PROGRAM FOR ECOLOGY AND ENVIRONMENT PROJECT

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E C O L O G Y

(Ecological and Environmental Systems)

RESEARCH PROGRAM FOR ECOLOGY AND ENVIRONMENT PROJECT *

Goals

The overall goal of the project is to demonstrate the practical and theoretical value of combining good ecology, good modelling and good policy analysis in the resolution of resource and environmental problems. There are effective examples of one or even combinations of two of these three, but no example exists of the combination of all three.

This goal will be implemented by analyzing specific applied problems, developing a framework for ecological indicators and by initiating concepts of environmental standards.

Organization of Research

Five essential criteria are used in the selection of sub-projects.

1) Focus on highly specific problems in which, as a minimum, there is either an existing body of long statistically valid ecological and environmental data and partially verified concepts or, failing that, an existing cooperating institution that is in the process of acquiring such data and concepts.

2) The problem must be digestible, i.e., theoretically within the state-of-the-art.

3) The problem must be relevant i.e., having the ecological, economic, physical and social dimensions of present resource and environmental problems.

4) The problem must intersect the interests of at least one other project at IIASA and at least one outside institution.

5) The implementation must be flexible enough to keep options open for succeeding steps.

In order to maintain continuity, the short to mid-term sub-projects will be developed within three broad applied areas and four conceptual/methodological ones as shown in Table 1. The applied projects will be used to illuminate the conceptual and methodological research, producing a matrix organization for the project similar to IIASA's as a whole.

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* Prepared by the Project Leader

Table 1.

Matrix Organization of Ecology & Environment Project & Time of Initiation of Projects to Dec. 1974

APPLIED AREAS	Conceptual, Methodological Areas			
	Behaviour of Ecol. Systems	Indicators	Standards	Methodology
Single-Species Management	Sept. 1973	March 1974	--	Dec. 1973
Ecosystem Management	Sept. 1973	Sept. 1974	Feb. 1974	July 1974
Environmental Management	--	--	--	Sept. 1974

Specific Programme for 1974

Table 2 summarizes the specific projects described below with emphasis on personnel, and a distinction between the stages of planning and implementation. Note, in particular, that the present ecology group of five scientists will leave August 1974 and a new group will be recruited, some of whom must overlap with the existing group.

1. Applied Projects

1.1 Single-Species Management

1.1.1 Budworm

We have now identified the first key project. It represents a classic problem of pest management, specifically that of the spruce budworm in the north-temperate forests of North America. A team of foresters, ecologists, entomologists and meteorologists have been studying this problem for approximately thirty years in Canada. Rigorous sampling proceedures have been used and the data have been well analyzed using multivariate statistical techniques. A preliminary computer model has been developed that emphasizes the causative links in the system and a large scale management programme has been in operation that concentrates on insecticide spraying. The ingredients therefore exist for a good demonstration case of broad interest to all countries coping with serious insect pest problems - good ecological data, a simulation model with a variety of management options, a cooperating NMO institution, and a history of management. Sophisticated model analysis and policy analysis are the missing pieces that IIASA could add. And this addition presents a challenge to the methodologists, since the complexity of the problem is just at the edge of the state-of-the-art of large-scale optimization techniques.

Project definition, hopefully with institutional commitment, will take place in mid January 1974 in a planning workshop involving IIASA's ecology and methodology group, and the Canadian scientists. The analysis stage is likely to require model expansion and refinement, stochastic modelling of weather and application of extended techniques of dynamic programming. The full programme should be concluded and reports written by mid-summer 1974.

1.1.2 New problem in pest management

As this project evolves, another will be planned to phase in at its completion. A number of possibilities exist, but we wish initially to concentrate on a possible project of pest management involving a vector-borne disease of man.

Table 2. Summary of Projects and Personnel, Ecology and Environment Project

General Area	Specific Focus	Function	IIASA Scientists				Other Cooperating IIASA Projects	Cooperating Outside Institutions
			Present Group (until Aug. 74)	New Recruits				
				No. or Names	Likely Source	Likely Project Location		
Single Species Management	Budworm	Planning and Implementation	Jones (Eco.) Rashid (Eco.) C.Winkler (Meth.) R.Winkler (Meth.)	0			Methodology	Environment Canada Inst. of Resource Ecology, Canada 1. U.S. Nat. Res. Council Cttee on Pest Mgt.
	New Problem	Planning	Holling (Eco.)					2. An USSR analogue? WHO Imperial College (UK) Institutions in target countries
		Implementation	—	2	target country, UK, USA USSR	Ecol. Biomed.	Methodology Biomedical	
Ecosystem Management	Alpine Areas	Planning	Holling (Eco.)				Water	4 Italian Institutions 1 Austrian MAB France? OECD water mgmt Institute of Resource Ecology, Canada USSR (Lake Baikal Group)?
		Implementation	—	Walters +2	Italy, Canada, Sweden, Czech.	Ecol.		
Environmental Management	Pollution/ Resource System	Planning and Implementation	—	Naito Sawaragi	Japan	Ecol. Indust.	Industrial Water Energy	Inst. of Applied Cybernetics, Poland Kyoto Univ., Engineering Dept. + ?
Behaviour of Ecological Systems	Resilience and stability measures	Planning and Implementation	Holling (Eco.) Jones (Eco.) Clark (Eco.) Rashid (Eco.) Fiering (Water)	all new personnel			Urban Water	
Indicators	Ecol. ind. and indices	Planning and Implementation	Clark (Eco.)	1	USSR	Ecol.	Urban Water	SCOPE, UNEP
Standards	Resilience and Standards	Planning and Implementation	Fiering (Water) Avenhaus (Eng.) Holling (Eco.)	?	?	?	Water Energy	SCOPE, UNEP
Methodology	Optimization, Modules	Planning and Implementation	Methodology and Ecology Group	all new personnel			Methodology	
Project Direction and Development	Ecol. and Environ.	Planning and Implementation	Holling (Eco.) 1973/1974	Felling ? 74/77	USA	Ecol.	IIASA Scientific Advisory Committee	External Advisory Committee

In this way, links could be developed within IIASA between the ecology, methodology and biomedical projects and outside IIASA with the World Health Organization. Planning and recruitment for this project is the responsibility of the present ecology group with implementation by those who replace this group (Table 2).

1.2 Ecosystem Management

1.2.1 Alpine Areas

The participants of the Ecology Planning Conference identified a regional problem of ecosystem management of interest to Italy, France and Austria. It concerns the problem of development of Alpine Areas and potentially could be of relevance to all those countries in North America and Europe with mountain terrain.

There are now two active Alpine research projects in Austria supported under the Man and the Biosphere Programme. Four Italian institutions have expressed a desire to be involved. Moreover, this project could be a modest but useful case study for the large scale computer model being developed by the Water Resources Project at IIASA. At the minimum it could provide an initial ecological sub-model for that project.

Four stages are necessary prior to full scale implementation of this sub-project:

a) identification of key Austrian scientists and informal committment of an Austrian MAB project by March 1974 to provide data.
b) identification of a sub-project leader experienced in modelling, limnology and regional development research by mid - February 1974 for recruitment by September 1974.
c) brief planning conference with, as a minimum, scientists from Austria, Italy, IIASA and the sub-project leader by late March 1974.
d) first workshop session with participating scientists as soon as IIASA's in-house computing facility is operating, probably by July 1974.

The goal of the workshop will be to develop a first crude simulation model in order to identify priorities for research and policy analysis, using techniques that have been well tested in similar circumstances by the present ecology group. A team made up of the sub-project leader and four resource specialist/programmers will serve as the temporary staff for this workshop.

If each of these stages proceeds as planned, the formal project will be implemented in September 1974 with responsi-

bility shifting to a group that will replace the present ecology group (Table 2).

1.3 Environmental Management

1.3.1 Environmental Pollution Control

Drs. Sawaragi and Naito of the Dept. of Engineering, Kyoto University, Japan have been recruited to develop a systems and control model of environmental pollution. They will arrive September 1974 and will extend their present model to include five major themes:

1) renovation of the system of production to minimize waste,
2) allocation and control of pollution sources,
3) planning and operation of treatment systems,
4) design and control of treatment processes and
5) evaluation of the effect of environmental degradation.

A key cooperating institution is the Institute of Cybernetics, Warsaw and others will be identified when this sub-project is established.

2. Conceptual/Methodological Research

The sub-projects Behavior of Ecological Systems, Indicators and Standards represent the major commitment of the present ecology group to August 1974. There are four sub-projects, each of which will be the subject of a separate report.

2.1 Behavior of Disturbed or Enhanced Ecological Systems.

2.1.1 Resilience and Stability Measures

Any policy for management of ecological systems must be based on an understanding of their response to disturbance. Examples of the kind mentioned above show that ecological systems fluctuate widely and are weakly damped. But they also demonstrate a high, but not infinite resilience i.e., a great capacity to absorb change without structural collapse. A theory, based on sound data and examples, that succeeded in quantifying relative measures of stability and resilience, that defined minimum dimensions and that coped with spatial heterogeneity would provide a strong theoretical base for a science of environmental management.

The specific research will rely on a set of models including analytic models now in active use, a complex model of an ecological process (predator/prey), a complex simulation model of an applied ecosystem problem (budworm in north-

temperate forests mentioned above) and a land use simulation model of regional recreational development (related to the Alpine Area study above). These models will be used to define ways to collapse state variables, convert them to dimensionless numbers and generate relative indices of stability and resilience. We will then illuminate this stability and resilience behavior by retrospective analysis of well documented studies of ecological, anthropological, hydrological and transportation systems.

2.2 Indicators

2.2.1 Ecological Indicators and Evaluation Indices

Environmental impact statements, regional or global monitoring schemes and the development of standards must be based in part on adequate indicators of the present and future state of ecological systems. And yet there is no general formalism for identifying such indicators and, from them, evaluation indices. These will be identified using the analyses in 2.1.1 above, as well as those of the budworm sub-project (1.1.1). A part of this activity will be conducted in cooperation with the SCOPE Workshop on Impact Studies in the Environment (WISE).

2.3 Standards

2.3.1 Resilience and Stability in Evaluating Standards

New constructs are required for measuring the effectiveness of environmental standards and for formalizing the economic and social costs of meeting them. These standards and man's responses to them should be constructed so as to make the natural behavior of ecological systems work with, rather than against man's interest. Again the specific applied projects and the theoretical analyses will provide the basis for such an analysis.

2.4 Methodology

2.4.1 Model and Policy Analysis

This final sub-project will concentrate on establishing a bridge between ecological models and policy analysis. This will require the development of techniques to analyze and simplify existing ecological models and to extend optimization techniques, like dynamic programming, so that they may cope with more complex systems. Scientists from both the Ecology and Methodology Projects are now engaged on both activities around the focus of the budworm project mentioned above. As a related activity, the ecologists have recently designed and implemented techniques to develop simple functions of key ecological processes that have been shown to

have great generality when tested against real data. There is the possibility, therefore, of developing a library of "ecological modules" that can be used, as hydrologists now use diffusion equations, as simple but key building blocks for ecological systems models. A report will be completed by July 1974 and a conference should be initiated in 1975 to establish the protocols for such modules.