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Sustainability of Farmed Lands: Current Trends and Thinking

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The authors of this report were engaged in February 1983 to prepare a brief report constituting "an overview of current trends and thinking in the agricultural community on the impacts of land use and soil quality on agriculture, with particular emphasis on current trends including energy costs." The contract entailed a verbal agreement that one of the contractors would attend the following workshops and symposium as a means of ascertaining the current views of soil scientists regarding the sustainability of the productivity of farm lands under contemporary use: the 1983 British Columbia "Soil Degradation Workshop" at Harrison, British Columbia, February 17-18; the Alberta Soil Science Workshop at Edmonton, Alberta, February 22-23; and the "Soil Erosion and Crop Productivity Symposium" of the American Society of Agronomy at Denver, Colorado, March 1-3, 1983. Because of time constraints in the contract and the participation specified in the above meetings, there is emphasis in this report on conditions in Western Canada. However, the general principles are broadly applicable.

In order to obtain the opinions of a considerable number of soil scientists, in addition to those contacted at the workshops and the symposium, questionnaires were sent to a widely distributed array of soil scientists in Western Canada. The reponses and co-operation obtained were excellent. More than thirty soil scientists responded, returning questionnaires and providing a large number of reprints, papers and other publications related to the topics concerned.

We are pleased indeed to acknowledge with genuine thanks and appreciation the fine support and assistance received from fellow agrologists. Many of their papers are among the references listed.

We are also pleased to acknowledge with genuine thanks and appreciation the very helpful editing done by Mr. Max McConnell, the Executive Secretary of the Canadian Environmental Advisory Council.

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FOREWORD

Introduction

This Report is a contribution to the national discussion on the future of agriculture in Canada. It supplements several recent thoughtful studies 1, 2, 3, and converges with them in concluding that sustainable production from farmlands is threatened under current institutional and technological arrangements.

Soil degradation and loss of arable land from agriculture are issues that are not normally perceived as having a high profile from an environmental point of view. Yet these issues are creating a growing level of concern in many parts of Canada. More and more evidence points to diminishing levels of native fertility and to the mounting losses of some of our most productive farmland.

In an effort to obtain a comprehensive overview of these problems, the Canadian Environmental Advisory Council commissioned Dr. C.F. Bentley, P. Ag., and Mr. L.A. Leskiw, P. Ag., to provide a background paper on current concerns, focussing particularly on the broader impacts of changing land uses and diminishing soil quality. The Bentley-Leskiw Report leaves no doubt that without changes in present farming practices, future agricultural production will be dramatically curtailed. Unfortunately, efforts to correct the problems are hindered by continuing myths about high levels in both quantity and quality of agricultural land in Canada.

Sustainability of Farmlands

In their assessment of agricultural problems, the authors present items of concern in three general categories that roughly indicate the extent of the farmers' control: those related directly to farm practices (in the farmers' domain); those mainly controlled by off-farm decisions (in the public domain); and those natural and external factors that can be controlled with difficulty if at all. The three are to some extent interrelated.

1) In the Farmers' Domain

These include issues such as salinization, soil erosion, depletion of soil organic matter and plant nutrients, inappropriate cropping and poor soil management systems, soil acidification, and soil compaction. Although these are most affected by farm activities, remedial action will often require assistance to the farmer at the socio-political level.

Salinization — the accumulation of injurious quantities of soluble salts in surface layers of the soil — has plagued irrigated agriculture for thousands of years. Now it is developing as a major problem on considerable areas of dryland farms in western Canada. Rough estimates suggest that in some areas salinization may be spreading at a rate of up to ten percent per year.

Soil erosion, in particular the loss of fertile topsoil through wind and water, is also a serious problem. Although difficult to measure, there is little doubt that direct losses from soil erosion are significant, as are the unwelcome side effects of sediment pollution in water and air.

Depletion of organic matter and of key soil nutrients are also identified as concerns that mount each year where cropping practices fail to offset the annual nutrient losses associated with humus disintegration and removal from the farm of each year's production. Related problems such as acidification and soil compaction result from intensive farming practices as farmers attempt to maintain high productivity with increased application of fertilizers, and with other mechanized activities.

2) In the Public Domain

Here are included such issues as land use regulations, conversion of agricultural lands to other uses, toxic contaminants, and land disturbances such as strip mining.

Land use regulations in particular are singled out as a subject of major concern as increasing amounts of prime agricultural land are diverted to other uses, frequently without a future recovery option for agriculture. Despite Canada's massive land base, only eight percent is suitable for continuing arable agriculture. Less than half of one percent can be classed as excellent to very good, and most such land is situated in highly populated corridors where alternative land use schemes are rampant. As prime agricultural land is lost, agriculture is shifted to much less productive land — and there are serious economic limits on how long this can continue. At the public policy level, means to stem the seemingly irreversible flow of land out of agricultural use must be found.

Strip mining and other land disturbances, while they affect smaller areas, have a potential nonetheless for reducing the agricultural land base. Such damage can be alleviated or offset by a responsible public policy approach that guides environmental planning so as to maximize benefits over a long time horizon.

3) Natural and External Factors

Bentley and Leskiw note that soils, climates, and demographic characteristics of the farm population have a substantial impact on the types and successes of farming in different agro-ecological regions. While many of the challenges posed by external factors are beyond the direct control of either the public or the individual farmer, much can be done by recognizing the constraints, and then developing policies and management programs that both maximize the opportunities and minimize the potential failures.

Finally, surveying the three classes of problems, the authors conclude that radically new but practical long-term soil conservation policies and programs are needed to ensure the sustainability of Canada's farmed lands. To achieve that goal, they say, *society must be convinced that the need for the advocated programs exists — and that the benefits will be real.* As argued in the Sparrow Report[2], the issues must be kept alive and before the public.

The CEAC Perspective

The Canadian Environmental Advisory Council perceives current farming difficulties as part of a larger picture involving threats to all renewable resources and to the economic enterprises associated with them. Furthermore, the difficulties are world-wide and not confined to Canada. Lester Brown writes:

Although the economic crisis of the eighties is exacerbated by economic mismanagement, its roots lie in the depletion of resources, both non-renewable and renewable . . . (The) unprecedented quadrupling in world food demand within 50 years is putting more pressure on many of the world's soils than they can sustain.[4]

Clearly, major environmental problems often grow incrementally and imperceptibly from policies and practices that have appeared to be benign. Today such policies and practices in agriculture, as well as in other renewable resource fields, must be challenged before they work irreversible harm on Canada's environmental wealth.

In a country such as ours where the economy visibly depends on the country's renewable resources, maintenance of that base should be a prime priority. Yet as stated in one of the working documents related to Council's submission to the Royal Commission on the Economic Union and Development Prospects for Canada[5]:

Canada's renewable resources are in highly serious stages of erosion and debilitation. Across the board we have eaten into the "capital" stock and have failed to maintain the quality and quantity of those resources necessary for their continued productivity . . . Canadians are still carrying with them the frontier psyche, viz. "There is always more over the hill."

Environmental crises reflect wrong attitudes and questionable goals. In previous reports Council has stressed the importance of an ethic based on awareness of interdependencies, devoted to maintaining the functional diversity and beauty of the world.[6] For too long many Canadians have conceived their environment as merely a store-house to be plundered, rather than a living environmental system whose sustainment requires foresight and care. Because the earth's ecological systems have not been valued as sustainers and preservers of life and life's activities — including national economies — no ethical-economic sense of obligation toward them has been evoked. With little sense of environmental responsibility the prevailing view has been that whatever pays best today *is* best and, indeed, is *necessary.* Catastrophes reported almost daily in the media prove that such logic is false.

A Conserving Agriculture

In Council's view, two major agricultural questions have to be faced: How can the productivity of the land be sustained, and who are to be the conservation farmers of the future? The questions are related, and neither can be answered satisfactorily except in the context of sound environmental goals. As a major land use to which a substantial population is directly or indirectly wedded, agriculture over the long term has to be seen as part of a total environmental strategy that aims to sustain food production in integration with care of diverse landscapes, organisms, air, and water.

Soil erosion is not only an agricultural loss; it is also a cost in sediment pollution borne by aquatic ecosystems. Heavy fertilizer use may burden the environment, perhaps acting synergistically with acid rain, even as it boosts production of the target crops. Thus land use practices are central elements in environmental issues, and environmental protection translates into good land use.[7] Quoting the Standing Senate Committee on Agriculture, Fisheries and Forestry:

Soil conservation cannot be dealt with in isolation from related issues such as water quality, land use, wildlife management, fisheries and forestry.[2]

Nor can soil conservation be separated from the contributions of good husbandry and stewardship made by those who wish to live on, and farm the land. Is it a coincidence that future prospects for both the soil and the rural family are endangered? It is also questionable if the family farm can survive without the concurrent survival of the rural community.

A major part of the problem with respect to current soil degradation and land misuse relates to a market-place which is very much oriented to the short run. Economics is not adept at valuing the future. Thus farmers are encouraged if not compelled to adopt practices and cropping patterns that are inconsistent with long-run productivity. Since most farmers cannot survive if they ignore the short run in the interests of a longer term gain, the unavoidable result is land use that conflicts with production sustainability.

High costs of inputs and low prices for farm outputs force farmers to draw down their soil's capital. Mined-out soils are less the product of ignorance than of economic forces shaped by rising energy costs on the one hand and by cheap food policies on the other. In the present climate, farmers simply cannot internalize the costs of rebuilding the soil and stay solvent. Without attention to such realities, all the talk in the world about conservation farming is strictly academic.

For similar reasons, land diverted from agriculture to other uses is rarely evaluated with respect to long-term production potential, nor with an eye to predictable and increasing future needs for food. Given this improvident view of tomorrow, social programs and policies need to shift focus, placing greater emphasis on *future profitability* rather than on that of today, thereby allowing the market system to effect the needed changes in land use practices. The Environment Council of Alberta, for example, has recently suggested that compensation payments for agricultural land threatened by withdrawal be set at six times its current productive value.[8]

This is *social cost pricing*. As argued in Environment Canada's submission to the Royal Commission on the Economic Union and Development Prospects for Canada, far from neutering market economics, social cost pricing can help to restore the true efficiency of the market system.[9]

Logically, then, Council places the major responsibility for encouraging ecologically sustainable agriculture squarely on the non-farming population and on the governments whose members are largely drawn from it. We are overwhelmingly an urban society; the rural population is small. Those policies and programs that will either nourish agriculture and rural communities or force both into decline are largely in the hands of townspeople and legislators. Quoting Fairbairn in his report sponsored by the Agricultural Institute of Canada:

To date, the urban majority has instinctively and remorselessly pushed the rural minority into a pattern of mining the land: larger farms, ever more monstrous machines, and costly rivers of chemicals.[1]

Now, from 1984 on, all townspeople, research agencies, and all levels of government must remorselessly push farming toward conservation practices, and be prepared for the good of the country to shoulder the costs.

Dr. J.S. Rowe
Member
Canadian Environmental Advisory Council

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INTRODUCTION

A Bit of History

During the last few years there has been rapidly increasing concern, worldwide, about the sustainability of the productivity of extensive areas of agricultural lands under contemporary usages. Soil scientists, other agrologists and environmentalists are groups that have been endeavoring to alert governments and the general public to the fact that in some regions there is increasingly urgent need for imaginative measures to halt serious degradation of agricultural soils.

The World Conference on Desertification held in Nairobi, Kenya, in 1977 was an international recognition that vast areas of cultivated and pastoral lands have been, and are being degraded to the extent that they have no current agricultural production. In additional large areas — millions of hectares per year — current usage is causing such degradation that the remaining agricultural production potential will soon be reduced to uneconomic levels unless effective remedial measures are taken very soon. Three Worldwatch publications confirm the effects of pressures on agricultural lands (Eckholm and Brown 1977, Brown 1978, and Brown 1979).

In November 1982, the 21st Session of the Food and Agriculture Organization (FAO) Conference adopted a World Soil Charter which the FAO staff had been directed to prepare. That Charter was also presented to the Executive Committee of the International Congress of Soil Science in New Delhi, February 1982. The World Soil Charter and the Plan of Action to Implement a World Soils Policy (ISSS 1982) are primarily concerned with prevention of the degradation of agricultural lands under use for agricultural production. Copies of these documents appear in this report as Appendix 1.

In the United States there has recently been an increasing amount of debate regarding the sustainability of agricultural production under current conditions. The magazine Science presented an editorial, "Soil for Oil?", which discussed whether American agricultural exports can be maintained in view of the extensive erosion and other types of soil degradation currently occurring there. In an article entitled "The Future of American Agriculture" (Batie and Healy 1983) the authors assessed attitudes at a recent interdisciplinary study of the long-term productivity prospect for American agriculture, and concluded that "perhaps a majority had an outlook which could be characterized as guarded optimism."

In Canada there was a great deal of concern about the sustainability of arable agricultural production in much of the prairie region of Canada as a consequence of erosion that occurred during the 1920's and 1930's. Millions of hectares of once cultivated land were so degraded that they were abandoned as farm lands. A comprehensive survey of soil degradation on the Prairies*, carried out by the University of Alberta in the late 1930s, found that, on the average, from Winnipeg to Edmonton, soils that had been cultivated approximately 25 years had lost about 20 to 25 percent of the original nitrogen and organic matter, as well as considerable amounts of phosphorus. However, the combination of the end of the drouth of the 1930's, the development of strip cropping and trash cover farming, the replacement of the binder and threshing machine by the combine, improved farm equipment, new improved varieties of grain crops, and the increasingly general use of fertilizers and pesticides on the Prairies resulted in steady yield increases and a general euphoria about agricultural productivity on the Prairies during the 1950s and 1960s.

In Eastern Canada abandonment of cultivation of very inferior lands and the combination of new agricultural methods, especially the dramatic increase in yields and production of corn and soybeans where those crops flourished, also resulted in considerable agricultural prosperity and optimism about the productivity of agricultural lands.

In British Columbia, agricultural expansion in the Peace River Region, "the last frontier", and intensification and specialization of agricultural production in the Fraser Valley as well as the Okanagan and Kootenay regions, also contributed to confidence in the improving productivity of farmed lands. But in 1974, recognizing the increasing competition for the very limited area of land suitable for agriculture, the B.C. government created the Agricultural Land Reserves to retain the suitable lands for agriculture.

In Canada, myths about the quantity and quality of agriculturally-suited lands have persisted to the present, and have contributed to a lack of realism regarding the sustainability and the agricultural production potential of this country.

Return to Reality

Reality is, however, slowly unfolding. Increasingly, during the past four or five decades, agrologists and farmers in the West have found that a variety of practices have become necessary to maintain, or to enhance, crop yields on arable lands that have been farmed for several decades. That has been most convincingly demonstrated by the rapid increase in the use of nitrogen fertilizer during the past two decades when

* In this report the word "Prairies" refers to the Prairie Provinces.

nitrogen fertilizer sales increased more than 30 times (Horner et al. 1980). A related indication of the effects of farming on the productivity of farm soils is a forecast, made in 1981, that by 1985 annual applications of more than 250,000 tonnes of lime may be needed in Alberta and northeastern British Columbia to offset the yield-depressing effects of soil acidity (Hoyt et al. 1981). Salinization is estimated to affect 2.2 million hectares of dryland and over 100,000 hectares of irrigated land on the Prairies — and dryland salinity may be increasing in some areas at a rate of 10 percent per year! (Vander Pluym in ASSWS 1981). Although admittedly extremely difficult to quantify, it has been estimated, by extrapolation of U.S. data to Canada, that soil erosion may be responsible for a 10 to 15 percent decline in crop yields (PFRA 1983).

Recent concerns about soil erosion in Ontario sparked a study to estimate the costs of soil erosion in that province. The resulting report (Wall and Driver 1982) estimated the annual cost of erosion in southern Ontario to be $68 million. Some soil scientists consider that to be a very modest estimate.

In late 1982 the Prairie Farm Rehabilitation Administration published the results of a massive attempt to evaluate the costs of soil degradation in the Prairies (PFRA 1982) and (PFRA 1983). That report estimates the present value to the year 2000 of measures to control soil degradation by erosion, salinization and decreased nitrogen supplying power of soils (organic matter decrease) at about $3.2 billion.

Another aspect of reality is the emerging comprehension that Canada has practically no remaining undeveloped prime agricultural land (Simpson-Lewis 1982). In Alberta concerns about the scarcity of, and the unnecessary conversions of quality agricultural land to non-agricultural uses, resulted in plans for province-wide public hearings to consider and discuss "Maintaining and expanding the agricultural land base in Alberta", which were initiated in the fall of 1983. That is particularly noteworthy since, among the provinces, Alberta has the largest area of land which is as yet undeveloped but is nominally suitable for arable agriculture.

The foregoing leads to questions regarding the sustainability of the productivity of farmed lands in Canada under historical, and contemporary, soil management practices and cropping systems. The questions posed are very timely because the era of exceedingly low-cost energy, whether for mechanical operations on farms or for high-energy agricultural inputs such as nitrogen fertilizers, has ended.

A timely question is: are attitudes changing regarding the sustainability of the productivity of Western Canadian farm lands? Let us consider that thought-provoking enquiry.

Factors Which Influence Sustainability

The farming regions of Canada are highly variable in soils, frost-free periods, amounts and characteristics of precipitation, as well as other climatic factors which affect — often determine — the types of commercial agriculture which are possible. It is no wonder then that many factors and practices have influences on the productivity of Canadian farm lands under use. A partial list of items to be considered in attempting an overall assessment of the sustainability of the productivity of our farmed lands includes the following:

Within the Domain of Farmers

Salinization.
Soil Erosion.
Depletion of soil organic matter and plant nutrients.
Cropping systems and soil management practices.
(Crop rotations and summer fallowing; moisture conservation — residue management, reduced or zero tillage, herbicides.)
Acidification, soil compaction, manure usage, grazing management.

Factors in the Public Domain

Land use regulations: soil conservation legislation and encouragement.
Conversions of high-quality lands to non-agricultural uses; drastic land disturbances.
Toxic contaminations: acidifying emissions; heavy metals; sewage disposal.
Agricultural education, research, extension.
Economic policies for agriculture.

Natural or External Factors

Soil characteristics: natural quality and composition.
Climate: precipitation and its distribution; frost-free periods and frost hazards; heat units and so forth.
Demographic characteristics of farmers.
International markets and economic conditions.

We cannot deal with each of the above factors in isolation. Many of them are interrelated, and sometimes they must be considered as offsetting influences. The following case illustrates the point. In a recent paper (Cardwell 1982), estimates were made of the sources of the increases which in 50 years raised corn yields in Minnesota from two to six tonnes per hectare. Some of the major components contributing to that yield change were:

Yield-increasing influences	Percentage of increase attributed
. hybrid corn	58
. nitrogen fertilizer	47
. herbicides	23
. changed planting techniques	46
Total increasing effects	174

Yield-decreasing influences	Percentage of decrease attributed
less nitrogen coming from manure, soil humus and legumes	28
more insect damage	8
soil erosion	8
corn after corn (mono-cropping)	7
other unknown factors	23
Total decreasing effects	74

Although the foregoing data are illustrative rather than precise, they are of assistance in comprehending the complexity of determining whether the productivity of Minnesota soils was being maintained during the 50 years concerned.

It is therefore with considerable trepidation that we embark on a discussion of some factors influencing the sustainability of the productivity of farmed lands under use in Canada.

FACTORS WITHIN THE DOMAIN OF FARMERS

Salinization

Salinization, the accumulation of injurious quantities of soluble salts in the surface layers of soils due to some type of human activity, has plagued irrigated agriculture for thousands of years. In the Tigris-Euphrates region of Asia Minor and in parts of what is now Pakistan, marvellous systems of irrigated agriculture which existed over 2,000 years ago were ruined and rendered practically or entirely useless by salinization. Since the construction of the Aswan High Dam on the Nile about 20 years ago, some Egyptian lands that had been irrigated for thousands of years without salinization have begun to show deterioration due to salinization attributed to the recently changed water regimes. In parts of California, such as the San Joaquin Valley, increasing salinity currently threatens the survival of irrigation there (Pillsbury 1981).

In the Northwestern Great Plains region of North America and in parts of the savanna region of Western Australia that have been cleared for arable agriculture, salinization is an increasingly serious and rapidly spreading form of land deterioration (Vander Pluym 1978). Recently, PFRA (1983) published an overview of land degradation on the Canadian Prairies and concluded that salinization, which is estimated to affect 2.2 million hectares of dryland on the Prairies and 0.1 million hectares of irrigated land (Vander Pluym 1981), may be causing annual economic losses about four to five times as great as the combined annual economic losses due to erosion, loss of nitrogen and acidification. Rough estimates suggest that in some areas salinization may be spreading at a rate of 10 percent per year. It is not implied that such a rate of salinization will be sustained for very many years — if indeed that estimate was or is a reasonable approximation of the rate of salinity increase in all of the semi-arid areas of the Prairie Provinces.

The effects of salinization on agricultural productivity are highly variable. Yields may be only slightly affected with a low level of salinization, but massive salinization may prevent any crop growth. In estimating the productivity losses attributable to salinization, Vander Pluym et al. (1981) assumed an average productivity reduction of 66 percent on all salt-affected land. Others have mentioned yield reductions of 50 percent (Lilley, 1982, and Sanderson, 1982).

Because of very low expenditures for research, the extent of salinization in the Prairies is inadequately known and mapped. Preventative methods have not received adequate study either. For similar reasons, reclamation methods for salinized areas of the Prairies, where reclamation is possible, are not well developed, and in some cases expenditures by farmers of about $1,000 per hectare have not produced satisfactory results.

PFRA (1983) has estimated that the cumulative present value, at a five percent discount rate, of benefits through 1983-2000 from control of salinity on the Prairies could be about $2.5 billion. Thus, the general perception is that unless vast urgent programs of research, prevention and reclamation are mounted very soon, salinization will deteriorate increasingly large areas of farm lands.

It must be added that it is technically and/or economically impractical to reclaim a considerable amount of salinized land on the Prairies. On the basis of current technology and economic relationships, the productivity of some salinized land is permanently impaired.

Some of the causes of man-induced salinization are discussed in the section on "summer fallowing" commencing on page 7.

Erosion

When erosion occurs it is predominantly topsoil, the most fertile and valuable soil layer, that is most affected. The finer soil fractions, richest in nutrients and humus, tend to be separated by the processes of erosion, and they constitute disproportionate amounts of what wind and water erosion remove from farm fields. However, since the cultivated layer of a hectare of land contains about 2,500 tonnes of soil, and as most annual erosion losses range from perhaps less than 100 kilograms to a few tonnes per hectare per year, the difficulty of measuring such losses can be appreciated — especially given the year-to-year variability in the weather conditions which cause or are conducive to soil erosion.

The effects of soil erosion on the productivity of farm lands are exceedingly difficult to determine. This is especially true in the case of continuing year-to-year erosion, which does not result in deep rills and gullies, or massive dust storms which affect urban residents and block highways or fill ditches. Because of lack of research, there are no good data to reveal how much the productivity of Prairie farm lands has been reduced by erosion. In the United States generally, Pimental et al. (1976) estimated that yields may have been reduced by 10 to 15 percent by soil erosion. More recently, Cardwell (1982) has suggested erosion may have reduced Minnesota corn yields by perhaps eight percent.

A recent paper by De Jong et al. (1982) reports on a new way to determine the approximate rate of loss of topsoil by erosion. Cesium 137 (^{137}Cs) is a radioactive element that came to earth as fallout from atmospheric nuclear testing of the early 1960s. Cesium 137 behaves much like calcium in the soil, attaching firmly, but replaceably, to soil particles. It therefore remains in the cultivated topsoil layer of farmed soils. By determining the reduction of Cesium 137 on a knoll near

Saskatoon, De Jong et al. (1982) concluded that the knoll has lost about 10 percent of its topsoil in approximately 20 years. But the authors obtained results from only one location. Application of that technique extensively on the Prairies should provide a meaningful way of determining the general rate of topsoil loss by erosion during the past two decades.

The foregoing estimates do not include other large costs of soil erosion. Air and water pollution, the shortened life of reservoirs due to excessive sedimentation, eutrophication of lakes, the clogging of roadside ditches and drainage systems, erosion and corrosion of structures and property are additional unmeasured costs of soil erosion by wind and water.

The question of what amount of soil erosion can be tolerated without accumulated deterioration of the productivity of farm land to levels where commercial agriculture cannot be continued is especially complex. In the United States an approximation of "the tolerable rate of soil erosion" has been set at a maximum soil loss of 11.2 tonnes per hectare annually, but Larson et al. (1983) correctly state that the effects of soil erosion losses on the productivity of agricultural soils differ greatly with different soils.

Agricultural practices may rehabilitate soils deteriorated by soil erosion. Fertilizers may be used to augment the available supplies of nutrients depleted by erosion. Crop rotations and soil management practices may protect soil surfaces from further erosion — and indeed may rebuild erosion-resisting physical characteristics of soils while simultaneously increasing the total nitrogen content of soils. During the "dirty thirties" some millions of hectares on the Prairies became so deteriorated by soil erosion that it was impractical to continue arable agriculture on them. However, after extended periods of being seeded down to grass or grass/legume mixtures, some of those lands have been returned to grain production — under soil and crop management practices which have been effective in protecting the fields concerned from significant recent erosion. The fundamental threat of soil erosion is that it may raise the costs of crop production to prohibitively high levels, making it uneconomical to sustain the type of farming being practiced.

But erosion still affects millions of hectares in Western Canada annually. That is attributable to a variety of causes including: use of some soils not suitable for arable agriculture; failure of some farmers, indeed of some large areas or sub-regions, to employ known and proven practical methods of soil erosion prevention; the lack of research to develop effective and acceptable methods to cope with soil erosion in some areas and/or on some soils; and other reasons such as perturbations of weather or climate which increase greatly nature's erosive forces.

A recent "guesstimate" by PFRA (1983) suggests that the present value of accumulated benefits, at a five percent discount rate, from soil erosion control on the Prairies during the next 18 years could be about $270 million. Speculative as that figure is, it clearly reveals that soil erosion, if it continues unabated, will effect a considerable reduction in the productivity of Western Canadian farm lands.

In Eastern Canada, especially in Ontario and Quebec, expansion of corn production has lead to substantial but inadequately quantified increases in soil erosion. The problem is especially serious where mono-cropping of corn is practiced or where the two row-crops, corn and soybeans, alternate from year to year. The high returns from production of corn and soybeans have sparked a trend to larger and larger fields — and with row-cropping that too has tended to increase water erosion.

In Ontario, concern about the trend towards increased soil erosion has lead to the estimation of the annual cost of soil erosion at about $68 million per year for southern Ontario only (Wall and Driver, 1982).

In the final analysis the amount of soil erosion, over time, will be largely determined by whether:

- Canada has the wisdom to make the research investments needed to develop effective means of minimizing erosion;
- the income incentives and stability needed to induce farmers to practice soil erosion prevention are effective in encouraging farmers to do so; and
- society has the will to apply meaningful sanctions to those who inexcusably permit or cause unnecessary soil erosion.

Soil scientists, and the more advanced farmers, now know that, technically, soil deterioration by erosion is largely unnecessary and therefore inexcusable.

Depletion of Soil Organic Matter and Plant Nutrients

Organic matter decline: When virgin soils are brought under arable agriculture the quantity of plant residues returned to the soil is reduced. Sometimes almost everything is removed, as was the case when crops were bound and hauled away to be threshed, or when straw and stubble was, and is, burned off. In addition, cultivation of soil, and the moist conditions when no crop is growing on a soil, accelerate greatly decomposition of the original soil organic matter. Systems of continuous arable cropping, as in the corn-soybean areas of Ontario and the Prairie grain production areas, tend to maximize the decrease of soil organic matter. In the Prairie Provinces soil organic matter has declined by an estimated 36 to 49 percent (Figure 1).

Under arable agriculture without grasses and legumes in the cropping systems, the organic matter content of soil declines and the ability of native soil humus to provide nitrogen for crops decreases. Usually, under such systems nitrogen fertilizers are needed if yields are to be maintained (Figure 2). Because of the relationships in Figure 2, there has been a dramatic increase in nitrogen fertilizer use on the Prairies and in the continuous corn areas of Ontario. But nitrogen is not the only plant nutrient depleted by farming.

Nutrient Depletion: Agriculture is unnatural and unless there is complete recycling of all plant and animal materials (including people and their wastes too!), there is an inevitable depletion of essential plant nutrients from farmed lands. Nitrogen and phosphorus are the nutrients most extensively needed and used as fertilizers. Disregarding losses due to erosion, there has been substantial depletion of these elements from Canadian soils — especially Prairie soils — by agricultural production since the inception of farming.

The following discussion of nitrogen and phosphate balances in Western Canadian agriculture is based on data in Horner et al. (1980), ASSWS (1981) and La Bosse and McSorley (1981).

Nitrogen: Prior to the 1960s the nitrogen content of exported Prairie grains exceeded nitrogen fertilizer applications by more than ten times. In spite of the rapid increase in usage of nitrogen fertilizer during the 1960s and 1970s (Table 1), it was not until about 1978 that nitrogen applications approximately equaled nitrogen removals in grains exported from the Prairies. Nitrogen removals in all harvested materials — grains, hays and fodder, crop residues and pasture grazing — of Western Canada are still more than twice the quantity of nitrogen fertilizer applications. However, a very substantial, but variable and inaccurately known amount of fertilizer nitrogen is lost to crops due to denitrification and/or leaching.

To a degree fertilization of the soil may, in some cases, affect the total environment — air, water, soil and sub-soil. The fate of fertilizer nitrogen is, however, exceedingly variable depending on such factors as the kind of soil, cropping systems, soil management practices, seasonal precipitation conditions, temperatures during the February-April spring melt, and others. While soil scientists have documented the reductions in soil nitrogen and fertilizer nitrogen under arable agriculture, as well as the variability in amounts and the uncertainties regarding their fate, this is an area which, from both environmental and agro-economic perspectives, requires intensified research. The results of that research should enable losses to be controlled in some situations, but, realistically, not necessarily in all.

Although there is a slowly increasing use of leguminous crops, which on average increase soil nitrogen somewhat, it is clear that, overall, farming in Western Canada is still depleting soil nitrogen in the region. It also needs to be remembered that usage of large amounts of nitrogen fertilizer increase the acidity of some soils, thereby depressing yields of common crops.

Phosphate (P_2O_5): Until the rapid increase in fertilizer usage which commenced in the 1960s, phosphate removals in exported crops exceeded additions in fertilizers by at least three-fold. By the 1970s increased use of fertilizers began to balance phosphate removals in grains. For example, during the period 1974 – 1978, phosphate removals in grain only were very nearly the same as fertilizer applications of phosphate. However, if phosphate uptake in grains, crop residues, hay and fodder, and by grazing are considered, and removal without returns is assumed, then fertilizer applications equalled only about 50 to 60 percent of removals during the 1974 – 1978 period. It is recognized that some of those removals do not occur and some manure is returned to the land. Overall, however, Western Canadian farm lands are still being depleted of phosphorus even though on considerable areas fertilizer additions currently exceed removals.

The proportion of fertilizer phosphate which is utilized by crops varies greatly. The rate of utilization is influenced by the same factors which affect the utilization of nitrogen, and also by the soil pH, soil minerology, and the chemical form of the phosphate fertilizer. However, the main removals of fertilizer phosphate from soils are by crops and by soil erosion. From an environmental perspective, there is therefore one primary concern, i.e. phosphate levels in water bodies as a result of soil erosion, compared to several concerns associated with fertilizer nitrogen.

The phosphorus status of Prairie soils merits consideration for several reasons. The soils of the region are generally rather low in crop-available phosphate. Soil tests in the fall of 1982 revealed the Prairies to have the lowest available phosphate status of any region in Canada and the United States (Anonymous 1983). Cereal grains have high requirements for phosphorus, about three-quarters of which ends up in the seeds — much of which is exported. Canada has no indigenous mine producing phosphate rock for fertilizers — all phosphate rock is imported. And finally, manufacture of phosphate fertilizers requires large amounts of ever more costly energy.

Thus, the sustainability of productivity of Prairie farm lands will be affected by the availability and cost of imported phosphate, and by the cost of the energy to process it into fertilizer.

Potassium, Sulphur and Other Nutrients: On the Prairies use of potassium and sulphur fertilizers is low compared to usage of nitrogen and phosphate. However, during the 1969 – 1979 decade use of potassium increased more than seven times and sulphur usage doubled (Horner et al. 1980).

(Table 1). Those increases result from some combination of improved methods for, and greater use of soil testing; increasing depletion of those nutrients in soils which had an initially low available supply; and increasing fertilizer awareness of farmers. For those reasons it is inevitable that the need for those and other nutrients will increase in the years ahead if the productivity of Western Canadian soils is to be maintained. However, with the exception of potassium, the quantities of other nutrient fertilizer applications are quite low and are therefore comparatively inexpensive.

Current technology enables the reliable identification of nutrient deficiencies and if there are incentive prices for farm products, productivity of farm lands will be sustained or enhanced with respect to the availability of nutrients other than nitrogen, phosphorus and potassium.

Cropping Systems and Soil Management Practices

Crop yields and their sustainability are affected greatly by cropping systems and soil management practices. In turn, those systems and practices are strongly influenced by agroclimatic characteristics and agro-economic conditions, including markets, in different regions. The cropping systems and soil management practices in the corn-soybean area of southern Ontario are in sharp contrast to those of the grain growing areas of the Prairie Provinces where precipitation/evapo-transpiration ratios, heat units, lengths of growing season, and markets require very different systems.

Because the commonest cropping system in the grain growing areas of the Prairies entails summer fallowing, and because that practice is very conducive to soil degradation, a discussion of it is in order.

Summer Fallowing: It is the most important cause of soil degradation on the Prairies. The reasons for that destructiveness are complex.

After the defeat of Louis Riel 100 years ago, it was too late for some of the farmer-soldiers to plant their crops. Good farmers tilled their fields a number of times during the summer to control weeds. The following year crops on the "summer fallowed" land were outstanding. Ever since, summer fallowing has been practiced on the Prairies, and currently, in spite of some reductions in recent years, about 30 percent of cultivated land is fallowed each year (Weaver et al. 1982).

Fallowing conserves some of the precipitation, and in the unnaturally moist warm fallowed soil, organic matter decomposition is rapid. Thus, insoluble and unavailable nutrients in organic matter, especially nitrogen, are converted to plant-available forms and accumulate in the soil — ready to nourish the crop of the following year. Thus, crops grown on land fallowed the previous year tend to benefit from accumulations of moisture and of available nutrients, and yields were, and sometimes still are, superior.

But summer fallowing tends to deteriorate land in several ways. Most soil erosion on the Prairies occurs on fallowed land. If land is clean tilled during fallow years, the bare soil is unnaturally exposed and wind and water erosion are encouraged by the tillage operations which crush and pulverize the soil. Fallowing accelerates the decomposition of soil organic matter and no crop residues are produced during the fallow year: the combined effects are a progressive decrease of soil organic matter over the years. Losses of nitrogen by denitrification and by leaching are greater from fallowed lands than from cropped fields. As soil organic matter is decreased by accelerated decomposition and erosion, and as tillage progressively breaks down soil structure, infiltration of precipitation is affected and runoff tends to increase. This, in turn, accelerates water erosion, contributes to wetness in low lying areas, and to reduced amounts of soil moisture on higher parts of fields. Summer fallowing is a major cause of higher water tables and salinization in groundwater discharge areas in the Prairies. It is the major cause of moisture leaching down in soils beyond the reach of plant roots. Leaching waters remove available nitrogen and dissolve salts in the soil parent materials. Thus, summer fallowing is a major factor contributing to the increasing need for and use of nitrogen fertilizers, and to salinization on the Prairies.

While the commonly cited reasons for summer fallowing are conservation of soil moisture for the following year's crop, weed control, and accumulation of available plant nutrients for higher yields, there are often other reasons for fallowing. Requirements for production of registered and similar seeds may specify that the seed must be produced on fallowed land. Warm soil temperatures in the spring speed the early growth of crops — and fallowed soils are normally warmer than soils of stubble fields. In the semi-arid region of the Prairie ecozone, soil moisture reserves in the spring before seeding are very important to crop prospects: if moisture reserves are low at what should be seeding time, a farmer has flexibility in being able to decide at that time to fallow, rather than to seed and run the risk of obtaining a poor crop because of the low soil moisture reserve. During the fallow year residue-borne diseases are largely eliminated as there is no living crop to support such diseases in the fallow fields. Finally, fallowing improves the efficiency of use of farm labor and machinery because fallowing is done during the summer when labor and machinery are not in use for production of the current year crop.

Overall, summer fallowing has soil-deteriorating effects on the Prairies. The cumulative effects of fallowing reduce the productive potentials of the lands concerned. Conservation tillage methods are important ways to reduce some of the adverse effects of fallowing. However, with continuance of cropping systems which include fallowing, and without forage crops in the cropping system, the grain crops being produced become increasingly dependent on fertilizer nitrogen to maintain yields. Conversely, by providing crops with needed nitrogen in the form of fertilizer, fallowing on the Prairies can be, and is being reduced.

Preferred Rotations: From several points of view the ideal cropping systems for arable lands employed for the production of grains and row crops are ones which entail alternating periods of forage crops, preferably including or consisting of some legume crop, and cultivated crops such as grains or row crops. Such cropping systems minimize soil erosion as well as pest and disease problems, while contributing to the maintenance of soil fertility and to the favorable physical properties of soils. Unfortunately such environmentally desirable cropping systems are more complex to finance and operate. In the short-term they are not competitive in economic terms with intensive grain production systems such as corn or corn-soybeans in Ontario, and the Prairie grain production systems.

Moisture Conservation: Moisture conservation is not only important in the Prairie Provinces but in other parts of Canada where irrigation is of increasing frequency and interest.

Cropping systems which entail combinations of grain and forage crops tend to use precipitation more efficiently than grain-fallow systems, as illustrated by the Breton Plot data in Alberta (Bentley et al. 1971).

One of the long-standing justifications for summer fallow on the Prairies is the conservation of moisture during the fallow year in order to sustain and enhance the crop grown the following year. However, it is now contended that the combination of more efficient conservation of moisture by soil and crop management techniques, and the appropriate use of fertilizers, enables continuous, or more continuous, grain cropping. This, in turn, reduces the rate of soil deterioration and the environmentally objectionable effects attributed to summer fallowing. On that basis the Canada Grains Council confidently contends summer fallowing can be reduced substantially on the Prairies (Weaver et al. 1982).

Two of the techniques advocated for improved conservation of moisture on the Prairies have environmentally positive aspects. By harvesting grain in such a manner as to leave adjacent stubble strips of differing height, more snow is held on fields over winter, and so in the spring more moisture from the snow melt enters the soil. Minimum or zero tillage reduces greatly, or completely, cultivation between the harvest of one crop and the seeding of the next crop on the same field, while reducing both wind and water erosion potentials markedly.

Herbicides are used for much of the weed control with minimum tillage, while with zero tillage, only herbicides are used to control weeds. However, effective testing and monitoring of herbicides as conditions of licensing and use are needed to ensure there are no adverse environmental effects.

Acidification, soil compaction and some other types of soil degradation under agricultural use are minimized by the preferred cropping systems which include the production of both forage and cultivated crops.

Acidification: Acidification is a form of degradation of increasing concern in parts of Western Canada. In the Prairies soil acidity may be natural or induced by human activities.

The virgin soils of Western Canada had, and have, pHs — the chemical measure of relative acidity or alkalinity — ranging from extremely acid to extremely alkaline. Most plants, particularly crop plants, do not thrive on very acid or alkaline soils. Alfalfa and barley are examples of crops whose yield declines sharply when soil pHs are less than six.

In the Peace River Region about 30 percent of the soils are naturally so acidic that growth of alfalfa and barley is at least somewhat depressed, and yields are therefore rather low (Hoyt et al. 1974). Some soils of the region are so acidic that it is impractical to attempt production of those crops without correcting the acidity by costly applications of lime.

There are extensive areas of Solonetzic soils in the Prairies, especially in Alberta. In recent years it has been established that the rather low yields on some Solonetzic soils is in part due to the natural soil acidity of their topsoils. Again, liming of the affected areas, which are commonly very uneven and erratic in distribution, will correct the adverse acidic condition.

Human activities may affect soil pHs in one or a combination of several ways. Soil erosion, especially on knolls, may remove topsoil, exposing subsoil which in such cases is usually alkaline and calcareous. Such eroded areas commonly have less plant growth than adjacent soils with more favorable pHs and higher organic matter contents. Nitrogen fertilizers undergo chemical changes in the soil which result in production of $H+$ ions — the pH-depressing and acidifying ion. Many industrial operations and motor vehicles emit oxides of sulphur and nitrogen which either by direct absorption from the atmosphere by soil particles, or in the form of so-called "acid rain", have acidifying effects on soils.

Much of the agricultural land in Eastern Canada is naturally so acidic that most common crops do not give economically profitable yields without liming. Indeed, provincial government lime assistance policies recognize the desirability of increasing productivity of acid soils by liming. Unfortunately, "acid rain" and use of nitrogen fertilizers magnify the acidity problems of some soils. In Eastern Canada measurable decreases in soil pHs have occurred and it has been estimated (Coote et al. 1980) that perhaps 40 percent is attributable to the acid rain phenomena and 60 percent to the use of nitrogenous fertilizers. The acid rain in that region results from acidifying emissions from industry and vehicles in both the United States and Canada, so control is a complex problem.

In coastal British Columbia and parts of the interior, the combination of natural acidity, high rainfall or irrigation, and considerable use of nitrogen fertilizer has resulted in a long history of liming to overcome unfavorable acidity of affected soils.

Although it has been clearly established that acidifying atmospheric emissions from some of the petroleum industry establishments in Western Canada do have some acidifying effect on soils within their spheres of influence, the significance of such acidification has not been quantified because of insufficient research. A few cases of intense soil acidification from sulphur dust carried from sour gas processing plants have occurred. Affected areas, usually a few tens of acres at most, have easily been reclaimed by liming.

In the Prairie Provinces generally, concern about soil acidity is recent. This is largely due to the recency of considerable use of nitrogen fertilizers. However, it was estimated in 1981 (ASSWS) that by 1985 nitrogen fertilizer-induced acidity may require use of over 250,000 tonnes of lime per year in order to offset the yield-depressing effects of acidity in Alberta and northeastern British Columbia. The use of lime in the Prairies is a new, relatively unknown, and rather costly practice which requires a special machine to apply the powdery material. It is virtually certain that regardless of official encouragements for farmers to lime acid soils, the use of lime will increase only slowly for some years at least.

As a consequence of the rapid increase in nitrogen fertilizer usage, and because of new understanding regarding the extent and effects of natural soil acidity, Prairie soil scientists now realize that liming will be an increasing necessity for maintenance of agricultural productivity of appreciable amounts of farm land. The Alberta Government has therefore instituted a lime freight assistance program with a view to increasing the productivity of acidified soils. However, economics — the costs and risks of investments in liming balanced against the prospective returns — will determine how much liming will increase productivity of acidified Prairie soils. Energy costs, to mine and process lime, to transport and apply it, will greatly influence how much liming will be done on the Prairies.

Other Degradations: A number of other factors such as overgrazing, failure to use recommended crop rotations, and soil compaction can all influence the productivity of agricultural lands. Quantification or evaluation of the effects of those factors is very difficult and consequently hard data are almost totally lacking. However, as mono-cropping increases, and as the sameness of some cropping systems and soil management practices continue, there is increasing awareness that, in some soils, a decline in favorable physical properties ("tilth") is affecting farm operations and performance of some crops.

Recently Paul and DeVries (1983) have reported that subsurface drainage, which reduces the dangers of soil compaction due to traffic on overly-moist soil, has had important beneficial effects in the lower Fraser Valley. However, the quantification of the adverse effects of compaction remain elusive even though that problem was recognized in the questionnaire discussed on pages 15 and 16 of this report.

Summary

Degradation of agricultural lands under use is clearly a topic of increasing concern. However, such deterioration may be categorized on the basis of severity, or of permanence, or of costs of reclamation — if indeed the latter is economically practical.

An increase in soil acidity due to use of nitrogenous fertilizers may severely affect yields, especially of sensitive crops. Fortunately, liming in accordance with soil test recommendations can correct acidity — and frequently increases productivity to levels above that of the original soil. But liming can be rather expensive, although the beneficial effects may last for a decade or two.

Soil erosion may reduce crop yields substantially although quantification of the reductions is usually very difficult. Perhaps loss of 10 to 20 percent of the topsoil in a field may not affect productivity greatly if an appropriate program of fertilization is followed — but fertilizers are costly and they do not replace valuable humus carried off by eroding wind or by water erosion. Topsoil loss usually reduces soil water-holding capacity, thus increasing drouth proneness. Erosion which removes all of the topsoil usually results in permanent impairment of productivity. Indeed, erosion sometimes prevents any future agricultural use of some affected areas by exposure of noxious subsoils, gravel deposits, or underlying geological bedrock. In most cases, however, appropriate use of fertilizers in combination with suitable cropping practices, sometimes production of forage crops only for long periods of time, can improve the productivity of erosion damaged soils, but perhaps may not return them to their original levels of productivity.

Salinization and/or waterlogging of agricultural soils usually results in severe impairment of agricultural productivity — or even the rendering barren of affected areas. Reclamation of affected soils, when possible, is usually expensive, costing as much as $1,000, or even more, per hectare. However, the productivity of reclaimed soils may increase rather slowly and perhaps not to the levels which applied before impairment. Salts removed by reclamation increase the salt content of waters and may affect the suitability for down stream uses including domestic water supply, irrigation, wildlife, recreation, and industrial purposes.

Soils that have suffered degradation due to reductions in organic matter contents are affected in at least two yield-affecting ways: reductions in the release of nutrients such as nitrogen to forms which are usable by crops; and impaired tilth plus increased compaction, both of which affect crop growth on some affected soils. Often water holding capacity is reduced too. In most cases a combination of erosion prevention, appropriate fertilization and a suitable crop and soil management program can improve soil organic matter content and crop yields, although perhaps not to the levels which existed when the affected lands were first cultivated.

Commercial fertilizers are not a panacea for all ills of the soil. Sometimes certain fertlizers have an adverse effect on the pH of some soils, or on soil micro-organisms — although they may have beneficial effects on those soil characteristics on some other soils. Commercial fertilizers, like manure, have potential for some adverse environmental effects too. However, rising energy costs, and therefore rising fertilizer costs, will tend to depress fertilizer usage. That may lead to lower grain production unless grain prices rise relative to energy costs.

FACTORS IN THE PUBLIC DOMAIN

Land Use Regulations

Land use regulations deal with such matters as soil conservation, conversions of land to other uses and drastic land disturbances such as mining and extraction of gravel. Such matters can have important effects on sustaining the productivity of agricultural lands.

The lack of soil conservation legislation and of policies or programs that result in adoption of effective soil conserving practices by farmers is evident in Canada. PFRA (1983) contends that massive programs are now needed.

Another concern is the continuing unnecessary conversion of high quality agricultural lands to non-agricultural uses. In Alberta land conversion was one of the reasons for the public hearings held on "Maintaining and Expanding the Agricultural Land Base."

Conversion of Agricultural Lands to Other Uses

Over half of the highest quality (CLI class 1) agricultural land in Canada is within 80 kilometres of the 23 major urban centres in the country (Simpson-Lewis et al. 1982). Urban and industrial growth, together with improved transportation and the Canadian penchant for rural living have led to conversion of significant amounts of the best agricultural lands to other uses during the past three or four decades. The effects of such conversions on the long-term sustainability of agricultural production in Canada are inadequately appreciated.

In Canada only eight percent of the land is suitable for continuing arable agriculture. Land suitable for arable agriculture is divided into four classes which differ as follows:

CLI Class	Unofficial Lay Person Quality Description	Fraction of Canada's Land Area•	Relative Production Potential for Arable Agriculture*	Relative Direct Costs of Production per kg of Product Produced*
1	Excellent to very good	0.45%	1.00	1.0
2	Good	1.8%	0.80	1.3
3	Fairly good	2.8%	0.65	1.5
4	Marginal	2.8%	0.50	2.0
		7.9%		

* These are approximations for common types of arable agriculture. However, for excellent farmers the direct costs of producing grains or other arable land crops on Class 4 land are about twice as much per bushel (or per tonne) as they are for the same quantity of the same product when it is produced on Class 1 land, even on the same farm! Based on Hoffman (1971).

• Simpson-Lewis et al. (1982).

The lands best suited for agriculture are also the preferred lands for many other uses, and in bidding competitions for high quality land, agriculture loses. Such competition is usually most intense around cities where most of the land is of high agricultural quality. Central Alberta illustrates these relationships clearly. Thompson (1981) estimates that if trends of the recent couple of decades are permitted to continue, then by the year 2000 in the Edmonton-Calgary corridor conversions of agricultural land to other uses will be approximately as follows:

Type of Conversion	Hectares (rounded) 1980-2000	% of Conversion Land in CLI Classes 1-3
Annexation*	140,000	76%
Rural subdivision	210,000	52%
Annexation & rural subdivision	350,000	

* Includes a component of direct conversion.

If realized, those conversions would constitute approximately two percent of all CLI 1-3 land in Alberta and would include some of the best soils and be in the best agroclimatic areas of the province. The net effect would be to decrease the agricultural production potential of Alberta, which has about 24 percent of the total agricultural production potential of Canada, by more than two percent.

Canadian figures (Table 2) for the period 1966 – 76 show that 62 percent of the agricultural lands converted to other uses were CLI Classes 1-3 — · prime agricultural lands! Since that time legislation in British Columbia, Quebec and Newfoundland has slowed such conversion in those provinces but data to show the effects are not yet available.

It is indisputable that unnecessary conversions of high quality agricultural lands to other uses — conversions which are usually permanent — are indeed reducing the agricultural production potential of Canada. Unless there is to be a decline in the total production of food by Canadian agriculture, the production lost from converted lands must be replaced by production on Canadian land of lower quality where direct costs of production are higher per unit of food produced. Any gaps in the domestic supply, caused by conversion of land which is in very limited quantity and devoted to specialized crops, would have to be made up by imported food. In either case, the effect of such conversions likely will be to increase the cost of food for Canadian consumers and for Canada's export market.

Strip-Mining and Other Land Disturbances

The petroleum industry, construction of reservoirs, land levelling for irrigation, power transmission, coal mining and gravel extraction entail land-disturbing activities with potential to affect the agricultural production potential of rather extensive areas. Prior to about 1960 there were few requirements controlling such activities after operators had obtained ownership of the surface and mineral rights. The moon-scape appearance of mined-out areas in the Estevan coal fields of Saskatchewan, some gravel and mine areas in Eastern Canada, and some pre-1960s coal areas in Alberta, are glaring examples of how unregulated mineral extraction can destroy almost totally the agricultural usefulness of considerable areas.

Concerns about the environment and the substantial effects of extractive industries on some farms and farming operations have resulted in the enactment of rather stringent regulations. For example, the Alberta coal policy requires that as a pre-condition to obtaining a mining permit the proponent must present a comprehensive reclamation plan which satisfies the following Government of Alberta requirement:

"The primary objective in land reclamation is to ensure that the mined or disturbed land will be returned to a state which will support plant and animal life or be otherwise productive or useful to man at least to the degree it was before it was disturbed."

Coal mining companies are required to post substantial financial bonds which are held until a "certificate of reclamation" has been obtained from the Government of Alberta. The first certificates of reclamation issued in Alberta were obtained by a coal mine at Forestburg in 1981 (Logan in CSEB 1982). That reclaimed area is now productive farm land.

Alberta now has legislation concerning pipelines, oil well sites and associated activities, seismic-lines, gravel pits, power lines and so forth, all of which require reclamation and/or minimization of adverse effects on the productivity of lands affected by those activities. Summaries of the more pertinent requirements are contained in the proceedings of a 1982 symposium "Agriculture and the Environment" (CSEB 1982).

Legislation governing land disturbing activities in the other provinces of Western Canada is generally similar to the Alberta provisions. A publication of the Lands Directorate of Environment Canada (Marshall 1982) provides a Canadian overview.

Reclamation of disturbed lands is a topic of high concern to soil scientists. The theme of the Alberta Soil Science Workshop in 1977 was "Soil Conservation Reclamation and Research". The 1983 program for that annual conference included a day devoted to soil conservation and reclamation: the latter topic focussed on strip mining and saline soils. There is much coal strip-mining in North Dakota and in Montana too. Annually, a conference considers progress and problems related to reclamation of strip mined areas in those States, and Canadian soil scientists are regular participants.

In recent years soil scientists and public agencies have become deeply involved in reclamation programs and research related to drastically disturbed lands. Indeed, a book of more than 700 pages (ASA 1978) entitled "Reclamation of Drastically Disturbed Lands" is concerned with restoring the production potentials of such lands. Application of existing knowledge and technology, which may entail costs of several to many thousands of dollars per hectare, makes it possible to meet the standard from the Alberta coal policy quoted above.

Toxic Contaminations

Agricultural land is the recipient of some toxic or contaminating materials in addition to acid rain. There have been, and continue to be, lead emissions from motor vehicles and accumulations that constitute significant contamination along heavy traffic routes. There is increasing concern about the effects of lead on health, and food is a major source of intake.

Sewage disposal problems increase as cities grow, and one method of disposal is application as sludge or by irrigation on agricultural land, which benefits from the nitrogen and other nutrients so supplied. However, sewage may contain cadmium and other heavy metal contaminants in addition to pathogenic organisms. Careful assessment should precede any program to dispose of sewage on agricultural land, and intense monitoring of products from that land is desirable.

Agricultural Education, Research and Extension

The increasingly sophisticated technology of agriculture results in the need for highly qualified agrologists for research and extension, and for ever better-educated farmers. Today, most successful farmers are operating a business employing more than $200,000 worth of capital. They need reliable research results transmitted to them by effective informed extension personnel. Such farmers need high levels of education in order to apply effectively the technical information they receive.

The inadequacy of the Prairie Provinces' provisions for agricultural research and extension, which compare rather favorably with such provisions in the rest of Canada, are graphically illustrated in Figures 3 & 4 and Table 3.

Economic Policies for Agriculture

The level and stability of income of farmers affects greatly the farming programs they follow. The questionnaire results given on page 15 of this report reveal a disturbing situation. The too frequent failure of farmers to employ recommended soil conserving and maintaining practices is attributed to uncertainty that they will obtain an economic return on the investments necessary to implement recommended practices. That clearly implies the need for economic policies for agriculture which will encourage farmers to maintain the productivity of their farms more effectively than is now being done in many cases.

Economic uncertainties make young people reluctant to embark on farming as a lifetime occupation and consequently there is a low rate of recruitment of young people to the occupation.

NATURAL OR EXTERNAL FACTORS

Soils, climate, markets and the demographic characteristics of farmers powerfully affect the types and success of farming in different agro-ecological regions.

Only five percent of Canada's land area is in CLI agricultural capability Classes 1 to 3. And less than 12 percent of all areas in Canada with any agricultural capability have an agricultural climatic suitability that is rated "fairly good" or better (Simpson-Lewis et al. 1982). The best areas in terms of soils and climate are the ones most threatened by conversions of agricultural lands to other uses, and the limited quantity of such quality lands is a natural and inadequately appreciated aspect of the Canadian scene.

Canadian farmers are an aging group. In 1976 more than 58 percent of farmers were over 44 years of age (Agriculture Canada, 1981). As a group, therefore, farmers tend to be conservative and resistant to change. Their average level of education compares unfavorably with the labor force in almost all other occupations in Canada. These characteristics of Canadian farmers are natural handicaps to adoption and implementation of improved soil conserving and maintaining farming practices.

It should be recognized that much of the economic uncertainty — the boom and bust cycle — is a result of the fact that about 30 percent of Canada's agricultural production is exported. International markets over which Canada has no control have very strong effects on Canadian agriculture. Lacking protective Canadian programs, the uncertainties of international markets affect soil conservation and maintenance in Canada.

THE VIEWS OF SOIL SCIENTISTS

The concerns of soil scientists about the sustainability of the productivity of agricultural lands in Canada have increased sharply in recent years. That is clearly reflected by the themes and topics of annual provincial soil science workshops since 1975. As one soil scientist said in February 1983: "Five years ago no one was talking about soil degradation; now everyone is concerned about it."

There are similar concerns in the United States. The Christian Science Monitor, a leading newspaper, has had several feature articles on the topic of agricultural land degradation. In 1983 both Science (Larson et al. 1983) and Scientific American (Batie and Healey 1983) have had major articles concerned respectively with soil erosion and the prospects for sustaining American agricultural production. In March 1983, the American Society of Agronomy held a nation-wide symposium for soil scientists and agronomists on the topic "Soil Erosion and Crop Productivity".

In order to obtain the opinions of a considerable number of soil scientists and other agrologists regarding degradation of agricultural lands under use and to ascertain their views about the sustainability of farm lands under use in Western Canada, two questionnaires were employed.

Opinions on Degradation

The first questionnaire requested the respondents to record their opinions on the relative importance of the predominant types of land degradation in various ecozones and under differing kinds of farming. They were also asked to rate the seriousness of each type of degradation they identified as low, medium or high. The tabulated results were converted to numerical ratings which enabled calculations of a type of comparative ranking based on the two evaluations. The results are summarized in Table 4.

It must be emphasized that Table 4 is merely an attempt to place numerical ratings on opinions which were not arrived at by any scientific method. However, the quantification of soil degradation factors is notoriously difficult — - and consequently the lack of clear technical data! Thus, the numbers in Table 4 at least reflect the opinions of a modest number of soil scientists in 1983, and seem to justify some conclusions.

- Overall, soil erosion is judged to be the most important form of soil degradation.
- Exclusive of the irrigated areas, the decline in soil organic matter content is deemed to be the second most serious type of degradation.
- Except in the wooded ecozone, salinization is considered to be about as serious, or more serious under irrigation, as the decline in soil organic matter content.
- Except for specialty cropping under irrigation, compaction is a rather lowly rated form of degradation.

Opinions on Sustainability of Productivity

The second questionnaire posed three questions. The introduction to that questionnaire and the first two questions, together with the results on a percentage basis from the 26 respondents, follow.

The energy crunch, the decline in the organic matter content of many farmed lands, and a variety of economic factors have recently been and currently are among the causes of some sharp changes in perceptions of agriculture in Western Canada.

1. Have your views regarding the sustainability of the productivity of our farmed lands changed during the last five years?

   31% No. 69% Yes. If Yes: 56% more optimistic; 44% less optimistic.

2. What is your current opinion regarding, in general terms for Western Canada, the sustainability of the productivity of farm lands under use:

   42%: productivity will be maintained.
   35%: productivity will be enhanced.
   15%: productivity will begin to decline in the near future.
   8%: productivity is already declining.

The foregoing results show clearly that there are conflicting opinions, among the agrologists surveyed, concerning the sustainability of the productivity of farmed lands in the Prairies. If a general characterization of the views expressed were attempted, it might be phrased in language similar to that employed by Batie and Healey (1983): "Overall, there seems to be cautious optimism."

Opinions Regarding Soil Conservation

The third question of the second questionnaire sought opinions regarding why recommended soil-conserving practices are not being employed by many Prairie farmers. The tabulated responses, on a weight-for-rank-basis, were transformed to numerical ratings and are entered below in the question as it was posed to the 26 respondents.

Many agrologists are of the opinion that soil conserving and maintaining technologies, which are well known and proven, are not adequately employed by many farmers.

Please rate (1, 2, 3, etc.) in order of importance those of the following items which explain failure of farmers to employ more fully soil conserving and maintaining technologies.

82: recommended practices are perceived as being impractical.
135: soil-maintaining practices cost money and returns on such investments are uncertain.
63: recommended practices are too difficult to employ.
89: the recommendations have not been validated under the harsh realities of a real farm.
104: adherence to old ideas; resistance to change.
*63: others causes.

If the foregoing opinions are even approximately correct, there appears to be need for new soil-conservation policies and programs if Prairie farmers are to be encouraged and assisted to adopt generally soil-conserving and -maintaining technologies which are of proven effectiveness and practicality, and which are economically attractive. Agrologists are not the only group holding such opinions. In December 1982 the Canadian Federation of Agriculture held a Soil Conservation Workshop. The report of that Workshop is attached (Appendix 2) because it presents so strongly the case — and urgency! — for new soil conservation policies and programs in Canada.

Summary Statement on Attitudes

The following is a summary statement of attitudes or outlook based on personal contacts, current literature, and the questionnaires. Soil scientists recognize that some lands degraded by erosion, salinization or some other causes cannot be reclaimed to their original levels of productivity at affordable costs. However, overall there is optimism that application of existing technologies would ensure maintenance, or in many case enhancement of the production potentials of most of the farmed lands of Canada.

* "Other causes" listed included: risk avoidance; the grain quota system; lack of long-term research data; recommendations have not been adjusted to larger farms; resignation to a way-of-life; poor extension services (several times); short-term pressures (several times); degradation is inconspicuous or not recognized.

SUMMARY

Myths to the effect that Canada's agricultural land resources "are almost limitless" and that the fertility of Prairie soils "is nearly inexhaustible" have persisted for too long. However, during recent years there has been a rapidly rising concern about the sustainability of the productivity of much of Canada's farmed land. It has been indisputably documented that massive soil degradation has occurred and is continuing to occur on vast areas of our farmland.

Central and Eastern Canada

In Central and Eastern Canada soil degradation is primarily due to: decline in the organic matter content of cultivated land, soil erosion which reduces soil fertility and impairs soil tilth, man-induced acidification due to use of nitrogenous fertilizers, "acid rain", and soil compaction which impairs moisture infiltration, aeration, and root development and penetration. Intensive row cropping such as continuous corn production or a corn/soybean rotation is a major concern due to the accompanying accelerated erosion and to the decline in soil tilth.

Prairie Provinces and British Columbia

In the Prairies, the main forms of farmland degradation are: soil erosion, decline in soil organic matter content and salinization due to irrigation or to "dryland saline seeps", impairment of soil tilth, and in some areas yield-reducing soil acidification resulting from use of nitrogen fertilizers. A public agency, the Prairie Farm Rehabilitation Administration (PFRA) has estimated the cumulative present value, at a five percent discount rate, of benefits through 1983 – 2000 from control of salinity, soil erosion and soil organic matter decreases in the Prairies to be about $3.2 billion. The extensive practice of summer fallowing is by far the most important cause of soil degradation in the Prairie Provinces.

In British Columbia, soil deterioration under use is primarily due to erosion, acidification and compaction.

Conversions and Disturbances

Unnecessary conversions of high quality agricultural land to non-agricultural uses are also of growing concern in Canada, and worldwide! A large proportion of the prime agricultural land in Canada is within commuter distance of the major Canadian cities. Conversions of significant amounts of those lands to non-agricultural uses reduces agricultural self-sufficiency of the provinces, and only the Prairie Provinces are now food self-sufficient on a net trade basis. Moreover, replacement of lost food production potentials in the vicinities of cities by development of more remote land of lower quality increases food costs because unit costs of agricultural production rise with use of lower quality land (excluding consideration of investment in land).

Strip mining, pipelines and other drastic land disturbances and industry-related activities adversely affect consequential areas of agricultural lands in parts of Canada. Rather recent legislation intended to control such activities and requiring reclamation where it is feasible was very necessary.

Problems

Past and continuing deterioration of farmlands under use in Canada result from several continuing problems.

- Lack of adequate agricultural research to quantify the problems concerned and to find practical technical solutions to them.
- Insufficient demonstration and promotion of the practicality and proven economic benefits of known soil conserving and maintaining farming practices.
- Persisting cycles of "boom and bust" which cause farmers to hesitate to invest in soil-conserving and -maintaining practices because of uncertainties of a return on such investments.
- The reluctance of contemporary society to discipline in meaningful ways those who inexcusably abuse and misuse the land resource in serious and indisputable ways.

CONCLUSIONS

The authors of this review are of the opinion that massive, sustained, long-term soil conservation programs and policies by Canadian governments are urgently needed to ensure the sustainability of productivity of Canada's farmed lands.

To achieve that, society must be convinced that the need for the advocated programs exists — and that the benefits will be real!

Table 1. Fertilizer usage in Western Canada has increased dramatically during the period 1938-1979. Economic conditions have caused some sharp variations. (Adapted from Horner et al. 1980.)*

Year	Purchases of Plant Nutrients thousands of tonnes			
	Nitrogen (N)	Phosphorus (PO)	Potassium (KO)	Sulphur (S)
1938	1	4	-	-
1948	6	25	-	-
1958	15	30	-	-
1968	190	230	-	-
1970	110	100	6	26
1972	160	150	13	33
1974	300	290	9	43
1976	360	275	18	38
1977	370	250	26	37
1978	480	320	32	37
1979	590	375	42	40

* Data rounded.

Table 2. Agricultural capability classes of CLI classified lands and conversions therefrom.

	Percentages of the Land Classified for CLI Agricultural Capability[1]			Percentages of Conversions to Urban Usages by Land Classification 1966-76[2]		
	1-3[3]	4-6	7	1-3[3]	4-6	Others[4]
British Columbia	5	45	50	20	31	49
Alberta	27	62	11	66	19	15
Saskatchewan	52	48	—	78	11	11
Manitoba	40	52	8	92	8	—
Ontario	30	23	47	78	14	8
Quebec	8	16	76	51	34	15
New Brunswick	19	54	27	25	47	28
Nova Scotia	22	10	68	42	9	49
Prince Edward Island	72	23	5	100	—	—
Newfoundland	.07	47	52	—	58	42
Canada	25	42	33	62	22	16

[1] Adapted from Simpson-Lewis et al. 1982 (Table 2).
[2] Adapted from Warren and Rump 1981 (Table 14 and Figure 8).
[3] CLI Classes 1-3 are the best or "prime" agricultural land.
[4] CLI Class 7 + organic + other lands.

Table 3. Comparison of agrologists' services in soils related activities. (Adapted from PFRA 1983.)

Per Agrologist Year	Montana	Saskatchewan
No. of farm units served	434	1,392
Hectares of cropland	124,000	378,400
Value of crops produced	$10 M	$47 M

Table 4. Opinions regarding land degradation in the Prairie Provinces. Responses to a questionnaire.

	Prairie Ecozone				Boreal Ecozone
	Irrigated Farming		Grain Production	Mixed Farming	Mixed Farming
	Mixed	Specialty			
Number of opinions	13	6	23	21	17
Type of Degradation	Percent of most unfavorable possible rating*				
Soil erosion	61	69	78	78	79
Decline in soil organic matter	40	40	67	62	57
Salinization	73	56	66	58	25
Fertilizer induced acidification	36	48	21	20	41
Soil compaction	18	35	10	9	14

* The "most unfavorable possible rating" (100%) would have resulted if all respondents had assigned first rank to a degradation factor and if all had also assigned that factor a "high" rating for its seriousness.

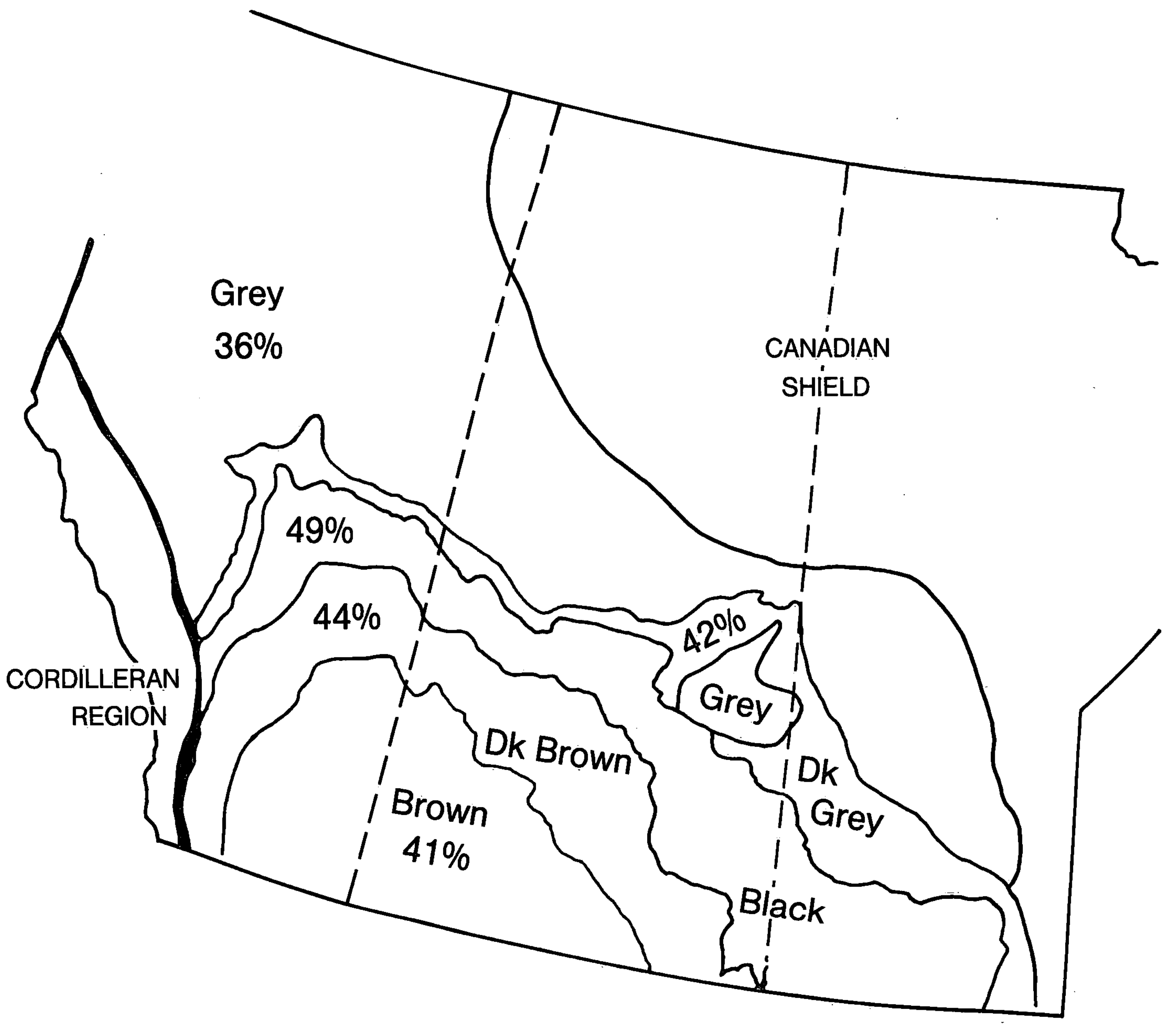

Figure 1: Percentage soil organic matter losses from the A horizons of soils in the various soil zones of the Canadian Prairies.

(From McGill et al in ASSWS 1981).

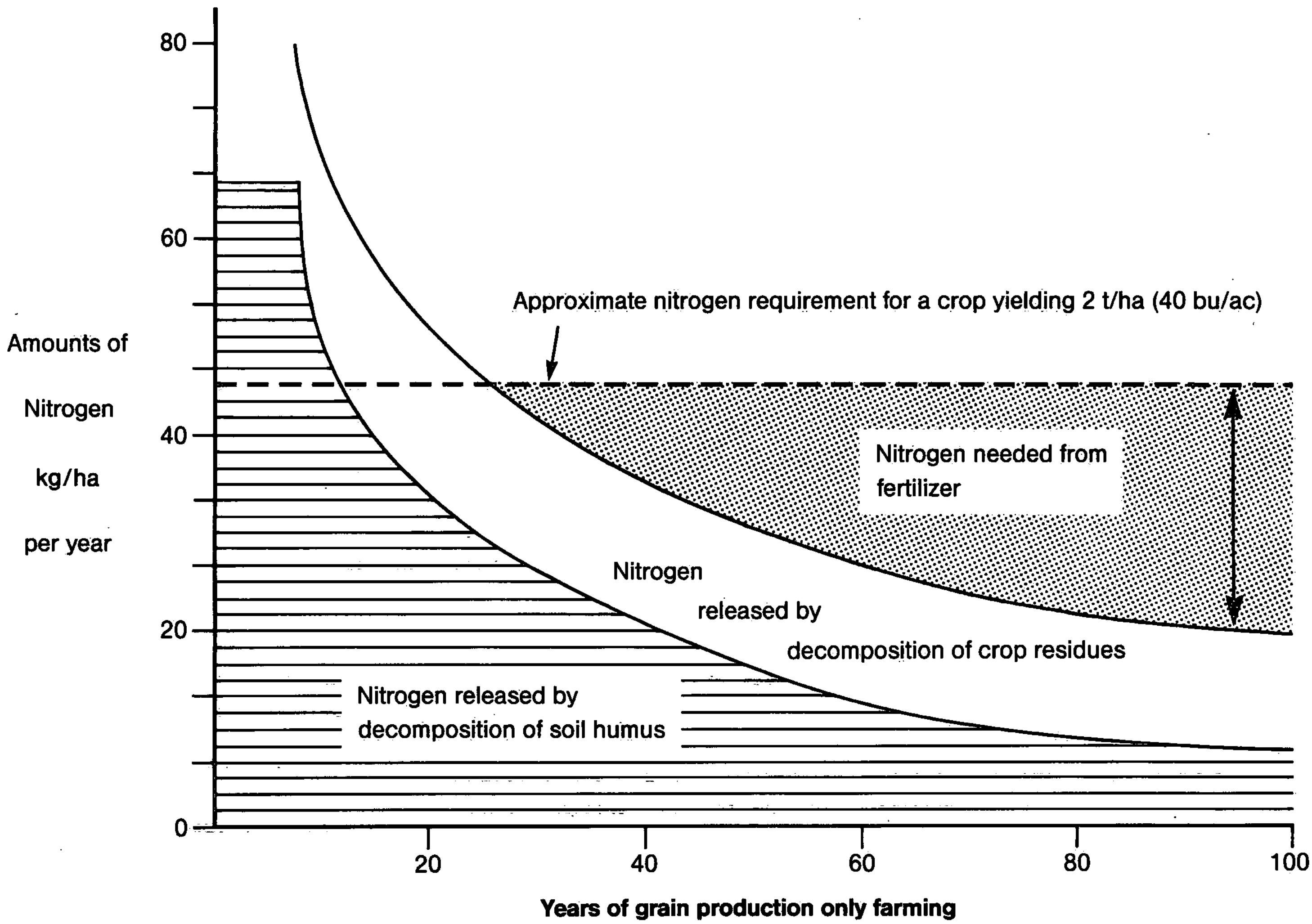

Figure 2: Diagramatic illustration of approximate sources of nitrogen needed to maintain grain yields of about 2 t/ha (40 bu/ac) of barley under a system of continuous grain production in the Prairie region. (Adapted from AFB 1982.) Note that this diagram illustrates plant requirements not supply, i.e., the amount of fertilizer nitrogen applied would normally be greater than the plant requirements because of losses due to denitrification and/or leaching.

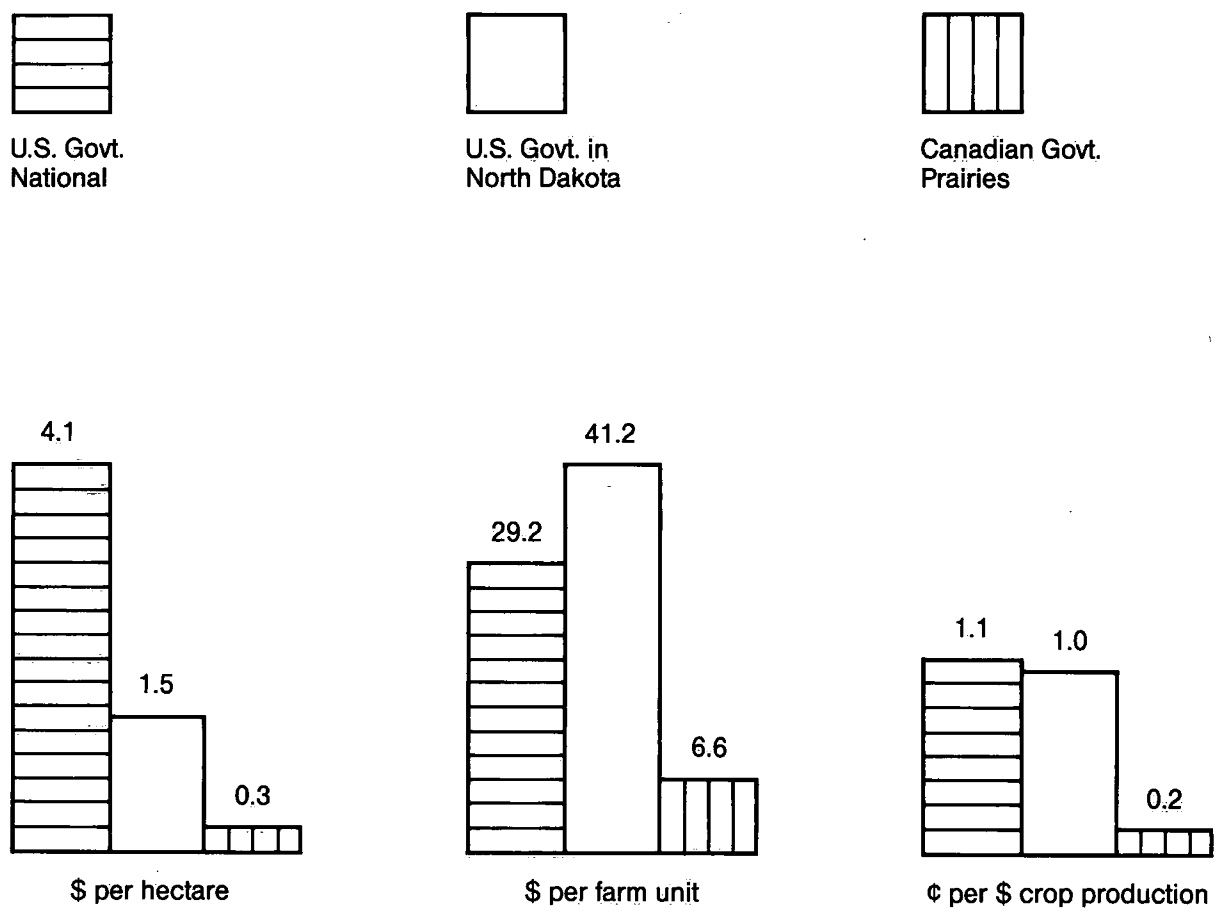

Figure 3: A comparison of American Federal Government expenditures on soil and water conservation and Canadian Federal Government expenditures on the Prairies, 1979. (Adapted from PFRA 1983.)

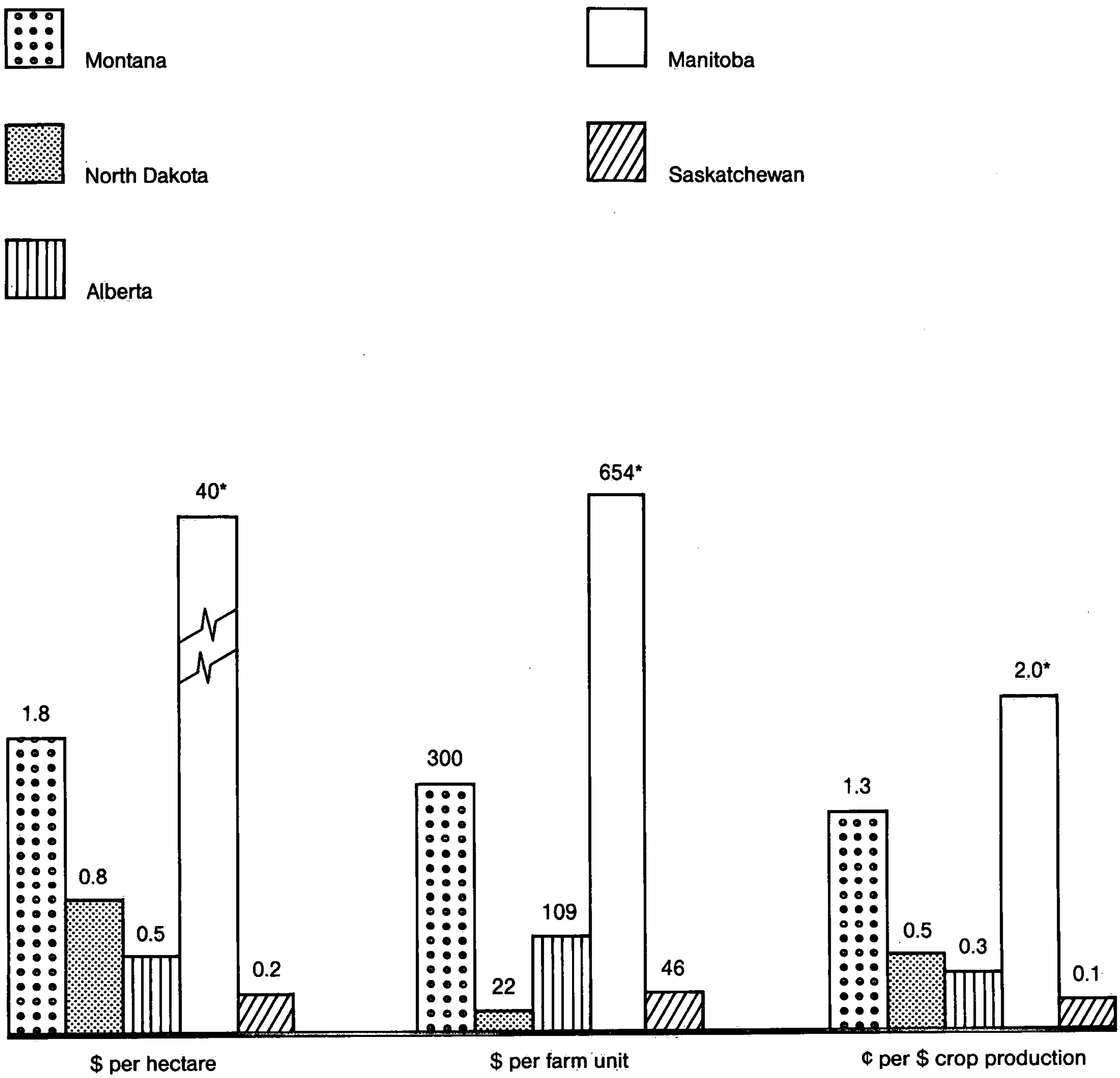

Figure 4: Comparative expenditures on soil and water conservation 1979 by Prairie Provinces and adjacent States. (From PFRA 1983.)

*The major part of the Manitoba expenditure was for drainage of wetlands or of flood prone areas.

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THE WORLD SOIL CHARTER

The 1974 World Food Conference in Rome recommended that the Food and Agriculture Organization of the United Nations prepare a World Soil Charter, setting out the principles for the optimization of the land use on a global basis. At the 21st Session of the FAO Conference, held in November 1981 in Rome, such a World Soil Charter was formally adopted. A copy of the Charter was presented to the Executive Committee of ISSS at its 12th General Congress in New Delhi, February 1982, by the Director of the Land and Water Development Division of FAO, Dr. R. Dudal.

The Principles that form the core of the Charter are as follows:

1. Among the major resources available to man is land, comprising soil, water and associated plants and animals: the use of these resources should not cause their degradation or destruction because man's existence depends on their continued productivity.

2. Recognizing the paramount importance of land resources for the survival and welfare of people and economic independence of countries, and also the rapidly increasing need for more food production, it is imperative to give high priority to promoting optimum land use, to maintaining and improving soil productivity and conserving soil resources.

3. Soil degradation means partial or total loss of productivity from the soil, either quantitatively, qualitatively, or both, as a result of such processes as soil erosion by water or wind, salinization, waterlogging, depletion of plant nutrients, deterioration of soil structure, desertification and pollution. In addition, significant areas of soil are lost daily to non-agricultural uses. These developments are alarming in the light of the urgent need for increasing production of food, fibres and wood.

4. Soil degradation directly affects agriculture and forestry by diminishing yields and upsetting water regimes, but other sectors of the economy and the environment as a whole, including industry and commerce, are often seriously affected as well, through, for example, floods, or the silting up of rivers, dams and ports.

5. It is a major responsibility of governments that land use programmes include measures towards the best possible use of the land, ensuring long-term maintenance and improvement of its productivity, and avoiding losses of productive soil. The land users themselves should be involved, thereby ensuring that all resources available are utilized in the most rational way.

6. The provision of proper incentives at farm level and a sound institutional and legal framework are basic conditions to achieve good land use.

7. Assistance given to farmers and other land users should be of a practical service-oriented nature and should encourage the adoption of measures of good land husbandry.

8. Certain land tenure structures may constitute an obstacle to the adoption of sound soil management and conservation measures on farms. Ways and means should be pursued to overcome such obstacles with respect to the rights, duties and responsibilities of land owners, tenants and land users alike.

9. Land users and the broad public should be well informed of the need and the means of improving soil productivity and conservation. Particular emphasis should be placed on education and extension programmes and training of agricultural staff at all levels.

10. In order to ensure optimum land use it is important that a country's land resources be assessed in terms of their suitability at different levels of inputs for different types of land use, including agriculture, grazing and forestry.

11. Land having the potential for a wide range of uses should be kept in flexible forms of use so that future options for other potential uses are not denied for a long period of time or forever. The use of land for non-agricultural purposes should be organized in such a way as to avoid, as much as possible, the occupation or permanent degradation of good quality soils.

12. Decisions about the use and management of land and its resources should favour the long-term advantage rather than the short-term expedience that may lead to exploitation, degradation and possible destruction of soil resources.

13. Land conservation measures should be included in land development at the planning stage and the costs included in development planning budgets.

REPORT OF THE SOIL CONSERVATION WORKSHOP DECEMBER 8 & 9, 1982 – OTTAWA (The Canadian Federation of Agriculture)

Across the country, in every region, Canada is experiencing a deterioration of its agricultural land base.

The reality of this deterioration has been obscured over the years, and still is, by the growing volumes of production that flow from Canadian farms as a result of scientific and technical advances in machinery use, varieties, fertilization, timeliness of cultivation and from expanded animal production, to name some. Nevertheless, accumulated indications are that the agricultural land base is deteriorating through loss of topsoil, decline in organic matter, deterioration in physical structure and chemical and nutritional imbalance. The challenge to Canadian farmers and to the Canadian public is to limit and reverse this deterioration. There is no doubt that the long-term costs of failure, economically, socially and environmentally will be very high. A major commitment, followed by sustained effort on all fronts, is required. The problems, and solutions that presently and potentially present themselves, are by their very nature long term; yet some problems are critical. On all fronts they need to be addressed.

With this broad statement, simplicity and generalization must give way to increasing complexity. It must be said that an understanding of the problem does not lend itself to finger-pointing and attaching of blame, since the economic and technical pressures and imperatives of modern farming cannot be ignored or easily dealt with. Present cropping practices are stressful to the land. In positive terms an understanding of how to crop land in accordance with its capacity for permanent, sustained production should be the objective. Tillage methods are central to the question, since cultivation of the land is itself the single greatest source of the problem, yet these must be adapted to the requirements of the soil and climate in all their variety and to the economic requirements for profitable production: but to say this just scratches the surface of the situation.

This stress on complexity is not intended as a counsel of despair. It is intended rather to emphasize that the response to the challenge of conserving our soils must be national in its dimensions, yet regional and most often site-specific in its method of attack. It must be sustained and systematic.

Although concern about the problems of soil conservation is by no means new, the 1970s has seen a rising level of awareness of the danger, and with it a greater understanding of the many-faceted and interrelated dimensions of the issues. Even so, the problem continues to receive on the whole a low level of priority in the preoccupations of farmers, policy makers, extension personnel and the general public. The reasons for this include the rising levels of production achieved in Canadian agriculture (as already noted), the economic pressures on producers for production efficiencies and short term productivity gains that are often not consistent with best conservation practice, the gradual nature of much of the degradation process, and the understandably sharp focus on commodity concerns not directly related to conservation questions by producers and their organizations. They are paralleled by a correspondingly low level of priority in budgetary terms by governments, and universities. There has been a reduction in university staffing for teaching and research in soil conservation that is in serious need of correction.

Nevertheless, conservation concerns are being given increasing emphasis by producers, scientists, governments and many members of the public, as the dangers of continued neglect of the problems become more apparent in the form of wind and water erosion, salinization, reduction of organic matter, soil compaction and loss of tilth — and externally in sedimentation problems in drainage systems, environmental damage and pollution by acid rain to name some. It was the conclusion of the conference that this increased interest and concern should be translated into expanded and widespread programs of action and public and producer education. How this might best be done was the principal focus of the Conference.

In approaching this task it is evident that a successful strategy must be based on a balanced and credible approach. It must firmly establish the necessity, indeed the urgency, of getting on with the job of ensuring that the quality of Canadian agriculture's land base is preserved on a sustainable basis for the future.

The conservation problems faced by the farming industry have arisen as a result of the farmers' response to new technologies and the pressures and opportunities of modern production and marketing. In Eastern Canada the abandonment of more traditional crop rotational systems in favour of single cropping; the costs and difficulties of adopting or maintaining known conserving cultivation techniques in the face of larger scale mechanization; the economic problems of utilizing increased yields of forage and the separation of crop and livestock production are all part of the story. In the West the deleterious effects of summerfallowing and tillage from the point of view of soil erosion and degradation are becoming increasingly recognized and systems and technologies that permit its elimination or modify its unfavourable effects are being more urgently discussed. These observations are little more than illustrative of a very complex situation and evolution.

What is clear is that:

On present knowledge there is considerable scope for improved conservation practice by many farmers that would be beneficial to them even in the short run. In this context the problem is one of producer understanding and awareness of the problem and effective education, extension and demonstration to encourage adoption.

On present knowledge there is considerable scope for improved conservation practice which nevertheless is held back by real constraints of an economic nature — sometimes because of higher capital investment requirements, sometimes because of reduced income flows in the shorter run; and sometimes because of the unacceptability of the risks associated with major changes in farming systems. The economics of soil conservation are often poorly understood: research is needed.

There is also scope for improved conservation practices by methods which, in part, may be unproved, or which are not sufficiently fully developed and adapted to the many specific circumstances of soil, climate, and crops. This is a significant element in the problem of salinization, and in the development of satisfactory zero or minimum tillage methods. There are some problems that have causes external to the farming industry, of which an example in those areas affected is the acidification effects of acid rain.

There are definite needs related to the development of economically valuable alternative crops for incorporation in rotations (the Maritime potato industry) and for developing markets and marketing systems for forages grown in rotation, in particular legumes.

There is a wide variation in the extent to which farmers adopt good conservation practices. Many do, but it should be recognized that while soil conservation is partly a function of superior management and care for the steward-ship of the land, it may also be a function of the economic circumstances of the producer, and his ability to forego short term maximization of returns in the interests of the longer term conservation of the soil. It should moreover be recognized that farmers are frequently an important source of innovation in conservation techniques.

It is often said, and with a good deal of truth, that the essential basis of knowledge already exists as to the nature of our soils, the damage being done to them, and what needs to be done to halt and correct that damage. Yet it is not true that the answers are all in and that the job is exclusively an educational one, important though this is. It is in fact becoming increasingly clear that a systems approach to dealing with conservation problems is needed. The full environmental effects and interrelationships in conservation issues must be identified; the various interests affected must be involved; the research and development work required to understand the nature of the problems in each specific situation must be undertaken and adequately adapted technologies developed, and the economics of the problem and of alternative remedial action must be explored. For these purposes much study and research continues to be required.

It should be noted that the Canada Committee on Land Resource Services is an important institution for government and university program co-ordination. This Committee could make a particularly useful contribution by bringing together in documented form a review and assessment of present conservation concerns, technologies available for problem correction, programs in place, and identified research needs.

The question of the nature and significance of economic constraints in relation to conservation objectives was the subject of substantial discussion. One aspect, as already noted, was the need for more analysis of the economic implications of the application of scientific findings and new conservation techniques, some of which can involve substantial modification of farmers' practices. There was consensus on this in principle, one participant suggesting that a rather more basic shift in approach, from an orientation to maximizing production to one of maximizing farm profits by a careful selection of investment alternatives deserves examination.

Whether and to what extent programs of monetary assistance or incentives to farmers are required is of course a continuing issue. A definite body of opinion in the Conference was of the view that such programs are required, for a number of reasons. These included: the assumption of some of the risks associated with adoption of new technologies before they are more fully proved and widely adopted; the stimulation needed to overcome producer conservatism in the adoption of new technologies; the public acceptance of some portion of costs associated, particularly in the short run, with the adoption of conservation technologies that do not appear economic to the producer but which have long-run benefits to the public; and the acceptance by the government of costs which arise out of external circumstances such as the incidence of acid rain.

There was also a view that the real need was adequacy and security of returns to producers, permitting them to follow optimum practices with respect to the stewardship of the land. Whether such economic security would ensure stewardship was also questioned. Also raised were questions of the role, if any, of direct regulation and penalties. These matters were not resolved but clearly must be subject to ongoing careful study and decision.

The meeting emphasized the need for co-ordination of effort and agreed that one easily neglected need is that of carefully examining how existing agricultural programs and policies, and farm-related tax legislation impact on farm policies as these relate to conservation requirements. Such examination should be undertaken both on policies and programs now in place, and also on those that might be proposed. It may often be possible to choose policy alternatives or modifications that reduce negative impacts on adoption of desirable conservation practices and/or strengthen positive ones.

On the side of government financing, too, the question was raised as to whether the priority importance of conservation needs did not justify examining the possibilities for reduction in other agricultural programs. In response some participants indicated that agricultural spending priorities must be looked at in a broader context of public spending priorities.

As to priority needs in the development of an adequate conservation policy for Canada, the Conference identified the following clearly:

- Programs of public education and information to heighten the awareness and understanding by the general public of the nature of conservation needs and problems and the requirements for addressing them. In this connection it should be noted that a good deal of stress was placed in the Conference on the increasing recognition of the need to look at conservation questions in a systematic way in all its environmental aspects and impacts on various social and economic interests.
- Determined efforts to ensure that at the base of conservation programs should be locally based producer organizations which at that level would make decisions on the expenditure of available funds.
- The making of immediate commitments at the highest political levels and as well at the level of the community, to the objectives of optimal resource conservation, and in particular of the agricultural land resource.
- The effective introduction in school curricula, especially at elementary school level, of education in soil and water conservation, and the associated need for adequate training of teachers.
- A much strengthened orientation of agricultural extension and education to conservation needs, issues and programs.
- Strengthened programs of research, especially on an interdisciplinary basis, to develop programs and technologies that are well adapted to the great variety of site-specific problems and circumstances that successful conservation efforts must take into account.

A National Action Committee on Soil Conservation

The Conference addressed the question of what, if any, new institutions or processes should be put in place, nationally, to help ensure a stronger and better co-ordinated program of action in the soil conservation field.

It concluded first that an elaborate or highly bureaucratized structure is not needed, nor is one that is competitive with or replaces existing institutions and agencies. It concluded, however, that there is a very real need for a small national group to be formed, including especially representatives of producers, but also professionals representative of the various regions and professional disciplines involved, that would meet the presently unmet need for an active monitoring, and action-stimulating process. It would keep present programs, activities and problems under review, and assist to chart a course of action for meeting the soil conservation challenge.

It would assist the fostering of improved communication with and between farmers' organizations, governments, universities and other relevant agencies, encourage efficient co-ordination of effort, and public awareness of policy requirements. A small amount of money and staff resources would be needed to service the group, but it would not be highly structured or institutionalized. It was agreed that the Canadian Federation of Agriculture should take the responsibility for establishing such a Committee, in consultation with the Chairman of the Canada Land Resource Services Committee and other appropriate persons, and to seek necessary funding for it.

Sustainability of The Productivity of Agricultural Lands

The energy crunch, the decline in the organic matter content of many farmed lands, and a variety of economic factors have recently been and currently are among the causes of some sharp changes in perceptions of agriculture in Western Canada.

1. Have your views regarding the sustainability of the productivity of our farmed lands changed during the last 5 years?

    ____ Yes　　　If Yes: ____ more optimistic; ____ less optimistic.

    ____ No

2. What is your current opinion regarding, in general terms for Western Canada, the sustainability of the productivity of farm lands under use:

    ____ productivity will be maintained.

    ____ productivity will be enhanced.

    ____ productivity will begin to decline in the near future.

    ____ productivity is already declining.

3. Many agrologists are of the opinion that soil conserving and maintaining technologies, which are well known and proven, are not adequately employed by many farmers.

    Please rate (1, 2, 3, etc.) in order of importance those of the following items which explain failure of farmers to employ more fully soil conserving and maintaining technologies:

    ____ recommended practices are perceived as being impractical.

    ____ soil maintaining practices cost money and returns on such investments are uncertain.

    ____ recommended practices are too difficult to employ.

    ____ the recommendations have not been validated under the harsh realities of a real farm.

    ____ adherence to old ideas; resistance to change.

    ____ other causes: please indicate what they are.

Date ______________________　　Name ______________________

Position/occupation ______________　　Address ______________________

______________________　　______________________

　　______________________

Agricultural/Environmental Interactions

____________________ **Ecozone** ____________________ **Farming**

Categories of Interactions

1. Effects of this type of farming on the land resource.
2. Stresses on such farming by external forces, natural and human.
3. Side effects of this agricultural activity on the environment.

Please rate listed items, including any you add in the spaces provided, in two ways:

- In the box on the left please list in order of seriousness (1, 2, 3, etc.) only those items which you consider to be of major significance in this ecozone and for this type of agriculture.
- In the space on the right please rate the intensity of the items as:

L (low); M (medium); or H (high).

☐ Erosion

☐ Organic matter depletion ____

☐ Fertilizer acidification ____

☐ Soil compaction ____

☐ Salinization ____

☐ ________________

☐ ________________

☐ ________________

☐ ________________

☐ Permanent land conversions to other uses ____

☐ Urban-like regulations ____

Chemical contaminations:

☐ acidifying ____

☐ toxic ____

Climatic hazards:

☐ frost ____

☐ drouth ____

☐ Damage by wildlife ____

☐ Land speculation ____

☐ ________________

☐ ________________

Water contamination:

☐ sediments ____

☐ chemicals ____

☐ livestock wastes ____

Air contamination:

☐ dust ____

☐ chemical sprays ____

☐ odors ____

☐ ________________

☐ ________________

☐ ________________

☐ ________________

Date ____________________

Position/occupation ________________

____

Name ____________________

Address ____________________

____

____

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