APPLICATIONS OF SYSTEMS ANALYSIS TO RENEWABLE RESOURCE PROBLEMS IN CANADA AND SOME CENTERS OF ACTIVITY

APRIL 1975

Dr. Alan Chambers
Consultant
University of British
Columbia

CANADA
Ministry of State for
Science and Technology

Technological Forecasting
and Technology Assessment
Division

INTRODUCTION

The most difficult task I faced in preparing this summary was to develop a working definition of systems analysis appropriate for a discussion of existing studies of resource or environmental systems in Canada. The principal reason for this difficulty is that I tend to approach the task from an integrated research and management point of view. Given that outlook, it is impossible to conceive of forests, water, wildlife, fisheries, and rangeland as separate resources, each lending itself to analysis or management in isolation from the others. Nor can communities of people and social problems be omitted. The essential ingredient of systems analysis as it is applied to resource and environmental problems then, is holism.

While systems theory is primarily a mathematical field, few studies of environmental systems have used formal mathematical techniques of analysis, description, and synthesis. Yet because they exhibit to some degree at least, organized attempts to dissect whole systems, examine individual components, and synthesize the information gathered, they seem logically to belong to the field of applied systems analysis. Conversely, many studies in the resource sciences are highly mathematical yet fail to

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Note: I am deeply indebted to Profs. P.A. Larkin and C.S.Holling for reviewing this paper and offering critical comments, most of which have been incorporated.

exhibit these essential properties of holism and synthesis. Although such studies do provide essential background for, say simulation models of environmental systems, and often display sophisticated mathematical techniques, I cannot, in good conscience, offer many of them as examples of systems analysis applied to resource and environmental problems in Canada.

In general then, one finds individuals or groups attempting an holistic approach without the benefit of systems theory and language and more importantly, with reluctant sanction of their discipline or institutional home. Individuals or groups that do have access to the theory, language, and computing machines may be denied the time and/or funding required to pursue studies other than those of particular resources in isolation. To be more explicit, the structure of our universities and resource agencies encourages a disciplinary, reductionist approach to problems that can only yield within an interdisciplinary, holistic framework. This frustration faces most of the groups listed in Appendix I, and results in a bibliography of studies, most which do not deal with whole systems of resources and people.

In the following discussion, I have tried to illustrate the evolution of techniques which will, if encouraged, develop into well-developed techniques and case studies of systems analysis applied to whole systems of resources andpeople in Canada. For convenience, these evolutionary paths are divided into two broad categories -- techniques, on the one hand, and institutions in which they may be applied, on the other. Most of the discussion centers on the evolution of techniques, both descriptive and prescriptive, because I suspect that is of greatest interest to this gathering. Neither the literature cited in the text, nor the organizations named in the Appendix purport to be the result of an exhaustive search. Indeed, to do both would require at least a full year of research, and would serve little purpose. The examples chosen are for illustrative purposes only.

DESCRIPTIVE TECHNIQUES

In the evolution of techniques used to describe resource and environmental systems the impetus has been a pressing need to articulate and to understand both spatial and temporal variation. Because the latter lends itself to easy numerical description and the former does not, evolutionary paths of descriptive techniques begin from widely separated points of departure. Hopefully, they are converging.

Spatial Variation

Most attempts by ecologists and resource managers to describe spatial variation in resource systems are, static and cartographic. When applied to problems of resource development and use, such examples represent attempts to synthesize knowledge of spatial variation, or better, to articulate a planning process that is to them, more rational than economic or political procedures. An early example of this approach is Angus Hill's Ecological Basis for Land-Use Planning (12). One example of a recent application of this class of techniques is the Creston Wildlife Pilot Project (21), a biophysical habitat approach to capability assessment and management potential of the wildlife resource in the vicinity of Creston, British Columbia. This particular study grew out of an international concern for a population of mountain cariboo that was threatened with extinction. Another example is an ecological study of the site of a new airport near Montreal at Ste.-Scholastique (23). Many similar studies are being done by government and private agencies in connection with major and minor resource developments in Canada that range from the proposed MacKenzie Valley Pipeline through logging in individual watersheds, to relatively small housing subdivisions.

Typically the approach is to gather data on the geology, soils, vegetation, climate, animal populations and current human use of an area. After producing a set of maps which describe spatial variation in these resources and/or uses, a group of synthesizers or planners will meet, identify or anticipate conflicts (either social or ecological) by superimposing one map upon another, and through dialogue, produce a set of alternate plans or guidelines for use that will reduce or eliminate the potential conflict.

Four studies illustrate an evolution of this static, non-mathematical technique for describing spatial variation toward the more numerical, dynamic, process-oriented techniques of systems analysis (7,15,17,39). All make use of computers and all include a wider range of variables than is possible using their predecessors.

By translating resource capabilities into economic terms, Thornburn, Magar and Nagle (39) working at the Pacific Forest Research Center in Victoria have produced a "Computerized Land Use Information System" that operates as follows:

> Canada Land Inventory and other maps are stored on a computer file with each point identified by coordinates on a square grid. The other maps include those of mineral locations, lakes streams and roads, drainage patterns, fisheries capability, forest cover, accessibility, present use and various administrative boundaries.
>
> For specified areas and land uses (single or multiple) the system accumulates physical capability data, which is translated into production capability based on data concerning product mix and industry structure. The estimated physical product is, in turn, processed through economic subroutines to generate economic effects. At present, final output includes the following economic measures: sales value (or total expenditure), value added, distribution of value added between factors of production, expected growth rates and stability of value added, net regional income and direct employment.

A slightly different approach was taken by Jacobs (15,16) working in Nova Scotia, and Johns and others (7,17) working in Manitoba. These studies are similar in that they deal with urban planning although the techniques are generally transferable to other environments.

The techniques used by Jacobs and Johns both attempt to describe the physical and biological resources of their study areas in terms of their ability to support human activities. In Jacobs words (15), The relationship of the relevant data [independent, resource] variables to each study topic [dependent human activity variable] is moderated by the regional context of the study area, its level of technology, economy, and development expertise, as well as the specific resource properties of the site. Consequently, the specific relationship of each independent variable to a dependent study topic is seldom direct. Four basic equation types are used to describe these relationships as a means of balancing a reasonable level of analytic accuracy and the intended operational utility of the results.

Examples of direct relationships occur when the increase or decrease of a variable, soil depth, affects a study topic, internal site drainage, in a linear manner. Frequently, characteristics of sites within a study area, such as a high water table, impose major constraints on all proposed built development. Exponential curves describe the effect of some variables, such as increased time/distance, on the relative attractiveness of activity locations, such as shopping centers. Quadratic curves serve to moderate the influence of a variable at either extreme of an interaction graph. Topographic slopes may be recorded in one percent intervals across the study area, but most development activities are sensitive only to the extreme conditions. Thus, slopes of 0-4% might be considered extremely desirable for industrial sites, slopes of 12% and greater are virtually unacceptable, while intermediate values from 4% to 12% slope tend to effect industrial location in a linearly decreasing fashion. Finally, step functions are used to describe discontinuous relationships between variables.

Determining the importance, or weight, of each independent variable relative to the case study topic can be achieved with the aid of Regression Analyses that describe existing weights, supplemented by the use of available expertise that might modify those weights based on future projections. Calibration of the weights assigned can be tested both statistically and pragmatically for fit in real world situations and the choice of weight and variables easily modified to better fit the existing conditions of a study area as more accuracy or detail is required.

The fusion of variables, their weights, and the equations which describe their interaction are combined to produce a final map output for each study topic examined. Mathematically this process can be expressed as:

$$S = f\left(\frac{w_1x_1 + w_2x_2 \ldots + w_nx_n}{w_1 + w_2 \ldots + w_n}\right)$$

$$= f\ \frac{\sum w_nx_n}{\sum w_n}$$

Where S = The study topic in question

x_n = A particular variable such as slope

w_n = Weighing factor

n = The number of variables

In application, the diversity or variation in both resource and activity variables is reduced, by the judgment of those undertaking the study, to include only those that are likely to be involved. In this way, the machine time required is reduced to an acceptable level. The range of dimensions used to describe the natural and social systems involved is interesting in that it includes variables which relate directly to human perception of the environment. (for example, visual complexity and topographic closure).

S u m m a r y

Attempts to describe spatial variation in environmental systems have evolved, because of the recognition of increased numbers of dependent and independent variables, from simple mapping of a single variable, through composite maps and/or overlay techniques, to simple mathematical descriptions of relationships between proposed human activities or uses and environmental or resource variables. Where spatial variation is acknowledged, to change over time, classification techniques must be coupled with those of simulation or projection, a task which is extremely difficult, but of great importance. Efforts to weigh or evaluate the environmental and social importance of the variation have evolved from individual judgments through traditional economic measures to cause and effect measures of human perception and flexible weighting schemes. These latter techniques introduce a kind of social dynamic in that they provide for the introduction of changing social values.

Temporal Variation

Efforts to describe and to understand temporal variation in resource and environmental systems begin very early in the development of the resource sciences. The motive has been, and remains, a need to predict the growth and yield of plant and animal populations either in terms of biomass, or economic value. Brief perusal of the literature of agriculture, wildlife biology, fisheries, and forestry reveals an incredible number of studies of this kind. When one adds published attempts to describe temporal variation in the flow and/or quality of rivers, and changes in climatic or weather patterns, any attempt to review the literature in order to document the evolution of these techniques assumes monumental proportions.

Nevertheless, three trends are apparent. The first has been a shift from comparative statics to dynamic models; the second, an ability to describe curvilinear as well as linear relationships; and the third, a shift from single to multivariate models. Superimposed upon all three trends has been the need to describe stochastic as well as deterministic processes, and a search for compatible methods of handling spatial variation.

While many studies display at least one of the implied requirements, no single technique delivers all five. The shift from comparative static descriptions of a single variable to more dynamic, multivariate systems can be illustrated by a sequence that originates with the traditional stand and stock tables of forestry, to simulation studies of whole stands (26). Random or random-like elements are frequently introduced using Markov chains or Monte Carlo techniques (11,27). Although not truly dynamic, Input-Output techniques are often used to describe changes over time, in systems of several variables (37). Linear programming techniques are frequently used to describe non-linear relationships when optimization of a single variable is intended, or when it is most important to retain the ability to disaggregate , and thus attempt to account for spatial diversity (22,38,42). Examples of dynamic, multivariate, curvilinear models can be found in fisheries, wildlife management, and other fields (2,13, 28,32,34,41). A summary of these descriptive modelling techniques used in the context of environmental impact assessment has recently been published under the sponsorship of Environment Canada and the United Nations Environmental Programme (25).

Although many names have been coined to designate particular techniques, in general, the basic description of temporal variation in resource and environmental systems is accomplished either by a set of linear equations or a set of non-linear (difference or differential) equations. Because linear systems are simple, a comparatively large number of variables can be included thereby imparting some ability to disaggregate spatially before the model becomes too large to be useful. This capability must be balanced against the greater reality of non-linear formulations which, while more closely describing the environmental processes in question, can handle fewer variables because of their increased complexity. This dilemma is critical in questions of resource management where the need for accurate predictions of growth and yield require both the realism of non-linear formulations and the ability to handle spatial variation even greater than that which linear description makes possible. Three studies illustrate the evolution of techniques in this direction. They are Jacobs'(15,16) effort mentioned earlier, the spruce budworm model which will be described in detail later in this meeting (8,14) and an application of Computer Assisted Resource Planning applied to forestry as it is developing through the efforts of Williams, Smith, and Young (38,42).

A description of this latter activity falls logically into six steps. The first is a land classification exercise such as that described earlier under spatial variation, and results in the identification of a large number of discrete land units. Information concerning each unit is then coded and stored in a computerized information retreival system. Because the number of discrete land units identified earlier may be very large, the third step in the Williams, Smith, and Young method is to group these units into larger land areas which will, in practise, receive the same forest management prescription because the spatial variation within each area or treatment unit remains low. This step is accomplished by factor and cluster analysis, and results in a number of treatment units that can be handled efficiently by a computer (about 100).

In many respects the fourth step is the most interesting part of their activity. Although still at an early stage of development, a simulation approach is used to determine two or three management options which might be applied to each treatment unit. The great potential of this approach will only be realized when a library of simulation models is available which can mimic the effect of logging practises on fish and wildlife populations, water yield, regime, and quality, and recreation values (aesthetics and access). While such a library of models will take some time to develop, the technique illustrates the blending of spatial and temporal techniques of synthesis.

Having determined a range of management options for each treatment unit, an LP optimization package is employed in the fifth step to find the "best" harvesting schedule. In the context of current tests, "best" is determined either in terms of wood or cash flows. The final or sixth step, an assessment of the impact of the "best" harvesting schedule on other resources remains in the formative stages, largely because of the need to disaggregate spatially and the incomplete development of simulation packages used earlier.

S u m m a r y

The evolution of techniques used to describe temporal variation has progressed from comparative statics through linear models, to curvilinear, dynamic models that can be used to mimic empirically observed population trends. Because resource managers require analytical methods that can cope with variation in both space and time, techniques used to describe variation in both these dimensions have begun to merge. As this blending takes place, more effective use of preseciptive techniques is beginning to appear.

PRESCRIPTIVE TECHNIQUES

The nature of the prescriptive device developed in any resource management problem depends largely on the objectives defined at the outset. In the case of highly structured, institutionalised groups such as a resource industry or its public service counterpart, these objectives are usually very clearly spelled out in corporate policy (profit generation) or the legislation which establishes a resource agency (Forest Service, Water Resources Service, Fisheries Service, etc.) In the case of those social constituencies that exhibit less definition and structure (the general public, for instance) specific objectives and referent groups are not easily identified. Through a continuing process of dialogue and debate, both formal and informal, objectives are continually redefined, prompting the need for methods of analysis, synthesis, and decision that can be responsive to changing environmental capabilities and changing social values. (4,5,18,29,40).

In the context of the well-defined objectives of a corporation or government agency, the questions are how much of a particular resource can we take, and where shall we take it from. Given adequate description of the temporal and spatial distribution of a single resource, these questions have been answered with relative ease by traditional economic techniques like cost-benefit analysis (9,10,33,36) and the scheduling techniques of linear programming (37,38,42) respectively. More recently, sophisticated techniques of control theory have been introduced (1,6).

As the social processes of dialogue and debate continue, two complicating factors arise. One is the growing realization and concern for the interconnectedness of resource systems, the other the currently intense question, who benefits? For example, by optimizing flows of wood from forest harvesting activities, implicit decisions respecting water resources, fisheries, and wildlife populations are made that are seldom optimal, and therefore elicit a strong response both ecologically and socially. And as hinterland people and the least wealthy are further disenfranchised (9, 24,33) concern for the distribution of benefits to various groups within Canadian Society will contine to grow.

The implications for resource and environmental decision making seem very clear. Decisions must, in future, be more sensitive to a wider range of social and environmental variables than they have in the past. Tactics available to accomplish this overall strategy are basically two. The first has to do with the restructuring and decentralization of resource agencies and industries. It is based on the premise that sensitivity to change in social and environmental variables decreases with distance (measured in terms of time, space or social strata) from a particular resource development. The second tactic which we can use to make resource and environmental decisions more sensitive is to develop multivariate descriptions (simulation models) of whole systems of resources so that we can anticipate the impact, or better, make the implicit decisions explicit(20,30,31). We need tools to test policy options prior to their application, particularly when decision-making institutions are highly centralized.

S u m m a r y

The evolution of multivariate techniques which describe the relationship between a number of social as well as environmental variabels is progressing, albeit slowly. Examples of the implementation of solutions derived from applications of systems analysis to resource and environmental problems in Canada are rare, perhaps because of the incomplete development of the techniques, perhaps because resource agencies have not evolved to the point where they can use them, or more likely, because of some combination of the two. Those examples which do exist make use of only the early descriptive techniques, as for instance the British Columbia Land Commission which has used Canada Land Inventory map overlays to help in its task of preserving productive agricultural land in that province. There is, however, a positive interest within several agencies in the development of these systems analytical techniques - - particularly when they include both descriptive and prescriptive capabilities. The Computer Assisted Resource Planning project described earlier is, for example, funded largely by the British Columbia Forest Service, and other provincial agencies are either co-operating or watching with much interest.

There are three additional ongoing projects that seek to combine ecological, social and economic modelling, sensitivity analysis, and decision theory in the examination of significant resource and environmental problems. One concerns the issue of forest pest management in New Brunswick (14) and will be described in detail later in this conference. The others concern salmon and watershed problems in British Columbia, and similar problems in and around the Gulf of St. Lawrence. These latter projects remain in the developmental stage so that little information is presently available.

CENTERS OF ACTIVITY

Because of the imperfectly developed communication channels in Canada, and because it is difficult to define precisely what is, or is not, systems analysis, the centers of activity which are identified in Appendix I will almost certainly miss many groups and include others whose activities may not be considered to be applied systems analysis. More important, perhaps, than a discussion of individual groups is some comment on the ephemeral process by which these groups are "given their head" in Canada. Groups that do detect ecological and social tension, usually because they are resident in the regions where it occurs, spend frustrating years attempting to find the time and resources to examine these problems in greater depth; to learn and to use techniques of systems analysis in a search for viable alternatives.

Without question, there has been some appalling work done in the name of systems analysis;enough to make any university or government agency reluctant to continue to devote its resources to such efforts. The subject is so difficult that it is a marvellous field for the mediocre. That is, if the best are difficult to understand, the worst have an excellent chance of going undetected. Those individuals in positions which give them the responsibility of allocating R and D funds are scientists trained to be skeptical of any new claim. This combination of training and responsibility clearly dictates the dampening of youthful enthusiasm.

Across Canada, however, there are a number of groups that perceive, and can document, evidence of ecological and social stress. For instance the ability of soils, given current practises of resource husbandry, (irrigation, fertilization, and harvesting techniques) to sustain agriculture or forestry and thus continue to provide the economic foundation of a community are seriously questioned in more than one region. In these same regions one can perceive signs of social stress, often manifest in an acceleration of the urbanization process. Government controls on these systems can be articulated in terms of monetary and fiscal policies, tax structures, tariff barriers, transportation subsidies and the like. Additional controls that can be identified are legal and jurisdictional, for example, methods of resource allocation. Given this perception and a commitment to form interdisciplinary teams to study the systems involved, it would seem prudent to facilitate at least some of the proposed research, even when it is necessary to add individuals skilled in the application of systems techniques.

Programmes and institutions that are assuming the tasks of funding and application of systems techniques are now beginning to emerge. At the international level there is the International Institute for Applied Systems Analysis which is relatively familiar to all of us here. Within Canada, perhaps the most noteworthy group is located in the

Institute of Animal Resource Ecology at the University of British Columbia. The Bedford Institute in Nova Scotia, several agencies in Environment Canada, a number of informal groups at several universities and others display considerable potential. The most recent initiative was taken last January by the Premier of Prince Edward Island when he announced the establishment of an Institute of Man and Resources that, hopefully, will be able to study resource and environmental problems using systems techniques (3). Given the continued development of these institutional homes, and some development funding programmes such as that proposed by the Canadian Man and Biosphere Programme, the potential that exists throughout the country can continue to develop the techniques of systems analysis and, at the same time, apply them to current problems of resource management in Canada. And with the continued interest and involvement of resource management agencies, the pressure to implement conclusions will grow stronger. At this point, when "optimal" policies are implemented, we will witness the critical experiment in which the real strengths and weaknesses of the systems approach will be exposed.

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APPENDIX I

CENTERS OF ACTIVITY IN CANADA*

* The organizations identified in the following pages are not the result of an exhaustive search, hence may exclude some centers which are actively applying systems techniques to resource and environmental problems in Canada. The uneven description of the centers which have been identified reflects the uneven information I have been able to gather in the time available for this study.

CENTER: Center for Environmental Systems Analysis
University of Toronto
Toronto, Ontario

This group is in the formative stages, and meets under the auspices of the Institute for Environmental Studies. It is intended to involve both terrestrial and aquatic ecologists, urban planners and geographers, social scientists including economists and sociolgists, engineers, and systems analysts expert in dynamic modelling and data management.

CONTACTS: K.F. Hare

H.H. Harvey

J.E. Paloheino

R.C. Plowright

H.A. Regier

and others from the Canada Center for Inland Waters and the Ontario Ministry of Natural Resources

CENTER: Center for Resource Studies
Queen's University
Kingston, Ontario

The Center for Resource Studies is a cooperative research organization, under the jurisdiction of Queen's University, sponsored by The Mining Association of Canada, The Department of Energy, Mines and Resources and Queen's University, to carry out investigations designed to contribute to Canadian non-renewable resource policies. It has become apparent to many individuals and organizations that Canada is moving into an era of great national concern regarding the role to be played by our natural resources. Many extremely complex problems are arising because of the interaction of the scientific, technological, economic, sociological, environmental, financial, legal, political and international aspects of resource development.

The Centre will carry out research projects selected and approved by the Board of Directors of the Centre. These investigations will focus particularly on the medium and long range problems of the mineral industry in Canada. The centre will concern itself with obtaining basic data, their verification and analysis leading to conclusions for consideration in the determination of Canadian resource policies. It is anticipated that many disciplines will be involved including: physical, biological and geological sciences; economics and business, geography, law, and the social sciences in general.

The objective of the Centre is to bring together the knowledge, expertise, experience, needs and views of members of the Mineral Industry the Government of Canada and the University, in an environment which will contribute to the solution of the complex problems of natural resource policy development.

(Center for Resource Studies, cont'd)

CONTACT: C.G. Miller, Executive Director

WORK PROPOSED OR UNDERWAY:

- The supply of exploratory efforts and new discoveries in the nickle and copper industries
- Economic implications of provincial mining legislation
- A proposed study of the future availability and use of a scarce metal

CENTER: Environmental Sciences Center (Kananaskis)
University of Calgary
Calgary, Alberta

This Center was established in 1966 through cooperation between various federal agencies and the University. Current work conducted at the center concerns energy resources, recreation, weather and climate, and the impact of urban industrial societies on the natural environment. A current proposal to study urban man-mountain environment relationships in an interdisciplinary way has been endorsed by the Canadian MAB committee and the Research Secretariat of the Alberta Department of Environment although sources of funding have yet to be found.

CONTACTS: Gordon Hodgson, Director

Peter Lester

Allan Legge

Allan Olmsted

Wm. Ross

Richard Duwors

CENTER: Environment Canada
Fisheries and Marine Service
Pacific Biological Station
P.O. Drawer 100
Nanaimo, B.C.

CONTACT: D.W. Narver, Project Coordinator and many others from various agencies.

WORK ONGOING:

- Carnation Creek Project: a major attempt to define and model the effects of logging on an aquatic ecosystem.

CENTER: Environment Canada
Fisheries and Marine Service
Ottawa, Ontario

CONTACT: C.L. Mitchell

WORK UNDERWAY:

- Biological and economic models of groundfish in the Northwest Atlantic

CENTER: Environment Canada
Inland Waters Directorate
Ottawa, Ontario

and

Canada Center for Inland Waters
Burlington, Ontario

CONTACTS: J.P.H. Batteke, CCIW

S. Madras, Faculty of Science, York University

WORK COMPLETED and/or UNDERWAY:

- A simulation model for longterm forecasting of waste loadings from population, land use, and economic activities in the Great Lakes Basin. Proc. 17th Conf. on Great Lakes Research. McMaster University. August 1974.
- Models of the St. Lawrence, Peace-Athabasca, St. John, Okanagan, and Lake Champlain-Richelieu basins which illustrate the use of hydrodynamic simulation, network analysis, and dynamic programming respectively.

CENTER: Environment Canada
Office of the Science Advisor
Fontaine Building, Hull, P.Q.

The Office of the Science Advisor provides policy advice and comment to departmental management on various intra, and international issues concerning resource and environmental management. Such issues have included:

- energy resources and policy
- food production and policy
- population
- environmental monitoring and assessment

The Office operates with inhouse staff in cooperation with experts in various fields from national and international sources.

CONTACTS: Asit Biswas, Director, Environmental Systems Branch

R.W. Durie, Director, Advanced Concepts Center

R.F. Fletcher, Senior Consultant, Science Policy Branch

Brian Emmett

Robin von Geier

Janice Tait

and many others

REPRESENTATIVE PAPERS: (Forthcoming or published)

Biswas, Asit K. (ed) 1972. Modelling of Water Resources Systems. Harvest House, Montreal (in two volumes)

(Office of Science Advisor, cont'd)

Emmett, B. 1974. Environmental modelling and assessment activities in Canada. 15 pp. mimeo.

Environmental applications of input-output analysis. Environment Canada, Environmental Systems Branch

Societal responses to emerging environmental resource situations confronting Canada. Environment Canada, Environmental Systems Branch.

WORK PROPOSED OR UNDERWAY:

- studies of growth: focussing on the balance between economic development, environmental quality, and social justice.
- studies of modelling techniques and quantitative analysis of environmental factors
- studies of the flow of scientific information to policy makers, and the response of existing institutions to rapid change in social and environmental factors.
- compilation of an annotated bibliography of futures studies, and the institutions which house them
- a Cultural Paradigm study, designed to explore shifts in fundamental social values
- a systems approach to environmental law and the role of multinational corporate management of resources
- studies of the implimentation of the Make-or-Buy policy

and others

CENTER: Faculty of Forestry
University of British Colubmia
Vancouver, B.C.

This group has been developing the Computer Assisted Resource Planning Programme described in some detail in the foregoing text. The exercise continues and will likely proceed toward implementation at some time in the future.

CONTACTS: D. Williams

S. Smith

G. G. Young

CENTER: Groupe Associé Montreal/McGill pour l'Etude de l'Avenir (GAMMA)

Sciences Economiques
Université de Montréal

GAMMA is a project designed to address the question, "Is indiscriminate, uncontrolled economic growth still desirable as a high-order goal for society in the 1970's?" It seeks, through a Delphi process, to resolve the following positions:

1. that of the standard economist which states that growth is good because it increases societies' range of choices

2. that of dissenting economists and others (Mishan, Galbraith, Schumacher) that growth is bad, or can be managed more effectively

3. that of intermediate or agnostic economists and others.

4. that the growth - no growth controversy is not the main issue, and that we are not moving, or should move toward a "conserver society".

The purpose of the study is to develop alternative designs for a "conserver society"

CONTACTS: Kimon Valaskakis, (University of Montreal)

Peter S. Sindell (McGill)

John G. Smith (McGill)

Tom Boyle (McGill)

- with others from various federal organizations

WORK UNDERWAY:

Conserver Society Project.

CENTER: Institute of Animal Resource Ecology
University of British Columbia
Vancouver, B.C. V6T 1W5

The overall goal of the systems ecology and management group within the IARE is to develop, test and apply the range of descriptive and prescriptive techniques and concepts needed for an ecological management science. The descriptive techniques involve computer simulation, Markov and "catastrophe" models of renewable resources problems. The problems studied are typically stochastic, multi-dimensional, spatially variable and non linear. The prescriptive techniques employed include simulation gaming, methods to generate a strategic range of objectives, optimization (linear and dynamic programming, control theory), policy feasibility checks, techniques to generate and evaluate indicators, and information formats useable and controllable by the decision maker. Considerable work is underway to analyze the stability behaviour of ecological systems. These techniques are being developed and applied with the focus of specific case studies concerning, particularly, insect pest management, forestry, fisheries and wildlife problems. Two examples are the study of forest ecosystem/pest management in New Brunswick and of salmon and water shed management in British Columbia.

CONTACTS:

S. Borden
F. Bunnell
A. Chambers
N. Gilbert
R. Hilborn
C.S. Holling
D. Jones
J. Kane
P.A. Larkin
R. Peterman
I. Vertinsky
C. Walters
N.J. Wilimovsky

PUBLICATIONS:

Bunnell, F., 1974. Computer simulation of forest-wildlife relations. In: Symp. on Wildl. and For. Mgmt. in the Pacific Northwest, OSU, Corvalis, Sept.11-12 1973. pp. 39-50.

Bunnell, F.L., L. Karenlampi & D.E. Russell. 1973. A simulation model of lichen-Rangifer interactions in northern Finland. Rep. Kevc Sub-arctic Res. Sta. 10. I-XX, P. 1-8.

Chambers , A.D., 1973. "The systems approach to resource allocation", IN Essays in Aspects of Resource Policy, Special Study No. 27, Science Council of Canada, Ottawa.

Chambers, A.D., 1974. "Purcell Study: Integrated resource management for British Columbia's Purcell Mountains", British Columbia Environment and Land Use Committee, Victoria, B.C.

Hilborn, R., 1973. "A control system for Fortran Simulation Programming", Simulation, 20:172-175.

Hilborn, R. with C. Walters, E. Oguss, R. Peterman and J. Stander, 1974. "Development of a Simulation Model of Mallard Duck Populations", Canadian Wildlife Service occasional paper No. 20.

Holling, C.S., 1971, "Development of a Recreational Land Simulator", pp 121-137 IN: W.L. Bathke and W.A. Haney (eds) Land Mangement in the 70's Concepts and Models, San Francisco Press.

Holling, C.S., 1973. "Resilience and Stability of Ecological Systems", Ann. Rev. of Ecology and Systematics, 4:1-23

(I.A.R.E., cont'd).

Fiering, M.B. and C.S. Holling, 1974. "Management and Standards for Perturbed Ecosystems", Research Report R-74-3, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Kane, Julius, Ilan Vertinsky and William Thomson, "KSIM: A Methodlogy for Interactive Resource Polocu Simulation", 1973, Water Resources Research, Vol.9 no.1

Kane, Julius, 1972, "Health Care Delivery: A Policy Simulator", Socio-Econ. Plan. Sci. Vol. 6, pp. 283-293, Pergamon Press.

Larkin, P.A., 1970, Management of Pacific Salmon in North America, In, " A Century of Fishes in North America", N.G. Benson, editor, Spec. Publ. 7, Amer. Fish. Soc., pp. 226-236.

Larkin, P.A." Simulation Studies of the Adams River Sockeye Salmon", J. Fish. Res. Bd. Canada, 28:1493-1502

Larkin, P.A. with N.J. Wilimovsky, "Contemporary Methods and Future Trends in Fishery Management and Development", FAO Technical Conference on Law of the Sea, February 1973, Vancouver, J. Fish. Res. Bd. Canada (in press.)

Vertinsky, I., "The Use of Aspiration-Level Behaviour Models in Political Science", American Behavioural Scientist, May/June 1969, pp. NS9-Ns12.

Walters, C.J., "Resource Management Deciion Making for the Next 50 Years: Roles of the Biologist and the Computer", Proc. West. Assn. St. Fish Game Comm., Vol. 50 1-7, 1970.

Walters, C.J. "An Interdisciplinary Approach to the Development of Watershed Simulation Models ", Technological Forecasting and Social Change (In press, 40 pp), 1974.

(I.A.R.E., cont'd)

Walters, C.J., "Obergurgl: A Microcosm of Economic Growth in Relation to Limited Ecological Resources", International Institute of Applied Systems Analysis Reports Series (In press, 38 pp).

CENTER: Institute of Environmental Studies
Dalhousie University
Halifax, Nova Scotia

This group has a strong background in marine ecology, and is now planning an analysis of land management techniques in Nova Scotia

CONTACT: Ronald Hayes

CENTER: André Marsan & Associés Inc.
Lavalin Group
4003 Decarie Blvd. Ste 225
Montreal, P.Q.

An environmental consulting firm, with Hydro Quebec and other resource development corportions as major clients.

CONTACTS: André Marsan, President
Peter Jacobs
Jean Doucet
Bernard Coupal
Jean-René Michaud

PUBLICATIONS:

Marsan, A.A. 1972. Etude préliminaire des impacts ecologiques de l'aménagement de la baie james. Rapport du Groupe de Travail Féderal-Provincial, Qualité de l'Environnement Ministère des Affaires Municipales, Quebec.

Marsan, A.A., D. Bisson, and J.R. Michaud. 1972. Simulation dynamique de la Riviere du Nord. Centre de Recherches Ecologiques de Montreal. 107 pp.

Marsan, A. 1973. Environmental impact assessment of the proposed St. Lawrence pipeline (preliminary). Rapport pour le compte de Bechtel Quebec Limitee. André Marsan and Associés Inc.

Marsan, A., C. Fontaine, J. Fontaine, and J.R. Michaud. 1973. Ecologies et développement: essai d'une methodologie d'integration. Ecologie de la zone du nouvel aéroport international de Montréal. Rapport final No. 2 vol. 2. 391 pp.

(A. Marsan, cont'd)

Marsan, A. and P. Jacobs. 1974. Planning the key to our environment's future. Can. Consult. Engineer. October, 1974.

CENTER: Ministry of State for Science and Technology
Technological Forecasting and Technological Assessment Division
270 Albert Street
Ottawa, Ontario

The TF & TA Division provides forecasts of likely advances in science and technology, with assessments of the effect these advances are likely to make on the quality of life in Canada. Particular attention is given to those advances that will be of maximum value in policy formulation and the advisory role of the ministry.

CONTACTS: A. R. Demirdache, Director

R. H. Clayton

H. Flinn

M. A. Comber

REPORTS: A General Survey of Energy Research and Development Activity in Canada: an outlook on the energy situation in Canada. February 1973.

La Méthod des Scénarios: une Reflexion sur la Methodologie et la Théorie de la Prospective. University of Quebec, 1974.

A Population Model. Queen's University Dept. of Mathematics, April 1974.

An Application of the Gibbons-Voyer Technological Assessment System Model to the Development of the Haldimand-Norfolk Region of Ontario. November 1973.

CENTER: Ministry of State for Urban Affairs
355 River Road
Ottawa, Ontario

The Macro Urban Programme Impact Model (MUPIM) is a long term project of this Ministry. It is primarily an application of input-output analysis, drawing heavily on the Statistics Canada Input-output Model of the Canadian Economy, and is comprised of a number of submodels, one of which deals with environmental issues. The environment submodel is basically a materials balance model which relates the production and discharge of residuals (pollutants) to levels of economic activity in various city regions of Canada.

CONTACTS: Martin Ulrich

James Angus

Tony Tsou

WORK UNDERWAY:

- Macro Urban Programme Impact Model (MUPIM)

CENTER: Ottawa River Project
University of Ottawa and
National Research Council
Ottawa, Ontario

The ORP is very large. It is a five-year project; at any time it involves 12 to 14 Ph.D.-level scientists and, including technical and student support, involves a total of between 30 and 50 people. The effort is split about evenly between the National Research Council Laboratories (Division of Biological Sciences) and the University of Ottawa (Departments of Biology, Civil Engineering, and Geology). The University side is being funded by a NRC Negotiated Development Grant of just over $500,000.

The subject of the study is contained in its title, "Distribution and Transport of Persistent Chemicals in Aquatic Ecosystems". Specifically, the persistent chemicals we are concentrating on are mercury and organochlorine compounds, especially DDT and PCB's. The geographical region being studied is a three-mile stretch of the Ottawa River just downstream of several pulp and paper operations which, traditionally, were heavy polluters.

One of the clear purposes of the study is to establish a model, hopefully a predictive model, of the overall behaviour of the system. Because the system is so complex, only simple questions would be asked of this model, such as the fundamental one, "How long will it take this section of the river to clear itself by natural processes?" This is reasonable, since mercury input in particular was stopped five or so years ago. The clear identification of such a predictive model at a gross level also helps us to keep on the track and not spread our efforts too thinly in detailed investigations of individual animals, chemical reactions, and so forth.

(ORP, cont'd)

CONTACTS: Q.Laham, Biology, U.of O. (Admin. Director)
D.R. Miller, NRC, Project Director

PUBLICATIONS: A number of puclications have emerged from this project. The most comprehensive review, and cource of individual contributions is available in

Miller, D.R.(ed). 1974. Distribution and transport of pollutants in flowing water ecosystems. The Ottawa River Project, Report No. 2. National Research Council, Ottawa.

CENTER: Le Groupe SYSOTEK
Faculté des sciences de l'administration
Université Laval
Ste-Foy, Québec

SYSOTEK is a new group of management scientists at Laval which seeks to apply systems techniques (system dynamics) to resources and the environment

CONTACTS: R. Joel Rahn

Claude Le Bon

Jean-Louis Malouin

Jean-Pierre Dolait

WORK PROPOSED:

- Energy, environment and economic growth in Canada

CENTER: University of New Brunswick
Faculty of Forestry
Fredericton, New Brunswick

There is close liaison between the UNB Faculty of Forestry, the Canadian Forestry Service, and the New Brunswick Dept. of Natural Resources. This interagency group has the potential of forming a strong interdisciplinary team with expertise in the application of the techniques of systems analysis to resource and environmental problems in the Maritimes.

CONTACT: C. Baldwin, Maritime Forest Research Center
Box 4000, Fredericton,

G. Baskerville	Faculty of Forestry
G. Weetman	University of New Brunswick
Alan Miller	Fredericton, N.B.

WORK PROPOSED OR UNDERWAY:

- One group of people is actively involved with Holling, Walters, and others in the Budworm modelling exercise referred to in the foregoing text
- a second group is actively promoting a project designed to approach the impact of forest management activities on the people of the maritimes (bibliographic reference 24)

CENTER: University of Saskatchewan
Faculty of Graduate Studies
Saskatoon, Saskatchewan

A group of social, physical and biological scientists has been actively promoting a whole systems study of Agricultural Saskatchewan for several years. The study would provide for documentation of social and ecological processes at work, and would identify economic and other policies which influence these processes.

CONTACTS: Elder Paul

Isabell Anderson

Stan Rowe

CENTER: Western Ecological Services Ltd.
211 - 11 Fairway Drive
Edmonton, Alberta

CONTACTS: Everett B. Peterson, President

Dawn M. Dickinson

REPRESENTATIVE PUBLICATIONS:

Bliss, L.C. & E.B. Peterson. 1973. The ecological impact of northern petrolium development. Proc. Fifth Int. Cong. (Arctic Oil and Gas: Problems and Possibilities), Fondation Francaise D'Etudes Nordiques, Le Havre, France. Report No. 301.

Peterson, E.B. 1974. Environmental considerations in northern resource development. IN: The MacKenzie Pipeline: Arctic Gas and Canadian Energy Policy. P.H. Pearce (ed), McClelland and Stewart Limited, Toronto. pp. 115-142.

WORK PROPOSED: Methods For Prediction of Resource Use Conflicts in Northern Canada. A Proposal. November 1974.

CENTER: Westwater Research Center
University of British Columbia
Vancouver, B.C.

Westwater was established in February 1971 by the UBC Board of Governors, and funded initially by a development grant from the Department of Energy, Mones and REsources. The Center's activities focus upon problems associated with preserving and enhancing the aulity of the water environment. It is intended to provide an improved foundation for decisions about policies and institutional arrangements for water management, catalyze interdisciplinary research, and direct that research toward the needs and interests of the people of Canada in general, and the people of British Columbia in particular.

CONTACTS: Irving Fox, Director

A.J.H. Dorcey, Asst. Director

K.J. Hall

and others from various departments within the university

PUBLICATIONS:

- Annual Report April 1972 - August 1973.
- Notes on Water REsearch in Western Canada (9 issues between March 1972 and January 1975)
- Technical Reports

1. A preliminary baseline study of Roberts and Sturgeon Banks. March 1973.
2. A preliminary water quality survey of the lower Fraser River System. April 1973.
3. Biology of the Lower Fraser River: a review. May 1974.
4. Further investigations into water quality conditions in the lower Fraser River system. August 1974.

WORK UNDERWAY:

- Water Quality Management in the lower Fraser River

COUNCIL ON CENTERS AT UNIVERSITIES FOR RESEARCH ON THE ENVIRONMENT (CCURE)

CHAIRMAN: M. Chevalier, Faculty of Environmental Studies
York University
4700 Keele Street
Downsview, Ontario

CCURE is an organization designed primarily to facilitate communication between various university centers working on related problems. This year it will meet June 1-3 in the Kananaskis Valley to discuss, among other things, the University of Calgary's Environmental Science Center proposal to study urban man-mountain environmental relationships using a systems approach. The project has been endorsed by the Canadian MAB Committees, which are now seeking the resources to fund the project.

1974-75 MEMBER ORGANIZATIONS:

- <u>Agassiz Center for Water Studies</u>
  University of Manitoba
  Winnipeg, Manitoba

  Principal Contact: Mr. Onno Kremers

- <u>AIR Environment Research Group</u>
  Faculty of Engineering Science
  University of Western Ontario
  London, Ontario
  N6A 3K4

  (519) 679-2437

  Principal Contact: Prof. J.L. Sullivan

- <u>Atlantic Provinces Inter-University Committee on the Sciences (APICS)</u>

  Acadia University
  Wolfville, Nova Scotia,
  P.O. Box 24, Halifax, Nova Scotia

  (902) 542-2201 Local 287

  Principal Contact - Prof. J.R. Winter

- <u>Centre de Recherche en Sciences de l'Environment</u>

  Universite du Quebec a Montreal
  B.P. 8888
  Montreal, P.Q.
  H3C 3P8

  (514) 876-3034

  Principal Contact - Prof. C. East

- <u>Center de Recherches Ecologiques de Montreal</u>

  Université de Montréal
  401 Est, Nue Sherbroke
  Montreal 406, P.Q.

  (514) 872-6670

  Principal Contact - Prof. R. McNeil

- <u>Centre de Recherche sur L'eau</u>

  Pavillon Pouliot
  Université Laval
  Quebec, P.Q.,
  G1K 7P4

  (418) 656-2131

  Principal Contact: Prof. A. Soucy

- Dunk River Interdisciplinary Research Project

  University of Prince Edward Island
  Charlottetown, P.E.I.
  C1A 4P3

  (902) 892-4121 ext. 161

  Principal Contact: Prof. L.F. Loucks

- Environmental Sciences Centre (Kananaskis)
  University of Calgary
  Calgary, Alberta
  T2N 1N4

  (403) 284-6344

  Principal Contact: Prof. G.W. Hodgson

- Environmental Studies Group (Forestry)

  Faculty of Forestry
  University of New Brunswick
  Fredericton, N.B.

  (506) 453-4666

  Principal Contact: Prof. R.B.B. Dickison

- Faculty of Environmental Studies

  York University
  4700 Keele St. N.
  Downsview, Ontario

  (416) 667-3011

- Institut National de la Recherche Scientifique (INRS-EAU)

  Universite du Quebec
  Case Postale 7500
  Quebec 10, P.Q.
  G1V 4C7

  (418)-51-4111

  Principal Contact: Prof. L. Rousseau

- Institute for Environmental Studies

Hultain Bldg.
University of Toronto
Toronto, Ontario
M5S 1A4

(416) 928-6526

Principal Contact:- Prof. T.C. Hutchinson

- Institute for Environmental Studies

Dalhousie University
Halifax, Nova Scotia

(902) 424-2211

Principal Contact: Prof. F.R. Hayes

- Institute of Urban and Environmental Studies

Brock University
St. Catharines, Ontario

(416) 684-7201

Principal Contact: Prof. A.W.F. Banfield

- Rideau Institute

Advanced Research Center for Behavioural
and Physical Sciences
85 Sparks Street
Suite 211
Ottawa, Ontario

(514) 932-4860

Principal Contact: Prof. S.C. Skoryna, M.D.

- Trent Water Group

Trent University
Peterborough, Ontario
K9J 7B8

(705) 748-1356

Principal Contact: Prof. D.C. Lasenby

- Water Resources Centre

University of Alberta Resource Centre
Agricultural Economics & Rural Sociology
315 General Services Bldg.
Edmonton, Alberta T6G 2H1

(403) 432-3222

Principal Contact: Prof. W.M. Schultz

- Westwater Research Center

University of British Columbia
Room 200, West Mall Annex
Vancouver 8, B.C.

(604) 228-2211

Principal Contact: Prof. I.K. Fox