Science Council of Canada

June 1972
Report No. 16

It Is Not Too Late — Yet

A look at some pollution problems in Canada's natural environment; an identification of some major concerns.

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February 16th, 1972*

The Honourable A.W. Gillespie, P.C., M.P.,
Minister of State for Science and Technology,
House of Commons,
Ottawa, Ontario.

Dear Mr. Minister,

In accordance with sections eleven and thirteen of the Science Council Act, I take pleasure in forwarding to you Science Council Report No. 16 "It Is Not Too Late - Yet: A look at some pollution problems in Canada's natural environment; an identification of some major concerns". As its title implies, this report does not pretend to provide solutions to all the problems of the Environment, but it does present some timely and useful views and recommendations that the Council feels deserve consideration now.

Yours sincerely,

O.M. Solandt,
Chairman,
Science Council of Canada.

*This is the date on which the manuscript was completed.

Summary of Recommendations

After assessing the present status of the quality of the physical environment of Canada, the Science Council recommends:

1. a) continuing Canadian participation and initiative in programs for international monitoring and research, to improve understanding of the trends in changes in the chemistry and physics of the atmosphere, related to the increase of pollutants and their possible long-term enivronmental consequences; and

b) the development of strategies to reverse harmful effects. (p. 15)

2. that projects having a possible significant impact on the environment should include, as essential elements of feasibility and planning studies, assessment of climatic and ecological consequences as well as proposals for the alleviation of harmful effects, before the projects are considered for implementation. (p. 15)

3. that the attention of federal and provincial governments focus on the environmental effects of modern industrial agricultural practices, particularly those of "monoculture" (i.e., the widespread and repetitious cultivation of single crops, usually annuals). (p. 18)

4. that increasing attention be given to the application of forest technology that is mindful of environmental considerations, as well as of maintenance of the long-term production and other advantages of forest lands. (p. 19)

5. that more effective planning strategies for multiple use of land resources in prime recreational areas (urban and non-urban) be developed for the enjoyment of a greater number of Canadians. (p. 21)

6. a) continuing Canadian participation and initiative in programs for monitoring and research, to improve understanding of trends in changes in chemical and physical features of the world oceans, related to the increase of pollutants and their possible long-term environmental consequences; and

b) the development of strategies to reverse harmful effects. (p. 22)

7. that a five-year major attack on the pollution problems of the Great Lakes-Saint Lawrence System be undertaken as a matter of urgency. (p. 24)

a) that the whole Great Lakes-Saint Lawrence System be subdivided, for the purpose of scientific activities, into three sections: the Great Lakes, the River (mainly freshwater, approximately from Cornwall to Rivière du Loup) and the Estuary (including the Gulf). (p. 24)

b) that the Federal Government take the initiative in creating boards to coordinate the work on the River and Estuary sections of the Great Lakes-Saint Lawrence System. The form of the initiative should be federal-provincial agreements similar to the one between the Federal Government and the Province of British Columbia for the study of the lakes of the Okanagan drainage (p. 24)

c) the examination of the consequences (climatic, ecological, etc.) of diverting water from one watershed to another, either into or out of the Great Lakes or the Saint Lawrence River. (p. 25)

d) that engineering work be contracted to Canadian firms of consultants employing Canadian talents, and that consultants be hired to assess the applicability to other systems of the results obtained from these studies (for example, to the Fraser River System). (p. 25)

8. that a sustained study of Middle North and Arctic ecosystems be carried out, to ensure intelligent development of land use with a minimum of environmental disturbance. (p. 26)

9. the creation of a politically independent organization, sponsored by the Federal Government, which would have as its basic role the provision to the public of facts about the environment. (p. 36)

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Introduction

In its Report No. 9, *This Land is their Land,* the Science Council stated that a stable and healthy environment of high ecological quality, maintained over the long term, should be defined as a new national goal, to be added to the six goals proposed in Report No. 4, *Towards a National Science Policy for Canada.* Since this recommendation was made, a Department of Environment has been created at the federal level. In various provinces, either Departments of Environment or other new administrative arrangements have been developed; at municipal levels, new attention is being given to environmental issues. The momentum generated by these activities now needs channelling. It is a time for setting priorities, for getting on with the job, for maintaining enthusiasms by action. In this spirit, the Science Council has prepared this commentary on current pollution problems in Canada.

It is abundantly clear that environmental questions have great scope. To those with the broadest perspectives, environment is so all-encompassing and so entwined with considerations of growth that whole new religions and philosophies are now needed to face the challenges of the future. In this context, environment is a perennial topic for discussion at all levels of society. At another extreme, some see environment only in terms of blemishes that tarnish technological achievement, and for which the simple and obvious solution is better technologies of rehabilitation and abatement. This superficial and cosmetic approach takes no advantage of man's ability to foresee and avoid crises. At this juncture, it is the Science Council view that the most rewarding approach to questions of environment is to couple the development of technological competence for better environmental management with accelerated development of our sensibilities to the social fabric which technology and economics serve. Our goal should be to devise the schemes that will ensure the orderly growth of Canada to a stable maturity.

Environmental questions are also characterized by their pertinence to the quality of life in all of the kinds of human habitat. This report is addressed primarily to the environmental aspects of resource management in non-urban areas. There are, of course, many other sets of environmental considerations. Resource use in non-urban areas is part of a pattern of land use, the other side of which is the increasing concentration of Canadians in large cities. Within these cities there is a whole group of social, economic and health questions which pertain to the design of the environments in which most of us spend most of our lives. The importance of these questions has been raised in Science Council Report No. 14, *Cities for Tomorrow,* and they will be further discussed in a subsequent report.

As a final point of introduction, it is useful to underline that the evaluation of environmental problems is currently a most difficult task. Most environmental situations are complex, and there is usually insufficient evidence on which to generalize or to predict with confidence. As a consequence, on many issues, even the more

knowledgeable scientists have expressed different and sometimes opposing views, and they will no doubt continue to do so for some time to come.

It is scarcely surprising that in these circumstances of bombardment with partial knowledge, the public mood ranges from reassurance, to awareness, through to alarm and even hysteria. There is particular need for balanced and frequent assessment to keep the problems in focus and our responses appropriate. This report attempts an assessment of some of our current Canadian environmental concerns. It is not comprehensive, nor is it a sufficient or lasting answer to the public demand for information. As development of Canada's potentials proceeds, there is every prospect of intensification of environmental problems. There is also indication of greater awareness - concern for the quality of living seems likely to become a major motivation of tomorrow's Canadians.

With this recognition - of the scope, complexity and inevitability of environmental problems, and of the increasing concern of citizens - this report concludes, and reiterates the recommendation, from Science Council Report No. 9 *(This Land is Their Land),* for a politically independent body that would primarily serve the public need for information and give the reassurance of review of such problems by an independent organization. While the Science Council has maintained concern for the environment for several years[1], it is apparent that a greater level of effort is appropriate now and mandatory for the future.

[1] The Science Council has referred repeatedly to environmental problems in Canada in previous reports, and in some measure these reports reflect the growing concerns of the past few decades. All of the following Science Council Reports contain discussions of some aspects of environment: No. 3, *A Major Program of Water Resources Research in Canada;* No. 7, *Earth Sciences Serving the Nation;* No. 8, *Seeing the Forest and the Trees;* No. 9, *This Land is their Land;* No. 10 *Canada, Science and the Oceans;* No. 12, *Two Blades of Grass: The Challenge Facing Agriculture;* and No. 14, *Cities for Tomorrow: Some Applications of Science and Technology to Urban Development.*

The Present State of the Environment in Canada

The landscape of Canada has been influenced by man in many ways. Wherever there has been agriculture, natural plant successions have been modified. In some cases, this has meant the replacement of natural forest with grassland; in other situations, where natural fire has been suppressed, it has resulted in the invasion of grassland by forests. Some lessons of land husbandry have been learned the hard way; there have been instances of soil erosion that reflected over-use of land, where we now follow more prudent agricultural practice. Wherever man has settled, his wastes have been added to the natural cycles of decomposition. Wherever man is numerous, his roads and railways have dissected the countryside and subtracted strips of land from natural production. These and similar effects of man on his environment were a part of our recent inheritance in Canada. In the minds of most they have become accepted as an integral part of development. Even intense local pollution, occasioned by an oil spill in a harbor, or by a mine in the wilderness, or by the smoke-stacks in coal- and wood-fired cities, was part of a scene in which some minor nuisances were taken as inevitable. There was always somewhere else to go, or else the nuisance wouldn't last long, or else the alternatives were, economically, quite out of the question.

The transition from these pioneer, folksy attitudes has been relatively fast and, unfortunately, it has not been well documented. Canada has learned substantially from other parts of the world, and in particular, has usually had the opportunity to anticipate by watching the United States. Our history of environmental concern is thus not easily dissociated from continental contexts. For whatever reasons, despite the attentions of many scientists over the years there is only a fragmentary record of the changes in Canadian environments that preceded the Second World War. Since then, the rapid growth in the more settled parts of Canada has brought an increasing awareness, and substantial evidence that intense development requires more attention to the inadvertencies of human business.

Recent concern with environment reflects a change in the structure of society. The conservation movements of yesteryear were largely related to land uses in the days of subsistence farming, bush logging and fur trapping by a scattered rural population. Even then, people were relatively concentrated in a small part of Canada, for the country is basically a few patches of arable land adjacent to a large, northern, sub-marginal backyard. Today, with greater pressures for agricultural economy and development of Canadian industry, and greater appetites for social amenities, the population is more concentrated, and becomes more so every year. More than 90 per cent of the Canadian population lives on less than one per cent of Canada's land. The environmental problems of today are those of an urban society with its urban industries and with large-scale technologies of agriculture, forestry and mineral extraction in the great land areas of the countryside.

As an added element, environmental impacts now transcend national and continental limits, and we have gained direct appreciation of the greater quantity of human activity everywhere in the world. Beginning with the news of world-wide radioactive fallout, there has

been increasing evidence of the global air circulations that disperse contaminants widely and imply the need for global action. The greater volume of world shipping, the greater displacements of ships, and the development of offshore drilling techniques, have generated new concerns about ocean pollution. It is now necessary for every nation to ponder not only the abuses it tolerates in its own territories, but also the problems it creates for others or receives from others.

To date, Canada has remained relatively free from serious internally-generated environmental problems, and is still a relatively minor contributor to changes at the global level. This fortunate state of affairs may give us time, although, as the rest of this report indicates, it may be later than we think. Already there are many examples of local blight and of shrinking latitudes for single-minded resource use. These examples should serve as sharp reminders of our capacity for environmental mismanagement, and of our responsibility to do better.

The Atmospheric Environment

The major flow of air crosses Canada from west to east. We receive well washed air from the large reservoirs over the Pacific and the Arctic. Between most of our major population centres there are large air spaces in which local emissions may be widely dispersed. Only in eastern Canada, which may frequently be downwind from large industrial centres of the United States, is there substantial reason for concern about the potential for high and chronic levels of air pollution over large areas.

In Canada, air quality problems are generally most conspicuous in urban areas or, locally, where the production of emission materials exceeds the rate at which they can be innocuously dispersed. Where these conditions occur, they are frequently prevalent only for short periods of time. In consequence, they have not aroused strong and sustained public reaction, except in the more extreme cases. Where local air pollution has become intense and persistent, it has in some cases prompted public complaint and public action.

A significant recent development was the passage in Parliament, on June 21, 1971, of Bill C-224, "An Act Relating to Ambient Air Quality and to the Control of Air Pollution". Effective implementation of the provisions of this act should ensure that Canadians will continue to enjoy air of high quality. Because most air pollution problems are local in nature, controls are best applied at the point of emission, the permissible rate of release of materials being a function of the number and height of sources, local meteorological conditions and local topographic features.

Some particular problems of air pollution have been created by large industrial operations in Canada. Pulp mills, for example, produce a pungent odour because their emissions contain mercaptans, which are apparently harmless to human health, but detectable in incredibly small quantities. When the wind is right, many of Canada's population centres (including Ottawa) are periodically reacquainted with air pollution.

Almost equally noticeable, and with greater consequences, are the emissions from large smelting operations. The problem of the Trail smelter, which has long since been largely rectified, is illustrative of the effects of a smelter and the effects of a program of control: a large area surrounding Trail was virtually denuded of vegetation by the effects of sulphur dioxide and other substances; with control, the landscape has gradually returned to a more natural state. Sulphur dioxide from Sudbury smelters has had widespread effects. Severe tree damage has been detected up to 30 miles from the emission sources; vegetation has been stunted within a 720-square-mile area; and, in a 10-year period (1953-1963), the loss in production of white pine in this area is estimated to have been $1 717 000. [1] Within a radius of up to at least 50 miles from Sudbury, there have been radical changes in the past decade in the acidity of the soft waters of the lakes. As the lake waters have become acidified, various species of fish have been exterminated; there are now no fish of any kind in at least 33 lakes, and soon they will be gone from at least 38 more. [2]

There can be little doubt that large-scale industrial emissions have potential for serious and widespread consequences. The effects of coal dust on buildings and vegetation in many parts of the industrialized world is well known. There are even well documented cases of the rapid evolution of black (melanic) strains of moths and butterflies which are adapted for the pollution-darkened background of their environment.

The control of large concentrated emissions at their sources is an obvious component of air quality maintenance for the future. We should get on with the job of regulation, developing control of emissions and carefully planning disposal systems for the smallest possible amounts of residues.

On a global scale, a growing body of fragmentary evidence suggests that the sum of a large number of local pollutants may be creating some world-wide air problems. The average concentration of carbon dioxide in the troposphere in the Northern Hemisphere has been increasing at the rate of 0.7 ± 0.1 p.p.m. per year over the last decade. This is much less than would be expected from an evaluation of the total increase of man-made emissions over the same period, indicating that there are some compensatory mechanisms in the global carbon dioxide cycle, but it is nevertheless an indicator of change. An increase in atmospheric carbon dioxide should, acting alone, cause an increase in global temperature due to the so-called "greenhouse effect"; accordingly, there has been speculation that world climate will become warmer.

Acting in the opposite direction is the possible effect of increasing quantities of particulate matter in the atmosphere, from industrial sources, jet aircraft, and so on. The screening effect of these particles should theoretically cause global air temperatures to fall. Considering that energy production and heat release, manipulation of surface and

[1] From a paper by Dr. S. Linzon, Chief of the Phytotoxicology Section, Air Management Branch, Ontario Department of Energy and Resources Management, delivered to the 63rd Annual Meeting of the Air Pollution Control Association, St. Louis, Missouri in June, 1970.

[2] From a paper by Dr. R.J. Beamish and Dr. H.H. Harvey, Department of Zoology, University of Toronto, delivered to the 25th Annual Meeting of the Canadian Committee for Freshwater Fisheries Research, Ottawa, January, 1972.

underground waters, change and destruction of vegetation, and changes to the Arctic ice pack may also cause changes in global air temperature, the net climatic result is difficult to predict. There is at present no compelling information on the nature of the total impact of air pollution on world climate.

It is nevertheless apparent that the many rapid changes in the earth's atmosphere should be carefully monitored, and that research on atmospheric processes should be intensified. If serious global effects are possible, Canada, like every other country, would be just as vulnerable as the rest. There is also the possibility that we may be more vulnerable than many others. Canada's productive land areas could be profoundly affected by any global air temperature change, either upward or downward, because most of our crops are sensitive even to small average air temperature variations.

In consequence of these considerations, the Science Council recommends:

a) continuing Canadian participation and initiative in programs for international monitoring and research, to improve understanding of the trends in changes in the chemistry and physics of the atmosphere, related to the increase of pollutants and their possible long-term environmental consequences; and

b) the development of strategies to reverse harmful effects.

International atmospheric monitoring may pose technical problems for developing countries, yet their participation in global networks is evidently necessary. Canadian assistance along these lines would be a desirable component in programs of the Canadian International Development Agency.

It is also apparent: that the number of Canadian-based data-gathering stations should be increased; that sound, standard and rapid methods for sampling and analysis of air specimens should be further developed; that further consideration should be given to the techniques of processing the very large quantities of data that will be thus generated.

Climatic changes may also occur in local areas as a consequence of large-scale human activity, such as seeding clouds to increase rainfall, construction of major dams, deforestation or the construction of airports (e.g., the changes observed when airports were built at Halifax and Gander). Noteworthy are the efforts being made to ensure that the consequences of the construction of the Sainte-Scholastique airport are examined. The Science Council considers that studies such as these should be carried out at an earlier stage of planning, and recommends **that projects having a possible significant impact on the environment should include, as essential elements of feasibility and planning studies, assessment of climatic and ecological consequences as well as proposals for the alleviation of harmful effects, before the projects are considered for implementation.** To improve our capabilities for making these assessments, there should be increased allocation of people and money in the general-circulation and physical-modelling of climatic-change research, using computer simulation techniques.

The Land Environment

Patterns of land use are major determinants of environmental quality, and it is apparent that the Canadian pattern is in a state of transition. Cities are growing at a rapid rate and, with them, the particular environmental problems that cities generate. Some authorities have concluded that, if the present pattern of urban sprawl continues until the year 2000, there will be virtually no land left in commercial agriculture in the Lower Fraser Valley in B.C., in southern Ontario between Cobourg and London, and in the Lower Saint Lawrence Valley between Cornwall and Trois Rivieres.[3] Also by that time, the estimated increase of housing facilities and all other related land uses could require that 3000 to 4000 square miles of serviced land be added to Canada's urban regions, which, in 1966, totalled roughly 2500 square miles.[4] If we wish to halt this process, or to temper it with new kinds of designs for living, it is important that we devise and apply strategies for regulating development and for planning land use. To this theme the Science Council will return in a subsequent phase of its study of environmental problems.

Associated with the growth of urban centres is the steadily diminishing population of rural areas, which are increasingly characterized by the patterns of large-scale agriculture and forestry, the company towns of remote resource development, and the clusterings of summer cottages on the lakeshores and streambanks wherever access and aesthetics combine to provide prime recreation. Additionally, it is now becoming apparent that Canada will soon tackle the development of the vast backyard of the country - the Middle North and the Arctic. These are trends in Canadian land use that are conspicuous and entail particular kinds of environmental problems.

Agriculture

Although prime agricultural land is gradually disappearing near urban centres in Canada (and, in consequence, the production of certain crops has decreased, so that we import what we could produce), the major trend of Canadian agriculture is increasing efficiency, larger scale, more intensive culture and greater capacity for environmental influence. The prairie provinces provide an excellent example. Most of the native grasslands have been ploughed for the production of cereals, forage and oil seed crops, excepting those areas which, because of climate, soils or topography, are better suited to ranching. Additionally, extensive parts of the aspen parkland belt along the northern boundary of the grasslands have recently been cleared for pasture or seed crops. The major environmental problems posed by this pattern of agriculture are just emerging and are of great potential impact.

Agriculture is increasingly industrialized; the trend is toward fewer

[3] A.D. Crerar, et al., "Urban Growth and Resources", in: Workshop A, *Resources for Tomorrow* Proceedings (Ottawa, Queen's Printer, 1962) pp. 191-195.

[4] These figures are crude estimates based on past high densities of 6000 persons per square mile. J.W. MacNeil. *Environmental Management*, Constitutional Study for the Government of Canada, prepared in 1971.

and larger farms, increased mechanization, use of less labour, introduction of new higher-yield varieties of crop species, greater inputs of chemical fertilizers and biocides, and more extensive use of irrigation. Growth-oriented agriculture of this kind can become so intent on increasing yields and economic efficiency that little attention is given to the symbiotic land-man interrelationship. The long-term effects of the emerging agricultural technology on the conservation of soils, on the nutrient value of crops, on the dynamics of crop pests, and on the land as an environment-for-living are not well known, and indeed, with few exceptions, are not being explored. Some of the potential consequences of energy-intensive industrialized agriculture can be enumerated:

a) loss of organic matter due to cultivation and cropping, plus loss of topsoil to wind and water erosion;

b) exhaustion of supplies of inorganic phosphates, which are a non-renewable resource. Recent estimates have indicated that supplies of phosphates may be inadequate to meet demands by the middle of the next century;

c) increase of eutrophication rates of nearby water bodies as a consequence of greater nutrient loads from widespread use of fertilizers (through transportation of particles by erosion, or by leaching to groundwater);

d) accidental damage to non-target plants and animals from aerial drift of biocide sprays;

e) adverse effects of the accumulation of biocides and their decomposition products in the soil and adjacent water bodies (see Science Council Report No. 9, *This Land is Their Land*);

f) salinization problems resulting from over-irrigation;

g) simplification of ecosystems and the danger of population explosions of pest species. Complex ecosystems are more self-maintaining and less subject to catastrophic changes and fluctuations of population numbers than are simple ecosystems. For example, the extensive monoculture of rapeseed undoubtedly contributed to the eruption of the Bertha Army worm in the prairie provinces in 1971. "Polycultures" of perennial species, such as native grassland and forage crop mixtures, are less susceptible to the effects of adverse weather, insects or disease. It is important to note in this regard that scientific evaluation of the optimum compromise in land use between monocultures and polycultures is not available;

h) pollution of soil and water with high loads of nitrates, phosphates and organic matter from concentrated animal production in feed lots;

i) elimination of waterfowl habitat from land drainage. The prairies produce 70 per cent of the waterfowl on the continent, and this production is critically dependent on the number of ponds, sloughs and marshes.

Advanced techniques of intensive agriculture, such as those employed in the prairie monocultures, create problems from which there is no ready escape. High crop yields are attained through use of selected strains, increased inputs of fertilizer, biocides and soil

sterilants to kill competing insects and weeds. Increased crop values raise the value of the land, making it necessary to maintain, and indeed increase, yields to even higher levels to ensure a fair return on capital value. In this way the farmer gets "locked in" to a particular technology, unable for economic reasons to give it up, even if it proves dangerous to the environment. Under the present system, a call for reduction in the use of fertilizers and biocides in the interests of protecting environment is considered a call for agriculture suicide, since maintenance of current yields depends on continued inputs of chemicals. A further danger of the single-minded drive to increase yields of special crops is loss of flexibility in land use. As an example, when the corn leaf blight recently struck the U.S.A., many farmers found it impossible to switch to the alternate crop of soybeans because the soybean is adversely affected by the residual herbicide atrazine used to control weeds in cornfields. Such problems will probably appear more frequently in the future.

In various degrees, these problems recur across Canada wherever modern practices of agriculture are forcing production to levels that may be higher than the sustainable long-term yield. History provides many good examples of the consequences. Accordingly, the Science Council recommends **that the attention of federal and provincial governments focus on the environmental effects of modern industrial agricultural practices, particularly those of "monoculture" (i.e., the widespread and repetitious cultivation of single crops, usually annuals).**

Forestry

The second major land use pattern in Canada is that generated by forestry practices. In general, it has been recognized that forest land should be managed for sustained yield of many commodities and values, including fibre, wildlife, water and recreational use. There nevertheless remain instances of clear cutting over large areas, for which natural regeneration is inadequate and in which planting programs are falling behind cutting rates. Each year at present, an average of about 500 000 acres of potentially productive cut-over and burned-over forest land is not reforested.[5] In consequence, the quality of the environment deteriorates and, in many places, plant cover is insufficient to prevent soil erosion. Additionally, the industry is characterized here and there by poor practices of road building, carelessness in preventing stream blockages, thoughtlessness in disposal of wastes, poorly planned slash burning, and many other examples of primitive forest harvesting technique. Undoubtedly, the pattern of forest land-use is improving, but it is important to realize that it will become crucial, as we rapidly approach the upper limit of capacity for sustained yield of all the commodities and values of our forests.

Problems of monoculture of trees also need attention. Natural

[5] J.H. Cayford and A. Bickerstaff, *Man-made forests in Canada*. Forestry Branch Publ. No. 1240. Canada Department of Fisheries and Forestry. Ottawa, 1968

stands are commonly of mixed species (it is to be noted, however, that forest fires may result in pure cultures). Ideal forestry practice would aim at providing an appropriate mix of species in a planned mosaic. While this may be far in the future, it is characteristic of much of our present forestry practice to go in the opposite direction, through design and inadvertence, creating ever-larger areas of single-species stands; the practice of planting a limited variety of species in reforestation programs is a typical example. As in the case of agriculture, we can be confident that large-scale monoculture is undesirable, but it is not clear what kind of mix or pattern of "polyculture" is optimal. Further research in these aspects of forest management is needed, and because it is long-term research, it should be started soon and given opportunity to continue.

In consideration of the foregoing, the Science Council recommends **that increasing attention be given to the application of forest technology that is mindful of environmental considerations, as well as of maintenance of the long-term production and other advantages of forest lands.**

Mining

Across Canada there is abundant evidence of the local blights that can be caused by mining, concentrating and smelting activities. Throughout the hinterland there are many derelict minehead buildings and shanty towns that reflect the ephemeral nature of many mining developments. Similarly, there are many tailings ponds, which have served the purpose of keeping wastes from streams, but remain as patches on the land on which few, if any, plants grow, except after many decades. The practice of cleaning up, covering up and re-planting after the operation has not been widespread.

Most current mining operations are better conceived from the environmental viewpoint. Though tailings disposal into lakes still occurs, there is more frequently a careful attention to the impoundment of toxic wastes, and this trend is encouraging. Mine buildings and mining towns are built with more concern for permanence and appearance. In brief, the mining operations of the back country are increasingly concerned with their local aesthetic and toxic effects, and are developing an attitude of responsibility for potential future uses of the site which they temporarily occupy.

The special blight caused by strip mining practices justifies particular attention because it affects such large areas of land in ways that are usually devastating to subsequent ecological succession. Ideally, strip operations should leave a landscape as good as or better than what was removed with the over-burden. Recent requirements (e.g., in Alberta and B.C.) for this sort of practice are to be much encouraged. It is important that these requirements be applied with vigour; otherwise, there is every likelihood that we will produce in Canada the same devastated landscapes that have been produced by strip mining in other parts of the world. On many steeply sloped sites, reconstitution of the original condition may be virtually impossible, and this could in some instances be sufficient reason for

prohibition of strip mining. (It may also be added that the stream-polluting effects of strip mining can be particularly troublesome. Characteristrically, there is heavy siltation in downstream areas. Where there are large-scale coking operations accompanying strip mining for coal, phenol concentrations may become high enough to kill fish or to taint their flesh so that it tastes like carbolic soap. The technologies for avoiding these effects are available and should be implemented.)

Although they are largely a thing of the past, gold dredging operations warrant mention because they have effects somewhat similar to strip mining, in the devastation they can leave behind. Typically, a thin overburden of soil is washed away, and the processed gravel forms piles with the larger boulders on top. It may take many years before a new "skin" of non-porous material can support a soil cover and vegetation. Hopefully, the days of large-scale gold dredging are in the past.

There is a long history in Canada of the effects of mining on the environment. In general, there has been marked improvement in techniques as the industry has developed and matured. This trend should be given continued encouragement.

Recreation

As Canadians have aggregated in cities, they have increasingly prized the opportunity to get out of them for some "time off". Recreation has become a ranking land use. Yet despite the almost universal recognition of and participation in outdoor recreation, there are surprisingly few quantitative studies documenting the habits of those involved, the social values of their activities, or the economic compromises they intuitively make in forming judgements. Many of these matters may be inherently qualitative, but it should be recognized that the need for outdoor recreation, and all that it entails aesthetically, is one of the prime forces in generating environmental concern. Any objective assessment of the quality of the environment should attempt scientific approaches to recreational values. Greater emphasis on studies that contain an appropriate mixture of social and natural science is much to be desired.

It must also be recognized that recreational use of land also generates its share of environmental problems. The proliferation of lake and stream cottages without adequate sewage treatment facilities is a source of health and eutrophication hazards. Hunters and campers cause devastating forest fires. Snowmobiles and skidoos compact snow with resultant effects on plants and animals at the snow-soil interface. Other environmental effects come quickly to mind to every summer camper or holiday-maker. Evidently it is desirable to educate, regulate and legislate, to prevent deterioration of much of the choice outdoor environment from unplanned or too intensive use. This is another facet of environmental science that needs greater emphasis if Canadian land use is best to serve future needs.

Finally, the trend toward greater private (and very often foreign) land ownership, especially in the prime recreation areas of Canada,

is disturbing; the Science Council questions those practices of land ownership which may, in the long run, prevent Canadians in general from enjoying the use of land and water which has been restored and is maintained at reasonable quality by their tax dollars. Steps have already been taken by some provincial governments to ensure for the general public freer access to non-urban recreational areas. It might be noted that, in the early 1950s the Government of B.C. made extensive reservations of Crown land to ensure that the public would have access to all lakes in the province. The moves of the Ontario Government in the Lake Simcoe area, and of the Government of Quebec in revoking the licences of exclusive fishing and hunting clubs, are to be commended. Another step forward would be the adoption of the project, "Un fleuve, un parc" [6], put forward by the Quebec Wildlife Federation. These commendable, but patchwork, actions should be considered as preliminary steps toward a long-term objective of assuring free access to all shorelines. Many countries [7] have laws guaranteeing this privilege to the public, and it is not utopian to work toward such a goal in Canada. In the meantime, the Science Council recommends **that more effective planning stategies for multiple use of land resources in prime recreational areas (urban and non-urban) be developed for the enjoyment of a greater number of Canadians.**

The Water Environments

The Oceans

The emergence of a significant awareness of man-made environmental problems on an oceanic scale is a recent development. It has been customary to think of the oceans as bottomless sinks, or enormous converters, for the natural discharges they receive as well as for the waste products of human activity. But recently, as the volume and variety of the wastes of civilization have accelerated, the concern has been voiced that perhaps the oceans have limited capacities, and we do not know just how much and what kinds of wastes can be deposited in the ocean with impunity. There are three novel aspects to man's effects on the oceans: (a) the discharge of compounds that do not occur naturally; (b) increased or decreased discharge of naturally occurring substances; and (c) the effect of sustained bottom trawling on the composition of the bottom fauna and on processes of ecosystem functioning.

Some pollutants are already present on a significant and widespread scale in the marine environment:

1. *Halogenated hydrocarbons,* such as DDT, DDE and PCBs, which are produced in large quantities, which are stable, which reach the seas by drainage from the land, by precipitation from the atmos-

[6] Tony Le Sauteur, "Un fleuve, un parc", 1971, Fédération Québecoise de la Faune, 6424 St-Denis. Montréal, P.Q.

[7] In Spain, as in the other countries under Roman law, there can be no private ownership of shorelines, whether on the sea, on lakes or on rivers. Sometimes in the past, resort hotels have obtained "administrative concessions", giving them more or less exclusive use of waterfront. Even these "administrative concessions" have recently been ruled illegal by courts.

phere, or by air-sea interactions, and which are readily absorbed and concentrated in marine organisms. Numerous other synthetic organic chemicals, in addition to the halogenated hydrocarbons, are entering the marine environment, but little is known about their distributions or their effects on marine ecosystems.

2. *Petroleum:* the chronic pollution of the oceans by petroleum appears to be upon us; the seriousness of the threat is unknown, although beaches throughout the Northern Hemisphere are already contaminated. Studies of the consequences and control of potential pollution hazards, resulting from the development of petroleum resources on the continental shelf, and in nearshore areas where the waters are highly valued for recreation and similar uses, are especially urgent. Canada has particular problems in this area, for which technological solutions cannot be borrowed from elsewhere (e.g., pollution caused by collision of icebergs with offshore drilling installations and with pipelines connecting offshore wells with coastal installations). In areas of shared responsibilities offshore, the federal and provincial governments should act in concert to initiate thorough studies of the potential impact of development on the local marine environment. Oil exploration on any of our coasts is a case in point. With the increasing volume of oil being moved upon and under the sea, regulations for improved navigation and control devices, while urgently needed, cannot totally prevent accidents that could result in serious damage. Capability for responding rapidly to emergencies needs further development, including the means for dealing with very large oil spills. Capability for reducing drainage to the sea of oil wastes and spills by way of rivers, and precipitation from the atmosphere of volatile substances, also needs development.

3. *Inorganic chemicals:* fuel additives such as lead, cadmium and selenium, and mercury used in industrial processes or from the burning of coal are among the most threatening; highly poisonous chemicals (cyanide, for example), transported in large quantities, could leak and create major catastrophes. The accumulation of mercury in the world's oceans has recently been a matter of considerable speculation.

The Science Council recognizes the need for global international action and recommends:

a) **continuing Canadian participation and initiative in programs for monitoring and research, to improve understanding of trends in changes in chemical and physical features of the world oceans, related to the increase of pollutants and their possible long-term environmental consequences; and**

b) the development of strategies to reverse harmful effects.

Freshwater and Estuaries

Freshwater is indispensable for human life. Rivers and lakes have always been the focal points for civilization. It is scarcely surprising that freshwater systems are usually the first to deteriorate as a consequence of human influence. Fresh waters are also the eventual recip-

ients of many forms of land pollution (and air pollution). Canada has more than 25 per cent of the world's fresh water. Over most of the area of the country, the lakes and streams are in a virtually uncontaminated state, but where Canadians and their industries are concentrated, freshwater pollution is common and may be severe. *In the view of the Science Council, freshwater pollution is the environmental problem that demands most urgent attention in Canada today.*

A fair proportion of the pollution of freshwater in Canada is on a scale that gives no cause for alarm. Where the discharges of wastes are small in relation to the volume of stream flow or to the size of a lake, the natural assimilative capacities may be adequate to decompose organic materials and sufficient to dilute toxins to harmless levels. But increasing numbers and volume of discharges, coupled in some cases with reduced water flows, commonly cause rapid deterioration once natural capacities are exceeded. Herein lies the basic difficulty of pollution control. Until it is necessary, nobody need worry; once it is necessary, everybody is affected. Increasingly, in Canada, many of our lakes and streams are changing from a state of incipient pollution to a condition creating concern. Waste treatment is no longer exceptional, but most wastes are not adequately treated. Progress is being made in many regions of the country through installation of sewage treatment plants and by increased control and recycling of wastes by industry. Many areas of Canada are only now entering a period of industrial development. In consequence, they can profit from past experience; they should require, and to a large extent are requiring, that new industries include pollution control as a basic capital cost and as an ongoing cost of doing business.

There are some particularly serious pollution problems, either in existence now, or forthcoming in a few years in some parts of Canada. For example, the potential for major problems in industrial and domestic pollution is indicated by the deterioration of some of the small tributaries and channels of the Fraser River in the Lower Mainland area of B.C. There are serious problems of pollution from industrial and agricultural sources in some of the main river arteries of the prairie provinces. Local pollution in parts of the Atlantic provinces is of a particularly serious nature. For many of the larger river systems the volume of waste discharges and the flow modifications, either present or proposed, have suggested the need for intensive studies of estuaries, so that we may adequately document the present situation as a reasonable baseline.

By far the biggest concentration of pollution problems is in the Great Lakes, the Saint Lawrence River, the Estuary, and the Gulf of Saint Lawrence (hereinafter cited as the Great Lakes-Saint Lawrence System). The land area in this drainage system developed earlier and more intensively than those in any other parts of Canada. Although water pollution in these areas as a whole may not have reached a uniformly critical level, certain areas have serious present problems. The Science Council is concerned that, if left unchecked, these prob-

lem areas could become the focal points of an increasingly rapid deterioration of the entire system. There is also substantial evidence of the need for better understanding of the properties of the whole system, as a basis for development of remedial measures. The Science Council therefore recommends **that a five-year major attack on the pollution problems of the Great Lakes-Saint Lawrence System be undertaken as a matter of urgency.**

In recommending that a five-year program on the Great Lakes-Saint Lawrence System be undertaken, the Science Council particularly stresses the need for:

a) improving our understanding of the system, so that policies can be developed to ensure progressive improvement of the water and the environment within the system, thus reversing the progressive deterioration of the past several decades; and

b) developing methodology, technology and expertise that could subsequently be used for the solution of similar, though less developed, problems across Canada (for example, in the Fraser River System).

The Science Council recommends **that the whole Great Lakes-Saint Lawrence System be subdivided, for the purpose of scientific activities, into three sections: the Great Lakes, the River (mainly freshwater, approximately from Cornwall to Rivière du Loup) and the Estuary (including the Gulf).**

The Science Council has observed that, for the Great Lakes section, present studies are on the whole well coordinated, at both the informal and the formal levels; noteworthy are the beneficial effect of the Canadian Board of the International Joint Commission, and the focussing effect of the Canada Centre for Inland Waters.

For the River section, it would appear that few steps have been taken in developing a coordinated approach for scientific investigation by the various interested university, provincial and federal bodies. The situation is somewhat better structured for the Estuary section. The Department of the Environment, through its laboratories in the Bedford Institute, is currently leading the planning for a systematic, integrated and multi-agency program on the biological, chemical and physical oceanography of the Gulf of Saint Lawrence. For this scheme, in addition to the participation of a number of other federal and provincial agencies, there is the involvement of several universities in the Atlantic provinces and Quebec - Groupe interuniversitaire de recherches océanographiques (GIROC) and the Marine Sciences Centre of McGill University, for example. A project leader has been appointed to provide overall scientific coordination. While these steps are commendable, even tighter coordination is required.

Accordingly, the Science Council recommends **that the Federal Government take the initiative in creating boards to coordinate the work on the River and Estuary sections of the Great Lakes-Saint Lawrence System. The form of the initiative should be federal-provincial agreements similar to the one between the Federal Government and the Province of British Columbia for the study of**

the lakes of the Okanagan drainage.

These boards should have responsibility for determining the objectives and standards of the system's water quality and quantity. To ensure that sufficient water reserves are available for all intended uses of the system, the Science Council recommends in particular **the examination of the consequences (climatic, ecological, etc.) of diverting water from one watershed to another, either into or out of the Great Lakes or the Saint Lawrence River.**

For the whole of the study of the Great Lakes-Saint Lawrence System, a first-order approximation of the total budget for a five-year program would be $10 million in the River section; an additional $5 million would be needed (spread over five years) for the Estuary region. Now that the current Canada-U.S. proposals are accepted, the funding already proposed for the Great Lakes region seems appropriate for the necessary activities.

To ensure that the knowledge acquired through these programs can be transferred to other parts of Canada and increase the capabilities of consultants for work on large projects, the Science Council recommends **that engineering work be contracted to Canadian firms of consultants employing Canadian talents, and that consultants be hired to assess the applicability to other systems of the results obtained from these studies (for example, to the Fraser River System).** It has been estimated that $250 000 per year would be needed for these services.

Middle North and Arctic

The Middle North and the Arctic are the great, relatively untouched regions of Canada which represent one of the national potentials that awaits development. The uses of land and water are substantially uncommitted, and the whole region can be developed in the light of past experience and with the assistance of contemporary technology. It is a challenge to Canada to develop the North in an enlightened and exemplary way. To do otherwise is obviously folly. It is evident from the present trend of events that northern development will not be long delayed, and it is past time for evaluating our state of preparedness. Most of the fundamental topographic mapping has recently been completed. Geological surveys have been extensive, though they are far from complete. Meteorological information is sketchy and of only recent vintage. More extensive knowledge of the distribution and characteristics of various kinds of frozen ground water, and of the effects of their disturbance, is urgently needed. In short, there is a substantial need for more intensive and extensive studies of the northern physical environment.

Biologically, the northern areas are noticeably under-studied. There is insufficient knowledge of the flora and fauna, of the patterns of ecological succession, and, particularly, of the ecological consequences of human activity. The recent proliferation of studies, engendered by the possibilities of long pipelines in the north, is testimony to major weaknesses in existing background knowledge. It

is not unfair to remark in passing that many of these studies are perforce superficial, and that much more investigation will be necessary before we collectively gain a knowledgeability appropriate for the years ahead. Particular attention should be given to comprehensive ecosystem studies in the coniferous sub-Arctic forests and the barren-land tundra. These kinds of studies would provide the sort of information necessary to predict the impact of change and to prescribe the best restrictions for tempering the effects of otherwise unwitting development. To this end, the Science Council recommends **that a sustained study of Middle North and Arctic ecosystems be carried out, to ensure intelligent development of land use with a minimum of environmental disturbance.**

The International Biological Program has developed the techniques and set the pace for this kind of scientific enterprise. They should be initiated in the northern environment immediately.

Some of the administrative aspects of northern development are troublesome. The sparse human population makes it unlikely that the patterns of change will be associated with strong public reaction. In these circumstances, more positive governmental policy and action are appropriate. Commendably, the Federal Department of Indian Affairs and Northern Development, which claims responsibility for the protection of the northern environment, has recently completed its work on the "New Land Use Regulations for the Yukon and the Northwest Territories"[8], and intends to bring them into force soon. These regulations are designed to protect northern lands from damage caused by companies and individuals engaged in resource exploration and development; if strictly enforced, these regulations should assure sound protection. In the same manner, the influence of the Federal Government's Arctic Waters Pollution Act (Bill C-202) should be useful, if it is strictly enforced.

Many of the problems of resource development in the north will not be so easily referable to the provisions of a single statute. Most of the major river systems cross several provincial (or territorial) boundaries, so communication should be strengthened to ensure an orderly pattern of resource use. The development of hydro-electric potentials is a particular case in point. Most of the untapped hydro-electric generating capacity in Canada is in the Middle North; British Columbia and Quebec are favoured with 70 per cent of it.[9] Construction of dams in these regions is already proceeding, but not without some signs of inadequate anticipation. The Bennett Dam on the Peace River, for example, was built without sufficient prior ecological consideration, and generated an environmental crisis in the Athabasca delta. It is not certain that a similar catastrophe will be avoided by hectic eleventh-hour studies in the James Bay area. To avoid similar future crises, an inventory should be taken of the possible sites for future hydro-electric generating stations, and

[8] "New Land Use Regulations Protect Northern Environment", in *Canada North of 60*, Vol. 1, Issue 2, p. 1, 1971.

[9] P. Camu, E.P. Weeks, and Z.N. Sametz, *Economic Geography of Canada*, MacMillan of Canada, Toronto, 1964.

decisions on development made on a basis which includes assessment of its ecological impact.

Finally, the Science Council observes, with respect to northern development, that attention should be given to providing incentives to attract some of our better young scientists into northern research. While much of the work required may lack the glamour of the frontiers of science, it is certainly loaded with national relevance and challenges to ability.

The Present State of the Environmental Sciences in Canada

Many previous Science Council Reports have documented how richly Canada is provided with scientists whose prime orientation is to natural resources and their management. To those abroad, Canadians are well known for their strengths in agriculture, forestry, fisheries, wildlife biology, geology, oceanography, meteorology, hydrology, and all of the cognate scientific activities associated with resource development. There can be no question that, in terms of manpower, we have an excellent base on which to build.

In broadest perspective, there are some fields of environmental science in which Canada (probably because of the attunement of its scientists to the social needs of the day) is deficient in facing the requirements for the future. The characteristic national emphasis in applied biology, for example, has not been reflected in attention to "pollution" research. Until very recently, such pollution-oriented research as was carried out in Canada was generally regarded as a second-priority type of activity, and there is scant Canadian scientific literature on effects of pollutants or the methodologies of pollution abatement. It is no accident that we have developed the capacity for designing jet engines, but do not yet have much more than an "out of sight, out of mind" technology of garbage disposal.

There is now underway, however, a strong shift in the scientific activities of both government and university, which should rather quickly develop national capabilities aimed specifically at the technical problems of pollution abatement. From a few active, and many latent, sources of interest, the "Resources for Tomorrow Conference of 1962" synthesized and expressed a broad concern about pollution. The National Research Council's (NRC) leadership in the Canadian participation in the International Biological Program and its establishment in 1964 of the Associate Committee on Water Pollution Research have been instrumental in stirring up some interest in environmental issues. The National Science Library, in collaboration with NRC's Environmental Secretariat, has established a Pollution Information Centre which includes a computer-based system for the storage and rapid retrieval of information covering all aspects of pollution. The Library's literature resources, about one-third of which come under the general heading of environment, provide the necessary back-up support for this new data base.

Within government laboratories, there have been shifts in relative emphases and increasing work on pollution problems. A detailed documentation is beyond the scope of this report, but suffice it to say that these trends are commendable. There remains the need for further reorientation, particularly toward the routines of detection, surveying and monitoring of pollution sources. The greater complexity and diversity of modern industrial technology poses much greater risks of accidental contamination by a wide spectrum of toxic compounds. Pollution research is no longer a sphere of activity in which amateur contributions are likely to be useful.

Universities have also shifted their programs in the direction of environment-related research. Much of this shift is not easily detectable because it comprises changes in individual research and

teaching within traditional university departments. However, much of the change is visible in the proliferation of "environment" courses, the appearance of some "environmental science" departments and faculties, and the establishment and growth of graduate studies in relevant fields.[1]

It is to be hoped that the recent emphasis on environmental research in Canada will be sustained and developed. This will move most quickly in concert with more efficient coordination among federal government departments and a more active exchange of information between senior people in Ottawa and their opposite numbers in each province. Environmental science and technology is, for obvious reasons, a particularly important area for federal-provincial collaboration.

There are some apparent deficiences in those specialized branches of science which are called upon for technical advice in connection with pollution problems. Deficiences are particularly apparent in the areas of toxicology, biosystematics, the chemistry of salt and fresh water, and systems simulation, and also in the overall ability to tackle large, complex, multi-component problems.

In the field of human toxicology, a modest amount of research is already being carried out, but there is far from sufficient knowledge of the effects of new, non-natural compounds; statistical health data capable of revealing the moderate, chronic ill-effects of environmental toxins upon human health have still to be developed in Canada.

More general toxicological knowledge – the effects of various compounds on all elements of flora and fauna – is much less well developed. These studies should come to grips with sub-lethal forms of toxicity, threshold levels of toxicity of heavy metals and toxic substances, the synergistic effects of different chemicals when introduced together in a biosystem, and the mechanics of accumulation of various harmful substances in the food chain. There is still an evident need for large-scale survey data gathered by technically sound methods. There is particular need for systematic evaluations of the toxicity of new compounds. Careful documentation of pollutants is much needed, to clear the air of falsely based anxieties which may generate overly quick "solutions" that serve only to compound problems.

There is a distinct lack in Canada of good taxonomists who can perform the necessary services of identification. Canadian universities and museums do not provide the task force necessary for the routine identification of the multitude of Canadian floral and faunal species. The particular need is for specialists in the systematics of the less well-known groups – the invertebrates, soil and water micro-organisms, and smaller plants.[2]

The chemistry of fresh water, sea water, and "mud", wherever

[1] The inaugural meeting of the Association of Canadian Faculties of Environmental Studies was held at York University, Downsview, Ontario, on April 23, 1971.

[2] P.A. Larkin and W.J.D. Stephen, *From Formalin to Fortran.* Science Council of Canada, Special Study No. 18. Information Canada, Ottawa, August 1971.

it occurs, has specific application to pollution problems. A complex of processes taking place in a mixture of organic and inorganic compounds is responsible for the biological and chemical changes that render toxins inactive or assimilable, or vice versa, and that degrade the degradable and prepare it for recirculation. These processes are not well understood and should be explored by environmental chemists; encouragement should be given to university programs aimed at producing Canadian scientists familiar with these problems.

The example of oil spills can be used to illustrate this point, and to underline the fact that Canadian research is necessary because it is frequently impossible to extrapolate the results from studies in warmer climates. With the mounting possibilities of oil spills in our waters, we must obtain the scientific underpinnings necessary to understand the effects of oil on the marine environment, and to develop the capability for dealing with these problems as they occur.

It is increasingly clear that environmental problems should not be handled piecemeal, and that their total complexity is such that systems-simulation techniques are a necessary policy-testing tool; this is particularly true of water problems, for which there is a conspicuous lack of Canadian expertise in systems simulation.[3] While systems-simulation techniques give us the tools with which to examine complex problems, their application to resource question is so typically fraught with assumptions, made necessary by lack of data or experience, that they may give distorted views of the properties of the very systems they are designed to simulate.

The obvious complement to systems modelling is large-scale resource-management experiments. Field work on this scale entails a multitude of problems in logistics, inter-agency and inter-sector collaboration, and the need for long-term continuity. Some of these problems are alluded to in Science Council Report No. 9, *This Land is Their Land.* We are now into a period when it is time to practise, rather than merely preach, the tenets of multiple-purpose use of land. Since well documented experience is the best guide to policy, it is appropriate to initiate large-scale experimental resource-management programs in many parts of the country. The fact that recognition of this need seems to have influenced the Canadian representations concerning the Man and the Biosphere (MAB) program of UNESCO is an important development. It is to be hoped that these and other schemes will eventually produce large, inter-agency, multidisciplinary resource-management studies.

As a final comment on the present state of the environmental sciences in Canada, the Science Council calls attention to the importance of foreign literature that is concerned with environments similar to those existing in Canada. The development of a better and more rapid translation service, particularly for Russian literature, whose content is most relevant to Canadian problems, is therefore to be encouraged.

[3] This deficiency has been recognized; an International Symposium on Modelling Techniques in Water Resource Systems will be held in Ottawa, May 9-12, 1972.

The Present State of Environmental Conscience in Canada

There is an old aphorism that asserts that citizens in democracies get the kind of government they deserve and, applied to the environmental situation in Canada, this is a fair comment on our history. Our national preoccupation has been growth. The great satisfactions of the older generations in Canada have largely been those that come from building a nation, and they have had good reason for pride. The temporary despoliation of some of our resources was a necessary by-product of attaining competitive stature. Rather recently, there has come the realization that the initial step of "opening up the country" is now over in large parts of Canada. There are fewer literally new frontiers, and we are now entering an era of stabilization and consolidation which will be productive only if it is marked by sophisticated husbandry of natural endowments. This realization has been brought sharply before us, partly by our own experience and partly by examples in other countries; but, whatever the source of knowledge, we are now collectively much more aware of the need for more thoughful development. Canadians have acquired an environmental conscience.

It is important that this new awareness be neither forgotten as a passing mood, nor exaggerated into a national panic. With forgetfulness, we would run the risk of coming closer to the extreme of converting a natural wilderness into another, maybe artificial, kind of wilderness in exchange for a transient prosperity. With hysteria, we might so react to environmental concerns that we unnecessarily deprive ourselves of the material benefits of modern technology. Somewhere between these extremes is the constructive median of orderly development, and this is perhaps the current summation of Canadian public opinion.

In some parts of the country the average mood is probably sensible and appropriate, while in others there may be much more need for strong and immediate environmentally-oriented action. Whether there is action depends largely on the local public attitude. The technologies for most common kinds of pollution abatement are available. There is no shortage of environmentally-oriented statutes. But it is characteristic of environmental problems that they have many unique regional and local features, and that they occur in particular sets of local, economic and social circumstances. For this reason, it is characteristic of environmental statutes that they are applied with a large modicum of ministerial discretion. They will evidently not be applied unless there is a public demand based on awareness.

Maintaining this sort of awareness depends heavily on providing the public with accurate information, and with reassurance that there are adequate machineries for review of environmental problems. Publicly supported organizations, whether government departments, agencies, non-profit institutes, or universities, should ensure that all the data they gather is made public without delay. There is an increasing tendency, particularly in government departments, to refuse publication on grounds such as: "the public will take the wrong meaning out of the information; the public is too ill-informed to

know what the data mean", and so on. Custodians of data should realize that we have and need a nation of well educated people; that these people have the right to make up their own minds; and that other scientists must have access to data if maximum progress at minimal cost is a goal. A program of planned ignorance is unacceptable.

Scientists should participate more and more in responsible organizations which keep the public objectively informed of the environmental problems of the nation, and of the solutions implemented to solve some of these problems. All scientists who have the opportunity of contributing usefully to public awareness of environmental problems should do so, and no pertinent information should be kept from public knowledge. Groups such as Pollution Probe, SPEC (Society for Pollution and Environmental Control) and STOP (Society to Overcome Pollution) have played an important role in awakening the general public. To make their efforts more effective, and provide a wider platform for expressing concern about such problems, these private environmental groups, and others like the CELRF (Canadian Environmental Law Research Foundation), should be encouraged to join forces in national organizations such as the Canadian Association for Human Environment.

Finally, there is continued need for "...the creation of a non-political organization sponsored by the government which would have, as its basic role, the provision to the public of facts about their environment, upon which they may base adequate value judgments". (Science Council Report No. 9, *This Land is Their Land,* p. 9). The mandate of this organization would be to suggest priorities - particularly when these affect more than one government, or several departments within one or more governments - to issue recommendations on methods for ensuring efficient coordination between economic, legislative and scientific pursuits, and to disseminate reliable and factual information of interest to the public. Fed by the failure to publish all data, the credibility gap between the public and the government agencies is growing, and appropriate means should therefore be developed to inform the public and to ensure that no pertinent information is willfully kept from public knowledge. This independent body should draw attention to gaps in, and the need for support of, environmentally-oriented research, and should provide the inspiration and leverage for new kinds of activities in universities, institutes and government departments. The functions of the proposed body cannot be fulfilled by the Advisory Councils formed by the Department of the Environment, which must serve the Minister. The functions described could best be performed by an independent Environmental Council, or alternatively, by active and well-funded standing committees of the House of Commons of the Senate, or of the Science Council. It will be worthwhile evaluating how well these functions are fulfilled regionally by the semi-independent Environment Council of Ontario, the Environmental Conservation Authority of Alberta, or the Environmental Council of Manitoba, and to examine what kind of public stand

they will be able to take. It is important, however, that a politically independent body be established as rapidly as possible at the national level, and to this end the Council again recommends **the creation of a politically independent organization, sponsored by the Federal Government, which would have as its basic role the provision to the public of facts about the environment.**

Epilogue

In the long view, it is abundantly clear that environmental problems are here to stay. The increasing numbers of people in the world and their increasing rate of consumption are beginning to show in a multitude of ways, so that man must now develop the techniques of living with himself and the environments he creates. It is the gaining view that, while the present state of affairs may not be too fraught with distress, and while we presently share a higher world-wide material standard of living than has ever existed, our accelerating growth will almost certainly bring a large measure of misery within a century. To avoid these dismal prospects, we will need a huge, carefully assessed, technological effort to tide us over, until we develop new philosophies for civilizations with equilibrium populations and stable economies.

In this larger context Canada, like every nation, has a special set of national considerations. We are fortunate in being further behind in our development and larger than most other countries, although our absolute size is misleading. We seem to have the opportunity to learn from the experience of others, and the time, money and ability to do something about it. But these advantages are perhaps not as large as they seem. The pace of our development is rapidly accelerating. In the minds of some, we could already be considered as overdeveloped because we are using our resources at a rate which, if copied by all the people in the world, would be beyond the capacity of the planet Earth to maintain it.

The driving internal motivation for growth is a set of social attitudes which has generated a pattern of economic and legislative activity that increasingly strengthens the commitment to even faster growth. There is an almost euphoric state of detachment that views increasingly rapid economic growth as essential to provide the money to solve all evils, and that believes, as far as the natural environment is concerned, that the scientists will always have the technological wherewithal, either to do the necessary repair job, or to push production to the new levels required. Until recently this attitude has seemed not unreasonable. But it is now recognized that we are creating problems faster than we are solving them and, as a result, that there is a backlog of things for scientists to do. With the present collective social attitude that growth for growth's sake is essential, the assistance that the environmental sciences can give to mankind is remedial and inadequate, rather than preventive and constructive.

These problems are not, of course, unique to Canada, and are being brought into even sharper focus in countries where there is greater density of population or less of a resource base to squander. The pattern that is followed in other countries in resolving the basic question of growth will influence Canada in many ways. Increasingly, we are a part of an international community which has all the potentials for raising the group to collective new heights or reducing them all to the same common denominator. The many dimensions of international relations may largely shape our national attitudes and the latitude we have to solve our internally generated problems.

On each of these matters there is a wide spectrum of views. It is quite certain that we have only weak perceptions of the properties of the complex social and economic systems that we have inherited and augmented. Better understanding will be vital to our long-term national interest. It should now be very clear in our minds that we should invest a substantial portion of our national effort in those kinds of activities which are most germane to the goal of environmental quality in its broadest sense. Society will have to learn to control its urge to apply technology just because it is available; this will require of the scientific community much more work on the development of the methodology and expertise for anticipating and avoiding adverse impacts of the use of the technology we have and of any new technology society may want to introduce. Our base of environmentally oriented scientists is excellent. It needs only to be developed and encouraged. Our base of understanding of the social and economic components is much in need of reinforcement. Given strengths in these areas, we will then need the sincerity, wisdom and determination to undertake reforms of our social and economic systems, so that they will reflect our more enlightened understandings. It is not too late – yet.

Appendices

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