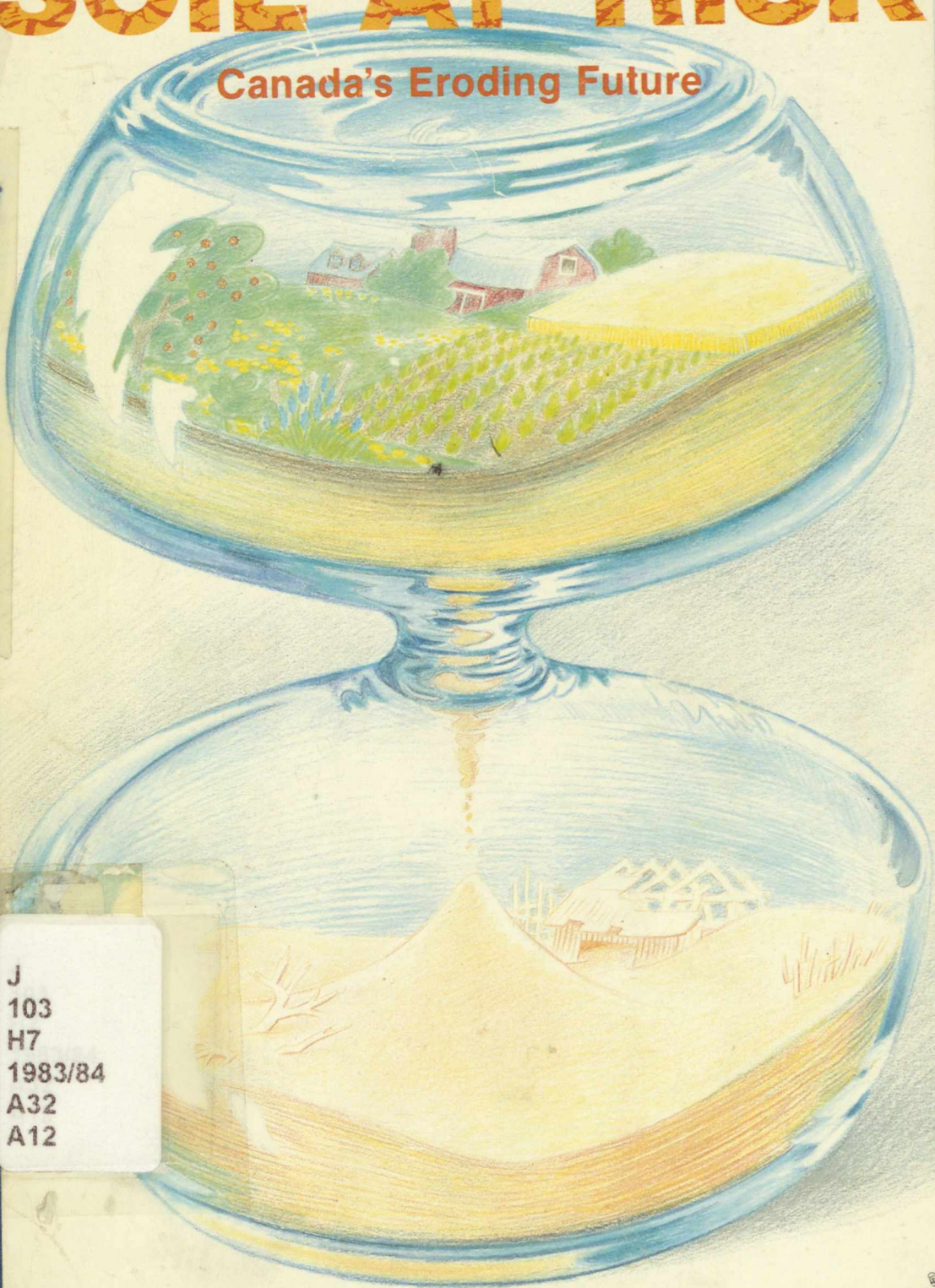
SOIL AT RISK

Canada's Eroding Future



A Report on Soil Conservation by the Standing Committee
on Agriculture, Fisheries, and Forestry, to the Senate of Canada.
Hon. H.O. Sparrow, Chairman.

Soil at Risk

Canada's Eroding Future

Additional copies of this report are available from the Clerk of the Committee at the following address:

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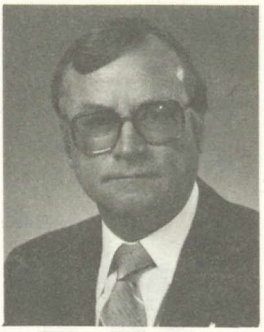
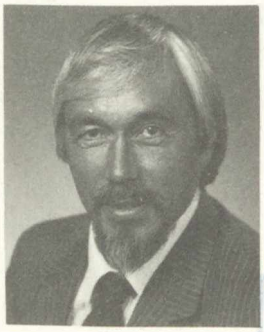
SOIL AT RISK

Canada's Eroding Future

Committee Membership



Hon. Herbert O. Sparrow
Chairman



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Hon. Martha Bielish

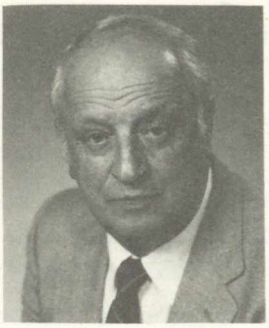
Hon. Lorne M. Bonnel

*Hon. Jacques Flynn

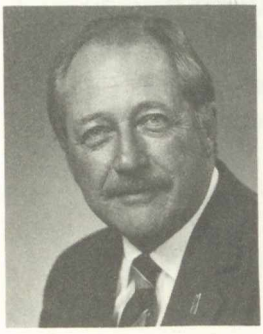
Hon. Jean LeMoyne

Hon. Fred A. McGrand

Committee Membership

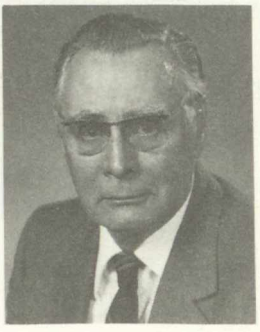


Hon. Jack Marshall
Deputy Chairman



Hon. Gildas L. Molgat

***Hon. S.A. (Bud) Olson**



Hon. Orville H. Phillips

Hon. Daniel A. Riley

Hon. Cyril B. Sherwood

Hon. David G. Steuart

***Ex Officio members**

** The following senators also served on the Committee from time to time during the examination: The Honourable Senators Margaret Anderson, Anne C. Cools, Renaude Lapointe, Fernand Leblanc, Yvette Rousseau and Paul Yuzyk.

Order of Reference

Extract from the Minutes of Proceedings of the Senate of Tuesday, February 7, 1984:

"The Honourable Senator Sparrow moved, seconded by the Honourable Senator Marshall:

That the Standing Senate Committee on Agriculture, Fisheries and Forestry be authorized to examine the subject matter of soil and water conservation throughout Canada;

That the Committee have the power to adjourn from place to place within Canada; and

That the Committee be empowered to engage the services of such counsel and technical, clerical and other personnel as may be required for the purpose of the said examination.

The question being put on the motion, it was—Resolved in the affirmative."

Charles A. Lussier
Clerk of the Senate

Preface

This report had its beginning two years ago with a ride in a small airplane over Saskatchewan. Like many farmers I knew that salinization was a problem but until that time I had not realized just how much of the productive land of our breadbasket was threatened by soil degradation.

The members of the Standing Senate Committee on Agriculture, Fisheries and Forestry agreed to investigate the problems of soil degradation and decided to hold hearings through-out the country to try to find out what was being done by farmers, by researchers and by governments.

What the Committee discovered was genuine distress at the prospect of a continuation of the status quo. It also discovered that there is, in fact, considerable work going on to conserve Canada's agricultural soils but that this work goes on in spite of, rather than because of, general economic conditions and government policies. Nevertheless, the Committee was heartened by the fact that governments are beginning to respond to the pleas and needs of those committed to conservation.

The Committee's major purpose in this report is to take the reader on the equivalent of an airplane ride over Canada to make clear what soil degradation is and how serious it is in all regions of the country. By increasing the awareness of this situation the Committee hopes to help make soil conservation a national issue. Our soils are at risk. Our future is eroding. It is time for action.

Hon. H.O. Sparrow, Chairman

June 1984

Acknowledgements

The Standing Senate Committee on Agriculture, Fisheries and Forestry would like to acknowledge the contribution of the many persons who made this report possible.

The Committee would like to thank all of those who participated in the Committee's hearings across Canada and those who took the time to write to the Committee to express their views.

The diligence of Ms. Sally Rutherford, Director of Research and of Mr. Len Christie and Mrs. Lynne Myers of the Research Branch, Library of Parliament is greatly appreciated. Mr. Denis Bouffard provided valuable assistance in his role as Clerk of the Committee. The hard work of Ms. Aileen Collins helped to bring this report into being.

The Committee is particularly grateful to Mr. D. Lobb, Mr. J. Laforge, Mr. H. Morrell, Mr. R. McNabb, Mr. C. Shelton, and Mr. R. Dionne for their aid with the farm studies.

The Committee would also like to thank Dr. T. Lien Chow, Dr. R. Coote, Dr. C. Baldwin, Mr. L. van Vliet, Dr. H. Vander Pluym, Dr. W. Pettapiece, Mr. H. Esquirol, Mr. L. Parent, Mr. C. de Kimpe and Mr. D. Sudom, among others who permitted the reproduction of photographs in the report.

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SUMMARY

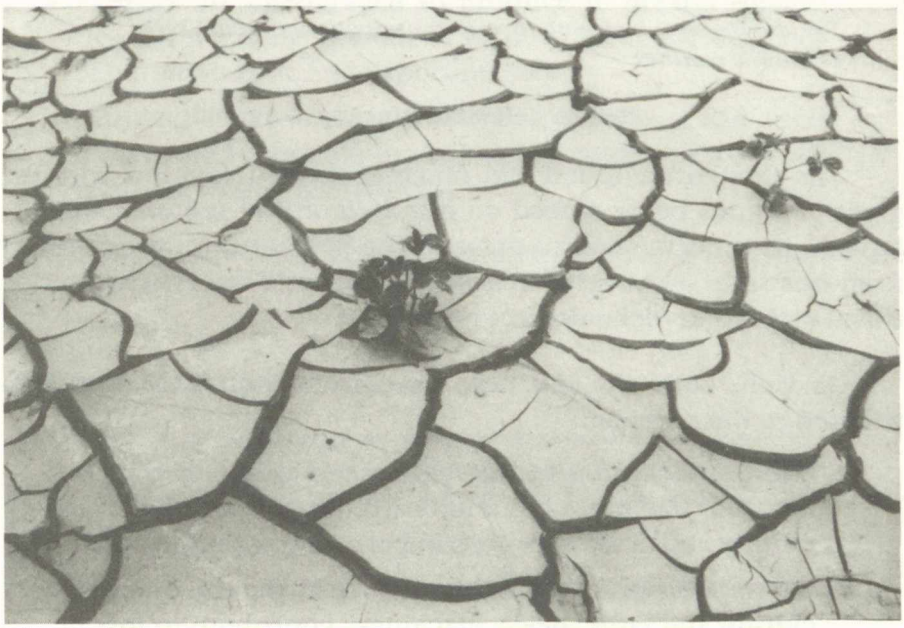
Soil erosion may well be the most underrated yet most damaging natural resource problem of the 80s. Must we wait for crisis conditions before action is taken to safeguard our scarce and dwindling soil resource base?

Soil Conservation Society of America, Ontario Chapter.

Canada is facing the most serious agricultural crisis in its history and unless action is taken quickly, this country will lose a major portion of its agricultural capability.

The Standing Senate Committee on Agriculture, Fisheries and Forestry has travelled extensively in Canada examining the issue of "soil degradation", a problem which is already costing Canadian farmers more than $1 billion per year in farm income. It has determined that we are clearly in danger of squandering the very soil resource on which our agricultural industry depends.

Based on the evidence presented to it, the Committee has made a number of recommendations designed to raise public awareness of the problem and to improve the dialogue between the public, farmers, governments and environmental experts.



Put simply, soil degradation is the depletion of the productive capability of Canada's precious soils and it is a costly problem.

- It is estimated that erosion of one inch of soil can reduce wheat yields by 1.5 to 3.4 bushels per acre.
- In Southwestern Ontario, the erosion problem has caused a loss in corn yields of some 30 to 40 per cent.
- On lands affected by salinization in the Prairies, crop yields have been reduced by 10 to 75 per cent, even though farmers have increased their use of fertilizer.

- It is estimated, at 1982 prices, that it would cost Prairie farmers $239 million in fertilizer to fully recover the present loss of grain production from wind and water erosion.
- More difficult to put a dollar figure on, but equally as serious, is the permanent loss of rich agricultural land to urban use. Between 1961 and 1976, Canada lost more than 3.5 million acres of farmland — the equivalent of the size of Prince Edward Island.

These figures do not reflect the cost of soil degradation to forest or recreational lands, or on wetlands. They also do not reflect the total cost of the problem to the Canadian economy.

Why Does Canada Have This Problem?

The dominant constraint to soil conservation is short term economic realities.

British Columbia Ministry of Agriculture.

The Committee found that much of the problem lies with the great pressures being placed on our agricultural sector. Canadian farmers have been asked to demand the last ounce of productivity from our soils — largely because of economic necessity, international prices and technological progress.

As well, both old and new agricultural practices have contributed to the problem.

- Old practices and technologies such as summerfallowing and the use of mouldboard plows contribute to salinity and erosion in certain parts of the country.
- New practices and technology, such as the use of monoculture and large, heavy machinery contribute to loss of organic matter, soil compaction and erosion.

Farmers who realize the necessity of taking conservation precautions find their implementation costly in the start-up stage. They may not be able to afford the expense of a new piece of conservation tillage equipment, or the loss of income caused by replacing a cash crop with a nitrogen-fixing rotation crop.

In these days of high costs and low commodity prices, the least expensive way to operate is often the only way a farmer can survive.

Increased Production

If the farmer is selling his product at less than the cost of production, he has no energy left to go beyond that. If we can bring about profitability in our farming operations, we can then point out to the farmer a better way of carrying on his operation.

Honourable Malcolm MacLeod, Minister of Agriculture and Rural Development, New Brunswick.

One of the main reasons our soils are rapidly being depleted is our preoccupation with increased productivity.

- The federal and provincial departments of agriculture have considered increased production a major priority, often without regard for the long-term consequences to the soil.
- Farmers are encouraged to produce in greater quantities, on the same amount of land, to meet the demands of both domestic and export markets.
- Until recently, relatively low cost fertilizer and fuels have made it possible for farmers to compensate for the resultant loss of nutrients.

Over the years this production priority has taken its toll on soil quality.

Conservation

The real progress is being made by farmers who have taken the bull by the horns, gone out and searched for information wherever they can get it ...and applied it to their own operation.

David Cressman, Ontario

In the past several years, a growing number of individuals and associations have become concerned with the serious impact of soil degradation.

Some major farm organizations have held seminars and conferences to discuss their mutual concerns and to try to find solutions to the pressing problem of soil degradation.

Farmers have formed educational and self-help groups, to provide moral support, and to exchange information. Groups such as the Warner-Dryland Salinity Control Association in Alberta, the

Manitoba-North Dakota Zero Tillage Farmers' Association, the Huron Soil and Water Conservation District in Ontario, and Soil and Crop Improvement Associations are typical of local bodies being established as farmers seek the most appropriate solutions to degradation problems.

The Role of Government

Responses to-date by government and the agricultural community have been out of scale with the magnitude and severity of the problem which only threatens to worsen before it gets better. The need is urgent for a major, well-organized and adequately funded response to soil erosion and soil degradation.

Ontario Soil and Crop Improvement Association.

In the past few years, Governments have begun to play a more active role in conservation — due in part to pressure placed on them by these interest groups.

Nonetheless, Government response in this area has not been great when one considers how little is spent on combating soil degradation in relation to overall agricultural expenditures. The Federal Government — which has always taken the major responsibility for agricultural research — has done little about the problem. Conservation-related research accounted for only 4.7 per cent of the federal agricultural research budget and for only 3.3 per cent of person-years in 1983.

In the latest round of Economic and Regional Development Agreement negotiations, both federal and provincial governments made some commitment to conservation, but their financial contributions were relatively small. With one-half of the ERDAs signed and the Agricultural Sub-Agreements completed, the Federal Government has, so far, commited only $8 million per year to conservation for the next five years.

Ignoring the Limits

This is soil that belongs to our children and its loss guarantees they cannot be as prosperous as we are regardless of all the fancy footwork of economists, tax experts, chemists and agricultural experts.

Ken Emberly, Manitoba.

Why should we be concerned about this apparent lack of commitment to soil conservation at the official level? The reason is fairly straightforward.

Although Canada is the second largest country in the world, very little of our land is suitable for agriculture.

- Almost half of our land area is totally unsuited for agricultural production because of our cold climate.
- A further 28 per cent of Canada has low temperatures and is so rocky or dry that there is virtually no potential for agriculture.
- Less than 9 per cent of Canada's land area is capable of being cultivated and of that, only about one-half is actually cropped. This 4.5 per cent, quite literally, is spread from coast to coast.
- The other 4.5 per cent is used for pasture, forests, recreational lands, transportation corridors and urban or industrial land.

There is no substitute for the agricultural land which Canada possesses, and indeed, the margin for error in trying to save the soil becomes smaller and smaller every year. We cannot ignore the limits of this vital resource.

A Canadian Perspective

There is a major difference between soil and forest and fisheries. Forests can be replanted and managed. Fisheries can be restocked. But once our soil is gone, that is the end of economic agricultural production. Our children's grand-children will not see a rejuvenation of our soils.

New Brunswick Institute of Agrologists

It is clear that soil degradation is costly not only to agricultural industries, but to the Canadian economy and our rich, full lifestyle. The facts speak for themselves.

- Agriculture is the foundation of the economies of many provinces and accounts for between 0.4 and 14 per cent of provincial incomes.
- While only 4 per cent of the population actually earn a living as "primary producers", fully one job in ten in Canada depends on agriculture or agriculture-related industries.

- Approximately 40 per cent of the nation's Gross Domestic Product is generated by the agribusiness sector.
- Agriculture is also important to Canada's balance of trade, making up a consistent 10 per cent of export earnings.

The facts and figures in this report are presented to call all Canadians to action — to show that soil degradation has become a *national* problem requiring *national* attention.

Soil degradation is more than a spectacular dust storm on the Prairies or a land use battle over the Niagara Escarpment or the Fraser Valley. It is a serious, ongoing problem in all regions of Canada. It is a multi-faceted problem which cannot be dealt with inexpensively or easily.

To actively conserve the soil requires a major commitment by all Governments, farmers and scientists. It also requires a commitment to action from all Canadians — coast to coast.

2

CONCLUSIONS AND RECOMMENDATIONS

We cannot afford the luxury of waiting for a crisis to make the effects of the loss of agricultural land apparent to everyone, for by then it will be too late.

Manitoba Conservation Districts Association.

Conclusions

Having heard and carefully considered the testimony of the witnesses who appeared before it, the Committee concludes that:

1. Soil degradation is a serious problem in *all* regions of Canada.
2. There is insufficient awareness of the existence and the severity of the problem within all sectors of society.
3. Because there is insufficient awareness of soil degradation, the solution of the problem has not been a priority.
4. Canada risks permanently losing a large portion of its agricultural capability if a major commitment to conserving the soil is not made immediately by all levels of government and by all Canadians.

Therefore, the Committee further concludes that:

5. Soil conservation cannot be dealt with in isolation from related issues such as water quality, land use, wildlife management, fisheries and forestry.
6. Because of the complexity of the issue and the ramifications that policies set at all levels of government have on soil conservation, a valid conservation effort demands policy and program coordination.
7. Existing policies, not necessarily directed at soils, can have the effect of discouraging good soil management.
8. There is a need for further basic research on the causes and effects of soil degradation.
9. There is also an overwhelming need for practical, on-the-ground research to determine (a) the costs of degradation to the farmer and (b) the costs and the benefits of the use of conservation practices on the farm.
10. While there is a great deal of information available about soil conservation, the transfer of this information and the accompanying technology to the farmer is the key to a successful conservation effort.
11. The practical technical information and expertise necessary to adapt conservation practices to individual farms is often unavailable to farmers because existing agricultural exten-

sion officers are overburdened, and soil management technicians are few and far between.

12. Farmers are often not able to underwrite the initial costs of some conservation practices without financial incentives or tax concessions.

13. Canadians must become aware that soil degradation has a major environmental impact, a potentially serious impact on consumers and an equally serious impact on the national economy.

Recommendations

Having reached the above conclusions, the Committee has determined that it is time for action. Therefore:

To establish a national commitment the Committee recommends:

1. That, because of its serious economic implications, the matter of soil degradation be added to the agenda of the next meeting of First Ministers, including Territorial government leaders, to demonstrate to the Canadian public the gravity with which all governments view the situation, to consider the recommendations of this report and to take action to implement them.
2. That a comprehensive federal soil and water conservation policy for Canada be developed and adopted immediately. It must (a) clearly state the Federal Government's intention to make soil conservation a priority in the development of all of its policies, programs or projects; and (b) require all departments to coordinate their efforts to make the most efficient use of resources and information.
3. That provincial governments also develop comprehensive soil and water conservation policies.

To begin to resolve policy conflicts, the Committee recommends:

4. That the Canadian Wheat Board modify the quota system to extend (a) full quota entitlement, at the "bonused" level of seeded acreage, to those remnant farmlands considered of marginal value for agriculture; and (b) partial quota entitlement, equivalent to current quota levels for summerfallow,

to extensive tracts of unimproved pastureland which form intergral parts of farm units.

5. That provincial governments strengthen and more conscientiously enforce their land use legislation to preserve agricultural lands.

To intensify conservation research the Committee recommends:

6. That the Federal Government establish Soil and Water Conservation Institutes in Western, Central and Eastern Canada for the purpose of carrying out applied research.
7. That the Federal Government provide greater funding for soil conservation research through the Natural Sciences and Engineering Research Council's Strategic Grants Program for Agriculture.
8. That the Federal Government use the Special Fund for Centres of Specialization Program in the Secretary of State as a model for a ten year program to develop regional centres of specialization in soil and water conservation at universities across the country.

To facilitate the transfer of technology the Committee recommends:

9. That the Prairie Farm Rehabilitation Administration (P.F.R.A.) extend its activity into British Columbia, particularly the Peace River District.
10. That all Federal lands, especially Agriculture Canada Experimental Farms and Research Stations, be developed and managed according to good conservation practices and become conservation showcases for the nation.
11. That agricultural and technical colleges increase their training of agricultural technologists to work in the field providing assistance to the individual farmer, thus providing an important link in the transfer of conservation technology.
12. That the Skills Growth Fund of the Department of Employment and Immigration, be modified to include agricultural land-based occupations, specifically the training of soil conservation technicians.
13. That all provincial governments adopt legislation encouraging the establishment of conservation districts or authorities such as those which exist in Manitoba and Ontario.

To provide a more favourable fiscal climate the Committee recommends:

14. That financial incentives be provided to farmers through federal-provincial agreements, appropriate to local needs, to help defray the costs of conservation practices.
15. That accelerated capital cost allowances be permitted on capital expenditures relating to soil conservation, such as conservation tillage equipment, grass waterways, terraces, etc.
16. That land tax assessment notices in all provinces clearly show the basis on which the land is being taxed so that the owner is aware of the worth of the productive capability of various portions of the land.

To increase awareness and to sustain a national conservation effort, the Committee recommends:

17. That the Federal Government declare a National Soil Conservation Week to ensure that soil conservation becomes, and remains, an important national issue.
18. That Provincial Governments commit themselves to the introduction of soil degradation and conservation studies at the primary and secondary school levels through the addition of environmental courses.
19. That the Federal Government sponsor a National Conference on Soil Conservation to promote awareness of soil degradation as a *national* issue and to foster coordination and cooperation amongst all of those involved.
20. That a Council on Soil and Water Conservation be established: (a) to provide a neutral forum within which the participants can discuss the issues and the actions necessary to conserve Canada's natural resources; (b) to encourage improved coordination and cooperation between the participants; (c) to review methods of dealing with the needs and demands of particular sectors; (d) to aid in the priorization of research and program demands; and, (e) to gather and disseminate information concerning conservation.

The Committee believes that if these recommendations are acted upon quickly the risk to our soils and to our future can be reduced - the time for action is now!

3

SOIL DEGRADATION: ISSUES AND ANSWERS

Civilization as we know it cannot survive the continuing loss of topsoil at current rates.

L.J.P. van Vliet, British Columbia.
(quoting Lester Brown, World Watch Institute).

As the Committee travelled across the country, it was told again and again that serious soil degradation problems exist in Canada. The problems differ in type and severity from region to region, but the message everywhere was the same.

- The productive capacity of our soil is deteriorating.
- The situation can be reversed, but it will take a major effort on the part of all Canadians.

There has been a lack of data in some regions which would help to quantify the extent of the problem. Reasonable estimates have been made in parts of Ontario and on the Prairies but not elsewhere. These estimates have, if nothing else, shown that soil problems are not isolated. They affect large areas of prime agricultural land and they must be dealt with.

The level of public awareness about the problem of soil degradation also differs from region to region. For example, the memory of the dust bowl in the Prairies has served to keep farmers and governments more atuned to the problems and the solutions than elsewhere in the country. In Quebec on the other hand, relatively good farm land and increased inputs of fertilizer have masked erosion. As a result, there is little official recognition of soil problems and little or no information to help farmers identify and deal with soil degradation. Severe degradation being experienced in New Brunswick has resulted in increased awareness of the magnitude of the problem, but this province lacks the financial means to take all of the necessary action.

To date one of the major drawbacks to soil conservation has been the emphasis on increased production. This has resulted in the creation of policies which have ignored or unintentionally worked against good soil management. Low commodity prices and high input costs have also pushed farmers to continuously increase yields — simply to remain financially afloat.

Even in provinces where soil degradation is a major concern priorities rest elsewhere. It was often pointed out that the priority in policy development and research dollars remains increased production. The Committee was told, for instance, that of the approximately 4500 projects listed on the Canadian Inventory of Agricultural Research, less than 500 touched on soils and fewer than 10 per cent of those dealt with soil conservation in 1981.

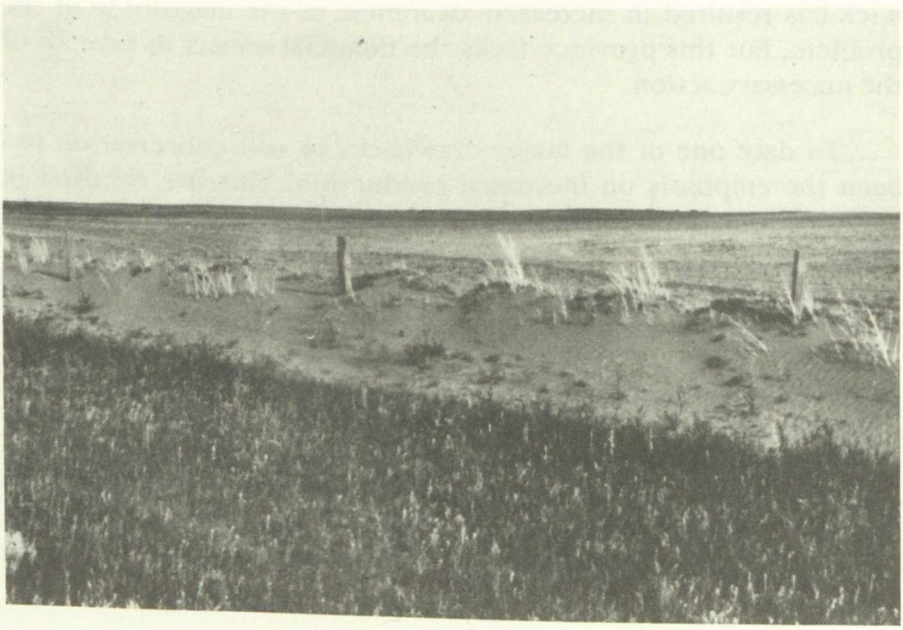
Getting it Together: The Jurisdiction Dilemma

> *...experience has been that the most successful agricultural programs have been based on federal/provincial cooperation. Less successful have been programs where the federal and provincial governments tended to run off in 11 or more directions.*
>
> **Christian Farmers Federation of Alberta.**

It was frequently pointed out that conservation is not an issue which can be addressed by only one level of government. Constitutionally, agriculture is a responsibility shared by the Federal and Provincial Governments. In addition, regional and municipal government decisions have an impact on land use.

It was suggested that all levels of government must carefully assess their policies and priorities and, most importantly, work together. Solutions and jurisdictions definitely overlap.

Overall, the Committee heard a plea — made by knowledgeable and concerned people, including farmers, scientists, extension workers and government representatives — for a serious and coordinated commitment by all participants to act *now* to conserve the basis of agricultural production in Canada.



Drifting soil piled up along a fencerow on the Prairies.

The Committee has come to believe that Canada does not have a choice as to how agriculture must develop in the 21st century. If Canada is to carry on even present levels of production after the middle of the next century, the work of conserving the soil must begin now in a serious and comprehensive manner. Whatever technological advances might be made, they cannot change the fact that soil is the basis and the constant of agricultural production.

Many witnesses were concerned with the lack of coordination — and sometimes cooperation — in the development and delivery of conservation policies, programs and services.

It was noted that coordination problems arise in part, from the fact that ministries of natural resources, environment, agriculture and fisheries, among others, with their different mandates, are all involved in the soil conservation issue since soil, water and land use are integrally entwined.

- Erosion is a major contributor to stream and river pollution.
- Salinity has a direct link to water table levels and drainage.
- The cost and suitability of land for agriculture must be examined in light of the need for recreational space and wetlands.

In Quebec, after 25 years of intensive cultivation. The organic soil is completely degraded, revealing the lighter coloured mineral soil.

Unfortunately individual departments or ministries often develop soil conservation policies or programs which duplicate those in other departments or which contradict programs developed elsewhere.

Many witnesses identified as a drawback to conservation the absence of an overall government commitment to soil conservation and the consequent lack of a comprehensive policy.

For instance, the Federal Government has a land use policy which defines land use allocation management principles and which all federal departments are asked to use as a basis for their federal-provincial agreements and environmental assessments. This land use policy is coordinated by an Interdepartmental Committee on Land. But the Committee was left with the impression that this arrangement is relatively ineffective for accomplishing the goal and has little impact on program development.

In Nova Scotia the Committee was told of a case where farms along a small river which runs into the Atlantic Ocean, suffer severely from flooding every spring. The result is severe water erosion and major crop losses. In the past, financial assistance for streambank protection was available under a federal-provincial agriculture agreement. When this agreement lapsed, it was not renewed and subsequently, the Nova Scotia Department of the Environment took over streambank management. This department, being unfamiliar with the needs of the agricultural community, did not provide the necessary assistance. Furthermore, farmers in the area now find themselves constantly at loggerheads with the Federal Department of Fisheries and Oceans, which is concerned only about protecting salmon stocks. The municipality is willing to act to aid farmers, but it has no funds of its own to commit to such a project.

The Nova Scotia problem is a good example of a serious failure on the part of two governments to approach a problem in a comprehensive manner. The result is that both fishermen and farmers may suffer.

The testimony was not all discouraging. The Committee was told that in Western Canada, the provinces have a good working relationship with the Prairie Farm Rehabilitation Administration — despite the fact that the PFRA duplicates some provincial services.

This 50-year-old federal body has been active in soil conservation since the 1930s and has recently become Agriculture Canada's leading conservation agency.

Witnesses were very pragmatic in their approaches to program delivery, suggesting that the agencies which are already in place should be used to provide the infrastructure to deliver the services. There was a clear desire to overcome interdepartmental and interjurisdictional squabbles and to get on with the job at hand. A number of witnesses suggested that a lead agency is needed to develop priorities and to coordinate program development, implementation and research.

From the farmers' point of view, it is not so important who delivers the information and programs, but that it be done effectively. Nearly all conservation work must be done at the farm level, given the very local nature of soil degradation problems. In some provinces, like Nova Scotia and Prince Edward Island, the central agency could be the Department of Agriculture Extension Branch. In other provinces, such as Ontario or Manitoba, it might be the Conservation Authorities or Districts. In Saskatchewan and Alberta, it could be a combination of the Extension Branches and the federal Prairie Farm Rehabilitation Administration.

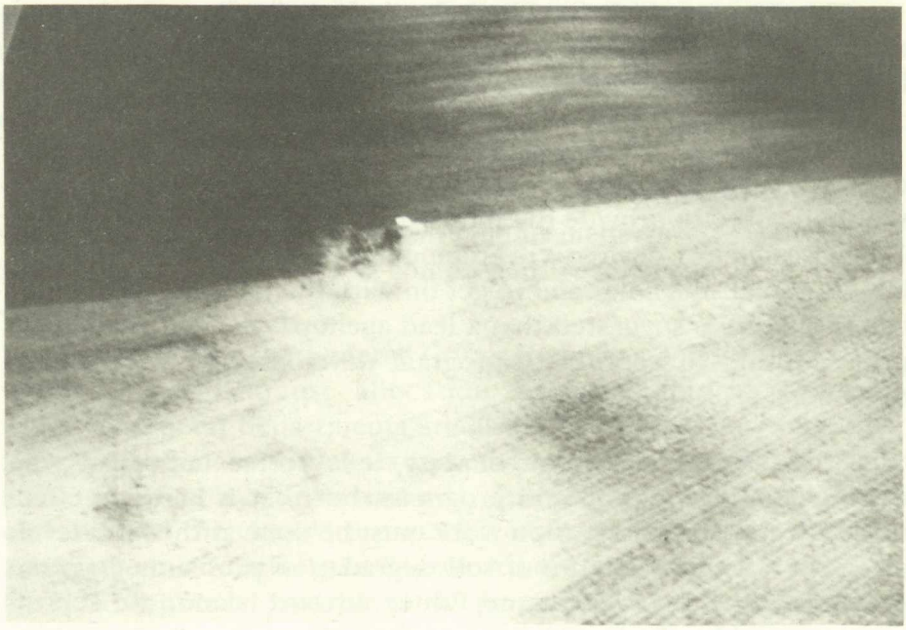
The establishment of an independent Council on Soil and Water Conservation, with membership to include all parties with a stake in soil conservation, could provide a neutral forum in which such jurisdictional problems could be discussed.

Disincentive Programs: Conflicting Government Policies

> *There must be an awareness that policies and programs initiated with the best intentions can inadvertantly lead to serious side effects.*
>
> **Dr. C.M. Williams, Saskatchewan.**

Governments develop policies and programs to accomplish certain goals. Sometimes these policies and programs have unforseen consequences, in areas far removed from their intended targets.

Witnesses gave a number of specific examples of policies which — intentionally or not — act as a disincentive to conservation.



Working across the field, a farmer plows under the white salt-affected soil.

In Western Canada, the Canadian Wheat Board quotas are seen as a deterrent to conservation. Quotas, which were established as a method of providing equitable distribution of available grain sales among producers, are based on the number of acres worked by the producer as opposed to the number actually seeded to eligible crops.

Because it is more economical to produce to the limit on some fields and save the cost of seed and inputs on others, many farmers have seen fit to work the land and then to let it lie fallow. While this practice was seen to be the best way to conserve moisture in fields and to control weeds, it has been proven in the last fifteen years that, except in a few areas of the Prairies, summerfallowing is more detrimental than beneficial.

In the past couple of years, the Canadian Wheat Board has modified its system to try to decrease summerfallow and provide a "productivity factor". Concern was expressed to the Committee that this "bonus acreage system" would encourage farmers to break marginal land to take advantage of the additional amounts they could then deliver to the elevator.

Witnesses also cited two government policies which they believe work to discourage soil conservation. The Western Grain

Severe water erosion on a sloping field of strawberries.

Transportation Act (WGTA), which affects export grain produced on the Prairies, and the Feed Freight Assistance Program (FFAP), which affects farmers in Eastern Canada and British Columbia, have opposite effects but the same impact.

By subsidizing the transportation of Western grain for export, the WGTA discourages the production of livestock in the West, thus preventing the development of a market for rotation crops of forages and/or grains other than wheat.

By subsidizing the transportation of feed grain into Eastern Canada, the FFAP makes indigenous production of feed grain uneconomical and thus forces farmers into producing a limited number of crops, or using rotation crops that have little economic value.

Witnesses cited a number of other examples of government policies which discourage conservation. These include:

- policies which encourage the draining of wetlands and sloughs to create marginal cropland;
- economic policies which force farmers to intensively cultivate marginal land for the cash it will return; and,

- tax assessment notices which do not differentiate between productive and non-productive land. The Committee was told that non-productive land would more likely be left intact if its true taxable value was known to farmers.

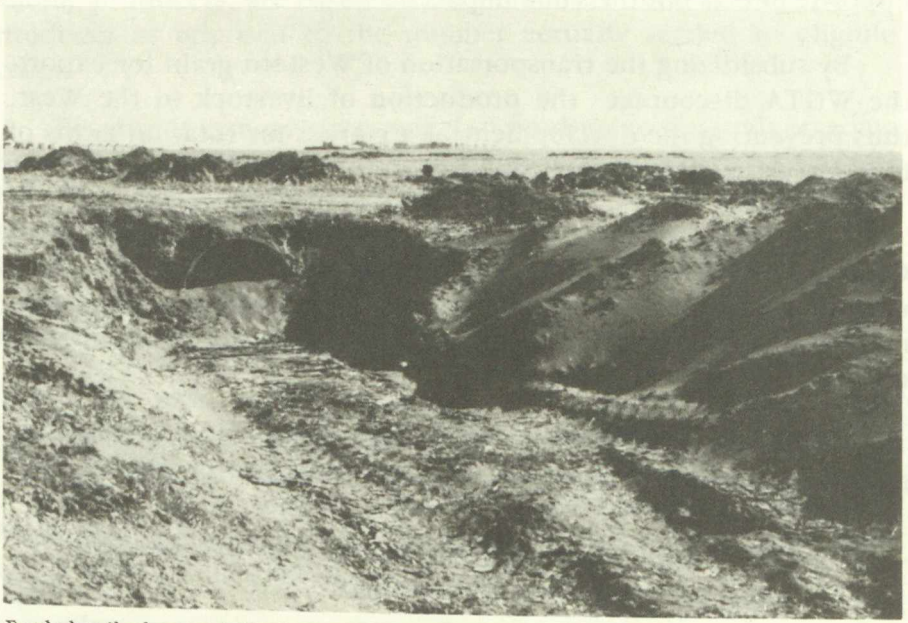
It was also suggested that wasteland or land not suitable for agricultural production be assessed at zero-value and appear as such on tax notices.

Many witnesses requested that Governments make an effort to examine their own policies in light of their potential adverse effects on soil conservation efforts and in light of policies emanating from other levels of Government.

Missing Pieces: Research Needs

> *In order to bring about the required changes in information, attitude and practice, it will require a quantum leap in the attention being paid to research and extension activities.*
>
> **Saskatchewan Institute of Agrologists**

Soil conservation research does not appear to be a high priority for any Government. As already noted, of all the agricultural research now being done by governments, universities and col-



Eroded soil plugs a drain. It is expensive to clear as well as being a waste of a natural resource.

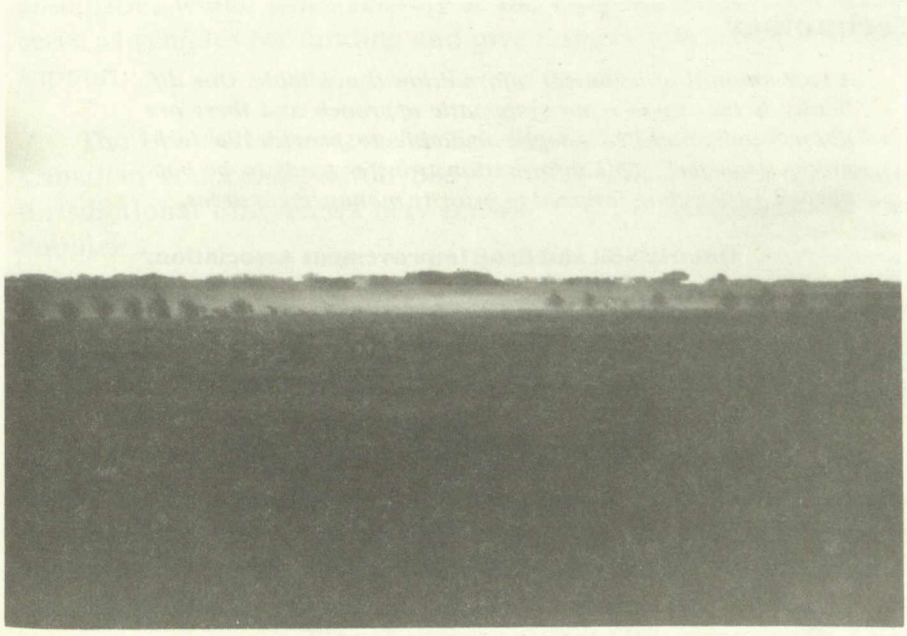
leges, and in the private sector only 50 research projects directly concern soil conservation.

Witness after witness expressed the need for applied research concerning conservation practices. There seemed to be a consensus that while more basic research was necessary, there was certainly enough information to start using it at the farm level. What is lacking is a body of information concerning efficiency, cost effectiveness and the applicability of some basic practices.

There is also a desire for research at the individual farm level to demonstrate the impact of certain conservation technologies. In this period of low commodity prices, farmers are unlikely to undertake conservation measures which are untried and potentially unprofitable.

Specific recommendations were made, regarding research, which have economic implications. These included:

- a need for increased research on varieties to be grown as rotation crops, with the development of winter-hardy cereals topping the list;
- a need for further research on herbicides (i.e. developing herbicides for specific uses, determining their effect on wildlife, people and water sources, and identifying the residues they leave behind); and,



A dust storm in Saskatchewan.

- a need for research into economic alternatives to chemical weed and pest control.

Most witnesses agreed that the Federal Government should continue its traditional role of funding and conducting basic research. They also recommended that the level of research be increased.

The Committee, for instance, was told that funding of agricultural engineering research, through the Natural Sciences and Engineering Research Council (NSERC), a federally supported funding agency, was well below that of chemical engineering research.

More private sector research and on-farm research conducted by farmers themselves, were mentioned as potentially useful sources of data. The joint University of Saskatchewan and Saskatchewan Agriculture FarmLab Program and the Prince Edward Island Plot Trial Program were cited as good examples of the type and quality of program required.

In all regions, there were requests for the development of centres of expertise and research, specifically for soil conservation, which could serve as resource centres for each area.

Down to Earth: The Transfer of Conservation Technology

> *A vast amount of technical information is available. One difficulty is that there is no systematic approach and there are not enough qualified people available to provide "a technology transfer". This information transfer tends to be haphazard, rather than targeted to priority management areas.*
>
> **Ontario Soil and Crop Improvement Association.**

While basic research is an important element in soil conservation, witnesses also cited a need for its practical application at the farm level.

The Committee was told that conservation requires a different approach on every farm. Individual farmers would be more likely to engage in new practices if they had, or had access to, the right information and technical expertise. But without the qualified personnel to help the farmer overcome the transition from traditional (and often successful) farming methods to conservation practices, the movement to conservation would be much slower.

There was a call for an increase in the number of extension personnel whose job it would be to deal with conservation, as opposed to crop production. Two presentations were made to the Committee in different parts of the country, specifically on this topic. The witnesses expressed the same basic point - that the present rate of funding for training of agricultural personnel is insufficient to meet today's needs.

The Committee was told that Federal Government technical training programs, such as the Skills Growth Fund, ignore all aspects of agricultural studies, and do so to the country's detriment. If the Government commited greater funding in this area, trained technicians could undertake much of the needed survey work which would determine the extent and severity of soil degradation. These technicians could also work with farmers to develop the individual farm plans necessary to the implementation of conservation practices.

Many witnesses considered that the best way to ensure conservation in Canada would be to set up a system parallel to the American conservation districts system. These districts are formed within each state, but exchange information and expertise through a national association.

Manitoba and Ontario have a number of similar districts or authorities which work actively at the farm and watershed levels, serve as vehicles for funding and give farmers moral and technical support.

The U.S. Soil Conservation Service was cited as a model for a Canadian soil conservation body, taking into account the major jurisdictional differences between the federal systems of the two countries.

It was suggested that having such a vehicle to provide funding for the specific purpose of conservation would be a major step forward from the present state of conservation programming.

Dollars and Sense: The Economics of Soil Conservation

> *Because of economic considerations—namely, poor returns, volatile prices, rising input costs, and generally a lack of economic stability, farmers have not been able to practice what they know they should.*
>
> **New Brunswick Federation of Agriculture.**

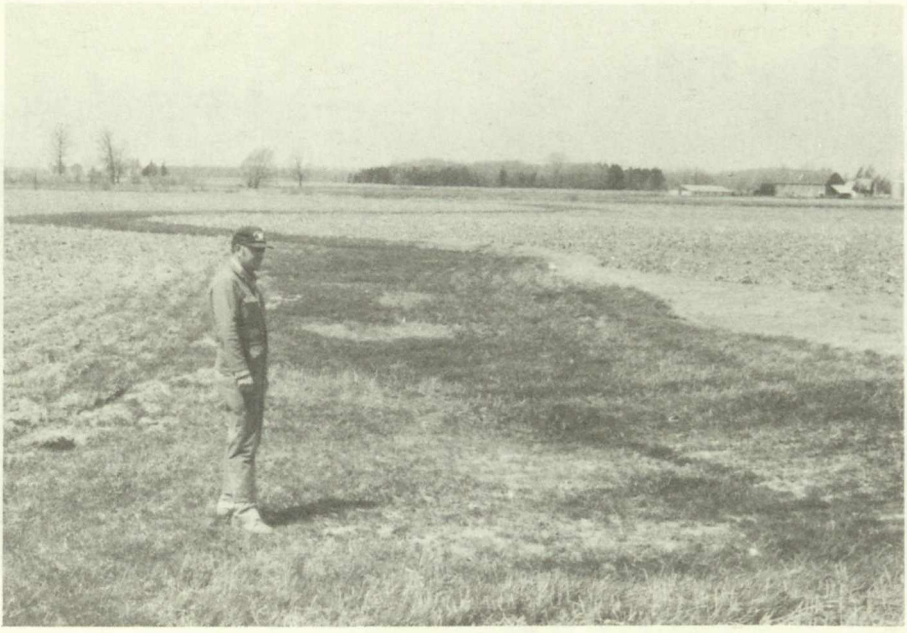
Uncontrolled soil erosion... an unnecessary loss!

Canadian farmers are being pushed and pulled in many directions. They all face increased input costs and high interest rates on the purchase of machinery and land, while some also see their equity falling. Thus, there is often not enough money to invest in new technology. The Committee was told that farmers do not intentionally want to hurt the soil. But the farmer must be able to provide for his family and to meet the cost of his overhead. In today's economic environment there is no room for risk.

Witnesses stated that while some practices can be implemented at a minor cost to the farmer, many others are expensive, at least in the start-up stages. The purchase of conservation tillage equipment, the construction of grass waterways or terraces, or the installation of major drainage works can be prohibitively expensive for some producers - although they may pay off in increased yields in years to come.

Because the effects of soil degradation are not easily apparent in the short term, farmers have no direct incentive to change their operations and to commit the necessary capital to adopt soil conservation practices.

Commited conservationists likened the present situation to one of "deferred maintenance" of physical plant in industry. This strategy can work in the short term to keep costs down. However,



Runoff can be safely channelled over a grass waterway.

in the long term it can cost dearly. Farmers trying to work with saline patches in the Prairies or with potato fields eroded to bedrock in New Brunswick, or farmers faced with 10 foot gullies in British Columbia or Ontario know this already.

The reality is that conservation is not cheap, nor is it a short term undertaking. Farmers are concerned about the fact that, while the costs are considerable and immediate, the financial benefits of conservation might not accrue for a number of years.

The Committee was told repeatedly that in order to convince the majority of farmers to use conservation practices, means must be found to make more funds available to allow them undertake the necessary work. A number of suggestions were made to the Committee concerning how best to financially aid the adoption of conservation measures. The Committee was cautioned, though, that these measures will not work, unless a number of conditions are met:

- producers must see programs as being fair and acceptable;
- programs must not be restrictive (although some witnesses believe that legislation might be necessary should farmers fail to act voluntarily); and,
- long-term effects of programs must be understood.

It began with a raindrop...

Witnesses mentioned a number of incentives which could convince farmers to adopt conservation measures.

It was thought that research on new, marketable rotation crops and the development of cash markets for such crops would provide long-term economic incentives.

In the short term, tax credits were the most popular type of incentive proposed. Such a tax credit could be applied to:

- conservation tillage machinery;
- the preservation of wetlands;
- the purchase of fertilizers and herbicides; and,
- investment in agricultural research.

It was pointed out that the drawback to such an incentive program is that it would benefit only those with taxable income.

Cost-sharing programs appeared to be more promising, but they would also have a drawback in that farmers would have to be able to afford their share of the cost.

There was a general feeling that additional Federal funding should be directed through the Provincial Governments to on-farm programs. This could be facilitated if the Federal Government would provide funding to the provinces through federal-provincial agreements specifically for conservation.

...and grew and grew.

The Committee has concluded that capital equipment and works relating to soil conservation should be made eligible for capital cost allowances. Beyond this measure, the Committee believes that further specific financial assistance measures require more careful study before being implemented. We would not like to see hastily devised programs fall into the category of "conflicting policies" or "disincentive programs" such as those mentioned above.

Financial assistance of the sort outlined above is not the only method of making money available for conservation. Many witnesses mentioned that the low price that farmers receive for their produce, relative to their costs, leaves too little cash in their hands to allow them to undertake needed conservation measures. They cited Canada's "cheap food policy" as a major roadblock to their use of conservation practices.

The Need to Know: The Issue of Public Awareness

> *In the summer after a heavy rainfall, we have tourists asking us why the river is chocolate-coloured. to which we reply that it is our soils that are being washed down the river... There is a tremendous lack of education in the minds of the public insofar as erosion is concerned. They do not realize that they are seeing their next 30 to 40 years' food supply passing in front of them.*
>
> **Jacques Laforge, New Brunswick.**

The bottom line according to witnesses, was the need to increase the level of awareness about soil conservation in Canadian society.

All sectors of society must understand the issues and be prepared to make a commitment to overcome soil degradation. These include:

- policy makers who must be sufficiently aware to develop the programs and to provide the necessary funds;
- the Canadian public which must be aware enough to grasp the issues and support such action on the part of government; and,
- farmers who must be informed, in order to be able to recognize their particular problems, to take advantage of services offered and to demand the services required.

It was in the area of developing awareness that testimony was most imaginative. Suggestions included:

- environmental studies as part of school curricula from primary grades upwards;
- proclaiming a National Soil Conservation Week; and,
- running 30 second conservation advertisements instead of beer commercials during hockey games.

Many witnesses believe that conservation is an issue for society as a whole since the supply of food at a reasonable cost depends on the conservation of our soil resource.

One of the main problems concerning conservation awareness is that the farming population is declining in number and society at large is becoming further removed from contact with the farms which sustain them. The result is the farming population's difficulty in affecting policy. Because the farm sector's dependence on the non-farm population for support will continue to increase over time, it is imperative that the non-farm population become sensitive to the soil conservation issue, as well as other farm issues.

The Committee heard many times that bringing policy makers, the research community, the public and farmers together would be an important step towards developing a conservation ethic. The Western Provinces' Conference on Soils, where participants from all sectors are able to meet and exchange ideas freely during two or

In his lifetime, onions and other vegetables will cease to grow on this marshland soil if steps aren't taken to control drainage and cultivation.

three days of seminars and presentations, could serve as a model for a National Conference on Soil Conservation.

It was thought that such a National Conference could provide a forum to meet the following objectives:

- the exchange of information about government programs;
- the success and failure of techniques and technology;
- discussion of new approaches; and,
- the development of the awareness that soil degradation is a serious national problem, requiring national attention.

Having earnestly considered the messages presented in writing and in person, the Committee believes that despite all of the problems and frustrations, there are many dedicated people already engaged in and promoting conservation. The problem is that these people are working to do a job that requires the commitment of all Canadians. The Committee hopes that by bringing the nature and extent of the problem into the spotlight, it will encourage those who have the responsibility to heed its call to action.

4

REGIONAL PERSPECTIVES ON SOIL DEGRADATION

As we travel across the country, we are discovering that soil degradation is a **very** *serious problem in all regions of Canada. Concern is being voiced by agriculturalists and provincial and federal governments, and to some degree the general populace, but there is still insufficient awareness of the problems and a need for a great deal more work to be done.*

Senator H.O. Sparrow, Chairman, Standing Senate Committee on Agriculture, Fisheries and Forestry.

REGIONAL PERSPECTIVES ON SOIL DEGRADATION

British Columbia

The physiography of the province, coupled with the variations in the climate, bestow upon British Columbia virtually all of the soil degradation problems found in the rest of the country, and a few more besides. The province has a very small agricultural land base to begin with, only 4% of the land having the combination of soils and climate which allows the production of agricultural crops. The prime land for production tends to be in the valleys and there is a great deal of competition for the land between the urban, agricultural and forestry sectors for its use. This competition, in fact, was so serious that, in 1973, it led to the passage of provincial legislation — the Agricultural Land Commission Act — designed to minimize the alienation of agricultural land. This was an important step since, before its passage, alienation of agricultural land for urban, industrial or residential use, was the dominant form of land degradation in the province. Unfortunately, the Act has fallen into disuse and the Committee would like to see stricter enforcement of its provisions.

On the land that is used for agriculture and for forestry, the major soil degradation problem is water erosion. Water management problems range from having insufficient water for irrigation, as in southeastern Vancouver Island, to having an excess supply in areas such as the Lower Fraser Valley.

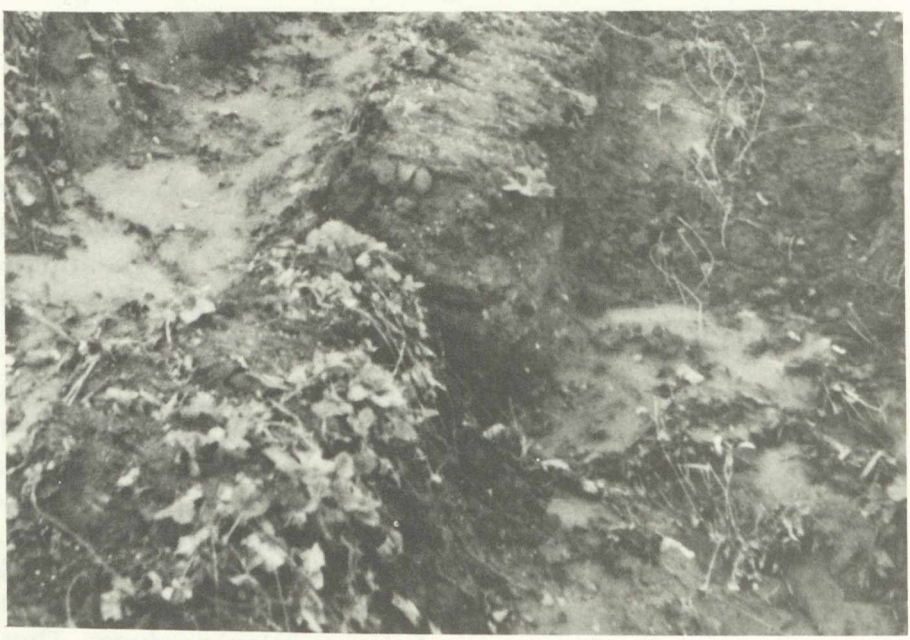
The overall level of organic matter in many areas of the province is thought to be on the decline and this brings with it problems of declining soil water-holding capacity and fertility. Many of the agricultural soils of British Columbia are naturally acidic, and the extensive use of commercial fertilizer has added, and continues to add, to this natural acidity. Soil compaction from land worked while too wet is another increasingly serious problem.

Why does British Columbia have these soil problems? In many areas of the province, the competition over land use pushes land costs up. As a result, landholdings tend to be small. This fact, plus the need for relatively stable incomes has pushed farmers to concentrate on one type of enterprise and to produce, year after year, crops which can provide a cash return (monoculture). Poultry and hog producers, for example, usually have small landholdings, often too small to handle the manure their operation produces. Thus manure, which is a good organic matter-builder in soils, is applied in excessive amounts on small holdings, which may result in excess

nitrate leaching into groundwaters. The fact that these ground waters are often used as potable sources is also a concern.

As noted, many areas of the province have gone to monoculture: raspberries and strawberries, corn, vegetables, orchards, canola, and so on. Producing the same crops year after year reduces the productivity of the soil. These specialized farms are typically situated away from the intensive animal production units and so often can not benefit from the manure produced by the latter. There appear to be fewer soil conservation problems on diversified farms such as dairy farms, where the applications of manure help preserve soil organic matter, and the forage crops protect the soil from water erosion.

With increased cultivation on intensively farmed land, native organic matter in soils declines over time. As mentioned above, in the case of monoculture, economic considerations are paramount in promoting certain practices which result in destruction of soil quality. For example, in the Lower Fraser Valley, a few days head start in the spring may give a farmer an economic advantage in harvesting his crop before the market is flooded by imports. That this practice also leads to serious compaction of the soil is a direct result of economic necessity.



Strawberries planted up and down the slope...

Not only agriculture, but forestry activities as well, are contributing to soil degradation in the province. The mass wasting and slumping that is occurring from forestry developments is a result of the forest industry being forced to harvest in steeper terrain. This is due to loss of forestland to other uses, because the valley bottoms have already been logged and because of the rapid expansion of forest harvests of virgin timber, without careful restocking and silvicultural treatments. There is also concern about nutrient losses in forestlands, the result of slash burning and removal of successive crops.

Agriculture in British Columbia is as diverse as any province of Canada; grain, canola, tree fruits, berries, grapes, 22 different vegetable crops and forage for seed and feed, are all grown in this province. With such a variety of agricultural practices, it is not enough perhaps to discuss soil degradation on a province-wide scale as we have just done. Let us take a brief look at each of the major agricultural areas separately, to identify the major types of soil degradation on agricultural land and their causes.

The Lower Fraser Valley is the major agricultural region within the province, being responsible for 50% of total provincial gross farm income. It is a favoured region in terms of climate, allowing a

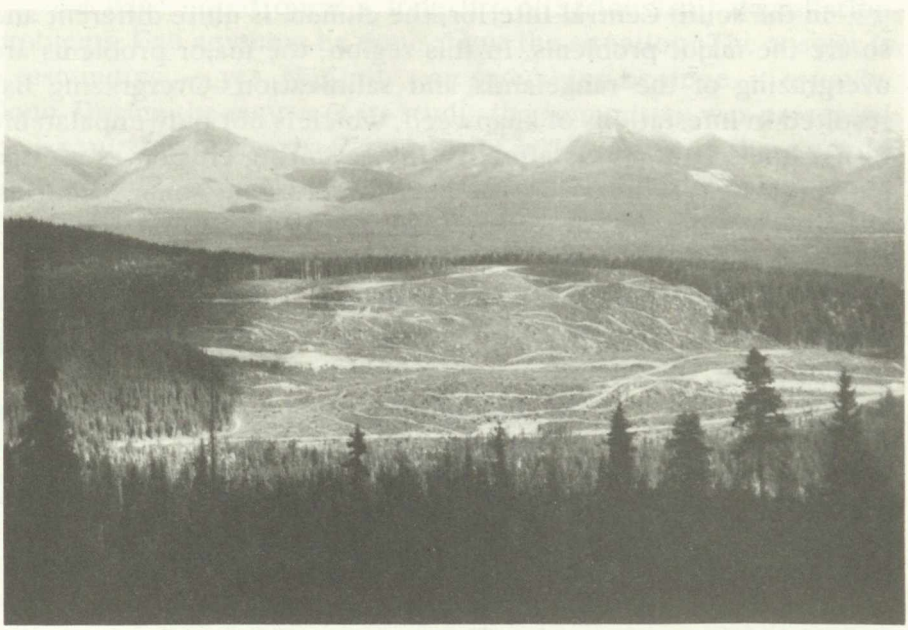
...expose land to water erosion.

Uncontrolled water erosion cuts a channel in a sloping field in the Fraser Valley.

wide variety of crops to be grown. It has been estimated that there are over 100 crops or cropping sequences used in B.C., and the majority are found in this region. What, then, are the natural conditions and the farming practices which are resulting in soil degradation in this area?

The area of agricultural land is small and so it is farmed very intensively. As already noted, to compete with American produce coming in from the south, farmers in this region try to get onto the land very early in the season. This often means that the land is worked when it is too wet and soil compaction and degradation of soil structure occur. Wind erosion can sometimes result, even in this wet area, if soils are left in a compacted condition.

Water erosion, the most serious form of erosion in British Columbia, is particularly severe in the Lower Fraser Valley due to the fact that many wide-row crops such as corn, potatoes and raspberries are grown in this region. After these crops are harvested, the soil is often left unprotected through the heavy rains of fall and winter. Unlike most other agricultural areas of Canada, the soil here does not freeze during the winter and so the effects of water erosion are often quite severe. Fall cover crops, contour ploughing, crop rotations and variations of conservation tillage may all hold promise in reducing the degree of water erosion.



Clear-cutting without quick protection from natural vegetation or seeded grass exposes the land to soil erosion.

The problem of excess water in this part of the province is made worse by urban encroachment. The area has a high rainfall, and the surrounding agricultural areas have to deal with the increased runoff from paved-over urban developments. Witnesses told the Committee that, although a good attempt to solve the problem has been made through Federal-Provincial agreements (under the Agriculture and Rural Development Act), "the problem is larger than the drainage works put in place." Clearly further efforts in the area of drainage programs could help reduce water erosion in this region.

Turning our attention to an important fruit growing area of the province, the Okanagan, we see another type of problem. The conflict over land used for agriculture, urban development, recreation and forestry is also very evident here. The pressure for different land uses has resulted in small holdings for agriculture, and so these areas are very intensively managed. Orchards are heavily fertilized and irrigated as are other forms of agricultural activity within this area. This intensive management has resulted in serious soil acidification and some water erosion. The acidification is so serious in some areas of the Okanagan that surface soil pH has been seen to drop from 6.5 to as low as 3.5, which is too acidic for the production of many crops.

In the south Central Interior, the climate is quite different and so are the major problems. In this region, the major problems are overgrazing of the rangelands and salinization. Overgrazing has resulted in infestations of knapweed, which is not only unpalatable to livestock, it is not as effective in preventing erosion as are the native grasses. Salinization has been observed in some localities, although it is not as serious a problem as it is on the Prairies.

In the more northern Central Interior, the soils are clayey in texture and are inherently low in organic matter content. During land clearing, the organic matter at the surface may be burned and the organic matter in the mineral soil may become buried during the clearing procedure. Since the soils are clayey in texture, they are prone to water erosion. In addition, the rapid melting of snow that often occurs in the spring produces abundant water for this erosion to take place. The use of more winter cover crops could help reduce this type of erosion.

The Peace River region of British Columbia is a growing agricultural frontier and it has soil degradation problems more closely related to Alberta's Peace River area than to other parts of British Columbia. In the Peace River District, the combination of long slopes, summerfallow, high snowfall and rapid spring runoff, and sudden, intense summer storms adds up to a high risk of water erosion. In addition, the presence of natural hardpans, soil compaction by heavy equipment and the heavy clay subsoil makes some soils so impermeable that even moderate rates of rainfall cannot be absorbed. The amount of soil lost by water erosion in this region is an average of 5 tons per acre (11.5 tonnes per hectare) annually. In one spectacular illustration of water erosion, however, a measured soil loss of 12 tons per acre (27 tonnes per hectare) occurred from a fallow plot during a single summer rainstorm.

A further problem arises because many soils of the Peace River District are naturally acidic. With the use of fertilizers, this acidity is intensified. A somewhat unique local phenomenon is the occurrence of areas of acid precipitation downwind from gas flares and gas processing plants. There appears to be no source of lime near the region which could be used in counteracting the growing acidification problem. The provincial government is currently giving serious consideration to a lime subsidy which would assist farmers in bearing the cost of transporting lime into the region. Such a program could be helpful in alleviating this problem, and the Committee urges that it be put in place quickly.

We have noted quite a long list of serious soil degradation problems. Can anything be done about the situation? The answer is a resounding — yes. Not only *can* something be done, it *must* be done. During the course of its study, the Committee was presented with a number of suggested courses of action. Some of these would require initiatives by the Federal Government while others need provincial, municipal or individual action. We are presenting all of those suggestions which we would like to see put in place. In this way, the Committee feels it can make the greatest possible contribution to an awareness of the issues on the part of all who read this report.

In fact, the need to increase awareness of soil degradation, on the part of rural and urban dwellers alike, was the most frequently mentioned issue during our study. In British Columbia, it was suggested that more emphasis should be placed on land stewardship at all levels of the education system, from elementary schools through to colleges and universities. In addition to this type of general education program, it was suggested that in-service training in soil conservation be provided to agricultural extension workers who deliver programs to the farmgate.

A number of witnesses commented on the distressing lack of personnel in the field of soil conservation to whom farmers can turn for advice, as well as on the lack of specific soil conservation programs in the province. One of the barriers felt to be standing in the way of effective conservation measures is "split jurisdiction" which sees soils as the responsibility of one ministry, water as the responsibility of another, and land use as the responsibility of yet another. No one body has as its mandate the husbanding of the soil resource. Similar comments were heard in other provinces, as well as with regard to the federal scene. Several witnesses in British Columbia urged that the mandate for soil conservation by all departments be clearly defined. In addition, some felt that an interagency coordinating body should be established to streamline the coordination of conservation programs in the province.

The need for additional long-term research was also noted as being essential and this is seen as being a federal responsibility. Perhaps even more important, is the need for practical farm-scale demonstration projects which will allow farmers to see what is involved in conservation and to see, firsthand, the results of such efforts. This point was repeated a number of times. The general feeling was that soil degradation problems are very local in nature, and therefore require local solutions. Programs imposed from "on-

high", by senior levels of government, without local input and/or local demonstration, are not expected to meet with much success.

A number of witnesses noted that in some other provinces and some neighbouring states, the creation of local conservation districts has proven to be a successful way of organizing conservation efforts. One witness suggested that, in the case of the Peace River District of British Columbia, the mandate of the Prairie Farm Rehabilitation Administration (PFRA) should be extended to include this region, since it is similar to the adjoining prairie area. The PFRA seems to be an effective way for the Federal Government, at least, to deliver soil conservation programs to the farmgate.

If new initiatives in soil conservation are to be undertaken, additional federal expenditure will be required, and mechanisms must be found by which this can best be accomplished. Witnesses provided several suggestions in this regard, noting that the new Economic and Regional Development Agreements (ERDAs), now under negotiation, should include a healthy component dedicated to soil conservation efforts. In addition, the Agriculture and Rural Development Agreements (ARDAs), previously mentioned, expired in 1983 and a new agreement is under discussion. The proposal for this new agreement earmarks funds for dealing with soil degradation (acidification and erosion specifically). It is urged that this proposal be accepted.

In summary, then, public awareness, better coordination, improved program delivery mechanisms and an increased commitment of funding by the federal and provincial governments in the field of soil conservation have been identified as the principal areas in which action is required in British Columbia.

The Prairies

North America's semi-arid Great Plains is a region of highly variable soil, temperature and rainfall conditions and is one of the world's richest and most reliable cereal grain-producing areas. The Canadian portion of the Great Plains comprises the southern and central portions of Alberta, Saskatchewan and Manitoba — a region known as the breadbasket of Canada. Like other regions of the country, this area is also beginning to show signs of serious soil degradation and the resultant productivity decreases. What factors have led us to this increasingly perilous situation, and how can we avoid ever more serious problems? A brief review of historical cropping practices and their effect on the soil will serve to explain the first question. Solutions to what is seen by some as impending disaster were suggested by witnesses who appeared before the Committee. These solutions will also be reviewed.

Agriculture in western Canada dates back to approximately 1870 when settlement first began on the Prairies. The completion of the Canadian Pacific Railway in the 1880s speeded up the settlement process and more and more acres were put to the plough. The natural high fertility of the soils, particularly their high organic matter content, enabled farmers to produce millions of tons of cereal grains and oilseeds with minimal use of fertilizer. In the early 1900s, the practice of only cropping land in alternate years (summerfallow) was introduced. It was developed as a means of storing scarce water for the cropping year, as a weed control measure and as a means of regenerating soil fertility. The total land now subject to summerfallow each year makes up 13%, 24% and 38% of the cultivated land in Manitoba, Alberta and Saskatchewan, respectively.

Unfortunately, in the long term, the perceived benefits of summerfallow have not proven to be "as advertised". In fact, quite the contrary is true. The wheat-fallow rotation cropping system is now believed to be largely responsible for the decline in organic matter content, increased soil erosion and the alarming increase in salt-affected land under cultivation in the southern prairies. In the words of one soil scientist:

> The long-hallowed and treasured practice of summerfallowing in a monocultural cropping system is perhaps the most singular mismanagement practice that has been in vogue since this country was opened up.

How has summerfallow contributed to the decline in soil quality? The crop residues incorporated into the soil have a carbon content some 40% lower than native grasses. This means that, under cultivation, organic matter input decreases over time. In addition, the incorporation of crop residues makes them decay much faster (30 to 50%) than did the native grasses, but no additional organic matter is added to the soil during the fallow year.

None of these differences is particularly serious in the short term. Their effect instead is cumulative, and therefore somewhat insidious. Recent studies have shown that as much as 40 to 60% of the organic matter present in virgin prairie soils has been "used up" by farm production. An equally startling fact is that, while the native soils in parts of the prairies originally released up to 125 pounds of nitrogen per acre (140 kilograms per hectare) per year, the same soil today may deliver as low as 9 pounds per acre (10 kilograms per hectare) if nitrogen fertilizer has not been used. The practical result for the farmer is that he must apply ever-increasing amounts of nitrogen fertilizer in an attempt to hold production at its current level.

Loss of soil organic matter also affects the ability of the soil to hold moisture. As the level of organic matter declines, more water runs off into low-lying areas or moves through cracks to lower

It's not the 1930's . . . it's wind erosion on the southern Prairies in the 1980's.

depths where it contributes to the spread of salinity. Also associated with a drop in soil organic matter is the tendency for surface soil to bake and crust.

Summerfallowing, in association with frequent working of the soil, breaks down soil aggregates which in turn reduces water infiltration and leads to water erosion. The lack of vegetative cover during the fallow year and the above-noted breakdown of soil aggregates leaves these soils very vulnerable to both wind and water erosion.

Another serious result of current agricultural practices is the increase in land affected by salts which is being cultivated. The wheat-fallow rotation system again appears to be the biggest culprit. It has disrupted the water cycle so that salts found naturally in the soils at some depth are being dissolved and brought to the surface layer. The presence of high salt concentrations at or near the surface renders the soil infertile. In some areas the telltale white patches on the surface are now increasing at a rate that can only be described as alarming.

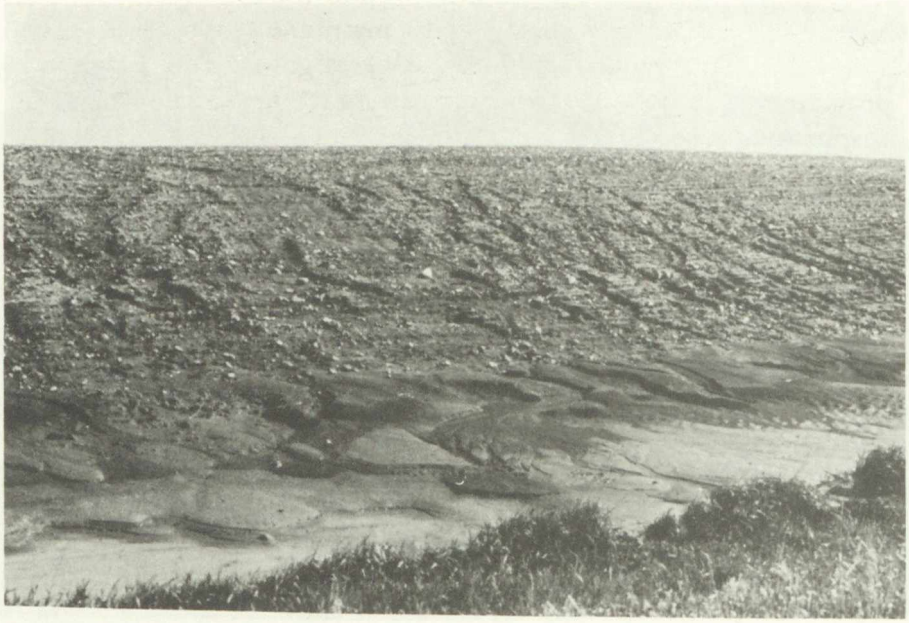
The soil degradation problems on the prairies outside of the semi-arid central and southern region are somewhat different, as one would expect, since the climate and certain cropping practices

The white patches of salt-affected soil reduce the area of grain production on this prairie farm.

are different. For example, water erosion is associated with the higher annual rainfall and snowmelt runoff in the wetter parts of this large region. These areas consist of the lower foothills and the Peace River District of Alberta, the northeastern part of the Great Plains region and the southern Manitoba floodplains.

In the Peace River District, one finds similar soil conditions to those in British Columbia's portion of the district, eg. soils in which a very fine textured horizon overlies a slowly-permeable subsurface horizon. This arrangement of soil horizons makes the soil very erosion prone. The progressive clearing of land in the upper branches of the Peace River is causing new water erosion problems. The drainage system is expected to handle greater amounts of runoff, and the siltation problem is at the same time reducing its ability to do so. In addition, the practice of summerfallow, although used less here than in the southern part of the prairie region, is also contributing to increased water erosion. Much work remains to be done on soil and water management in the Peace River District.

The lower Alberta foothills are suffering from problems similar to those just described for the Peace River District. Land clearing, grazing and cultivation near streams is causing increased runoff and siltation problems which are, in turn, having an adverse effect on fish habitats. Measures which are being used to stabilize the



Summerfallow in the Prairie Provinces leaves the soil unprotected from summer rains and water erosion.

soils include grass waterways, contour cropping and legume rotation. Such procedures are being tried not only in the Prince Albert-Tisdale Region of Saskatchewan but also in the upper Assiniboine Basin and Duck and Riding Mountain areas of Manitoba, which have similar problems.

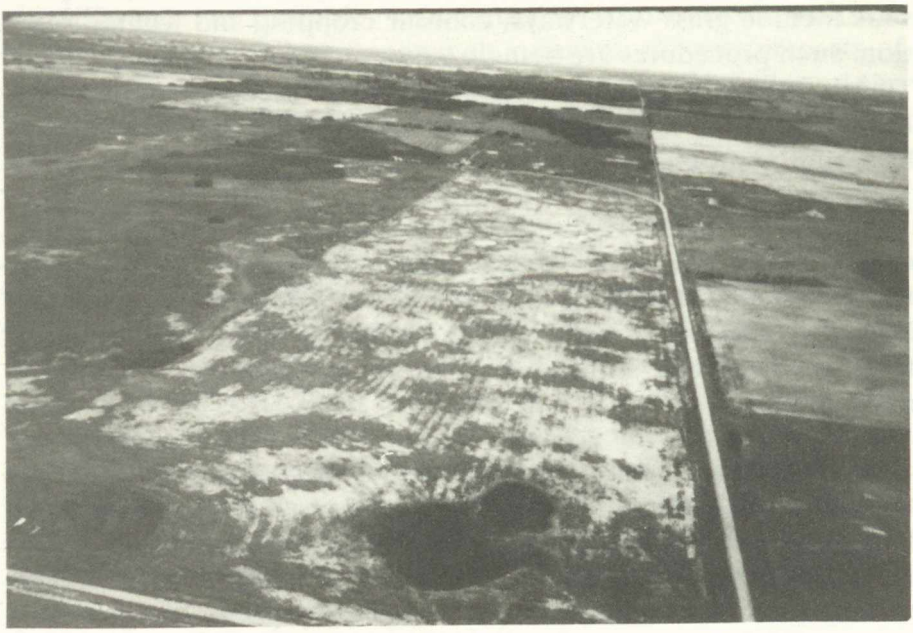
In areas with more intense storms, the problem is of the same nature — but of a greater degree. Such areas include the Tiger and Pembina Hills, Turtle Mountain and the Red River Valley of Manitoba. Over most of the prairie region, water erosion could be lessened, to a great extent, by reducing the summerfallow area as much as possible.

Soil acidification is also a concern in the Peace River District, as well as in the Meadow Lake-Lloydminster area of northwestern Saskatchewan. In these areas, leaching has depleted the soils of calcium and other bases, leaving them with a pH of below 6.0. The extensive use of ammonium fertilizers is making the situation even worse, and the potential for yet greater acidity problems from this source is viewed with alarm.

The supply of lime which could be used to offset the acidification process is of concern in the parts of the prairies which are affected, as it is in British Columbia. It is not locally available and particularly for the Peace River District, transportation costs are onerous.It is estimated that about 358,000 tons (350,000 tonnes per year) of lime are needed just to maintain current pH levels across the whole prairie region. The Alberta government does have a program which provides financial assistance to offset the cost of transporting lime.

The above review of soil degradation problems in the Prairies shows very clearly that something must be done. The current agricultural system is obviously not a sustainable one. We are effectively "mining" the soil and are about to reach (or in some cases have already reached) the point where the soil is mined out. The situation is so serious, in fact, that some claim we must think in terms of rehabilitation of the soil rather than in terms of conservation in its more narrow sense.

Fortunately there is light at the end of the tunnel. Parts of Europe and much of the United States faced similar problems 20, 30 or even more years ago and so techniques have been developed to return more organic matter to the soil and to reduce wind and water erosion. Canada is also developing new techniques appropriate to our climatic and soil conditions.



The light coloured patches are the knolls from which the top soil has eroded. Badly eroded fields do not produce good or profitable crops.

One of the most promising techniques is conservation tillage. Basically, this is a system of production in which the crop is planted directly into untilled standing stubble with a minimum of soil disturbance. Chemical weed control is used if necessary. The "ultimate" form of conservation tillage is the zero or no-till system. This system, like all other degrees of conservation tillage, offers a number of advantages over wheat/fallow rotation. For instance, by maintaining a permanent cover of crop or stubble, wind and water erosion are greatly reduced. By reducing water runoff, the no-till method also reduces the amount of fertilizer and other chemicals finding their way into rivers and lakes. Most importantly perhaps is the fact that it reverses the decline in organic matter in the soil. The stubble left in the fields traps snow and slows runoff as it melts in the spring. This means that soil moisture can actually be improved by using this system of continuous cropping.

The use of conservation-tillage is not widespread in western Canada but there are a growing number of farmers who are practicing this method. Their experience will serve as an example to others that conservation-tillage can be made to work. Several witnesses told the Committee that they have not suffered economically because they use this practice and that their yields are as good as or better than they were under traditional cropping

practices. With regard to organic matter, one farmer reported an 18% increase in soil organic matter above the level found in soil under conventional tillage, after just seven years of zero-till.

Not all farmers practising conservation tillage have reported such success, particularly in terms of the economics of the system. Because chemicals rather than tillage are used to control weeds, input costs rise with the cost of herbicides. Several witnesses expressed the desire to see more funding for research into improving the effectiveness and reducing the cost of herbicides. These farmers are convinced that no-till or some other form of conservation tillage is the way to preserve soil quality. But they are caught in an economic squeeze. Their plea is to make this conservation practice affordable in the short term.

Research is also needed in developing new conservation tillage equipment or adapting existing equipment so that it is optimized for Canadian conditions. Crop residue management, rotational cropping systems and winter-hardy cereals were identified as other areas in need of additional research, as was the effect of agricultural chemicals on people, soil bacteria, domestic animals, wildlife and aquatic life.

If conservation farming methods, including zero-till, crop rotations, grass waterways and the use of winter cover crops are to receive wider public acceptance, much more will have to be done in the realm of applied conservation research and practical, on-farm demonstrations. The changes which must occur in prairie agricultural practices are nothing short of an "agricultural revolution". Also, to convince farmers of the need for change, research must be done to show them the financial cost of the current rate of soil degradation. Conservation will never be justifiable as a "benefit" if no cost is assigned to degradation. Once farmers are convinced that degradation is costing money and the appropriate applied research results and demonstrations, of new, viable farming systems are available at the farm level, they will be much more open to change.

The establishment of a regional Soil and Water Conservation Institute to carry out *applied* research to develop cost effective conservation techniques, is endorsed by this Committee. No institute or agency currently performs this essential function.

In terms of on-farm demonstrations, a good example of how such demonstrations can be carried out is the "FarmLab Program", run jointly by the Saskatchewan Department of Agriculture and the

University of Saskatchewan. One part of this program is devoted to locally initiated projects designed to demonstrate proven, but unfamiliar, technology at the farm level. In 1983 alone, some 250 projects were undertaken and nearly 50% of those projects were related to soil conservation. The other part of the program supports basic agricultural research at the University. Alberta's "Farming for the Future" program similarly carries out a wide range of studies, including soil conservation, at the farm level and promotes soil conservation methods. In Manitoba, the provincial government is trying a different approach in that it is seeking to make soil conservation a major activity of the already existing watershed conservation authorities. Their contact at the farm level is seen as important if conservation technology, once developed, is to be effectively transferred to the farm sector. The province also offers a home study course on soil conservation and over 2000 people took part in last year's program.

The Federal Government is viewed as having a major role to play in carrying out basic long-term research into all aspects of the soil degradation/conservation problem but most witnesses agreed that on-farm delivery of information and assistance would be better handled by existing (often provincially-controlled) institutions. The major exception to this idea is, of course, the PFRA which is a federal entity but has historically dealt at the farmgate. This role should continue, but with more emphasis on conservation than has recently been the case .

The availability of appropriate conservation technology and techniques, and their delivery to the farmer is a very important issue in promoting the improvement of soil conditions. But during the Committee's travel in western Canada, another issue overshadowed even this important aspect of solving our soil problems. That issue is conflicting government policies.

The reduction of summerfallow and a change from cereal monoculture is promoted by many experts as a means of halting the decline of prairie soils. At the same time, Canadian Wheat Board delivery quotas apply to all cultivated acres. This includes acres under cereal and under summerfallow. Recent de-emphasis of summerfallow by "bonusing" the seeded acreage has had the desired effect of removing some incentive to summerfallow. But the "bonusing" policy has created another conflict by encouraging farmers to cultivate marginal land which should be left in its natural state.

Federal policies exist which promote the growing of grain as opposed to more diversified farming systems. Some witnesses believe that by discouraging the livestock industry in western Canada, these policies promote soil degradation. For example, the Western Grain Transportation Policy still subsidizes the export of grain from the prairies and, at the other end of the tracks, the Feed Freight Assistance Program encourages the import of grain from the west to eastern Canada — again encouraging grain and discouraging the livestock industry in the west. (This also discourages eastern farmers from growing their own grain — a practice from which eastern soils could benefit.) Reworking the Western Grain Stabilization Act to better reflect commodity prices is also identified by some as a means of applying pressure to western farmers to diversify their income sources by diversifying their farming operation. In summary, then, one could say that federal policies affecting agriculture must become, or be made retroactively, more sensitive in their impact on sound soil conservation practices.

Governments are not alone in the task of bringing about a greater awareness of the problems of soil degradation and of the potential solutions. Many farm organizations are now involved in spreading the word. Organizations such as the Warner Dryland Salinity Association, the Manitoba-North Dakota Zero Tillage Farmers' Association, the Alberta Farmers Conservation in Crop Production Association and Manitoba Conservation Districts, all of whom appeared before the Committee, are typical of the organizations which have sprung up across the prairies in response to the threat of serious deterioration of our soils. These, and other similar associations, should be given every possible assistance, as they are invaluable in the fight against soil degradation.

The declaration of a National Soil Conservation Week could also help to create an awareness of Canada's soil problems in the general population and to garner public support for the major undertaking that overcoming these problems will require.

Central Canada

The soil degradation picture in central Canada is not much brighter than in the rest of the country. The most common soil degradation problems in Ontario and Quebec are erosion by water, compaction, loss of organic matter and acidification. Wind erosion occurs mainly on certain intensively cultivated sandy soils in southwestern Ontario. Long-term contamination of soils by heavy metals found in the sewage sludge being spread on some farmland in Ontario and by atmospheric pollutants from industrial and automotive sources throughout the region is a growing concern. The disruption and mixing of the soil on sand and gravel extraction sites, on pipeline routes and to a lesser extent along larger drainage ditches creates serious local problems over a substantial area of good agricultural land.

If one were to summarize very briefly the major reasons for the soil degradation problems in this part of the country, one would come up with the following list. First of all, the increase in row crop production, principally corn, has been quite dramatic. This expansion has brought with it the phenomena of increased tillage and more continuous production which in turn have resulted in lower organic matter levels and in a breakdown of soil structure. Also, as new varieties of corn have been developed which can mature with less heat, corn production has moved into areas to the north and east of traditional corn farming areas in southwestern Ontario and consequently into more easily erodable soils.

Another factor which deserves mention on this list of "disturbing trends" is the tendency towards specialized cash-cropping. As a result of this move, less forage is grown and, because livestock are not part of most cash-crop operations, less manure is being returned to the land. Both changes are exacerbating the problem of declining soil organic matter and, consequently water erosion. More attention should be paid to the inclusion of rotational crops if this decline is to be reversed. Cash-cropping also tends to lead to increased farm size and mechanization. The hazards of removal of fence rows and windbreaks are well known, as is the compaction which occurs when large machinery is used on certain soils when they are too wet.

A third trend which bears mentioning is the increasing amount of farmland which is rented rather than owned by the farmer. Many

leases are verbal agreements with no "obligations" spelled out in detail and most are for one or two years at a time. As a result, the renting farmer is reluctant to take any conservation measures for which the payout is only in the long term.

Having now looked at the soil degradation problem of Ontario and Quebec in a general way, we can look at the specific areas where these problems occur.

Since 1960, there has been a large reduction in the area of hay and small grains grown in southern Ontario and southern Quebec. They have been replaced by row crops, primarily corn, and this in turn has led to increased depletion of organic matter in the soil and to serious erosion by water. The soils are not as well protected from the effects of running water under row crop cultivation as they were under cereals and forage crops. An example from southern Ontario illustrates this point. The soil loss under continuous corn cultivation has been measured at 5.5 tons per acre (12 tonnes per hectare) annually on fairly level land and up to 21 tons per acre (49 tonnes per hectare) on a 10% slope. Loss is reduced to about 3 tons per acre (7 tonnes per hectare) with corn and hay in rotation. In contrast, erosion from pasture land is less than 0.5 tons per acre (1 tonne per hectare). The magnitude of the problem can be highlighted if one considers the fact that corn acreage in Quebec has increased by five times in the last 20 years.

Row crops like corn under conventional tillage do not protect the land from water erosion . . .

In eastern Ontario and eastern Quebec where the shift away from pasture and cereal crops has been much slower, there is a proportionally smaller water erosion problem. Southwestern Ontario has a problem of high annual runoff and severe summer storms which combine to bring increased water erosion.

The severe impact of soil erosion has been recently demonstrated in field studies in Waterloo County. Grain corn yields on severely eroded fields were reduced by over 36% from production levels on non-eroded soils. Consequently, losses in gross return from corn production in 1982 and 1983 ranged from about $40 per acre ($100 per hectare) to over $161 per acre ($400 per hectare) depending on the degree of soil erosion.

In southwestern Ontario, parts of eastern Ontario and southern Quebec, there is a growing wind erosion problem. The land is ploughed in the fall, and the furrows are thus exposed to wind erosion late in the winter, the spring and early summer. This problem is particularly serious in regions which have been cultivated for the past 80 or 90 years and where fencerows and windbreaks have been removed for field enlargement and intensive row crop production. The Ontario Ministry of Agriculture has now recognized that a serious problem exists and the Ministry recently concluded a study designed to put a dollar cost on losses which are being incurred.

. . . but crop residues and zero tillage help to stabilize the soil.

Their findings indicate that in terms of yield reduction, nutrient loss and pesticide losses, sheet and rill erosion from row-cropped land is costing Ontario farmers about $68 million annually. Losses due to soil compaction and other forms of soil degradation were not included in this study and so would be incremental to the $68 million noted above.

In Norfolk, Dufferin and Simcoe counties, the sandy soils are susceptible to blowing but in some cases the planting of windbreaks has helped to reduce the problem. These are areas where vigilance must be maintained to keep wind erosion from becoming a greater problem.

The continuous cropping and tillage of soil, particularly in the intensive farming zones of southern Ontario and southern Quebec, has led to soil compaction and structural deterioration. Such damage occurs mainly from frequent tillage and working of wet soil with heavy machinery. This is viewed by some observers as potentially the most serious cause of soil degradation in the region.

Little work has been done on soil acidification in the Great Lakes-St. Lawrence Lowlands Region. But it is presumed that the effects of acid rain, which are currently showing up in the lakes and streams of this part of the country, are also changing soil pH. A

From foodland to wasteland . . . wind erosion on unprotected soil in Ontario.

second, and probably more serious contributor to the problem of acidity, is the use of large amounts of nitrogen fertilizers in the most intensively farmed parts of this region.

This heavily populated part of Canada is subject to soil contamination from industrial and municipal waste disposal. Where sewage sludge is spread on farmland, there is some concern about the buildup of heavy metals such as mercury, cadmium, arsenic, lead, chromium, nickel, copper and/or zinc which may result from this practice.

The intensive fruit and vegetable production (of the Niagara area for example) has resulted in large amounts of chemical pesticides being used. Over the years the use of pesticides and herbicides has led to slightly elevated levels of arsenic, copper, mercury and/or lead in some areas.

In the Lac St-Jean area of Quebec, it has been noted that fluorine contamination of the soils, due to the fallout from an aluminum smelter, has increased. A similar problem has been documented in the soils near Cornwall, Ontario. Metal contamination resulting from smelting operations has also been noted near a cobalt-nickel smelter (cobalt, copper and nickel) in the Timiskaming district of Ontario and near the two nickel smelters at Sudbury (nickel, copper, zinc, iron and sulphur).

The removal of sand, gravel and stone for use in construction projects has disrupted the soil structure in some parts of this region. Some 165,500 acres (67,000 hectares) have been mined for aggregates and, at least in the Kingston to Oshawa area, 50% of this development is on Class 1 and 2 soils. This represents a loss of good soil since it is very unlikely that this soil can be reclaimed after the mining activity is over. Construction of pipelines and large drainage ditches can cause similar soil degradation and short-term reduction in productivity.

One additional serious threat to agricultural land is particularly evident in central Canada — urban expansion. The seriousness of the situation can best be appreciated by considering a few facts. Over one-third of Canada's Class 1 agricultural land is within two hours drive of Toronto. When climatic factors as well as soil conditions are taken into account, it is more accurate to say that half of Canada's best farmland is within that radius. Couple these facts with the knowledge that from 1966 to 1971 Ontario lost 26 acres (10.5 hectares) of improved farmland every *hour* and one

Vanishing farmland . . . small channels formed by runoff can develop into devastating gullies.

can appreciate the enormity of the loss. The expropriation of some 79,000 acres (32,000 hectares) of prime agricultural land for the construction of Mirabel Airport is another example of the conflict between land use for urban expansion and agriculture. Quebec now has provincial legislation regulating land use so some progress is expected in preserving what prime agricultural areas remain.

In both Ontario and Quebec higher profile and seemingly more pressing issues than soil degradation have long held the spotlight. This is beginning to change, more in Ontario than Quebec, in recent years. The organic soils of southern Quebec are being badly eroded by the wind and if nothing is done to reduce the rate of loss, these fertile soils could be lost within 20 years.

As has already been noted, the Ontario Ministry of Agriculture and Food (OMAF) has conducted several studies to determine the areas most affected by soil erosion and to quantify the cost of this erosion to farmers in Ontario. The startling results of these studies have given soil degradation a higher profile in the farming, bureaucratic and political communities alike. In fact, OMAF has implemented a grant system to provide engineering help and financial assistance to farmers who undertake remedial action to stop serious water erosion. This Soil Conservation and Environmental Assistance Program has been welcomed by many as a step in the

Wind erosion of organic soils in Quebec.

right direction. On the other hand, it has been criticized for not providing nearly enough funding to really attack the soil erosion problem and for not dealing with methods to counter sheet erosion — seen by many as the major soil erosion problem in Ontario.

A number of witnesses identified the lack of a lead agency and the lack of clear departmental responsibilities in regard to soil conservation as major stumbling blocks to effective action in this field. In Ontario, the effect of runoff (sediments and chemicals) from farmland on water quality has been a prime moving force behind the increasing awareness of soil degradation as an issue. It is also the reason why not only agencies involved with agriculture, but also those concerned with the environment and water pollution, are involved in soil conservation. As a result, at least two federal agencies (the Departments of Agriculture and Environment), and three provincial agencies (Ministries of Agriculture and Food, Environment and Natural Resources through its local Conservation Authorities) have made some input into solving soil degradation problems. As a number of witnesses pointed out to the Committee, each of these agencies has issued statements and/or reports on the severity of the problem, and some have suggested ways to solve the problem. Unfortumately, negligible efforts have been made to solve problems in the field. No single agency is in charge and farmers are often left confused as to whom they should ask for what assistance.

An example of the frustration being felt is found in the experience of the Thames River Watershed Study. This study was a cooperative effort by the three provincial ministries and was administered by the Conservation Authority. The three year study outlined the problems in the watershed and recommended remedial action. The study was sent to the three ministries involved in late 1982 but to date, virtually no action has been taken, largely because of the difficulty in determining accountability for various aspects of the problem. A Cabinet Committee is currently considering this problem and seeking to define more clearly the role of each Ministry and, hopefully, to name one of them as the lead agency in the fight against soil degradation. Given the urgent requirement for effective action to halt soil degradation, the Committee would like to urge that this decision be reached quickly as it will certainly aid the effective use of any federal assistance which may be forthcoming as a result of this report. Program delivery and clear cut program responsibility are seen as two of the basic necessities for effective action.

Many witnesses in Ontario and Quebec, as in every other province, noted the importance of locally-initiated solutions to local soil degradation problems. Since the problems faced by individual farmers vary considerably even within a small area, programs to deal with them must be very flexible to allow appropriate allocation of assistance, be it technical or financial. With this in mind witnesses recommended that existing agencies with good grassroots contacts could best deliver the needed government programs.

The Conservation Authorities made a strong case for their suitability for such a task, pointing out that, as in the case of the Upper Thames River and the Auscible-Bayfield Conservation Authorities, they are already helping farmers deal with soil conservation. Given sufficient funding and manpower they feel they could fill a real need in this area. Other witnesses suggested that OMAF extension personnel, if similarly augmented in terms of people and funding, could provide the necessary farmgate program delivery. This Committee sees merit in both approaches and is less concerned with who performs the function than with the fact that help is made available to farmers. The task ahead in battling soil degradation is simply too important and too urgent for any willing and able group to be left out. However, as mentioned previously, a system must be established where a lead agency is made responsible for coordinating the effort and for seeing that soil conservation does not fall between the cracks in a bureaucratic stalemate.

The situation in Quebec seems to be resolving itself more slowly than in Ontario at the present time, although Quebec is one of only two provinces (British Columbia is the other) with very strict legislation on land use. This legislation, which is much stricter than that in British Columbia, appears to be addressing effectively the problem of loss of agricultural land to other uses. However, like the British Columbia legislation, it deals only with keeping the area in agriculture and not with preserving the quality of the soil.

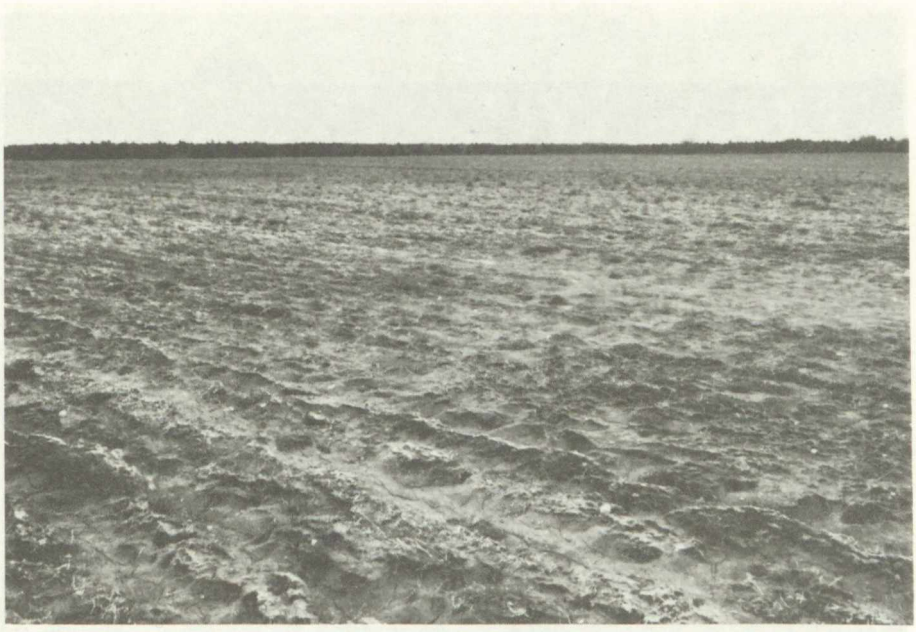
Several witnesses noted that in Quebec there is a shortage of basic research into the exact nature and extent of soil degradation. No studies on the cost of erosion to Quebec agriculture, comparable to those carried out in Ontario, have been completed and several witnesses urged that further research of this nature be undertaken. Once this basic information is in hand, more conservation specialists will be required in the province to carry out any program which may be adopted. One witness suggested that an effective conservation program would have to provide a full package. In other words, it should consist of on-farm technical aid to identify specific erosion problems and to develop a long-term plan for ameliorating the situation. Financial assistance will probably then be required to help farmers implement the plans, since farmers in Quebec, as elsewhere, are feeling the effects of low commodity prices.

Government programs are not the only means by which farmers receive help in combatting soil degradation. A number of farm organizations perform an education function and still others provide more technical support. Soil and Crop Associations are very active in eastern Canada and they hold information sessions for their members on conservation methods. In another example of self-help, a small group of five Kent County, Ontario farmers formed a no-till club. They each invested $2,000 and this sum was matched by the Kent County Soil and Crop Improvement Association to purchase no-till equipment. They will each be using the equipment on ten-acre test plots over a period of three to five years and OMAF will be monotoring the results to determine profitability, and effects on soil structure and erosion.

The local initiation of such cooperative projects, which farmers themselves see as practical and beneficial, should be a part of any strategy addressing the conservation issue in Central Canada as in other parts of the country.

The Atlantic Region

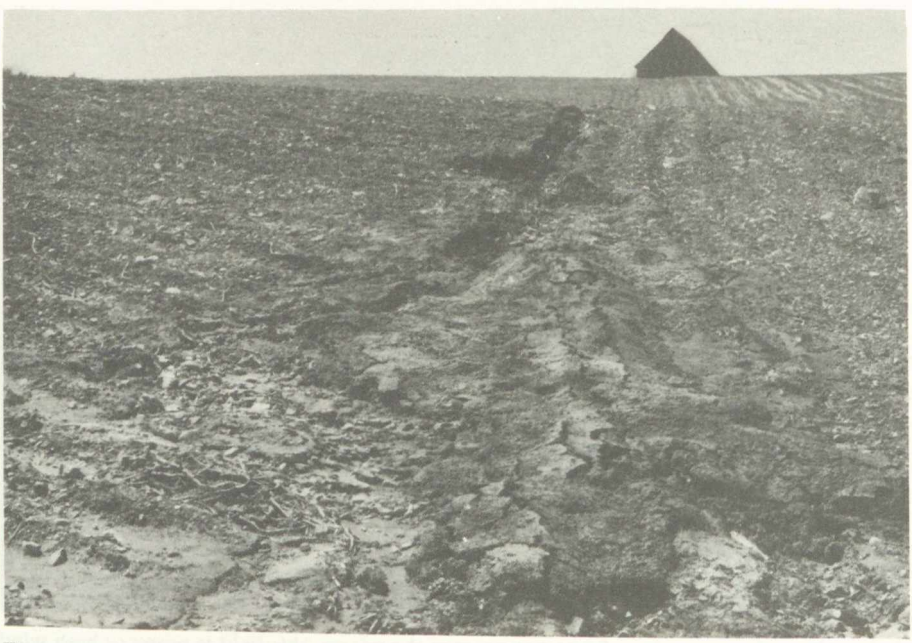
Natural soil conditions vary somewhat from province to province within the Atlantic region, but they share many common features. Generally, the topography is rolling to steep and the climate is relatively cool and wet. Intense rain storms commonly occur in the spring and fall affecting both seeding and harvesting. The soils of Nova Scotia were described to the Committee as being naturally acidic, poorly drained, lacking in natural fertility and with a relatively shallow top soil underlain by compact sub-soil. Similar comments hold for the soils of New Brunswick. Prince Edward Island's soils present a very similar picture, being generally shallow, low in natural fertility and organic matter, acidic, and with a low clay content. These soils also described as being structurally fragile and highly erodible. In a similar vein, Newfoundland has soils which are typically shallow, have a low clay content varying from loam to silty sand, with frequent stoniness. Unlike the other regions of Canada which we have discussed in this section, the Atlantic region clearly had the least favourable soil conditions to begin with. As a result, the effects of certain agricultural practices are even more pronounced here than in other regions of the country. Soil degradation, in some parts of the Atlantic region has, in fact, already reached disastrous proportions.



Left without the protection of a covercrop over the winter, this field is prone to both wind and water erosion.

Generally stated, the most serious form of soil degradation throughout the Atlantic region is erosion by water. This includes not only the effects of rainfall and runoff but also shoreline and stream bank erosion as well. In addition, the wet climate leads to many soil compaction problems as soils must often be worked when still wet. As noted above, the region's soils are naturally acidic; thus the acidifying effect of heavy applications of nitrogen fertilizer is severe in this region. The low levels of organic matter in virgin soils also means that cultural practices which rob the soil of organic matter have a greater impact (or at least a more immediate one) than they do in other parts of the country. We may now examine in more detail these soil degradation problems to determine how, why and where they occur, and to consider possible solutions.

Water erosion is listed as the number one soil degradation problem in both Prince Edward Island and New Brunswick. In the latter, province, losses of up to 18.0 tons of soil per acre (40 tonnes per hectare) annually have been recorded. Water erosion is also a serious concern in Newfoundland, but is less so in Nova Scotia where a greater proportion of the agricultural land is under forage crops. In Nova Scotia, however, upland areas left without a fall cover crop suffer from water erosion and the Shubenacadie-Stewiacke River Basin has been identified as a problem area due to runoff.



Water erosion leaves its mark on a cultivated and unprotected potato field.

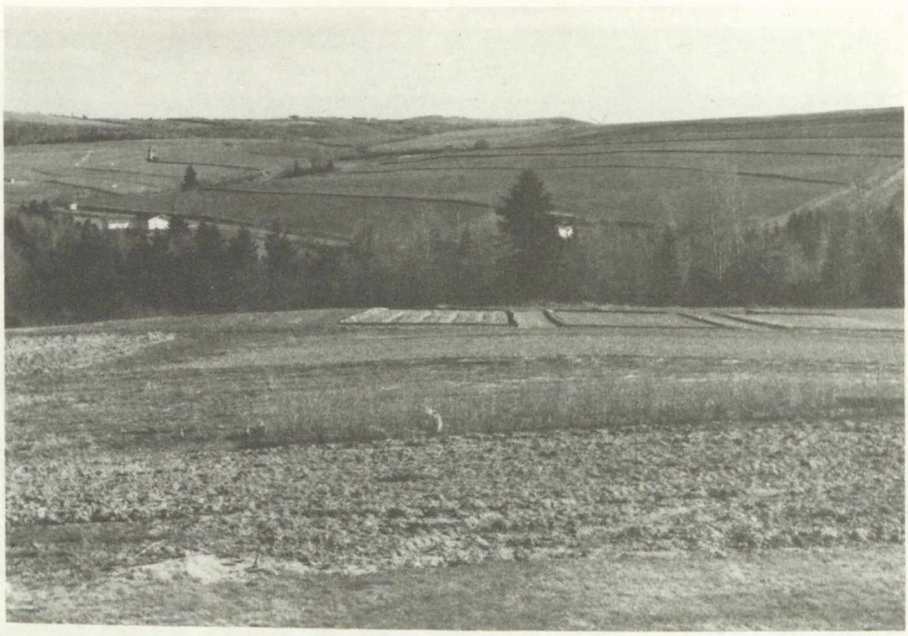
In New Brunswick and Prince Edward Island, the potato growing areas are particularly vulnerable to water erosion since this crop is grown in rows, often up and down slopes, facilitating runoff. The practice of continuous potato production means that the soil is not well protected when it is most vulnerable. The potatoes are harvested late in the fall, often too late to allow for a cover crop to be planted, thus leaving the soil exposed to the heavy fall and winter rains. The situation in Prince Edward Island and New Brunswick is exacerbated by the late winter - early spring freeze-thaw cycles. This phenomenon results in rain and meltwater flowing over a partially frozen soil surface, and is responsible for 80% of Prince Edward Island's soil runoff problems. Also, due to the high return from potato farming as compared to small grains, and the absence of livestock on most farms, crop rotation normally is not seen as economically viable for potato farmers.

Some measurements of soil erosion rates have been made in Prince Edward Island over a five-year period. Values ranged from just 0.1 tons per acre (0.2 tonnes per hectare) under sod to 9 tons per acre (19.6 tonnes per hectare) with potatoes growing up and down the slope. If the potatoes are grown across the slope, this value can be reduced by one-third, indicating the importance of cultivation practices. Other conservation measures which are being promoted include sub-surface drainage. New Brunswick, for exam-

Parallel diversion terraces and chisel-plowed land protect these fields from erosion.

ple, has a province-wide, sub-surface drainage program and close to 984,000 feet (300,000 metres) of sub-surface drainage pipe are installed annually in this province. Grass waterways, strip cropping, crop rotations and runoff control structures such as "parallel-diversion-terrace systems" are further measures which can and should be used. In New Brunswick some 15% of the land used for potato production has had some erosion protection work done. It is estimated, however, that fully 75% is in need of some form of protection.

The government of Prince Edward Island under a jointly-funded program with Agriculture Canada, has implemented 47 land management demonstrations across the province. These demonstrations include sub-surface drainage, ditching, land levelling, diversions, french drains, grass waterways and fall seeded crops. This program has been judged a success since it offered farmers a chance to see at first hand on-farm working systems. It is still too early to judge the success which the program will have in persuading farmers to adopt the technologies which were demonstrated. As elsewhere in the country, the cost of undertaking soil conservation measures will deter many would-be conservationists in Atlantic Canada. This is especially true if the benefits of the practices being promoted are unproven, or poorly understood by the farmers. This highlights the importance of increased funding

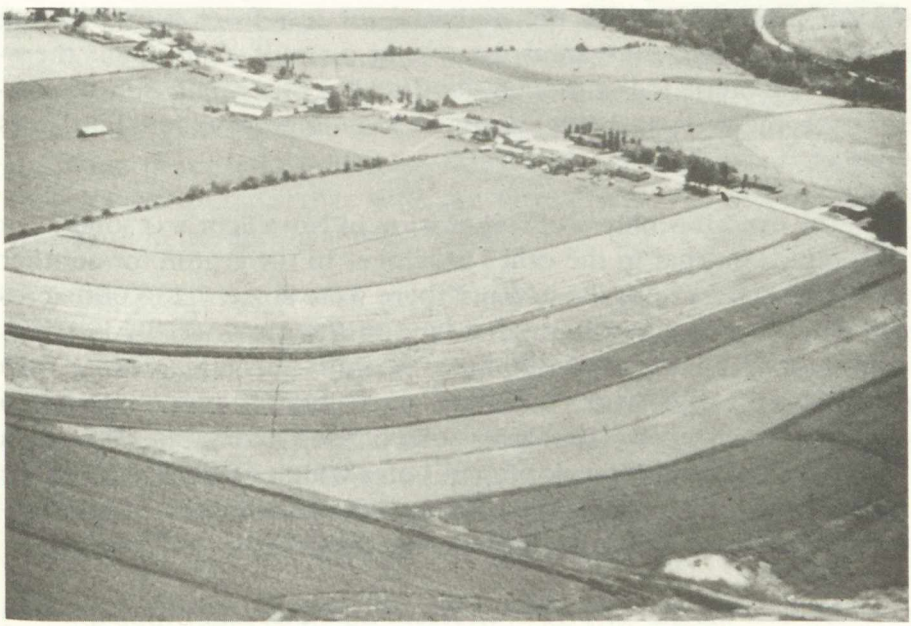


On long slopes the soil is protected from erosion by a system of diversion terraces . . .

for research and on-farm demonstrations of conservation technologies and practices.

The New Brunswick Department of Agriculture and Rural Development has recognized the severity of the problem as well, and has now established a Soil and Water Section in its Agricultural Engineering Branch to promote sound soil and water management practices. Engineering extension personnel are involved in providing planning, design, lay-out surveys and construction and maintenance supervision services to farmers who undertake erosion control projects such as terracing, strip-cropping, drainage and stream bank protection. Unfortunately, the limited financial resources of the province mean that only two people (one professional engineer and one technician) are working full-time on soil erosion problems, with four others working part of their time in this field. Nonetheless, it is clear that a determined effort is being made in these two provinces to begin correcting the serious water erosion problems which they face.

Despite the effort which is already being made, witnesses identified some specific areas where research is still required to ensure that conservation practices can be made to work. More research is needed to identify and develop more suitable cover crops which can be sown after potato harvest late in the fall. Conservation til-



. . . together with strip-cropping in rotation and grassed waterways.

lage systems adapted to the soil and climatic conditions of the Atlantic region are also needed, as is work on drainage systems and strip-cropping. A prime concern for a number of witnesses was the need for more qualified extension personnel to assist them in identifying their particular problems and in choosing an appropriate course of action. There is a need also for some sort of cost-sharing arrangement between governments and farmers to offset the high initial cost of certain measures.

The situation in Nova Scotia is somewhat different from that in the other provinces in that the three most serious erosion problems — shoreline erosion, stream bank erosion and flooding — have causes; which are largely external to agriculture. Protecting farmland from ocean wave action is a very costly undertaking, and is certainly well beyond the means of individual farmers. At one time the Federal Government accepted major funding responsibility for this work but the onus now falls totally on the Province.

Stream bank erosion occurs throughout the province from time to time. Studies have been recommended to examine the feasibility of controlled logging practices, green belts along watercourses and wooded buffer strips along streams flowing through agricultural lands. A small program of financial assistance for measures to combat stream bank erosion is in place. Flooding occurs periodically on some 118,600 acres (48,000 hectares) of Nova Scotia soils. Most farmers recognize the potential for loss from such flooding and leave flood prone areas in grass as a result. One ought therefore to conclude that although flooding is a potentially serious erosion problem, it is being dealt with in a way which limits its impact.

The overall problem of soil erosion in Nova Scotia is somewhat different from that in the other provinces in the region for another reason. At the turn of the century there were some 1,236,000 acres (500,000 hectares) of improved land in the province. By 1981 this total had dropped to 442,300 acres (179,000 hectares). More than 741,000 acres (300,000 hectares) once farmed have reverted to continuous crops such as grass, blueberries and trees. The Nova Scotia government is examining policies which would enable some of this land to be brought back into production but under management conditions which would preserve its quality.

As noted previously, a considerable portion of farm land is in forage crops. The acreages of wheat, barley and corn for silage have increased recently in Nova Scotia and crop rotations are being pro-

moted. As in the rest of the Atlantic region, the Committee heard complaints that the federal Feed Freight Assistance Program, which subsidizes the cost of transporting feed grains from Western Canada to the Atlantic, is inhibiting the local production of these crops. This in turn means that there is little or no incentive for farmers in the Atlantic region to grow feed grains in a crop rotation system. By promoting potato monoculture in some areas, and other specialized cropping practices in others, this policy is inadvertently depriving the soil of needed organic matter. The Maritime Farmers Council, an affiliation of the Nova Scotia, New Brunswick and Prince Edward Island Federations of Agriculture and Coop Atlantic have developed a proposal which calls for restructuring of this transportation assistance so that it is not a deterrent to local grain production and greater use of the local soil base. Their proposal is that the assistance be paid directly to the livestock producers on the units or end-products which they produce. Imported feed grains would then reach their true transportation cost levels and locally grown feed crops would be able to compete.

Wind and water erosion problems on agricultural land in Newfoundland may not seem to be terribly important in a national context, given the small amount of agricultural land in that province. But it is the very fact that there is so little good land that makes its preservation essential. In this province, row crops are ploughed up and down the slopes intentionally to increase runoff in the spring. While this practice may increase erosion it is an essential one for the farmer if he is to have time for a crop to mature. Summers are short and cool, and so it is essential that they be able to get on the land as early as possible in the spring. Soil compaction is another particularly serious problem in Newfoundland and occurs because the climate dictates that soils are virtually always worked when wet, both in the spring and in the fall.

Overpasturing is also a problem and again results primarily from necessity. Pasture land, like other agricultural land, is scarce and so farmers trying to make a living from dairy farming or other livestock production tend to overstock their land. Conservation programs are not in place in Newfoundland but the Provincial Government, like all others in the Atlantic region, intends to make funding for soil conservation work a major part of their next Economic and Regional Development Agreement.

An additional common concern which the Committee heard in the Atlantic provinces is that too little time and effort is spent by federal agencies in examining the specific soil degradation prob-

Overgrazing by goats hinders the establishment of natural cover making erosion prone Newfoundland soils even more susceptible.

lems of this region. In the national view, except for potato production, agriculture in Atlantic Canada is not the "big time" and often the problems here are overlooked. And yet, on a provincial scale, agriculture ranks first or second in terms of contribution to Gross Provincial Product in all three Maritime provinces. It is clear to the Committee that an Eastern Soil and Water Conservation Institute, identical to the Western Institute which it proposes for the Prairies, would be a welcome addition to federal efforts in applied research and information dissemination. The Committee therefore recommends that such an Institute be established.

5

SOLUTIONS CAN BE FOUND: CASE STUDIES

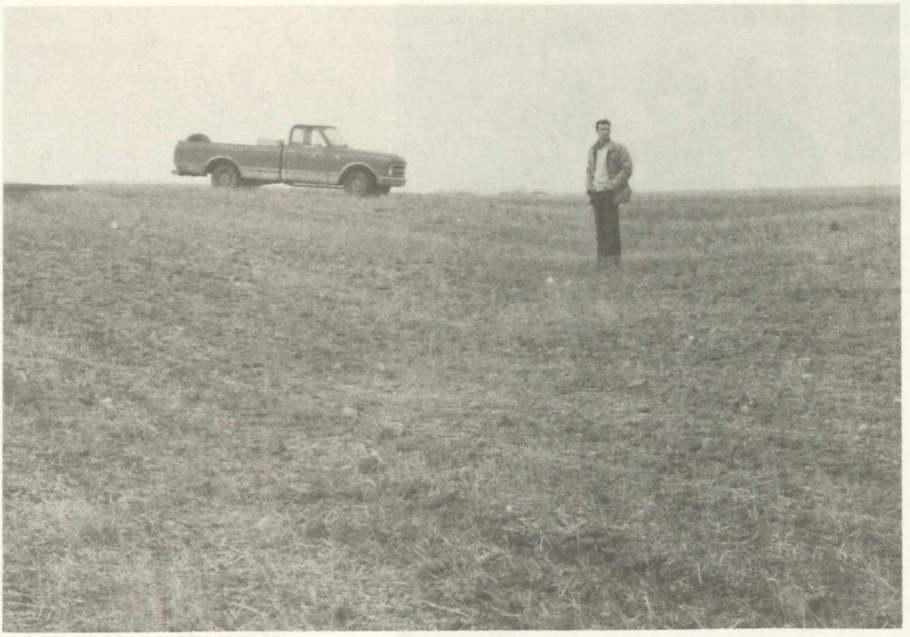
The McNabbs,

Minnedosa, Manitoba

The guiding motive for Bob McNabb was that there had to be a better way to manage the soil than the traditional tillage practices he had used at the beginning of his farming career. His interest in finding that way was strengthened by an awareness of soil degradation problems, particularly water and wind erosion, and concern about the adverse effects of excessive cultivation on his farm.

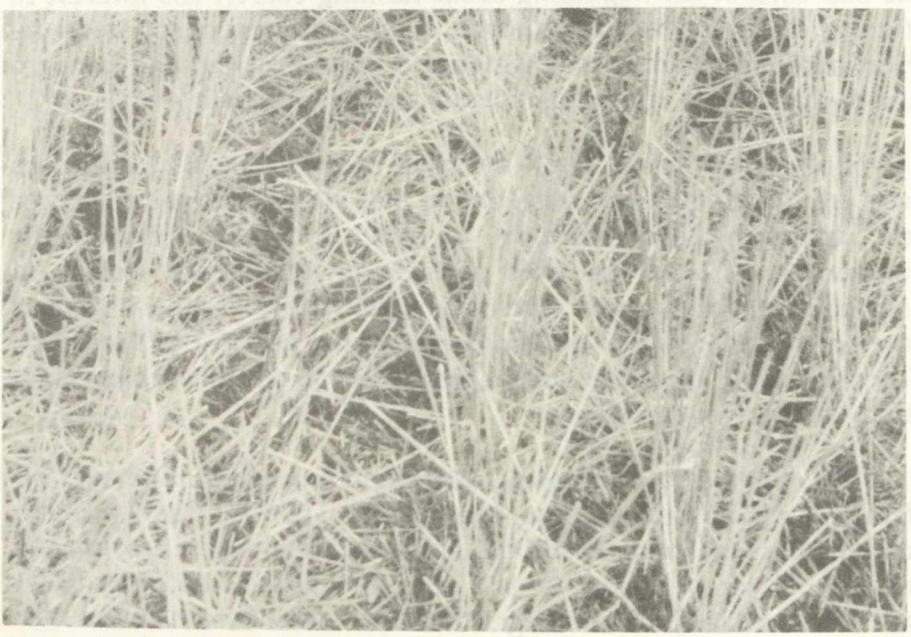
Before this farmer's son returned to the land, his experience was moulding him to be receptive to new viewpoints and to accept the challenge of new ventures. In 1969, Bob graduated from the University of Manitoba with a Bachelor of Science degree in Agriculture. For the next seven years, he worked as a bush pilot in the northern regions of the Prairie Provinces and in the Northwest Territories. He liked the challenges of the job and the requirement to make his own decisions.

This proved to be a good background when Bob took over his father's farm near Minnedosa, Manitoba in 1976. The soil was predominantly clay loam on rolling land, subject to water erosion and occasional wind erosion. He had seen the gullies created by heavy rains. The rotation had been grain, oilseeds and fallow, under conventional tillage. Bob recognized that changes in soil management were necessary. The first change was to introduce continuous crop-



Rooted flax stubble and crop residues from zero tillage prevent erosion in this draw on the McNabb farm.

ping. Other new practices were adopted later. Consequently, there are no rills or gullies now, even in draws where one would expect to see evidence of water erosion.



In zero tillage, standing wheat stubble and distributed crop residues provide excellent protection against water and wind erosion. The next crop is sown between the rows of stubble.

The present system of soil management consists of zero tillage and continuous cropping on all 800 acres of cropland. A rotation of wheat, oilseeds and barley or oats is followed. Winter wheat is being gradually worked into this rotation. It will help to spread the farm workload and may reduce herbicide costs since winter wheat competes strongly with weeds. All crops are planted directly into untilled standing stubble with a minimum of soil disturbance.

Field experience has shown that the management of crop residues after harvest, fall weed control, crop rotation, and the use of a suitable seed drill are very important management factors for successful zero tillage cropping. Therefore, after combining, the straw is distributed more evenly by a light pass with tine harrows. This operation will be eventually eliminated by a good straw spreading attachment on the combine. Also during the fall, herbicides are applied to control such weeds as Canada thistle, narrow-leaved hawksbeard and quack grass, and nitrogen is knifed into the soil.

The remainder of the required fertilizer is applied at seeding when the crop is put in with a disc drill modified to work through surface residues. By harvest time in the second year 75% or more of the straw and standing stubble from the preceeding crop is completely broken down. The rate of decomposition of crop residues seems to increase during the initial years of zero tillage as the particular micro-organisms multiply in the soil. These decomposed residues add organic matter to the soil surface while decaying roots maintain the organic matter in the deeper layers of the soil.

Bob McNabb's search for a more effective soil management system was greatly helped by attending a workshop in 1978 that was organized by the Manitoba-North Dakota Zero Tillage Farmers' Association; assistance was provided by the provincial Department of Agriculture. Prior to that time he had read about no-till cropping. But in this association, he met optimistic people who became not only a source of encouragement, but the source of virtually all his new information on the practice of zero tillage.

The process of adopting this new approach to soil management occurred over a few years. In 1979, Bob decided to try zero tillage. He rented a suitable drill from a local farm equipment dealer for $5 an acre and put in some Bonanza barley in the first week of June. It turned out to be the best crop of barley he had grown and strengthened his interest in the practice. Since that drill was up for sale next year, Bob bought it and put in half his crop under no-till. The harvest was good. Consequently, in the following year, three quar-

ters of the crop acreage was sown by no-till methods with equally encouraging results.

At this point, Bob McNabb had to make a major decision whether or not to continue with zero tillage and to accept whatever exposure to increased risk that it might bring. It surely wasn't an easy decision for a young farmer with a family of five dependents and substantial financial commitments. He had few supporters beyond his father and his friends in the Association. However, after the situation was considered carefully with his wife Elaine, the decision was made to proceed entirely with no tillage in 1982. That year, Bob began to burn the bridges by selling his diskers.

The results have continued to support their decision to operate completely with the zero-tillage system. On his own farm, Bob McNabb has observed the following major benefits. Under this system of soil management, he has not sacrificed yields which have remained equal to or better than yields obtained under conventional tillage. It has not added to his production costs or caused him to lose any money. From her position of farm bookkeeper, Elaine agrees with this observation. Organic matter in the soil was increased significantly over a period of five years. This observation was also verified by Jim McCutcheon of Homewood, Manitoba, who has been in zero-tillage for ten years. He is convinced that this system will reverse organic matter decline. Bob McNabb and others have observed that the friability of the soil is considerably improved under no-till cultivation. Rain infiltrates the soil much more readily, particularly on heavier soils. Zero tillage has not delayed crop maturity. Water and wind erosion have been totally eliminated.

The cost of weed control is the main problem to be overcome in this system of soil management. Zero tillage brings about a shift in the weed pattern resulting in the survival of more hard-to-kill annual as well as perennial weeds. Herbicides are available to deal with this problem, but their application can be costly, particularly in the short term. Consequently, it is important to keep herbicide costs affordable. Unlike their colleagues in North Dakota, where State conservation districts had a three-year cost-sharing program contributing $15 per acre toward weed control which helped to extend the acreage of no-till cropping, in Manitoba, no-till farmers must bear the entire cost of chemical weed control. As its cost increases, purchasing herbicide could become a greater problem, particularly depending upon the kinds of weeds that have to be treated and the level of returns from grain. In trying to find a solu-

tion, the Manitoba-North Dakota Zero Tillage Farmers' Association has discussed the problem with manufacturers who have shown interest in developing cost-effective herbicides.

Effective seeding equipment is becoming less of a problem. The Association has just completed a research project with the Agricultural Engineering Department of the University of Manitoba and Versatile Farm Equipment to analyze the performance of seed openers. The Association has also discussed with the Prairie Agricultural Machinery Institute and the University of Manitoba the farm-scale testing of seed drills for the successful seeding of winter wheat. During the past two years, more Canadian companies have begun building suitable drills.

Bob McNabb believes that he has found a better way of soil management in the zero tillage system. He is convinced that this system can, without doubt, solve most soil degradation problems in his region. After what he has seen on his own farm, he said that it would be very difficult to go back to conventional tillage.

The soil conservation practices demonstrated by Bob McNabb and other local innovators have been quietly observed by some farmers in the district despite their initial doubts. He told the Committee that there has been a increase in the number of farmers in his area who have purchased seed drills with the intention of slowly getting into zero tillage through the production of winter wheat. Furthermore, the number of farmers in his area who have cut down on the frequency of tillage has increased.

The Morrells,

Qu'Appelle, Saskatchewan

Harold Morrell, who farms near Qu'Appelle, Saskatchewan, was faced with destructively creeping salinization. On the north half of one of his four sections, some 8 to 10% of the land suffered severe yield reduction. Elsewhere, nearly 10% of the land showed some reduction in yield from salinity. He was concerned particularly by the accelerated advance of saline areas during the 1970s. His observations have been confirmed to the Committee by the Saskatchewan Wheat Pool in their brief; a recent survey indicated a significant growth of salinization in southeastern Saskatchewan. This is in addition to the severely affected areas in the province, centered on Yorkton-Watrous and Rosetown-Swift Current. Harold had read articles in the farm papers by Dr. Don Rennie and others on the causes and control of salinization. He realized that something had to be done to stop its advance on his farm. A discussion one evening with the director of the Indian Head Research Station helped to focus his counter-attack.

In 1946, Harold and Edna Morrell had undertaken to finish clearing the home section (640 acres). At that time, there were three quarters of arable land and one quarter under poplar. On the rich clay loam soil, Harold grew wheat, oats or barley in the common two-year grain-fallow rotation. His cattle grazed on about 70 acres of native pasture and other land that was sown to oats. On

A large, low-lying saline patch that grew very little wheat and so continues to be blackened earth until the Morrells overcome salinization.

the higher land, there were some recharge areas around sloughs surrounded by poplars, willows and native grass. The significance of the natural vegetation of these areas in the process of salinization was not recognized then and they were cleared at the same time as the adjacent land. About 10 years or more afterward, the

Crop residue cover reduces erosion.

first small saline seeps appeared on lower land. The problem got worse as the grain-fallow rotation continued in use.

Five years ago, Harold Morrell and his son Gordon, who together farm the four sections, decided to eliminate summerfallow from their cropping pattern as a major thrust in their attack on salinization. Since there were no longer any cattle on the farm, there was no use for alfalfa that could be planted on the recharge areas or for salt-tolerant wheat grasses or rye grasses that could be planted on saline seeps as recommended by the Warner Dryland Salinity Control Association in Alberta. Consequently, their soil management program is centered on continuous cropping of wheat and oilseeds in a three-year rotation, with about two-thirds of the acreage in wheat. Weeds are controlled with suitable herbicides. When the land is cultivated in the fall, nitrogen fertilizer is deep banded and a heavy covering of crop residues is left on the surface to minimize water and wind erosion.

The changeover process from summerfallow to continuous cropping required some changes in machinery, in the use of herbicides and fertilizers, and in operating procedures. Since press drills were not effective in the heavy grain stubble left on the surface, the Morrells purchased an airseeder which can be used to band fertilizer as well as do a good job of seeding. To obtain the additional yield benefit of good contact between seed and soil in this kind of seedbed, a packer was added to the machinery inventory. As the weed pattern changed in this cropping system, specific herbicides were needed to deal effectively with such weeds as Canada thistle, without leaving harmful residues for the following oilseed crop. The usual herbicides for the control of wild millet, wild oats and other grasses in oilseeds also were applied. Under continuous cropping, more fertilizer is needed than in the wheat-fallow system and, therefore, soil testing becomes even more economically important. Furthermore, on the acreage farmed by Harold and Gordon, it was difficult to obtain their total increased requirements of fertilizer from local dealers. Consequently, when Gordon hauled oilseeds to more distant markets, he backhauled fertilizer to be stored in suitable bins beside the machinery shed.

Good husbandry practices are followed elsewhere on Sunnyhills Farm. An evergreen windbreak surrounds the farmstead and affords shelter from the ceaseless prairie winds to a fine garden maintained by Edna Morrell. In addition to vegetables, she grows strawberries, raspberries and apples within the windbreak. Gordon Morrell maintains several hives of bees here to provide an ample supply of excellent honey.

The continuous cropping system used by Harold and Gordon Morrell is producing good results in their fight against salinization. The major success is that it has stopped the spread of salinity. Furthermore, production on the less severely salinized areas is being improved. On these areas, wheat is yielding two-thirds or better of the after-fallow yield and oilseed yield is equal to after-fallow yield. Finally, the severe saline seeps, which had been blackened land, are beginning to grow some wheat again. In a few years, Harold expects to see a more significant improvement on these locations. Furthermore, the savings in fuel costs from reduced cultivation partly balance the costs of additional fertilizer and herbicides. When grain prices are good, the revenue from the increased production of the continuous cropping system covers the additional costs of having more land in crops.

The chief problem the Morrells have experienced with their continuous cropping system has been the availability of effective herbicides against perennial weeds, without leaving harmful soil residues. In recent years, they had a problem with one herbicide recommended for Canada thistle in cereal grains, for which complete residue information was not given in the initial recommendations. It had adverse effects on succeeding canola crops and on the crop rotation. Fortunately, newer herbicides do not have such residue problems. Another aspect of their system, which is not necessarily a problem, is that it requires a lot of steady work after harvest to finish the necessary cultivation and combined fertilizer application. Additional fall cultivation is needed on land being sown to oilseeds, in order to prepare a finer seedbed with less surface trash that adversely affects the early growth of the oilseed crop.

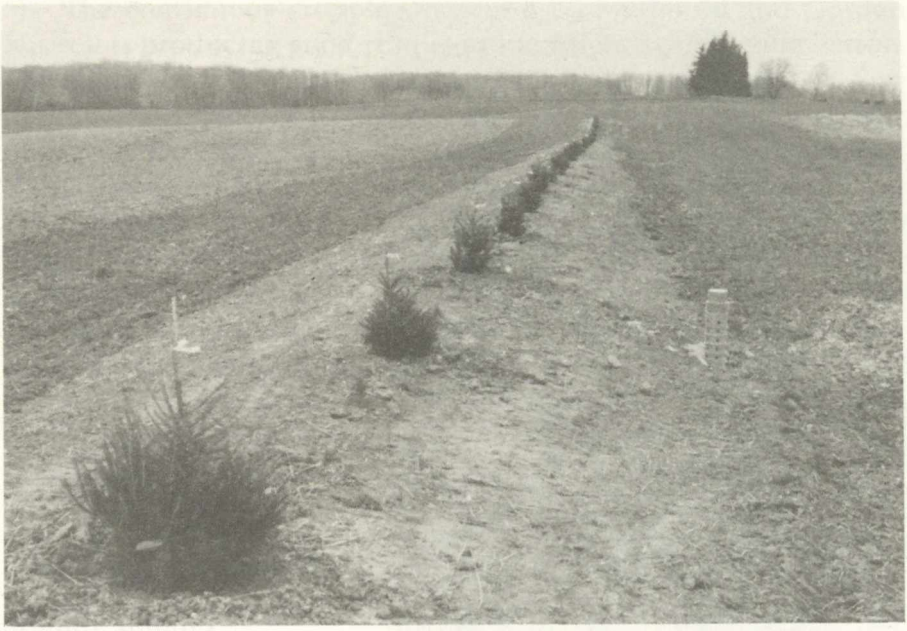
The Morrell family of Sunnyhills Farm are on the way to winning their war against salinization but it remains a serious problem on many other farms in that region. Although the operators of other farms recognize the problem, they have not changed their cropping systems yet because it is difficult to change radically one's traditional ways of farming. Additionally, the capital costs associated with the changeover are an inhibiting factor.

The Lobbs,

Clinton, Ontario

Donald Lobb, who operates a cash crop farm near Clinton, Ontario, is in the habit of making farm management decisions based on sound economic reasoning. As his farming operations and those of neighbouring farms shifted increasingly into cash crops, the evidence of soil erosion and degradation accumulated. The area became more affected by water erosion and occasional wind erosion. On his own farm, Donald saw rills and washouts. Municipal drainage ditches were filling with soil at an increasingly rapid rate, adding to his assessed costs. Even his grassed waterways contained topsoil from higher cropland. During a period of 12 years between 1970 and 1982, about 10 inches of topsoil had been transported to the bottom of a sloping field in a half acre watershed on his farm. The economic significance of these observations was brought home by the decline in yields from the tops of knolls and slopes where erosion was occurring. There was a measured 23% reduction in yield between these areas and adjacent depositions of topsoil. The yield losses were not caused by a lack of phosphorus and potash, as shown by soil tests, but more likely by a reduction in organic matter on the eroded locations. Consequently, he recognized the importance of keeping the soil and its organic matter intact.

The encouragement and necessary information to help Donald to tackle these soil erosion problems came mainly from American



Modified terrace with inlet pipe to subsurface drains and evergreen windbreak control both water and wind erosion.

sources. The American farm magazines to which he subscribed were constantly describing the problems of soil erosion and stressing the need for soil conservation. When he attended conservation field days in Michigan, the people there emphasized short-term

Zero tillage, with winter wheat planted through soybean crop residues, completes the erosion control measures on the Lobb farm.

economic considerations like saving fuel, machinery costs and time, along with saving soil. They knew that conservation practices are adopted primarily for their economic advantage and not for idealistic reasons. Donald Lobb credits their enthusiasm for encouraging him to undertake soil conservation measures on his farm. He noted that other farmers have been similarly influenced. Most of the farm groups in Ontario that are actively carrying out soil conservation and making it work, trace their beginning back to a trip to the United States where they saw these practices being used successfully.

The Lobb family, Donald, Alison and their children, have farmed this land since 1961. Donald had graduated from the Western Ontario Agricultural School in the preceding year. At first, some 40% of the acreage was in forage for their beef cattle and sheep enterprises. There was no visible erosion in those years. More recently, when cash crops dominated the 450 acres, the need for soil conservation measures intensified.

Donald's awareness of wider conservation concerns brought him into the Soil Conservation Society of America (Ontario Chapter). In 1983, after serving in the Huron Soil and Crop Improvement Association, he became the founding Chairman of the Huron Soil and Water Conservation District, the first grass-roots soil conservation movement formed in Ontario. Its foremost objectives are to co-ordinate the resource conservation efforts of various provincial government departments and agribusiness; to develop crop production systems which effectively reduce soil losses and thereby economically sustain production; and to promote the best conservation measures applicable to specific situations.

The present combination of conservation practices on Donald's farm includes the arrangement of fields across the slope wherever possible, grass waterways, a modified terrace system with drop inlets connected to subsurface drains, windbreaks on the berms of terraces or elsewhere along the margins of fields to intercept the prevailing westerly winds and reforestation of rough land. A four-year rotation is used. It comprises two years of corn, one year of soybeans and one year of cereal grains (winter wheat or barley). In addition, no-till cropping practices are applied on rolling land to about 40% of the crop acreage. Tillage is reduced to a minimum on the remaining land.

The development of these practices occurred over a period of 15 years. After the initial construction of grass waterways, the

fields were rearranged to allow cultivation across the slope wherever it was practical and new windbreaks planted. Fortunately, much of Donald's farm has reasonably uniform slopes which made such an arrangement widely applicable. Drainage was installed to reduce surface runoff. Crop production was based on the rotation described above. However, even this combination of practices was not enough to minimize soil erosion. In 1981, after several months of gathering information, Donald Lobb commenced with no-till crop production. He had recently acquired a no-till planter. This first year was spent in just trying to understand the system and gain some experience with equipment, weed control and other practices. During the next two years, he carried out numerous comparisons of production practices within the no-till system to adapt it to his land which includes several soil types ranging from sandy loam to clay loam and clay. Each year, he based these comparisons on specific objectives to evaluate crop sequence responses, crop variety responses, cover crop management and weed control products and methods for the no-till system. Furthermore, he built the modified terrace system and seeded buffer strips along the drainage ditches. Considering the progress he was making in the adaptation of zero tillage, it was time to purchase a seed drill designed for the system. By 1984, about 40% of his crop acreage was managed profitably under zero tillage.

As Donald becomes more familiar with the no-till system and learns how to extend it to less well-adapted soil types, he expects to have 60% of his cropland under this system which would then control most of the erosion. The remaining 40% of the land is much less affected. He admits that there is much to learn in order to achieve this target. However, he believes that the necessary expertise will be acquired from comparisons between production practices within the no-till system itself. In Donald's opinion, this is where the priority must be to advance the development of the system. Fair comparisons between properly applied no-till practices and conventional practices serve as benchmarks only to measure progress in learning how to use the new system.

The results so far have been encouraging. On a sandy loam soil, well adapted to no-till, barley and corn under zero tillage have outyielded conventional tillage. Although the results have been variable and sometimes with reduced yields, depending upon the site, Donald's record corn yields have been produced with zero tillage. With regard to corn, some of the variation in yield under this system depends on the variety used on a particular soil. It is also known that crop yields under no-till return to normal after the sys-

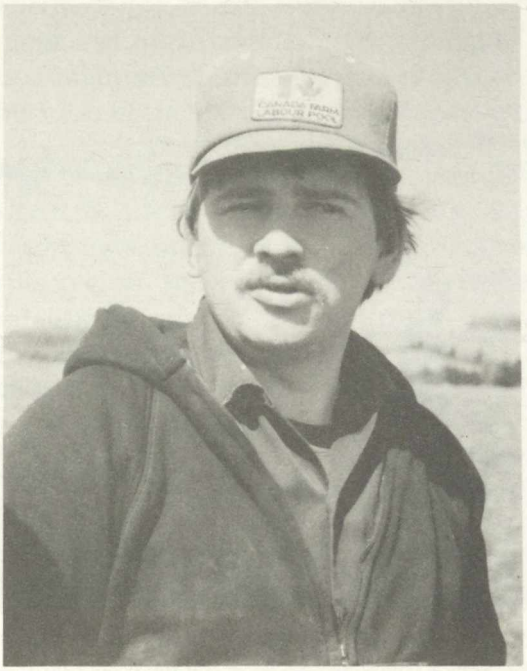
tem has been in operation for several years. Furthermore, corn production under zero tillage on clay soils is more successful with a crop rotation. Consequently, there is a need to develop a complete crop production package adapted to the new system.

While there is some increase in costs during the adaptation period, Donald Lobb is looking forward to lower operating and capital costs with the no-till system. As the percentage of cropland under zero tillage is increased, he anticipates substantial savings in total machinery costs and labour for the pre-harvest phases of crop production, possibly as much as 40% less than conventional tillage. These savings easily offset increased herbicide costs. His experience indicates also that large tractors may be replaced with a size smaller, thereby contributing to lower costs. The total investment in machinery for the no-till system will eventually be less than what would be required for conventional tillage. There is also a levelling-off in the seasonal workload with the no-till system, particularly during the planting season and harvest. One other noteworthy benefit is that the system keeps a farmer off the land during the wettest times in the spring and fall, which helps to reduce soil compaction problems. Donald expects that it may take 10 years to see all the benefits of zero tillage.

The main problem areas are weed control and properly designed seeding machinery for zero tillage. The weed pattern changes from prevalent annual weeds to perennial weeds which may, however, become confined to patches easier to control by spot treatments. However, the availability and registration of effective and economical herbicides to deal with the changing weed pattern is the most critical problem. Manufacturers of herbicides cannot always justify the cost, in our small market, of getting a registration in Canada for some product available to farmers in other countries. Canadian farmers need help with this problem because suitable herbicides are essential components of the no-till system. The machinery companies are developing equipment that will be better adapted to zero tillage. Although suitable corn planters are more readily available at reasonable cost, seed drills are almost prohibitively expensive. Consequently, farmers adopting no-till are making various adaptations on their existing seeding machinery to make it more effective.

One other serious problem, even for Donald Lobb, is the lack of a technical support service knowledgeable in conservation tillage systems and able to advise farmers about the most suitable practices. Without such a service, the adoption and adaptation of new tillage practices are delayed.

Donald Lobb concludes that the no-till system will effectively control soil erosion on his farm and sustain the productive potential of the land. It will also maintain crop yields and reduce his production costs. However, there is a need to approach the new system with caution and not to expect everything to work immediately. One should not make too many assumptions based on experience with the system elsewhere, but learn to adapt it to the specific conditions on one's farm.

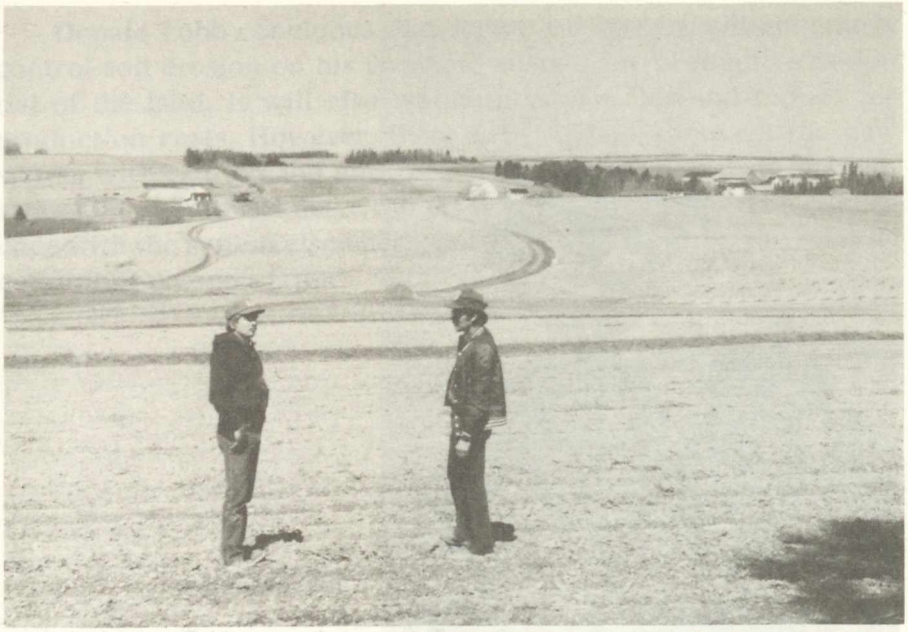


The Laforges,

St. André, New Brunswick

On this hilly farm near the village of St. André in the county of Madawaska, New Brunswick, the crop rotation based on the two main enterprises of potatoes and dairy cattle had not been entirely effective in keeping the soil in place. In relatively recent years, when the farm was enlarged and advanced technology was applied to crop production, it was more economical to plant a complete field to potatoes or some other single crop, usually up and down the slope. But erosion worsened as more water was moving down these long slopes. Every spring, Jacques Laforge saw small gullies about a foot deep on land that was bare over the winter. On the slope of potato fields, he saw fewer and smaller potatoes per hill. The information about soil conservation that was reaching farmers contained a frightening outlook on soil erosion. Jacques realized that he had to develop a more effective system to control the flow of water across his fields and to preserve the soil, not only for economic advantage in the near future, but also for his children's future. He knew that, in order to survive in an increasingly complex agriculture, it was necessary to maintain the productivity of the soil.

While working with his father prior to taking over the family farm in 1979, Jacques had witnessed these developments. As a young farmer representing the third generation on this land, he and



Contoured diversion terraces leading into a grass waterway, contour tillage with a chisel plow, strip cropping and crop rotations form a complete soil conservation system on the Laforge farm.

his wife Patricia together with their three children, depend entirely on the productivity of the farm for their livelihood. It is rolling land with long, complex slopes typical of much of New Brunswick's northern potato region. In past years, the crop rotation was two years of potatoes, followed by one year of grain (oats) and two years of grass (clover, timothy). At first, the fields were small and usually divided the slopes between potatoes and hay. The soil was in fairly good condition then, without severe erosion. As the trend to specialization in potatoes swept through the upper St. John River Valley, the fields were enlarged for single crops and erosion problems increased. Cultivation was changed to go across the slope with some benefit. However, the change of field direction and the rotation were not totally effective in reducing erosion to a tolerable level.

Jacques Laforge demonstrates a keen appreciation of these past developments and of progressive new directions. He is noted as an innovator willing to try new things and for his active role in several farm and community organizations. Among these, the Grand Falls Soil and Crop Improvement Association continues to be very supportive of his conservation efforts. In 1983, he was selected by the Association, at the local and provincial levels, to be a delegate to the Canadian Federation of Agriculture soils seminar in Ottawa.

Furthermore, because of his soil conservation efforts, farm management and organizational work, Jacques Laforge was among the top nominees selected by the Sussex Jaycees in the 1984 Maritime competition of their Outstanding Young Farmer Program.

In the present soil conservation system, diversion terraces are used to direct water safely across 8% slopes to rock-lined grass waterways. According to a new approach to soil conservation in this region, these terraces are spaced widely enough apart to permit strip cropping between them. This system is also well-adapted to mixed farming. On some 315 acres of tillable land, a crop rotation is followed to maintain the organic matter and productivity of the soil. It consists of one year in potatoes or peas, followed by one year in grain and two years in hay. This rotation is supported by the production of seed wheat and the dairy enterprise. The production of row crops one year in four helps to better maintain better the structure of the soil, but requires some compromise between needing more land or planting fewer acres in potatoes. Manure is applied in this rotation to reduce fertilizer costs. Alfalfa is also grown to improve the soil and to provide better quality forage for the dairy cattle. Although mixed farming operations are not typical of most potato growers, the Senate Committee was told that some growers are now entering into co-operative arrangements with neighbouring dairy farmers for the purpose of getting hay into the rotation on potato farms. In this exchange, potatoes are planted by the grower on an agreed area of the dairy farm.

Soil conservation on the Laforge farm began in 1980 with a comprehensive farm survey to map soil types and topography prior to designing the engineered structures and the soil management program. This work was done by a soil conservation engineer based at the New Brunswick Department of Agriculture office in Grand Falls. The terraces and grass waterways were constructed in 1982 with financial assistance from provincial grants sponsored under a five-year federal-provincial agricultural development program. Then the contour cropping and rotation commenced on the arable land. A further practice of sowing oats immediately after harvesting peas was used to provide some protection against erosion. The oats were pastured during the early fall, then left uncultivated until the spring. In 1983, Jacques purchased a chisel plow to begin minimum tillage on some of the arable land.

This soil conservation system effectively keeps the soil in place and prevents the formation of gullies. In potato production, it has given higher yields and more grade one potatoes per acre. With

contour cropping, potatoes are more evenly sized throughout the field. The prevention of soil erosion keeps the organic matter in place and thereby contributes to improved crop production. There is also a substantial saving of fertilizer and lime that are not washed off the land. Consequently, within a few years, the application of phosphorus and potash could be reduced. Furthermore, the contour cropping and minimum tillage practices have contributed to a significant reduction in fuel consumption to compensate for the increased time or labor of fieldwork on the contoured land.

The chief problem in this system for Jacques Laforge was the cost of engineering work on the diversion terraces and grass waterways. Fortunately, the provincial grants defrayed about 50% of the cost. Consequently, he will begin to recover his own investment in these structures within five years. Beyond that period, he expects the economics of soil management to become more favorable. In his case, the payback period is shortened because previous practices had lessened the deterioration of the soil. However, he must endeavor to improve the productivity of his soil by means of crop rotation. Such an improvement could enable him to obtain the required production of potatoes from fewer acres and to increase the output from other crop and dairy enterprises. Finally, as new machinery is purchased for cultivation and harvesting, he will have to consider smaller equipment adaptable to contour cropping, yet economical to operate.

In summary, this soil conservation system is effectively controlling water erosion on the long slopes of Jacques Laforge's farm. His soil management practices will certainly keep the land in a well-maintained state for his children. In the meantime, he is demonstrating that good soil conservation goals can be more readily achieved in a mixed farming operation. His example will help to promote a better appreciation of such a soil conservation system throughout his community.

Glossary

Acid Soil: A soil having a pH of less than 7.0 due to an excess of hydrogen ions (H+). Ammonium and potassium fertilizers contribute to soil acidity.

Acre: A measure of land 4,840 sq. yds. or 0.405 hectares.

Chisel Plough: A type of very heavy cultivator, with large section tines, the points of which incline forward, and are drawn through the soil at a depth greater than in normal ploughing. The underlying layers are burst without subsoil being brought to the surface.

Compaction: The process by which soil loses pore space by means of impact.

Conservation: 1. The optimum rational use of natural resources and the environment, having regard to the various demands made upon them and the need to safeguard and maintain them for the future. 2. The protection of the soil against erosion or loss of fertility.

Erosion: The wearing away of the land surface, particularly soil, by running water, ice and wind, etc. Ploughing up and down slopes can lead to gully formation, and light and friable soils can blow away in strong winds when exposed, usually in the spring.

Forage: Certain crops consumed in the green state by livestock, particularly cattle and horses.

Grass Waterway: A grassed channel that is provided to carry stormwater away from a point where it is likely to cause erosion.

Hectare: A metric unit of land measure. 10 000 sq. metres. Equivalent to 2.471 acres.

Humus: Soil made from decayed vegetable matter, containing valuable plant foods.

Monoculture: The growing of the same crop on a field year after year.

Mouldboard: A curved steel plate on the body of a plough which turns over the furrow slice. Also called breast or shell-board. Design varies according to the type of plough. The general purpose mouldboard is almost flat and is twisted along its length, producing a continuous almost unbroken furrow slice.

Rotation: A cropping system in which two or more crops are grown in a field in a fixed sequence. One of the benefits of rotation include

reduced accumulation of disease and pests which accompany monoculture, weed control, the maintenance and improvement of fertility, spreading the risk of specific crop failure. In recent years farming has moved away from rigid traditional cropping programmes to more simplified systems due to various developments. These include the production of pesticides and artificial fertilizers, improved and increased mechanisation, and guaranteed crop prices.

Saline Soil: Soil containing enough salts to interfere with crop growth.

Soil Degradation: The process by which the productive capability of the soil is diminished ie. by erosion salinization compaction, acidity, etc.

Summerfallow: Land left unsown, usually for a season to conserve moisture in the soil and to allow the accumulation of nitrogen. During this period the land is ploughed and cultivated to kill perennial weeds by desiccation. The practice of fallowing is now less common.

Terrace: A horizontal or gently sloping ridge or offset made in a hillside to conserve moisture or to minimize erosion.

Tilth: The physical condition of the topsoil after tillage. A fine tilth consists of small clods and loose, crumbling soil particles. In a coarse tilth, comparatively large clods constitute most of the broken material.

Ton: 2 000 pounds or 0.907 tonnes.

Tonne: 1 000 kilograms equal to 2 204.6 pounds or 1.102 tons.

Watershed: A region or area bounded by a water parting or draining ultimately to a particular watercourse or body of water.

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Appendix I

Degradation of Canadian Soil Resources

The physical processes of soil degradation are many and varied. While there is often a close relationship between the various processes in a given area, they are in fact quite distinct and are usually the result of differing causative factors. To simplify their examination, processes of soil degradation can be divided into three broad categories: loss of soil material; chemical deterioration; and physical deterioration. Each of these categories will be discussed briefly in this chapter as to the nature of the problems and their extent in Canada.

Physical processes do not result in serious degradation of soils without the interference of man. Agricultural practices can make the problems much worse. In recent years, changes in the economics of agricultural production have promoted the adoption of certain practices contributing to soil erosion. These practices include the extension of cultivated land and cropland, the extension of row crop acreage in Eastern Canada, the maintenance of extensive summerfallow in Western Canada and reduced utilization of grasses and legumes in crop rotations. Particularly during the 1970s, diminishing returns under the cost-price squeeze increasingly pressured farmers to change their farming operations and land use, simply to maintain or improve the viability of their farm businesses. Farmers increased the proportion of land sown to crops yielding higher returns such as wheat in the Prairie Provinces and corn, soybeans or other profitable row crops in Eastern Canada and British Columbia. Technological improvements in corn and soybean varieties, in machinery and in herbicides, encouraged the regional expansion of these crops as well as the expansion of monocropping. Increasing specialization in cash crop farming greatly diminished the use of rotations incorporating forage crops for livestock. Land use was intensified through increasing the area under crops, using bigger machinery and developing larger fields. Farmers also increased the scale of their operations through the purchase of additional land often at prices which, in some regions, exceeded the immediate net retuns per unit of the new land. The increased capitalization for production improvements and larger farms, together with increasing interest rates, exacerbated the cost-price squeeze and added to the pressure for increased output from the land. Quite clearly, there are factors other than the physical nature of the soil which determine the extent of soil erosion.

A. Loss of Soil Materials

1. Erosion by Water

Erosion of soil by water is the most widespread type of soil degradation and occurs in all provinces to some extent. In fact, this type of erosion occurs, at least in a minor way, on all soils under the action of rainfall, melting snow, furrow irrigation and streamflow. The adverse effects of rainfall are widespread, but damage by the other agents can cause serious local problems if allowed to continue without control.

Water erosion occurs on sloping land when the intensity of rainfall exceeds the capacity of the soil to absorb it, resulting in runoff. The degree of erosion by rainfall is determined by five major factors:

(i) the soil's resistance to being broken down by raindrops or running water, which is a function of particle size distribution, organic matter content, permeability, degrees of aggregation and structural stability;
(ii) the intensity of rainfall or runoff events;
(iii) the degree and length of slope, which determine the amount and rate of runoff concentration;
(iv) the presence of frozen layers in the soil profile; and,
(v) the vegetation cover or residue which protects the soil from raindrop impact and retards runoff and soil movement.

Erosion by water can remove many of the nutrients needed for crop growth. It can also remove fine-grained soil particles and soil organic matter, reducing the capability of the soil to support plant growth. Erosion by water can also reduce the volume of topsoil and consequently the water-holding capacity. A thin topsoil also leads to poor root development which, in turn, means uneven crop growth.

At any one locality, a number of these factors may act together to determine the potential for erosion.

The steepness and length of slope have been noted as factors which affect the rate of water erosion. In general terms, steeper and longer slopes suffer more water erosion. For example, field measurements have shown that, under similar soil and climatic conditions, a 14% slope 72.0 feet (24 metres) long could lose

approximately twice as much soil as a "standard" slope (given as 9% and 72 feet (22 metres) long), or up to four times as much if the same slope was 295.0 feet (90 metres) long. Longer slopes receive the accumulated runoff from higher land.

As noted above, the vegetation cover is also an important factor in determining the degree of water erosion. Crops differ in their ability to control erosion. Row crops such as corn and potatoes give little protection to the soil because the crop does not provide a canopy against falling rain until late in the season and widely spaced plants offer little resistance to runoff. Small grains give medium protection, but summerfallow used in conjunction with grain production in some areas, offers no protection. Legumes or grasses for hay and pasture give a high degree of protection as well as improving soil structure against erosion under subsequent crops.

While soil erosion by water is found in all parts of Canada, it is particularly serious in the following areas: the potato fields of Prince Edward Island and New Brunswick; the corn belt of southern Ontario and Quebec; the escarpment area of Manitoba; the Peace River region of Alberta and British Columbia; and the lower mainland of British Columbia. In each of these locations, the factors contributing to high rates of water erosion are different.

One example of how such a combination of factors can result in a serious water erosion problem can be found in Atlantic Canada where potato monoculture is the predominant farming enterprise. The areas from which potatoes are harvested in the fall are generally left bare over the winter. This leaves the soils exposed to the high fall and winter rainfalls at a time when the naturally slow permeability is reduced even further by freezing. The soils are bare during the freezing and thawing of early spring, allowing more erosion to occur. In addition, fence row removal to accommodate larger and heavier machinery has added to the problems of longer slopes (on which greater water erosion occurs). This example clearly shows the complex interaction of physical factors and management practices in determining a soil's susceptibility to water erosion.

Why should we be concerned about soil erosion? It is a matter of concern because, eventually, it causes significant reduction in crop yields. For example, research in the United States and Canada has established that the loss of one inch of topsoil can reduce wheat yields by about 1.5 to 3.4 bushels per acre (102 to 229 kilograms per hectare). Cropping and tilling practices can have a

dramatic effect on the rate of water erosion. For example it has been determined in Alberta that in two years of a fallow-wheat rotation, soil erosion totalled 13.3 tons per acre (30 tonnes per hectare).

The effect of such removal on soil productivity can be further illustrated by the following example. On a dark brown soil (chernozem) with 8 inches (20 centimetres) of topsoil removed, the average yield of wheat over eight years of continuous cropping was 8 bushels (540 kilograms per hectare). This can be compared to a yield of 22 bushels per acre (1,500 kilograms per hectare) on a similar but non-eroded soil.

On soils which have poorer structure in the lower horizons than these dark brown soils, even greater yield reductions could be expected. In fact, it has been estimated that some 30% of cropland in the Prairie Provinces is exposed to potentially serious productivity losses from water erosion.

The losses of yield and plant nutrients caused by soil erosion are not insignificant in monetary terms. At 1980 prices, the difference in yield of wheat between the above-mentioned eroded and non-eroded dark brown soils cropped on a 2-year rotation with fertilizer was valued in one study at $16 per acre ($40 per hectare).

If soil nutrients are lost to erosion they must be replaced by the use of additional fertilizer. This replacement is a costly process. The Agricultural Institute of Canada's (AIC) Task Force on Soil Erosion estimated that the additional annual replacement cost of nutrients lost by erosion was in the range of $6 - $12 per acre ($15 - $30 per hectare). The value of nutrients lost by erosion was estimted at $11 per acre ($28 per hectare) in potato fields in Prince Edward Island and at $10 - $12 per acre ($25 - $30 per hectare) on sloping fields in British Columbia. Erosion does not only cost farmers in terms of lost yield and fertilizer. Canada, in fact, loses a part of its agricultural heritage as the limited areas of vitally important Class 1 and 2 soils are permanently degraded by erosion to lower capability categories.

The regional impact of yield reductions and losses of nutrients and pesticides can accumulate to substantial sums. In a recent joint study, the Ontario Ministry of Agriculture and Food and the Ontario Institute of Pedology estimated that the annual total soil erosion costs on cropland across the southern part of the province alone were about $68 million. In the five counties with the greatest erosion losses (Kent, Elgin, Middlesex, Oxford and Huron), the

total loss by water erosion averaged about $15 per affected acre ($37 per hectare) of row crop and small grains.

2. Erosion by Wind

Wind erosion begins when loose particles on the soil surface are detached by the intensity of the wind and bounce along the surface to dislodge others. A less important, but still significant, process in wind erosion is surface creep, which is a sliding and rolling motion of heavier particles. The most visibly striking wind action of the wind is the suspension of fine particles in turbulent air being blown away as clouds of dust.

As in the case of water erosion, a number of important factors determine the rate and severity of wind erosion. The main factors are:

(i) the resistance of soil particles to being moved along the ground by the drag of the wind, which is determined by the size of the soil particles and their aggregates, and their moisture content;
(ii) the velocity of the wind, which depends partly on the shelter provided by windbreaks and crops;
(iii) the roughness of the soil surface, which determines the drag of the wind at the surface itself; and,
(iv) the plants or crop residues on the soil surface, which protect it from the wind.

Wind erosion is primarily a problem in regions with a dry climate, and with fine sandy soils. Particles larger than fine sand are heavy enough to resist the prevailing wind speed and smaller particles tend to clump together and form larger aggregates. However, all soil types will suffer from wind erosion if they are sufficiently dry and/or the wind speed is high enough.

If one looks at the combined effects of soil conditions and climatic factors, the areas with highest wind erosion risk are the brown soil zone of southwestern Saskatchewan and southeastern Alberta; the sand plains of Norfolk and Elgin counties in Ontario; around Cape Tormentine in New Brunswick; part of the Annapolis Valley of Nova Scotia; and the eastern two-thirds of Prince Edward Island.

While they can do nothing about the climate or the soil type, it is nonetheless possible for farmers to affect the degree of wind erosion. They can alter field width, plant or residue cover and surface

soil roughness. For example, by keeping areas of exposed soil to narrower widths, as in alternate fallow and strip cropping aligned crosswise to prevailing winds, soil loss is reduced. Windbreaks are another obvious method by which wind erosion can be reduced.

The type of residue cover left on the soil is another of the factors within a farmer's control. There is a great variation in effectiveness at reducing wind erosion, depending on the type and degree of cover. For instance, on a given soil the maximum soil loss from wind erosion, with no vegetative cover, is 71 tons per acre (160 tonnes per hectare) per year. By leaving a fairly heavy trash cover (890 pounds per acre, or 1,000 kilograms per hectare), the loss could be cut by 60% to just 31 tons per acre (70 tonnes per hectare) per year. Using cover is a more effective control mechanism than reducing the width of exposed land. Even without cover, forming the soil into ridges, another factor under the farmer's control, is almost as effective as 890 pounds (1,000 kilograms) of trash cover on unridged land. The combination of that quantity of cover and ridging gives maximum reduction of soil loss.

It is not possible to accurately measure the extent or severity of wind erosion. Visual observations of blowing or drifting soil are relied on to indicate the existence of the problem. In recent years, western farmers have been relaxing their efforts at preventing wind erosion, efforts which were very strong in the years following the "dust bowl". For example, windbreaks are being removed to accommodate larger machinery. As a result, the wind erosion problem is once again increasing in severity and extensive drifting occurred in the spring of 1976 and 1981 and 1984. Clearly, continued vigilance on the part of farmers is required to keep this problem from becoming more serious.

The widespread use of summerfallow in the Prairie Provinces is a practice which exposes large areas to wind erosion. It is a common practice on over 40% of the cultivated land in the brown soil zone of southeastern Alberta and southwestern Saskatchewan.

The reasons given by farmers in Western Canada for summerfallowing tend to be region-specific. For example, moisture conservation is given most frequently as the primary reason in southeastern Alberta and southwestern Saskatchewan. In other regions, weed control, nitrogen release and fertilizer saving are stated more often as important reasons. Where soil moisture is adequate, the acreage of canola is more extensive and continuous cropping of cereal grains more frequent, perennial weeds can become a serious

problem. Summerfallow is perceived as being an effective method of control for such weeds. Moreover, summerfallow is known to accelerate the release of nitrogen in the soil and thereby reduce short-run fertilizer costs.

In all regions, farmers recognize that yields of grains and oilseeds are more reliable after summerfallow than after stubble. Consequently, the fallow is used for crops with the highest payoff, namely wheat and oilseeds. Since this effect is greater in the drier regions, the use of summerfallow to increase moisture and nitrogen levels in the soil has some rational basis from the farmer's point of view.

The principal economic factors that determine the use and extent of summerfallow in drier zones of the Prairie Provinces are reducing operating costs, minimizing income variability and maximizing net income. The cost of soil erosion to the Prairie Provinces may be estimated in part by looking at the fertilizer which must be used to offset related yield reductions and by calculating the lost income associated with reduced yields.

It is estimated that the annual soil loss on the Prairies by wind is about 176 million tons (160 million tonnes) and by water is approximately 129 million tons (117 million tonnes). Since this rate of erosion greatly exceeds the rate of soil formation, the soil losses and their effect on crop yields are cumulative over the 65 years during which prairie soils have been farmed. Consequently, the present total loss of potential grain production is estimated to be equivalent to 171 million bushels (4.6 million tonnes) of wheat. To recover part of this loss, additional fertilizer valued at $239 million per year must be added. Up to 15% of the lost production cannot be recovered by additions of fertilizer and this loss is estimated to have been $129 million at 1981-82 wheat prices. The total measurable cost to the Prairie Provinces therefore is presently about $368 million per year or an average of $5 per acre ($12.31 per hectare) of cultivated land.

From the estimates of soil eroded, nearly 58% of that total cost is caused by wind erosion. If soil losses continue at the estimated rate, the total cost will also increase by about $5.66 million each year. In addition, there are other less easily quantifiable costs such as increased power requirements for tilling eroded land, removal of severely eroded land from production and damage to growing crops.

Other parts of Canada also suffer from wind erosion, although to a lesser degree. In Eastern Canada, susceptible soils are exposed

to wind erosion by the increasing use of row crops and monoculture in cash crop farming and a trend toward crops that leave soils with insufficient cover after harvest. For example, on some sandy soils in southern Ontario there has been a shift from tobacco to corn and the consequent elimination of a winter cover crop of rye. In the Maritime Provinces, intensified production of row crops (corn, vegetables and potatoes) and reduced off-season protection of the soil by crop residues or cover crops are the principal predisposing factors in wind erosion.

3. Loss of Soil Organic Matter

In their natural state, soils reach an equilibrium with respect to soil organic matter. Plants grow in the soil, utilizing nutrients held in the organic matter. Each year plants lose some or all of their leaves or needles, or they die and decay, renewing the organic matter in the soil. When soils are cleared, plowed and tilled, they begin to lose organic matter as the natural balance is upset. Removal of crop residues through harvesting interrupts the cycle of renewal. After a number of years, the soil will again reach a balance between input and loss. The new balance is determined by the crop which is grown, the way in which crop residues are managed, the type and frequency of cultivation, the fertilizer and manuring practices which are used and finally by the climate. In other words, for every area, given the crop management system and the local climate, a characteristic organic matter content will evolve. This new equilibrium level will, however, almost always be less than that which existed in the virgin soil at that site.

Loss of organic matter is of concern because it is such an important component in maintaining agricultural productivity. A significant decline in the organic matter content increases the susceptibility of the soil to compaction and to erosion by water or wind. Furthermore, the organic matter is a major source of nitrogen and micronutrients and it increases moisture retention.

The most common causes of organic matter reduction and subsequent soil deterioration are intensive or excessive tillage, including summerfallow, and insufficient use of legume/grass forage crops in the rotation. Under such conditions, soil organic matter is being broken down faster than it is being replaced. Consequently, the infiltration rate of the soil and its capacity to bear heavy equipment are impaired.

The loss of soil organic matter is a widespread problem in Canada, being primarily dependent on the original organic matter

content of the soils (high on the Prairies and low in the Maritimes) and the effects of cropping practices. For example, while Prairie soils are naturally high in organic matter content, they have lost nearly 45% of their original content since cultivation began there at the turn of the century. Summerfallow is the main reason for this decline. As this practice is reduced, the loss of soil organic matter should slow.

The reduction of organic matter through excessive fallow tillage in the Prairie Provinces increases the loss of nitrogen, thereby necessitating the addition of more fertilizer to offset the deficiency. Nitrogen and phosphorous are already the major nutrient limitations to crop production in Alberta. Obviously, the maintenance of soil organic matter can bring about significant savings in fertilizer expenditures.

In Ontario and Quebec, frequent and excessive tillage are seen as being responsible for decline in soil organic matter content of as much as 50%. The soils of the Atlantic Provinces are naturally lower in organic matter and, particularly in Prince Edward Island, intensive tillage of row crops such as potatoes, accompanied by high rates of water erosion, has resulted in a serious deterioration of soil structure.

In Eastern Canada, in general, crop rotations of row crops and forage crops could raise the percentage of organic matter in the soil by over 25% above that occurring under continuous corn and thereby provide a greater reserve of nitrogen. Furthermore, water-stable aggregates and resistance to erosion would increase.

B. Chemical Deterioration

1. Soil Salinization

Soil salinization is a natural phenomenon often occurring without man's intervention. In general terms, the process involves the redistribution of salts which occur naturally in soils. Water percolates into the soil in one location, dissolving the salts and transporting them as it moves downslope. At a second location, often the base of a slope, a depression or at a point where the slope or the soil type changes, the water again moves toward the surface where it evaporates leaving behind an accumulation of salts at or near the soil surface. The salt flats and saline depressions commonly found in the arid prairie region are the result of this process. The salts involved are usually sulphates, chlorides, carbonates and bicarbonates of calcium, magnesium and sodium.

This naturally occurring phenomenon can be made much worse by man's actions. Most commonly, man intervenes by altering the natural water table and the water flow patterns in soil. The construction of roads, railways, irrigation canals and towns or villages can all cause an alteration in these two important parameters. Such disruptions can lead to salt accumulations in areas where none existed before or to the spread of existing saline deposits. As important as these factors are, they tend to be local in nature.

Changes to the hydrological cycle brought about by certain agricultural practices, on the other hand, are more widespread. The shift away from native perennial grasslands and wooded depressions to annual grain crops is a major factor in the increased incidence of soil salinization problems in the arid prairie regions. The annual grain crops use less water than the perennial ones, leaving more water to percolate into the soil, raising the water table. The higher water table results in more areas where water comes to the surface by capillary action and evaporates, leaving the accumulated salts in the soil. A rising water table in the vicinity of irrigation canals due to leakage or to the excessive application of irrigation water has the same results.

As the above description indicates, salinization is primarily a problem in the arid regions of Canada. Therefore, except for a few sites in the interior of British Columbia, soil salinity is a problem of the Prairies.

It is a problem which usually occurs in small areas of 2 to 25 acres (one to 10 hectares), but when all of these small occurrences are added together, they total some 5.4 million acres (2.2 million hectares) in Canada's dryland regions. To this total can be added 247,000 acres (100,000 hectares) of irrigated land suffering the effects of salinization.

Dryland salinity is considered to be the major soil degradation problem in the Prairie Provinces because of its growing extent and economic impact on agricultural production. The widespread use of summerfallow is implicated as the most important factor contributing to the development of saline seeps. Although there are differences of opinion among soil scientists, it appears that Canada's 5.4 million acres (2.2 million hectares) of salinized soils are being extended at a rate of some 10% yearly and that this expansion will persist, at least in the near future.

Solutions to the problem of salinity in dryland regions include producing crops which use up more of the available moisture. Such

crops include alfalfa and other forages. However, the lack of markets for these crops and the fact that they leave the soil too dry for a succeeding grain crop mean that such control measures are hard to promote. Thus, the problem of salinization in dryland areas will not be an easy one to address.

In irrigated areas, lining canals to prevent leakage and using sprinkler irrigation systems to prevent over-application of water are measures being successfully implemented to reduce the extent of salinization.

Crop yields on salt-affected areas can be reduced by 10% to 75% or more depending on the concentration of salts in the root zone. On the average, yields are reduced by at least 50%. Consequently, the total annual loss of crop production alone from salinity in the Prairie Provinces is estimated to be at least $260 million. Furthermore, given the rate of expansion of saline areas, the farmers of this region are losing an additional $26 million annually.

2. Soil Acidification

Like salinization, soil acidification is a natural process in which easily soluble elements such as calcium and magnesium are removed from the soil and replaced by hydrogen or aluminum, lowering the soil's pH. If the soil has a naturally high level of calcium and magnesium to neutralize the acidity, the process is much slower. Conversely, if the soil is low in these elements, it will be naturally acidic.

In the context of this report, it is not the natural process of acidification which is of concern but rather the accelerated acidification which results from man's activities. The two main causes of accelerated acidification are the addition of sulphur to the soil and the application of nitrogen fertilizers.

Sulphur can be added in its elemental form, as a sulphide or as sulphur dioxide. A variety of chemical reactions in the soil can result in the subsequent production of sulphuric acid, and thus the soil becomes more acidic. Sulphur can be added to the soil through acid rain or atmospheric emissions (from combustion of fossil fuels, sulphide ore reduction and sulphur removal operations at natural gas plants), and through the use of sulphur-containing fertilizers.

The heavy use of nitrogen fertilizers also leads to increased acidity. Again, as with sulphur, chemical reactions in the soil result in the increased acidity.

The risk of soil acidification is greatest in Eastern Canada where soils naturally contain less of the calcium and magnesium ions which can act as a buffer against acids. This is also the part of the country which is subjected to relatively high rates of sulphur and nitrogen oxide deposition from atmospheric sources (acid rain). The areas at highest risk are sandy soils in Ontario (Elgin, Norfolk, Simcoe, Ontario and Durham Counties, plus numerous small pockets in eastern Ontario), almost all of the agricultural soils of Quebec, New Brunswick and Prince Edward Island, and most of the farmland of Southern Nova Scotia and Cape Breton Island.

The addition of lime can help to alleviate the problem of acidification, so that not all of the areas noted above as "at risk" suffer from the problem. Those areas which do suffer from soil acidification under existing management practices include all the areas in Ontario noted above and much of Prince Edward Island. In Quebec, acidification is most serious in the Outaouais and the Lac St. Jean region. New Brunswick's Saint John Valley between Grand Falls and Woodstock and Tormentine area are affected. And in Nova Scotia, the New Glasgow area, Shelburne County and parts of the Annapolis Valley have a serious problem with soil acidification.

Even moderate soil acidity can reduce yields except in crops like blueberries or potatoes which are adapted to or tolerate acid soils. In fact, in the Atlantic Provinces, soil acidity of pH 5.5 or lower is accepted in potato production to control soil-borne diseases such as potato scab. However, in southern Ontario, where soils are subjected to the greatest impact from nitrogen fertilizers and acid rain, acidic conditions unfavourable to good root growth of many crops commonly occur. In Western Canada, acidity below pH 6.5 is considered to limit agricultural production since acidity inhibits the release of nitrogen from organic matter to supply the needs of crops.

Since the yields of forage crops, some cereals and oilseed crops are reduced at pH 6.0 or below, acid-tolerant crops such as oats and rye may be used as a temporary response to soil acidity. The adaptation of farming systems to strongly acid soils is obviously somewhat limited by the narrow choice of cereals and grasses capable of tolerating pH 5.5 or lower.

The maintenance and improvement of crop production on acid soils is most easily achieved by the application of lime. In Alberta and British Columbia, liming can significantly increase the yields

of various crops; for example, alfalfa, by 50% to 100%; barley, by 5% to 15%. Generally, the value of increased yields exceeds the cost of liming.

In Western Canada, estimates relating to acidification due to fertilizer use indicate that a minimum of 358,000 tons (350,000 tonnes) of lime per year are needed just to maintain the present pH levels of the most affected soils. Over twice that amount is needed to raise the pH values of these soils by 0.5 units. Furthermore, without more widespread use of lime, 20% of Alberta's soils will be acidic by 1985 and 40% of the soils in the Peace River region alone will become acidic. Unfortunately, the use of lime in the Prairie region is greatly limited by inadequate supplies and high transportation costs.

Agricultural lime is applied to improved land in Ontario even though many soils in the province are based on calcareous parent materials. However, the rate of liming is only 20% to 25% of that required to neutralize acidity from atmospheric and fertilizer sources. This deficiency is becoming apparent quickly on intensively-farmed sandy soils. In Quebec, where soils are less well buffered, the use of lime is about five to six times the Ontario level. That rate is sufficient at present to prevent increasing acidity.

In the Atlantic Provinces, much larger quantities of lime are applied regularly to improved farmland, varying from an annual rate of 230 pounds per acre (260 kilograms per hectare) in Prince Edward Island to 3,570 pounds per acre (4,000 kilograms per hectare) in Newfoundland. These quantities of lime presently exceed the combined acidity from atmospheric and fertilizer sources. Regular applications of lime in such quantities are necessary because most soils in the region have developed from acidic parent materials and have low levels of organic matter.

3. Soil Contamination

Under this heading we consider the deterioration of soil quality by chemicals other than those already discussed. It is a broad category which includes all other aspects of atmospheric fallout, sewage and industrial sludge disposal, pesticide residues and biological contamination.

Although widely-used herbicides usually do not persist in the soil at levels poisonous to plants for more than a year, decomposition may be delayed in heavy soils and cool climates. After corn

crops, atrazine carryover has necessitated careful choice of crop sequence particularly in Ontario. Some herbicides like paraquat may become bound to clay particles and so become more persistent. This experience raises concern in the Prairie Provinces where increased use is being made of herbicides under minimum and zero tillage.

The disposal of sewage sludge on farmland in British Columbia, some areas of the Prairie Provinces and especially in Ontario is a growing practice that should be more carefully monitored. Although it is a valuable source of nitrogen and phosphorus, sewage sludge contains varying amounts of such heavy metals as mercury, cadmium, arsenic, lead, chromium, nickel, copper and zinc. All of these chemicals can be retained in the soil so there is a danger of incremental buildup, to levels which are poisonous to plants, through repeated applications of sludge. The Ontario Ministry of the Environment has developed guidelines for sewage sludge disposal to prevent excessive heavy-metal accumulation. Not all provinces have in place procedures for monitoring sludge disposal.

Atmospheric industrial fallout is also a source of heavy metals and other troublesome chemicals. It is frequently a problem for limited areas downwind from an industrial source. Examples of that are the deposition of lead and zinc from the smelter at Trail, British Columbia, and nickel, copper, zinc, iron and sulphur from smelters at Sudbury and the Noranda-Rouyn area. The soils of Cornwall Island in eastern Ontario have been alleged to be contaminated with fluorine from an aluminum smelter to the point of affecting animal health. A similar problem associated with aluminum smelting has been observed in the Lac St-Jean area of Quebec. Ontario is threatened by large quantities of industrial emissions from within its own borders as well as from the United States. Furthermore, the fuel consumption of concentrated numbers of motor vehicles also contributes to atmospheric emissions of lead. This whole aspect of soil contamination is one where more effective control measures are needed.

C. Physical Deterioration of Agricultural Land

1. Soil Compaction

Soil can be compacted in a number of ways. For example, repeated loading by heavy machinery pushes soil particles closer together eliminating, or at least seriously limiting, the amount of pore space. Other equipment, such as roto-tillers, breaks up soil

aggregates and vibration from equipment can lead to denser packing of soil particles. Similarly, the loss of soil organic matter, discussed earlier in this report, can also contribute to soil compaction. If soil is worked when it is in a wet condition, such as happens with fall harvesting of potatoes in the Atlantic Provinces, the air is literally squeezed out of the soil, collapsing the soil structure.

No matter which of the above practices leads to soil compaction, it represents a potentially serious deterioration of soil quality. It results in very poor conditions for root growth by inhibiting the movement of air and water through the soil. In the latter case surface ponding, run-off and soil erosion are the end results. Roots cannot penetrate through compacted soil to reach deeper layers which hold additional water and nutrients from which the growing crops could benefit.

The extent of the soil compaction problem in Canada is not well documented. In general terms, however, it is associated with the frequent tillage practices of continuous monoculture row-cropping. Soil compaction seems to be at its worst in areas with either coarse textured (sandy) soils or very fine textured (clayey) soils. Those soils with a mix of particle sizes are more resistant to compaction.

Given the above general statements one can identify areas where soil compaction is a problem. For example, the Lower Mainland of British Columbia has clay soils which are frequently tilled when wet. In addition, the equipment used in the Atlantic Provinces for harvesting potatoes is very heavy and vibrates a great deal. In southern Quebec, farmers growing corn and sugar beets on both clay and sandy textured soils are experiencing compaction problems. In this latter case, internal drainage has been reduced to the point that ponding is occurring and crops are being damaged.

2. Soil Mixing and Disturbance

The installation of soil and gas pipelines and surface mining activities are the two major causes of soil mixing and disturbance on agricutural land in Canada. Of all the surface mining activities carried on in this country, the extraction of coal, sand and gravel most affect agricultural soils.

Coal, for example, underlies extensive areas of productive prairie soils, and its extraction disrupts these soils. Even when the

topsoil is stripped and stockpiled prior to mining, the subsoil is severely altered through mixing; groundwater flow patterns are changed; surface topography is altered. Saline seeps can develop as a result of these disturbances and a great deal of effort at grading and levelling is often required to return the soil to a state where it can again be used for agriculture.

A similar problem in which deeper, less-weathered material becomes mixed with topsoil occurs where pipelines have been installed. In general terms, the soil over the pipeline has become compacted and has a lower productivity than the undisturbed soil. These problems are particularly notable in the humid regions of the country. On the other hand, for certain crops, the productivity can actually be improved on occasion. For example, if calcium-rich material is brought nearer to the surface, pH levels can be raised. Alfalfa is one crop which benefits from the higher pH levels arising from such mixing.

Sand and gravel extraction and stone quarries are a particular problem since they tend to remain open and used for long periods of time. These operations result in fairly drastic changes to the topography and the topsoil which has been saved is inadequate for complete reclamation. In these cases, reclamation for recreational use, and not for agricultural use, is the only possible atlernative.

The extent of land disturbed for the extraction of sand, gravel and stone in eastern Canada was estimated to have been 84,000 acres (34,000 hectares) in 1977; 60% of this area was in Ontario and 30% in Quebec. In the western provinces, estimates of agricultural land disturbed for the extraction of construction material are 34,600 acres (14,000 hectares) in British Columbia, 27,000 acres (11,000 hectares) in Saskatchewan and 22,000 acres (9,000 hectares) in each of Alberta and Manitoba.

Strip mining of coal adds 6,180 acres (2,500 hectares) to the area of disturbed land in Alberta, 12,300 acres (5,000 hectares) in Saskatchewan and 11,000 acres (4,500 hectares) in New Brunswick. Renewed interest in coal as a fuel for the generation of electricity and for industrial processes probably means that further large areas of prairie soil will be disturbed. In fact, some 80% of Alberta's shallow coal deposits are in agricultural regions of the province. Alberta now has strict regulations involving the reclamation of land used for strip mining. It takes an average of five years for reclamation to be completed and a further five years before the soil returns to a productive state capable of supporting agriculture.

Appendix II

List of Witnesses

March 7, 1984: Ottawa: (Issue No. 1)
Hon. Eugene F. Whelan, P.C., M.P.
Minister of Agriculture.

Department of Agriculture:
Dr. Harry M. Hill, Director General, P.F.R.A.;
Mr. J. Nowland, Special Advisor, Research Branch;
Dr. Ron Halstead, Director General, Program Coordination, Research Branch;
Mr. Peter Connell, Deputy Minister.

March 8, 1984: Ottawa: (Issue No. 2)
Department of Soil Science, University of Saskatchewan:
Dr. Don Rennie, Chairman.

March 15, 1984: Ottawa: (Issue No. 3)
Department of Land Resources Science, University of Guelph:
Dr. Murray H. Miller, Professor.

March 22, 1984: Ottawa: (Issue No. 4)
Agriculture Canada Research Station, Fredericton, N.B.:
Dr. Lien T. Chow;

Macdonald College, McGill University:
Dr. Guy Mehuys.

March 29, 1984: Ottawa: (Issue No. 5)
Department of Soil Science, University of British Columbia:
Dr. Les Lavkulich.

Department of Environment:
Dr. William B. Mountain, Assistant Deputy Minister, Environmental Conservation Service;
Mr. L. C. Munn, Director, Research Development Branch, Lands Directorate;
Ms. Wendy Simpson-Lewis, Program Officer, Ecological Land Classification and Evaluation Division, Lands Directorate.

April 9, 1984: Winnipeg: (Issue No. 6)
Manitoba-North Dakota Zero Tillage Farmers' Association:
Mr. Robert C. McNabb, Minnedosa, Manitoba, President;

Mr. Gordon McFee, Dauphin, Manitoba and Mr. Jim McCutcheon, Homewood, Manitoba Manitoba Directors of the Association.

Department of Agriculture of the Province of Manitoba:
Hon. Billie Uruski, Minister;
Mr. G. J. Gartner, Deputy Minister;
Mr. Crawford Jenkins, Chief, Land and Water Management Section, Land and Water Branch;
Mr. Herb Schellenberg, Agricultural Resource Economist, Policy Development Branch.

United Grain Growers, Winnipeg, Manitoba:
Mr. Lorne Hehn, President;
Mr. Roy Custer, Russell, Manitoba, First Vice-President.

Mr. Kenneth Emberley, Manitoba.

Mr. George E. Coffey, Carlyle, Saskatchewan.

Mr. Ed. Mayer, Winnipeg, Manitoba.

The Manitoba Conservation District Association:
Mr. Clint Whetter, Deloraine, Manitoba, President;
Mr. Bill Poole, Deloraine, Manitoba, Manager, Turtle Mountain Conservation District;
Mr. Kurt Schmidt, Waldersee, Manitoba, Chairman, Whitemud Conservation District.

Dr. Leonard Sawatzki, Department of Geography, University of Manitoba, Winnipeg, Manitoba.

Mr. Allan Chambers, Board Member of the Manitoba Cattle Producers Association.

Mr. Alfred Sykes, Belmont, Manitoba.

Ducks Unlimited Canada:
Dr. Wayne Cowan, Agricultural Adviser, Public Relations Department.

The Pembina Valley Regional Development Corporation:
Mr. Donald Alexander, Member of the Agriculture Sub-Committee.

April 10, 1984: Saskatoon, Saskatchewan: (Issue No. 7)
The Saskatchewan Institute of Pedology:
Dr. John Stewart, Director.

Department of Agriculture of the Province of Saskatchewan:
Mr. Jack Drew, Deputy Minister.

The Prairie Farm Rehabilitation Administration:
Mr. George Brown, Director, Soil and Water Conservation.

The Palliser Wheat Growers:
Mr. Hubert Esquirol, Director.

Hoechst Canada Company:
Mr. David Drexler, Research Director;
Mr. Arthur Froechlich, Sales and Marketing Manager.

Mr. Carl Wilke, Yellow Grass, Saskatchewan.

The Saskatchewan Wheat Pool:
Mr. Ted Turner, President;
Mr. Dan Schmeiser, Research Division.

Dr. C. M. (Red) Williams, Professor, Department of Animal and Poultry Science, University of Saskatchewan.

The Saskatchewan Institute of Agrologists:
Mr. Fred E. Fulton, Professor, Department of Soil Science, University of Saskatchewan;
Dr. Les Henry, Past President.

Mr. Josh Storey, Pathlow, Saskatchewan.

Dr. H. Furtan, Head, Department of Agricultural Economics, University of Saskatchewan, (also appeared on behalf of Mr. D. G. Sigudson and Mr. G. E. Lee).

darWall Consultants:
Mr. J. Wallace Hamm, Soil Chemist.

Farmwest Management:
Mr. Robert J. Bens, President.

Canadian Organic Producers Marketing Cooperative Limited:
Mr. Alfred Moore, President;
Mr. Allan Dietrich, Vice-President;
Mr. Elmer Rathje, Director.

April 11, 1984: Edmonton: (Issue no. 8)

Department of Genetics, University of Alberta:
Dr. Jan Weijer, Professor of Genetics.

The Christian Farmers Federation:
Mr. Almbert Tuininga, President;
Mr. John Kolkman, Research and Policy Coordinator.

Dr. William B. McGill, Professor and Chairman, Department of Soil Science, University of Alberta.

The Soil Conservation Society of America, Alberta Chapter:
Mr. A. W. Fedkennhauer, Past President.

Olds College, Olds, Alberta:
Mr. Bill Souster, Instructor, Plant Science Department.

Unifarm:
Mr. George Friesen, Lacombe, Alberta, Chairman, Land Use Committee.

The Warner Dryland Salinity Control Association, Warner, Alberta:
Mr. William (Ken) Norris, Chairman.

Alberta Cattle Commission:
Mr. Christopher J. Mills, Manager;
Mr. Ted Wheat, Marwayne, Alberta, Delegate of the A.C.C.

Alberta Wheat Pool:
Mr. A. MacPherson, President;
Mr. A. Beattie, Manager of Public Relations.

Mr. Kent Harrold, Lamont, Alberta.

Alberta Farmers Conservation and Crop Production Association:
Mr. Michael Toth, Bassano, Alberta, Public Relations Coordinator.

April 12, 1984: Vancouver: (Issue No. 9)

Ministry of Agriculture and Food of the Province of British Columbia:
Mr. Ronald A. Bertrand, Director, Soils Branch.

The British Columbia Institute of Agrologist:
Mr. Martin G. Driehuyzen, Soil Specialist, Soil and Water Management Branch of the B.C. Department of Agriculture and Food, and Acting Chairman, Land Use Committee of the B.C.I.A.

Mr. Dennis Darragh, Vancouver, B.C., Member, DeMong Memorial Society.

The Soil Conservation Society of America, British Columbia Chapter:
Mr. Laurens J.P. van Vliet, President.

The North-West Bio-Dynamic Agriculture Society, Chilliwack. B.C.:
Mr. Ernst Lubben, Secretary.

The Fort St. John and District Chamber of Commerce, National Farmers' Union, Region 8, and the City of Fort St. John:
Mr. Hartmut Haidn, Cecil Lake, B.C..

Dr. Terence Lewis, Burnaby, B.C..

April 17, 1984: Ottawa: (Issue No. 10)

The Canadian Federation of Agriculture:
Mr. Glenn Flaten, President;
Mr. David Kirk, Executive Secretary;
Dr. Marjorie Bursa, Chief Economist.

May 1, 1984: Guelph, (Issue No. 11)

The Ontario Soil and Crop Improvement Association:
Mr. Laurence Taylor, President.

The Ontario Institute of Pedology:
Mr. Galen Driver, Program Manager, Soil and Energy Management, Plant Industry Branch, Guelph Agriculture Centre.

The Ministry of Agriculture and Food of the Province of Ontario:
Dr. Robert McLaughlin, Director, Plant Industry Branch, Guelph Agriculture Centre;
Dr. Vernon Spencer, Director, Capital Improvements Branch.

The Rondeau Bay Watershed Agricultural Steering Committee:
Mr. Jack A. Rigby, Chairman.

Ecologistics Limited:
Mr. Dave Cressman, President.

Mr. Jim McGuigan, M.P.P. (Kent-Elgin)

Department of Agricultural Economics and Extension Education, University of Guelph:
Mr. Willen van Vuuren, Professor.

The Ontario Hay Association:
Mr. Fritz Trauttmansdorff, Vice-President.

May 2, 1984: Guelph, (Issue No. 12)

The Ontario Institute of Agrologists:
Mr. Paul Fish, Chairman, Soil Conservation Committee;
Mr. Don McArthur, Executive Director.

The County of Oxford:
Mr. Charles Tatham, Warden of the County of Oxford, Woodstock, Ontario.

The Association of Conservation Authorities of Ontario Subcommittee on Soil and Water Conservation:
Mr. Dennis O'Grady, Agricultural Technician.

Mr. Charles Shelton, Ingersoll, Ontario.

The Thames River Implementation Committee:
Mr. Art W. Bos, Agricultural Diffuse Source Control Program Co-ordinator.

The Soil Conservation Society of America, Ontario Chapter:
Mr. Bryan D. Boyce, President;
Dr. Charles S. Baldwin, Soil Erosion and Sedimentation Committee.

The Ontario Farm Drainage Association:
Mr. Kenneth R. McCutcheon, President.

Mr. Heinz Kumpat, Kitchener, Ontario.

May 3, 1984: Montreal: (Issue No. 13)

Mr. Jean-Louis Dionne, Researcher on Soil Fertility, Agriculture Canada Research Station, Lennoxville, Québec.

Mr. Alain Pesant, Soil Physicist, Agriculture Canada. Research Station, Lennoxville, Québec.

Mr. Christian de Kimpe, Researcher in Soil Chemistry, Agriculture Canada Research Station, Ste-Foy, Québec.

Mr. Léon-Etienne Parent, Researcher in Organic Soils, Agriculture Canada Researcher Station, St-Jean-sur-Richelieu, Québec.

Mr. Maurice Hardy, Consultant in Agrology, St-Vincent-de-Paul, Québec.

Dr. Stuart B. Hill, Associate Professor of Entomology, Faculty of Agriculture, Macdonald College, McGill University, Ste-Anne-de-Bellevue, Québec.

L'Union des producteurs agricoles du Québec:
Mr. Gérard Gras, First Vice-President;
Mr. François Côté, Director, Study and Research Section.

Mr. Jean-Paul Raymond, President of the U.P.A. Local, Ste-Scholastique, Québec.

Mr. Girard Millet, Member of L'Ordre des Agronomes, Montreal, Québec.

Mr. Romuald Lemire, Baieville, Québec.

May 8, 1984: Fredericton: (Issue No. 14)

The Department of Agriculture and Rural Development of the Province of New Brunswick:
Hon. Malcolm MacLeod, Minister;
Dr. Michael J. Dillon, Agricultural Land Policy Analyst, Planning and Development Branch;
Mr. Ibrahim Ghanem, Associate Director, Plant Industry Branch;
Dr. Chesley E. Smith, Executive Director.

The New Brunswick Federation of Agriculture:
Mr. Thomas A. Demma, Secretary-Manager.

L'Association pour l'amélioration des sols et cultures de Grand-Sault:
Mr. Gilles Pierre Côté, Director;
Mr. Rhéo Ouellette, Member;
Mr. Ronald Gagnon, President;
Mr. Jacques Laforge, Member.

The New Brunswick Institute of Agrologists:
Mr. David Carlisle, Past Chairman, Land Use Committee;
Mr. Jean-Louis Daigle, Chairman, Land Use Committee;
Mr. Karel Michalica, Member, Land Use Committee.

The Victoria County Soil and Crop Improvement Association
Mr. Lance C. Bishop, President.

The National Farmers Union (District 2, Region 1), Perth, N.B.:
Mr. Darell MacLaughlin, President;
Mr. Jacques Laforge, Member.

Dr. H. van Groenewoud, Maritimes Forest Reserve Centre, Fredericton, N.B.

Mr. David C. Davies, Manager, Harvesting and Utilization Branch, Department of Natural Resources of N.B., Fredericton, N.B.

May 9, 1984: Charlottetown: (Issue No. 15)

The Department of Agriculture of the Province of Prince Edward Island:
Dr. Awni Raad, Director, Plant Industry Branch.

The Prince Edward Island Potato Marketing Board:
Mr. Don Anderson, General Manager;
Mr. Allan Parker.

The Prince Edward Island Institute of Agrologists:
Mr. Kais Deelstra, President;
Mr. Donald E. Himelman, Member of the Institute.

The Prince Edward Island Department of Community and Cultural Affairs:
Mr. C.S. Clair Murphy, Chief Officer, Marine Environmental Section;
Mr. Amar Menon, Head, Microbiology and Shellfish Section, Environmental Protection Service, Atlantic Region.
Mr. Arthur Smith, Director, Fish and Wildlife Division.

The Prince Edward Island Museum and Heritage Foundation:
Mr. Ian Scott, Director;
Dr. Ian G. MacQuarrie, Member.

The University of Prince Edward Island:
Dr. Walter Fobes, Professor and Chairperson, Department of Economics.

Mrs. Betty Howatt, Tryon, P.E.I..

The National Farmers Union (Region 1, District 1):
Mr. Urban Laughlin, Summerside, P.E.I. District Director;
Ms. Marie Burge, Charlottetown, P.E.I., Resource Person for Education and Research.

Mr. Arthur Smith, Charlottetown, P.E.I..

The Prince Edward Island Soil and Crop Improvement Association:
Mr. Winston Cousins, Secretary-Treasurer.

Mr. Chris Mermuys, Montague, P.E.I..

May 10, 1984: Halifax: (Issue No. 16)

The Department of Agriculture and Marketing of the Province of Nova Scotia:
Mr. Jack D. Johnson, Director, Soils and Crops Branch;
Mr. David E. Robinson, Economist, Marketing and Economics Branch.

The Municipality of Colchester County:
Mr. Laurence Nason, Warden;
Mr. Ross Hill, Deputy Warden.

Dr. D.G. Patriquin, Biologist, Biology Department, Dalhousie University, Halifax, Nova Scotia.

The National Farmers Union:
Mr. Alfred Nieforth, Carrolls Corner, N.S, Spokesman for the N.F.U.

Department of Rural, Agricultural and Northern Development of the Province of Newfoundland and Labrador:
Mr. M. Dale Sudom, Director, Soil and Land Management Branch, and President of the Agriculture Institute of Canada, Newfoundland and Labrador Branch.

The Nova Scotia Federation of Agriculture:
Mr. Donald R. Downe, President;
Mr. Hank de Boer, Director.

Mr. Ronald H. Loucks, Halifax, Nova Scotia.

The Technical University of Nova Scotia:
Dr. Jack R. Burney, Associate Professor and Head, Department of Agricultural Engineering.

May 15, 1984: Ottawa: (Issue No. 17)
Ontario Ministry of Natural Resources:
Mr. A. D. Latornell, Deputy Regional Director, Central Region.

June 5, 1984: Ottawa: (Issue No. 18)
The Agricultural Institute of Canada:
Dr. Clayton M. Switzer, President;
Dr. Murray Miller, President, Canadian Society of Soil Science.