainty is sufficient, and what are we willing to pay for it?"

Such thinking must be applied to industrial development projects which impact to one degree or another on the environment. I cannot state, however, what degree of risk is acceptable when considering potential environmental damage. Those decisions are largely political and must necessarily be made on a case-by-case basis, using the level of knowledge available.

I believe the reason we are all here for these few days is that we have recognized this truth. I think it is incumbent upon us to convince others of the validity of the Adaptive Management approach; that man must be able to move ahead by experimentation and correction of small failures.

Theme 4

Continuous monitoring and assessment during project construction and operation permits management to intervene to correct mistakes.

If the key to adaptive management is flexibility and the ability to plan and act in the face of uncertainty, and if developers should be able to deal with small failures as they come up, we must have a way of continuously assessing the success of project environmental management programs. If our original predictions about process emissions or environmental impact turn out to be wrong as we construct and operate a project, we need to know they are wrong and have a way to decide what to do about it. In some cases, we may not have much time to correct a problem.

Very few people focus on the need for continuous monitoring and assessment of environmental control programs. To date the emphasis of almost everyone involved with environmental assessment has been on new project approval. New plant permits usually include monitoring requirements, but rarely provide for assessment of the data collected. Monitoring is generally aimed more at spotting permit violations than at developing a rationale for changing control and impact mitigation strategies.

I believe that as regulatory schemes mature, a framework for ongoing assessment will develop and that these schemes will become more permissive of flexible control strategies. This is an area that needs more emphasis as we promote Adaptive Environmental Management.

CONCLUSION

In conclusion, I want to reiterate that I am confident that we are fast approaching a time when harmonization of economic and environmental goals will be a common goal of industry, governments and environmental pressure groups. There is now general agreement around the world that environmental assessment and management are required, and there is a growing concensus that the assessment techniques first employed under NEPA and its progeny are flawed. Adaptive environmental management approaches as outlined in Adaptive Environmental Management and Adaptive Policy Design offer an exciting step forward in this field that merits the serious consideration of senior administrators and policy makers everywhere.

CHANGES AND CHALLENGES IN ENVIRONMENTAL MANAGEMENT

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Footnote* The author regrets that time constraints made it impossible to prepare the full text of this paper for circulation in advance of the meeting. The views in this "extended summary" are those of the author and not necessarily those of the UK Departments of Environment and Transport.

INTRODUCTION

1. This paper examines the needs for adaptive assessment procedures and the criteria they must fulfill if they are to be of practical use to those engaged in controlling development.

2. It assumes that the adaptive environment impact assessment process has been devised in order to enhance the quality of decisions on changing land use or changing environmental policies. To do this it needs to be shown to reduce uncertainties about the behaviour of environmental systems (or make unavoidable uncertainty more obvious), reduce the likelihood of misunderstandings between the people and groups involved in development control and environmental management, and be seen to be cost-effective (i.e. it must not demand information gathering and analysis, or impose time penalties, out of due proportion to the benefits derived). If it does not do all these things, at least it needs to do enough of them well enough to offer a significant benefit compared with systems previously in use.

3. To put it simply, what individuals and groups making decisions about the environment want to know is what effects are likely if it is disturbed in particular ways. They do not need to know how the many components of complex environmental systems work.

BACKGROUND

4. It is important to recall that human communities have always decided on environmental development after some process of

analysis, even if this has been intuitive and at the individual level. Often even "primitive" communities have evolved quite sophisticated environmental management systems (e.g. for multi-species shifting cultivation plots in South East Asia) as a result of trial-and-error learning over many generations. "Farming lore" of this kind retains great influence even in the most developed countries. But intuitive judgements have often gone wrong. Bronze Age forest clearances using fire produced truncated soil profiles and diminished fertility in many North-West European areas. Early industrial processes like that for alkali (caustic soda) manufacture in Britain caused locally devastating air pollution with hydrochloric acid. Even the water closet, bringing great improvement in domestic sanitation, created disease and environmental deterioration in 19th century Britain because the waterborne wastes were discharged directly into rivers used for drinking.

5. Few - if any - people could have foreseen these effects at the time. But mistakes of this kind are still being made. In many places primitive forest clearance methods are wasting fertility and threatening to cause erosion - or even climatic change. In many Eastern Mediterranean regions irrigation schemes have gone wrong because of salt accumulation in the soilds. With the recognition that the focus of development is now centered on the Third World has come the equal acceptance that ways must be found of helping those guiding and carrying out that development to ensure that the resources so urgently needed are not wasted unnecessarily. And it is also obvious that any methods for achieving this guidance must be simple, easily

understood, and not demand scientific and technical resources on a greater scale than developing countries can provide. It is probably also true that the methods must be capable of decentralization and application at the level of the local community.

APPROACHES

6. The traditional approach (at least amid scientists) to studying the environmental effects of development proposals has four steps:

   (a) Describe and analyse the environmental systems involved;

   (b) Describe and analyse the developments proposed;

   (c) Superimpose (b) on (a) and evaluate the likely consequences and the extent to which more environmental study will be likely to reduce uncertainty and changes in development plans will be likely to reduce environmental damage;

   (d) Monitor the real impact of the development, once sanctioned, and provide for continuing adjustment through management, as it proceeds.

7. There is nothing inherently wrong with this approach. What has gone wrong is the way the various steps have sometimes been elaborated, and the things that have been left out.

8. Scientists have often wasted resources by over-elaborate environmental surveys. For example, consider a scheme of development involving release of pollutants to an estuary. Estuaries are complicated systems: their depth, tidal regime,

freshwater flow patterns, temperature and oxygen gradients, water composition, sediment types and plant and animal life may need to be surveyed in great detail if a "complete" picture is sought. Estuaries also change greatly, even from year to year so that a "complete" picture is unlikely in less than a decade. But the real question is whether a "complete" picture (whatever that may be) is really needed to evaluate a proposed development.

9. Is likely to be more effective to describe less and analyse more. It is also likely to be better not to separate the scientific surveys as "background" to be done before, and apart from, analysis of the development. The latter is, after all, the context for the policy questions. These are about whether the development, as planned, is a sound investment of people's lives and resources. The decisions must rest on human social judgements. They will take account of the physical character of the environment, and the changes the scientist may forecast; but the judgements will often be weighted strongly by political, economic and other issues as well. For this reason the social context of the interaction: the environmental, industrial and other goals of the particular community must be fully considered in the process. And it must be tempered by understanding of the policy instruments available to the Government or "management authority" concerned. For however desirable they may appear to the theoretical ecologist or development consultant, some actions are just not feasible within national social contexts. In some countries, for example, development of new areas for agriculture would

be much sounder if the people doing forest clearance were trained in soil conservation and had better tools and more capital. In others land reform breaking up big land holdings may be a prerequisite to better agriculture (while elsewhere consolidation of peasant holdings into big units may be desirable). Experience shows that such reforms are generally slow, difficult and even perilous to national stability: meanwhile development often will not wait.

10. The key to the assessment process is interaction between the developer, the scientist and whoever is charged with evaluating the acceptability of the environmental effects and imposing management controls. The process must start by posing realistically the questions the latter needs to have answered in order to decide on the proposals. To do this all three participants need to try to agree on the nature of the problems: to "define and bound" these. They have also to agree on the key features of the systems involved, and the interactions that must be understood if the answers are to stand a chance of being right. Some sort of "model" - in a sense of organized rational framework for thinking about the system involved - is essential but at the outset it need not be very complicated or mathematical. What we are after is a process that improves thought rather than amasses data.

11. The criteria for success of such an approach may be suggested as:

    (a) it should encourage environmental scientist, developer, and regulatory authority to define the questions in a common language;

(b) it should help to ensure that no significant interaction in the system is overlooked - but that analysis is not complicated, and effort wasted, by gathering data about unimportant issues;

(c) it should assist mutual recognition of the degree of uncertainty which remains when a decision is taken, and hence collective responsibility for it;

(d) it should encourage the decision, and the subsequent management system to check on predictions and allow for adaptations if things start going wrong (the degree of subsequent adaptability in the development is one of the issues to be considered when it is sanctioned);

(e) it should cost no more, and take no longer, than previous systems: ideally it would be cheaper and quicker than they were.

LINKAGE TO PRECEDING MANAGEMENT SYSTEMS

12. Different countries have evolved different ways of planning the use of their national environmental resources and controlling development, and since political and administrative traditions, skills and resources vary widely it is obvious that this diversity will continue. At the same time, there are international arguments for "good neighbour" practices where trans-frontier pollution may arise from development, and for the avoidance of trade distortions through imposition of non-tariff barriers as an incidental consequence of environmental protection measures. If we are to promote better ways

of predicting the effects of projected development it seems clear that must:

(a) be capable of assimilation within many different national frameworks;

(b) yet provide for a reasonable comparable quality of judgement in the end (and preferably reasonably comparable cost).

13. In the UK we have a system of planning and development control evolved over many years and especially since 1947. Two main levels of analysis and judgement are involved:

(a) the "structure plan" level in which broad policy objectives for land development are defined for counties;

(b) the "development control" level in which specific development proposals are examined individually, by the authorities of the districts in which they are located.

14. Very large development proposals are often, however, "called in" for analysis and decision by the responsible Minister. Public enquiries allowing all those concerned to state their views are also a common feature of the process.

15. Over the past 8 years there have been many discussions of whether the sensitivity of the UK process would be improved by adding to it some more formalised environmental impact assessment procedure. One consultant's report proposed that this be done for certain types of development (the largest potentially most damaging) in certain areas of particular environmental value of sensitivity. However concern has been expressed that the added precision would not be worth the

costs of data acquisition and analysis, plus the possible time penalties, and the most recent Ministerial announcement (in August 1978) was of the selective use of more formal procedures for a very limited number of the very largest developments.

16. This is a good illustration of the caution national administrations understandably display when they already have established environmental management systems that are widely accepted and work. It does not mean that these systems cannot be improved - or that improvements are not sought continually - but that every proposed change needs to be carefully evaluated. And UK recent experience includes some cautionary tales.

17. In Scotland great efforts have been made to evaluate the likely impacts of oil related developments on the mainland and at the terminals at Flotta (Orkney) and Sullom Voe (Shetland). Consultants, University teams and groups from Research Councils and statutory conservation organizations have all been involved. Yet despite these efforts there has already been one ship-handling accident resulting in fuel oil spillage and serious harm to bird species and other wild life at Sullom Voe, and allegations of oil pollution caused by irresponsible (and, indeed illegal) pumping out of ballast-tank washings offshore. It may be argued that no amount of environmental impact analysis would have helped prevent these incidents, which arise from well-known hazards the frequency of which must remain one of the crucial uncertainties in the system - and a factor which (once the development decision has been taken) can be dealt with by continuing management effort. Certainly, where human error is a factor one can do

no more than point to where it has the potential to be most damaging, insert "fail-safe" systems and adopt the best possible warning, training and supervision.

18. But conversely it may be argued that an adaptive assessment approach would highlight these as key interactions from the outset, and forced all concerned to quantify the probability of the various risks, to state explicitly what levels were acceptable and to review the management practices accordingly. I hope this meeting will argue its way through dilemmas of this kind.

QUESTIONS

19. I suggest that the key question for the Policy Seminar is whether the technique of Adaptive Assessment and management is capable of practical application in the diverse circumstances of developed and developing countries - with their widely differing amounts of information about their environments - and under the diverse legal and administrative systems of the world's nations.

20. The tests are, perhaps, those I have set out in paragraph 11. In addition, however, we may need to ask ourselves whether some re-thinking may be needed about the public acceptability of risk. We all know as citizens that the world can only be a relatively safe place (and that mortality will be a 100% experience). Environmental risk - in the sense of some change, some of it unexpected, - will inevitably follow from man's interactions with environment. New methods may help us forecast and reduce it. But impact assessment procedures can only

help us to prevent change we define as unacceptable, in an acceptably high proportion of cases. We must not oversell a new approach: a thing systems analysts and computer modellers have, perhaps been prone to do in the past.

21. Some people may argue that the kinds of language and method systems analysts and environmental scientists employ are fundamentally unsuited to the direct debate between the assessor and regulator of development proposals, the champion of the features liable to change, and the developer seeking change which he postulates as beneficial. On such a view, the process of adaptive assessment and management is essentially a research tool - or at best a tool for a specialist consultant. This, too, is a central debating issue for the seminar.