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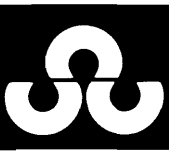

Science Council of Canada

January 1973
Report No. 19

Natural Resource Policy Issues in Canada

January 1973

Natural Resource Policy Issues in Canada

Incorporating an overview of previous Science Council studies of the natural resource sciences

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Ottawa, 1973

November 27, 1972*

The Hon. Jeanne Sauvé, P.C., M.P.,
Minister of State for Science and Technology,
House of Commons,
Ottawa, Ontario.

Dear Madame:
In accordance with sections eleven and thirteen of the Science Council of Canada Act, I take pleasure in forwarding to you the Council's Report No. 19, *Natural Resource Policy Issues in Canada.*

Yours sincerely,

Roger Gaudry,
Chairman,
Science Council of Canada.

*This is the date on which this Report went to the printer.

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Summary and Recommendations

Searching for more effective ways to use science and technology in the development and management of Canada's natural resources, the Science Council of Canada became aware that economic, jurisdictional and institutional problems limit the application of existing knowledge. We therefore began hoping to identify a more objective method for the allocation of science spending than that which now exists, and became acutely aware that such spending must be wed to policies which the federal and provincial governments have yet to articulate, and that such spending will reflect the real differences in priorities in the different regions of Canada.

Resource-use programs cannot be implemented in isolation. The development of one resource frequently restricts, and may even pre-empt, the development of another, and all resource developments have implications with respect to conservation and the environment. But because resource disciplines and our institutions (government, educational, and industrial) have grown in relative isolation, their efforts are often disjointed. The unique Canadian jurisdictional milieu compounds the problem. Horizontal links between disciplines, between our institutions and between various levels of government will have to be built and strengthened. Earlier Science Council Reports on the natural resources recommended some such links, and others are recommended here.

To couple the efforts of various levels of government, of competing industries and of diverse disciplines is no easy task. It will require modifications to existing institutions, the free flow of information, new attitudes, new analytical tools and modified spending patterns. Such changes cannot be expected overnight, but some of them can be initiated now. Until such changes do take place, decisions involving many of our natural resources will be made by default rather than by deliberate analysis and judgement. Toward the latter objective, the Science Council of Canada makes the following recommendations. This list is composed of recommendations taken out of context; we strongly urge readers to refer to the pages indicated, to study in context those recommendations which interest them.

Analytical Tools

1. Statistics Canada should devote a substantial effort (both staff and money) to a more detailed development and rapid updating of its Input-Output model. Federal and provincial departments should be encouraged to make use of the impact analysis provided by the model to gain insights into the real effects of natural resources and resource-based industries on the economy (page 19).

2. Federal and provincial departments with resource and environment jurisdictions should fund systems studies of total resource management on a regional basis. Present studies should be strengthened, and new initiatives begun. The simulation models developed should include social, economic and environmental factors, and information derived from them should be freely available (page 21).

Past Reports and Recommendations of the Science Council

3. Measures should be taken which would result in a greater degree of coordination of research and related activities among the resource sciences and between governments, industry and the universities (page 24).

4. There should be a shift in emphasis from basic to applied research (page 25).

5. More research should be conducted by the private sector, and proportionally less by government. We believe that this would increase (a) the probability of more applied and development work, and (b) the chances of economic returns (page 26).

6. Research funding mechanisms should be modified to include more direct involvement of mission-oriented departments or agencies of the Federal Government (page 26).

Jurisdictional Problems

7. At an appropriate federal-provincial meeting, the Secretariat of the Canadian Council of Resource and Environment Ministers should be strengthened and renamed a National Resource Management Authority. The structure of the Authority should permit the concerns of all levels of government, industry, labour, professional organizations and citizens' action groups to be expressed and considered during analysis by the Authority of policy alternatives which are later to be considered by the CCREM (page 32).

8. This National Resource Management Authority should develop and coordinate long-range policies for integrated management of resources and the environment, and should be concerned with the development of policies for the prudent and efficient use of both renewable and non-renewable resources. These proposed policies and their background studies should be published and freely available to the public (page 32).

9. Further, this National Resource Management Authority should increase support for programs to heighten public awareness, and encourage mechanisms for community involvement in decisions affecting resources and the environment (page 32).

10. The use of regional resource management authorities, exercising delegated powers and functions which cross the boundaries of jurisdiction established by the British North America Act, has been a most successful device in many resource areas. To close the gap between policy and practice, the use of such authorities should be extended, and their successes and failures studied (page 33).

The Environment

11. Federal and provincial agencies and the professional societies should encourage universities to broaden their undergraduate programs in the primary resource fields so as to develop graduates competent to enter resource and environmental management work. Particular attention should be given to attracting students from the social and behavioural sciences, economics and law (page 37).

12. Federal and provincial granting councils and agencies should provide increased funding to expand and strengthen interdisciplinary research

programs in the resource area, particularly those which include the social and economic problems of resource management. It is noted that commitment to a problem rather than to a discipline, and to teamwork and systems modelling rather than to publication, are ingredients which have shown success in building interdisciplinary groups (page 37).

13. The search for more realistic measures of the environmental costs of resource exploitation and of the use and benefits of conservation in Canada should be intensified, as a matter of urgency (page 37).

14. Industrial institutions should incorporate the concepts of durability and recycling in process and product design and, in cooperation with all levels of government, establish effective programs for the recycling of municipal, industrial and agricultural wastes (page 38).

15. Operations and planning for resource exploitation, transportation corridors and centres of population in the North should not proceed ahead of the development of Man's understanding of the North or the establishment and use of effective mechanisms to provide protection where necessary. Sustained research support for those aspects of Northern studies which will provide this understanding should be increased substantially to offset the increasing pressure to capitalize on short-term profits by immediate exploitation (page 38).

16. Canadians as individuals, and their governments, institutions and industries, should begin the transition from a consumer society preoccupied with resource exploitation to a conserver society engaged in more constructive endeavours. Ideally, Canada could provide the leadership necessary to work toward more equitable distribution of the benefits of natural resources to all mankind (page 39).

The Economy

17. The Federal Government should intensify bilateral negotiations with foreign governments to achieve more favourable tariffs which, where economically feasible, would encourage increased value-added in Canada (page 45). (Should such bilateral negotiations prove unsuccessful, the benefits available from Canada's resources may be realized only by more negative taxation and ownership measures, some of which are listed on page 46.)

Spending on Science and Impediments to Change

18. The Ministry of State for Science and Technology should press for the removal of the impediments to increasing extramural funding of research and development by all departments and agencies of the Federal Government (page 50).

Introduction

This Report was written because the Science Council of Canada is of the opinion that science and technology can be used more effectively in the development and management of Canada's natural resources. It is an attempt to identify gaps in our approach to resource research, development and management, and to recommend ways of closing those gaps. It is neither a review of the primary resource industries nor an inventory of available resources, but rather, an exercise designed to uncover some of the shortcomings in our dealings with natural resources and to suggest ways in which we can compensate for, or correct, those deficiencies.

The shortcomings we have identified stem largely from two sources. The first is the overspecialization of both individuals and institutions; the second is the unique Canadian jurisdictional milieu. Acting alone or in tandem, these phenomena have contributed to economic, environmental and social consequences which now preoccupy many Canadians, among which one finds unemployment, pollution and alienation. On the pages which follow, we address these shortcomings, and some symptoms and possible remedies; we reiterate several concerns and conclusions from past Science Council publications which have dealt with some of Canada's natural resources (Table 1). We conclude that more effective use of science and technology in the development and management of Canada's resources is limited by economic and jurisdictional constraints, which are therefore discussed at some length.

At the inception of the study from which this Report has grown, we had hoped to identify guidelines for the allocation of research and development funds. That is, we had hoped to identify some system for science spending which would be more responsive to social and economic objectives than to pressure groups and lobbyists. Upon close inspection, however, it became apparent that pressure groups and lobbyists provide an essential service to those who must articulate social and economic objectives. They provide the critical view, the mirror if you like, which is so necessary for policy makers who must weigh the consequences of pursuing some objective by whatever means chosen. Our search therefore became a quest for a mirror less likely to distort the reflected image than are the more traditional pressure groups and lobbyists. Although not entirely successful, we have identified two analytical techniques which we hope will attract greater attention from policy makers at all levels of government. Neither technique is distortion-free, but, because they offer analytical strengths until recently denied the policy maker, they are discussed both in this Report and in the study[1] made as a background to it.

This Report begins with discussion of these two analytical techniques which, although not new in themselves, have potentially significant contributions to make to the improvement of decision-making processes associated with the development of our natural resources. The techniques are input-output analysis and systems simulation modelling; that they are not in extensive use at present is a cause for some concern. We note that simulation modelling has recently achieved much publicity, some might say

[1]This background work will appear at a future date in the form of a Science Council Special Study entitled *Essays on Aspects of Resource Policy.*

Table 1 – Science Council Publications Reviewed in this Report

Title	Date
Science Council Reports	
Report No. 3, **A Major Program of Water Resources Research in Canada**	September, 1968
Report No. 7, **Earth Sciences Serving the Nation – Recommendations**	April, 1970
Report No. 8, **Seeing the Forest and the Trees.** A Report on Forest Resources Research	October, 1970
Report No. 9, **This Land is their Land.** A Report on Fisheries and Wildlife Research in Canada	October, 1970
Report No. 10, **Canada, Science and the Oceans**	November, 1970
Report No. 12, **Two Blades of Grass: The Challenge Facing Agriculture**	March, 1971
Report No. 14, **Cities for Tomorrow:** Some Applications of Science and Technology to Urban Development	September, 1971
Report No. 16, **It Is Not Too Late – Yet:** A look at some pollution problems in Canada's natural environment; an identification of some major concerns	June, 1972
Related Science Council Special Studies	
Special Study No. 5, **Water Resources Research in Canada,** by J.P. Bruce and D.E.L. Maasland	July, 1968
Special Study No. 10, **Agricultural Science in Canada,** by B.N. Smallman, D.A. Chant, D.M. Connor, J.C. Gilson, A.E. Hannah, D.N. Huntley, E. Mercier, M. Shaw	September, 1969
Special Study No. 13, **Earth Sciences Serving the Nation,** by Roger A. Blais, Charles H. Smith, J.E. Blanchard, J.T. Cawley, D.R. Derry, Y.O. Fortier, G.G.L. Henderson, J.R. Mackay, J.S. Scott, H.O. Seigel, R.B. Toombs, H.D.B. Wilson	November, 1971
Special Study No. 14, **Forest Resources Research in Canada,** by J. Harry G. Smith and Gilles Lessard	May, 1971
Special Study No. 15, **Scientific Activities in Fisheries and Wildlife Resources,** by D.H. Pimlott, C.J. Kerswill and J.R. Bider	June, 1971
Special Study No. 16, **Ad Mare: Canada Looks to the Sea,** by R.W. Stewart and L.M. Dickie	September, 1971

notoriety, from the publication of the book *The Limits to Growth.*[2] While we will not plunge into the debate about the validity of that book's assumptions or conclusions, we would make the point that the validity of a technique is not determined by any ultimate judgement on one exercise in its use. This discussion of "Analytical Methods" will appear first because we wish to refer to these techniques subsequently throughout the text.

The second chapter draws together a number of common concerns, conclusions and lines of argument which have emerged from previous Science Council Studies and Reports concerned with specific natural resources. This we have done to reinforce earlier arguments, to refine some proposals and to reiterate the need for action in a variety of quarters – action which, to date, has not been forthcoming in many cases.

The third chapter attempts to face up to what we perceive to be one of the major problems of resource management in Canada today – the jungle of conflicting jurisdictions created by the particular division of powers and responsibilities under our country's constitution. We have tried to advance some pragmatic suggestions of ad hoc measures which can be used to circumvent problems, given the willingness of our country's political powers.

The fourth section contains a brief statement of our concern for those

[2]Meadows, D.H. and D.L., *The Limits to Growth*, Edited by Dennis Meadows, MIT Press, Cambridge, 1972.

actions relating to resource management which we see to be necessary if we are to achieve the goals of environmental quality to which we aspire in Canada.

In the fifth chapter, we deal with the importance of resource development to Canada's economy, and touch on the much debated issue of the desirable degree of "value added" to Canadian natural resources in Canada prior to their exportation.

In the final section, we return to a familiar Science Council concern, the promotion of innovative activities outside federal departments and agencies. While we welcome the Federal Government's announcement of its "Make or Buy" policy for the procurement of research and development, we note a number of remaining impediments which will have to be overcome if such a policy is to be implemented.

Throughout this Report we make a variety of recommendations. Some are short-term, and require only minor tinkering with present administrative structures to see them implemented. Others are long-term, implying long-range changes in the nature of the Canadian political structure, and even fundamental adjustments in society itself – all of which would require some basic changes in our values and perceptions. We accept the fact that implementation of many of our recommendations will present immense difficulties, but believe attempts must nevertheless be made.

Analytical Methods for the Resource Policy Maker

Input-output analysis and systems analysis are simply two techniques for writing essays. But because the essays are written in the symbolic language of mathematics, they sometimes generate mistrust among those not fluent in that language. Others credit the essays with complete objectivity, perhaps because they are mathematical. Neither view is correct. Like any essay, mathematical models incorporate the judgements and values of their authors. Unlike other essays, mathematical models make the judgements and values explicit by the language they use (explicit, that is, for those who can read that language). The premises upon which these particular analytical essays are based are therefore difficult to disguise. Given this transparence and a return to the analogy used in the introduction, the quality of the mirror and its reflected image are easily assessed.

Here, then, are two methods for manufacturing and employing these mirrors, methods which policy makers and analysts alike may use to help them find optimum paths toward any objective.[3]

Input-Output Analysis

Input-output analysis was originally developed by economists to analyze relationships between producing and consuming sectors of a single economy. Its use has since been extended to studies of metropolitan areas and single enterprises, to engineering applications, and to studies of interregional utilization of natural resources. In all instances, the approach is simply to identify individual parts of the given system, then describe the interdependence of these parts by a set of linear equations.

One application of the technique led Statistics Canada to develop a model of the Canadian economy. The following paragraphs illustrate the way in which that model could be used to search for an answer to one of Canada's economic problems – "should Canada preferentially encourage the development of secondary manufacturing industries which are dependent upon Canadian resources?"

"In a complex industrial economy, a given industry exists and prospers in an environment having many sources of material inputs, fiscal pressures, technological impacts and organizational influences. In many instances, inadequacy of any one of these elements may well transform the enterprise from success to failure. In view of this, it may appear to be unrealistic to try to identify a simple relationship in which a given primary resource industry can be identified as being the *major element* on which other industries 'depend' for their existence. Nevertheless, an exercise of this kind is useful in revealing the nature of the linkages which likely exist in the economy. An instrument which permits this kind of assessment is available in the Input-Output model developed by Statistics Canada."[4]

[3]For an expanded discussion of issues raised in this chapter, the reader is referred to W.D. Bennet, "Science Expenditures and the Contributions of the Resource Industries to the Canadian Economy", and A.D. Chambers, "The Systems Approach to Resource Allocation". These will appear at a future date as sections in the Background Study to this Report, a Science Council Special Study entitled *Essays on Aspects of Resource Policy*.

[4]Bennett, W.D., *op. cit.*

The input tables of this Input-Output model describe the primary inputs (wages, salaries, profit, etc.) and intermediate inputs (commodities) going into various industries in Canada. The output tables describe the products of these industries in similar terms. By defining a dependent industry as, say, one in which the resource commodity input is more than half the value of all commodity inputs, and then by examining the appropriate input tables, we are able to identify those industries which depend upon particular Canadian resources and, thus, their contribution to the Canadian economy (Table 2). Because the Input-Output model can also be used to measure the effect of increasing the demand for any chosen commodity by a fixed amount, it is also possible to trace the impact on the economy of an increased demand for products of particular groups of industries.

Table 2 – Contribution of Resource and Resource-Dependent Industries, 1969 ($ millions)

Value Added	Agriculture	Forestry	Fisheries	Minerals	National
By Resource Industry	2 918	599	139	2 643	
By Dependent Industry	1 003	1 765	82	2 352	
Total Value Added	**3 921**	**2 364**	**221**	**4 995**	**70 133** (GDP)
*Total as % of GDP**	*5.5*	*3.3*	*.3*	*7.1*	*100*

*GDP – Gross Domestic Product
Source: Estimates by Science Council.

Table 3 compares the impact of increased demand for a number of selected commodities on wages, salaries and earned income throughout the economy. It is important to note here that this is the effect on all wages and salaries, in all industries, of increased demand for a specific commodity. In general it may be concluded that, despite the wide variation in labour intensity from one industry to another for a given increase in output, no single industry or group of industries can be characterized as having a significantly higher impact on national employment (assuming wages and salaries and earned income are representative of employment). In other words, we might expect roughly the same increase in the number of jobs throughout Canada from stimulating a given increase in production in the metal extractions industry as in any of the manufacturing industries. It should be noted that the Input-Output model at present does not incorporate the capital investment which might be required to generate a given increase in output.

Brief use of the model leads to several ideas. For one thing, it suggests that, given the present structure of the Canadian economy, "numbers of jobs created" cannot be used as the sole criterion for identifying those industries which we would be well advised to encourage. What of job variety, of secure supplies of raw materials and of markets for the products of industry? We consider these questions in a later section, "Resources and the Economy". The point here was simply to illustrate the usefulness of input-output analysis, and particularly of the Statistics Canada model of the Canadian economy, to those concerned with the outcome of various policy options.

Table 3 – Impact of $1 000 000 Expenditure* on Various Industrial Products, 1961 ($000)

Industrial Product	Total Industrial Production (gross)	Gross Domestic Product (GDP) at Factor Cost	Imports	Wages and Salaries (w & s)	Net Income of Unincorporated Business (NIUB)	w & s + NIUB	Surplus
Agriculture	4 368	1 527	244	570	442	1 012	515
Fish and fur	4 197	1 611	243	621	459	1 080	531
Forest products	4 670	1 576	239	890	204	1 094	482
Minerals	3 463	1 412	169	610	103	713	699
Food, feed, tobacco	4 775	1 456	297	723	248	971	485
Wood and paper products	4 581	1 516	258	853	140	993	523
Refined and fabricated metal products	4 207	1 367	312	747	105	852	515
Transportation and communication equipment	4 203	1 337	386	809	111	920	417
Chemicals	4 021	1 325	316	700	110	810	515
Iron and steel	3 885	1 299	353	716	99	815	484
Machinery	4 231	1 431	331	850	118	968	463
Aircraft	4 372	1 448	386	949	125	1 074	374
Motor vehicles	3 938	1 198	433	703	99	802	396
Electrical equipment	4 413	1 443	345	882	120	1 002	441
Pharmaceuticals	4 600	1 492	289	852	142	994	498
Chemicals (other)	3 603	1 283	275	610	90	700	583
Rubber	3 948	1 311	362	748	105	853	458
Textiles	4 131	1 308	415	801	120	921	387
Metallic minerals	3 394	1 429	171	620	91	710	618
Non-metallic minerals	3 536	1 431	171	647	100	748	683
Coal	4 814	2 014	246	1 158	150	1 308	706
Oil and gas	3 036	1 265	114	416	104	519	746

*The input-output data is currently being updated by Statistics Canada to 1967. It is unfortunate that these more recent figures were not available at the time of publication, but preliminary indications are that the conclusions drawn from the 1961 data, presented above, are in no way affected by the updating process.
Source: Statistics Canada, unpublished data.

However useful this model may be, it represents just one of several possible views of the Canadian economy. Its projections and assessments are therefore limited. Many benefits accrue from natural resources which are not included in Canada's system of national accounts, particularly those associated with environmental quality. Others, such as recreational benefits, are inadequately incorporated. At the same time, there are external costs associated with the resource industries which are omitted. Despite these limitations, the Science Council is of the opinion that further refinement of models of this type will provide useful tools to policy makers, and assist in a better understanding of the complex interaction of the resource industries with the Canadian economy.

It is perhaps appropriate to mention here a possible extension of the use of the Statistics Canada Input-Output model. Representing as it does the flow of commodities throughout the Canadian economy, it has the latent potential to incorporate external costs, particularly those associated

with pollution, through the introduction of appropriate coefficients. This might be further investigated by those interested in developing social indicators.

The Science Council recommends that **Statistics Canada devote a substantial effort (both staff and money) to a more detailed development and rapid updating of its Input-Output model. Federal and provincial departments should be encouraged to make use of the impact analysis provided by the model to gain insights into the real effects of natural resources and resource-based industries on the economy.**

We are aware that other federal agencies, notably the Bank of Canada and the Economic Council of Canada, are engaged in econometric modelling. However, it is our view that Statistics Canada is the appropriate body to assume a long-term "operational" role in this activity. The proposed refinement of Input-Output techniques would be a valuable contribution to the improvement of the quantitative analysis of resource problems in Canada.

Systems Analysis or Simulation Modelling

Two principal differences separate input-output analysis from the systems approach. First, the systems approach seeks to describe the interdependence of the individual parts of the given system by non-linear rather than linear equations; in this respect, it is an attempt to reduce the artificiality of the input-output description. Secondly, the systems approach incorporates time as an independent variable; that is, it attempts to account for the passage of time. The systems approach therefore results in a dynamic model, as opposed to the static model most frequently produced by input-output methods.

Like input-output analysis, the systems approach can be used to develop models, or analytical essays, of real situations. These models in turn can be used in the same way that input-output models are used – to help policy makers and analysts in their search for solutions to particular problems. A related, but distinctly separate, use of these techniques is described in the following paragraphs.

Faced with the need for decisions with widespread social, economic and environmental implications, the policy maker has, ideally, been able to gather together a number of advisers in areas ranging from economics, through engineering and law, to the environment. These advisers consider what consequences might result from a range of decision alternatives, and suggest one or two alternatives which appear "best". Such luxury is increasingly difficult to find. The advice of specialists is frequently conflicting, and adds to the policy maker's dilemma, rather than resolving it. Add to such conflict the number of languages (jargon) which policy makers must learn in order to communicate with the various specialists, and the problem becomes darker still.

What tactics can a policy maker employ to relieve his predicament? He can "fly by the seat of his pants", as indeed he may now be forced to do. Or he can turn the dilemma back to the specialists; he can force them to resolve many, if not most, conflicts before advising him of consequences

which they anticipate will result from alternative decisions. Secondly, he can insist that the advisers assume at least part of the responsibility for communicating effectively with him.

Because they can be used to structure group or multidisciplinary studies of given problem areas, both the systems approach and input-output analysis are mathematical modelling techniques which can be used to realize the above decision-making tactics. Their utility hinges upon the use of mathematical symbols rather than jargon, their demand for empirical data and, perhaps most important, their ability to impose a broad perspective on a group of specialists. Placed under the constraints imposed by either approach, advisers or specialists are forced to resolve many of the conflicts inherent in their previous advice. As each part of the problem area is identified and then described, the advisers must agree that both the identification and the description are adequate. Because mathematics is chosen as the descriptive language, explicit logic is submitted for the vagaries of other languages and, perhaps more important, no one is permitted to retreat to arguments couched in his or her particular jargon.

By using either approach to structure group studies of particularly complex problem areas, the policy maker and his advisers arm themselves with a mathematical model which can facilitate communication within the group. Rather than asking each adviser what outcome he would expect to result from a particular action, the policy maker "asks" the model, and receives a synthesis of the advice of all his advisers in tabular or graphic form. The models, therefore, simply provide the policy maker with experimental tools. By experimenting with a model of the real system rather than with the system itself, the policy maker can increase his understanding, then make decisions to be applied to the real world with more complete knowledge.

However useful these new tools might be, their limitations must not be overlooked. While they provide a method for resolving conflicts, for facilitating communication, for dealing with vast amounts of data and for guiding policy analysts, they neither replace nor make obsolete any of the policy maker's existing tools. The most common failing of these new techniques lies in our frequent failure to recognize their limitations. The language they use cannot express emotion very well, yet emotion is what motivates many of us. Perhaps most dangerous is the tendency of some users to become infatuated with the models which are built and with the computing machines they require. For this reason, the Science Council emphasizes that the techniques should be applied with great care, but applied nonetheless.

In the application of these or any other techniques to the study of resource policy in Canada, the recognition of two inescapable conditions is essential:

1. The geographical distribution of Canada's natural resources divides the country into a number of rather distinct resource regions.

2. The political distribution of Canada's natural resources has placed their control largely in the hands of provincial governments.[5]

There are several immediate implications of these conditions. First, regional differences are inherent in the system. Secondly, the role of the

[5]Exceptions are the Northwest Territories and the Yukon.

Federal Government is, or should be, synergistic; it therefore follows that studies of national resource policy must begin at the regional level and place heavy emphasis on the involvement of provincial governments; and because the role of provincial governments is, or should be, synergistic with respect to intra-provincial regions, the studies should include municipal and regional governments where they exist. Finally, resource developers should be involved, be they private, public, or Crown Corporations; it is their response to the rules which governments impose, and to their own profit motive, which represents the transition from theory to practice and therefore determines our progress.

Simulation models have recently received a great deal of attention, both in scientific journals and in the public press. In that context, they have been used to draw our attention to the inexorable forces of population growth, energy consumption, resource depletion and environmental degradation. The interdependency of these and other factors is crucial and complex, but our attempts to understand their effects, one upon another, have only just begun. We have, nevertheless, groups in a number of Canadian universities, government departments and industrial consulting firms which are specifically concerned with such complex problems, and which are attempting to apply the techniques of systems analysis and simulation modelling. Like embryonic groups everywhere, they are struggling to exist. But because the problems they wish to investigate are so immense and so critical to Canada's affairs both at home and abroad, we wonder why their struggle has to continue with so little encouragement. The Science Council therefore recommends that **federal and provincial departments with resource and environment jurisdictions fund systems studies of total resource management on a regional basis. Present studies should be strengthened, and new initiatives begun. The simulation models developed should include social, economic and environmental factors, and information derived from them should be freely available.**

Review of Previous Science Council Publications and Recommendations

Since July 1968, the Science Council has published a series of fourteen Reports and Special Studies (Table 1) concerning Canada's natural resources. The structure of this series was heavily influenced by the traditional, piecemeal approach to resources. First we considered water resources, then the earth sciences, forestry, fisheries and wildlife, oceanography, and agriculture. While such an approach remains valid in many situations, it can lead to a fragmentation which must be balanced by an integrated viewpoint. Such fragmentation can occur not only along the disciplinary lines described above, but also among institutions or sectors of our economy. Both types of fragmentation, sectoral and disciplinary, have been recognized in our past publications and have been the object of past Science Council recommendations.

Virtually all of our Studies conclude that **measures should be taken which would result in a greater degree of coordination of research and related activities among the resource sciences and between governments, industry and the universities.** These recommendations are based on the reality that the research, development and management effort in any given resource area today is highly fragmented in each of the three major sectors of our economy – the government sector, the industrial sector and the university sector; for effective implementation of research, development and management programs, it is essential that a large measure of coordination in these activities be established. Almost without exception, each of the Reports arising from these Studies has therefore recommended the establishment of some institutional structure which would ensure the necessary degree of coordination. The agriculture Report (No. 12) recommended the establishment of an Agricultural Research Coordinating Council; the forestry Report (No. 8) recommended creation of the now-functioning National Forestry Advisory Council (the federal Department of the Environment has also created the National Fisheries Advisory Council, and both these groups report to the Minister of that Department); the earth sciences Report (No. 7) recommended the establishment of a National Advisory Committee on Mineral Resources Research. These and other coordinating bodies were to be concerned with the coordination of research activities in a particular discipline. That is, they were conceived as tools with which to begin to integrate the efforts of a particular discipline in industry, government and university.

Closely related to the above recommendations were discussions which focussed on *the need to bring the disciplines together.* Report No. 8, while being principally concerned with forestry, gives very high priority to the call for an "integrated, coordinated, multiple-purpose approach" to resource development and management (page 16). Similar discussions are found in Reports No. 7 (earth sciences), 10 (oceanography) and 12 (agriculture). Each was prompted by the knowledge that many of our social and environmental ills are consequences of single-minded resource policies. A dam on some northern river does more than supply hydro-electric power to some southern metropolis; it has positive and negative impacts on other natural resources and on the environment. Forestry practices can have profound effects on the water cycle, and are as intimately linked with the wellbeing of fish and wildlife as are the elements leached from mineral

concentrating operations. The disposal of mine tailings can affect the aesthetic, hence recreational, potential of an area, and smelting operations, gas-processing plants and oil refineries have been known to affect surrounding forestry and agriculture. The herbicides and insecticides so necessary for intensive agriculture can kill indiscriminately. Detailed narratives and documentation of the effects of specialized resource practices invariably conclude with a recommendation to coordinate the efforts of individuals and organizations concerned with resource research, development and management. Most explicit is Report No. 9 (fisheries and wildlife), in which the Science Council calls for the creation of an Environmental Council of Canada and a Department of Renewable Resources. It is encouraging that the Federal Government has established its Department of the Environment, thus taking the first step toward integrating the work of several disciplines within its organization. Similar environmental departments have been formed by the governments of Alberta, Manitoba and Ontario, and are being planned by most other provinces. Last spring, the Canadian Environmental Advisory Council was appointed to advise the federal Minister of the Environment; while the form of this Council differs from the one specifically recommended by the Science Council, the move is a step in the right direction. No less encouraging has been the establishment of somewhat similar agencies in Alberta, Manitoba and New Brunswick, and consideration of such agencies by other provinces.

A second common conclusion of our Reports is that **there should be a shift in emphasis from basic to applied research.** This recommendation stems from a widespread and growing conviction that the investment made in research activities must yield a greater return to society than has been the case in the past.[6] Most of our Studies have found the fundamental research that is being conducted in the various laboratories throughout the country to be of good quality; but there is a common awareness that the gap between the fundamental research and its application is very broad indeed, and must be narrowed through greater emphasis on applied research. In the case of agriculture, the economic and logistic problems of marketing and transportation now limit that industry's progress; to quote from Report No. 12, "A greatly expanded research effort is required in areas such as farm management, marketing, pricing, transportation and international trade" (page 26). In the case of forestry (Report No. 8), a similar concern with applications is evident: "The subjects in need of most urgent attention include forest land recreation, environmental quality, fire control and use, products utilization, engineering, economics and products marketing and forest genetics" (page 12). Retaining a strong concern for ecological problems and those relating to the quality of life, Report No. 9 recommends that research expenditures on fish and wildlife should shift from the dominant emphasis on biological science to a better balance with social and economic studies. Our marine sciences Report (No. 10) also addressed the problem of the relevance of research, and recommended that "the criterion

[6]It must be noted that there are areas of activity for which there is inadequate background information currently available. Obviously, the recommendation for a shift from basic to applied research should not apply to them.

of relevance...become absolutely central in supporting much university research in the marine field" (page 27).

A third general recommendation which emerges from the various Reports relates to the sector of the economy where the dominant effort in research should be conducted. Almost without exception, we conclude that **more research should be conducted by the private sector, and proportionally less by government. We believe that this would increase (a) the probability of more applied and development work, and (b) the chances of economic returns.** This kind of recommendation has various impacts in the different resource areas because of the widely diverse degrees of involvement of each sector currently practised in the different resource areas.

For example, in fisheries, where the degree of involvement of the private sector in research is negligible, we conclude that "there is sufficient prospect for return on investment that industry should be coaxed out of their traditionally passive role in research and technology" (Report No. 9, page 29). At the same time, we urge that the federal contribution to fisheries research should continue to be large, both because of the international considerations and also as a means of encouraging development of provincial performance. In fact we recommend in Report No. 9 that "the target for 1988 should be a distribution of effort that is 54 per cent federal, 23 per cent provincial, 13 per cent industry, and 10 per cent university – a sharp shift away from the present domination by the federal government" (page 29). It should be noted that in 1968 the distribution of effort among the four components described above was 75 per cent, 19 per cent, 0 per cent and 5 per cent respectively.

Our agriculture Report (No. 12) addresses itself to the same problem, but recognizes the presence of obstacles which impede achievement of such an objective. "A significant expansion of research performed in the agricultural sector of Canadian industry is urgently needed, but there should be no illusions about this being an easy task; the industries involved are largely foreign-owned and to date have in most cases lacked any commitment to doing research in Canada" (page 33).

In the mineral industries the situation appears to be a little different. In contrast with other resource areas, the mineral industry is the principal employer of earth scientists and in fact is responsible for nearly two-thirds of the total national expenditure on earth science research. Accordingly, the emphasis is not so much on the distribution of the R & D effort as it is on the absolute level. Science Council has found a low level of research activity relative to the economic importance of mineral resources, and insufficient coordination among the various performers of mineral resources research.

A fourth conclusion common to our past Studies relates to the funding mechanisms for research. **Research funding mechanisms should be modified to include more direct involvement of mission-oriented departments or agencies of the Federal Government.** Thus we recommended that "increased support [for university forestry faculties] should come from the department responsible for federal forestry activities and not from the National Research Council. The National Research Council should continue to perform its vital balance-wheel role" (Report No. 8, pages 15-16). In our Report on

the earth sciences (No. 7) we recommended more direct involvement in research funding by the proposed National Advisory Committee on Mineral Resources Research. This Committee was envisaged as having an advisory role to the Minister of Energy, Mines and Resources; but it was also recommended that "The Committee...have adequate funds to stimulate the growth of mineral resources research through cost-sharing research programs" (page 19). With reference to such recommendations, we would make two additional observations.

First, their intent is to suggest that the capacity of industry and of the universities to contribute to Canadian society is greater than is now realized. To make more complete use of that capacity, more direct communication between industry, government and universities is required. Research funding mechanisms which would permit easier and more direct involvement of government departments with industry and universities is one way to encourage such communication.

Secondly, rather than specifying departments and agencies of the Federal Government alone, we encourage provincial, regional and municipal governments to involve the universities and industry more directly in joint community activities.

In summary, four general recommendations are common to all of the primary resource areas. These are:

a) more coordination of research, development and management within and between institutions, and between disciplines;

b) more applied research;

c) more research in the private sector;

d) more participation in research funding by mission-oriented government departments.

The Science Council continues to support such recommendations. As a general guide to the directions that research policies should follow, the four above principles are both desirable and necessary.

In addition to the above recommendations and conclusions, which were common to all Science Council publications listed in Table 1, three other themes recur. One concerns the inadequate natural resource management programs, both undergraduate and graduate, that are found in our universities. The second involves the great and growing need to examine the social, political and environmental implications of resource research, development and management policies. Thirdly, a number of the reports touch upon the implications of foreign control of Canadian resources. All three themes simply amplify the cry for more coordination between governments at all levels, whether municipal, provincial, or federal. They also point an accusing finger to those artificial barriers between disciplines erected for reasons of professional insecurity, and to government policies which permit, or at worst aid and encourage, increasing foreign ownership of Canadian resources. Evolution to bring our institutions, the disciplines and our people to pursue common goals is desperately needed. The Science Council believes that at least part of the recipe for that development lies in the recommendations of this report.

Jurisdictional Questions

In any consideration of natural resources and how they can best serve our society, jurisdictional questions soon surface and become paramount. If, for instance, we were to possess complete knowledge of our resources – where they are to be found and in what quantities, what benefits can be derived from them, how to derive those benefits for the least cost measured in whatever terms – without also possessing jurisdictional control, our knowledge would be useless. In Canada, the present jurisdictional milieu imposes great constraints on the way in which our resources are developed and managed.[7]

"There are two main parameters of jurisdiction over natural resources in Canada: one is ownership of the resource; the other is legislative authority. The former is a product of constitutional history in Canada. The latter is a result of those provisions of the British North America (BNA) Act which divide legislative powers between the Federal Parliament and the provincial legislatures. Where both ownership and all aspects of legislative authority coincide there is plenary power over the resource, and the government, whether federal or provincial, has full and exclusive authority to manage the resource. With respect to petroleum resources in the Arctic Islands, for example, the Federal Government enjoys such full and exclusive authority. But where ownership and legislative authority are divided, as is the more usual case, no one legislative body or government can unilaterally control the destiny of that resource.

"The way in which ownership can affect jurisdiction should be explained. It is obvious that a legislative power over a resource may result in an exercise of jurisdiction over the resources, but it is not so apparent why ownership can give an effective jurisdictional claim on a resource. The Federal Parliament has exclusive legislative authority over interprovincial and export trade in commodities. No province can set up legislative barriers against the free flow of commodities among the different provinces of Canada.

"However, through ownership of petroleum resources, the Province of Alberta can probably legally control and even prohibit the export of gas from Alberta to another province. It acquires this *de facto* jurisdiction over interprovincial trade in the resource when it issues natural gas licences to the producing companies; these licences automatically terminate if the company should export gas to another province without a permit issued by the provincial Cabinet. The Province is not legislating to prohibit export of gas; it has no power to so legislate. The licence-holder may lawfully export the gas subject only to federal legislative controls. But if the gas is exported, his provincially-granted licence to produce will terminate. Because he cannot possibly continue exporting gas without his licence to produce, the *de facto* result is a provincial veto over interprovincial and export trade in the resource."[8]

[7]For a more detailed discussion of some of the issues raised in this chapter, the reader is referred to Thompson and Eddy, "Jurisdictional Problems in Natural Resource Management in Canada", to be published at a later date by the Science Council of Canada as a Special Study entitled *Essays on Aspects of Resource Policy*.

[8]Thompson and Eddy, *op. cit.*

In fact, this very example of split ownership and jurisdiction is promoting federal-provincial conflict. Because Alberta's present supply of oil and gas exceeds her immediate requirements, and because Albertans derive certain benefits from the sale of those resources, the Alberta Government's policy is to export gas and oil at a rate which it judges to be optimum. However, that rate is determined not only by the market and Alberta policy, but by Federal Government policy as well. The National Energy Board, in its attempt to consider not just Alberta and Albertans, but also all of Canada and all Canadians, has placed restrictions on the export of natural gas from Canada. But in not providing Alberta with an alternative to the export market, and in failing to convince Albertans that the federal policy is wisest, the Energy Board's restrictions have allowed a serious federal-provincial conflict to develop. Clearly, some neutral forum where such conflicts can be resolved is desperately required.

Private ownership of resources further complicates the jurisdictional milieu. Most land suitable for agriculture has come under the ownership of private individuals and corporations. Although the extent of the problem varies regionally, much of our mineral wealth, some of our forest resources and some rights to harvest fish and game, to use water from passing streams and to take advantage of our recreational resources are privately owned. An example of the latter situation, currently before the courts, involves private ownership of Lake Erie waterfront by both residents and non-resident aliens.

Proprietorship gives jurisdiction over rights to exploit a resource and is therefore capable of frustrating legislative authority.

To even further compound jurisdictional complexity, one often finds a host of government departments and agencies, both federal and provincial, either directly or tangentially concerned with the drafting and application of legislation affecting one or more resources. The need to stop the increasing fragmentation of jurisdiction and of research and management authority has been recognized in the formation of provincial and federal departments of the environment. Perhaps more important has been recognition of the need for coordination of federal and provincial resource policies, evidence of which may be found in the existence of the Canadian Council of Resource and Environment Ministers (CCREM).

Because CCREM involves the political decision-makers, yet remains apart from Parliament and the legislatures, it provides a meeting place for as many as eleven different policies affecting a single resource. It is perhaps the only vehicle which gives us any hope of harmonizing different views and resolving disputes involving resource jursidictions.

While CCREM appears to be the senior decision-making body where disputes involving resource jurisdictions can be resolved, it cannot be expected to search for and analyze a full range of policy options. Nor can CCREM be expected to search for and implement resource development and management techniques, which are often best developed and applied regionally. Like the senior policy forum however, organizations which can provide these services now exist. The first, or policy analysis, function is presently performed by the secretariat of CCREM. Examples of organizations capable of performing the second, or resource development and

management, function are to be found in the Eastern Rockies Forest Conservation Board, in the Prairie Provinces Water Board, in Ontario's Conservation Authorities and in other illustrations of intergovernmental cooperation in resource research, development and management.

From its headwaters in the Rocky Mountains, the Saskatchewan River system carries life-giving water to the plains of Alberta and Saskatchewan, before emptying into Manitoba's Lake Winnipeg. Both Manitoba and Saskatchewan therefore have a vital interest in what happens at the headwaters, but they are without jurisdiction over resource management in that region. This interest was recognized in the Eastern Rocky Mountains Forest Conservation Act (RSC 1947), which established the similarly named Board to protect the watersheds and manage the forests of the eastern Rocky Mountains "with a view to obtaining the greatest possible flow of water in the Saskatchewan River and its tributaries". Other examples of federal-provincial synergism may be found in various agricultural product marketing boards and in agreements signed under the Agricultural and Rural Development Act (ARDA, Queen's Printer, Ottawa, 1966-67).

Erosion and abandonment of marginal agricultural land, the rapid spring runoff from these lands and resultant flooding of a number of Ontario communities, along with recognition of the need for community involvement in resource management decisions, led to the Ontario Conservation Authorities Act (RSO 1946). Notable among the features of that Act are its recognition of the watershed or catchment basin as the natural unit for resource management and its provision for a blend of provincial and municipal jurisdictions. It also provides an example of provincial-municipal synergism.

Most of the ingredients necessary to overcome constraints on integrated resource research, development and management in Canada now exist. Some of these ingredients, and the linkages between them (Figure, following), need strengthening. All should be employed more vigorously than they have been in the past. Toward these objectives, the Science Council makes the following recommendations:

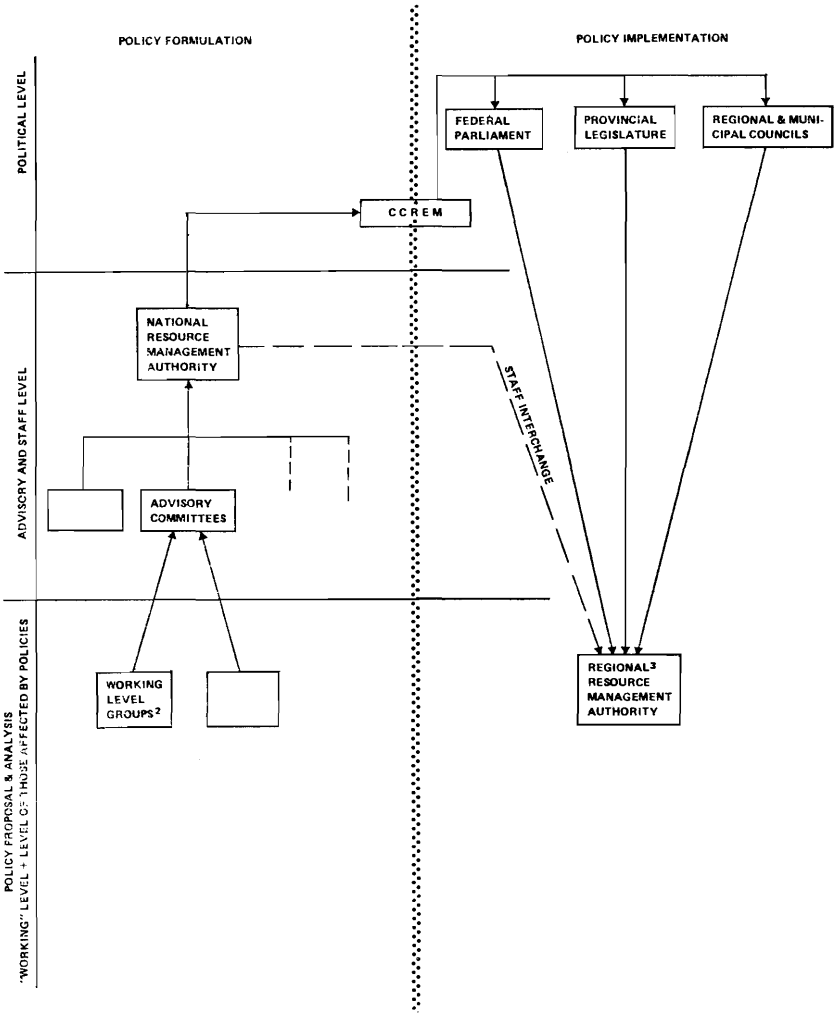
At an appropriate federal-provincial meeting, the Secretariat of the Canadian Council of Resource and Environment Ministers should be strengthened and renamed a National Resource Management Authority. The structure of the Authority should permit the concerns of all levels of government, industry, labour, professional organizations and citizens' action groups to be expressed and considered during analysis by the Authority of policy alternatives which are later to be considered by the CCREM.

This National Resource Management Authority should develop and coordinate long-range policies for integrated management of resources and the environment, and should be concerned with the development of policies for the prudent and efficient use of both renewable and non-renewable resources. These proposed policies and their background studies should be published and freely available to the public.

Further, this National Resource Management Authority should increase support for programs to heighten public awareness, and encourage mechanisms for community involvement in decisions affecting resources and the environment. The current Man and Resources program of the CCREM will

provide valuable insight into problems of awareness and community involvement. But for the community to become fully aware and involved in resource management decisions, those decisions must be made regionally. Indeed, **the use of regional resource management authorities, exercising delegated powers and functions which cross the boundaries of jurisdiction established by the British North America Act, has been a most successful device in many resource areas. To close the gap between policy and practice, the use of such authorities should be extended, and their successes and failures studied.** To deal with problems in the River and Estuary sections of the

Figure – Relationship of Local and National Resource Management Authorities to Existing Structures.



Note: These authorities are intended to function only in the resolution of disputes arising from fragmented jurisdictions.

[1]Currently, the secretariat of CCREM.

[2]e.g., federal or provincial public servants, labour or industrial representatives, professional society representatives, citizens' groups.

[3]Exercise delegated jurisdictions and authority with autonomy. Examples: Ontario's Conservation Authorities, Eastern Rockies Forest Conservation Board, Prairie Provinces Water Board.

Great Lakes-St. Lawrence River System, we recommended the establishment of two such authorities in our recently published environment Report (No. 16).

If conflicts arise from fragmented ownership and jurisdiction within Canada, they must certainly arise in discussions of questions of resource research, development and management affecting two or more nations. Canada is deeply concerned with the exploitation of offshore mineral deposits, and with the management of both anadromous species of fish and those which spend their entire lives in an ocean environment. The ships of many nations harvest marine products along our coasts. Several of our rivers cross and recross our national borders, and solutions to pollution problems in international waters will certainly involve international agreements.

Some of the agreements, treaties and conventions through which Canada has been dealing with international resource use conflicts are discussed in our fisheries and wildlife Report (No. 9) and Special Study (No. 15). These publications point to a number of areas where increased international cooperation is essential for more effective management of resources and the environment. But perhaps most curious of the problems which Canada must resolve before she can contribute fully to the resolution of international jurisdictions is the following:

"The BNA Act conferred on Parliament an implementation power with respect to treaties. However, it did so in terms of Imperial treaties. After Canada gained full international powers through the Statute of Westminster in 1931, the courts were not able to bridge the generation gap sufficiently to recognize that the power to implement Imperial treaties, given in 1867, should be construed as a power to implement Canadian-made treaties after 1931. Consequently, Parliament has full legislative powers with respect to the pre-1931 treaties such as the International Boundary Waters Act, but it does not have legislative power to implement a modern-day treaty in which the subject matter falls within provincial jurisdiction. If Canada should enter into a treaty with the United States to manage and protect the Porcupine Caribou Herd which annually migrates from the northern Yukon into Alaska, it could not legislate to carry out its obligations were the Yukon a province. Nor could Canada at present legislate to carry out the Migratory Birds Convention if it were newly concluded."[9]

Yet, "The Migratory Birds Convention and its enabling Act no longer provide an adequate basis for the management and protection of migratory birds" (Study No. 15, page 84).

Until Canada matures beyond her hundred-year adolescence, many important international resource decisions involving oil and gas, water, migratory birds and animals, and marine resources will be made by default, rather than through deliberate judgement.

[9]Thompson and Eddy, *op. cit.*

The Environmental Perspective

The Science Council has dealt with environmental problems in several previous publications. A wide-ranging statement is to be found in Report No. 16, *It Is Not Too Late – Yet*. A discussion of the problems of recycling is presented in Chapter IV of Report No. 14, *Cities for Tomorrow*, pages 47-56. For an articulate view of global concerns, the reader is also referred to *Only One Earth: The Care and Maintenance of a Small Planet*, by Barbara Ward and René Dubos (A.W. Norton and Co. Inc., New York, 1972).

"Without water, air and a place to stand men cannot live, but nature has provided these elements so abundantly in Canada that we take them for granted. To our great benefit we have harnessed our waters as sources of energy, used them as channels for transportation, developed them for industrial and municipal use and spent our leisure hours in recreation upon them, but in the process we have often reduced our streams, lakes and rivers to sewers for refuse. When we examine our vital surroundings we often see that careless advance has left us with the smell of polluted air, the taste of dirty water and the sight of devastated landscapes. We have not learned to conserve and care for natural riches.

"In these basic respects our ancestors of prehistoric times were better off than we are today; their air was pure, their rivers clean and their habitat luxuriant. What benefit our mechanical advances if nature becomes a slum? What triumph our ingenuity in flying to the moon if our surroundings are dirty? Today everyone realizes this neglect, many demand palliatives, some have a duty to rectify errors. How are we to enjoy the benefits of nature without destroying them in the process?" (Science Council Report No. 3, on water resources, page 3).

Recognizing that there are limits to the punishment our environment can absorb, we have begun to make compensating gestures. We now speak of primary, secondary and tertiary treatment of sewage. We draft land use regulations, and we legislate against air pollution. Such gestures are necessary and should continue. If they fail to relieve the symptoms at which they are aimed, at least they generate the public awareness that will be necessary if we are to be successful in curing the underlying disease.

Is that underlying disease industrialization? To halt environmental degradation, must we stop developing new technologies and employing those which generate "wastes"? Even if we had the option of turning back to pre-Industrial Revolution days, the Science Council does not believe such action would be necessary. The disease is not technology itself, but the highly specialized, single-minded way in which it is developed and practised in our society.

When individuals or institutions become too specialized, their view of the world narrows, and they engage in unnecessary competition. Individual disciplines or departments compete with one another when they might work more effectively together. Many of the jurisdictional problems discussed earlier can be traced to competition between federal and provincial governments or, perhaps more kindly, to a lack of cooperation. And one

industry competes with another for the use of natural resources which, in an atmosphere of mutual trust and cooperation, could serve both well. While individual governments, disciplines, and industries alternate between aggressive and defensive postures, resource decisions are made by default and environmental problems multiply.

To develop a climate in which environmental problems will diminish, where more emphasis in placed on cooperative development and less on the competitive exploitation of Canada's natural resources, the Science Council makes recommendations in five areas of social activity.

Education

Federal and provincial agencies and the professional societies should encourage universities to broaden their undergraduate programs in the primary resource fields so as to develop graduates competent to enter resource and environmental management work. Particular attention should be given to attracting students from the social and behavioural sciences, economics and law. This recommendation is made in the belief that such programs would, if problem- rather than discipline-oriented, attract many highly motivated students and faculty members who cannot now make the contribution they otherwise might.

Research

Because research is associated with the educational process, it is hoped the following recommendation will lead to modifications in our educational institutions, but not those institutions exclusively. **Federal and provincial granting councils and agencies should provide increased funding to expand and strengthen interdisciplinary research programs in the resource area, particularly those which include the social and economic problems of resource management. It is noted that commitment to a problem rather than to a discipline, and to teamwork and systems modelling rather than to publication, are ingredients which have shown success in building interdisciplinary groups.**

A second recommendation concerning research centres on the problem of environmental and economic measurement. When we assess existing industry, or propose new developments, our efforts to determine the weight that should be given environmental aspects of resource exploitation are severely hampered by our inability to assess the cost of long-term effects of low levels of pollution. Slow rates of environmental degradation, such as certain man-induced changes in forest and agricultural soils, reduced ecological diversity, or changes in water and air quality, cannot be measured on a monetary scale. Perhaps in consequence, the discharge of "wastes" from industrial and other human activity has always been free. To effect a change, we must develop methods to assess these previously unrecognized costs. The Science Council of Canada therefore recommends that **the search for more realistic measures of the environmental costs of resource exploitation and of the use and benefits of conservation in Canada be intensified, as a matter of urgency.**

Resource Use

Problems of pollution, solid waste disposal and resource depletion ultimately lead to the concept of recycling.[10] In its broadest sense, recycling includes the use of waste material from one industry to advantage in another, as well as the remanufacture of products once their usefulness is ended. In order to conserve energy, the concept also implies increased product durability so that the frequency of remanufacture is diminished. With this broad meaning in mind, the Science Council recommends that **industrial institutions incorporate the concepts of durability and recycling in process and product design and, in cooperation with all levels of government, establish effective programs for the recycling of municipal, industrial and agricultural wastes.**

While recycling policies will help solve many existing problems, they will also involve changes in employment patterns, transportation and trade. Their implementation must therefore be gradual but deliberate, and develop through close cooperation, not just of government and industry, but of one industry with another.

Northern Development

In the development of any region, there must be a close relationship between that development, the region's people and their resources. Perhaps more than in any other region, the environmental effects of resource management in Canada's North must be given careful attention. For thousands of years wildlife and fish have supported the indigenous people, and these resources can continue to be the basis for healthy communities which seek to maintain this life-style. However, misguided exploitation of minerals, petroleum and water have already caused damage and threaten to destroy the resources upon which existing communities depend.

During the past two or three years we have become aware that our knowledge of the North is inadequate – inadequate, that is, to formulate an integrated development plan for that vast region of Canada. Crash programs to collect badly needed information, often *after* development decisions have been made, will neither relieve the knowledge deficiency nor provide strong foundations for a sound development policy (which, interestingly, would still be unimpeded by the jurisdictional problems that beset the rest of Canada). A sustained, organized research effort is badly needed.

The Science Council recommends that **operations and planning for resource exploitation, transportation corridors and centres of population in the North should not proceed ahead of the development of Man's understanding of the North or the establishment and use of effective mechanisms to provide protection where necessary. Sustained research support for those aspects of Northern studies which will provide this understanding should be increased substantially to offset the increasing pressure to capitalize on short-term profits by immediate exploitation.** This support should be in the form of

[10]Recycling is discussed in Science Council Report No. 14, *Cities for Tomorrow*, Chapter IV, pages 47-56.

funds, personnel, transportation facilities and access to existing government and industry information.

The Global Context

The discussion and recommendations to this point have been limited mainly to the internal problems and policies of Canada. Although obvious, it is necessary to state clearly that Canada's policies for management of resources and the environment should consider the long range (fifty to one hundred years). They should be developed with the clear understanding that Canada is but one of the communities (small but rich) in the "global village". We should recognize the folly of policies which could lead to a heavily armed global community existing under severe strains due to environmental deterioration, misallocation of resources, crowding, or irreconcilable extremes of poverty and affluence.

Those who preach gloom and doom, quoting projections based on current trends and practices, have often, with justification, been labelled hysterical. But it seems neither wise nor prudent to ignore the very clear warnings which our environment is giving us, simply because of a basic faith in mankind's ability to deal with problems. The rate of deterioration of the environment, the increase in the population and in longevity, and our rate of resource consumption suggest that we will be able to provide solutions to these problems as quickly as we create them only if we are determined to do so. This level of determination is not yet in evidence.

As a country which has been lavishly endowed and which has always subscribed to a policy of helping the less fortunate, Canada will want to play a major role in assisting the Third World where possible. Concern about environmental degradation, the quality of life on a global scale and our relationships with many countries which are not our traditional trading partners are playing an increasing role in Canadian foreign policy. We cannot, then, afford to misuse those resources that we will need to provide that help, nor can we afford to let others misuse them. We cannot continue to endorse continental or global resource policies which will contribute only to the disparity between rich nations and the poor. A small number of nations now consume a large proportion of the earth's resources. Within this global context, the Science Council recommends that **Canadians as individuals, and their governments, institutions and industries, begin the transition from a consumer society preoccupied with resource exploitation to a conserver society engaged in more constructive endeavours. Ideally, Canada could provide the leadership necessary to work toward more equitable distribution of the benefits of natural resources to all mankind.**

It might appear that this recommendation for movement away from a growth-oriented society is in direct conflict with other recommendations the Science Council has made. This is not the case. It should be possible to work toward satisfaction of the short-term demands for employment and material benefits without jeopardizing long-term goals. Every effort should be made to keep the solutions to the short-term problems compatible with long-term goals.

The Science Council is well aware that arguments in favour of moving

Canada to become a "conserver society" will be met with a range of reactions from agreement to incredulity – and to outright opposition. To those who find our proposals Utopian, we would add a reminder of what has already been achieved in the recycling of metals in Canada. At the present time, a large portion of all metallic articles made in Canada, especially iron and steel, are produced from recycled material. A large factor in this achievement has been the substantial use of recycled scrap by the steel industry. Looking to the future, one can predict with some confidence increased recycling of fibre products; but one can also see the need for much new technology to cope with the recycling of polymers – perhaps the most difficult of all materials to recycle on the large scale.

The avenues open for the development of new, salable technologies in the field of recycling are many in number. Canada's present strength in the metallurgical sciences, for example, seems to be an attractive base from which to move forward, to show that Canada can be a leader in moving away from the present patterns of ultimately self-defeating resource squandering, and to show that the move can be made without sacrificing the standards of living to which Canadians aspire.

In the short-to-medium term, the contribution of increased recycling to the conservation of natural resources which can be realistically expected will be a diminution of the rate of growth of annual resource consumption, rather than a net decrease in annual consumption, which is a much more distant prospect. Direct contributions will be a reduction of solid waste problems, with subsequent savings to municipalities, and reduction of the air and water pollution and land use problems associated with solid waste disposal.

Resources and the Economy

Some of the most frequently asked questions concerning Canadian resource development centre on the issue of jobs. "Why do we export so much raw material?", and "Why isn't more value added in Canada?". These questions reflect concern for both the number and the variety of employment opportunities available in Canada, and become more pertinent than ever at a time when both unemployment and raw material exports are increasing. The way in which Canada's economy developed has much to do with both the questions and their answers.[11]

Capital investment, both public and private, is required to develop the resources of any region or nation. Characteristically, public capital is employed in the early stages to provide transportation routes and other essential services, with private capital entering later. In Canada, much of the private capital has come from other countries. In consequence, much resource ownership (and, therefore, some jurisdiction) is in the hands of non-Canadians.

The reasons for foreign development of Canadian resources are as varied as the resources themselves. In most cases, large foreign firms develop resources in Canada because those resources are used in the manufacture of an intermediate or final product elsewhere. Thus, many U.S. steel firms own iron ore deposits in Canada, and recently firms from other countries, notably Japan and Sweden, have begun to invest in Canadian mining operations to obtain coal and concentrates of base metals such as copper. Iron ore, asbestos, gypsum, wood pulp, oil, gas and electricity are examples of raw materials produced in Canada but destined for processing or use elsewhere.

Much resource development activity in Canada is undertaken by foreign firms which are active at more than one stage of the production process; these firms are said to be vertically integrated. While a great deal has been written about why firms choose to integrate, it is clear that they do so to reduce risks and increase profits. Vertical integration, whether backward from the final product manufacturer or forward from the raw material producer, normally reduces risk. A steel manufacturer buys iron ore mines to secure his supply of raw material, while an iron ore miner buys a smelter to secure a market for his iron ore. In most cases where firms have integrated backward into Canadian resources, there is no domestic processing beyond a very preliminary stage.

A number of reasons can be advanced to explain the limited involvement of Canadian firms in resource development. The two most important are:

1. An inadequate supply of Canadian capital for ventures of this sort.

2. Restricted market access. A resource has value only to the extent that it can be turned into an intermediate product which, in turn, has a wide variety of uses in the manufacture of many different types of final products. To sell an intermediate product produced efficiently (i.e., on a large scale), it is necessary to have access to a large market (*viz.*, the U.S. market).

[11]For an expanded discussion of issues raised in this chapter the reader is referred to W.D. Bennett, *op. cit.* and A.J. Cordell "Implications of Ownership and Regional Development". These will appear at a later date as sections in a Science Council Special Study entitled *Essays on Aspects of Resource Policy.*

Typically, tariff structures of industrially developed countries allow raw or slightly processed resources to enter their markets duty-free. Intermediate products face a tariff. Large producers of intermediate products who have secured final markets in the U.S., Japan and Europe can therefore integrate backward to Canadian resources. But a manufacturer of intermediate products in Canada faces two serious impediments:

(i) because of tariffs, it will operate at a competitive disadvantage in the foreign market vis-à-vis manufacturers in that country; and

(ii) long-established market relationships and other non-tariff barriers severely restrict and sometimes deny access to manufacturers outside the protected market.

Given this long-standing economic milieu, it is not surprising that Canada has become a trading nation dependent upon exports of raw materials. Nor is it surprising that the diversity of employment available in Canada is limited.

While few would argue that Canada should not pursue policies leading to a greater number and diversity of jobs in Canada, heated debate may envelop discussions of how to achieve this goal. Such discourse frequently focusses on one of a number of tactical questions among which one finds:

a) the promotion of Canadian technology in order to make Canadian firms more competitive;

b) changes in the existing industrial structure (multinational corporations);

c) Canadian ownership of resources and manufacturing enterprises;

d) processing Canadian resources at home; and

e) changes in the existing tariff, export tax and royalty structures.

Although all five are exceedingly important, the first two have been discussed at some length in two earlier publications of the Science Council.[12] This Report is more specifically concerned with the last three as they relate to Canada's resource industries.

Does it matter whether Canadians or foreigners develop Canadian resources? Considering the tariff structures of the U.S. and other industrialized countries, and *taking into account value added only*, the behaviour of foreign or Canadian-owned or -controlled firms does not appear to differ significantly. However, there are alleged to be a number of significant but difficult-to-measure costs associated with foreign development of Canadian resources. For instance, what price does a foreign parent pay its Canadian subsidiary for resources shipped from Canada? To what extent do foreign firms automatically engage foreign or foreign-controlled engineering, advertising, geological, economic and environmental consulting firms? To what extent do foreign firms import instruments and other machines which they require in Canada? What management, research and associated opportunities are lost to Canadians as a result of foreign ownership?

Definitive answers to these questions are, at best, extremely difficult to

[12]Science Council of Canada Report No. 15, *Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing*, Information Canada, Ottawa, October 1971.

A.J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council of Canada Special Study No. 22, Information Canada, Ottawa, December 1971.

obtain. It seems certain, however, that if resource ownership carries certain jurisdictional powers it would then seem foolish to permit them to reside outside Canada, particularly if such jurisdiction can be used to encourage better husbanding of Canadian resources by firms of whatever nation.

Should Canadian resources be processed before export? That is, should secondary manufacturing industries dependent upon Canadian resources be preferentially encouraged? In the opinion of the Science Council, the answer is an unqualified "yes". If we produce and sell iron ore, we provide employment for miners alone. If, in addition, we were to smelt this ore, turn iron into steel and steel into a range of finished products, the diversity of employment opportunities would increase. And if we were to add Canadian labour to our international trading list, selling both labour and resources (as finished products) rather than resources alone, the number of employment opportunities available in Canada would also rise, as we began to draw more, expendable, income from labour, and less from our capital reserves (resources).

Could these objectives of increased numbers and greater variety of jobs not be better achieved by encouraging any secondary manufacturing? Why restrict this encouragement to firms dependent upon Canadian resources? The answer to these questions arises first from the above argument and from the earlier discussion about why firms integrate into Canadian resources (i.e., to secure a supply of raw materials), and secondly, from an assessment of the impact of resource industries on the Canadian Economy.[13]

Recall from our earlier discussion of the Statistics Canada Input-Output model that, given the present structure of the Canadian economy, we might expect roughly the same increase in the number of jobs from stimulating resource extraction as from any of the manufacturing industries. The case for tying economic policy, or an industrial strategy, to resources and their dependent industries must therefore rest on the earlier arguments for vertical integration and a stable supply of raw materials, and for increased variety and stability of employment opportunities in Canada, as well as on the need to gain freer access to world markets in order to support our position as a trading nation.

Because much of Canada's economy relies upon international trade, any attempt to shift our dependence from the export of raw materials to the export of finished or partly finished products is likely to disturb our international balance of payments. Skillful piloting indeed will be required to guide the Canadian economy slowly and steadily from one dependency to the other, while avoiding the instability that could result from a sudden, rapid change.

With Canada's present pattern of industry, it is essential to maintain a strong export position in world markets, and this in turn calls for reciprocal imports. If Canada is to provide the job opportunities mentioned earlier and at the same time remain a trading nation, we must first determine the commodity areas in which imports should be strong and those in which domestic production might effectively compete on world markets. Successful adoption of the policy, or industrial strategy, to which such an

[13]W.D. Bennett, *op. cit.*

analysis might lead would then require negotiation with consuming countries to have trade barriers removed or reduced. Thus, in the opinion of the Science Council, the development of a sound industrial strategy will involve:

a) the identification of those industries which depend upon Canadian resources and which, if encouraged, can have far-reaching effects on the Canadian economy; and

b) bilateral negotiations with foreign trading partners to reduce trade barriers.

With reference to the first problem, there are two fundamentally different approaches. One is to trace the path of various resources from extraction to finished product, documenting the addition of value (labour and/or other resources) at various stages of processing. The second approach involves a detailed examination of the role of specific resources in the Canadian economy as it presently exists; an example of the latter would be an extension of the Statistics Canada Input-Output model which is discussed in greater detail in the background material.[14] Any final analysis would necessarily involve some aspects of each approach. The object of the exercise would be to identify those industries and job opportunities, dependent upon Canadian resources, which currently reside and are developed outside Canada; but action taken to patriate some of those opportunities without a detailed appreciation of effects such action might have at home would seem less than wise.

Promising methods for investigating complex problem areas, such as the development of an industrial strategy, were examined earlier under the heading "Analytical Methods for the Resource Policy Maker". However, any serious analysis of Canadian resources and the industry they can support must be undertaken with detailed knowledge of the position which Canada's trading partners would likely adopt. Access to markets, the tariff structures in the industrialized countries and the industrial structure (of vertically integrated firms) within which Canadian resources are exploited are all factors which compel Canadian and foreign-owned firms to behave in a similar manner. The Science Council therefore makes the following recommendation: **The Federal Government should intensify bilateral negotiations with foreign governments to achieve more favourable tariffs which, where economically feasible, would encourage increased value-added in Canada.**

Successful negotiations would ultimately lead to removal of tariffs. But the goal, more value added in Canada, would not necessarily follow. Industries and communities, both in Canada and elsewhere, which are dependent upon the export and import of Canadian resources will remain dependent on that traditional relationship. With the removal of tariffs, resource exports would therefore remain at their present level at least, but a very severe impediment to increasing the value added in Canada would be removed. Then, given control of their resources, Canadians might apply the technology, the capital and the initiative they are known to have to developing a much different Canadian economy than now exists.

[14]W.D. Bennett, *op. cit.*

While the federal budget of May 1972 has given a considerable boost to secondary manufacturing and mineral processing in Canada, increased depletion and depreciation allowances and reduced corporate income taxes cannot provide a lasting solution. If more favourable tariffs cannot be negotiated, then Canada might explore other methods of deriving increased benefits from its resources. A wide variety of approaches can be taken, but all are based on an acceptance of the existing situation (i.e., increased value-added cannot be achieved in Canada because the importing countries refuse to agree). Thus, increased benefits in the form of revenues must be tied to the export of resources and the following alternatives might be explored:

1. The feasibility of increasing the rate of royalties. In this regard, attention must be given to reactions by existing firms, to demand for products in world markets, to current and projected profits of firms in the industry, etc.

2. The possibility of placing an export tax on resources flowing out of Canada. Since one of the effects of an export tax is to raise the price of the resource internationally, careful consideration must be given to the present structure of world prices and the extent to which an action of this sort would price Canadian resources out of the market.

3. The extent to which public ownership of specific and carefully selected Canadian resources could generate revenues for all governments in Canada. Here consideration must be given to access to foreign markets by Crown-owned resources, to the cost of appropriate payments to those who presently control the resources and to the extent to which capital can be raised in Canada for continuing exploration and extraction of the resources.

It may be that one or some combination of these may be both feasible and desirable; on the other hand, careful study may show that in each case anticipated costs outweigh the benefits.

Some Impediments to Change

In the Introduction to this Report, we indicated our interest in the way in which federal expenditures on science were allocated to various resource areas. Later, we drew attention to a number of recommendations common to previous Science Council Reports concerning Canada's natural resources. In making these recommendations, the Science Council has argued that if there were more participation in research funding by mission-oriented government departments, progress might be made toward the three following objectives:

1. more dialogue, thence coordination, between governments and other sectors of the scientific community and the economy;
2. more research in the private sector; and, as a result,
3. more applied research.

While we continue to support the various tactics which we have recommended, our major concern has been with progress toward the above objectives. The Science Council would therefore welcome any tactical method employed to move toward them; yet we see Federal Government expenditures on "in-house" research increasing at a greater rate than those on extramural research (Table 4).

Table 4 - Current Expenditures by the Federal Government on R & D in Natural Resource Areas, by Field of Application ($ millions)

Field of Application	Intramural			Extramural			Total		
	1970	1971	1972	1970	1971	1972	1970	1971	1972
Agriculture	46.4	50.3	50.9	0.7	0.7	0.7	47.1	51.0	51.6
Fisheries	17.9	19.3	21.7	0.9	0.8	0.8	18.8	20.1	22.5
Forestry	17.0	18.4	15.3	0.2	0.8	0.8	17.2	19.2	16.1
Mineral Location and Extraction	11.6	12.1	12.3	0.5	0.4	0.5	12.1	12.5	12.8
Northern Development	5.1	5.9	6.8	2.1	2.1	2.4	7.2	8.0	9.2
Pollution Abatement	9.5	11.6	12.9	1.8	1.9	2.1	11.3	13.5	15.0
Water Resources	3.8	4.1	4.2	2.2	2.4	2.6	6.0	6.5	6.8

Note: 1970 and 1971 are fiscal years; fiscal year 1972 refers to 1971-72.
Source: Statistics Canada, *Federal Government Expenditures on Science, 1970-72*, DBS Cat. No. 13-202, Information Canada, Ottawa, 1972.

We are pleased to note the announcement (August 15, 1972, by the Minister of State for Science and Technology in Toronto) of the Federal Government's new "Make or Buy" Policy, under which "the onus [will be] on the government departments to place their R & D contracts with private industry". This statement is the first essential step, providing as it does the political decision to embark on a serious program of "contracting-out"; but to allow the program to achieve its full potential, a whole string of bureaucratic impediments – some procedural, some attitudinal – will have to be overcome. In the following few paragraphs we have provided a sampling, by no means complete, of the kinds of impediments which lie ahead. In later, more appropriate Reports, the Science Council will attempt a more complete investigation[15] of the impediments to the successful implementation of the contracting-out policy.

[15] Such a study would have to touch on factors, like the need for increased project management capability in government laboratories, which have been omitted from the present study.

In the Federal Government

Within the Federal Government, the most limiting impediments appear to lie in the management, budgetary and contracting systems practised by the Federal Government; they offer little or no incentive to departments and agencies to contract out their R & D requirements.

The Budgetary Cycle

The components of the budget are: the A budget – cost of carrying on the same program as in the current year; the B budget – extension of programs and new capital projects; the X budget – present expenditures to be discontinued. The Total Expenditure budget is, thus, A + B − X. It has been alleged that the timing of individual component submissions does not permit ready adjustment within the aggregate amount. The A and X budgets are submitted first, and considered by the Treasury Board prior to setting up guidelines for the B budget. The necessary process of "R & D euthanasia" is thus discouraged, as departments are reluctant to sacrifice old activities before knowing how their new proposals will fare.

Rigidity of Staff and Facilities

Where a contract involves the transfer of an in-house activity to university or industry, the problem of transferring government personnel to other activities is a very real one, as is that of utilizating or disposing of equipment and laboratory space. Greater mobility and flexibility of scientific personnel would appear to be desirable.

Costing Procedures

In departmental budgeting, the cost of an activity or sub-activity does not incorporate the departmental overhead. The cost of contracting to industry is thus perceived by the research manager as very much higher than the cost of doing the same work in-house. Conversely, where the cost of overhead is not included in a contract, as is the case with some university contracts, the contractor may well find the arrangements unacceptable. This question of overhead allocation clearly requires further examination and the development of a uniform but liberal government policy to make such contracts more generally acceptable to both parties.

Foreign Ownership[16]

Government research managers are reluctant to place contracts for new projects with, or to transfer existing work to, foreign-owned subsidiaries because of the not unreasonable belief that the results of such work will not necessarily benefit Canadians. But will they patronize less well-established Canadian firms? There is a need for government guidelines on these questions.

[16]For further discussion of this topic, see also:

A.J. Cordell, "Implications of Ownership and Regional Development", in *Essays on Aspects of Resource Policy* (the Background Study to this Report, to be published later by the Science Council); and

A.J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council Special Study No. 22, Information Canada, Ottawa, 1971.

Department of Supply and Services

Pressure is being exerted to have all contracts for R & D placed through the Department of Supply and Services (DSS). Such contracts frequently require a close relationship between contractor and customer, particularly in the early stages of problem definition and specification development. Research contracts should therefore be drawn by the department involved, and not by DSS, which is unlikely to have the understanding and sympathy necessary to develop a truly satisfactory contract service in many areas of research and development.

As a more satisfactory balance develops between sectors with increasing extramural activity, regional problems will arise and have to be met by an equitable distribution of extramural funds. Such future problems simply reinforce the notion that a magic formula for the allocation of funds among different resource activities within the Federal Government has not, and probably cannot, be developed. The need for flexibility is paramount. The Science Council therefore recommends that **the Ministry of State for Science and Technology press for the removal of the impediments to increasing extramural funding of research and development by all departments and agencies of the Federal Government.**

In Industry

If government is to engage in extramural research and development activities, it must be able to identify contractors which are able to accept and carry out that work. The industrial budgeting process and demands for a short-run payoff sometimes impede the development and maintenance of capable research groups.

R & D as an Overhead Expense

Many industries which maintain research and development facilities look upon those facilities as an overhead expense. Viewed in this light, industrial R & D budgets are subject to rapid cuts from time to time as economy drives dictate. With rapid fluctuations in staff and facilities, the sustained research effort necessary to realize occasional payoffs is impossible to maintain. With no payoff during times of comparatively high expenditure, management that is unfamiliar with the innovative process becomes disenchanted, and the tendency to slash R & D budgets is reinforced.

R & D as an Investment

Those industries which view R & D as an investment frequently budget a percentage of net profits for those facilities. Because there is no short-range relationship between net profit and R & D payoffs, large R & D budget fluctuations result. Again, the continuity of staff and facilities is subject to frequent interruption, and the sustained research effort necessary to realize payoffs is broken.

Government granting programs intended to support industrial R & D often meet resistance because of the excessive staff time recipients must devote to the paper work and reporting procedures upon which the grants depend.

In the Universities

Not unlike those in government and industry, some of the impediments within the universities are associated with budgets. However, divergent (but not necessarily incompatible) goals of the university and its staff also erect hurdles.

Research Facilities

The capital cost of research facilities can be enormous, but contracts between government and university seldom allow for this budget item. In order to construct facilities which would permit them to do more contract R & D, the universities must either "rob Peter..." or seek capital funds elsewhere.

Publish or Perish

The publication policies of universities place constraints on the applied research which they can undertake for industry. Neither unpublished mission-oriented reports nor multiple-authored articles are considered good evidence for promotion. A university staff member who undertakes work which will not lead to senior authorship of articles in refereed journals therefore jeopardizes his future.

Budgets

Members of university staffs whose salaries are paid from grant or contract revenue are hired only for the duration of that grant or contract. Standing alone, such policies cannot be questioned, for who can commit himself under conditions of uncertain revenue to making expenditures? However, within the university this policy is paired with the familiar practice of granting appointment without term (or tenure) to capable staff members paid from more stable sources of revenue. Acting in parallel, these employment policies create two kinds of appointments within one institution, generating associated tensions within the staff. Together, these policies effectively limit both the applied research which can be done within our universities and the involvement of both staff and students in current problems. One or both of two corrective measures are possible. First, the contrasting employment policies should be replaced by one consistent policy. Secondly, the uncertainty of obtaining government contracts, and the consequent instability of that source of revenue, can be removed by changing government contracting policies. Perhaps the occurrence of the first is dependent upon that of the second.

We have listed some of the impediments which prevent change. Of these, a few may be operative in specific instances, while others may be universally applicable. The Science Council urges the Ministry of State for Science and Technology, the universities and industry to examine them further and attempt to remove constraints on the increased participation of industry, government and the universities in the research, development, and management of Canada's resources and the industries they support.

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