Background Study for the Science Council of Canada

May 1973 Special Study No. 27

Essays on Aspects of Resource Policy

by W.D. Bennett
A.D. Chambers
A.R. Thompson and H.R. Eddy
A.J. Cordell

May 1973

Essays on Aspects of Resource Policy

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Foreword

Over the past two years the Science Council has been engaged in an integrative study of policy problems relative to Canada's renewable and non-renewable resources under the general heading of a "Resource Overview". This work culminated in the issue of Science Council Report No. 19, *Natural Resource Policy Issues in Canada.*

In the course of this activity a number of essays were written on different aspects of the problem so that the Council had a synthesis of facts, figures, opinions, and options available to it. Some of the essays prepared represented a pulling together of material already in the literature into reasonably convenient form; others either presented new material or a synthesis of existing work which was not conveniently available elsewhere. The Council Committee on the Resources Overview, chaired by Deputy President Armstrong of the University of British Columbia, decided that those essays which fell into the latter categories should be published as one of the series of background studies, under the title of this volume, *Essays on Aspects of Resource Policy.*

This present volume, therefore, differs from its predecessors in that each of the essays is an independent work by a separate author (or pair of authors) and that each stands on its own as a self-contained contribution. Each, of course, had its rôle in helping to form the Council's own opinions as expressed in Report No. 19.

Dr. Bennett, in the first essay, deals principally with integrative techniques that are already fairly well developed but which can be applied more widely with a bit of extra effort.

Dr. Chambers, in the second paper, makes a case for a major effort to bring the strengths and insights of systems analyses and simulation modelling to bear directly on the problems of resource allocation. In this we can profit from the development of techniques of the systems approach taking place in many centres around the world; however, nobody is going to apply them to Canadian problems effectively but Canadians.

The third paper, by the well-known authority on constitutional law, Professor A.R. Thompson and his colleague at the University of British Columbia, Dr. H.R. Eddy, pulls together in a very few pages the principal jurisdictional problems facing Canada and Canadians in natural resource management. These problems are embedded in the British North America Act and are feeding on the current crop of political conflicts.

The final paper by Dr. A.J. Cordell, on the implications of ownership, shows a return to this subject by the author of our background study on the Multinational Firm (Special Study No. 22). It draws on many of the insights which we gained in the course of our study of industry over the last three years.

As with all background studies published by the Council, this report represents the views of the authors separately, and are not necessarily the views of the Council. The Council is publishing this report because it

thinks the collection of essays will make a contribution to a better understanding of natural resource policy issues in Canada.

P.D. McTaggart-Cowan,
Executive Director,
Science Council of Canada.

March 1973

Errata

Page 92, reference 2: *for* 1967 *read* 1867
Page 92, reference 7: *for* Ruling *read* Reports
Page 92, reference 9: *for* Ruling *read* Reports
Page 92, reference 10: *for* Offshore Minerals Reference, (1970), Supreme Court Ruling, Supreme Court of Canada. 1st supp., chapter 5, subsection 9 *read* Revised Statutes of Canada 1970, 1st supp., chapter 5, section 9
Page 92, reference 11: *for* Ruling *read* Reports
Page 94, reference 24: *for* Ruling of the Supreme Court of Canada, *read* Revised Statutes of Canada
Page 95, reference 31: *for* Ruling Supreme Court of Canada *read* Revised Statutes of Canada
Page 95, reference 34: *for* Ruling Supreme Court, *read* Revised Statutes of Canada
Page 95, reference 40: *for* Ruling of Supreme Court of Canada, *read* Revised Statutes of Canada
Page 96, reference 43: *for* of 1969, Washington, D.C. *read* 42 United States Code Annotated, sections 4321–4347.
Page 96, reference 44: *for* Ruling of Supreme Court of Canada, *read* Revised Statutes of Canada

[illegible] Council of [illegible] Special Study No. 27
[illegible] on Aspects of [illegible] Policy, by [illegible]
[illegible] Chambers, A.R. Thompson, H.R. [illegible], A.[illegible]

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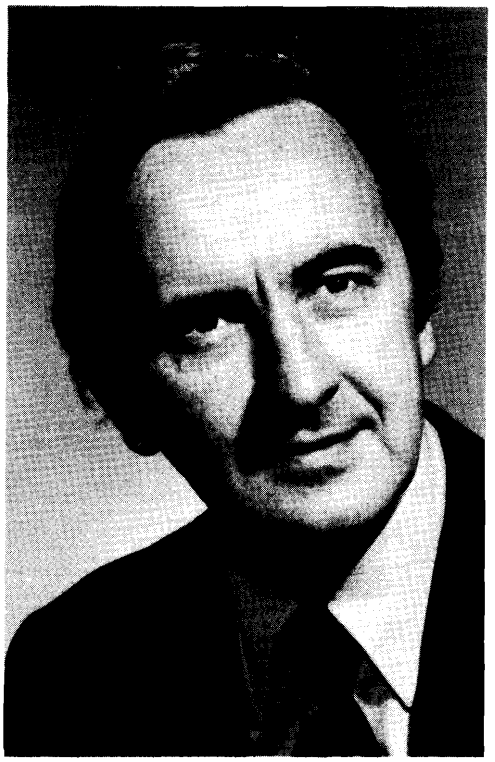
I. Science Expenditures and the Contributions of the Resource Industries to the Canadian Economy

by W.D. Bennett



W. Donald Bennett

Dr. Bennett is at present the Science Counsellor at the Canadian Embassy in Washington, an appointment he accepted in September 1972. Prior to this, he was a Science Advisor with the Science Council of Canada for a period of four years. Before joining the Council, Dr. Bennett was head of the physical metallurgy research laboratories of Falconbridge Nickel Mines in Thornhill, Ontario during the period 1962–68, where he was instrumental in developing new facilities and programs. He has also held positions as an advisory engineer with both Canadian Westinghouse Co. Ltd. and Canadair Ltd. relating to research in nuclear engineering and has worked as a research metallurgist with the Mines Branch of EMR. He is the author of several papers in the field of physical metallurgy.

Dr. Bennett received his B.Sc. (Honours Physics) in 1943 from Sheffield University, England, served as a Radar Officer in the Royal Navy, returning to obtain a Ph.D. from Sheffield in 1949. He held a post doctoral fellowship at NRC from 1949–51. He is a member of the Association of Professional Engineers of Ontario, a Fellow of the Institute of Physics, and a member of both the Canadian Institute of Mining and the American Institute of Mining and Metallurgical Engineers.

Summary

Expenditures on research and development in the renewable and non-renewable resources, when directed towards economic objectives should be assessed at a national level in terms of their eventual impact on the economy. Such research produces increases in efficiency or productivity which show up as increases in performance. This improvement in performance is reflected in an impact on the economy as a whole, which can be measured using the Canadian Input-Output model.

A characteristic of the resource industries is that they support a number of associated industries dependent on primary resources. A method of readily identifying such industries on a national scale is developed with the use of the Input-Output model. The significance of such resource-dependent industries to the Canadian economy is evaluated and the importance of continued strength in this segment of industry is emphasized.

The limitations of impact analysis using the Input-Output model for use in science policy are discussed. It is concluded that its usefulness is primarily for the short-term and merits additional support and the incorporation of further refinements into the model. For the long-term, more dynamic computer simulation techniques are needed for modelling the basic structure of resource trends and their interrelationship with each other and with the environment.

Acknowledgement

The above work was made possible only by close cooperation with the Input-Output Research and Development Division of Statistics Canada, whose assistance is gratefully acknowledged.

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Introduction

Large expenditures are made annually on research and development in the area of natural resources. The majority of these expenditures have as their declared objective the improvement in the efficiency or productivity of a particular resource industry. A significant proportion of the research and development is funded by the Federal Government. Even though we assume these expenditures are being optimized within each resource segment, it is pertinent to ask to what degree they are being optimized on a national scale for maximum economic benefit, whether this be measured in terms of increased employment, contribution to Gross Domestic Product (GDP), tax contribution, corporate profits or any accepted combination of these parameters. If the objective of research and development is increased productivity or efficiency, will such improvements in one industry benefit the national economy more than in another? Clearly, if such economic measures are to be used, then the criteria for establishing priorities must be examined. Methods of implementing such priorities by emphasizing or de-emphasizing the effort in one or more areas, using the power of government spending must also be studied.

It has become almost commonplace to observe that criteria other than those related to economic aspects are important in evolving policy decisions. However, in the area of the primary resources, it is obvious that economic considerations occupy a very important, if not dominant, position. The Science Council has in an earlier report (No. 15)[1] urged the development of a co-ordinated industrial strategy on a national scale. The need for such a strategy becomes equally apparent in a review of the resource industries. In examining the impact of the resource industries on the economy it is evident that the secondary effect produced by the supply of intermediate commodity and service inputs to these industries is a significant one which should not be overlooked. It is also clear that the development in Canada of resource-dependent industries, which have an even greater impact on the economy is severely restricted by foreign, and particularly U.S., tariffs. With Canada's present pattern of industry it is essential to maintain a strong export position in world markets, but this in turn calls for reciprocal imports. A National Industrial Strategy would determine in which commodity areas imports should be strong and in which commodity areas we should specialize domestically to build a healthy export trade. It would appear that the resource-dependent industries should be given special attention as they have the potential to incorporate the benefits of secondary industry without displacing existing production capacity in the natural resources. It is however first necessary to evaluate the significance of these industries in the economy.

The Need for Quantitative Assessment

In discussions on the appropriateness of R & D expenditure allocations between large aggregates of resource industries the question invariably arises as to what contribution these resource areas are making to the economy. Usually the query is couched in terms of output, employment opportunities, value added or contribution to gross domestic product. Should research and development expenditures be related to industry contributions to the economy, or should they be related to areas of opportunity and future potential? There are, of course, important areas of activity or concern which make little measurable contribution. Many aspects of water resources, air quality, environment protection, and whole areas of ecology, make a direct contribution only in so far as their regulation and control show up in the national accounts. On the other hand, the declared objectives of many mission-oriented government research laboratories are to improve the efficiency of specific resource industries. The goal of all industrial research is obviously related to improved profitability, which is largely a function of increased efficiency and production. University research is to some extent related to the sectors of industry and government in that it supports the training of graduates for these sectors or undertakes mission-oriented research for industry or government. Research and development are thus to some degree already directed toward increasing or maintaining the contributions of specific resource areas to the national economy.

The two points of view, research directed toward economic opportunities and research directed toward social needs and concerns are not irreconcilable. The areas of resource industry under discussion, particularly when taking into account the full area of industrial dependence on resources, are large and diverse. The opportunities within each are many and providing that governments supply appropriate regulations and controls, good management should optimize the R & D activities for the greatest social and economic benefit within each resource area. As an interim measure and subject to one proviso, it would appear desirable that there should be some relationship between R & D and the contribution made by the resource industry to the economy. The important proviso is that government should accept a responsibility for a variety of inter-resource problems associated with optimizing land usage, protecting the environment, and planning the long-term conservation of all resources for future generations. This is in fact represented by the present regulatory rôle of government, the importance of which should not be diminished by the following analysis.

The failure to relate research and development expenditures on a national scale to some sort of economic contribution parameter has in the past resulted in the neglect of large segments of the economy which make major contributions to the national prosperity. There are some obvious examples which have only recently become areas of public concern. Transportation, which forms a significant component of the Gross National Product (GNP), has been supported by major R & D expenditures only in areas where defense applications were the objective. The wholesale and retail trades, again representing major components of the GNP have been

practically free from any form of R & D input, despite the public concern for the quality and reliability of consumer goods, the excessive concentration of retail distribution centres, and the inherent dangers of excessive and insidious advertising practices. The construction industry might be cited as another example of low science input: labour inputs are rising more rapidly than the capital inputs and price increases are relatively high.

It is appropriate to mention here that any measures of economic benefit, discussed in the analysis which follows, do not take into account the negative spillovers associated with external influences on the physical and social environment. No system of accounts has yet been developed which would incorporate quantitative assessments of such diseconomies, but this does not imply they are not of concern, nor that the search for such measures should not continue. Neither does it offer a reason to abandon an attempt to develop more sophisticated measures of more traditional economic benefits. A national system of priorities for the allocation of resource-related R & D funds, on the basis of perceived economic benefits from improved industrial performance, would not necessarily result in R & D programs devoid of environmental goals. Regulations on air and water quality, for example, would dictate increased R & D expenditures within this area for economic motives alone. It would be in the inter-resource areas that weaknesses would occur and it is for this reason that the important proviso is added above that government should accept responsibility for increased activity in the interface areas.

An assessment of the contributions made by the various resource industries is clearly necessary. More controversial is a discussion of the desirable relationship between this contribution and associated research and development expenditures. In the following chapters the concern will be primarily with different methods of assessing an industry's contribution, but the ultimate objective of developing a relationship between this contribution and desirable expenditures on science will not be forgotten.

Direct Contributions

In assessing the contributions made by different industries to the national economy and also in making comparisons between different industries there is a real danger of double accounting. This is an error frequently made in comparing the total output of an industry with the Gross National Product. If "gross" output is to be used as a criterion, then it must be compared with the "gross" output of the national economy (almost three times the GNP). In other words, for realistic comparisons one basic rule must be imposed: **the total of the industry concerned and all other sectors, so considered, should add up to the national total.**

A suitable framework for making consistent and comprehensive comparisons is provided in the System of National Accounts developed by Statistics Canada. It is the Income and Expenditure Accounts which provide measures of incomes and expenditures on goods and services with the totals adding up to equal amounts, namely Gross National Product (GNP) or Gross National Expenditure (GNE) respectively. Other accounts provide measures of the contributions of each industry to national output, of supply and demand for individual commodities, and of inputs and outputs for individual industries. There are many ways of making comparisons. On the input side, it is interesting to compare labour and capital inputs, while on the output side a comparison may be made of production output or of exports. The output may be either *net* value of production representing value added by the industry, or *gross* output including the value of all intermediate[2] inputs. The GDP at Factor Cost[3] is a convenient measure of the value added by a given industry to the total economy.

Table I.1 compares all of these parameters of both input and output. It should be noted that both GDP and employment represent direct contributions to the economy, whereas the output represents the sum of both the direct contribution of the industry and the intermediate inputs in the form of commodities from other industries. The use of output thus tends to reflect the degree of dependency of the resource industries on other industries. In making output comparisons it is essential to use corresponding "gross" output figures for the national economy.

Taken altogether, these primary resources contribute a little over

Table I.1 – Selected Measures of Comparison between Resource Industries and the National Economy

	1969 GDP $ millions	1967 Output $ millions	1970 Exports $ millions	1971 Employment thousands	1971 Capital Expenditures $ millions
Agriculture	2 918	4 322	1 136	510	973*
Forestry	599	1 290	67	72	85
Fisheries & Wildlife	139	176	67	22	–
Mines, quarries & oil wells	2 643	3 840	2 253	129	1 705
Total Primary Resources	6 299	9 628	3 523	733	2 763
Total National	**70 133**	**95 036**	**16 427**	**8 079**	**19 788**

*includes fishing

Source: Statistics Canada, *Canadian Statistical Review.* Catalogue No. 11-003.
Statistics Canada, *Industrial Corporations.* Catalogue No. 61-003.

9 per cent to the GDP with a very large range (a factor of 20) apparent between the largest and smallest contribution.

The trend over the past thirty years is in the direction of a decreasing contribution from approximately 20 per cent of GDP in 1939 to the 9 per cent value current today. Within the primary resources themselves, taken as a group, the Fisheries and Forestry components have remained approximately constant at roughly 3 per cent and 10 per cent of the group respectively. Agriculture has declined from close to 60 per cent down to about 45 per cent while Minerals have increased from about 30 per cent to 43 per cent over the thirty year period. It is emphasized that these are percentages of GDP. In actual dollars they have all increased as shown in Table I.2.

In terms of both output and exports, the agricultural and mineral industries are dominant, both making similar contributions. Employment is significantly higher in the agriculture than in the other resource areas.

Table I.2 – Gross Domestic Product at Factor Cost by Resource Industry, 1930–1968
(in millions of dollars)

Year	Agriculture	Forestry	Fish & Wildlife	Minerals	Total Primary Resources	Total National
1930	629	61	30	183	903	5 351
1940	682	100	29	363	1 174	6 045
1950	1 694	354	97	649	2 794	16 273
1955	1 636	480	79	1 047	3 242	24 860
1961	1 519	383	91	1 421	3 414	34 966
1968	2 602	556	154	2 494	5 805	63 623

Source: Statistics Canada, unpublished data.

Indirect Contributions

The Dependent Industry Concept

In a complex industrial economy, a given industry exists and prospers in an environment with 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 (to be determined) "depend" for their existence. Nevertheless, an exercise of this kind may be worthwhile to reveal the nature of the linkages that likely exist in the economy, and thereby to more adequately depict the total effect on the economy of a given primary resource than is accomplished by comparisons of GDP or output.

A particular example of linkage between industries and of the inadequacy of a direct comparison of GDP is found in the Forestry industry, where the primary resource, Forest Products, consists essentially of round logs. It is clearly necessary to include sawmills, which are closely associated with the Forestry industry. But how far can this be extended? Should the Veneer and Plywood industry be included, or the Furniture industry? The indigenous forestry products may form only a small part of the commodity inputs, if imported woods and other materials are used predominantly. An impartial and precise method of defining and identifying dependent industries must be found.

An instrument which permits this kind of analysis is available in the Input-Output model developed by Statistics Canada and described in their Input-Output tables[4]. These tables, which form a part of the total System of National Accounts provide statistical estimates of the industrial structure of the economy. The input tables represent the pattern of "commodity inputs" (or intermediate inputs) and primary inputs (wages, salaries, profits, etc.) being channelled into different industries and also show the distribution between industries of a given commodity. In preparing these tables Statistics Canada is obliged to honour the confidentiality of information relating to individual companies. This requires that the information be maintained at a sufficiently low level of disaggregation so as to preserve the anonymity of individual companies. Thus, commodity groups are listed in various degrees of disaggregation ranging from a low of 40 to a high of 644 commodities, while industry groups are similarly treated from a low of 16 to a high degree of disaggregation given by 187 industry classifications. Working at a given level of disaggregation, it is then possible to quantitatively determine the magnitude of the commodity inputs, originating from a given primary resource, going to each of the industry groups concerned.

The relationships provided by the Input-Output model, now make it possible to introduce a working hypothesis which will permit the "dependent" relationship between an industry and a resource commodity to be determined. The yardstick adopted here to identify such "resource-dependent" industries is based on the relative size of the resource commodity

input, compared with the total commodity inputs. All the industries in the input tables are scrutinized and where the ratio of the value of the resource commodity input divided by the total value of all commodity inputs is high, the dependency is taken to be high. In order to establish a clear distinction between the dependent and independent, a critical value of this ratio must be defined. To be specific, an arbitrary value of one-half has been adopted, above which industries are defined as resource-dependent. In selecting a value of one-half, as the dependency indicator, the danger of double accounting is avoided, whereby an industry might be counted as dependent on more than one resource.

The process described above, while identifying those industries immediately dependent on the resource commodity (first order dependency), does not evaluate the full range of dependent industries. The process must be a reiterative one, as in some cases there will be industries dependent on the combined inputs of commodities from both the primary resource industry and the first-order dependent industries. It is necessary to repeat the analysis using the same dependency ratio, but with the commodities which form the output of both the resource industry and its previously identified dependents being used as the crucial commodity, instead of the resource commodity alone. This will identify second-order dependency, but the process must be repeated until no further dependent industries of a higher order are identifiable. For example, having identified sawmills and veneer and plywood industries as dependent on forest products, the next step is to search the input tables for industries which are dependent on the combined outputs of the forest product, sawmill, veneer and plywood industries. Once sash and door industries and the pulp and paper industry are identified as industries of second-order dependency, the process must be repeated until no further industries qualify as dependents.

Table I.3 summarizes the results of the process described, listing the dependent industries for four resource commodities and separating them into different orders according to the sequence of identification in the reiterative process. In Table I.4 are listed the "values added" by both the resource industries and their dependent industries. Also shown is a comparison of total outputs from the different groups of resource and dependent industries. It is interesting that, on a comparison of GDP, agriculture outperforms the mineral industry, but the dependent industries put the mineral industries well in the lead on total GDP or value added. In a comparison of total output the two are almost equal reflecting the greater quantity of intermediate inputs to agriculture. Forestry is characterized by a relatively large dependent industry component.

When R & D expenditures are compared with the total output, as in the last three lines of Table I.4, the percentage for fisheries is seen to be particularly high.

Dependent Industries and Tariff Barriers

While on the subject of dependent industries it is appropriate to digress a little and ask why more dependent industries have not flourished in Canada. In those resource industries which export a large portion of their production, the tariff barriers in world markets and particularly in the U.S.

Table I.3 – Pattern of Resource-Dependent Industries

Resource Inputs	Resource-Dependent Industries		
	First Order	Second Order	Third Order
Agriculture			
Primary agricultural products	Meat processors Poultry processors Dairy factories Flour mills Vegetable oil mills Leaf tobacco processing	Feed mills Tobacco products manufacturing Leather tanneries	Shoe industries
Forestry			
Forest product inputs	Sawmills Veneer and plywood	Sash and door Pulp and paper	Paper box and bag manufacturing
Fisheries			
Fishing and hunting inputs	Fish product inputs		
Mineral			
Mineral resource input	Smelting and refining Petroleum products	Iron and steel mills Non-ferrous metal rolling and casting	Steel pipe and tube mills Fabricated structural metal Metal stamping Wire and wire products

Source: Dominion Bureau of Statistics, *The Input-Output Structure of the Canadian Economy, 1961.* System of National Accounts. Cat. No. 15-501 and 15-502. Plus a later unpublished version by Statistics Canada.

Table I.4 – Contribution of Resource and Resource-Dependent Industries (1961)
(in millions of dollars)

Value Added	Agriculture	Forestry	Fisheries	Mineral	National
By Resource Industry	1 880.0	425.8	90.4	1 562.4	
By Dependent Industry	599.9	1 237.0	40.6	1 330.6	
Total Value Added	**2 479.9**	**1 662.8**	**131.0**	**2 893.0**	**35 000** (GDP)
As percentage of GDP	7.0	5.0	0.4	8.2	100.
Total Output	6 424.4	3 784.9	316.5	6 997.9	65 217
R & D Expenditure	75.	24.	33.	66.	400.
R & D as percentage of Output	1.2	0.6	10.4	0.9	0.6

Source: Dominion Bureau of Statistics, *The Input-Output Structure of the Canadian Economy, 1961.* System of National Accounts. Cat. No. 15-501 and 15-502.
Science Council of Canada Report No. 19 and miscellaneous other sources.

market are significant in determining the strength of dependent industries. The raw material will frequently enter the U.S. duty free, but there is a rising rate of tariff as the export is more refined and finished. For example, nickel accounts for 3 per cent of all Canadian exports and of this, 51 per cent enters the U.S. market. Approximately 82 per cent of the nickel exported to the United States is in refined form (raw cathode nickel) and is subject to a relatively low tariff rate (at present in abeyance), but higher tariffs are imposed on semi-finished nickel alloy, ingots and stainless steel (see Table I.5) while the crude material enters the U.S. duty free. Similarly, escalating tariff structures face agricultural, forestry and fisheries products entering the United States. This type of tariff structure discourages the expansion and creation of dependent industries in Canada and there will be little significant growth in these areas until the reduction of such tariffs is negotiated.

Table I.5 – 1969 Nickel Exports to U.S.

Form	Short Tons	Percentage	U.S. Tariff
In matte	69		free
In oxide sinter	19 491	18.3	free
Refined metal (normally raw cathode nickel)	86 768	81.6	flakes – 8¢ per lb.* anodes – 8¢ ad valorem*
Finished metal		Small	angles, shapes, sections – 14% ad valorem bars, plates, sheets, strips – 19% ad valorem
Total	106 328	100.0	

*This tariff was suspended in 1969 during nickel shortage.
Source: Canadian Minerals Yearbook 1969, Distribution Office, Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa, 1970.
Tariff Schedules of the U.S. Annotated, 1970, U.S. Tariff Commission, Washington, D.C., 1970.

Impact Analysis

The Input-Output tables, in addition to describing in detail the primary inputs (wages, salaries, profit, etc.) and intermediate inputs (commodities) going into selected industries, also incorporate "Impact" tables. These tables measure the effect on the economy of increasing expenditure on final demand for any chosen commodity by a fixed amount (usually $1 000 or $1 000 000). Such an increase in output involves increases in various inputs and in the case of the intermediate inputs they in turn require further intermediate inputs of their own. Input-Output analysis makes it possible to trace and measure the total impact of successive rounds of these expenditure flows. In doing this, certain statistical relationships between consumer demand and industry supply, and between industry output and industry inputs are assumed. The Input-Output analysis thus provides measures not only of the total direct effect on a particular industry, but also of the indirect effect on other interdependent industries, produced by a given increase in expenditure on final demand for a commodity. In the sequential process of measuring the various intermediate inputs it is possible to integrate the primary inputs of the various industries involved, giving the total impact of the increase in output on, for example, Wages and Salaries. With some modification the model can also be used to derive the contribution to taxes and to corporate profits.

The potential of the model for this particular study lies in its ability to predict the various impacts on the economy of increasing final demand in any commodity or group of commodities. If the object of research and development is to increase the total production of a resource industry, then the impact analysis will compare the benefits of increased production in various industries.

The impacts of increased expenditure on final demand in a number of selected commodities have been compared by Statistics Canada, allowing for the effects of the additional consumer spending involved (the consumer multiplier).

In Table I.6 an increase in final demand of $1 000 000 has been selected and the effects of such an increase in 22 industrial products are itemized in separate horizontal rows. The total industrial production in each case is a gross figure and is approximately four times the increased expenditure on final demand due to the double accounting that occurs in adding the production of intermediate commodities which are included in subsequent production. The gross domestic product at factor cost represents the value added to the economy and exceeds the $1 000 000 by an amount corresponding to the "value added" associated with consumer spending.

A few notes of explanation:

1) Net income of unincorporated business (NIUB) refers to income other than wages, salaries and corporate profits (e.g., farmers, doctors).

2) Surplus, roughly defined, includes corporate profits before payment of dividends and taxes, depreciation, interest paid less investment income.

3) Final demand includes consumer spending, government spending, capital spending and exports.

It may be concluded from this analysis that the impacts as measured

Table I.6 – Impact of $1 million Expenditure (in thousands of dollars)

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

Source: 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.

by wages and salaries (W & S + NIUB) in general show relatively small differences between expenditures on different products, although the largest increase in employment occurs with increased demand for renewable resource products (Items 1, 2 and 3), and for coal (Item 21) when using a finer breakdown of products. However, these resource products are ones in which it is difficult to further increase final demand (primarily export markets), by the application of science and technology. Aircraft products (Item 12) and electrical equipment (Item 14) have a similarly large impact on employment, with the smallest impacts being associated with minerals (Item 4), chemicals (Item 16) and motor vehicles (Item 13). The largest increases in imports are also associated with the latter. The greatest increases in corporate profits correspond to minerals (Item 4).

The analysis does not of course take into account the type of employment incorporated in the total impact on wages and salaries. Additional coefficients would have to be introduced into the model to be able to assess the impact on, for instance, highly qualified manpower.

In comparing the impacts on wages and salaries (W & S and NIUB) shown in the table, it should be remembered that these represent the sum of the impact throughout the economy. For instance, an increase in final demand of $1 000 000 for agricultural products produces a total impact on wages and salaries of $1 012 000, but the impact on wages and salaries (W & S and NIUB) in the agricultural sector is only $439 000 (not shown in table). The ratio of these two figures (2.3) represents a "multiplier" factor. Contrary to popular opinion, the total national employment opportunities associated with increased production in the resource industries compare favourably with other industries.

From this brief description of the Input-Output model, it should be apparent that such models have great potential as aids to decision making at a national level. A particularly obvious and topical example would be in the formation of an Industrial Strategy where the model would assist in the selection of industries for the process of specialization and rationalization. An important question that frequently arises, in this connection, concerns the optimization of the use of labour in the growth of different segments of industry. The problem has usually been dealt with in the past by using over-simplified arguments, based on the relative importance of capital and labour and the distribution of labour between industries. Manufacturing industry is said to be "labour intensive", while primary resource industries are "capital intensive"; the current distribution of labour shows that 24 per cent is involved in manufacturing while only 1.5 per cent is engaged in the mining, oil and gas industries. It is then argued that the only obvious policy for economic growth that will maximize job opportunities is one that encourages manufacturing rather than resource industries. The conclusion may or may not be correct, but the argument is certainly invalid as it does not take into account the different degrees to which these industries depend upon commodity inputs (intermediate inputs) from other domestic industries and from abroad. Only by using an Input-Output model is it possible to compare the full impact of one industry on the total economy with that of another, thus providing a more rigorous basis upon which the labour utilization question can be judged.

As a specific illustration, the effect on labour utilization of increasing the final demand for mineral products might be compared with an equivalent demand for motor vehicles. Conventional wisdom would tend to identify the total impact on employment with the low labour intensity of one group and the high labour intensity of the other. Using Input-Output analysis it can be seen that the impact on wages and salaries (including income of unincorporated businesses) of a $1 million increase in expenditure in final demand would be $713 000 for the mineral products and $802 000 for the motor vehicles. There is still a significant difference, but not as great as would be imagined from a study of direct employment in the two industrial areas. The impact table also shows that the contribution to GDP would be greater in the case of mineral products, due primarily to lower imports and higher corporate profits in the mineral industry.

The impact is proportional to the net commodity expenditure, which does not have to be $1 000 000 and could be very small or even negative. It may be looked upon as a rate of increase with commodity expenditure. The impact can of course apply to any of the parameters listed in Table I.6. If the goal of a national strategy was to optimize any one of these parameters, production reduced in an area of low impact, but increased in an area of high impact, would on the whole be beneficial to the economy.

It is perhaps appropriate to mention here some of the refinements being considered at present by Statistics Canada, which would considerably improve the usefulness and reliability of the Input-Output model. There would appear to be a sufficient number of potential users and applications to warrant a greater allocation of funds and personnel to up-dating the data base and maintaining it in a reasonably current condition. A useful modification would be the introduction of the concept of industrial activity to handle the high degree of interdependence between mining and primary metals, where vertical integration and multiple production are prevalent. The impact of capital expenditures required to produce additional output is another much needed refinement.

The present model may be modified so that the impact of the resource industries is not measured, if interest lies solely in assessing the impact of manufacturing industries and it is assumed that additional demand for resource commodities will replace existing export activity. This would be accomplished by equating the import co-efficients for the resource commodity to unity. In this study it has been assumed that additional demand for resource commodities, as intermediate inputs to other industries, would be added to the existing export demand. Both models are legitimate and the choice of the most appropriate would depend on government policy.

One further use of the model, in the context of developing an Industrial Strategy, is in the estimation of the impact of a given increase in production on the balance of international trade. If it is assumed that the expenditure on final demand for any selected industrial product is entirely in exports, then the Input-Output tables will give the imports involved and the corresponding change in the balance of trade. This may be estimated with the resource commodities required being in excess of previous demand or replacing exports (import co-efficients equated to unity). The latter condition naturally involves a much smaller impact on the trade balance and, incidentally, corresponds with a policy of resource conservation.

Implications for Science Policy

The foregoing discussion is intended to draw attention to a number of analytical methods that may be useful in giving a clearer and more comprehensive picture of the economic significance of the various primary resource industries. The complexity of optimizing the domestic system as a whole should not detract from the importance of other considerations such as maintaining a healthy balance of international payments, regulating the degree of foreign control in strategic industries and encouraging regional development on a carefully planned basis. It is important to emphasize here the need to use as broad an outlook as possible in a total assessment of the economic consequences of growth in the primary resources.

There remains the difficult question of what implications this assessment has for Science Policy. Assuming that the exercise has been successfully carried out, and that both the present contributions to the economy of the resource industries and the impacts of increased production (or reduced prices) have been measured, what guidelines do these provide for Science Policy? Before answering this question, an earlier recommendation should be recalled: that government must accept a responsibility for a variety of inter-resource problems associated with optimizing land usage, protecting the environment and planning for the long-term conservation of all resources for future generations. The last of these is particularly important in the context of this discussion, as in the long-term the structure of Input-Output models will change. By careful planning and use of newly developed methods of modelling the dynamic characteristics of complex systems, using conceptual computer simulation, this change can be predicted and controlled. It will be possible to predict conflicts between world trade patterns, growth in resource usage, population growth, land usage and environmental quality. Science can then be directed toward alleviating these conflicts in Canada.

For the relatively short term and until such simulation models have been perfected, there is much to be gained by the judicious use of the economic parameters outlined earlier. Research and development directed toward increased production, new products, increased efficiency or improved competitiveness, should have to stand the test of what such improvements will do for the national economy as a whole. It is not a question of whether research and development should be strong or weak in areas of high GDP contribution or high labour content; the criterion must be one of impact on wages and salaries or government taxes, or a combination of both these and other selected parameters, which will be determined by political goals. This is not put forward as an argument for more mission-oriented research, but as a case for re-aligning existing patterns of orientation. The component of basic research will be a necessary one, but this aspect is discussed elsewhere, in the Science Council's report on basic research.

From a strictly quantitative view, the impact of research on the economy takes place in two distinct stages. First, research produces increased efficiency or productivity, as evidenced by reduced price or increased production. Second, this improvement in the performance of the industry is

reflected in an impact on the economy as a whole. The Input-Output tables provide the relationship between increased output (or reduced price) and the impact on the economy, but the relationship between R & D and improved performance of the resource industry is more difficult to assess. Before R & D can be related to the full impact on the economy, a value judgement must be involved in determining the relationship between R & D input and increased output, efficiency or price reduction (in the case of the price model).

If we are dealing with the effects of increased output on the model, the relationship between output (V) and R & D expenditures per annum (S) will have certain boundary conditions. There is presumably a share of the market which will be obtained without any R & D ($S=0$) and a gradual levelling off in the effectiveness of R & D as S becomes very large. The relationship might be expressed in the form:

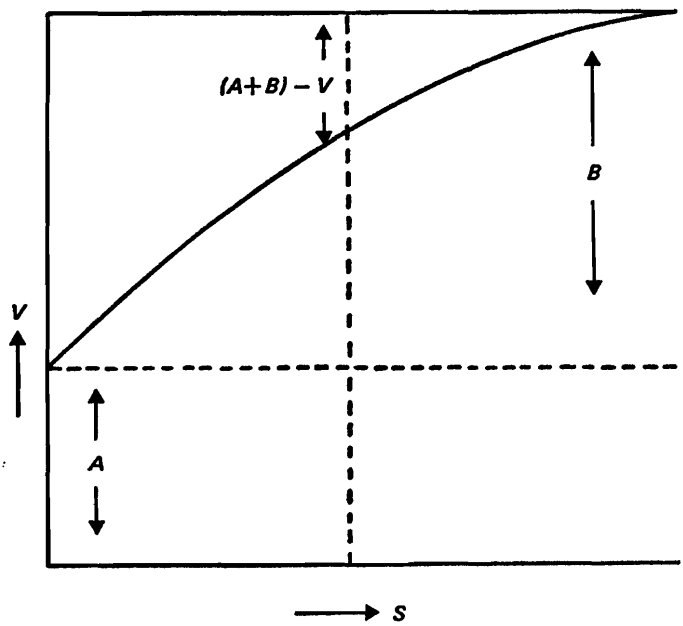
$$V = A + B(1 - e^{-kS}) \tag{1}$$

where A, B and k are constants peculiar to a given industry

A is the value of V when $S = 0$ and $A + B$ is the value when S is very large

k determines the rate of logarithmic approach from A to $A + B$

B represents that share of total possible production which may be attributed to R & D



The effectiveness of R & D will be given by the first derivative of (1)

$$dV/dS = k \cdot Be^{-kS} \tag{2}$$

$$= k \cdot ((A + B) - V) \tag{3}$$

which says in effect that for a given science expenditure (S constant) the effectiveness of research and development in increasing or maintaining

production, is proportional to the product of the potential improvement $((A+B)-V)$ and the gradient of logarithmic approach (k).

If the impact measured by the Input-Output tables is taken as a multiplier (i.e., the total impact, divided by the commodity expenditure) and this is identified as *Ip*, then the impact of a given science expenditure on the economy will be given by *Is*, where

$$Is = k \cdot Vp \cdot Ip \tag{4}$$

Vp being used to express the potential production $((A + B) - V)$

k which determines the shape of the *V-S* curve shown above may be looked upon as a research opportunity factor. (The steepness of approach to saturation increases with increasing *k*.)

Equation (4) thus states that the impact of increased research and development expenditures on the economy will be proportional to the product of the opportunity in the field, the impact multiplier and the potential production. The impact *Is* may refer to impact on wages and salaries, impact on GDP, impact on taxes, or any combination of these.

The lesson to be learned from the foregoing analysis is that the impact of science expenditures on the economy is a combination of a number of factors and is not entirely dependent on production impact obtained from the input-output analysis. There would be a direct relationship only if it could be assumed that the effectiveness of research (dV/dS) was equal in different fields.

The effectiveness of R & D is a difficult quantity to measure, but using the above analysis it may be viewed as the product of research opportunity and production potential. For lack of suitable criteria research opportunity might be assumed to be equal in different fields. This is not as wild an assumption as it might first appear, because until the research is done, the opportunity cannot be fully evaluated. Furthermore, the larger the aggregations of industry, the greater the variation in activity within each aggregation and the more likely the equality of research opportunity. Allocation of research funding on a basis other than the equality of research opportunity would call for some very positive identification of the differences in order to be fully justified. The production potential will be reflected in the availability of markets and of capital and to a certain extent the existing size of the resource industry. The effectiveness of research will thus be determined by the Impact, availability of markets and capital and the size of the industry.

From this rather crude analysis it would seem that the use of the direct contribution to the economy, described earlier, would be misleading as a guide to the allocation of R & D funds. The Impact is more important, but where the Impact is highest the market potential is frequently low. This would seem to indicate that resources-related R & D directed toward dependent industries, such as wood and paper products, and metal products is most likely to have an impact on the economy as a whole.

Reference should be made to the Appendix for an example of how, with some qualifications and assumptions, the quantitative approach could be used to assess the ultimate benefits of R & D.

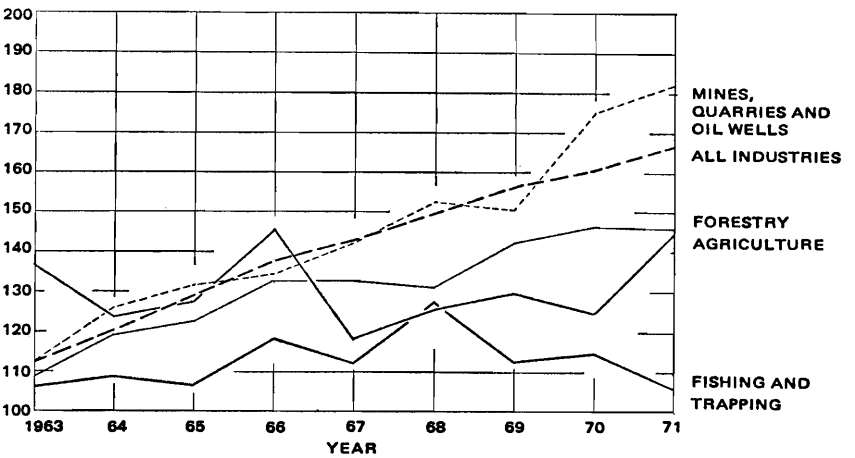
Trends in the Resource and Resource-Dependent Industries

In addition to studying the complexities of the interaction between the resource industries and the economy it is also desirable to know something about the trends in the resource and resource-dependent industries. The health, viability and future prospects of the resource and associated dependent industries in Canada are of vital importance to any review of science expenditures in these areas. Many factors will determine the future performance of these industries, the availability of labour and capital, exchange rates, tariff and non-tariff barriers, the international balance of payments and the application of science and technology, being but a few of the factors which will have either direct or indirect impact on performance. While the effects of many of these are difficult to predict individually, their combined pressure over the past decade is revealed in statistics published by Statistics Canada and represented as time series in Figures I-1 to I-6. Three indicators are used, production as represented by volume of production index, employment and corporate profits. The resource industries and resource-dependent industries are shown on separate diagrams.

There are some significant trends in the production index. The performances of the resource industries, compared with a national index of production, fall into two categories, the mineral and forestry industries, which have shown a rising rate of production comparable with the national average and the agriculture, fishing and trapping industries which have shown little if any growth (Figure I-1). The resource-dependent industries show a different pattern of growth when compared with the national average. In Figure I.2 it can be seen that while the primary metal industries have shown a growth rate at least comparable with the national figure, the wood, paper and allied industries have shown a lower growth, with a decline in recent years. Turning to corporate profits, Figures I.3 and I.4, an even gloomier picture is portrayed. In all but the mineral industries profits remained either constant or declined. The profits in the primary metals, wood and paper industries are compared with all manufacturing in Figure I.4. Despite the poor performance of manufacturing in general, the wood and paper industries show an even greater decline in profits, with the primary metals industries performing only a little better.

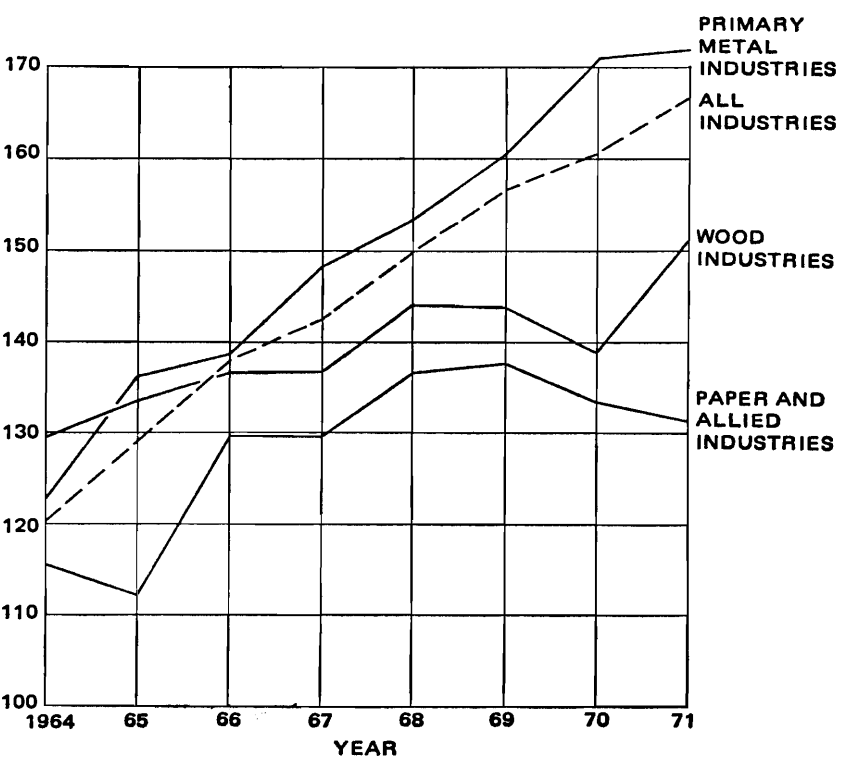
The employment indices for both the resource industries and the resource-dependent industries (Figures I.5 and I.6) have one trend in common, they show either a decline in employment or a rate of increase lower than the rate of increase in the production index. This may be attributed in general to increased productivity due to either greater capitalization or improved factor productivity (improved technology, management and other efficiencies). Employment reduced for these reasons does not necessarily mean that these industries have a negative effect on the rate of increase in national employment. Increased capital expenditures on construction and capital goods means increased employment in the building and building supplies industries and in the capital goods industries. Improved factor productivity means increased employment in the service and high technology industries.

Figure I.1 – Volume of Production Index, Resource Industries (Real Domestic Product 1961 = 100)



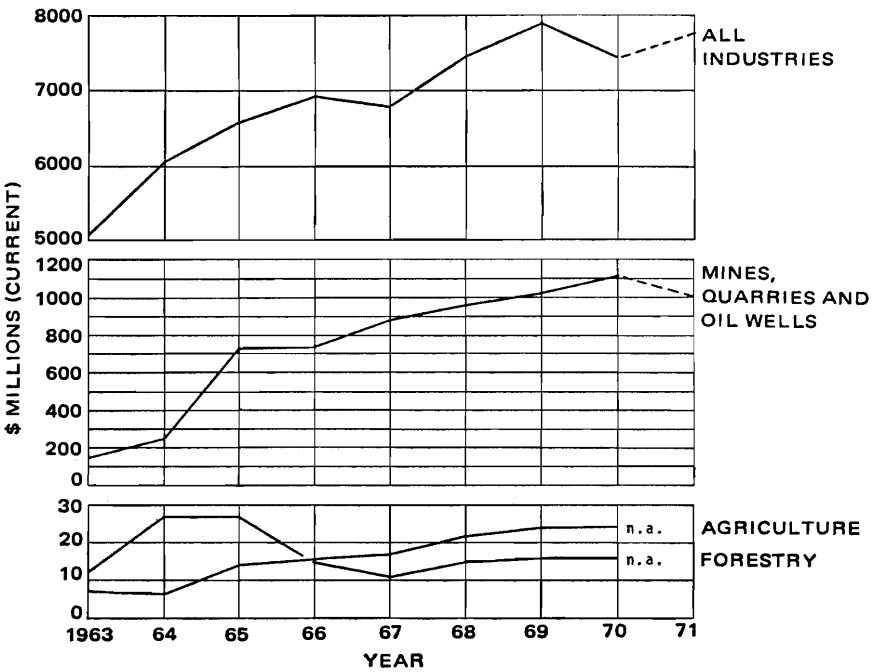
Source: Statistics Canada, *Canadian Statistical Review.* Cat. No. 11-003.

Figure I.2 – Volume of Production Index, Resource-Dependent Industries (Real Domestic Product 1961 = 100)



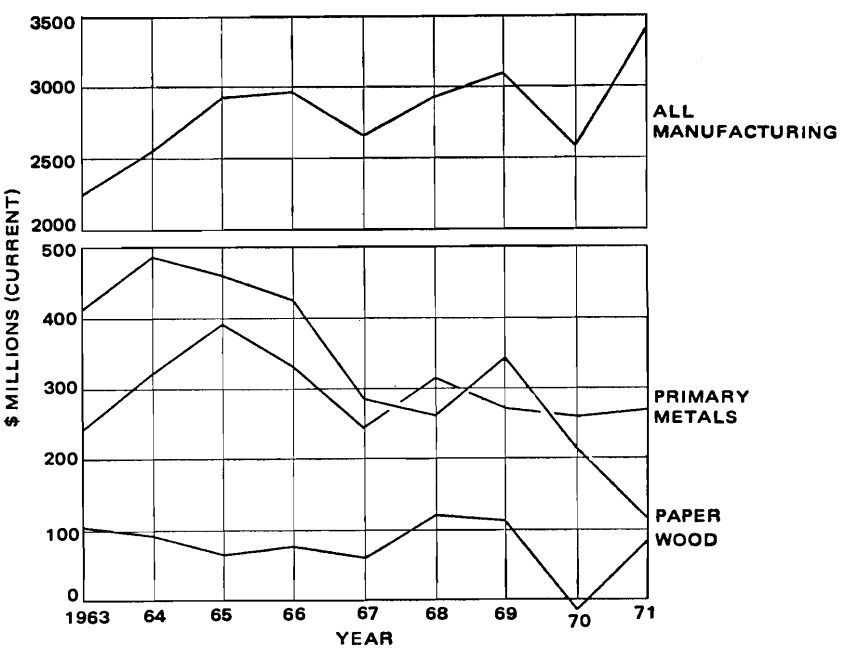
Source: Statistics Canada, *Canadian Statistical Review.* Cat. No. 11-003.

Figure I.3 – Corporate Profits, Resource Industries



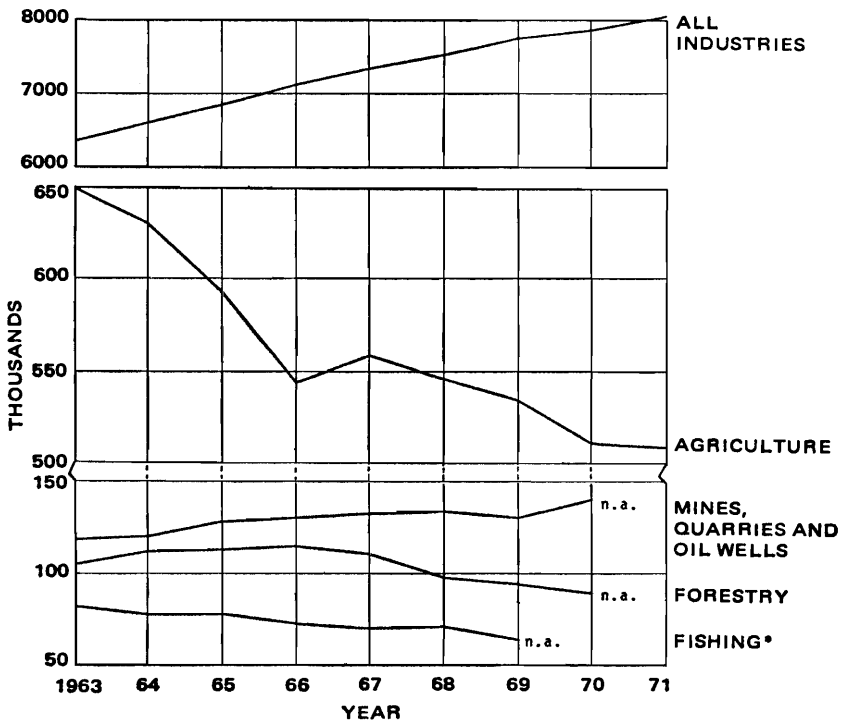
Source: Statistics Canada, *Canadian Statistical Review.* Cat. No. 11-003.
Statistics Canada, *Industrial Corporations.* Cat. No. 61-003.

Figure I.4 – Corporate Profits, Resource-Dependent Industries



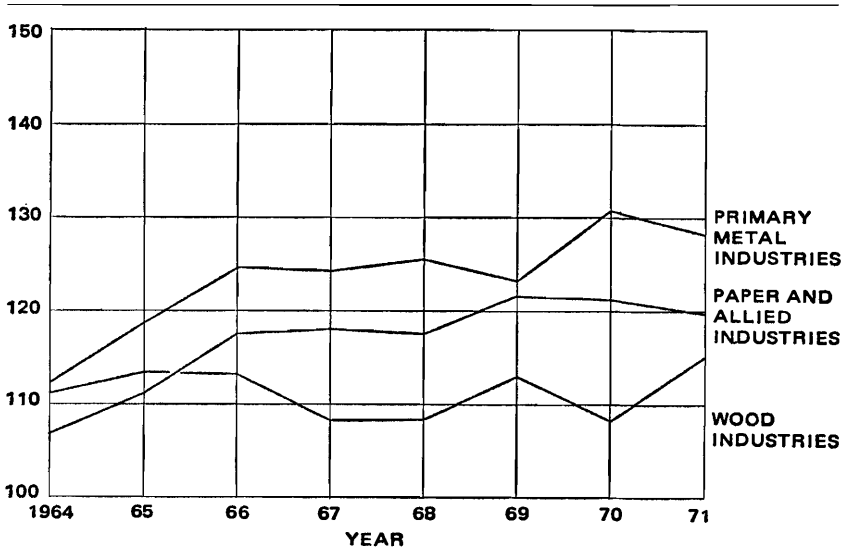
Source: Statistics Canada, *Canadian Statistical Review.* Cat. No. 11-003.
Statistics Canada, *Industrial Corporations.* Cat. No. 61-003.

Figure I.5 – Employment in Selected Resource Industries



*Trapping figures are not included.
n.a. not available
Source: Statistics Canada, *Canadian Statistical Review*. Cat. No. 11-003.

Figure I.6 – Employment Indexes, Resource-Dependent Industries (1961=100)



Source: Statistics Canada, *Canadian Statistical Review*. Cat. No. 11-003.

Reference has already been made earlier in this study to the advantages of promoting the resource-dependent industries. It should therefore be a matter of concern that none of these industries are growing at a rate greater than the national industrial average (using the volume of production index). The primary metals industries are the best performers, holding their own with the average, but the wood, paper and allied industries are at present in a decline despite the growth which is apparent in forest products.

In addition to the political and economic desirability of promoting resource-dependent industries there are at present distinct technological opportunities. Many such industries, particularly those associated with mineral and metal extraction and the pulp and paper industry have, in the past, had a propensity to produce a high level of air and water pollution. This has recently resulted in the shut-down of a number of older plants in both the U.S. and Japan, as stricter laws protecting the environment are enforced. The consequent shortage of certain types of plant capacity is a trend which will no doubt continue. The opportunity for science and technology rests in the challenge to produce new and cleaner processes to fill the gap. (An example is the present world shortage of copper smelting capacity.)

It is suggested that the resource-dependent industries be given special attention in a National Industrial Strategy as their growth has the potential to absorb some of the output of the resource industries thus alleviating the balance of payments problem which could be associated with increased growth in other secondary industries. Impediments to the growth of these industries, such as tariff barriers should be reduced by negotiation wherever possible.

Conclusions

The quantitative approach to assessing the impact of research and development on the economy is not the panacea for all science policy, but it does provide some useful guidelines. If the goal of research related to the resource industries is an entirely economic one, such as increased employment (as represented by wages and salaries), increased taxes, increased corporate profits or a combination of any number of these, then there is a quantitative approach to assessing the allocation of R & D funds on a national scale. The federal government is heavily involved in both government and university research in both the renewable and non-renewable resources and has the ability to provide or remove incentives for research in industry. It therefore has the means at its disposal to allocate and implement priorities in research and development funding.

In the quantitative assessment of research impact on the economy there is still room for further data. A particular need is to include the recreational value of resources. This could be done by assuming a major resource input to the tourist and recreational industries associated with forestry and fishing and to include these as dependent industries.

The identifiable resource-dependent industries would appear to be a segment of industry meriting closer attention, as their growth would not only have a considerable impact on the economy, but such growth would have the ability to absorb and replace resource exports rather than competing with them. This latter characteristic does not normally apply to other secondary industries, where increased exports will disturb the international balance of payments unless complimentary imports are increased or existing exports decreased.

It may appear that many aspects of environmental protection associated with the resource industries would be neglected in any quantitative assessment of research impact, but this is not necessarily the case. Once funds have been allocated on an economic parameter basis, the management of these funds would still be left to the discretion of the three sectors. Furthermore, appropriate government legislation on environmental issues has the potential to make research related to environment protection as profitable from an economic standpoint as that directed toward increased production, productivity or employment.

In the short and medium term the quantitative assessment of research impact on the economy is attractive as a rational alternative to the present traditional approach to allocating science funds. It has, however, a major weakness for the long term in that it does not take account of trends which could lead to major changes in the economic structure. The research carried out today will find application in ten or twenty years time and it is important that it be related to conditions which will prevail at that time in the future. There are today inexorable forces of population growth, energy consumption, food consumption, land usage, mineral depletion, and environmental pollution, which will, to a large extent, determine these future conditions, barring major catastrophies of a discontinuous nature. It is therefore essential that new methods of computer simulation be applied to modelling the basic structure of these resource trends and their interrela-

tionship, in order to enable impending crises to be averted by heavy emphasis on certain areas of critical research. Such modelling techniques will take time to develop to the stage where they can be used with confidence and their forecasts accepted by governments. In the meantime the quantitative assessment of research impact should be fully assessed and the results used in a framework of national goals.

The responsibility for assessing research impact on the economy, for initiating computer simulation studies and for implementing the results in pressing for any re-allocation of funds which may be necessary, is clearly the responsibility of the Federal Government. Only this level of government has sufficient power through funding to significantly change the allocation of funds to research and development.

References

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

2. Intermediate inputs represent commodities consumed in the process of production.

3. GDP, the Gross Domestic Product at Factor Cost is the GNP reduced by both income received from non-residents and indirect taxes less subsidies (GDP at Market Prices is GNP less income from residents).

4. Dominion Bureau of Statistics, *The Input-Output Structure of the Canadian Economy, 1961*. System of National Accounts. Cat. No. 15-501 and 15-502.

Appendix– Effectiveness of R & D Expenditures Related to National Employment Opportunities

With some assumptions and approximations it is possible to assess the probable impact on future employment opportunities of Federal Government R & D expenditures and to use these figures to allocate priorities now. The relationship derived previously on the subject is the following:

$$Is = k \cdot Vp \cdot Ip$$

where Is is impact of a given science expenditure on the economy (impact on employment is chosen here)
k is the research opportunity factor
Ip is the impact coefficient (total impact divided by figure for increased final demand)
Vp is the maximum possible increase in production

In order to be able to arrive at some estimates for Is the following assumptions must be made:

Assumptions

1. "Research opportunity" k is equal in different fields.
2. All research is oriented toward economic gains and that different assessments will be used for R & D related to regulatory rôle.
3. Regional impact is not considered in allocation of research priorities. (Efficiency dominates over distribution of benefits).
4. Potential increase in the market Vp is either a) proportional to existing market (output) b) equal in different fields.
5. For this particular analysis, benefits of research are measured as increases in employment income throughout the economy.

The results of an analysis of the effectiveness of R & D expenditures, based on these assumptions are given in Table I.7. There are two possibilities:

a) Vp proportional to existing market. Column D then represents the Benefit/Cost ration of R & D.

b) Vp equal in different fields. Column C then represents the Benefit/Cost ratio of R & D.

Assumption a) would appear the more likely state of affairs and the italicized figures in Column D compare the benefit/cost ratios; high in agriculture and food products, low in fisheries and dependent industries. The present allocation of R & D expenditures appears to bear little relationship to the benefit/cost figures, being particularly low in minerals and forestry (with dependent industries) and high in fisheries. Even with the extreme and unlikely assumption b) that Vp is equal in different fields (column C) the expenditures in minerals and forestry are still low. When expenditures in industry are also included, however, these anomalies are less evident, although fisheries R & D still stands out as very high in comparison with the benefit/cost ratio.

This type of analysis should not be used in isolation, but should be associated with a concurrent analysis of R & D for regulatory functions in the fields concerned.

Table I.7 – Effectiveness of R & D Expenditures (Benefit/Cost) Related to Employment Nationally

A	B	C	D		E	
Field	Total Output Resource and Resource Dependent Industries†	Impact of Final Demand on Employment Resource and Resource Dependent Industries‡	Probable Effectiveness or Impact of Unit R & D Expenditure on Employment (Benefit/Cost)§		Present R & D Expenditure (1971) By Field of Application Normalized*	
	$ millions	*Ip*	Arbitrary Units	Normalized*	Federal	National
Agriculture	6424	1.0	64	*1.6*	2.0	1.7
Fisheries	316	1.1	3	*0.1*	0.9	0.6
Forestry	3785	1.0	38	*0.9*	0.6	0.7
Minerals	6998	0.8	56	*1.4*	0.5	1.0

† 1961 figures (will be updated)
‡ Impact in $ millions on wages and salaries of $1 million increase in final demand
§ Proportional to *VpIp*
* Averaged to unity

II. The Systems Approach to Resource Allocation

by A.D. Chambers

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After working for a number of years as a survey crewman, telephone installer and commercial pilot, Dr. Chambers attended the University of British Columbia where he received a B.S.F. degree in 1964. During the following year, he was employed as a field officer with the Conservation Authorities Branch of the Ontario Department of Energy and Resources Management where he obtained some first-hand experience with local perceptions of, attitudes toward, and attempts to deal with, resource management problems.

In 1967 Dr. Chambers received an M.F. degree from Duke University and began teaching Forestry Technology at Selkirk College, the first of British Columbia's new community colleges. He subsequently returned to the University of British Columbia to take part in an interdisciplinary program designed to look for new approaches to problems in resource management. He received a Ph.D. from that university in 1971.

Dr. Chambers is a member of the Association of British Columbia Professional Foresters, the Canadian Institute of Forestry, and the Ecological Society of America.

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Introduction

Reference to the increasing complexity of the world in which we live has become trite, yet the methods with which we try to grasp and deal with that complexity change very slowly if at all. A decision designed to ease some economic ill may have both economic and social repercussions which even the most experienced and astute legislator did not anticipate. Similarly, the social consequence of some decision taken to correct an undesirable environmental malady might dwarf the original problem. Such echoing has become so familiar throughout our society that terms like "spin off", "trade-off" and "side-effect" have come into constant use in conversation on subjects as diverse as space research, regional development, and the pill. The echoes are symptoms of the increased complexity of the decision makers' milieu, and its diminished capacity to absorb error.

Historically, man's approach to complex situations has been to divide and conquer. Instead of working with whole systems, we study manageable segments in isolation, thus learning something of the structure and function of those segments and subsequently how to manipulate them. The success of this reductionist approach is nowhere more evident than in such sciences as physics or medicine. But it is also apparent in government where new ministries are created in response to an increasingly complex society, and in industry where greater specialization of labour has been used so effectively to meet the complex demands of free enterprise markets. The success of the reductionist approach has so reinforced its use that over the past number of decades we have increasingly become a society of specialists who know more and more about less and less.

Such specialization results in a rapid increase in our total knowledge, the "information explosion", but it also results in a communications breakdown. Specialists in one field do not communicate with those in another because of language (jargon) barriers and because they are physically separated one from another. But of even greater importance, their communication with decision makers may be incomplete and their advice conflicting – particularly when that advice concerns resource allocation. In such situations the need for some method which will facilitate communication and help resolve conflicting advice becomes paramount.

One technique that meets the above requirement has come to be known as systems analysis, simulation modelling, or the systems approach. On the pages that follow, both the technique and an example of its application to a resource problem are described, albeit briefly. The example was not chosen because it represents the range and complexity of resource use conflicts to which the technique may be applied. It does not. Rather, it is simple but complete enough to show both the strengths and the limitations of the approach. In addition, I hope it reveals simulation models to be nothing more than mathematical essays about particular problems, and that being essays, they necessarily reflect the judgement and values of their authors.

Of specific concern to the study described here were the flow of land from agriculture to single family housing and one environmental consequence of crowding. We were looking for underlying rules, hence more

understanding. Similar studies might choose to examine the flow of resources or resource ownership within, or between systems. For example, we need objective assessments of the consequences of foreign ownership, resource export, and the wholesale employment of alien academics. Resources considered could be restricted to land, to minerals, to people, to institutions, or such resources might be considered simultaneously. Alternatively the approach might be applied to the institutional interface between a particular group of people and their resources in a search for rules or laws which govern the production and distribution of wealth. The approach is applicable to studies of a whole country or of some fraction of its geography or people, although the level of complexity to which such studies can be taken must certainly differ as well as the reasons for their initiation. Common to all such studies, however, is the need for an holistic approach. A description of one follows.

The Approach

Quite simply, the systems approach is nothing more than reductionism with a twist. Complex wholes are dissected into manageable units, but with a view toward putting them back together again. Primary interest remains with the functioning of the whole system rather than with that of some individual organ or cell. In describing the approach, jargon rears its ugly head but can be dispatched with a description of the terms: boundary, feedback, and system.

Terminology

Boundary

Picture a one room house. The atmosphere within the house is separated from the world outside by the floor, roof, walls, doors, and windows. Within the house are a heater and thermostat. The house is warmed at a rate determined by the effectiveness of the heater, and cooled at a rate determined by the effectiveness with which the floors, walls, and roof isolate the interior from the rest of the world. The doors and windows provide us with an opportunity to adjust the rate of cooling – or more generally, with an opportunity to adjust the extent of communication between the system and the rest of the world, but the quality of the walls, roof and floor determine the maximum isolation possible. These boundaries with their adjustable features and limits are common to all systems. They determine the exchange that takes place between the system and the rest of the world.

Feedback

Just as there is a flow of information between the systems and the external world, so there is also an internal flow that cycles between individual parts or components of the system. The jargon for this internal flow is feedback and is meant to imply only that the state of the system in one time interval is conditioned by its state in a previous interval.

Consider our own bodies for instance. If our temperature increases above normal our metabolism slows and we begin to perspire. When we are cold, our pores close and we begin shivering, an involuntary exercise designed to return our body temperature to normal. In both cases, the corrective action is an attempt to reverse the warming or cooling trend and is called negative feedback. If however our temperature drops too low we enter a region of positive feedback where cooling reinforces cooling and death will result if we are left to our own resources.

System

A system then, is anything isolated partially or completely from the rest of the world, and within which there is a cyclical flow of information or interdependency of parts. A system is described in terms of its boundaries and internal feedback loops. One might therefore speak of a "heating system" in terms of walls, heaters, and thermostats, an "environmental system" in terms of watersheds and nutrient cycles, a "social system" by identifying a particular group of people and the way in which they interact

with one another, or an "economic system" by focussing on the monetary links between people, their institutions, and their resources.

Identifiable Steps

In adopting the "systems approach" to some problem area, one must first define the boundaries recognized. In doing so the effectiveness of these boundaries in separating the system from the rest of the world is either implicitly or explicitly acknowledged. There are three subsequent steps: analysis, synthesis, and simulation.

Analysis

Having defined the boundaries of a system, attention is turned toward its internal parts and linkages or feedback loops. Characteristically the analysis begins by drawing a flow diagram in which component parts or processes are identified and connected with arrows which designate the flow of information between them (Figure II.1). Each of these components may be further subdivided until the desired level of resolution is reached and a mathematical description of the smallest parts begun. During the entire reduction exercise analysts are forced to define each parameter used to describe a given process, specify the nature of each parameter (constant or variable) and if variable, to identify the origin of that variable within the model system or provide for its manipulation from outside. The behaviour of variable parameters generated within can be either deterministic (calculated exactly) or stochastic (calculated in probabilistic terms) but the analysts must decide which. All participants in the analysis are therefore forced to state clearly and unequivocally their assumptions and knowledge of the system in question.

Synthesis

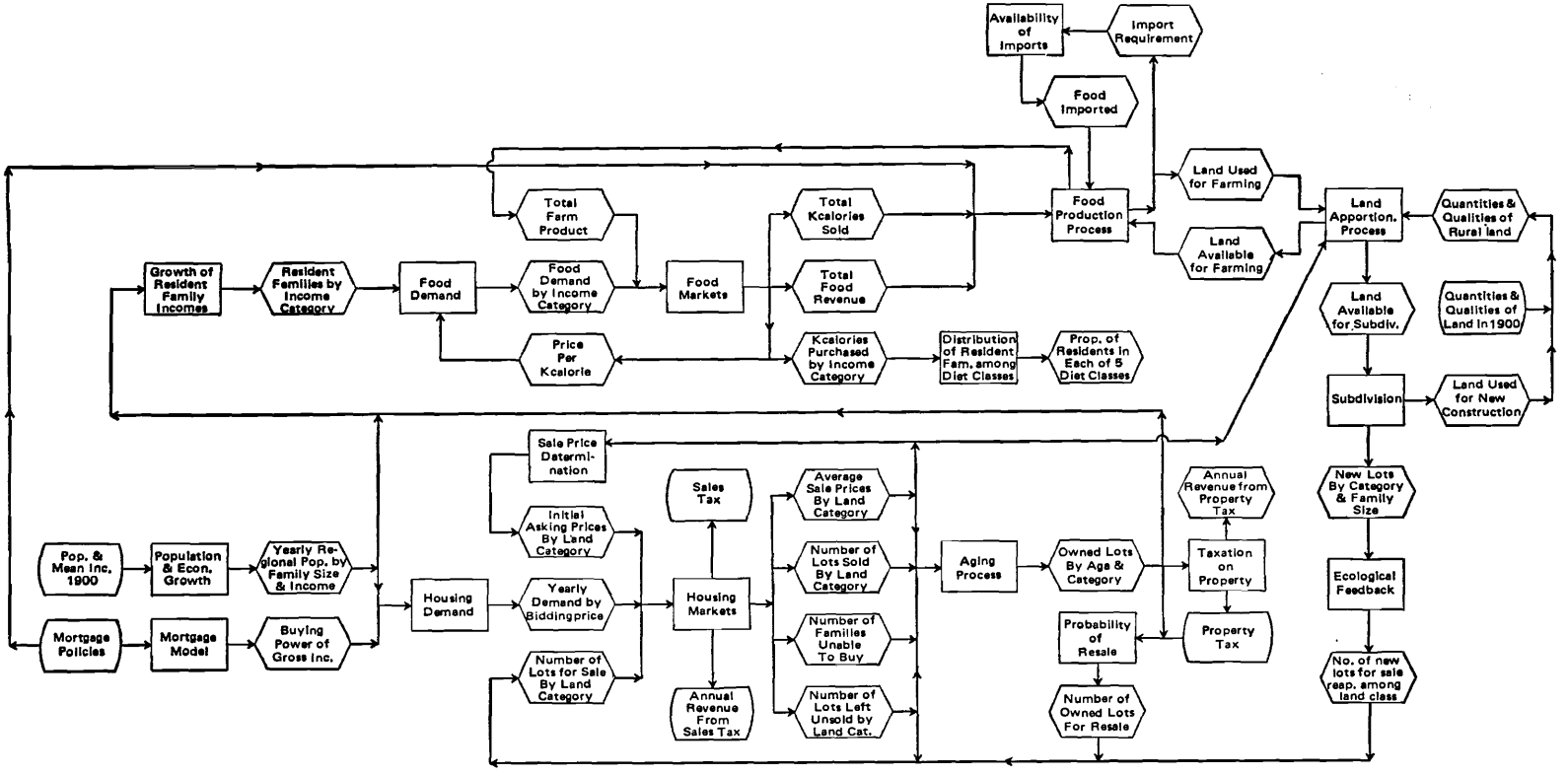
As the analysis proceeds, existing laws and/or data are sought with which to test hypothesized relationships. Where no data can be found, an experimental program is begun or the conjectural nature of the relationship made explicit. Invariably the structure and form of the model changes as individual parts are rejected, modified, or accepted on the basis of their empirical validity. Rejections necessitate a return to the "drawing board" for new ideas to be tested until finally, mathematical caricatures of each relationship to be included in the model have been assembled. These individual parts are then linked together to produce a mathematical model of the real system.

Simulation

Simulation is simply experimentation with a model of a real system rather than with the system itself. Such experimentation allows one to learn something of the system's behaviour so that decisions to be applied in the real world may be made with more complete knowledge. The model then acts as an extension to our memory, helping to keep track of the behaviour of all segments or components while one is changed.

Here lies the great strength of simulation models and their propensity for abuse. So long as we recognize that projections are made only for those

Figure II.1 – Regional Land Development Simulator Flow Diagram



Source: A.D. Chambers and Resource Science Centre

parts of the system the builders have chosen to include in the model, that the interaction between these and the excluded parts are therefore absent, and that because the model is incomplete and comprised of mathematical caricatures, projections must be viewed with suspicion, simulation studies can aid the anticipation of natural or induced change.

Strengths and Weaknesses of the Systems Approach

The principal weakness of the approach lies with the simulation model as discussed above. Those who credit models with the ability to predict the future are indeed unfortunate. But perhaps more unfortunate are those who would believe such claims. They are grasping irrationally. For those who would use the approach to learn more about a given system, its strength lies in two principal features:

1. It provides an analytical framework within which complex systems may be viewed profitably, and

2. It can facilitate communication on two planes:

a) between specialists, viz., between biologist, economist, sociologist and engineer;

b) between adviser and advised, viz., between consultant and decision maker.

Successful application of the approach demands communication between members of the analytical team as the complex whole is first identified, then dissected into its constituent parts and hung upon the analytical framework. Such communication facilitates the organization and reunion of mathematical descriptions of these parts as a model of the original system. The resulting simulation model provides an experimental world or laboratory which can help all concerned to anticipate some consequences of inaction or alternative courses of action.

An Application: The Construction of a Regional Land Development Simulator

The Gulf Islands of British Columbia lie in the most protected waters of the Pacific Coast of North America. Their beauty is widely acclaimed. It is not surprising, therefore, that these islands are experiencing an accelerating influx of summer and permanent residents. So rapid has been this development recently that one frequently hears stories of deteriorating quality. The same story is heard elsewhere with reference to rich agricultural lands and our continued ability to meet our own food requirements.

Using our society's traditional measure of value, the market and ballot box, no justification can be found for claims of lost quality or the misuse of an agricultural resource. On moving from agriculture to more intensive surburban uses, value accrues to the land; prices certainly rise; and how often are governments changed on a platform of "land use"? Yet stories of lost quality and land misuse continue and seem intuitively correct.

In an attempt to view the development of the Gulf Islands objectively, a group of students and faculty of the University of British Columbia applied the systems approach to a study of the islands. The aim of the exercise was to test the utility of the approach to such problem areas: its initial focus was the demand for and supply of building lots on the Gulf Islands. The study subsequently identified and linked processes which describe the apportionment of land to development and agriculture: the subdivision of building lots and consequent changes in their quality, the production of food, the demand for both building lots and farm products, and auctions or markets in which supply and demand interact. The resulting Regional Land Development Simulator mimics the development of the Islands over a 100-year period, given certain assumptions concerning the level of agricultural technology available, future rates of taxation, population and economic growth, the distribution of wealth, and the availability of the islands to developers. More briefly, the model simulates the distribution of the islands as small privately owned parcels of land, and an indigenous food supply to island residents.

Figure II.1 relates the subroutines (rectangles) and linkages (hexagons) which comprise the model. To illustrate the simplicity of many of the assumptions upon which this model depends, one subroutine (*subdivision*) is described in detail in Appendix II.1. To avoid tedium and because the model is intended to portray the utility of the technique rather than provide a background upon which to base specific decisions, only cursory explanation is given the remaining subroutines.

Model Description

Demand for Building Lots

Each year (iteration) the model generates a number of families with a range of incomes, wanting to purchase a lot on the Gulf Islands. Three subprocesses or subroutines are used to generate this demand.

1. The *Population and Economic Growth* subroutine mimics historical census figures until 1961. Beyond that year rates of population and economic growth can be changed at will, so that booms and depressions,

pestilence or population explosions can be introduced.

2. The *Mortgage Model* provides opportunity to manipulate interest rates and amortization periods, hence the maximum price of property a family with a specified income can purchase. It simply provides an opportunity to introduce or remove "tight money" policies.

3. The subroutine labelled *Housing Demand* is analogous with a sieve through which the population is strained to find the number, size, and income of families wishing to purchase a building lot on the Gulf Islands. The sieve's mesh is adjustable using income and family size, which, in combination with a proportionality constant, specify those families in the market for Gulf Island property.

Supply of Building Lots

Similarly, for each year the model generates a number of parcels of Gulf Island land for sale. Six submodels or subroutines perform this task.

1. The *Aging Process* simply returns existing lots to the market according to an age-dependent probability which grows to 1 over a 60-year period.

2. *Taxation on Property* allows tax rates to be increased or decreased, generating revenue for government services.

3. *Probability of Resale* simply speeds the return of existing lots to the market when property taxes are high.

The three submodels above deal only with parcels already in service as building lots. The following three are concerned with the subdivision of "undeveloped" land into building lots.

4. The *Land Apportionment Process* calculates an amount of land available for subdivision each year in each of seven land quality classes. Initial differentiation of land qualities is based on the slope of the terrain, distance to water (lake or ocean) and certain characteristics of the vegetation. For residential use, waterfront property clothed in the Arbutus and shore pine typical of the region is more desirable than a steep, nearly treeless, rocky hillside several miles from the waterfront. Proximity to the ocean assumes a much diminished rôle in determining the desirability of a parcel of land for agriculture. Slope and vegetational characteristics dominate that judgement. Although terribly simple, such abstractions are essential to the modelling effort.

A developer's effort to buy land for subdivision is assumed to be proportional to the size of and trends in recent markets for land of a given quality. But his attemps to purchase land for subdivision are not always successful. As the amount of "undeveloped land" declines, its availability to developers also declines as residents begin to resist further development. In addition, land may be withheld from developers by "zoning" it for agriculture only.

5. *Subdivision* mimics the process by which a developer looks at lot prices, the size of the market, the area and price of land available for subdivision, and anticipated development costs. Two levels of developer sophistication are included in the submodel. The most sophisticated buy undeveloped land and hold it for future development, while smaller, less well financed developers must buy, subdivide, and sell in the same market period.

Both large and small developers produce a size and number of lots which they expect will yield a specified minimum profit. That minimum is defined as a proportion of the expected selling price. Lot size is determined by the pursuit of this profit, given the demand and amount of land available for subdivision, and may be constrained by a policy intervention which specifies a size below which lots cannot be subdivided.

6. The *Ecological Feedback* submodel is conceptually comprised of many parts. Only one, the impact of small lot subdivision on quality is included in this model. *Ecological Feedback*, therefore, simply revises the quality of newly subdivided parcels according to an empirically tested relationship between lot size and subjective preference.

By reducing the quality class of lots subdivided into small sizes, the market in which they are sold changes. That is, within the model there are seven markets in each market period, one for each quality of land. Lots which suffer a quality reduction will, therefore, incur a price reduction as well because of the market change. This consequence is reflected in market information received by the developers and in their assessment of demand for the next market period.

Interaction of Supply and Demand

Having generated a number of lots and a demand for them, the subroutine labelled *Sale Price Determination* calculates an initial or "asking" price for lots each year. Calculations are based on price trends over the past three years (market periods) and a constant which indicates the degree of optimism among developers. The subroutine labelled *Housing Markets* then receives three pieces of information:

1. initial asking price;
2. the demand for building lots (a vector of the number of buyers by price of property they are able to buy); and,
3. the supply of building lots (a vector of the number of lots by quality category).

Proceeding from highest to lowest quality lots, supply is compared with demand. At each comparison three situations can occur. These situations and subsequent action of the *Housing Markets* are as follows:

a) When expressed demand exceeds supply, there are fewer lots than buyers able to pay the initial asking price. Lots are then sold on a "first come, first served" basis. That is, the number of lots sold to each income category is proportional to the number of bidders therein.

b) When demand equals supply, there are equal numbers of lots and buyers able to pay the prices asked. The initial asking price therefore becomes the market price, and lots are sold to all bidders.

c) When supply exceeds demand, there are more lots than buyers able to pay the initial asking price. In this event, lots are sold to those bidding the initial asking price, which is then lowered and more lots sold. This process is repeated until all lots are sold or until the price drops to a floor (half the selling price two years before), below which no one will sell. In this event, unsold lots are carried forward to next year's market.

This view of the market, although oversimplified, provides a convenient meeting place for lots and buyers generated in the other submodels.

A nearly identical auction is used to distribute agricultural products through the subroutine labelled *Food Markets.*

Demand for Food

Rather than concentrating on the contribution which agriculture makes to the economy of the islands, a concern which might well provide the focus of such an effort as this, consideration is given only to the food demands of the resident population. Two subroutines are used to calculate this demand.

1. The *Growth of Resident Family Incomes* assumes that local incomes rise or fall in unison with those in the rest of the country and produce each year, a vector of number of resident families by income category.

2. *Food Demand* translates the above families by income category vector to food demand, assuming that below subsistence (2 000 kcalories/person/day) all income is used to purchase food. Above subsistence, demand is a function of price and income which rises to an asymptote of 4 000 kcalories/person/day.

Supply of Food

Within the model all land that has not been subdivided into building lots is assumed to be available for farming. After making this assumption two subroutines are used to generate a food supply.

1. The *Food Production Process* is intended to simulate the activity of farmers using the land and technology at their disposal to produce food in response to demand expressed in the market. When demand exceeds the production possible using one level of technology, the technological input is increased so that demands can be met. The total amount of land used for agriculture therefore fluctuates as the levels of four technologies are increased, one at a time, until a maximum production is reached. To punctuate the fact that the existing model is intended to demonstrate a technique rather than provide a background for specific decisions, the maximum production possible within the model roughly corresponds with the yield of industrialized rice culture in the southern United States (10 kcalories/m^2/day). The possibility of such yields on the Gulf Islands is extremely doubtful. To be useful in specific situations, closer empirical ties would be necessary.

2. In addition to the supply generated within the system, food may be imported. The subroutine labelled *Availability of Imports* simply provides for that possibility and assumes no price differential exists. That is, the price of imported food, like that of food grown at home, is subject to the forces of the local food market which, as mentioned earlier, functions like the market for building lots.

Graphical Output

The graphical output of the model is shown in Figure II.2. The abcissa of both graphs is time and represents the interval 1900 – 2000. The upper graph is intended to reflect conditions in the food markets, hence traces the price of food and average diet level of the resident population. The lower graph traces the price of building lots in each of four quality classes, and the impact of small lot subdivision on the quality of the environment. The

latter index is developed in greater detail in Appendix II.2. To meet the demand for food in 1989 imports are required. That is, the model system can no longer rely on an internal supply of food to maintain the existing average diet level. At this point the decision maker is asked what amount is imported.

Simulation Studies

Armed with the model just described, a consequent measure of skepticism, and earlier cautionary notes, attention can be turned toward the value of simulation models, the anticipation of trends given particular policy decisions. In the context of this model, toward what goals are policies to be directed? Perhaps the best possible world would be one in which there were stable prices for both food and housing, where we retained the option of growing our entire food supply if necessary, and where the average diet remained at an opulent level. Conventional wisdom suggests that an increased rate of economic growth would solve our problems, yet there are those who disagree. Population growth, they say, must be stemmed. And of what value are conventional tools like property taxation, zoning, and lot size restriction, in working toward our goal. Although its relationship to the real world is only anecdotal, the model can help us to anticipate some of the consequences of various actions. Figures II.3 through II.8 show the results of the simulated development of the islands with interventions of various kinds applied in 1965. For convenience each of these figures also displays the uninterrupted output. To minimize searching through text and figures, all figures are grouped at the end of this discussion. The interpretations which follow refer to the model and its internal workings and are not statements about reality.

Consider first an increase in the rate of economic growth. Examination of Figure II.3 suggests that food prices would rise more quickly and that diet levels remain essentially unchanged under such circumstances. The increased prosperity is reflected in an increased demand for building lots which drives the price of housing up at an accelerated rate. Developers respond to the increased market by

1) withdrawing land from agriculture at an accelerated rate, bringing the system to dependency upon an external food supply earlier, and

2) subdividing smaller lots which have a proportionately greater impact upon environmental quality.

A reduction in population growth from 2.8 to 1.0 per cent (Figure II.4) appears to have the reverse effect upon the quality and price of building lots. Because land is withdrawn from agriculture more slowly, the system remains self sufficient with respect to food production for a slightly longer period although food prices and average diet level remain unchanged.

The elimination of population and economic growth within the model produces some rather interesting effects (Figure II.5). Both food prices and diet level are stabilized, and following an initial drop, the price of building lots appears to stabilize. In response to demand from outside the system (people wanting to move to the Islands) developers continue to subdivide the Islands, but at a much diminished rate. The sustained depression of lot quality is therefore replaced, at least in part, with the large oscillations

characteristic of early development. That is, although small lots are produced their rate of production is low. The comparative resilience of the system is maintained so that there is recovery. The system can "bounce back" to some degree.

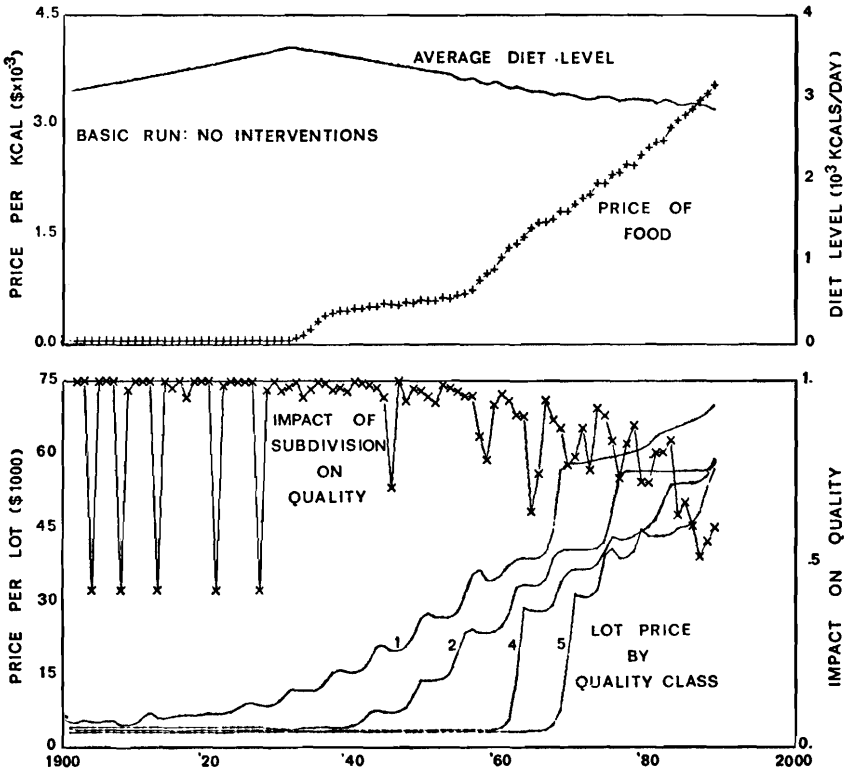
Figures II.6, II.7 and II.8 represent the use of some specific tools available to provincial and municipal governments. Within the model, the imposition of a property tax (Figure II.6) simply hastens the return of developed lots to the market, the assumption being that the added expense would encourage those who do not need, say, single family housing, to move elsewhere. The imposition of such a tax leads first to an increased supply of lots, then to a reduction in prices. At these reduced prices, the lots come within reach of a greater number of families. Upon detecting the greatly expanded market, developers respond as they did earlier, by

1) withdrawing land from agriculture at an accelerated rate, bringing the system to dependency upon an external food supply earlier, and

2) subdividing smaller lots which have a proportionately greater impact upon environmental quality.

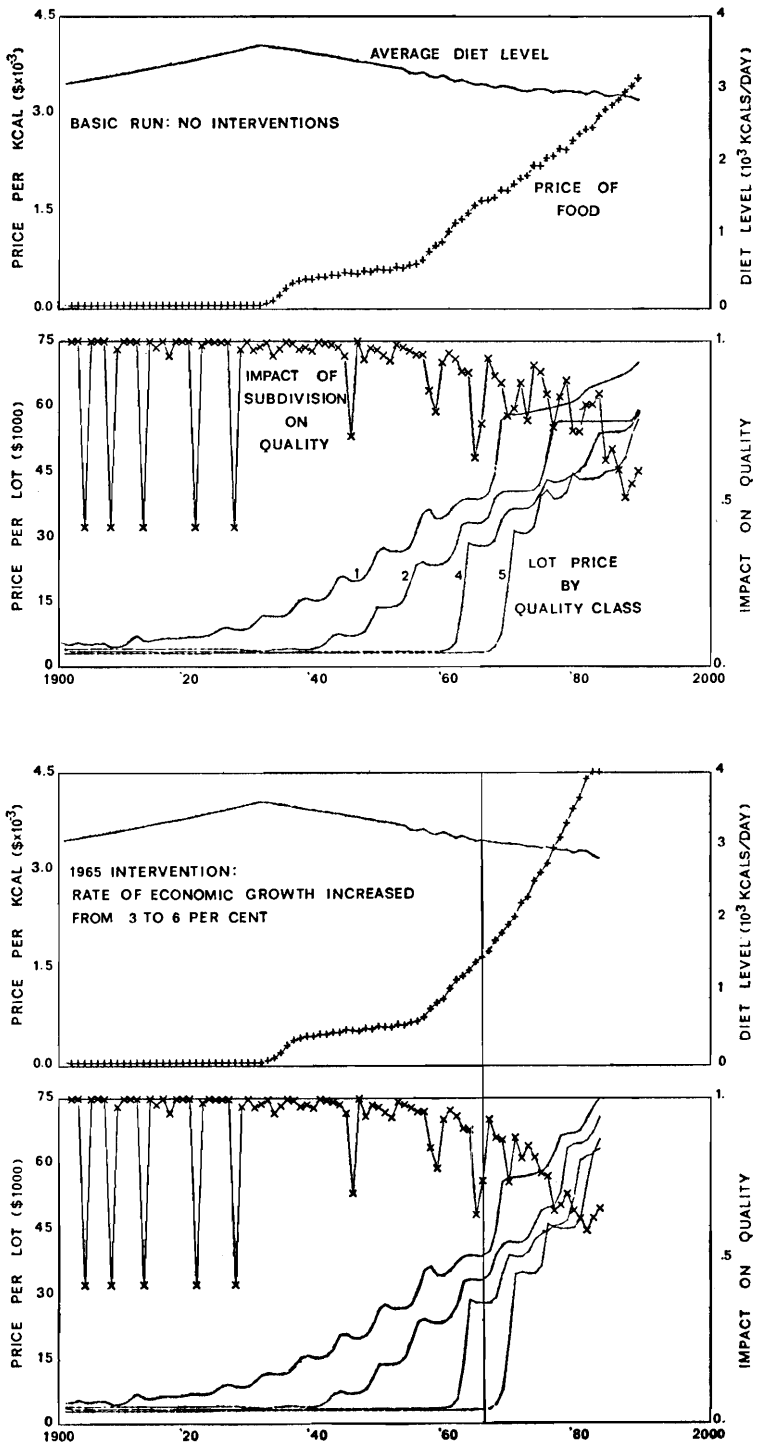
Only the imposition of a minimum lot size relieves the impact of further small lot development upon environmental quality (Figure II.7). An unexpected consequence of such a policy is the maintenance of the simulated system's ability to supply its own food requirements, undoubtedly because such a policy precludes further profitable development, hence retarding further growth. Figure II.8 reveals the effect of a simulated zoning of agricultural land. As might be expected, such a policy maintains the system's ability to supply its own food requirements, but so restricts the amount of land available for subdivision that only very small lots, with their concomittant impact on quality, are produced.

Figure II.2 – Graphical Output of the Regional Land Development Simulator



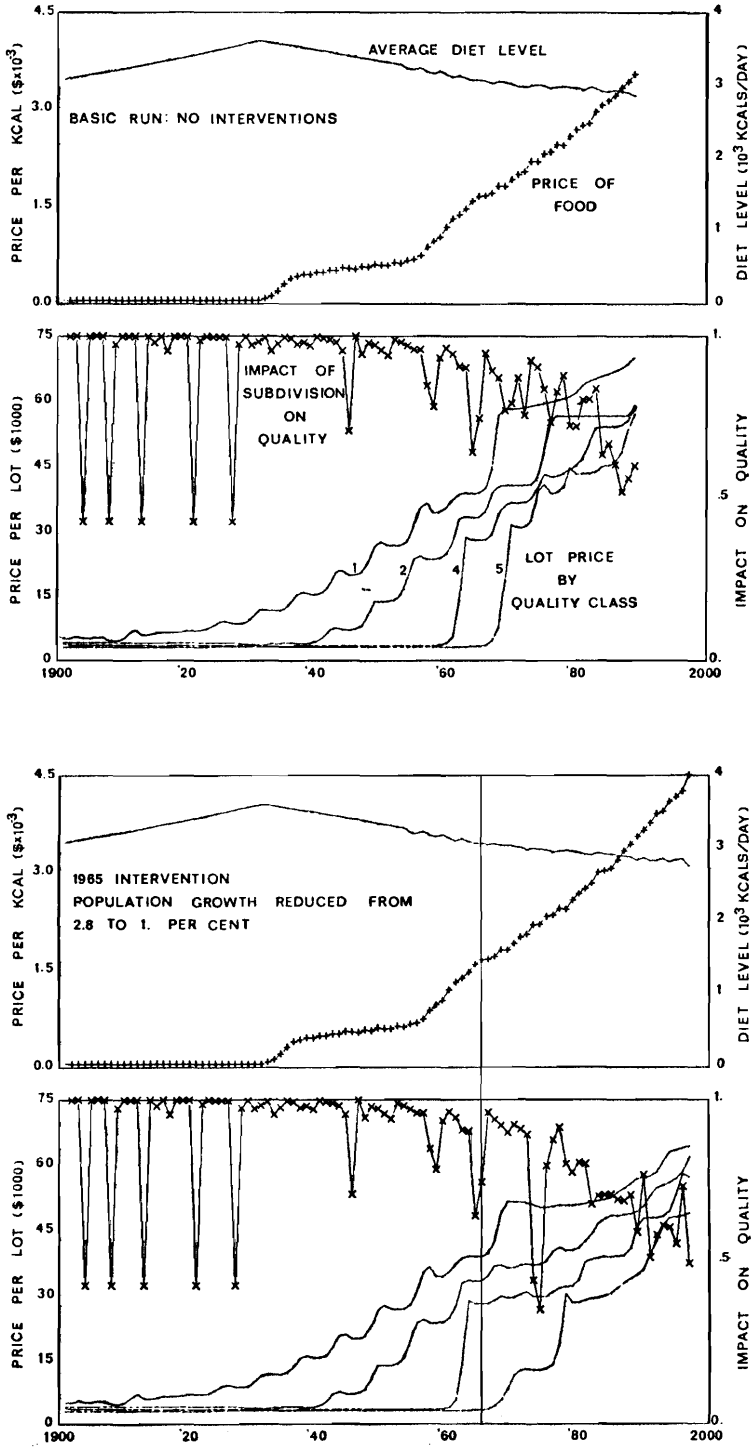
Source: A.D. Chambers and the Resource Science Centre

Figure II.3 – Simulator output showing the effect of an increased rate of economic growth from 1965



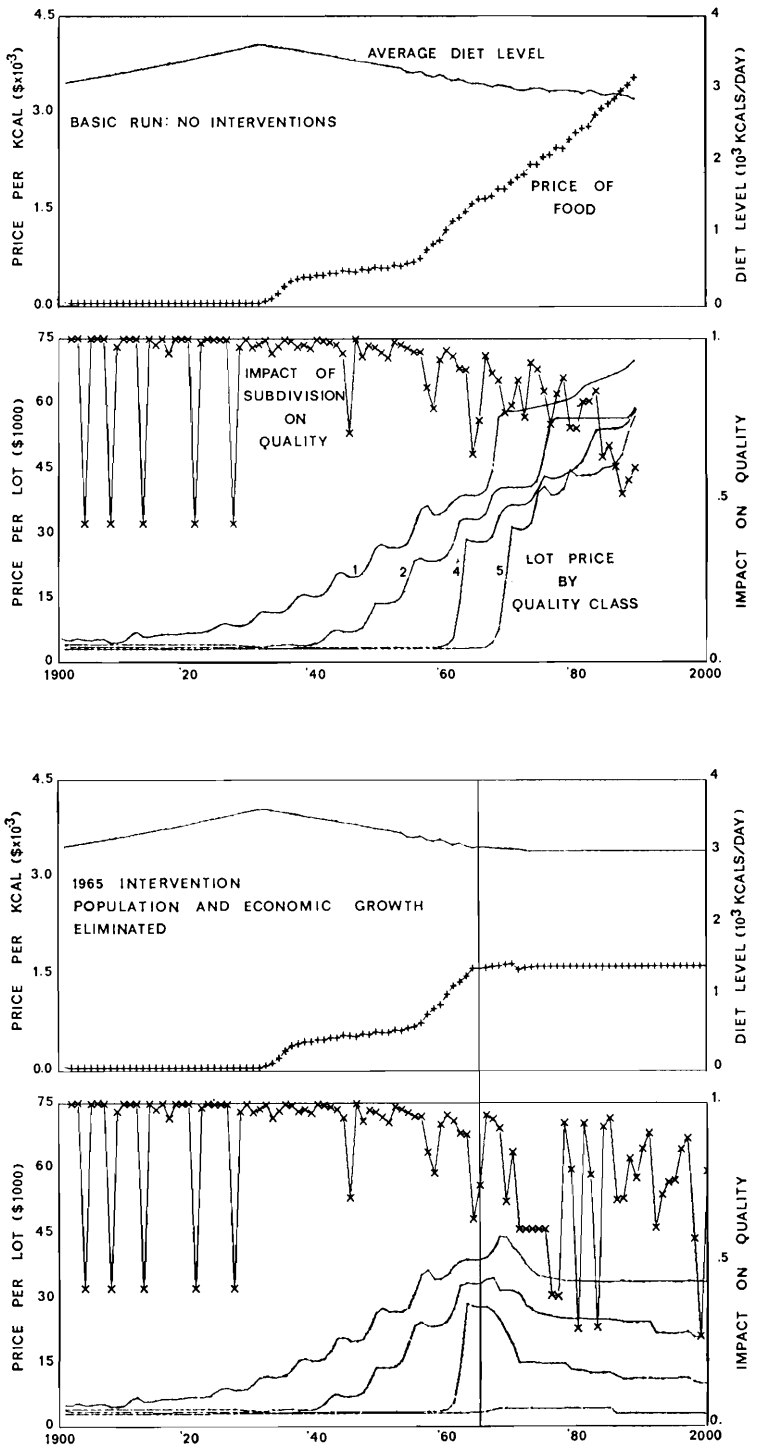
Source: A.D. Chambers and the Resource Science Centre

Figure II.4 – Simulator output showing the effect of a reduced rate of population growth from 1965



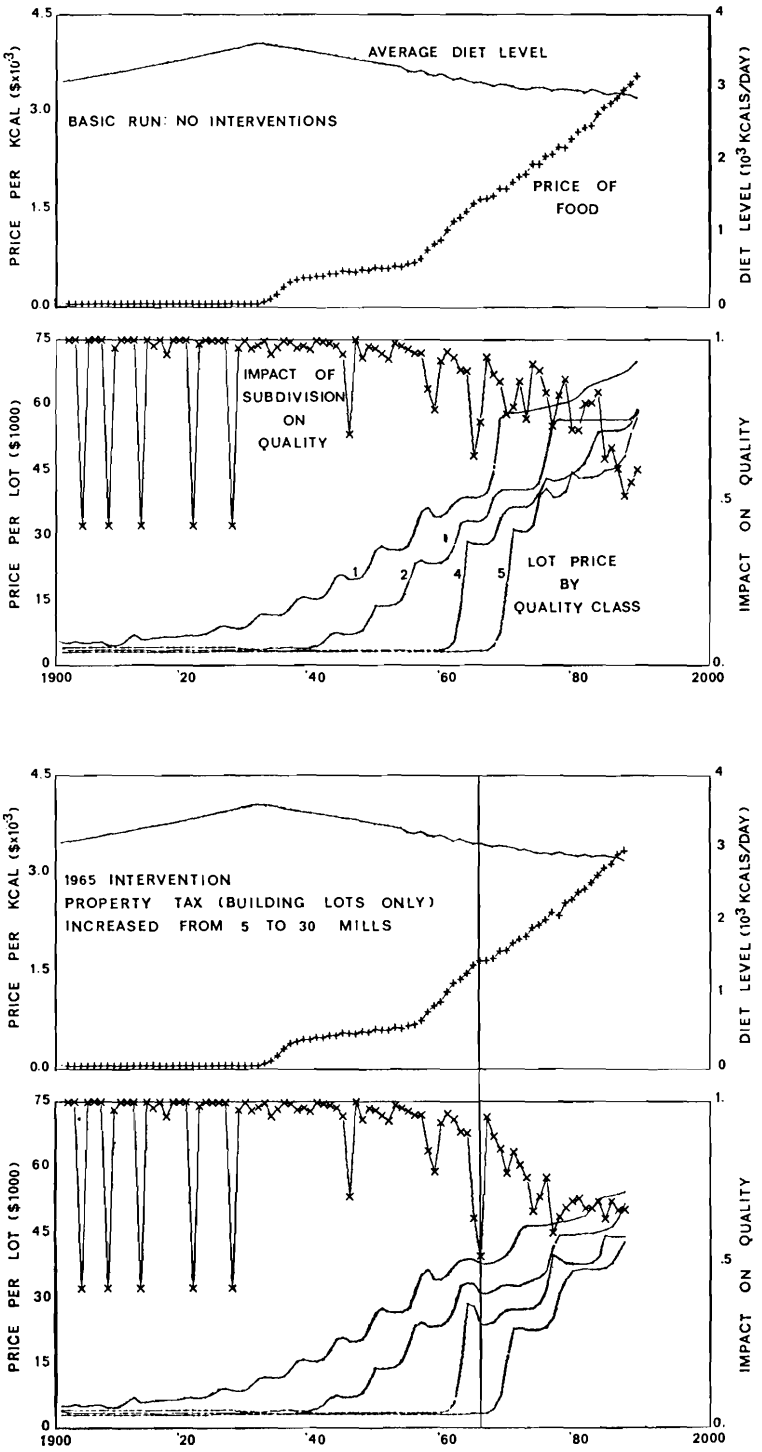
Source: A.D. Chambers and the Resource Science Centre

Figure II.5 – Simulator output showing the effect of zero population growth from 1965



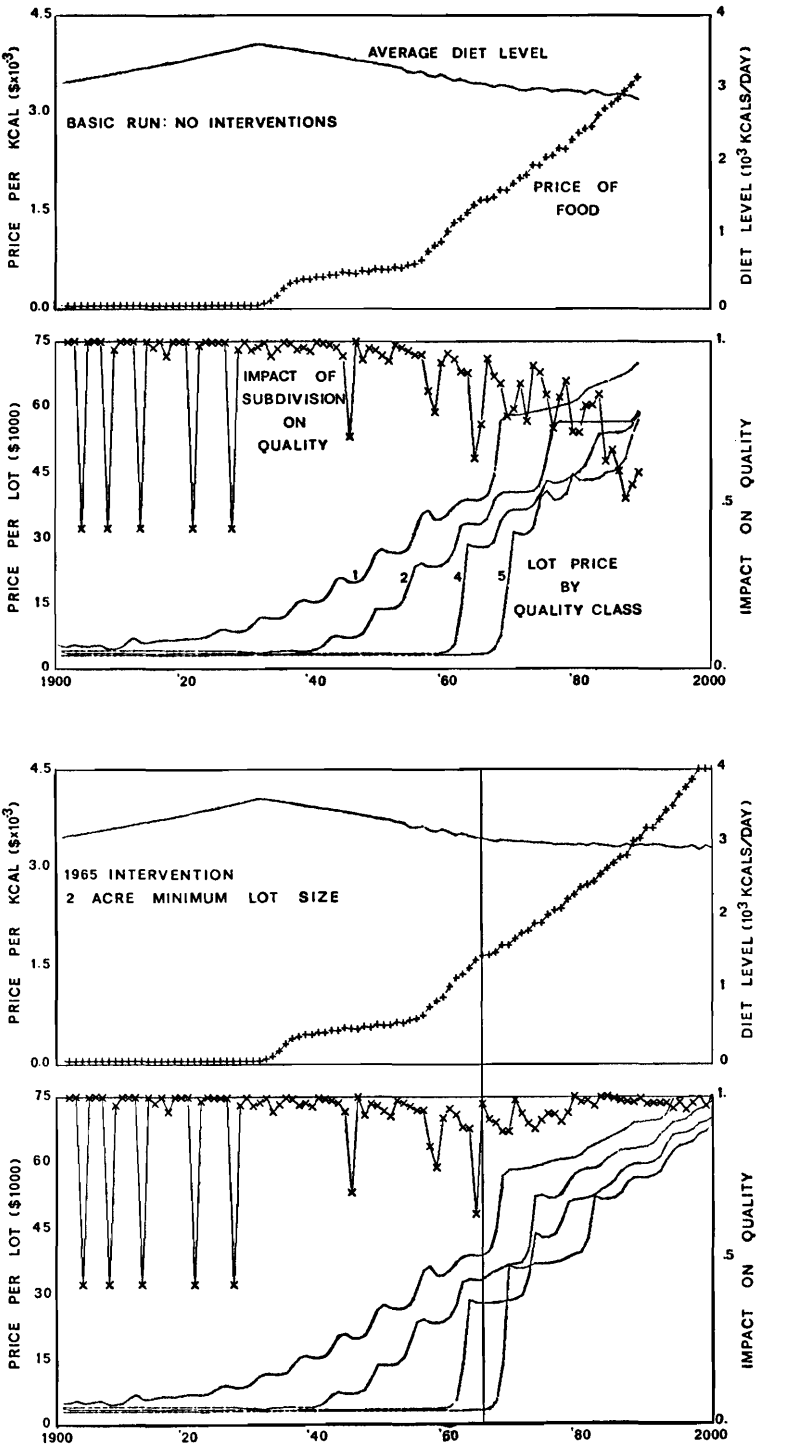
Source: A.D. Chambers and the Resource Science Centre

Figure II.6 – Simulator output showing the effect of an increased property tax on building lots only from 1965



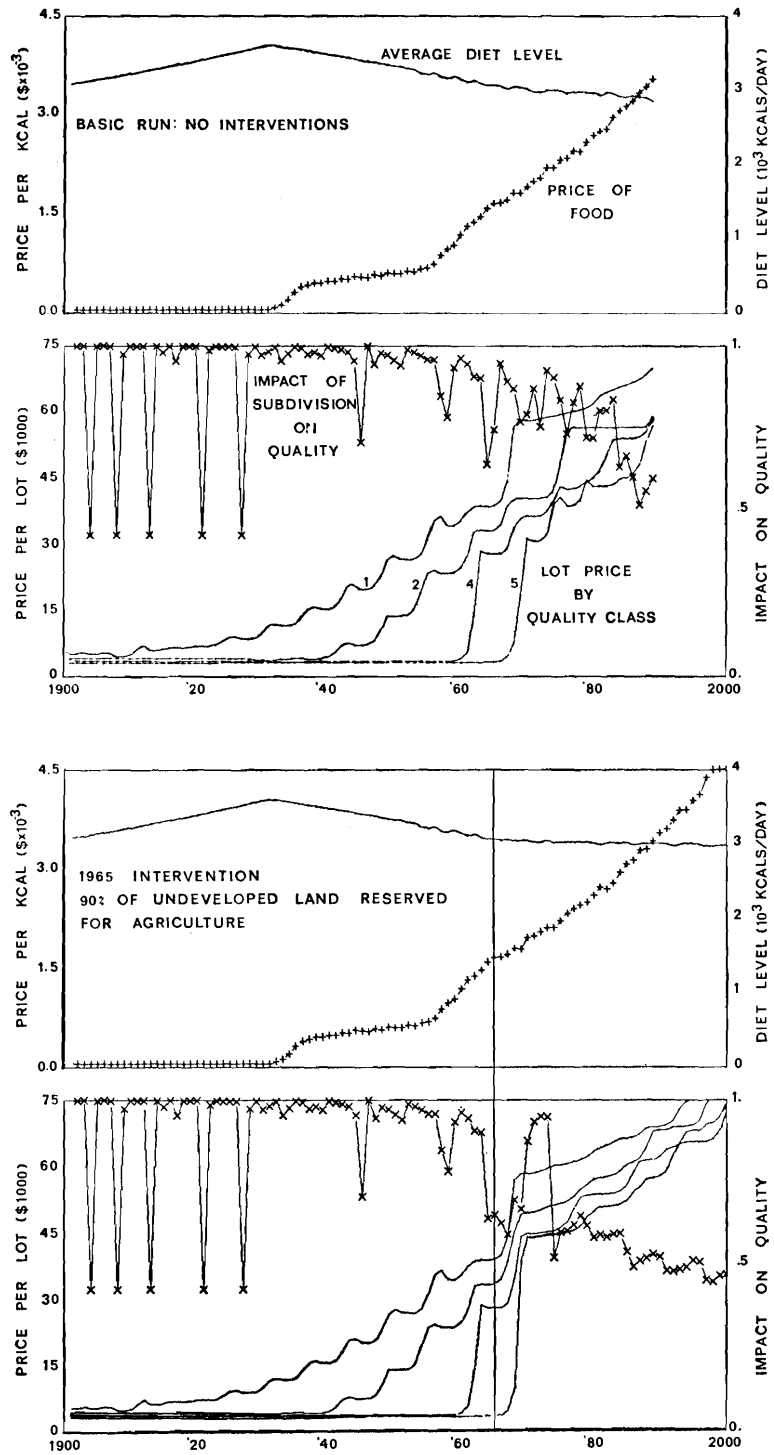
Source: A.D. Chambers and the Resource Science Centre

Figure II.7 – Simulator output showing the effect of lot size restriction from 1965



Source: A.D. Chambers and the Resource Science Centre

Figure II.8 – Simulator output showing the effect of an agricultural land bank implemented in 1965



Source: A.D. Chambers and the Resource Science Centre

Perspective for Other Applications

The model just described was the product of an interdisciplinary look at the flow of land from one use to another and concentrates upon a particular system of land and people. The exercise was most useful to those who participated in the initial definition and analysis for it provided a strong analytical framework and helped them to communicate with one another. The systems approach provided a new, rigid discipline which forced each individual to distill his own thoughts concerning the subject at hand. The distillate was then made explicit for others in the chosen language of communication, mathematics. In addition, the exercise produced a simulation model or sounding board on which decision makers may try different policy interventions and receive – not a preview of the future – but a synthesis of the advice of one group of specialists. The outcome of specific policies on the model system can provide decision makers with the focus for some rather detailed thoughts before they make a decision to be applied to the real system.

At the national level, the approach could be used to structure studies of energy policy, mineral policy, or indeed, policy affecting the benefits available from any of our resources. An extremely simple example might examine the development of Canadian oil reserves. The boundaries of the system would, of course, be the borders of Canada, the independent variable time, and state variable(s) some measure(s) of the influence of oil upon Canadians (GNP, balance of payments, pollution, social indicators, jobs, etc.), which depend upon the flow of oil within Canada *and* between Canada and other nations. During the course of such a study it might become apparent that greater benefits would result from increased use of Canadian oil within Canada, or that benefits could be greatly increased given the solution to some particular technological problem. The study might, therefore, suggest a redirection of research or that greater emphasis be placed upon the development of some particular technology. In another vein, such a study might punctuate the wisdom of a policy which exports all Canadian oil reserves as quickly as possible, thereby exporting a number of pollution or other problems as well.

Whether considering oil, agriculture, minerals, forests, water, or resource policy generally, recognition of two inescapable conditions is essential to all studies of national resource policy:

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

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

The immediate implications of these conditions are first, that regional differences are inherent in the system and secondly, that the rôle of the federal government is synergic. 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 rôle of provincial governments is synergic with respect to intra-provincial regions, the studies must include 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 toward whatever objective.

Given the increasing complexity of the decision maker's milieu and its diminished capacity to absorb error, the systems approach has become an essential tool for planning resource development. But the rapidity with which the technique is being recognized as an aid to Canadian decision makers might be cause for alarm. While the technique is useful, the Canadian behaviour has been to "want it now" rather than "plant the seed and let it grow". Witness the new Canadian universities. Wanting it now provides fertile soil for charlatans and imports. Supposing the charlatans can be stopped at the door, the imports carry the values of another society straight to the policy level.

In the application of the systems approach to the allocation of Canadian resources one imperative stands above all others. The human reference of all such studies must be the Canadian people. That is, the analysis must reflect our own values and concerns. A necessary requirement of such studies is, therefore, that they be performed by Canadians. There are capable millions of us from which to choose.

Appendix II.1 – A Detailed Description of the Subdivision Subroutine

Within the model, the subdivision process determines the number and size of lots produced each year. Conceptually, developers subdivide lots only when they expect a profit, hence they must be able to compare expected costs and revenues. Here, total expected revenue is a simple linear function of number and price. Costs are calculated using the total cost function developed as follows:

Let the total cost (TC) of producing a number of lots be comprised of land purchase (P) and subdivision (S) costs, so that

$$TC = P + S \tag{1}$$

Now consider land purchase (P) alone, and let the area to be subdivided be g acres. If these g acres are purchased for b dollars per acre,

$$P = bg \tag{2}$$

and the total cost function becomes

$$TC = bg + S \tag{3}$$

Now allow g acres to be subdivided into n lots of size s, and let some unstated proportion of s represent that land used for roads, parks, schools, and other public property so that

$$g = ns \tag{4}$$

Substituting (4) in (3) above, we obtain

$$TC = bsn + S \tag{5}$$

Next, consider the contribution of legal, survey and realty fees to subdivision costs (S). Such fees are frequently calculated as a proportion of the market price of the property in question and can therefore be modelled as some proportion (k) of the selling price (r) of the n lots produced.

$$S = krn \tag{6}$$

This relationship holds even for the particular case where g acres are bought and then sold intact, for in that case just one lot is produced.

Now consider that land and labour are the two inputs required for lot production. One of these inputs may be decreased and a given level of production maintained only by increasing the other input. That is to say, ten lots might be produced from fifty acres of land with a small amount of labour. To produce ten lots from one acre, additional water must be transported to the site, more elaborate waste disposal systems must be built, and roads must be more durable. The cost of servicing a single lot may therefore be considered inversely proportional to its size (s). This relationship is conveniently included in the subdivision costs (S) by modifying equation (6) as follows:

$$S = krn\,(1 + (L/s)) \tag{7}$$

where L is a constant describing the technology available for servicing lots. The expression L/s represents additions to subdivision costs which

result from lot smallness. Where technology is inexpensive and highly developed, or not required to adequately service small lots, L is very small. But where additional water must be imported, sewage exported, or other expensive technological problems arise as lots become smaller, L may be adjusted upward to account for those difficulties.

Turning finally to the relationship between total cost and number of lots produced, tradition suggests regions of increasing *and* decreasing returns to scale. Because such a curve is complex mathematically, the other cost-production relationships highly simplified, and production always in the region of diminishing returns anyway, no region of increasing returns is included here. Since the aim of this exercise is to produce a generalized total cost function which can be tuned to a given set of conditions, all features of the function must be flexible. With respect to a region of diminishing returns, this flexibility must provide opportunity to adjust (1) the level of production where diminishing returns begin to occur, and (2) the rate at which returns diminish. These objectives are met simply and conveniently by modifying equation (7) as follows:

$$S = krn\,(1 + (L/s)) + m(e^{pn} - 1) \tag{8}$$

where m and p are constants. The parameter m effectively determines entrepreneur efficiency, or the number of lots which can be produced before diminishing returns begin to occur. Once begun, the rate at which returns diminish is determined by the parameter p. Substituting (8) in (5), the total cost equation now becomes

$$TC = bsn + krn\,(1 + (L/s)) + m(e^{pn} - 1) \tag{9}$$

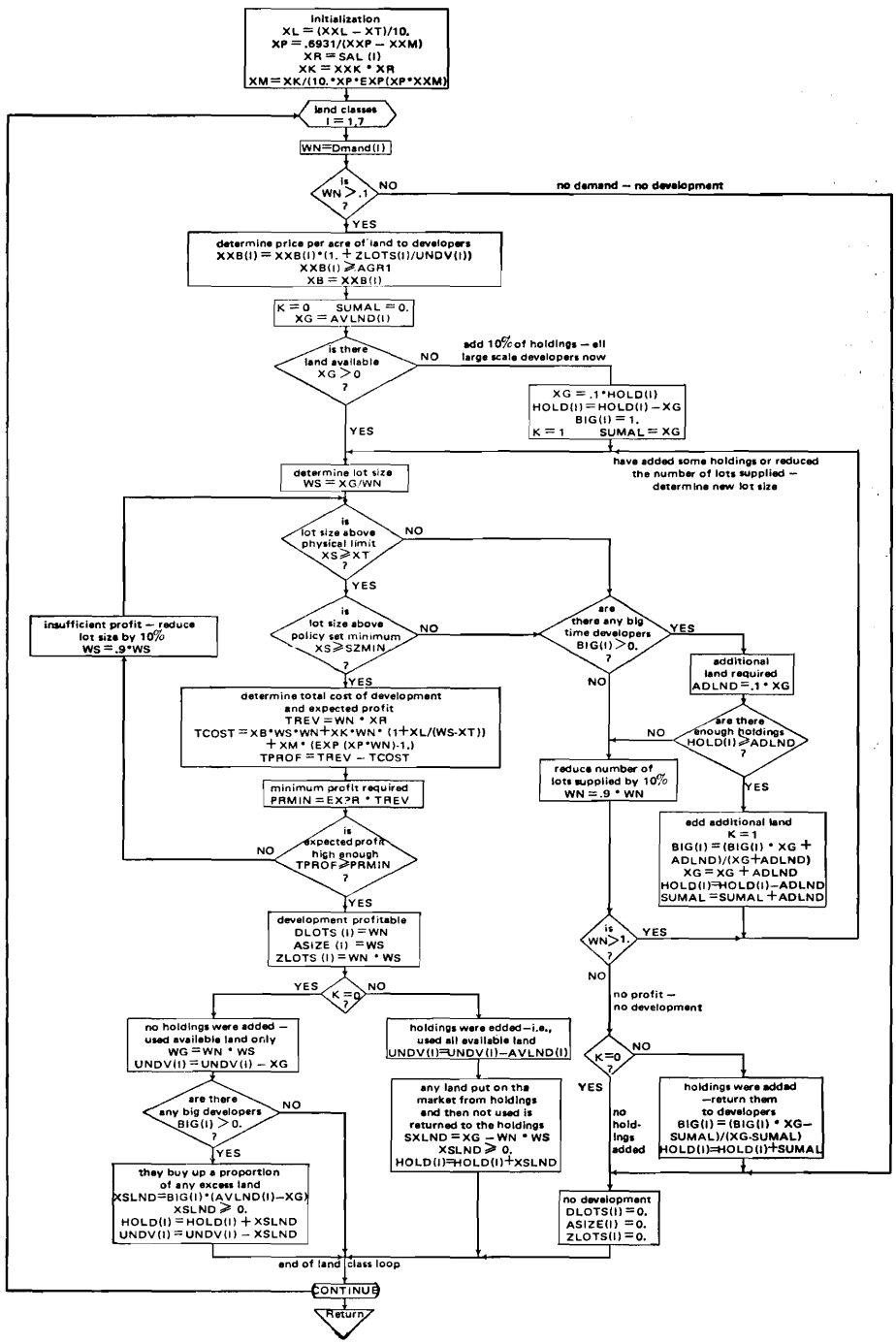
Although equation (9) is highly simplified, the input constants provide the flexibility required to accommodate subdivision problems of different regions. Equipped with both total cost and total revenue functions, a flow diagram (Figure II.9) now serves as a reference for the detailed description of the subdivision subroutine.

Looking first at the last market, the hypothetical developer observes the number of lots sold and the rate of price increase, estimating for each land quality (I), the number of lots which will be sold in the next market. This number, received from the previous subroutine, is DMAND(I). If no demand is anticipated in quality class (I), no development takes place. If a demand is anticipated, the developer sets DMAND(I) equal to WN, the initial number of lots he expects to produce, and asks what price he must pay for undeveloped land. That price (XXB) is assumed to rise and fall at half the rate of change in lot prices during the last two market periods.

From a previous examination of the market for undeveloped land, (*Land Availability*), the developer "knows" that AVLND(I) acres of quality (I) land are for sale if he should decide to buy them. If there are any large-scale developers involved, then an alternative source of land for development resides in HOLD (I), the number of acres of quality (I) land which they bought previously. An initial amount of land available for subdivision (XG) is therefore established.

With the number of lots to be produced (WN) and the land area available for their production (XG), the hypothetical developer can

Figure II.9 – Flow Diagram of the "Subdivision" Process.



Source: A.D. Chambers, "Simulation of cottage lot subdivision: a synthesis of social, economic, and environmental concerns", Ph.D. thesis submitted to the Resource Science Centre, March 1971.

calculate the size (WS) of these proposed lots. If the lot size (WS) is equal to or greater than the minimum size permitted by government policy (SZMIN), profit anticipated from the proposed venture (TPROF) is calculated as the difference between total cost and expected revenue (TREV). Total revenue (TREV) is simply the product of expected demand (WN) and expected selling price (XR), while total costs are calculated using the total cost function developed earlier (equation (9)).

The minimum profit which will prompt developers to subdivide (PRMIN) is calculated as a proportion (EXPR) of anticipated total revenue (TREV). If the difference between costs and revenue (TPROF) is equal to or greater than the minimum required for subdivision to occur (PRMIN), subdivision takes place and the remainder of the subroutine performs the bookkeeping chores. If, however, there is insufficient profit, lot size is reduced 10 per cent and the anticipated profit recalculated. This process of lot size reduction continues until subdivision occurs, or until lot size falls below the policy minimum.

In the event that lot size becomes too small, and big developers with land holdings are operating, the amount of land available for subdivision (XG) is increased and the process of profit calculations and size reduction is repeated. When the large developers' holdings have thus been disposed of, and still no subdivision has taken place, or in the event the large speculator option is not in use, the number of lots to be produced (WN) is reduced by 10 per cent and the process of profit calculation and lot size reduction repeated yet again.

By reducing the size and number of lots to be developed in response to the combined forces of market price, development costs and profit expectation, the stage is set for simulated degradation of environmental quality. While this subroutine, like that following and all others in the model, presents a terribly simple, suspect view of the processes it is supposed to describe, it improves upon the "supply and demand" cliché, if only because it remains suspect after moving through one level of complexity and from the static to dynamic situation.

Appendix II.2 – The Graphical Representation of Quality

In developing the measure of quality traced in Figures II.2–II.8 three notions are required:

1. In the context of the simulator, the quality of the system at any time can be represented by the "quality area" therein. As shown in the following table, this measure is simply the sum of the products of weighting factors and areas of land in each quality class. First quality land is given more weight than second quality land, second more than third quality land, and so on. Weighting factors are therefore the quality class numbers in reverse order.

Table II.1 – Calculation of the "quality area" in a system at one point in time.

(1) Land Class	(2) Area (acres)	(3) Weighting factor	(2) x (3)
1	1 000	7	7 000
2	2 000	6	12 000
3	9 000	5	45 000
4	1 000	4	4 000
5	1 000	3	3 000
6	1 000	2	2 000
7	1 000	1	1 000
Total "quality area"			**74 000**

2. The total quality of the system may be divided in two parts. The first is that portion of the total which has been developed (sequestered by individual families) and is a measure of quality in direct use. The second is that portion of the total which remains undeveloped and is a measure of the capacity of the system to absorb or "bounce back" from quality losses resulting from the subdivision of small lots.

3. Total quality and each of its parts are subject to change.

Several "barometers" with which to monitor the system's quality are apparent. The first possibility which springs to mind, total quality, is not appropriate for three reasons. The first and most important is that people perceive differences, not total quantities. The second and third reasons concern the larger parcels of highest quality land which are developed early in the history of the system. Much of the total quality is contained in these parcels which, in reality, are returned to subdividers more slowly than "undeveloped" land. They therefore act as a buffer, or delaying mechanism, in the degradation of total quality. Within the model, the delay is complete. Once developed, parcels are never returned to developers. Such recycling would add little of consequence to the model. People perceive and evaluate differences. Rates of change rather than total amounts are therefore the appropriate measures of quality.

Suppose some land area A is subdivided in a given year. Depending upon the land classes from which A is drawn, its undeveloped quality can be calculated (as in Table II.1) and expressed as the quality-area developed (QAD) in that year. If, after subdivision, some of that quality is lost because lots produced are too small, the quality lost can also be calculated and expressed as quality area lost (QAL). Then the proportion P* of the

*Note that the proportion P is related to the instantaneous rate of change in quality, r, as follows: $P = 1 - r$ where $r = QAL/QAD$.

undeveloped quality of A, which is retained after subdivision, is

$$P = (QAD - QAL)/QAD$$

While the above proportion is important: alone it is insufficient. Early in the development of a region small lots are produced, but these "errors" would (intuitively) have minimal impact on the whole system. As more and more of the region is developed, its resilience of capacity to absorb quality losses is diminished. Small lots produced late in the history of development have much greater impact than those produced earlier. The proportion P should therefore be modified by some measure which reflects the changing resilience of the system.

Consider the land area which remains undeveloped at the start of the given year. Its quality area is a measure of the system's resilience (notion 2. above), some part of which (QAD) is withdrawn for development that year. Then the proportion R of the undeveloped quality area (QAR) which remains unsequestered at the year end is:

$$R = (QAR - QAD)/QAR$$

The quality impact line represents the product of the two proportions P and R, and is plotted on an ordinate scaled from zero to one.

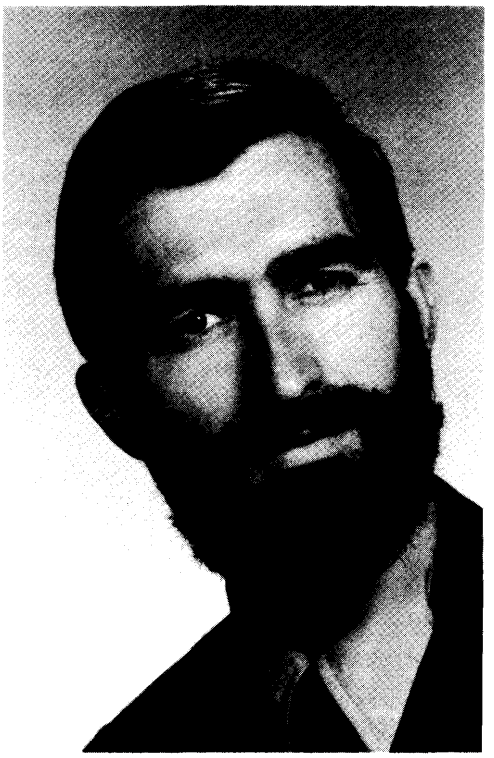
III. Jurisdictional Problems in Natural Resource Management in Canada

by A.R. Thompson and H.R. Eddy

A.R. Thompson

In 1950 Dr. Thompson began his teaching career at the University of Alberta. From 1953 to 1957, he was a member of the editorial staff of the leading publisher of legal books. In 1957 he returned to the University of Alberta and remained at the Law School until 1969 when he accepted an appointment as Professor of Law at the University of British Columbia. Dr. Thompson teaches courses in Real Property Law, Petroleum and Natural Gas Law, and Mining and Forest Law. He was a founding member of the Canadian Petroleum Law Foundation and is on its Board of Directors. He is a member of the International Council of Environmental Law and a Director of the National and Provincial Parks Association. His interest in the legal problems of the Canadian north is reflected in his membership on the Canadian Arctic Resources Committee and on the advisory committee of the Arctic Development and Environment Programme of the Arctic Institute of North America.

Dr. Thompson was the general editor of "Butterworths Ontario Digest", and is co-author of Lewis and Thompson, "Canadian Oil and Gas". This work is a six volume treatise covering Canadian oil and gas law and petroleum statutes and regulations. In his rôle as an expert on oil and gas law, he has given evidence in cases before Canadian courts and before the Australian Royal Commission on petroleum exploration and drilling in the region of the Great Barrier Reef. He has also served in an advisory capacity to governments.



Howard R. Eddy

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The Scope of the Study

In an ecological sense, all phenomena, including man himself, are natural resources which must combine for man's welfare. To speak of their "management" is to presume upon man's overbearing confidence in his technological ability and to forget man's ignorance of complex ecological relationships. We are only beginning to conceptualize management systems that reach beyond short-term single project descriptions such as a mine or a dam, to long range integrated schemes such as a drainage basin plan or a comprehensive ocean area plan. Our examination of natural resource problems is still divided into fragmented components of the natural resource ecosystem. Science Council's studies have grouped around six resources ideas – water, mineral resources, forests, fish and wildlife, agriculture and ocean resources.[1]

These studies have identified specific foci for research that will contribute either to increased production of things useful for man or to restoration or preservation of natural qualities beneficial to man. The studies include recommendations about institutions to direct such research and to translate its results into improved mechanisms for harmonizing man and his natural environment.

This jurisdictional study is aimed at revealing legal constraints that might impede recommended research or frustrate implementation of its results. By legal restraints we mean the elements of Canadian constitutional law and practices, and the provisions in existing federal and provincial statutes, that cast uncertainty over proposals for new programs for managing, utilizing, or conserving natural resources. In preparation for this jurisdictional study, a series of background papers has been prepared, giving detailed attention to the six resources areas previously mentioned. These papers consider both inter-jurisdictional problems between the federal government and the provinces and among the provinces themselves, and individual management systems established for specific resources in the multitude of federal and provincial statutes that bear on resource management. For those seeking in-depth treatment of specific resource problems, this study is in no sense a synopsis or condensation of these papers. Rather, this study will seek to present both generalizations about jurisdictional problems besetting natural resource management and specific recommendations about how improved laws might contribute to better management.

Whither the Constitution

This study and the background studies have been derived from the existing constitutional framework in Canada. At a time when Canadian politicians are striving for revision of the Canadian constitution,[2] a first question is whether resource management strategies should anticipate early changes in this framework. We think the answer is no! There are many illustrations that the process of constitutional change is a slow one. We believe that such change is likely to occur on a gradual basis with cultural and institutional changes, such as language rights, minority rights and make-up of a constitutional court, preceding jurisdictional changes. The present momen-

tum for constitutional change in Canada may well exhaust itself before it touches the distribution of jurisdiction over natural resources between the federal and provincial governments. One type of institutional change that should be considered is amendment of the constitution to facilitate inter-delegation of legislative powers so that in appropriate cases a province can delegate a legislative function to a federal instrumentality or vice versa.[3] The significance of such an amendment is that it would remove an impediment that now hinders legislative schemes designed to enable governments to cooperate in solving resource management problems.

The existing jurisdictional intermix in natural resource matters in Canada is too complex to be completely disentangled. Nor are there compelling reasons for a single jurisdictional base. Where an essence of the federal idea is regionalism, as in Canada, many spatial factors involved in sound management of natural resources dictate provincial jurisdiction whereas others suggest federal jurisdiction. The first comprehensive Canadian study on environmental management concludes:

"Effective management strategies applied in any one of these jurisdictional situations necessarily concerns both orders of government. This appears to be an almost inescapable conclusion from the foregoing analysis. It flows not only from the fact that environmental problems are dominated by spillovers. It flows also from four characteristics that stand out in each part of the analysis: ecological interdependence; physical interdependence; problem interdependence; hence jurisdictional interdependence. The overriding corollary of this, of course, is intergovernmental cooperation, at all levels and in all possible forms. It is difficult, if not impossible to visualize any political or institutional structure, or any system of powers, that would reduce the importance of such cooperation or that would work without it"[4].

In our view this passage is equally as applicable to natural resource management as to environmental management, should there be any differences between the two.

Recognition of the need for cooperation is not new in Canada. Already there are important and successful institutional arrangements for achieving federal-provincial co-ordination in the field of natural resources, the most notable of which are the Mines Ministers Conference and the Canadian Council of Resource and Environment Ministers. The new Canada Water Act and the new Clean Air Act are aimed at cooperative federal-provincial management, and there are many instances of successful cooperative endeavours in specific resource situations.

We believe that resource management strategies evolved today must be predicated on a continuation of the present constitutional framework for the foreseeable future. In any event, no future changes are likely to eliminate the jurisdictional interdependence of various levels of government in natural resource problems. Cooperation between governments is now essential and will continue to be so. Probably the most fruitful direction that constitutional change can take with respect to natural resource management is toward improved conditions for cooperative efforts between governments.

The Parameters of Jurisdiction

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 the provisions of the BNA Act that 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 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, as is the more usual case, ownership and legislative authority are divided, 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 resource, but it is not so apparent why ownership can give an effective jurisdictional claim on a resource. The explanation can best be made by giving two examples. The federal parliament in Canada has legislative authority over aliens and nationality. Nevertheless, because the Province of British Columbia owns the forest resources in that province it can assert a *de facto* jurisdiction over aliens in such a vital issue as whether they will be denied employment in the forest industry. Just such a denial was upheld by the Privy Council during the 1920s.[5]

The second example deals with the export of natural gas, either to another province or outside Canada. 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 resources 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.

Proprietorship of the resource base gives jurisdiction over a resource through the conditions attached to sales of rights to exploit the resource. This jurisdiction is separate from, and capable of frustrating, legislative authority over the resource given by the BNA Act.[6]

Ownership Jurisdiction

British colonial policy generously afforded to each colonial territory the benefit of revenue derived from the natural resources of the colony. Although legal title was, and is, vested in the Crown, the beneficial use of the resources was placed under the control of the colonial governments.

On Confederation, the confederating provinces retained for themselves the bulk of their Crown lands and resources. This policy was continued on the entry of British Columbia and Prince Edward Island into Confederation. But when Manitoba was created out of federal territory in 1870, and again in 1905 on the creation of Alberta and Saskatchewan, the federal government retained the ownership of the natural resources within their boundaries. Not until 1930 were these provinces restored to an equal status with the rest of Canada.

One can generalize today that the provinces own natural resources within their boundaries. One can also generalize that the federal government owns northern and offshore resources. In the Yukon Territory and in the Northwest Territories (which include the eastern and high Arctic), the federal government, with few exceptions, owns resources. The federal government owns the seabed resources in the Canadian portion of the Arctic continental shelf. It also asserts ownership of resources in the shelf off the east and west coasts, but there are unresolved provincial claims. A decision of the Supreme Court of Canada[7] has given seabed resources off the west coast to Canada against the claim of British Columbia, but there are remaining uncertainties about boundaries. For example, the province claims that the Strait of Georgia comprises "inland waters" belonging to the province. On the east coast, Quebec, Newfoundland and the Maritime Provinces claim the seabed resources of both the territorial sea and the shelf beyond.

These generalizations about provincial and federal ownership are no sooner pronounced than caution requires that many exceptions be acknowledged. Within the provinces there are federally-owned resources in cases such as Indian lands[8], federal public works, defence lands and national parks. In the territories land in the urban areas such as Whitehorse and Yellowknife is administered by the territorial governments as if they were the owners. Since federal government policy has been to place the territories on the road to provincehood, it is argued by some that the federal government must ultimately account as trustee to the territories or their successor governments for the management of their natural resources.

Finally, when describing ownership of natural resources in Canada, it must be recognized that from earliest settlement the sovereign has been selling and leasing lands and other natural resources. The effects vary both regionally and according to the particular resource in question. Most economically useable farmland in Canada has passed into private ownership. In the settled portions of the eastern provinces, mines and minerals have passed usually with surface grants of lands to private individuals and corporations. Similarly in Manitoba there is a large percentage of private ownership of mines and minerals. But as one moves west, the percentage of such ownership declines. In Alberta approximately 86 per cent of all

mines and minerals remain in provincial ownership. Where mines and minerals were not granted along with surface rights to homesteaders, the early establishment of a policy of leasing minerals rather than of making outright grants has served to maintain the public position as landlord and proprietor.

Outright grants of forest lands were also discontinued soon after Confederation. The result is continued public ownership of most forest resources, with only limited and conditional tenure being awarded to private industry.

The fish, wildlife and water resources do not readily fit into the ownership patterns we have described. Unlike agricultural lands, and unlike forests and minerals, all of which are fixed and immovable, fish, wildlife and water have a migratory or ambient quality. Usually, they are regarded as common property in the natural state. Private property in them is acquired by reducing them to possession, as where a fish is caught and lies in the creel, or water is held within a container. But though fish, water and wildlife are not privately owned in their natural state, the right to take them and reduce them to possession can, itself, be owned, and is normally incident to the ownership of the land where they happen to be. At English common law, the owner of the bed of the stream has the exclusive right to catch fish, and the owner of the park has the exclusive right to shoot deer. The shoreline proprietor has the riparian right to use water passing by in the river. From the point of view of ownership jurisdiction, this different legal treatment of fish, wildlife and water is not significant, for ownership of the right to take or use the resource is as effective a source of ownership jurisdiction as ownership of the resource itself.

Our pioneer heritage, particularly in western and northern Canada, discouraged private ownership and exploitation of rights to fish and hunt. Water scarcity in parts of western Canada led to abolition or severe restriction of the riparian right to take water. These reasons, combined with large public land holdings, leave the rights to take and use fish, wildlife and water largely in public ownership. This generalization applies less in the settled parts of eastern Canada than in the north and west.

Today, when one speaks of publicly-owned resources, it is the unalienated resources that are usually meant. It is with respect to these that governments in Canada have both the greater responsibility and the greater opportunity to provide sound management. It is upon these resources that the exercise of ownership jurisdiction has effect.

In summary, ownership confers a form of jurisdiction over resources that is scarcely less far-reaching than legislative authority. The basic Canadian pattern gives ownership of provincial resources to the provinces and of northern and offshore resources to the federal government. There are, however, many exceptions and continuing disputes about offshore regions. Public ownership of agricultural lands is practically eliminated but limited disposition policies with respect to other resources have preserved substantial public ownership.

Legislative Jurisdiction

There are many provisions of the BNA Act that have a bearing on jurisdiction over natural resources. In some cases the relationship is not obvious by a mere statement of the provision. To catalogue these provisions would not be helpful without complex explanations unsuited to this overview. Such a detailed analysis is included in the background papers. This study will approach the subject from a functional classification of resource management problems.

The first problem of resource management is to allocate the resource between the public and private sectors and, if the allocation is made to the latter, to choose among competing entrepreneurs. The terms and conditions on which rights are granted, are of fundamental importance because they establish the base lines for further management strategies. If, for example, all the petroleum and natural gas exploitation rights in the Yukon and Northwest Territories are made available to entrepreneurs on the basis of free entry so that all rights are quickly taken up, and if these rights are to endure for a decade, then for a decade the federal government must forego more enlightened management strategies grounded on allocation.

Allocation is initially a power based on ownership. In terms of legislative jurisdiction, this power is fortified in the case of the provinces by section 92 of the BNA Act which gives a province legislative power over "the management and sale of public lands", over "property and civil rights within the province" and over "matters of a merely local and private nature within the province". If the resource is federally-owned, ownership jurisdiction is reinforced by section 91 (1A) of the Act which states that Parliament may legislate with respect to "the public debt and property". Should the resources be Indian lands, the Act confers on Parliament jurisdiction over "Indians and lands reserved for Indians".

It is an easy but misleading conclusion that the allocative function is jurisdictionally the exclusive prerogative of the owner of the resource, be it the federal or provincial government. However, in the case of provincially-owned resources, there are federal legislative powers that can indirectly affect the allocative function. For example, the federal government through income tax policies, its control over export trade, or its control over banking can influence whether the allocation of a resource will be to national or foreign entrepreneurs, or to large or small investors. Tax and fiscal policies also dictate whether it is feasible to conserve resources or necessary to exploit them.

The second problem of resource management is production or conservation of the resource. At this point legislative jurisdiction becomes more entangled. In general, power to control production rests with the government that owns the resource. Thus, each province regulates forest and mineral production within its boundaries. Federal legislation governs mineral and petroleum production in the north and offshore. These jurisdictions flow from the same provisions of the BNA Act that give legislative control over the allocative function.

In the case of forestry, the federal government confines its rôle concerning production in provincial areas to paying for and conducting

research. But with respect to fish and water, the federal government plays an active management rôle both on its own and in cooperation with provincial governments. As to fish, this rôle stems from Parliament's exclusive legislative authority over "sea coast and inland fisheries". In this case, one would think that a provincial government could not regulate fishing, but, despite the grant of exclusive legislative authority to Parliament, a province can legislate respecting its ownership of the fish and incidentally can control some aspects of the taking of fish.

As to water, the federal government finds its regulatory jurisdiction under a number of sections in the Act, each responsive to one of the many ways in which water is useful to mankind. Parliament may legislate with respect to "navigation and shipping" and "sea coast and inland fisheries". The jurisdiction to legislate for agriculture gives the federal government fragments of power over water as in the case of water storage and irrigation projects like the Gardner Dam in Saskatchewan. Certain water pollution prohibitions, like the penal provisions in the Canada Water Act, find support in federal jurisdiction over "the criminal law".

Parliament has power to implement imperial treaties affecting Canada. The federal government, through implementation of the International Boundary Waters Treaty, 1909, has control over waters crossing or forming the border with the United States. The control is exercised through participation with the United States in the International Joint Commission. In the case of interprovincial waters (and most drainage systems cross at least one provincial boundary) it is argued that Parliament acquires power simply through its legislative jurisdiction to pass laws for the "peace, order and good government" of Canada, but this argument remains moot.

The entanglement of power over production methods exists not only because ownership and legislative jurisdiction are divided between federal and provincial governments but also because the resources, themselves, in true ecological form, produce jurisdictional mix-ups. That is, there is nothing in physical reality which neatly corresponds to the law's categories of resources. What does exist can only be dealt with by exercising jurisdiction based on a number of these categories. For example, the federal government may be able to prevent or regulate drilling for oil in provincial waters to protect the fisheries because Parliament has legislative authority over sea coast and inland fisheries. Parliament's legislative authority to implement the Migratory Birds Convention, which entangles its jurisdiction with provincial jurisdiction derived both from the BNA Act and from ownership of wildlife, also gives the federal government legislative power to regulate the development of other resources such as forests or minerals to the extent that their use might destroy or interfere with waterfowl.

Power over the problem of production and conservation is complexly entangled. Existing arrangements represent an accommodation of interests reached during the early years of this century. Today new interests challenge legislators to produce new management strategies that will respect all interests.

A third problem is transportation and marketing of the natural resource product. As long as these functions occur wholly within a province, the provincial legislature has authority to regulate them under its jurisdic-

tion over "property and civil rights", "local works and undertakings" and "matters of a merely local and private nature". But when transportation or marketing crosses a provincial or international boundary, Parliament may exert its legislative jurisdiction over works and undertakings that cross provincial boundaries and over "trade and commerce". While it may seem that there is a clear demarcation line between federal and provincial powers, the clarity is illusory. There is great uncertainty as to the extent to which the federal authority can reach back into the province to regulate economic aspects of the transportation facility within the province before it crosses the boundary. There is also uncertainty as to the extent to which the federal authority can regulate *production* of the product within the province as a means of achieving market regulation or control of export trade.

This latter uncertainty now is a factor in the development of policy by the National Energy Board with respect to the marketing and export of natural gas. The desire of consumers in the eastern provinces of Canada that they be protected against escalating prices caused by the United States demand for Canadian gas leads them to urge the Board to regulate producer prices in Alberta. Producers and the Province of Alberta claim that the Board, which is established under federal legislation, has no jurisdiction to so regulate producer prices.

On the other hand, in the case of potash, which is a single-province resource in Canada, the Province of Saskatchewan has passed legislation which implements an arrangement made between the province and the State of New Mexico whereby the North American and foreign markets for potash are divided up and production of potash within the province is restricted to the Saskatchewan share and allocated rateably among the various producing mines in the province. Similarly, Alberta has a prorating scheme for oil which restricts production to market demand and allocates production to fields, pools and wells within the province. Thus, provincial producer regulation quite effectively controls an export market.

A fourth and final problem involves the aspect of international relations with respect to resources. Laymen would correctly assume that legislative jurisdiction to deal with other nations respecting resources resides primarily with federal government. The uncertainty lies in determining how far the federal hand may reach into spheres that are otherwise provincial in order to carry out its international obligations. The BNA Act conferred an implementation power with respect to treaties on Parliament. However, it did so in terms of Imperial treaties. The courts, after Canada gained full international powers by the Statute of Westminster in 1931, were not able to bridge the gap between colony and nation sufficiently to recognize that a power to implement Imperial treaties given in 1867 should be construed as a power to implement Canadian-made treaties after 1931. Consequently, Parliament has 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 to the extent that 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.

Canada's status in international law has at least supported its claim to jurisdiction over seabed resources in the *Offshore Minerals Reference*.[9] In result, and if this case is also applied on the east coast, the federal government has full jurisdiction to deal with all ocean and seabed resources, minerals as well as fish. But again the jurisdictional waters are muddied, for anadromous fish spawn in provincial waters and become subject to provincial proprietorship when they are there, and offshore drilling for oil inevitably involves provincial coastlines, at least in concern at the threat of pollution, and in dependence on a logistic base whose economic control is within provincial powers over labour and business.

There are two sources of legislative jurisdiction that can have effects at all functional levels with respect to natural resources. They are the federal jurisdiction to declare works to be for the general advantage of Canada, and the authority of both federal and provincial governments to decide how the public funds will be spent.

The declaration jurisdiction gives the federal government power to take complete control over the physical facilities connected with some or all aspects of a resource, as has occurred with respect to wheat marketing. Because such a declaration is a drastic encroachment on provincial powers, it can politically be used only in grave situations where there is widespread consensus that federal control is necessary and desirable.

The spending authority of governments in Canada is virtually uninhibited. It is the federal government, with a larger income base than the provinces, that is usually charged with using its spending power to distort the distribution of legislative jurisdiction contained in the BNA Act. But the legal limit of the spending power appears to be that its exercise must not amount to pre-emption of operational control in a field exclusively assigned to the provinces. Short of this limit, federal spending may underwrite or contribute to provincial programs, with or without conditions. It may support a full range of research, including research into provincial as well as federal aspects of natural resource management. Practical restraints on federal spending in research are political and institutional rather than legal.

Conclusions about Jurisdiction

Enough has been written to make it clear that the framework of power over natural resources in Canada is a complex one and that no single government can pursue a resource management policy entirely on its own. The various resource fields do exhibit different jurisdictional patterns with some falling mainly in the provincial sphere and others mainly in the federal sphere. These cases of dominance by one or the other government reflect the history of resource ownership and the distribution of legislative powers in the BNA Act rather than conscious resource management policies of today. That this distribution seems in many cases haphazard and illogical reflects the fact that in 1867 agriculture, forests and fishing were the main resources. They were not seen in today's terms of conservation, multiple use, technology and international marketing, and capital movements. Nor

were resource interrelationships understood in those halcyon days.

Each government in Canada is responsible to its electors to maximize the benefit of resources, whether produced or conserved. Each will see benefits in its own way in the light of its own perceptions about its electorate and their needs and wants. Each will exploit its positions of strength and will manoeuvre to shore up its weaknesses. But benefits to the nation can only be maximized through cooperation. It will not come easily; neither ignorance or inertia, nor entrenched interests or short-sighted expediencies, should be permitted to stand in the way.

The Decision Making Process

Two observations must be made about present resource management generally. The first concerns a failure to gather data; the second concerns the legal tests used in examining conflicts of legislative jurisdiction.

First, in dealing with issues such as foreign ownership, northern development, or corporate taxes, alternatives which will detrimentally affect exploitation are usually well-known and well-publicized by industry groups. Alternatives which subsidize industry groups at the expense of the general public, native peoples, co-ordinated resource management, or Canada's long-term interests as a nation, are often not as well-documented or as well understood. There is a failure to gather and evaluate relevant management data.

Second, legislation establishing management agencies is analysed in narrow constitutional categories such as "timber and wood" or "sea coast and inland fisheries". Modern problems of management, which involve marketing as well as production, cannot be approached intelligently with these categories. Problems of resource interaction cannot be analysed reasonably with respect to these categories. Particular *ad hoc* decisions can be made by the courts, but these decisions offer little guidance for the future. Often, both levels of government find uncertainty over jurisdiction preferable to judicial resolution of their conflicts over management policy.

Two recommendations of general applicability follow from these observations. They apply to all of the resource areas concerned in this study.

Our first recommendation is that combined legal, economic and social studies of specific resource industries and the interrelationship between these industries be encouraged for the purpose of establishing sources, consequences and measures of current trends. Legal input to such studies is required to obtain treatment of legal parameters such as tax policy as variables rather than as fixed constraints.

Our second recommendation is that legal and political science research into the operation of federal-provincial management authorities exercising delegated powers should receive a high priority. Such an authority is generally created under a federal-provincial agreement to carry out administrative functions that cross the boundaries of jurisdiction established by the BNA Act. Implementation of the delegated administrative structures foreseen in the *Canada Water Act*[10], and improvement of such structures, is of vital importance to Canadian resource management. These structures have implications for the management of all resources, although

differing mixes of power with different resources require quite different federal and provincial inputs. This recommendation also applies to such institutions as provincial marketing boards exercising delegated powers with respect to commerce within the federal jurisdiction.[11] The use of such bodies to achieve a national policy accommodating both federal and provincial interests is essential if judicial decisions which ignore resource interactions are to be avoided. Until judicial decision making in the field of resource legislation becomes less controlled by rigid conceptualism, sound planning demands that federal-provincial cooperative institutions be fully utilized.

We believe, however, that these institutions fulfil a function in balancing interests that is desirable in itself, even if a revised BNA Act no longer made them a practical requirement. Because this interest balancing function could become more effective if more were known about the operation of these institutions, and because such knowledge could result in more sophisticated devices to achieve this function within the constitutional framework of the BNA Act, we believe study of these institutions deserves a high priority throughout the whole field of resource management.

Study of the operation of federal-provincial authorities should lead to insights into their proper design to achieve balanced representation of interests in the management process.[12] Such a federal-provincial body, in possession of the data referred to in the first recommendation, is in our opinion the *sine qua non* of rational resource management.[13]

The Science Council of Canada Studies

In preparing this study, we have considered the recommendations contained in Science Council's individual resource area reports. Our conclusions can only be summarized in a study of this length. The degree of specificity which can be given to our conclusions is in large measure predetermined by the extent to which the legal pre-suppositions of Science Council's recommendations correspond to existing legal and political institutions and patterns or activity. Law is perhaps the most retrospective of the sciences. The certainty of our conclusions can only be tested against judicial decisions on past facts. Where radical departures from existing practices are proposed, our conclusions about them can only be tentative predictions of what courts would decide should the programs be called into question.

A. Agriculture

The institutional structure of Canadian agriculture has been badly crippled by the BNA Act. The Act contains concurrent agriculture powers, which allow the federal government paramount control over "agriculture" but give the provinces full power to fill in the blanks in federal policy. Since agricultural land passed into private ownership at an early stage in our history, one would expect this statement of the "agriculture" power to have produced a simple and harmonious institutional structure under primary federal control.

The reality, of course, is neither simplicity nor federal control. The

reason is that agriculture, for constitutional purposes, is considered to be the *growing* of a farm crop. Control over marketing of agricultural products and the inputs to farming activities fall not under the "agriculture" power, but under the economic powers of the provincial legislatures and the federal Parliament. These powers are divided in a manner that makes an integrated regulatory policy for marketing possible in only two ways: delegation to an interjurisdictional board or use by Parliament of the declaratory power.

A minor consequence of the existence of the "agriculture" power has been the organization of federal in-house research around the sorts of problems – plant disease, seed improvement, crop yield improvement – which clearly fall within the "agricultural" power. By contrast, marketing research, which cuts across the ill-defined boundary between federal and provincial control, has been slighted.

Science Council's recommendations concern problems within both the "agriculture" power and the economic powers. In the case of preservation of farmland in urban areas, they invade the field of local planning. This latter area is provincial in constitutional theory and history, with the actual decisions taking place on the municipal level. Absent proof of a national problem of a most serious nature, federal activity in local planning would hinge on a provincial delegation to federal-provincial cooperative institutions or on federal use of the spending power.

Science Council's recommendations for the reorganization of agricultural research – in particular the shift away from federal in-house research – should produce institutions whose priorities are more in keeping with the scope of agriculture's problems, and less influenced by the constitutional scope of "agriculture" powers. The recommended research centres and university groups could also draw on provincial funds and concerns. In drawing this support from the spending power of both governments they could function in a much more flexible manner than an exclusively federal research branch.

The most striking feature of the recommendations is their orientation toward export marketing and large-scale farming. These goals would require a far-ranging reorganization of existing legal institutions. Existing legislation cannot be said to promote export-oriented capital-intensive agriculture. There is a lack of structure and co-ordination in the existing law, which can best be described as a collection of *ad hoc* political solutions to individual agricultural problems. There is no coherent agricultural policy revealed by the statutes, either federal or provincial.

In such circumstances, an assessment of current agricultural policy, as a resource policy, requires settlement of questions which are neither legal nor constitutional. If "agribusiness" is the goal, then complete legislative overhaul is required. The same overhaul would be required if family farms at any cost were the goal.

It is clear however that Science Council's recommendations will be impossible to implement without passing marketing control into federal hands. This will require use of the declaratory power or of federal economic powers.

The declaratory power is, in our view, an unusable device in this

case[14]. Federal economic powers in marketing extend to export and interprovincial trade. Creation of a dual marketing scheme, with control over export and interprovincial trade in federal hands, and control over intraprovincial trade in provincial hands, is logically and constitutionally possible. Economically it is absurd, since it would require producers to conform to two sets of regulations and quotas simultaneously, to meet two independent product standards and to allocate production to one or the other market before it makes sense to do so in terms of distribution and marketing considerations. Such a system would be an administrative monstrosity.

The only alternative is delegation. Assuming there is an export or interprovincial aspect to the market, a federal authority can be created to which provincial regulatory powers can be delegated. But unless the export and interprovincial market is economically of primary importance, or the total market is disorganized by provincial regulation, there is little incentive to producers to seek federal marketing. They are more likely to press for delegation of federal regulatory powers to a provincial marketing board, or to accept the inefficiencies of a dual marketing system.

Thus, many factors favour a continuance of marketing control in provincial hands. Unless this control is driven into federal hands through the economic consequences of the Manitoba Egg Case[15], provincial interests will continue to hold an effective veto over evolution of national agricultural policies. Existing provincial marketing schemes are likely to offer substantial opportunities for frustrating the growth of Canadian "agribusiness". It is only after the economic effects of the Manitoba Egg Case become clear that one can assess the feasibility of a national marketing policy aimed at fostering "agribusiness" for other than traditional export crops. Given provincial control of farm extension services, the task of selling "agribusiness" to the farmer and to the provinces to obtain voluntary delegations from the provinces to federal marketing boards may be impossibly difficult.

Implementation of the goals seen by Science Council for Canadian agriculture requires a national political decision to rebuild the economic, social and administrative infrastructure of agriculture. Widespread national consultation on these and alternative goals is essential. Without a national commitment, attainment of the goals involved will be impossible, and provincial pursuit of competing strategies will result in confused marketing and waste.

Science Council's call for simultaneous development of strategies for people and land displaced from farming is of the greatest importance, in the event that export "agribusiness" is politically feasible. Even if not, techniques for encouraging rural growth and taking pressures off urban Canada are deserving of study on their own merits.

In summary, we recommend that research in agriculture be reorganized to reflect the problems of the resource area, rather than the peculiarities of the BNA Act. Science Council's recommended structure would achieve this result. We emphasize that the legal and institutional structure of agriculture, and especially its marketing institutions outside the traditional export crops, offer substantial barriers to implementing the bulk of

Science Council's recommendations for new directions in agriculture. We recommend also that research into rural growth be considered on its own merits, as well as evaluated as part of a program for people and land displaced from farming. Such growth may well be desirable apart from questions of agricultural policy.

B. Forests, Minerals, Wildlife and the Inland Fishery

As was pointed out above, the influence of ownership jurisdiction on the agriculture resource is negligible. By contrast, the resources grouped here are subject to ownership jurisdiction in many very important respects. Because the provinces own their forest lands and the greater part of their minerals, because the property in uncaptured fish and wildlife is in the provincial Crown, and because these resources tend to be located physically within only one jurisdiction, the powers of ownership are sometimes the decisive elements in management control[16]. Legislative jurisdiction under Sections 92(13) and (16) of the BNA Act complements this ownership jurisdiction, and, in the case of privately-owned forests and minerals, is the sole basis of provincial management control.

These resources are often found together on the same parcels of land. Exploitation of any one has direct consequences for the others, and a sound management policy must recognize this interdependence. Even when only one legislature is concerned, however, statutory structures created for the management of these resources usually ignore this interdependence. Integration of management often depends on informal liaison between managers rather than on a legally structured co-ordination of policy. It is no surprise to those familiar with resource problems that such informal procedures may fail to prevent mismanagement.

Not only the conflicts between these resources in a single province require co-ordination. Because exploitation of these resources for the same product occurs in several jurisdictions, there must be a close co-ordination among the various governments involved in management of the particular resource to avoid unseemly competition. Unless this co-ordination exists the highly concentrated resource industries will simply play the resource managers concerned against each other to obtain excessively favourably development arrangements.[17]

The similarity of these resources as to ownership jurisdiction and their conflicts over land use are strong arguments for considering formal liaison between the resource advisory committees that are proposed for the individual resources. We would recommend as a minimum that the advisory committees exchange and evaluate in terms of consequences for their own resource the reports of the other committees.[18]

The Forest Resource

Exploitation of forests in Canada for timber and pulp presently occurs almost exclusively on woodlands owned by the provinces and managed on a sustained yield basis. Such management involves varying degrees of private participation and varying degrees of security for large scale investment. Federal woodlands involvement must generally be based on the spending power.[19] It has consisted of creating and funding research and

experimental institutions to assist the provinces. Implementation of woodlands research results will require provincial initiatives.

Direct federal management opportunities in the forest industry are limited. Federal powers seldom rise above a possible veto on provincial action. Successful federal activity will involve use of the spending power to assist and encourage provincial, industry, and university activity in woodlands research. So long as the scale of this activity is not such as to effectively pre-empt provincial management, such spending is within federal power.[20]

Greater federal involvement is indicated where significant multi-provincial interests exist, such as in the case of watershed protection where the watershed crosses provincial boundaries.[21] Such a federal interest in successful multi-use management as protection of anadromous fish can legally justify greater federal participation in forest management.

Organization of research activity on a provincial base will create a national need for co-ordination and for a clearing house for information exchange. These rôles can be economically combined with the advisory rôle on federal activity. It is perhaps superfluous to point out that such an advisory committee can properly fulfil its rôle only if it is truly representative of provincial as well as federal viewpoints on forest resources. The structure suggested in Science Council report No. 8, *Seeing the Forest and the Trees*, would achieve such national representation.

The recommendations of Science Council with respect to increased woodlands research by industry reveal inadequacies of a legal nature. Industries whose forest tenure is shorter than the growth cycle of the timber will gain little economic benefit from the results of such research and will therefore have little incentive to do it.[22] In addition, what industry learns through its own investment in research is likely to be treated as proprietary – and the national interest requires that such information be public.[23] Responsibility for development of management techniques through research should not be separated from the right to manage – a right which the provinces zealously retain.

We recommend with respect to the forest resource that provincial woodlands research be encouraged and that federal arrangements for woodlands research be arrived at in close cooperation with provincial officials and viewpoints. We further recommend that federal involvement be tailored to the specific problems of individual woodlands areas. Programs designed to recognize specific federal and multi-provincial interests in a particular area should be preferred to general programs. The advisory committee sought by Science Council would be in a good position to achieve such tailored recommendations.

Mineral Resources

In addition to the direct involvement of the federal government through ownership of mineral resources in the northern territories and offshore, there must be federal participation in the management of mineral resources located in the provinces because problems such as foreign ownership,[24] production primarily for export, and foreign attempts to pre-empt Canadian minerals require that the federal presence be both strong and effective.[25]

Science Council Report No. 7, *Earth Sciences Serving the Nation – Recommendations*, in our opinion inadequately covers the mineral resource area. This is not to fault the merits of such proposals as increased provincial educational efforts on the secondary level in basic earth sciences, or the establishment of a national committee representative of federal, provincial, industry and university interests to advise on federal activity in support of earth sciences research. So long as research, and not operational pre-emption of provincial ownership and legislative jurisdictions, remains the goal of such a federal program, the program is constitutionally unobjectionable. So long as the advisory committee is truly national, provincial interests and priorities should be known and respected in its recommendations.

The report's weakness is the narrow scope of its recommendations. For example, the recommendation as to core banks and a national geophysical clearing house treats a symptom rather than the problem. The problem is that Canadian mineral legislation sees mineral explorers as entrepreneurs competing in the search for minerals. Competitors who spend large sums to acquire data will closely protect that data. Its value to them is enhanced by secrecy. A core bank and clearing house cannot be fully effective so long as such competition remains the basic system.[26]

Unless the processes of exploration and acquisition of mineral claims are changed, systems for data pooling are unlikely to be effective. Voluntary systems are unlikely to collect much data; involuntary systems[27] are likely to be more productive of staking rushes than of a rational pattern of mineral development and a sound advancement of scientific knowledge.

Science Council should place a high priority on research into a more rational framework for mineral resource management. Such research should include a wide range of subjects to which lawyers, economists, political scientists, and sociologists can contribute their skills and insights. In particular, one should ask whether entry on land for prospecting purposes should be free and whether it should be given a universal priority over other uses of land and over wilderness and wildlife values.[28] Studies should be directed to methods of accounting for the costs of infrastructure and other externalities of mineral exploration and development so that public management policies can be based on realistic cost-benefit studies. Systems of mineral tenure should be re-examined. It is not obviously true that claim-staking methods established in the Klondike in the 1890s should prevail in the Yukon today – or elsewhere in Canada. Research into which of the various kinds of tenure offered in different mineral jurisdictions in Canada optimizes return on the investment dollar, and what other interests they serve, is required. We recommend that research into a rational framework for mineral resource management be undertaken on a priority basis.

Major environmental decisions about mineral resources, such as authorizing large scale open-pit mining, smelter location and emission standards, tailings and effluent disposal criteria, or oil spill hazards and contingency planning, are the focus of considerable public pressure. Technocrats tend to over-emphasize the public's inability to make a knowledgeable contribution to these decisions. They often ignore the rôle of public pressure, focussed through participation in the decision making process,

in producing changes in the legislation which creates and guides their discretion. Research is required into the methods whereby the public demand for broader inquiry and investigation in advance of commitment to development can be satisfied.

Failure to accommodate public demand for visible attention to environmental factors will increasingly politicize resource management decisions, and further imperil the security of resource investments. It will also increasingly radicalize the critique of resource policy. We therefore recommend research on legal means of assuring a credible public input in the mineral development decision making process.

In the case of minerals in the north and in the offshore regions there is urgent need for research into methods whereby the conflicts over resource ownership and management can be speedily resolved so that federal legislators and administrators in the north will know whether they represent the people of Canada as a whole or the citizens of a future northern province when they deal with northern minerals, and so that oil companies will know the responsibilities which they owe to the respective federal and provincial authorities when they exploit the offshore petroleum resources. We recommend that this research be undertaken.

Wildlife and the Inland Fishery

Unlike other resources, whose management has been based on dispositions of limited ownership interests to individuals and corporations by the provincial or federal authorities, wildlife and the inland fishery have been managed as common-property resources, that is, resources which no one owns and to which all have free access.[29] Economically significant inland fisheries have suffered from over-capitalized exploitation owing to this free access for all. Perhaps as a direct consequence of common-property management without creation of safeguards, major inland fisheries have been destroyed by over-exploitation and by poor water quality management.

The wildlife resource has survived through government decisions against its exploitation. Economic exploitation has been barred, and a combination of restrictions on use and relatively low human population has left even southern Canada with appreciable wildlife resources.

The complexity of constitutional jurisdiction over these resources is out of all proportion to their economic importance. For example, an intricate pattern of delegations of administrative powers between governments attempts to reconcile the distribution of particular fisheries powers in the BNA Act with the economic significance of the various fisheries either to Canada as a whole or to one or another of the provinces.[30] The problem is basically that of reconciling provincial ownership, federal legislative control, and varying degrees of economic significance. Marketing of fish and fish products proceeds under complex delegations based on the export significance of the particular product[31] in the particular region of Canada where it is exploited.

By contrast, the wildlife resource in southern Canada has only two federal aspects.[32] These aspects are based on an Empire treaty, the Migratory Birds Convention[33], and on the federal power over Indians. The constitutional complexity produced is, from a wildlife manager's point of view,

almost random. An historic accident and the hunting habits of native peoples impose a combination of federal supremacy and haphazard veto power over provincial management.

Science Council's recommendations that research be undertaken into recreation, use of biocides, ecosystem dynamics, and educational broadening of scientists involve legitimate uses of the federal spending power. The creation of agencies to sponsor or fund environmental research is, legally, an unobjectionable use of federal funds.

Creation of a *Canadian Wildlife Act* appears to contemplate federal cooperation in provincial wildlife management. If such cooperation should extend beyond co-ordinating the solutions to problems arising with respect to migratory birds and Indian hunting, its jurisdictional basis is the federal spending power. Pursuit of goals similar to those of the *Forestry Development and Research Act*[34], would be possible. However, providing an effective land basis for such activity in southern Canada would require provincial cooperation because of the provincial ownership of the public lands[35].

The recommendation for a unified federal renewable resource department has already been largely implemented by the establishment of the Department of the Environment. New initiatives for encouraging multiple-purpose resource management are now available. As a result, the recommendation for socio-economic studies and research is particularly timely. Legal input into such projects, and an introduction of legal materials into the graduate programs envisaged, would be desirable.[36]

C. Water

Water is, in some important respects, a proprietary resource.[37] But the value of rights in water is so closely associated with the use of its flow, for power or for disposal, and with water quality, that where the water crosses jurisdictional boundaries inter-jurisdictional problems alone condemn non-integrated proprietary administration as wasteful[38] and inefficient. In some cases federal jurisdictional responsibilities for fisheries, navigation and the conduct of foreign affairs create a necessity for a strong federal presence. Intelligent management must consider as a minimum all interests involved in a major drainage basin. If diversions are feasible, intelligent management must also take into account interests beyond the basin. The recommendations of Science Council Report No. 3, *A Major Program of Water Resources Research in Canada*, are constitutionally sound. We would, however, further recommend:

1) that the study of inter-jurisdictional agreements and their implementation be given a high priority; such study should isolate institutional reasons for the successes and failures of particular schemes;

2) that attempts to create or simulate market forces in the legal apparatus for water-allocation decisions be undertaken on a pilot project basis[39], and be subject to continuing evaluation against other decision making techniques;

3) that, recognizing that conflicts of jurisdiction inherent in water management in Canada must be balanced on a different basis in each different factual context, a wide variety of institutional solutions to these conflicts be studied; the focus to be on the operation of such institutions – not on

jurisdictional problems in the abstract.

D. Marine Resource

Because of federal ownership jurisdiction over the seabed resources of the continental shelf and probably of the territorial seas as well, and because of federal legislative jurisdiction over navigation, foreign affairs, and fisheries, federal opportunities and responsibilities are more important here than in any other resource area. Provincial interests should not, however, be discounted. There is no fishery without fishermen. The marketing of fish products and the local social and economic impact of the fishery raise concerns of great importance to the coastal provinces and it is upon these that provincial jurisdiction touches. Thus, while an offshore fishery for export raises mainly federal issues, a coastal fishery may for reasons of water quality be affected by provincial action or be subject to a provincial marketing scheme. Effects may be physical as well as economic. For example, pollution resulting from federally-authorized oil or mineral exploitation may foul provincial foreshores. Because of this interaction between regional and national interests, we recommend that even in this area, provincial interests be recognized through provincial representation on national advisory commissions and on administering bodies such as offshore petroleum conservation committees.[40]

Two of Science Council's more detailed recommendations involve schemes which illustrate possible direct effects on provincial interests.[41]

The proposals for the Gulf of Georgia deal with an area where proprietary interests are in dispute between the federal government and the province of British Columbia. Conflicts over mineral proprietorship highlighted by proposals for a national marine park in the Gulf, and disputes over hydro development of the Fraser River show that extent to which the interests of the two governments are entangled.

Similarly, works necessary to control the salinity of the Gulf of St. Lawrence, and thereby to control its ice cover, may involve substantial river diversions in Quebec. In spite of the ultimate impact on "navigation and shipping", the hydro potential of such diversions would clearly involve provincial interests. The secondary effects of such a project on climate also raises legal questions of great complexity. It is clear that if a private person were to modify the climate, questions of tort law would arise. These questions fall within the provincial legislative jurisdiction.[42] Their just resolution is as much a part of a sound management decision as to whether or not to carry out such a project as the engineering feasibility studies.[43] In human terms, these questions are more important. An argument that these questions can be ignored because the federal Crown would execute the project is a perversion of both common sense and law. For the government to do wrong because it can make itself immune from suit is impolitic. It is also contradictory to present federal policy.[44] We recommend that these questions receive the study and the early place in the critical path of project evaluation which their importance demands.

By contrast Science Council's recommendations for increased ocean research and a federal Crown corporation to promote ocean-oriented research and development raise no jurisdictional problems. The federal pro-

prietary base in offshore resources could justify even operationally-oriented spending. Similarly, the federal interests in the ocean fishery, federal power over foreign affairs, and Canada's international treaty obligations are a full justification for federal activity far beyond the research for which Science Council has called. However, we question whether such a Crown corporation should not also include provincial participation.[45] The absence of existing institutions in this area means that innovation will be much easier than in areas where established institutions exist. We recommend that study of this proposal include consideration of possible ways in which the federal and provincial interests and responsibilities can be co-ordinated.

Conclusion

The general tenor of our recommendations is for closer federal-provincial cooperation in the resource management field. But we would be misunderstood if we were thought to be advocating cooperation as one advocates national unity or patriotism or other such familiar virtues. Rather we are advocating the study at an *institutional and administrative level* of all possible ways of achieving integration of federal-provincial management of natural resources. If rationalization of management is the goal, such integration must be achieved, no matter how many difficulties obstruct the path to federal-provincial cooperation.

References

1. Why not air? Like water, air has economic use for dissipating heat and other wastes and needs increasingly sophisticated management. Development of legal analysis of management problems is only beginning.

2. British North America Act, 1867, as amended (hereafter referred to as the BNA Act) is the statutory embodiment of the constitution covering such matters as public property and division of legislative jurisdiction.

3. We recognize that such delegation is not acceptable with respect to basic parts of the constitution such as language and cultural rights.

4. J.W. MacNeil, *Environmental Management*, Privy Council Office, Government of Canada, 1971. Page 175.

5. British Columbia, exercising its ownership perogatives, issued forest cutting permits on the condition that they would be cancelled should Chinese or Japanese aliens be employed, or, in the event of breach of this condition, that the permits would not be renewed. A refusal to renew on the ground that Chinese had been employed was sustained by the court, see *Brooks-Bidlake and Wittall Ltd. v. Attorney-General for British Columbia*, 1923, A.C. 450.

6. Although proprietary jurisdiction has historically been important from the provincial point of view, it is an important source of federal power in the North, on the continental shelf, and beneath the territorial sea, and within federal enclaves such as defence installations, Indian reserves and national parks.

7. *Offshore Minerals Reference*, (1967), Supreme Court Ruling 792, Supreme Court of Canada.

8. In some cases, Northern Quebec for example, Indian lands are owned by the province.

9. *Offshore Minerals Reference*, (1971), Supreme Court Ruling 792, Supreme Court of Canada.

10. *Offshore Minerals Reference*, (1970), Supreme Court Ruling, Supreme Court of Canada. 1st supp., chapter 5, subsection 9. The device of delegation to an administrative board is the legal technique for avoidance of problems of divided jurisdiction. The *Canada Water Act* is designed to allow provincial jurisdiction over segments of interprovincial waters to be delegated to authorities created under the Act. Thus, all legal power over the waters is united in one management body. This process of delegation is still affected by constitutional impediments that prevent straight forward delegation of rule-making powers; hence, our previous recommendations about improving the delegation process in any revision of the BNA Act.

11. See *Prince Edward Island Potato Marketing Board* v. *H.B. Willis Inc.*, (1952), 2 Supreme Court Ruling 392.

12. It has been the usual practise to simply delegate federal power to persons comprising a provincial board. More sophisticated agencies are, however, possible. See, for example, the management board of the *Creston Valley Wildlife Management Area Act*, British Columbia Statutes, 1968, Chapter 14, subsection 17, which includes both provincial and federal representatives, and the joint board of the *Eastern Rocky Mountain Forest Conservation Act*, Statutes of Canada, 1947, chapter 59; 1952, chapter 41;

1957, chapter 23.

13. Cf. the recent announcement that the premiers of Quebec, Newfoundland, and the Maritime Provinces have decided that a "suitable regional agency" with representation from the five provinces and Canada "would be desirable" to administer offshore oil and gas developments. Vancouver *Sun*, August 3, 1972.

14. Use of the power depends on there being identifiable "works" upon which the declaration can operate, and upon a strong political commitment to federal control. Such a commitment presupposes the state of affairs – an economically important product – which Science Council hopes to see created. Federal control of wheat marketing through the declaratory power was achieved through a background of total market failure and judicial destruction of co-ordinated federal-provincial marketing legislation. It would be most undesirable to await such a political crisis but a crisis is required to accumulate the national commitment necessary to invoke the declaratory power against established institutions.

15. *Attorney-General Manitoba* v. *Manitoba Egg and Poultry Association*, (1971) 19 Dominion Law Report (3d) 169, (Supreme Court of Canada). It had been customary to rely on techniques of grading and health regulations to prevent penetration of the provincial market by outsiders. Quebec's attempt to exclude outside producers by a specific licensing system halted penetration of the Quebec market by Manitoba producers. When Quebec lower courts sustained the legislation, Manitoba enacted the same system and referred it to the courts. On appeal, the Supreme Court of Canada invalidated the scheme. However, the previous barriers to entry may still give provincial boards sufficient control to maintain an orderly market. If so, there will be little producer pressure for national marketing.

16. Federal policies may be frustrated by the exercise of provincial ownership jurisdiction. For example, the economics of mineral exploitation are a function of both provincial and royalty arrangements and federal tax policy. Federal tax incentives could be offset by high rates of royalty.

17. Even under the settlement proposed by the federal government for Atlantic offshore oil, there will be six Canadian jurisdictions involved. In addition there are St. Pierre and Miquelon and U.S. state and federal claims. Each Canadian jurisdiction offers exploration and development rights in its offshore region. In some cases these rights are offered in overlapping areas because of ownership disputes. In all cases, the varying terms and conditions contained in exploration and development permits and leases invite shopping between jurisdictions. The multiplicity of administration plagues industry planning and management.

18. The relationship of these committees with the less-broadly based and more operationally-oriented function of the Canadian Council of Resource and Environmental Ministers (CCREM) and its secretariat should also be considered. In many respects, the rôle of the committees could be aided by close liaison with the CCREM.

19. See, for example, the *Eastern Rocky Mountain Forest Conservation Act*, Statutes of Canada, 1947, chapter 59; 1952, chapter 41; 1957, chapter 23.

20. See *Attorney-General Canada* v. *Attorney-General Ontario*, 1937,

Appeal Case 355, for the Privy Council of Great Britain. Federal powers to spend may be essentially unlimited – the extent of the power is an intensely political subject, which recent federal governments have chosen to leave unsettled by the courts.

21. As in the Saskatchewan watershed. See note 12, *supra.*

22. It is true that a realistic estimate of tenure may include the expectancy of renewals of leases. Industry could be expected to carry correspondingly greater burdens of woodlands research where these expectations exceed the duration of the current tenure.

23. Note the Science Council's recommendations concerning the proprietary data of the mineral industry, Science Council of Canada Report No. 7, *Earth Sciences Serving the Nation – Recommendations*, Information Canada, Ottawa, 1970 and our comments at p. 87, *infra.*

24. The figures reported for 1968 under the *Corporations and Labour Unions Returns Act*, Ruling of the Supreme Court of Canada, 1970. Chapter C-31 indicates control of 58.1 per cent of the assets in mining. See *Financial Post*, Toronto, April 17, 1971. p. 33. However, the definition of control used (50 per cent of shares, directly or indirectly in foreign hands) is most unrealistic. A major company can easily be controlled by stock interests as low as 10 per cent of total shareholdings if the stock is widely held.

25. Witness the arrangement sought by U.S. natural gas companies in the High Arctic, and Japanese interest in acquiring long-term contracts in western Canada.

26. Most public exploration data is federally obtained. In southern Canada, this results in the anomaly that management data is accumulated by the non-managing government. Provincial data required for management has been woefully underfunded.

27. Suggested changes have included compulsory disclosure of data under penalty for non-disclosure or disclosure as a condition of further rights to explore or exploit. Offering tax write-offs in exchange for data is probably an extremely wasteful technique and amounts to a subsidy of exploration.

The government holding proprietary power over the resources can quite clearly expropriate data. It is not clear, however, that the federal government would be able to expropriate data as to provincial lands. The most likely source of federal power for such expropriation would appear to be the power over the census and statistics.

28. The present position in Canada is that potential mineral exploration may so jepardize other types of surface developments or be so inconsistent with preservation of wilderness that the most economic or beneficial use of the land cannot always be realized.

29. Such management has important economic and legal consequences. Economically, the resource becomes over-exploited due to market failure. The government then protects the resource by restricting exploitation to below the capacity of existing techniques. Economic waste is thus produced.

Legally, no user of the resource has a legal right to it until his capture of it. Therefore he cannot protect the uncaptured resource from destruction through pollution, even if that destruction is unlawful. Only govern-

ment has the power to protect such a resource before capture, absent special statutes conferring such rights on all citizens or users of the resource.

30. For example, in the North and the Maritimes, management and enforcement of fisheries legislation is federal. In Quebec and the inland provinces, management of all fisheries is provincial, although regulation of fish products and fish moving in export and interprovincial channels is federal. In B.C. federal regulation extends to salt water and anadromous fish, while provincial proposals are validated by the federal government with respect to fresh water fish. In some provinces federal powers over the oyster fishery have been delegated to the province.

31. See, for example, the *Saltfish Marketing Acts* of Newfoundland and Nova Scotia, S.N. 1970, No. 8; S.N.S. 1970, chapter 14 (not proclaimed) and the federal *Saltfish Act*, Ruling Supreme Court of Canada 1970, 1st supp., chapter 37.

32. In the northern territories, wildlife, apart from migratory birds and Indian rights, is not federally regulated in its aspect as game because Parliament has delegated legislative power to the territorial councils which has been exercised by the territorial Game Ordinances. The federal authority finds its expression in the functions of the Canadian Wildlife Service.

33. Empire treaties are those executed prior to Canada's achieving control over its own foreign relations. Under the BNA Act, section 132, the federal government has legislative jurisdiction to implement them. The present Migratory Birds Convention is such a treaty. But, as has been pointed out, the federal government has no power, apart from its usual legislative jurisdiction, to implement treaties concluded by Canada since Canada gained control over its own foreign relations.

34. Ruling of Supreme Court, 1970. Chapter F-30.

35. Even in Northern Canada, it seems difficult to establish wildlife reserves such as the proposed Arctic International Wildlife Range in the Yukon because of its prior commitments of the northern lands to oil and mineral exploration rights.

36. E. Peterson, *The Rationale for a Teaching and Research Programme in Environmental Law*, (1970), unpublished manuscript available from University of British Columbia Faculty of Law.

37. The source of provincial power over water is basically the same as that of their power over forests and minerals. Typically, the western provinces have a statute providing that the province owns the water. Such an assertion does not, however, change a province's constitutional right with respect to powers over water and its use.

38. The concept of an ownership which disappears at the provincial boundary to be replaced with another ownership, is not likely to lead to rational water use. It places undue value on being the upstream province, and allows that province to impose costs on downstream users.

39. Computer simulations of water marketing deserve a high priority. It is quite possible that anti-competitive forces would make a mockery of an actual market in water rights. Hopefully, computer simulations and critiques of these simulations, would reveal such market imperfections.

40. See *Oil and Gas Production and Conservation Act*, Ruling of Supreme Court of Canada, 1970. Chapter O-4, subsection 4.

41. Science Council of Canada Report No. 10, *Canada, Science and the Oceans*, Information Canada, Ottawa, 1970.

42. If the effects of modification were sufficiently far-reaching geographically, federal jurisdiction might arise, in addition to the provincial tort jurisdiction.

43. Note Science Council of Canada Report No. 10, *This Land is Their Land*, Information Canada, Ottawa, 1970. If the wildlife of Canada deserve such studies, surely the people of Canada do. The recently developed technique of requiring government to produce environmental impact statements, and subjecting projects to delay for failure to produce an adequate statement, provides a tool which deserves close study in Canada. See (U.S.) National Environmental Policy Act of 1969, Washington, D.C.

44. *Crown Liability Act*, Ruling of Supreme Court of Canada, 1970. Chapter C-38, subsection 3(1). It is of course true that a statute authorizing such projects could confer Crown immunity. Sound management demands assessment of the costs which such a statute would impose on private persons who were injuriously affected by the project.

45. For example, there might be provincial representation on the Board of Directors. See for example, *Creston Valley Wildlife Management Area Act*, British Columbia Statutes, 1968. Chapter 14, subsection 17.

IV. Resources: Implications of Ownership

by A.J. Cordell

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Other:
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I. Resources and Regional Development

This essay is general in nature and many of the points raised will be familiar to the specialist in the field. It seeks to bring together various aspects of current knowledge regarding industries in the resource sector.

Resource development has contributed to the economic development of Canada; both nationally as well as regionally[1]. Thus, there can be no question that development of the Canadian economy from the earliest colonial period has been based largely on extraction of natural resources. Early colonization and development was based on fishing, furs, timber, and agriculture for local and then export markets. Mineral production also began at an early date. Resource processing[2] and resource-based and other manufacturing has always tended to lag resource extraction by a considerable margin, especially in the two non-agriculture resource sectors that have come to be predominant: mineral and forest resources. Although this continues to be true to a degree, a large and diversified manufacturing industry has developed in Canada, only a small part of which is based upon natural resources.

The economic exploitation of resources requires large amounts of capital investment. Traditionally, both public and private capital are involved in the earliest stages. Development of an infrastructure of roads, railways, geoscience data collection, mapping surveys and publications (topographic, legal, geodetic, aeronautical, hydrographic, etc.), resource-economic data collection, etc., all lead to the final outcome: identification and efficient exploitation. A great deal of public and private capital is involved at the earliest stages. In the intermediate and later stages the capital (except in those cases where the venture is conducted by the government) is largely private.

Much of the development leads to benefits which are, in large part, non-quantifiable. For example, mineral exploration activities have led to the opening of new mines in hitherto remote localities, areas of settlement have been expanded, and a communications network associated with inhabited centres has been established. Communities that have been built up around mining camps serve as bases for further development. In Labrador, northern Quebec and Ontario, a few of the towns that have grown serving the mining industry include Labrador City, Schefferville, Chibougamau, Noranda, Kirkland Lake and Timmins. Further west are Red Lake, Thompson, The Pas, Lynn Lake, Cassiar and many others.

Most of these settlements were initially established by mining companies and other private capital, and to supply them a road and railway network has been developed that has been paid for by both industry and government. Much railway development in the past quarter century has been associated with mineral development: for example, iron ore companies built the 357-mile Quebec, Labrador and North Shore Railway, provincial authorities built the line to Chibougamau, and the federal government paid much of the cost of the railway to the rich lead-zinc deposits at Pine Point on Lake Athabasca. Mineral industry products consistently make up nearly half the freight carried by Canadian railways and more

than half the value of freight carried on Canadian canals and inland waterways.

Road-building programs exist in a number of provinces to encourage the mining industry and, in many cases, road-building costs are shared by mining companies. In the past, shared-cost programs involving the federal government have been responsible for providing roads to remote areas, and in some cases they remain the only means of access for industry and tourists alike.

The Canadian mineral industry is the most important, in terms of value of output, of all primary resource sectors. The value of its production has grown from the equivalent of about 1.5 per cent of GNP at the time of Confederation to about 7 per cent of GNP at the present time. Much of this growth has taken place since the end of World War II and was the result of an unprecedented demand for minerals by industrialized economies. Initially, Canada's reaction to this demand was an increase in exports to the United States and the United Kingdom. During the 1950s and 1960s the Canadian mineral industry grew as Japan and the European Common Market became consumers of significant quantities of Canadian minerals. The value of production grew from $280 million in 1930 to $1 billion in 1950, $2.5 billion in 1960, and is currently estimated to be $5 billion.

All provinces participate in mineral production, if only of sand and gravel as in Prince Edward Island. However, production tends to be concentrated in certain provinces. Ontario is the largest producer and its mineral industry is perhaps the most diversified in terms of the range of commodities produced and the degree to which they are further processed. Nearly one half of the total value is derived from copper and nickel but Ontario is also the major gold producing province and contributes to the national mineral output substantial quantities of iron ore, silver, uranium, zinc, salt, and structural materials.

Alberta has the second highest value of provincial mineral output but this is concentrated in petroleum, natural gas and associated sulphur which constitute about 85 per cent of its total output. Quebec also has a relatively diversified mineral industry. Asbestos, copper and iron ore each account for about 20 per cent of the provincial total. However, the province is second only to Ontario in the production of gold and construction materials and is the only province that produces titanium dioxide. British Columbia was the fourth largest provincial producer in 1967 but its mineral industry is growing the most rapidly of any other province. Although no single mineral is predominant, copper represented about 20 per cent of the provincial total in 1967 and its relative importance is expected to accelerate during the early 1970s. Several new copper mines planned or under construction will be among the world's largest and will ship concentrates under contract to Japan. The Saskatchewan mineral industry is also based largely on petroleum and natural gas (73 per cent in 1967) but it has recently become a major producer of potash, which accounted for 20 per cent of total production in 1967. Four-fifths of Newfoundland's mineral production is represented by iron ore produced in Labrador. The province's mineral industry is beginning to diversify but other minerals continue to be overshadowed by growing iron ore production.

II. Foreign Development of Canadian Resources

Canada has to a large extent relied on foreign sources to supply the large amount of capital necessary for resource development. Large foreign firms, often multinational or global in their activities, have been willing to develop Canadian resources because it has proved to be profitable.

This has led to a situation where a significant amount of Canada's resources are neither owned nor controlled by Canadians (Table IV.1).

The reasons for foreign development of Canadian resources are as varied as are 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, etc. Recently, firms from other

Table IV.1 – Non-Resident Ownership* of the Canadian Mineral and Forest Industries, 1965 and 1968

	Per cent of Industry Assets Owned by Non-Residents	
	1965	1968
Total Mineral Industry	**64.4**	–
1. Total Mining Industry	*57.9*	*62.8*
Total Metal Mining	38.5	44.2
Gold Mines	16.6	49.4
Iron Mines	87.5	87.7
Other Metal Mining	10.3	17.2
Total Mineral Fuels	80.9	82.3
Coal Mines	33.7	53.0
Oil and Gas Wells	81.5	83.1
Total Other Mining	48.8	57.1
Non-Metal Mines	72.3	85.0
Quarries	9.2	9.5
Mining Services	31.7	37.9
2. Total Primary Metals	*59.1*	*55.2*
Iron and Steel Mills	26.1	14.4
Iron Foundries	11.4	33.9
Smelting and Refining	87.3	87.9
3. Total Non-Metallic Processing	*36.9*	*51.6*
Cement Manufacturing	31.5	60.1
Concrete Manufacturing	4.4	1.7
Ready-Mix Concrete Manufacturing	9.5	25.3
Clay Products	34.7	28.1
Glass	47.4	54.6
Other Non-Metallic Processing	81.7	89.5
4. Total Petroleum and Coal Products	*99.6*	*99.7*
Petroleum Refining	99.8	99.9
Other Petroleum and Coal Products	82.8	74.0
Total Forest Industry	**36.1**	–
1. Primary Forestry (Logging)	*17.6*	*13.1*
2. Total Woods Products Industry	*28.2*	*30.8*
Sawmills	32.2	38.1
Veneer and Plywood	40.8	34.3
Planing Mills	3.8	2.4
Other Wood Products	16.6	–
3. Total Paper and Allied Industry	*39.4*	*38.9*
Pulp and Paper	38.6	38.4
Paper Boxes and Bags	30.9	25.3
Other Paper Products	64.3	59.3

*As measured as a percentage of total industry assets owned by reporting firms that were themselves 50 per cent or more controlled by non-residents.
– not available.
Sources: 1) Corporations and Labour Unions Returns Act (CALURA), 1968. (Part I–Corporations).
2) Unpublished data supplied by Statistics Canada.

countries such as Japan and Sweden have begun to invest in Canadian mining operations and, in this case, the most common objective is to obtain concentrates of base metal such as copper.

Among examples of commodities produced in Canada that are destined primarily for use by the foreign parent firm and which undergo little or no domestic processing beyond the mineral concentrate stage are iron ore, asbestos and gypsum. In the latter two cases, costs of packaging and shipping the product in more advanced stages of processing would make such processing in Canada uncompetitive with that in consuming countries.

Such firms are said to be *vertically integrated.* A vertically integrated firm is one that is active at more than one stage of the production process. That is, it has decided to grow or expand its operations not by doing more of the same, but rather by merging with its present activities some one or more operations which precede or follow its present activities in the production process. A great deal of economic theorizing has been written concerning this phenomenon. Why do firms at one stage (e.g., retailing) integrate backward (into distribution) or further backward (to manufacturing) or perhaps become involved in the exploitation of the resource itself.[3]

Sometimes a firm will integrate forward to a stage of the production process that is closer to the final consumer. By expanding in a vertical fashion the firm enters a market where it has not been previously active.

Some writers have shown that this is done to obtain control of the original resource in order to establish a monopoly position in the final market where the manufactured item is sold; others have demonstrated cases where vertical integration is practised to ensure a long term and stable supply of a vital raw material essential to the manufacture of either the intermediate or final product.

Generally speaking, vertical integration like any other diversification is an attempt to provide for stability of profits through reduction of risk. Thus, we have *horizontal integration*, where a steel maker buys another steel maker in order to reduce competition and risk, and we have *conglomerate integration*, where a steel maker buys a food company in order to combine a cyclical business with a non-cyclical business. Vertical integration, whether backward from the final product producer or forward from the raw material producer, similarly normally reduces risk, e.g., a steel manufacturer by buying iron ore mines assures his raw material supply, while an iron ore miner buys a steel mill in order to have an assured outlet for his raw material.

Vertical integration in the oil industry basically took place for the same risk reduction motive. However, in oil, as in a number of other industries, it was further found that vertical integration could become the key to development of a monopolistic industry which charged monopolistic prices (i.e., prices higher than those dictated by cost), and hence much greater profits.

However, in most industries where vertical integration is strongly developed, the key to monopoly power is control of the original raw material. When a small group of companies controls the necessary raw material, it is almost impossible for a potential competitor to enter the industry. On

the other hand, almost any other aspect of the production and distribution process can be entered by a potential new competitor who has enough money to spend. For example, in oil, a crude oil producer can build pipelines and refineries, hire scientists and technical people for research and development, build service stations, etc., and laboriously build up a completely vertically integrated business. On the other hand, absent the crude oil, all of this vast network is worthless. Similarly, raw bauxite is the key to aluminium company profits, iron ore to steel company profits, raw copper to copper industry profits.

Looking more specifically at the history of the integration of the oil industry in the United States, we find that the key starting point was the refining level, from which companies integrated both backwards and forwards. The basic reason was that profits at the refining level were very unstable, subject to wide swings as the cost of the crude oil fluctuated. Thus, refiners integrated backward, either through purchase of crude oil producers or by wildcat exploration, in order to ensure that overall profits would remain relatively stable, since low crude oil profits would be offset by high refinery profits and vice versa. Particularly because of occasional gluts of oil, oil refiners integrated forward to ensure that they would have markets for their crude and refined products.

In fact, vertical integration had been used to achieve a degree of market power such that effective monopoly control existed. In the United States, for example, the common ownership of anthracite mines and railroads once made it possible for the companies concerned to withhold cars and to collect high transportation rates from other mines. Ownership of pipelines has afforded the major oil companies a similar advantage over independent refineries. The most celebrated case of the abuses of vertical integration arose in the General Motors-Du Pont antitrust case. Du Pont owned 23 per cent of all GM stock. This led to an outcome where GM bought two-thirds of its paint supplies from Du Pont. Other suppliers were effectively excluded from competing for GM's business. The U.S. Supreme Court declared Du Pont ownership to be in violation of the U.S. antitrust laws since the ownership and effective vertical integration led to the exclusion of others from the market.[4]

Thus for a variety of reasons Canada's mineral production is predominantly undertaken by foreign-owned firms and production is far in excess of domestic needs. About 60 per cent of mineral production is exported in raw, processed and fabricated forms.[5]

It is against this background that we raise the question of why more Canadian firms do not become involved in resource exploitation. The answer varies but essentially there are two main reasons why this has not been the case.

a) Inadequate supply of Canadian capital for ventures of this sort.

b) The resource only has value to the extent that it can be turned into an intermediate product that in turn has a wide variety of uses in the manufacture of many different types of final products. To produce the intermediate product efficiently, i.e., on a large scale, it is necessary to have access to a large market (viz., the U.S. market). Typically, the U.S. tariff structure allows the raw or slightly processed resource to enter the U.S. free of duty.

Intermediate products face a tariff. The large U.S. producers of intermediate products (who have established final market sources, e.g., the steel companies) can therefore integrate backward to the resources. It doesn't pay a Canadian company to establish large production runs since

– because of the tariffs, it will operate at a competitive disadvantage in the U.S. market vis-à-vis a U.S. company; and

– it must develop market outlets for the intermediate product in the U.S. market. Here it runs into long established market relationships which it often can not penetrate.

To overcome the tariff/access to U.S. market problem, some large Canadian resource firms are integrating forward into the U.S. market. That is, they ship the raw product duty free into the U.S. and process it into the intermediate or final stage in the U.S.

This leads to an answer to the question that is raised time and again: Why isn't there more value added *in Canada* as regards Canadian resources? Tariffs in the U.S. market, inadequate access and knowledge of the many and varied buyers of the intermediate or final products have effectively precluded the creation of more value added activities in Canada.

Thus, probably the two most important limitations to further mineral processing in Canada are restrictive trade policies and industry structure. Both of these are very much interrelated since consuming countries use trade policy to encourage and protect domestic processing industries by levying low or no tariffs on crude materials and strongly progressive tariffs or quotas on imports in more highly processed forms. In many if not most industrial nations, the establishment of processing facilities was based originally on domestic mineral production. As local resources became exhausted or insufficient, such nations seek to maintain their domestic processing industry by importing raw materials. In the past, transportation costs were such that an economic case could be made for refining or processing close to the point of extraction. However, given recent trends in the low-cost shipment of bulk commodities over long distances, transportation is decreasingly a factor in determining location of post-concentrate processing facilities, other than within an individual country. For example, transportation costs for raw materials were at one time an important factor in determining steel plant location. This is no longer true, as indicated by the rise of Japan's steel industry which is based almost entirely on imported raw materials.

We can now provide a preliminary answer to the question: Does it matter whether Canadians or foreigners exploit Canadian resources? Based on the U.S. tariff structure (and similar situations prevail in other industrialized countries, viz., Japan[6]) and, at this juncture, *only looking at value added* (employment creation), *the behaviour of U.S. or Canadian firms would not appear to significantly differ.*

A large part of the resources used in the production of goods for the Canadian market are refined and fabricated in Canada. Many are shipped out to be fabricated and are imported embodied in the final product, e.g., zinc in automobiles. The key point is that the manufacturing industry that has developed is not oriented (for the reasons mentioned above) toward the manufacture of intermediate and/or final products based on Canadian

resources. If Canada wishes to pursue a policy of encouraging or enforcing more domestic mineral processing, then the greatest scope obviously lies in the area of manufacturing. Success in such a policy would require negotiation with consuming countries to have trade barriers removed or reduced. Otherwise, Canadian manufactured items will continue to be uncompetitive in such markets.

It should be emphasized that removal of the trade barriers may turn out to be a necessary but not sufficient condition for achievement of more value added in Canada. The existence of vertically integrated firms that have made substantial capital investments according to a particular structural configuration may militate against significant structural changes in the short-term. Consequently, gaining accessibility by favourably altering the tariff barriers may not prove to be a significant enough stimulus to radically alter the traditional behaviour of vertically integrated firms who have shipped unprocessed resources out of Canada for such a long time.

Canada undoubtedly does have some bargaining powers in this respect in that it is a major world supplier of raw materials which other industrial countries require[7]. (See Tables IV. 2 and IV. 3.) However, such bargaining power is limited to the extent that supplies of such resources are available in other countries that do not object to their export in unmanufactured forms.

Additional value added in Canada must be tied to the entire question of an industrial strategy. Which resources and therefore which manufacturing industries should be supported? Considerations of market conditions for the final product worldwide will have to be weighed against availability of the resource in Canada vis-à-vis other countries.[8]

To recapitulate, the current relative performance of Canadian as compared with foreign firms in the matter of value added in Canada does not appear to differ significantly.

Table IV.2–Canadian Production of Selected Minerals in Relation to World Production, 1968

Selected Minerals	% of World Production	Canada's Rank	Largest Producers
Nickel (mine production)	48	1	(No. 2–U.S.S.R., 21%)
Zinc (mine production)	23	1	(No. 2–U.S.S.R., 11%)
Asbestos	47‡	1	(No. 2–U.S.S.R., 27%)
Silver (mine production)	17	1	(No. 2–Mexico, 15%)
Potash (K_2O equivalent)	17	2	U.S.S.R., 20%
Molybdenum*	18	2	U.S.A., 73%
Titanium Concentrate (from Ilemnite)	21	2	U.S.A., 30%
Cadmium (smelter production)	15	2	U.S.A., 31%
Gypsum	10‡	2	U.S.A., 18%
Cobalt (mine production)	9	2	Congo, 51%
Uranium* (U_3O_8 concentrates)	16	3	U.S.A., 55%
Lead (mine production)	11	3	U.S.S.R., 16%
Aluminium (primary metal)	11	3	U.S.A., 36%
Platinum group metals (mine production)	14	3	U.S.S.R., 58%
Gold (mine production)	6	3	S. Africa, 67%
Iron Ore	7	4	U.S.S.R., 27%
Magnesium	5	4	U.S.A., 48%
Copper	10	5	U.S.A., 20%
Petroleum†	3	9	U.S.A., 24%

*Excludes communist countries.
†Petroleum figures are from U.S. Department of Mines Bulletin 650.
‡Figures for 1967.
Source: Canadian Minerals Yearbook, 1969, Mineral Resources Branch, Department of Energy, Mines and Resources.

Table IV.3–Canadian and World Reserves of Selected Minerals, 1968

Selected Minerals	Reserves Canada	World	Percentage of world reserves in Canada
Nickel (million pounds)	20 000	147 000	13.6
Zinc (million tons)	25	123.73	20.2
Silver (million ounces)	640	5 500	11.6
Molybdenum (million pounds)	500	10 827	4.6
Titanium (thousand tons)	25 250	146 850	17.2
Cadmium (million pounds)	369	1 420	26.0
Cobalt (million pounds)	386	4 810	8.0
Uranium (thousand tons)	1 190[1]	4 887[1]	24.3
Lead (million tons)	12	83.3	14.4
Aluminium (million tons)	0	1 168.4[2]	0
Platinum (million troy ounces)	16	424	3.8
Gold (million troy ounces)	N.A.	1 197	–
Iron (million long tons)	35 727	250 329	14.3
Magnesium (million tons)	N.A.	2 580	–
Copper (million tons)	10.0	307.9	3.2
Sulphur (million long tons)	155	2 470	6.3
Petroleum (billion barrels)	8.4	454.8	1.8
Natural Gas (trillion cu. ft.)	48	1 144	4.2

Notes: Short tons are used unless otherwise indicated.
In most cases reported here the reserves are those that can be mined profitably under present technologic and economic conditions. For example, the amount of iron ore reserves would triple if potential reserves were included, but these could not be extracted profitably under present conditions.
[1]Reserves consist of reasonably assured and estimated additional available ore. Assumes upper limit on price to be $30 per pound.
[2]Aluminium equivalent.
Source: All figures are from U.S. Department of Mines Bulletin 650.

III. Foreign Development of Canadian Resources: Possible Costs

Of course many other aspects of this question must be examined: the extent to which the integrated firm charges a "fair price" to itself (the transfer pricing problem), the extent to which profits are remitted or, alternatively, are plowed back in further exploration activities. Still other implications relating to ownership must be examined; where are inputs to the resource exploitation process bought? That is, to what extent do foreign firms automatically engage foreign engineering, geological and geo-physical consulting firms? To what extent do foreign firms import instruments and other machines for exploration? Do Canadian and foreign firms differ as regards the extent to which they purchase their inputs? If so, then there *are* implications as regards the development of the resource support industries inlcuding specialized consulting firms.

In this latter regard it is alleged that Canadian-controlled engineering, geological and advertising consultants have often been unsuccessful in bidding on large projects in Canada in cases where financing is to be obtained in other countries, especially the United States. Institutions providing financing rely heavily upon feasibility and design studies and accept the work of consultants from their own countries more readily than that of Canada. This has encouraged the establishment of large, foreign-controlled engineering subsidiaries in Canada.

It is also alleged that the high degree of foreign control of the Canadian oil and gas industry leads to an outcome where nearly all technical and scientific information is sent via computer tape to research centres such as Houston, Texas where research based upon it is undertaken. In this field little basic geological research is undertaken in Canada and Canadians who wish to advance in the field are required to leave Canada. Another possible problem area relates to the extra-territorial extension of foreign laws into Canada. It has been alleged, for example, that U.S. antitrust and other laws and regulations have had an impact on the potash industry with respect to both the establishment of rates of production and the sales to certain countries, viz., the Peoples Republic of China.

The problem of allocated export markets is not peculiar to vertically integrated foreign-owned resource firms. Rather it is part of the larger problem of the multinational firm itself which operates in many countries with a view to maximizing profits for the global corporations.[9] Thus, it may be the case that the resource-providing sector of a vertically integrated foreign firm is not maximizing its export opportunities to countries other than the one where the other parts of the firm are located.

Other possible areas where benefits are lost to Canada because of non-indigenous ownership are: management development opportunities, research and development, associated industries, related advertising, public relations and management, and engineering consulting services.

It should be underscored that many of the allegations and questions raised above are based on a review of trade journals and internal documents which have been produced by various government departments as working papers. Knowledge of the behaviour and performance of multi-

national firms in the manufacturing sector[10] has been used in identifying possible problem areas in the resource sector. Rigorous documentation of the extent to which the above actions occur (and the extent to which Canada loses by these actions) can only be accomplished as part of a large and more comprehensive study.[11]

References

1. Herbert Marshall, Frank A. Southard, Jr. and Kenneth W. Taylor, *Canadian American Investment: A Study in International Investment*, The Ryerson Press, Toronto, 1936. Pages 6-11, *passim.*

2. A distinction is often made between resource processing and resource-based manufacturing but the division between these is not well defined. In metallic minerals, it is generally considered to occur at the prime metal (ingot) stage, but for others it may occur after very light, initial processing (e.g. milled asbestos fibre) or immediately after resource extraction (e.g. gypsum).

3. Cf. R. Caves, *American Industry: Structure, Conduct and Performance*, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1967. For an interesting discussion of vertical integration with specific reference to various industrial groupings see Walter Adams, (ed.), *The Structure of American Industry: Some Case Studies*, The MacMillan Company, New York, 1961.

4. For a comprehensive discussion of the behavioural patterns of international oil companies who are both multinational and vertically integrated see Michael Tanzer, *The Political Economy of International Oil and The Underdeveloped Countries*, Beacon Press, Boston, 1969. See also Clair Wilcox, *Public Policies Toward Business*, Irwin, Toronto, 1960. In this book a number of U.S. antitrust cases involving the abuses of vertical integration are present in detail.

Of course monopoly power can arise in the absence of vertical integration. For example, access to key technology protected by patents often confers a high degree of market power.

5. See also, Herb Gray (Chairman), *Foreign Direct Investment in Canada*, Privy Council, Information Canada, Ottawa, 1972. Pages 45-50, where the conclusion is reached that ". . . backward vertical integration – the extension by a firm into the earlier stages of the productive process – [is] the major determinant of foreign direct investment in the resource industries."

6. Imports of metals into Japan are planned and must be approved by the Japanese government (MITI). Tariff and quotas apply to the import of refined nickel, copper, zinc and other metals. The imposition of tariff quotas is in part a protectionist policy to promote domestic refiners-smelters. There appears to be no tariffs on the import into Japan of ore or concentrates.

The required ore or concentrate for Japanese industry is obtained from foreign mining developments partially financed through Japanese loan and equity capital and from purchase on the open market. The Japanese government has encouraged Japanese smelters to set up purchasing cartels so that one smelter may act as a purchaser for all. Competition between

Japanese smelters, forcing up ore prices, is thus avoided.

7. Despite recurring claims that the world is growing short of resources in the long run, the short run seems to be characterized by fluctuations and/or excess supply. However, Canada does control a significant amount of certain materials. (See Tables IV.2 and IV.3.)

8. In discussing the possibility of a national industrial/resource strategy it should be recalled that the provinces are the owners of most Crown rights to land and other natural resources within their boundaries by virtue of Sections 109 and 92 of the BNA Act and similar provisions relating to the western provinces and Newfoundland.

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

10. *Ibid.*

11. It is especially urged that intensive analysis be undertaken before recommendations for action are made. For example, at one time India was a major source of world manganese supply. In view of its strong position, it imposed an export tariff to increase revenue from exports. Exploration in other countries soon discovered plentiful reserves that were more economical than those in India. Currently, India is no longer a significant exporter of manganese.

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