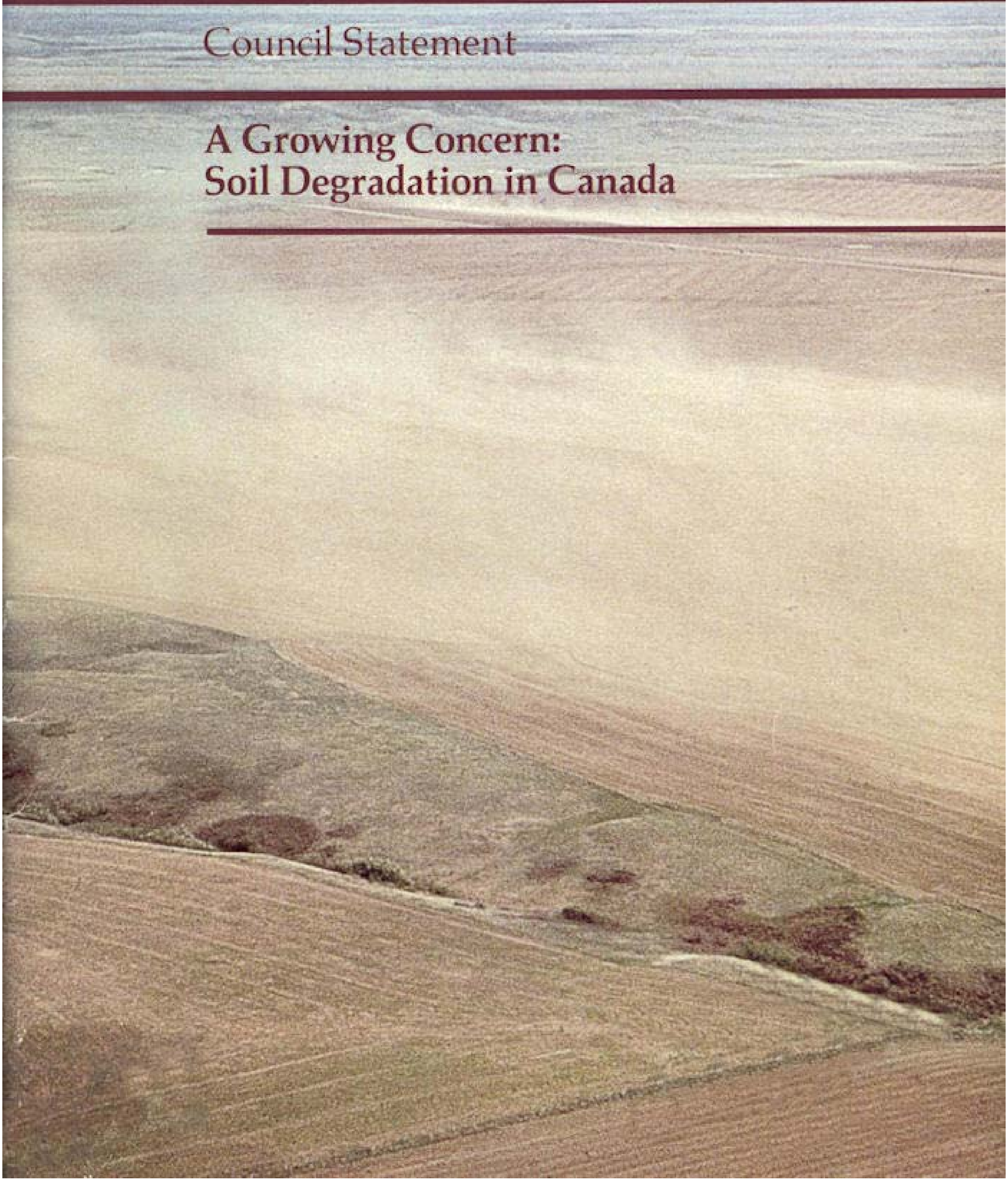
Science Council of Canada
Conseil des sciences du Canada

Council Statement

A Growing Concern: Soil Degradation in Canada



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September 1986

Science Council of Canada
100 Metcalfe Street
Ottawa, Canada
K1P 5M1

Catalogue No. SS31-14/4-1986
ISBN No. 0-662-54476-5

Cover:
Wind erosion of topsoil near Elbow, Saskatchewan.
Photo: courtesy of Prairie Farm Rehabilitation Administration.

September 1986

The Honourable Frank Oberle, PC, MP
Minister of State for Science and
Technology
House of Commons
Ottawa, Ontario

Dear Mr Oberle,

In accordance with Section 13 of the Science Council of Canada Act, I am forwarding to you a Council Statement entitled *A Growing Concern: Soil Degradation in Canada.*

The views and recommendations contained in the Statement have been unanimously agreed to by all Members of Council.

Yours sincerely,

Stuart L. Smith
Chairman
Science Council of Canada

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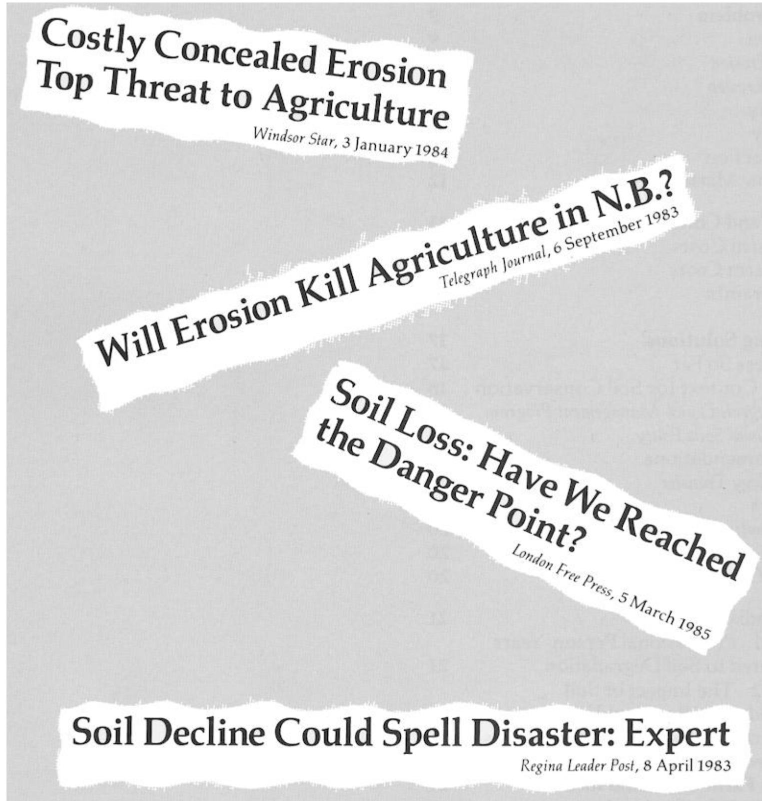


Costly Concealed Erosion Top Threat to Agriculture

Windsor Star, 3 January 1984

Will Erosion Kill Agriculture in N.B.?

Telegraph Journal, 6 September 1983

Soil Loss: Have We Reached the Danger Point?

London Free Press, 5 March 1985

Soil Decline Could Spell Disaster: Expert

Regina Leader Post, 8 April 1983

Introduction

In the mind of the general public soil degradation is most often associated with drifting soils on the Prairies during the "dirty thirties." However, soil degradation poses a much greater threat to Canadian agriculture today than it ever has in the past. Headlines such as those opposite publicize only the sensational events or disclosures that capture the media's imagination. They leave the impression that the problem is episodic. In fact, soil degradation is an ongoing, insidious problem that occurs in all parts of the country at a cost of over $3.0 million per day or $1.3 billion annually. [1] Losses associated with soil degradation now exceed $20-$25 per hectare of agricultural land in Canada, or 38 per cent of net farm income[2]. For many farmers, the cost of soil degradation represents the difference between profit and loss.

Given the prominent role that agriculture plays in the Canadian economy, these losses place a heavy tax on all Canadians. In 1983 the primary production, processing, and distribution of agricultural products in Canada accounted for almost 10 per cent of the gross domestic product.[3] Over 650 000 Canadians, or 6 per cent of the workforce, depend on agriculture for their livelihood. The foreign exchange earned by this sector also makes a vital contribution to the standard of living enjoyed by all Canadians. In 1984 Canada exported over $9.8 billion worth of agricultural products to the rest of the world and registered a $4.4 billion surplus in agricultural trade. This surplus accounted for over 20 per cent of Canada's total merchandise trade surplus in 1984.[4]

Agriculture is particularly important in the Prairie Provinces. The Prairies contain almost 80 per cent of Canada's agricultural land. This land, farmed for less than 100 years, produces 55 per cent of agricultural output in Canada and almost $10 billion in farm cash receipts annually. Primary agriculture and downstream processing on the Prairies account for 8.4 per cent of regional economic activity and for 11.6 per cent of total employment in the region. Agriculture also plays a significant role in other provincial and regional economies.

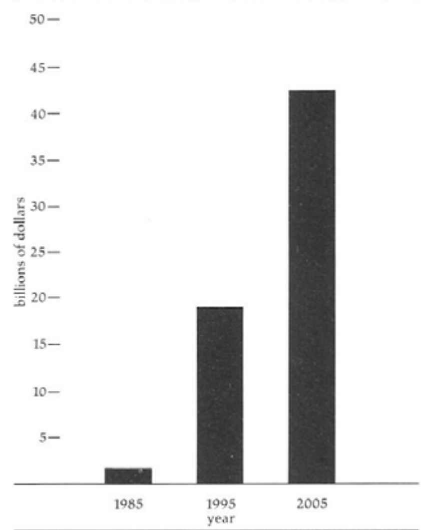
It might appear that Canada, with its vast territory, has almost unlimited agricultural potential and that the progressive degradation of some agricultural soils is a lamentable but not catastrophic occurrence. Unfortunately, this is not the case.

Despite its geographical area, Canada has a limited agricultural resource base. The combination of a cold climate and a glacially scoured landscape renders much of the country unsuitable for agriculture. Over 76 per cent of Canada's land base has virtually no agricultural potential due to low temperatures and dryness. The suitability of the remaining 24 per cent of the country for agriculture depends, among other things, on soil capability. In fact, less than 9 per cent of our domestic land base has soils that are capable of maintaining field crops (see page 8).

The economic viability of agriculture in all regions of the country depends upon the productivity of the top 10 centimetres of topsoil. While topsoil is constantly being formed, it is also constantly being depleted. Under present farming practices, this depletion can far outstrip the rate of formation. For example, it has been found that, where row crops such as corn are produced on a continuous basis, a loss of 7.6 centimetres of topsoil reduces yields by 19 per cent.[5]

The contamination of topsoil with salt, or salinization, is another form of degradation. In Alberta it has been estimated that crop land affected by salinity loses from 50-100 per cent of its normal productive potential and costs farmers $80 million per year in lost yields.[6] As already noted, the total cost of soil degradation across Canada, not including off-farm costs, is $1.3 billion annually. If these losses are allowed to continue, the cumulative cost of soil degradation to the Canadian economy could be enormous by the turn of the century.

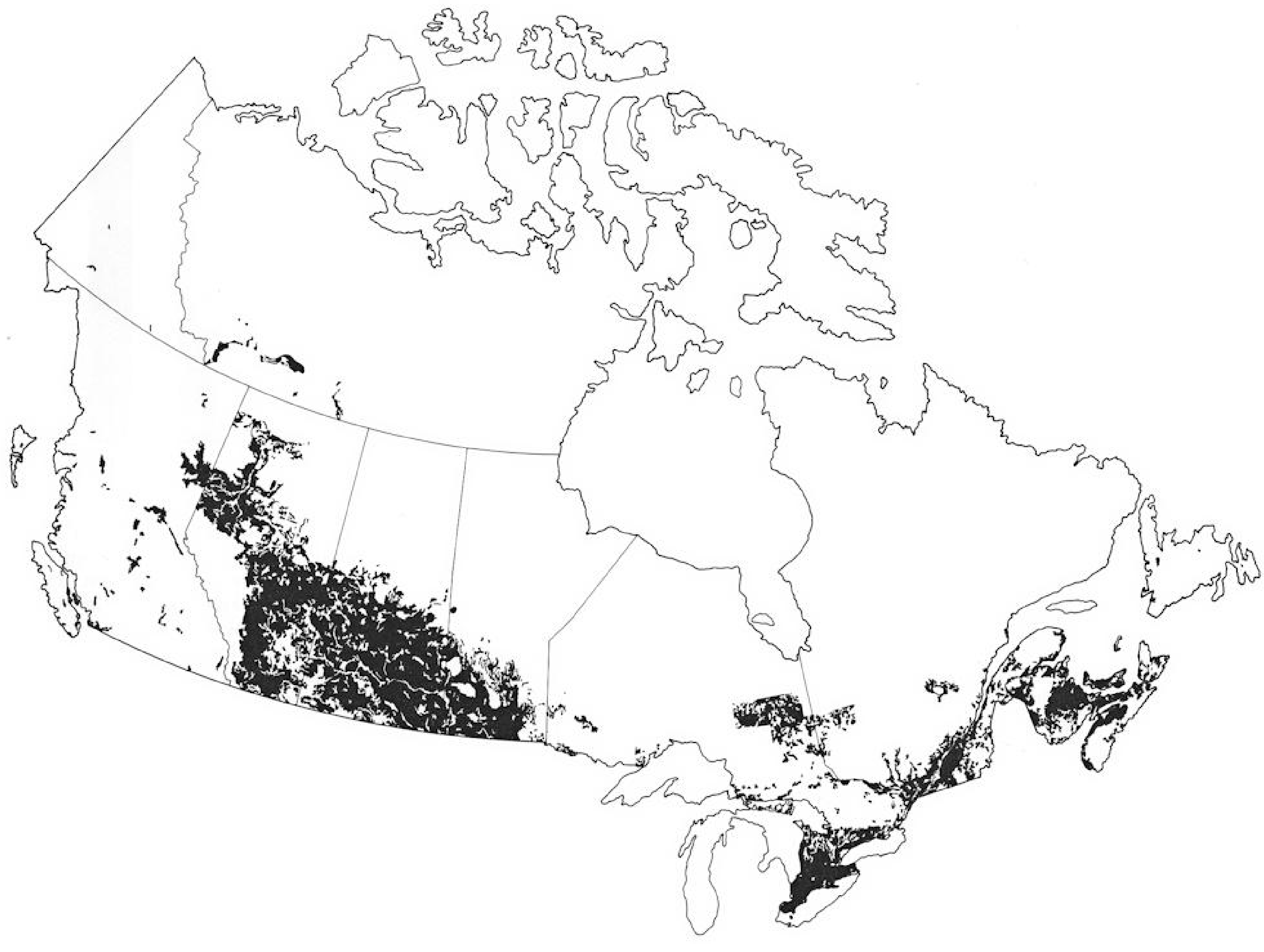
Cumulative Cost of Soil Degradation in Canada



At a time when public policy in Canada is geared toward increasing economic growth and regional development, it is almost inconceivable that so little effort is being directed toward mitigating these largely avoidable losses and to maintaining the jobs and economic benefits associated with a viable agricultural sector. There are no new frontiers to put to the plough. To increase, or even sustain present production levels, the fertility of Canada's agricultural soils must be maintained. The soil degradation that afflicts large tracts of agricultural land in Canada threatens the long-term viability of the agricultural industry and the economic prosperity of all Canadians.

Agricultural Soil Capability in Canada.*

■ Soils capable of maintaining field crops (Canada Land Inventory Classes 1-4).



* Based on Canada Land Inventory (CLI) soil capability data. CLI Class 1-3 soils are capable of sustained production of field crops with normal conservation practices. CLI Class 4 soils can maintain a restricted range of field crops and are subject to severe limitations. These soils require special management and conservation measures.

Source: Adapted from "Canada: Soil Capability for Agriculture," in *The National Atlas of Canada,* 5th edition (Ottawa: Energy, Mines and Resources Canada, 1980).

The Problem

No area of cultivated land in Canada is unaffected by, or does not have the potential for degradation. Some problems are more serious in certain regions than in others. However, whatever the type of degradation, the result is the same - diminished productivity, reduced yields, and financial losses in one of Canada's most important industries.

Although scientists are now well aware of most of the causes of soil degradation, they have much less information on the extent of the problem. Estimates for the more serious forms of degradation have been developed for the Prairie Provinces and parts of Ontario. However, due to limited research on soil problems in general, there is less information on the extent and severity of soil degradation in other regions.

Five major types of soil degradation are prevalent in Canada today:

- erosion by wind and water;
- soil salinization;
- acidification;
- compaction;
- loss of organic matter.

Erosion

The loss of topsoil from erosion by wind and water is the most widespread form of soil degradation in Canada. Erosion reduces the organic matter content of soil, weakens its structure, diminishes its water-holding capacity, and lowers productivity. The problem affects agricultural land from Vancouver Island to Newfoundland; it costs Canada millions of dollars annually and affects millions of hectares. Although erosion is a natural phenomenon, which usually occurs in general equilibrium with the rate of soil formation under native vegetation, inappropriate agricultural practices can increase the rate of soil erosion dramatically. In the grain growing areas of Western Canada alone, 5.2 million hectares or 14 per cent of improved farmland in the region have lost significant amounts of topsoil because of erosion.[7] Moreover, if losses continue at the same rate, an additional 1.1 million hectares could be affected by the year 2008.[8]

Wind Erosion

Wind erosion is caused by high winds blowing on dry unprotected soil. A soil's susceptibility to wind erosion is greatly increased through excessive tilling, summerfallowing, or failing to leave crop residues or cover crops in place.[9] Removing windbreaks to facilitate the use of large machinery is another practice that can increase losses due to wind erosion.

Wind erosion is often associated with Western Canada and the dust storms of the "dirty thirties". However, the extremely dry conditions that have plagued this region throughout the 1980s have caused serious erosion from wind on the Prairies in the last five years. In addition to summerfallowed fields, newly planted areas where seed has not yet taken hold have also proven vulnerable. In the sprin of 1985, many farmers were forced to replant their entire crops after severe wind storms. Topsoil losses due to wind erosion are particularly severe in dry southern regions. For example, in one area of Saskatchewan, it has been estimated that winds erode 5.6 tonnes of soil per hectare annually.[10]

Wind erosion is not only a Prairie phenomenon. In southern Ontario, unusually dry spring weather combined with high winds during the last three years has led to significant wind erosion in a number of areas. Soils in this region, which are largely used for row crops, are particularly susceptible. Wind erosion is also a major source of degradation on the light-textured organic soils of Quebec, where up to 400 000 cubic metres of topsoil are lost per annum.[11] Although wind erosion is not a serious problem in much of Atlantic Canada, it is a problem in Newfoundland (because of the thin soils and rocky terrain that prevail throughout the province) and a concern in much of Prince Edward Island.

A wind-eroded grain field near Ponteix, Saskatchewan. Photo: courtesy of Prairie Farm Rehabilitation Administration.

Wind erosion on a field in southern Ontario. Photo: courtesy of Charles Baldwin.

Eroded cropland in southern Ontario. Photo: courtesy of Charles Baldwin.

Water erosion on a potato field in Bangor, Prince Edward Island.

Water Erosion

Water erosion occurs when the supply of moisture from precipitation or runoff exceeds a soil's capacity to absorb it. Inappropriate farming practices can greatly increase the susceptibility of soil to water erosion. The use of summer-fallowing, the incorporation of crop residues, or the failure to plant a cover crop for the winter all leave soils exposed to erosion. Increased reliance on monoculture row-cropping with corn or potatoes also facilitates erosion in certain areas since these crops provide inadequate protection to soils and little resistance to runoff. Water erosion usually occurs in rolling areas where soil has been left without a cover of vegetation or crop residue. Under these conditions, excess moisture collects topsoil from slopes and deposits it in ditches or in nearby streams. This process can drastically reduce the productivity of entire fields.

In British Columbia two major areas have experienced significant losses due to water erosion, the Peace River District and the Lower Fraser Valley. The sloping fields and finely textured soils of the Peace River District make this area extremely vulnerable to runoff during snowmelt or heavy rains. It has been estimated that 11.5 metric tonnes of soil per hectare are lost annually on grain producing fields in this region.[12] Up to 25 per cent of the land in the area is believed to have suffered a total loss of topsoil due to erosion.[13] The sloping topography of the Fraser Valley is also susceptible to water erosion where fields are planted in row crops or orchards.

The effect of water erosion on Prairie soils is often underestimated yet it accounts for over one-half of all topsoil losses in this region. In some areas, water erosion has removed topsoil to the extent that subsoils are exposed or dredged up by tillage operations.[14]

Some regions in Ontario and Quebec have also proven particularly prone to water erosion. In southern Ontario, where row-cropping with corn or soybeans is widespread, water erosion has been estimated to cause the loss of between 2 and 18 tonnes of topsoil per hectare annually. In fact, in some areas, 40-60 per cent of the land cropped is prone to water erosion 15 In plot trials northeast of Quebec City, water erosion removed 1 kilogram of topsoil per hectare on improved pasture, and 60 tonnes per hectare on bare soil. This dramatically illustrates the impact that alternative management practices can have on a soil's susceptibility to erosion. In the Appalachian region, southeast of Montreal, soil losses from water erosion of up to 50 tonnes per hectare have been recorded over a four-year period. As much as 30 per cent of land cropped in hilly areas is moderately or severely eroded in the province of Quebec.[16]

Water erosion is the most serious form of soil degradation in Atlantic Canada. Almost 75 per cent of agricultural land in this region has the potential for severe water erosion. The soil structure is generally poor, the topography hilly, and annual rainfall heavy. These conditions, combined with inappropriate farming practices, have rendered some areas extremely susceptible to erosion. In the potato-producing regions of New Brunswick and Prince Edward Island, annual losses of up to 20 tonnes of topsoil per hectare are not uncommon.[17] In the upper Saint John River Valley, many fields are now so severely eroded that production is no longer economically feasible. In Nova Scotia, soil losses of up to 40 tonnes per hectare per year have been reported on corn fields subjected to continuous cropping.

Salinity

Salinity occurs almost exclusively in the Prairie Provinces. There are actually two types of soil salinity, primary salinity, in which soil is naturally saline, and secondary salinity, which is usually associated with inappropriate management practices.

In Alberta soil salinity is triggered by the downward seepage of excess water, which dissolves soluble salts into the groundwater system. These salts are carried to the surface in the discharge area and deposited on topsoils. In Saskatchewan the dominant process appears to be artesian pressure, which forces excess moisture and salts to the surface. Since salts are toxic to plants, large accumulations in topsoil can inhibit plant growth and drastically reduce yields. Secondary salinity usually occurs in salt-susceptible soils due to the use of cropping systems that do not require as much moisture as indigenous vegetation. This excess moisture must then find an outlet. Although inappropriate irrigation or drainage techniques can increase salinity, the major cause appears to be the long-established practice of summer-fallowing large tracts of cultivated land on the Prairies in order to retain moisture.

Until recently, in much of the semiarid Prairie region, farmers regarded summerfallowing every second or third year as the only way to reduce the high risk of crop failure. However, even under the very arid conditions prevailing in the brown soil zone, the moisture loss due to water percolating below the rooting depth is quite high. This water disturbs the delicate salt balance in soils and eventually seeps to the surface on hillside slopes or depressions, depositing salts on topsoil. Although summerfallowing contributes to soil salinity, and there has been a corresponding reduction in its use, the ease and economics associated with this method of dryland farming have made it difficult for some farmers to abandon the practice altogether.

Saskatchewan, with approximately 40 per cent of its cultivated farmland under summerfallow each year, has experienced the highest incidence of soil salinity. In fact, salinity is now regarded as a serious threat to agricultural productivity in the province. It affects 1.2 million hectares of cultivated soils and is spreading. [18]

Salinity is also a serious concern in central and southern Alberta where some 370,000 hectares of improved farmland are affected by manmade or secondary salinity.[19] Because of Manitoba's more temperate climate and even rainfall, secondary salinity is not a problem in the province.

A saline canola field north of Battleford, Saskatchewan. Photo: courtesy of Hubert Esquirol.

Saline cropland north of Weyburn, Saskatchewan. Photo: courtesy of Prairie Farm Rehabilitation Administration.

Acidity

Soil acidification is a natural process that is influenced by soil type, climate, and vegetation. Although native vegetation has little difficulty growing in acid soils, most field crops require the maintenance of adequate pH levels. In soils with a pH below 6, crop yields can decrease substantially. To facilitate the economic production of field crops, most acid soils must be treated with lime to neutralize excess acidity.

Acidification is a widespread phenomenon on many soils, particularly in areas with high rainfall. Although much acidity is a result of natural soil conditions, some soil management practices, such as the excessive application of inorganic fertilizers, have contributed to the acidification of agricultural soils. Faced with low commodity prices and a deteriorating soil base, many farmers now regard the extensive use of chemical fertilizers as necessary to enhance yields and generate higher cash returns. The use of nitrogen fertilizer has increased by 1000 per cent on the Prairies during the last 20 years and has more than doubled in other regions. [20] This increased reliance on nitrogen fertilizer has increased soil acidity in many areas.

Acid soils can be found in virtually every region of Canada. In Quebec a large portion of the 1.65 million hectares devoted to cereal and forage production has a low pH and requires liming.[21] In Ontario 10 per cent of the coarse-textured soils in the southern and western regions are acidic, as are most soils in the northern part of the province.[22] The majority of soils in Atlantic Canada are also acidic, and some soils in New Brunswick and Nova Scotia have a pH level of less than 4. Areas that have the highest risk of acidification include Prince Edward Island, the Annapolis Valley and southwest Nova Scotia, western New Brunswick including the Saint John River Valley, and isolated pockets of Newfoundland.[23] In fact, most agricultural soils in Atlantic Canada require the periodic application of large quantities of lime to correct excess acidity.

Acid soils are also prevalent in the Peace, Omineca, lower mainland, and East Vancouver Island regions of British Columbia. In total, 346,000 hectares of cultivated land in B.C. have a pH of less than 6.[24] In Alberta 13 per cent of the province's improved farmland is naturally acidic as is 37 per cent of improved land in Saskatchewan.[25] The continued application of nitrogen fertilizers to these predominantly sensitive soils can only aggravate the acidity problems in this region.

This scene in the Lower Fraser Valley of British Columbia shows soil compaction and puddling caused by repeated travel over wet, poorly drained soils.

Compaction

Compaction increases the bulk density of soils, which in turn diminishes oxygen diffusion and water infiltration, retards root development, and reduces crop yields. Clay soils in humid regions of the country are the most susceptible to compaction, particularly when they are planted with row crops, which require intensive tilling in seasons when soils are wet. Moderately moist soils that are subjected to excessive tilling or are repeatedly travelled over by heavy machinery will also become compacted. Moreover, the processes of degradation are often intertwined. Soils that have been subjected to erosion or have lost organic matter due to inappropriate management practices usually have a poor overall structure and are particularly prone to compaction.

Compaction is widespread in British Columbia, and is regarded as a more serious problem than surface soil erosion in the Fraser Valley. In Quebec the fertile St. Lawrence lowlands are especially vulnerable, although most cropland in the province is compacted. Soil compaction is also a problem in the corn and soybean growing regions of Ontario. In fact, approximately 25 per cent of the area devoted to row crops in the province suffers from some degree of compaction.[26] The Atlantic provinces are plagued by naturally compacted subsoils and hardpans in addition to compaction from farming activities on moist soils. In this region, almost one-third of the good crop land has poor soil structure or low permeability. Soils with poor structure are common along the Northumberland shore and in central Nova Scotia and most of New Brunswick.[27]

Organic Matter Loss

Organic matter occurs naturally, to a greater or lesser extent, in all virgin soils. To facilitate good crop growth, both adequate nutrient levels and good soil structure are imperative. Organic matter is an important source of soil nitrogen and micronutrients, and serves as a bonding agent necessary for good soil structure. It also increases the water-holding capability of soils.

A pronounced decline in soil organic matter is usually associated with intensive tilling, summerfallowing, or the failure to employ appropriate crop rotations. The use of summerfallowing, or a management system that does not include nitrogen-fixing rotation crops, depletes organic matter more rapidly than it can be replaced. A soil with little organic matter is almost inevitably lacking in nutrients and is prone to erosion, compaction and increased runoff.

Unfortunately, little research has been done on this topic, and few statistics exist on the extent of organic matter depletion in Canada. However, some information does exist on rates of depletion. Reductions in organic matter of 30-35 per cent have been recorded in the province of Quebec for soils cultivated for 50 years or more under traditional cereal-hay rotations.[28] Land that is subjected to continuous row-cropping, such as the corn belt in southern Ontario, is believed to suffer significantly higher rates of depletion. Large areas of agricultural land in both British Columbia and Atlantic Canada are naturally low in organic matter and require careful tending to preserve organic matter and prevent serious deterioration of soil structure.

Under virgin grass, Prairie soils have high levels of organic matter. However, the breaking of this land and its subsequent cultivation has, over time, decreased organic matter content by 40-60 per cent.[29] The resulting decline in productivity has precipitated a major increase in the use of fertilizers on Prairie soils, which has contributed to the spread of soil acidity in the region.

Costs and Constraints

The causes and economic consequences of soil degradation, in all its forms, are at least as varied as the types of degradation occurring in Canada. The overall cost of soil degradation, in terms of reduced yields and financial losses, is already unacceptably high and continues to increase. Moreover, the longer that remedial action is postponed, the more difficult and costly it will be to implement corrective measures.

Topsoil drifting along a fenceline near Indian Head, Saskatchewan. Photo: courtesy of Prairie Farm Rehabilitation Association.

Costs of Soil Degradation in Western Canada ($ millions)

	B.C.	Alta.	Sask.	Man.	Total
Erosion	10	200	220	10	440
Organic Matter Loss	11	144	170		325
Acidification	5	5	50		60
Salinity	—	80	120	12	212
Compaction	12				12
Total	38	429	560	22	1049

Source: D.A. Rennie, "Soil and Water Issues and Options in Canada," paper presented to the Canadian Agricultural Outlook Conference, Ottawa, 9-10 December 1985.

Costs of Soil Degradation in Central and Eastern Canada ($ millions)

	Ont.	Que.	Atlantic	Total
Erosion	68	10	11	89
Compaction	21	100	6	127
Acidification	1	4	6	12
Total	90	114	23	228

Source: D.A. Rennie, "Soil and Water Issues and Options in Canada," paper presented to the Canadian Agricultural Outlook Conference, Ottawa, 9-10 December 1985.

On-Farm Costs

In the Prairie Provinces, secondary salinity and erosion together account for an estimated $642-million loss annually. Yield losses from salinity may be as high as 100 per cent and average 50 per cent on affected soils in this region. Losses from erosion average 20-70 per cent of yields depending on soil type and climate. Acidity in Alberta and Saskatchewan also affects yields, and can lower expected output by 25 per cent.[30] These losses, if they are allowed to continue, represent a serious drain on the agricultural economy of Western Canada. Losses from soil degradation on the Prairies now exceed $1.0 billion annually, and could increase to $2.7 billion within 20 years.[31] The cumulative cost to western farmers in terms of lost revenues and increased expenditures could be devastating if ameliorative action is not taken.

Although the absolute and relative losses due to soil degradation in Central and Eastern Canada are much less than the losses in the more agriculturally oriented provinces, they are nevertheless significant. Yield losses due to water erosion of up to 30 per cent have been recorded on corn fields that are moderately to severely eroded.[32] A minimum loss of $68 million from water erosion has been estimated for southern Ontario alone.[33] Compaction in Central Canada reduces yields by 10 per cent and costs over $120 million per annum. In total, the cost of soil degradation in Central Canada is approximately $204 million annually. Estimates of the cost of soil degradation in British Columbia and Atlantic Canada are $38 and $23 million respectively.

If no attempts are made to alleviate the degradation of agricultural soils in Canada, the annual cost of soil degradation could reach $2.0 billion in 10 years and 3.4 billion in 20 years. By 2005 the cumulative cost to the Canadian economy could exceed $42 billion. Today the producer is shouldering the full cost of soil degradation. But producers cannot carry the burden much longer. Ultimately, these costs will have to be passed on to consumers, in the form of higher prices or increased farm subsidies.

A water-eroded corn field in Quebec. Photo: courtesy of Christian de Kimpe.

Off-Farm Costs

The figures quoted do not include the off-farm costs of soil degradation. Wind and water erosion result in the deposition of topsoil in ditches, along fence lines, and in streams and rivers. During periods of severe soil drifting, irrigation ditches in southern Alberta fill with silt. In Ontario, deposition often dams municipal drainage ditches. Both must be dredged at considerable expense. Moreover, sedimentation harms aquatic life. In Nova Scotia, salmon spawning grounds are damaged annually by sedimentation as are fish habitats in waterways across the country. Sedimentation can also destroy aquatic organisms that serve as food for fish. The pesticide and fertilizer residues that often accompany sediment also cause serious damage. Fertilizers can accelerate the growth of aquatic plants to the point at which they interfere with water supply or recreational uses. When these plants die, the demand for oxygen by decomposing organisms reduces the chemical quality of water. Expensive treatment is also required for municipal water sources that have been contaminated by sediment.

Detailed information on the off-farm effects of soil degradation is available only for the Great Lakes region of southern Ontario. However, the Ontario Erosion and Sedimentation Coordinating Committee has estimated that sedimentation due to agricultural production causes $91 million in damage annually. The costs include sediment damage to inland lakes and waterways, the cost of dredging ditches and harbours, recreational fishing losses, and water treatment costs. At the national level, the off-farm costs of soil degradation are obviously many times greater.

Constraints

The implications of permitting soil degradation problems to continue unchecked are, at best, serious and, at worst, devastating for the agricultural industry in Canada. However, there are numerous obstacles to mitigating, let alone overcoming, soil degradation in every region of the country.

The principal cause of degradation is often inappropriate management practices on susceptible soils. Yet these practices continue because of financial constraints, inadequate research and technical information, and conflicting government policies.

Most farmers are aware of the soil problems that exist on their own land. However, in many cases economic factors force them to ignore or even aggravate these problems. In New Brunswick, for instance, continued low potato prices, combined with the high cost of equipment and storage facilities required for alternate crops, compel most farmers to plant a cash potato crop every year. Because this practice prevents adequate crop rotation and the planting of forage crops, soil erosion continues unabated. Farmers are powerless to act as more of the productive capacity of their soil washes into the Saint John River each spring. The end result will likely be similar to that which has occurred on some potato fields in northeastern New Brunswick, where topsoil has been worn away to bedrock.

Other examples can be found in Ontario and Quebec, where monoculture and specialized production systems have largely replaced mixed farming. As a result, livestock producers frequently do not have enough land to produce their own feed, and thus have no use for animal wastes that would build organic matter.[34] In contrast, farmers specializing in crop production have little use for nitrogen fixing forages that would provide nutrients to soil. They also lack the natural fertilizer that mixed farming would provide. The efficient production of wide-row cash crops, such as corn or soybeans, is often accomplished using heavy machinery on large fields, which leads to overworking and compaction of the soil. The removal of fences to facilitate this practice also leaves fields exposed to wind and water erosion. The increasing tendency to use leased land for producing field crops also hinders the adoption of conservation measures, since it is seldom in the financial interests of temporary tenants to engage in soil-building practices.

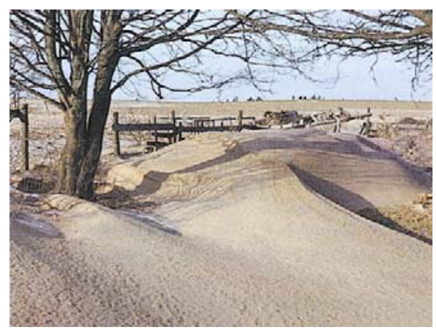
The cost of conservation measures can also be a deterrent. For example, one of the most effective ways to combat erosion is to modify tillage practices. Conservation tillage, using either zero or minimum till, reduces soil disturbance and significantly decreases the risk of erosion. This management system typically includes minimal tilling with specialized equipment, continuous cropping, and protecting soil in the off season with a crop or residue cover. Under this system, crop residue is not ploughed down in the fall and new seed is planted directly into undisturbed soil through the previous year's stubble.

This practice already has many advocates in Manitoba and Ontario, and there would be more but for the high cost of appropriate machinery and herbicides required to produce adequate yields. Unfortunately, with present commodity prices, these requirements are beyond the resources of most farmers. Other conservation measures can be similarly unattractive. Proper irrigation and drainage systems to alleviate salinity and runoff are difficult and expensive to install. Lime can be used to neutralize acid soils, but many farmers, especially in areas where lime is not readily available, find the expense too onerous.

These financial constraints are compounded by the paucity of site-specific information available to farmers on the cost and efficacy of conservation measures. Specific techniques to reduce erosion on the organic soils of Quebec are not appropriate on the brown soils of Alberta. Cropping patterns appropriate in Manitoba may not be suitable for the much drier soils of southwestern Saskatchewan. What works on one field may not work on a neighbouring field. Thus, beyond general guidelines, there is a need for precise information that is unavailable in most areas. Moreover, it is beyond the present capability of most government extension branches to examine every hectare of land under cultivation and make recommendations. There is definitely room for a private-sector initiative to provide a source of expertise and advice in this matter. However, there is currently little incentive for the private sector to do so.

The limited information that is available from research establishments concerning new management techniques is rarely presented in a format that is comprehensible to non-experts. In general, there is a need for more contact between researchers and extension personnel or farm operators to make each aware of the others' requirements and to facilitate the development of affordable on-farm conservation techniques.

Government policies can also militate against the adoption of conservation practices. For example, crop insurance regulations in some provinces strongly favour crops seeded on fallow land and discriminate against stubble cropping, thus encouraging the continued use of crop-fallow management systems.



Topsoil removed from a ploughed field by high winds in Prince Edward Island.

Transportation policies, such as the Feed Freight Assistance Program, discourage the production of rotation grains in the Maritimes by subsidizing the import of low-cost feed from Ontario and the Prairie Provinces. The Western Grain Transportation Policy encourages the production of export grains in Western Canada at the expense of livestock feeds. This has discouraged the production of livestock and forages in the Prairies and reduced the availability of animal residue necessary to strengthen soil structure. Agricultural marketing policies are geared almost entirely toward the sale of principal crops at the expense of rotation crops. As a result, many farmers are forced to engage in monoculture because there is no ready market for alternative production. All of these policies unintentionally hinder the adoption of soil conservation measures in a cost-efficient manner.

Another serious obstacle to soil conservation is the lack of research on soil degradation problems. In 1984 only 23.3 person-years were devoted to soil conservation research across Canada. This includes research undertaken in universities and by both levels of government. In fact, less than 1 per cent of total agricultural research funding was directed toward conservation-related work in 1984.[35] As a result, the extent and severity of soil problems in Canada have not been fully documented, and many sensitive regions requiring immediate action have not been identified or addressed. There is also uncertainty about remedial measures that the agricultural industry might adopt to alleviate further soil degradation.

The cost to the general public of arresting, or at least mitigating, the decline of agricultural soils in Canada will be high. However, the long-term cost of continuing to engage in exploitive agriculture, or of failing to alter the economic circumstances that encourage soil degradation, will definitely be higher.

Seeking Solutions

The Science Council of Canada wishes to draw Canada's attention to the fact that soil degradation is a serious problem. Although the subject requires further research, the evidence and opinions collected in all parts of the country indicate that soil degradation endangers Canada's agricultural competitiveness and capability. The economic costs of leaving the problem unresolved will be high. Productivity will suffer and our capacity to produce food will deteriorate. Erosion and sedimentation can also degrade entire landscapes. The problem is not just one for farmers - it affects the well-being of all Canadians.

Progress So Far

The situation, however, is not utterly bleak. Documents such as the Sparrow Committee's *Soil at Risk*[36] and the Agricultural Institute's *Will the Bounty End?*[37] have raised public awareness. The Canadian public has been told, often in forceful terms, of the importance of maintaining agricultural land. Conferences on land and soil issues have been held and the results made public. Publications aimed at the general public have also appeared.[38]

Farmers are now more aware of soil conservation. Across the country, farmers working alone or in small self-help groups are actively tackling their soil problems. Groups such as the Warner-Dryland Salinity Control Association in Alberta, the Manitoba-North Dakota Zero Tillage Farmers' Association, and soils and crop improvement associations in Ontario and Prince Edward Island work toward the goal of soil conservation and sustainable agriculture.

Large farm organizations, such as the Canadian Federation of Agriculture, have released public statements and lobbied in several provinces for better soil management. Provincial departments of agriculture have responded (within the limits of available financing and personnel) with several programs. Alberta has its Farming for the Future initiative; Saskatchewan has Farmlab (which has been renamed the Agricultural Research Fund). Prince Edward Island has mounted an ambitious campaign of hedgerow renewal, subsurface drainage, and expanded use of limestone. The Prairie Farm Rehabilitation Administration has revived its original mandate of soil conservation. Agriculture Canada is working toward a comprehensive soils policy and is cooperating with the provinces and regions in conservation activities.

There is thus much interest and activity in the preservation of soil. However, research must be accelerated, particularly on farms. Educational and public awareness programs must become more dynamic. Funding is a problem at all levels. The maintenance of soil quality depends upon a healthy and profitable agricultural economy, and vice versa. Although there are some success stories and public concern is increasing, maintaining soils for sustainable agriculture will require a major commitment from farmers, governments, and the Canadian people.

To foster this commitment, the Science Council of Canada makes 12 recommendations. They are not original but are intended to reinforce recommendations made by others. Ideally, they should be implemented within the context of an integrated land-management program and a national soils policy, both of which are essential if the damage caused by soil degradation throughout Canada's farmlands is to be reversed.

Policy Context for Soil Conservation

An Integrated Land-Management Program

The optimal solution to soil degradation in any area lies in the provision of an integrated land-management program, together with the necessary information programs, technical and material inputs, and government direction to transform the plan into reality. The program must be as site-specific as possible; some areas need field-by-field, even slope-by-slope analysis and prescription.

Such an approach requires:

- willing cooperation from the farmer, who must be convinced of the necessity and utility of "micromanagement" through extension and education programs;
- provincial or regional extension services to provide soil analyses and cropping recommendations. This in turn requires additional trained staff, as well as analytical and data-handling capabilities;
- services and subsidies to provide on-farm assistance to implement conservation practices such as drainage programs, strip-cropping plans, contouring, or liming programs;
- planning and information services with enhanced research and monitoring capabilities, preferably in actual farm situations.

A National Soils Policy

On a wider scale, conservation farming will become widespread only with integrated government programs, carefully developed government food and agriculture policies that include conservation as a major component, and increased support from the Canadian public. To facilitate this effort, a national soils policy is required to provide a framework for evaluating other policy initiatives and to ensure that all government policies foster soil conservation. Such a policy is needed to assess the impact of present and future transportation policies, crop insurance and support programs, and agricultural marketing policies on the adoption and practice of conservation farming in Canada.

Recommendations

Technology Transfer

Much of the research currently being done on soil conservation is carried out in test plots; the results cannot always be transferred to farm sites.

The Science Council recommends that provincial governments develop technology transfer programs for soil conservation and provide trained personnel to work with scientists and farmers to translate research findings into applicable farm management techniques. The federal government should work closely with the provinces and ensure that federal research institutions participate in provincially directed technology transfer programs.

The lack of soil specialists in Canada hinders attempts to overcome the problem of soil degradation; more researchers are needed in most areas of the country.

The Science Council recommends that federal and provincial governments provide direct funding and technical support to agricultural and technical colleges to increase the number of soil conservation specialists trained in Canada.

Because conservation is such a site-specific and crop-specific activity, provincial departments of agriculture must develop integrated soil management plans tailored to individual situations. This can only be accomplished if soil specialists work directly with farm operators through extension programs. However, most extension workers in agriculture are not soil specialists and many are already overworked.

The Science Council recommends that all provinces appoint additional soil conservation specialists to work with local extension personnel and farm operators to develop and implement regional soil management plans.

One of the most effective ways to transfer agricultural technology is for farmers to teach other farmers. Soil conservation self-help groups are invaluable in facilitating this process. Because group members have similar soil types, topography, and climate, they are able to share experiences, successes and failures, as well as conservation equipment. The atmosphere of shared experience and objectives makes the adoption of new technologies less formidable.

The Science Council recommends that governments provide increased funding for soil conservation associations whose membership falls within natural geographic or demographic boundaries such as watersheds or rural municipalities.

Research

Current research on soil degradation, in relation to all agricultural research, is inadequate: for instance, within Agriculture Canada, soil conservation research accounted for less than 1 per cent of total research spending in 1984, or 6 cents per hectare of improved farmland in Canada.

The Science Council recommends that Agriculture Canada increase its soil conservation research budget to a minimum of 25 cents per hectare of improved farmland and that the allocation of person-years to soils research be tripled.

Since many agencies are involved in soil research, their efforts must be coordinated; the Canadian Agricultural Services Coordinating Committee, with its Canada Committee system, should play a dominant role in ensuring that unnecessary duplication or overlap of research effort does not occur.

The Science Council recommends that the Canadian Agricultural Services Coordinating Committee investigate soil research requirements across the country and coordinate research activities by establishing a National Conservation Agency. This Agency should cooperate closely with Agriculture Canada, Environment Canada, and their provincial counterparts, but should function independently.

For most practical purposes, the causes of soil degradation are known. Because resources are limited and not all areas can be addressed immediately, the most urgent requirement is to determine where problems are most severe and how they can be overcome.

The Science Council recommends that federal and provincial governments increase site-specific research to assess the severity of soil degradation under given physical and climatic conditions and to locate the most sensitive areas and most appropriate methods of ameliorating severe situations.

For the farmer, soil degradation increases costs and lowers productivity. At present there is inadequate appreciation of the relationship between degradative processes and costs among farm operators and extension personnel.

The Science Council recommends that federal and provincial governments undertake additional research to quantify the relationship between soil degradation and crop productivity and emphasize cost-benefit studies on specific conservation practices at the farm level.

Coordinating Policies and Programs

The development of agricultural policy in Canada has been a piecemeal affair since the inception of the country. Goals are established and discarded or superseded by other goals. In recent years, undue emphasis has been placed on supporting individual commodities, self-sufficiency, and export promotion regardless of the effect on agricultural soils. A carefully developed policy guideline on soil conservation is required. Since agriculture is the joint responsibility of federal and provincial governments, both levels of government must participate actively in the development of such a policy.

The Science Council recommends that federal and provincial departments of agriculture develop a Soil Conservation Policy for Canada that clearly delineates the respective financial and jurisdictional responsibilities of each level of government in the provision of soil conservation services and funding.

Similar policy statements have been developed in other areas, for instance in the National Wildlife Policy.

Ad hoc agricultural policy making has resulted in the establishment of many individual policies to deal with particular problems in specific areas of the country. Some of these policies impinge on agricultural development in other regions, or militate against the adoption of conservation farming practices.

The Science Council recommends that federal and provincial governments review and, where appropriate, modify all policies that affect the adoption of soil conservation practices. Federal and provincial governments should also develop suitable transportation and marketing programs for soil-building rotation crops; these programs should be in accordance with a National Soils Policy and should complement other conservation policies and programs.

Financial Assistance to Farmers

The initial cost of soil conservation is often high, and continuing conservation efforts, such as expanded crop rotations, may be prohibitively expensive in today's agricultural market.

The Science Council recommends that federal and provincial governments provide limited financial assistance to farmers to defray the costs associated with the initial production of rotation crops and the implementation of other conservation measures.

Public Education and Awareness

Since soil degradation is a long-term phenomenon, its consequences are not obvious to the general public. To secure the sizable financial commitments necessary to combat this problem, the public must be made aware of the importance of high-quality agricultural soils to the Canadian economy.

A coordinated and continuous campaign to educate Canadians about the problem should begin in the schools, and continue in the media and in local demonstrations and activities.

The Science Council recommends that federal and provincial governments take appropriate steps to ensure that all young Canadians are exposed to conservation education and environmental studies, and develop a public awareness campaign on soil degradation and the critical importance of conservation agriculture to Canada.

One way to focus this initiative would be to formally establish a high-profile national Soil Conservation Week.

Appendix

Table 1. Professional Person-Years Allocated to Soil Degradation Research*

	Western Canada	Canada
Soil Quality	5.83	13.45
Erosion	0.53	5.21
Salinity	3.22	3.22
Drainage	0.43	1.36
Total Soil Degradation Research	10.01	23.24
Total Soils Research	60.79	198.81
Total Agricultural Research	673.40	2031.30

* Includes federal and provincial government researchers and university researchers.

Source: Canadian Agricultural Research Council, Inventory of Canadian Agri-food Research (database), 1984.

Table 2. The Impact of Soil Degradation: Regional Variations on Costs of Soil Degradation in Dollars per Hectare and as Percentages of Other Farm Costs and Income.

	Annual Soil Degradation Costs Expressed as:				
	$ per Hectare of Farmland	% of Net Income	% of Operating Costs	% of Agricul-tural Chemicals	% of Carrying Charges on Long-term Liabilities*
B.C.	21.9	33.6	6.7	130.0	44.5
Prairies	19.2	79.0	16.7	106.0	122.5
Central	25.5	18.1	4.6	48.2	43.7
Atlantic	15.3	17.3	5.0	44.9	66.2

*Assumes 12% annual carrying charge.

Source: Agriculture Canada, *Handbook of Selected Agricultural Statistics, 1984* (Ottawa: Supply and Services Canada, 1984).

Table 3. Farmland and Improved Farmland Supply in Canada (Thousands of Hectares)

	Total Farmland [1]	Total Improved Farmland [2]	Total CLI Class 1-3 [2]
British Columbia	2 179	946	950
Alberta	19 109	12 526	11 301
Saskatchewan	25 947	19 684	17 600
Manitoba	7 616	5 504	5 301
Ontario	6 039	4 519	7 888
Quebec	3 779	2 360	2 371
New Brunswick	438	192	1 516
Nova Scotia	466	178	1 234
Prince Edward Island	283	203	418
Newfoundland	33	10	5
Canada	65 889	46 122	48 584

*Canada Land Inventory

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Notes

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14. Agriculture Canada, *Agricultural Soil and Water Resources in Canada: Situation and Outlook,* (Ottawa: Supply and Services Canada, 1985), 6.
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16. Mehuys, op. cit., 37-39.
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26. Ibid., 210.

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