The Alberta GPI Accounts: Agriculture

Report # 19

by

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Pembina Institute
for Appropriate Development

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About this Report

This is one of 28 reports that provide the background for the Genuine Progress Indicators (GPI) System of Sustainable Well-being Accounts. It explains how we derived the indices that were earlier published in *"Sustainability Trends 2000: The Genuine Progress Statement for Alberta, 1961 to 1999."* The research for this report was completed near the end of 2000. The appendices provide further background and explanation of our methodology; additional details can be obtained by contacting the authors. Appendix A includes a list of all GPI background reports. The agriculture sustainability account addresses issues such as trends in crop yields, pesticide and fertilizer use, farm debt, soil erosion, and salinity.

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About the Authors

Mary Griffiths joined the Pembina Institute as an Environmental Policy Analyst in May 2000. She brings strong research and policy analysis skills as well as an extensive background and in-depth understanding of a wide range of environmental issues. Mary works with the Energy Watch team on environmental and energy advocacy issues and with the Institute's Green Economics Program on genuine progress indicators for Alberta. She has long been an advocate for the protection of the environment, both in her previous employment and in her volunteer activities. Mary holds a Ph.D. (Medical Geography), University of Exeter, UK and a B.A. (Geography), University of Exeter, UK.

Sara Wilson joined the Pembina Institute in August 2000, as a member of the Green Economics Program. She works on establishing measurements of ecological well-being and community sustainability reflected in genuine progress indicators using time series analysis and valuation methods. Sara aims to promote better physical and economic accounts that will reflect our natural capital, quantitative and qualitative degradation, and the ecological and social costs of losses in ecological integrity. Before joining the Green Economics team, Sara completed the water account and forest account for the Nova Scotia GPI. In addition, she has three years' experience as a forest ecology researcher and three years' experience in environmental education. Sara holds the following degrees: MSc.F. (Mixed Boreal Forest Disturbance Ecology), University of Toronto, and B.A. Hon. (International Development Studies and Environmental Geography), University of Toronto.

Mark Anielski is Director of the Green Economics team, and has considerable experience in public policy analysis including natural resource, energy, royalty and fiscal policy issues in both the public (Alberta Government) and private (GPC- Government Policy Consultants) sector. He also serves as Senior Fellow to the U.S. economic policy think-tank Redefining Progress in Oakland, California and authored the 1999 U.S. GPI report with journalist Jonathan Rowe. He currently advises the National Round Table on Economy and the Environment's Sustainable Development Indicator Steering Committee on the development of indicators for measuring sustainability in Canada. Mark teaches business and the environment in the University of Alberta's School of Business. His expertise is varied and broad including accounting for sustainable development, natural resource accounting, public policy analysis, business planning and performance measurement. Mark pioneered the development of natural capital accounts for Alberta's timber, oil, gas, coal and other natural capital as well as having experience in the development of performance measurement systems, land use planning and non-market resource valuation, royalty policy analysis (forestry, oil and gas), and analysis of subsidies for both government and private forestry, energy and financial service industries. He holds a Masters degree in forest economics, plus bachelor degrees in economics and forestry.

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The contents of this report are the responsibility of the Pembina Institute and do not necessarily reflect the views and opinions of those who are acknowledged above or the opinions or positions of Western Economic Diversification who helped fund the research.

We have made every effort to ensure the accuracy of the information contained in this document at the time of writing. However, the authors advise that they cannot guarantee that the information provided is complete or accurate and that any person relying on this publication does so at their own risk. Given the broad scope of the project and time constraints, it has not been possible to submit the entire report for peer review. The material should thus be viewed as preliminary and we welcome suggestions for improvements that can be incorporated in any later edition of the work.

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1 Executive Summary

Agricultural production increased dramatically between 1961 and 1999, with cattle numbers and wheat, barley and canola production doubling or more than doubling. These increases were possible due to crop breeding and increasing use of inputs such as fertilizers and pesticides. Farmers spent 59 percent more on fertilizers, and the amount spent on herbicides and other pesticides has grown by 145 percent since 1981. Because these increasing expenditures on inputs were not matched by the prices received for farm output, farm debt has risen approximately 100 percent—in total as well as on a per-farm basis—and shows no sign of slowing. At the same time, the number of farms has decreased 17.9 percent since 1961. Practices such as reduced summerfallow and increased conservation tillage have improved, and the rate of loss in soil organic carbon is slowing. However, further conservation improvements are needed. One growing problem is salinity, as surveys of central and southern Alberta show the area affected by visible salinity has expanded by about six percent since the 1950s.

Noteworthy

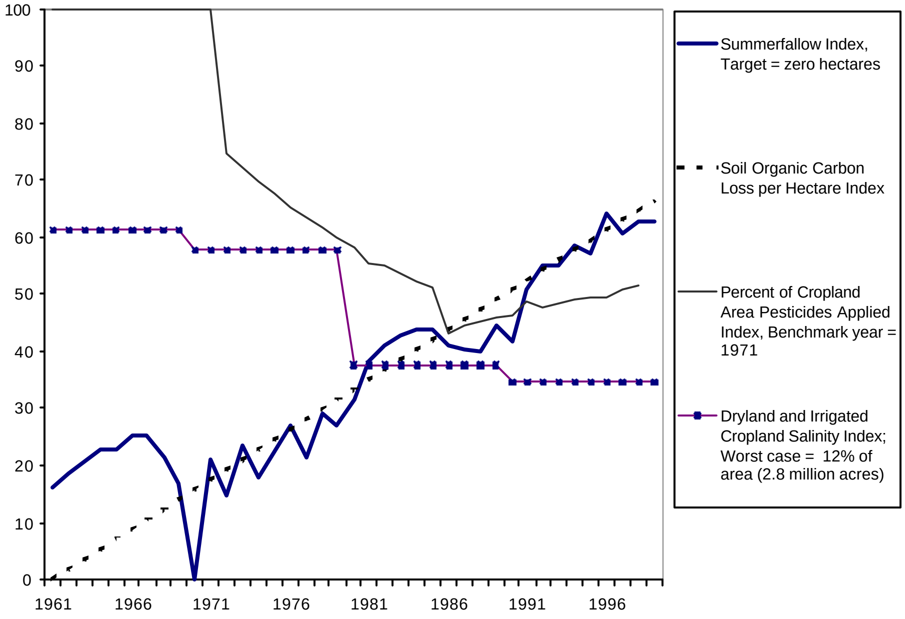
- The acreage planted to crops grew by 51% and cattle numbers doubled between 1961 and 1996 in Alberta.
- The percentage of cropland to which herbicides and other pesticides were applied grew from 33% to 75% between 1971 and 1986. Since then, this has declined to 66%.
- On average, wheat, barley and canola yields per acre increased by about 3% annually between 1961 and 1999, and the area on which pesticides or herbicides are used has increased on average by 2% per annum.
- Between 1971 and 1996, total farm debt increased from about $4-billion to $8-billion, in constant 1998 dollars.
- On a per-farm basis, the real debt burden has increased 101% since 1971, for an annualized rate of 3.5% from an average of $65,973 (1998$) per farm in 1971 to $132,421 (1998$) in 1999.
- The number of farms declined from 73,212 in 1961 to a low of 57,245 in 1991, followed by an increase upwards to an estimated 60,103 farms in 1999.

Six indices were used to assess agricultural sustainability, as the figure below shows, including:

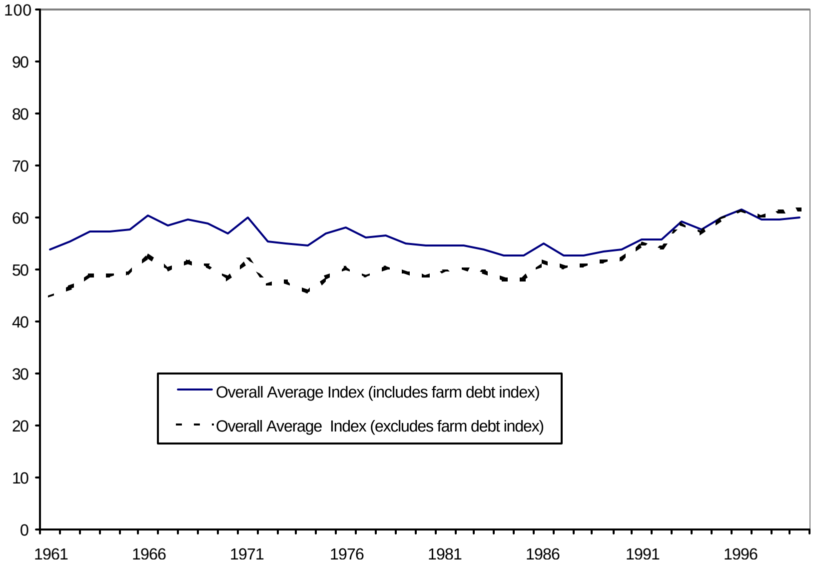
1) the cropland area in summerfallow (target = 0 ha; improving);
2) the percent of cropland on which pesticides are used (best year benchmark = 32.6 percent; increasing);
3) dryland and irrigated land salinity (target = 0 ha, with worst case scenario twice the current area; worsening);
4) the rate of loss of soil organic carbon (target = 0 kg/ha/yr; improving);
5) average yield per acre for wheat, barley, and canola as a proxy for productivity (best year benchmark = 109 bushels/acre; increasing); and,
6) average farm debt per farmer (best year benchmark = $37,400; worsening).

The rate of loss in soil organic carbon on agricultural land and the amount of cropland area in summerfallow have improved since 1961. But the percentage of cropland area to which pesticides are applied, and the area affected by salinity have worsened. Can the increase in production seen over the last 40 years be maintained? Is it environmentally and economically sustainable? While improved tillage practices have cut wind and water erosion, reduced yields due to salinity could be costing farmers over $60-million a year. Fertilizers, manure and the return of other organic matter (such as straw) to the soil can retain soil nutrient levels. However, it is possible that the trend in increasing yields may be depleting the productivity of cropland. In addition, it is doubtful that farmers will be able to continue covering the cost of increasing inputs, given the rapidly rising costs of fuel, fertilizers, and herbicides; increasing farm debt; declining net income; and the current prices for grain on world markets. The burden of debt is significant and continues to be a factor in the long-term viability of farming.

Indices for Summerfallow, Salinity, Loss of Soil Organic Carbon, and the Percentage of Cropland to which Pesticides were Applied, 1961 to 1999



Agriculture Sustainability Indices, 1961 to 1999



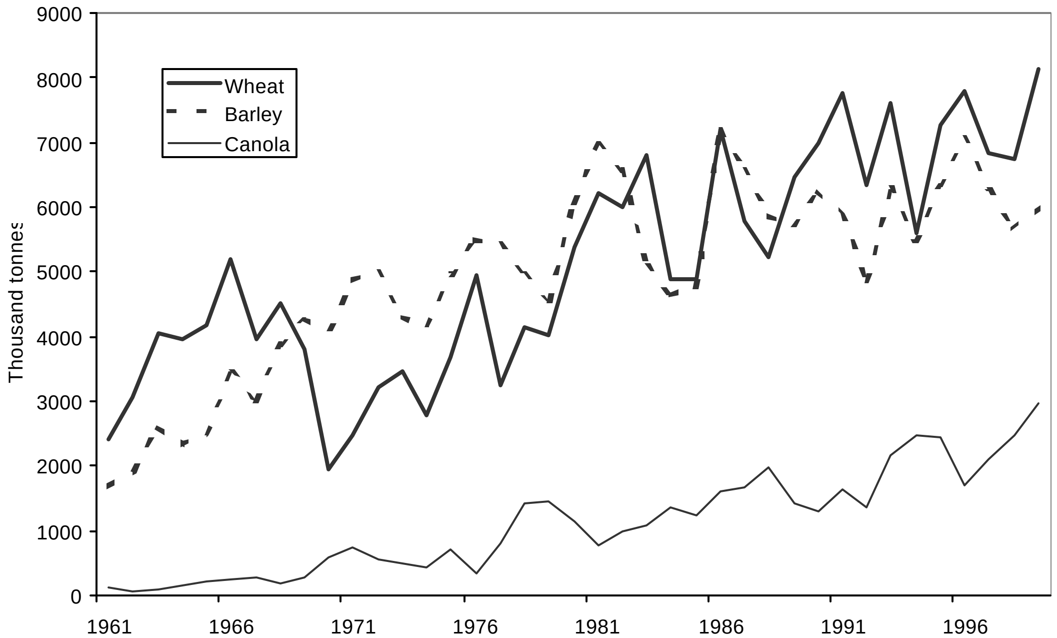
The costs of unsustainable agriculture in 1999 were: $10.5-million for on-site costs of erosion on bare soils; $2.3-million for off-site costs of erosion on bare soils; $4.8-million due to reduced yields from salinity on irrigated land; and $53.3-million due to reduced yields from salinity on dryland cropland, for a total of $70.9-million. In 1999, the first aggregate index scores 61.5 (an increase from 44.7 in 1961), and the second aggregate index scores 55.9 (an increase from 53.9 in 1961).

2 Trends in Agricultural Production

> *In 1999, Alberta farmers generated a record $6.55 billion in sales of crop and livestock commodities, the second highest amount in Canada after Ontario. Alberta's receipts were 2.2 percent higher than in 1998, mainly due to increased sales in the livestock sector (up 9 percent). This sector accounted for 61 percent of total sales while the crops sector contributed a further 36 percent. Alberta is the leading producer of cattle and calves in Canada (about 50 percent of national sales). The province's top three revenue crops are wheat, canola and barley.*[1]

Alberta's agriculture and agri-food industry made up an estimated 4.9 percent of the province's Gross Domestic Product in 1999.[2] The above figures reflect the strength and continued growth of Alberta's agriculture. The total area under crops rose from 15.6 million acres in 1961 to 23.6 million acres in 1996, an increase of 51 percent.[3] The area in wheat increased by 30 percent (from 5.6 to 7.3 million acres), the barley acreage doubled (from 2.9 to 5.8 million acres) and canola, which was first recorded as rapeseed in 1966, was grown on 3.1 million acres by 1996.[4] The increase in the production of Alberta's three most important crops[a] is shown in Figure 1.[5] In 1996, the total area in farms (improved and unimproved land) was nearly 52 million acres (210,292 sq km), which is 31.7 percent of the province.

Figure 1: Alberta's Production of Wheat, Barley and Canola, 1961 to 1999



Source: Alberta Agriculure website at www.agric.gov.ab.ca/economic/yearbook/crops.html

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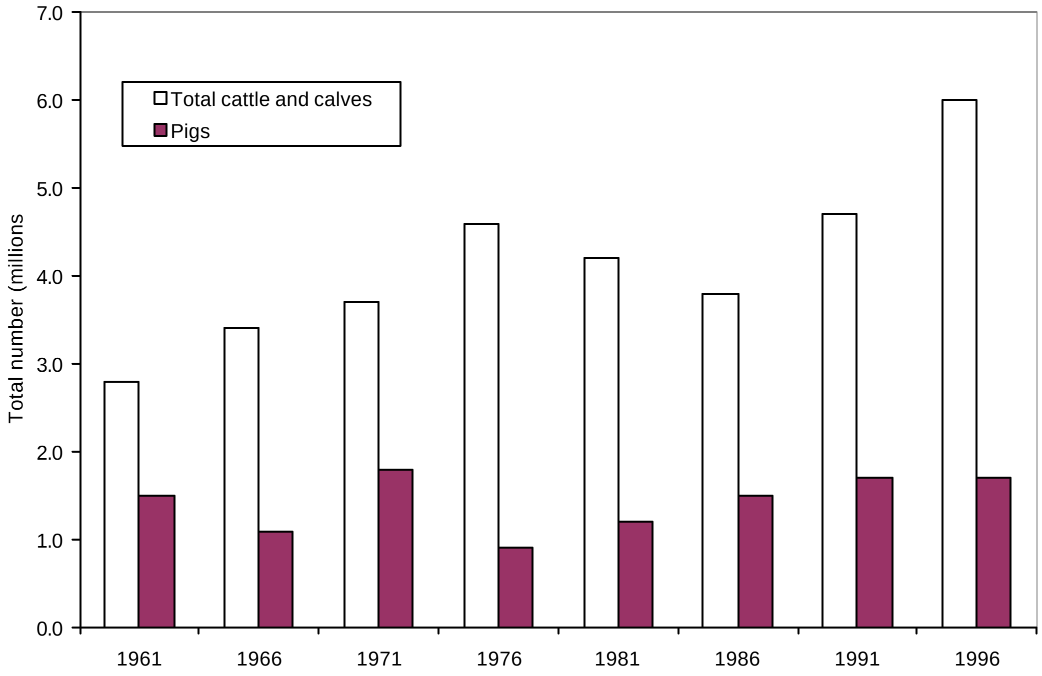
[a] Wheat, barley and canola account for 95 percent of the major crop acreage in Alberta.

Cattle numbers have also increased rapidly, with the total number of cattle doubling between 1961 and 1996 (Figure 2). While the total number of hogs fluctuated with the traditional boom/bust hog cycles, there was little growth in total numbers. However, the production of hogs became concentrated on far fewer farms. In the 1961 census, 41,000 farms raised hogs, with an average of 36 hogs per farm. By 1996, the number of farms had declined to one-tenth of the number in 1961 (less than 4,200 farms), but the average number of hogs per farm had increased by more than 10-fold (to 415 per farm). The number of cattle per farm tripled in the same period. The increased concentration of cattle and hogs is far greater than would occur as a result of the 19 percent reduction in the number of farms (from 73,200 to 59,000) between 1961 and 1996. It points to the increased geographical concentration of livestock activities that is raising environmental concerns (see *GPI Report 25, Water*).

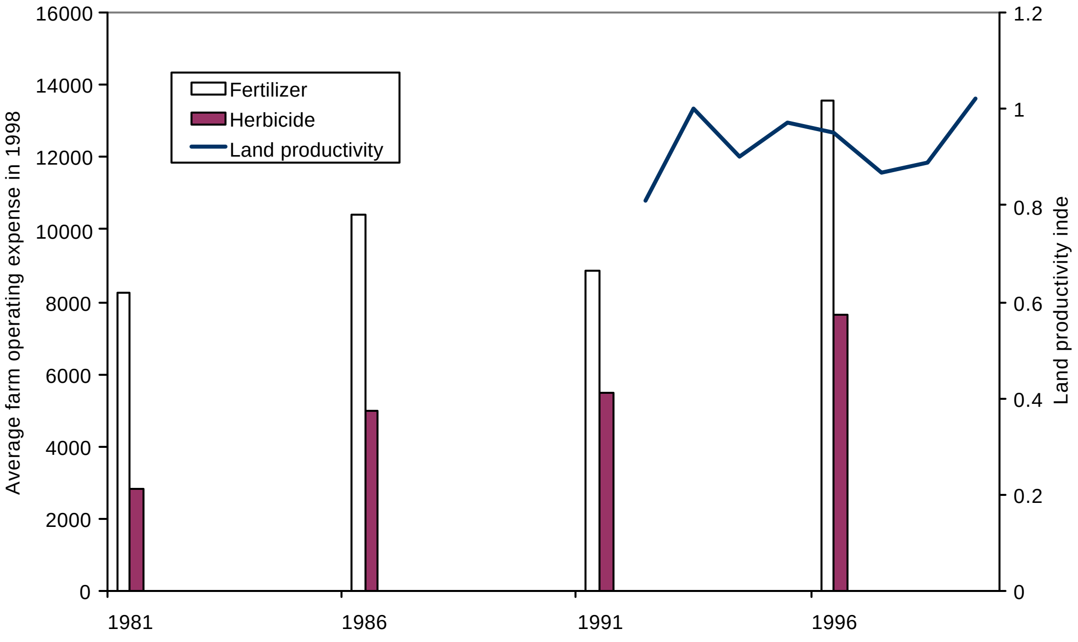
Figure 2: Alberta's Cattle and Pig Population, 1961 to 1996



Source: Historical Overview of Canadian Agriculture, Statistics Canada, 1992, Table 1

The government's measure of agricultural performance is expressed in terms of land productivity, as crop yields per acre. Land productivity, measured in this way has been increasing. Indeed, in 1999 it reached 1.02 tonnes per acre, exceeding the government target of 0.98 tonnes per acre (see Figure 3).[6]

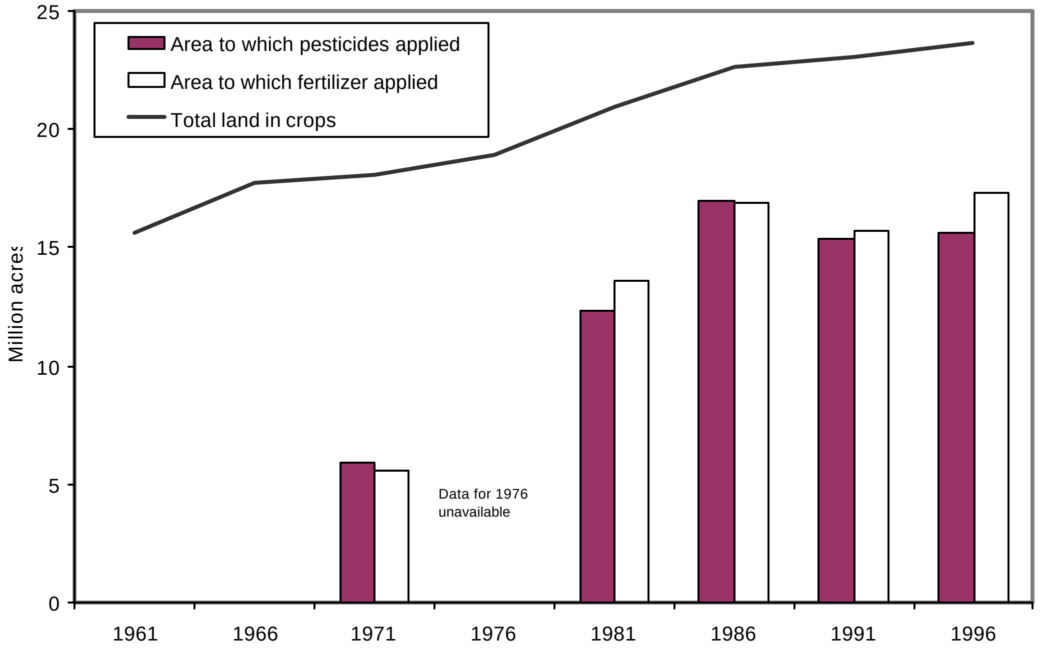
Figure 3: Alberta's Farm Operating Expenses and Land Productivity, 1981 to 1996



Sources: Historical Overview of Canadian Agriculture, Statistics Canada, 1997; Land Productivity Index from Measuring Up, Alberta Treasury, June 29, 2000

This increase in land productivity reflects improvements due to plant breeding, improved agricultural practices and the increased use of fertilizers and pesticides. Although fertilizer and pesticide use has been increasing and the total cropland area continued to grow, the area on which pesticides and fertilizers are used has declined slightly since 1986 (Figure 4). However, the total weight of fertilizer applied in Alberta increased faster than the area of land to which it was applied. In 1970, 242,000 tonnes of fertilizer were applied and by 1995 this had increased more than three-fold to 1.03 million tonnes.[7] In fact, the amount of fertilizer applied per hectare increased by 36 percent between 1970 and 1995.

Figure 4: Alberta's Total Land in Crops, and Fertilizer and Pesticide Use, 1961 to 1996



Source: Historical Overview of Canadian Agriculture, Statistics Canada, 1997

The actual amount spent on selected farm inputs in constant 1998 dollars is shown in Figure 5.[8] Farm expenditure on fertilizer and lime increased by 59 percent over the 15-year period, 1981 to 1996, while the amount spent on herbicides and other pesticides increased by 145 percent. As the area of land treated with fertilizers and herbicides and other pesticides increased by only a quarter in that period, part of the increase in expenditure is probably due to increased application rates and part may be due to increases in price (in constant dollars).[b]

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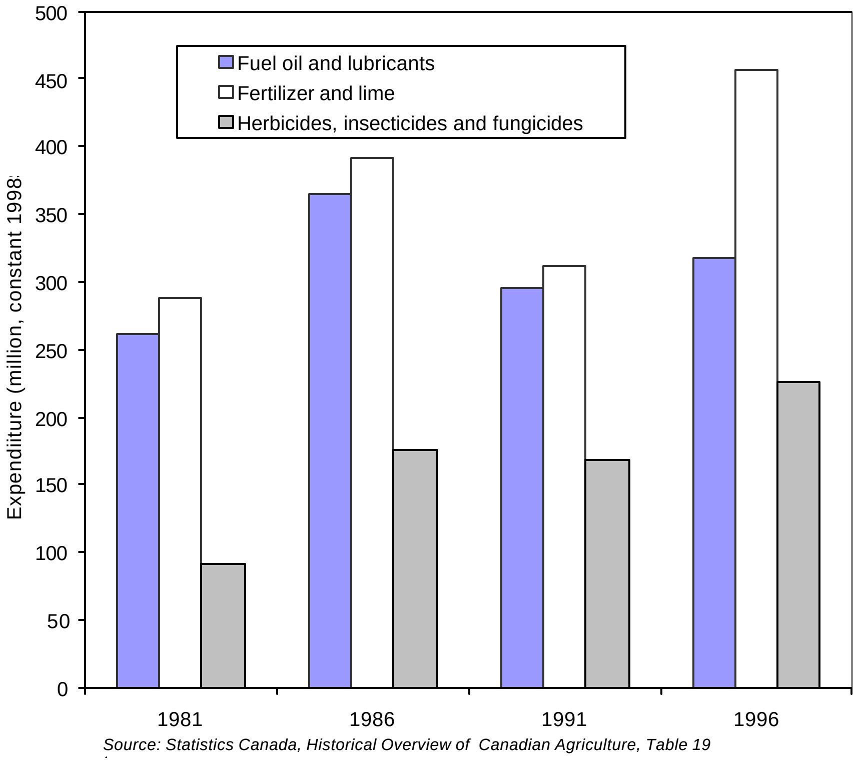
[b] Unfortunately no figures could be found in the time available, to compare the tonnage of fertilizer and pesticides applied in 1981 with the expenditure and acreage figures provided by Statistics Canada, as the data in *Human Activity and the Environment* are only for 1970 and 1996.

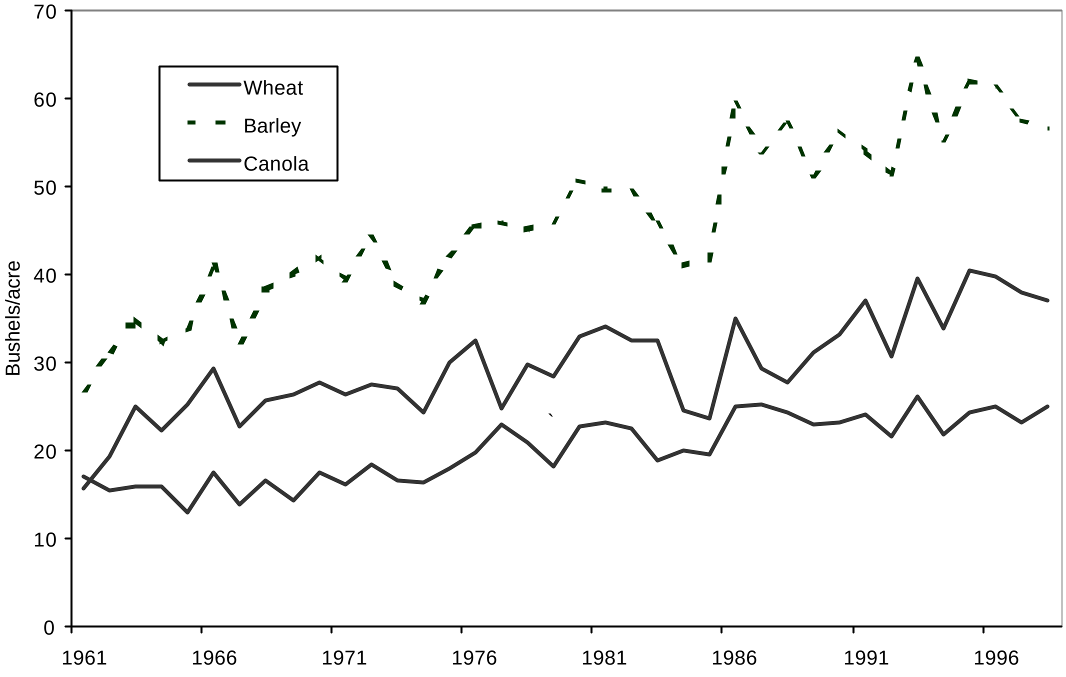
Figure 5: Expenditures on Selected Farm Inputs in Alberta, 1981 to 1996



Source: Statistics Canada, Historical Overview of Canadian Agriculture, Table 19

The actual yields of the main crops (wheat, barley and canola), naturally fluctuate with the weather, but they have all shown a steady increase since the 1960s, with barley yields nearly doubling and wheat yields increasing by nearly half (Figure 6).

Figure 6: Alberta's Wheat, Barley and Canola Yields, 1961 to 1999



Source: Alberta Agriculture, Food and Rural Development

Some rapid changes in crops have occurred in recent years as a result of plant breeding. In 2000, 78 percent of the canola acreage in Alberta was herbicide-tolerant. Most of this acreage, comprising 56 percent of the total canola acreage, was sown to genetically modified canola.[9] Canola is the main genetically modified crop in Alberta. Although genetically modified corn and soybeans have been developed, they are not common crops in Alberta.[10] Agriculture Canada is conducting research in Alberta on genetically modified crops as part of a 12-year project that is examining organic matter, crop quality and soil health. As only one year of the study has been completed with genetically modified seed, no results are yet available on their effects on the agricultural system.

The questions that arise are whether the long-term trend in yields is sustainable and whether farmers will be able to afford the inputs, given the relatively low commodity prices that are currently being paid on the world markets. In addition, there are questions regarding the sustainability of current rates of fertilizer, herbicide, and pesticide applications, and how these inputs are affecting the greater environment, human health, and wildlife habitat.

3 Factors Affecting the Sustainability of Agriculture

While the situation with respect to increasing crop yields looks good, the long-term sustainability of agriculture needs closer examination. We cannot solely judge the success of agriculture from current yields because these may be achieved through practices that are only viable in the short term and may be causing environmental damage. Are current agricultural practices sustainable? Will the current high and increasing yields lead to losses in soil productivity over the long term that could result in lower yields in the future?

In the following sections, we make a preliminary attempt at answering these questions. The answers depend on a variety of factors relating to the management of the soil and the maintenance of nutrient levels. If adding artificial fertilizers and using pesticides to increase yields in the short term causes environmental degradation, these practices are not sustainable. Agriculture Canada has recently set up sample plots across the province that should, in the long term, provide information on whether soil health is being maintained. Manure can replenish soil nutrients but, if not properly managed, large concentrated livestock populations can contaminate land and water and affect air quality. Wind and water erosion have also affected the long-term productivity of land in the province and the carbon content of the soil. Furthermore, salinity has been reducing agricultural yields in some locations. Attention is also given to irrigation use and organic agriculture, and how each affects sustainability. Finally, we will look at the change in the extent of agricultural land, as urban spread often results in land being taken out of production, which also affects the long-term sustainability of agriculture.

3.1 Factors Affecting Water and Air Quality

We start with the impact of agriculture on water quality. This is dealt with in more detail in GPI Report #24 on water, but must also be mentioned here, as it has important implications for the long-term sustainability of agriculture. A 1998 report entitled "Agricultural Impacts of Water Quality in Alberta," produced under the Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement, examined the effects of pesticide use, fertilizer use, and livestock operations on ground and surface waters. The study found that the concentrations of nutrients (phosphorus and nitrogen from fertilizers and manure) and bacteria in shallow groundwater and surface waters within agricultural areas often exceeded water quality guidelines. Pesticides were also detected frequently, sometimes at concentrations exceeding the guidelines. The CAESA report concluded that "[T]he results of this study clearly show that current agricultural management practices on many farms are not adequate to sustain water quality, particularly in the high and moderate intensity agricultural areas of Alberta. More work must be initiated to encourage producers to improve management of livestock wastes and crop inputs."[11] They found that the problems were greatest in areas of medium and high intensity agriculture and "…as agricultural intensity increased, the potential for contaminant detections and exceedence of the water quality guidelines also increased."

Basically this means that agriculture, as practised at the present time, is not environmentally sustainable for, as the report states, "[S]ustainable agricultural growth in Alberta depends on good water quality."[12] Practices that cause environmental degradation must be stopped. It is possible that water contamination could be having an impact on agricultural output, as the study found that irrigation water quality guidelines for herbicides were exceeded in a number of irrigation canals. The study pointed out that more research is required to identify which practices are responsible for water contamination and to determine effective ways to prevent it. Research is also needed to find out whether crop yields are already being reduced by herbicides in irrigation water.

One of the main problems is livestock manure. This is evident from the type of water contamination found in the CAESA study and the fact that the contamination was greater in medium- and high-intensity agricultural areas. High levels of nitrogen and phosphorous found in streams and groundwater come from manure as well as from fertilizer applications**.** Alberta does have a *Code of Practice for the Safe and Economic Handling of Animal Manures*[13] and, according to the Alberta government website, "[T]he Code of Practice encourages environmental sustainability." However, these practices are neither mandatory nor are they monitored, and it is up to municipalities to adopt the Code. Certainly more stringent regulations and standards are required. As the CAESA report points out "…there exists a small number of poor managers who do not abide by the rules and codes designed to protect society as a whole…Environmental regulations must be in place, and enforced, to deal with producers who deliberately or consistently contaminate water resources."[14]

Some agricultural practices not only contaminate water, they can also have a detrimental effect on air quality. For example, tillage and soil erosion cause air pollution because of the particles that become airborne. In addition, herbicides have been found in rainfall in southern Alberta.[15] However, it is important to mention that the pollution may not be coming from agricultural sources, as the herbicides found—2,4-D, bromoxynil and dicamba—are also used on urban lawns and golf courses.

Concerns have also been raised about the air quality near huge feedlots. An air monitoring survey carried out in 1998 and 1999 in the Lethbridge area found that hydrogen sulphide exceeded the Alberta 1-hour Ambient Air Quality Guidelines for two hog operation sites.[16] Also, ammonia levels were usually higher near intensive livestock operations than at control sites. However, this preliminary study was not a comprehensive evaluation of odours from intensive livestock operations and more detailed monitoring is needed to ascertain the exact effects of these operations on air quality and the repercussions for human health.[17] If current agricultural practices are causing problems, this certainly raises concerns about whether Alberta government plans to approximately double livestock production in Alberta are environmentally sustainable.[18]

With these concerns in mind, we now evaluate some other environmental impacts of agriculture in more detail.

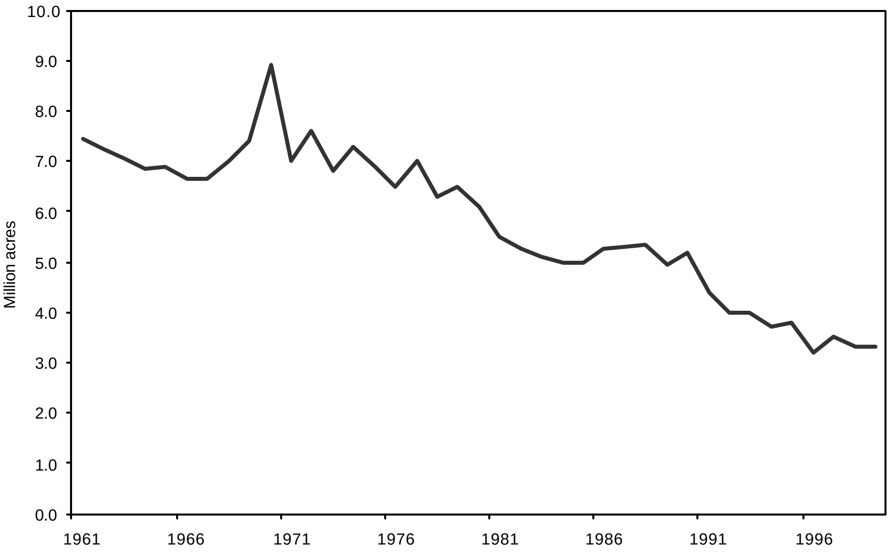
3.2 Wind Erosion

Reports of the dust-bowl conditions of the 1930s are a reminder of the damage that wind can do to unprotected fields. The problems continue and it is estimated that wind erosion damaged 900,000 hectares (two million acres) of agricultural soils in Alberta during the 1980s.[19] In the past, it was difficult to measure the exact losses due to wind erosion, but a recent study found that one barren cultivated site lost over 150 tonnes of soil per hectare in a one-year period, while a conventional fallow site lost 57 tonnes/hectare in a three-month period. While some of the blown soil resulting from wind erosion may contribute to fertility in the area where it is deposited, and the use of manure can help restore soil fertility on eroded lands, "[the] prevention of wind erosion is a key toward enhancing the sustainability of agriculture on the semi-arid Canadian prairies."[20]

Lerohl (1992) has estimated that the reduction in value of cultivated land in Alberta in 1990 due to the cumulative effect of erosion since 1926 was $97-million. This amount is approximately 0.6 percent of the value of farmland in Alberta or four percent of the value of the erodible lands, based on an estimate of the number of acres eroded from 1926 to 1990.[21] This trend shows significant increases in the amount of eroded land over time, but a slight decline in terms of the proportion of cultivated land that has been eroded. Lerohl (1992) assessed the actual depreciation of the capital value of land by assuming that erosion began in 1926, when the necessary data series start, and by capitalizing the accumulated lost returns due to erosion at 10 percent. However, a 10 percent discount rate is too high when considering non-market environmental costs. For example, a typical social discount rate is closer to four percent.[c] Lerohl (1992) concluded that the value of the productivity loss was "a recognizable but moderate amount." He stated that "recent...evidence on the effects of erosion on yields in Alberta suggest there are typically few if any yield reductions due to erosion."

While Lerohl's conclusion suggests that, presently, wind erosion is not affecting yields, it will still have a long-term impact. However, the decline in summerfallow and the increase in zero tillage and other conservation practices means there is less extensive wind erosion than in the past. Soil conservation efforts have reduced the traditional practice of summerfallow by half since 1961, with the fallow area declining from 7.4 million acres to 3.6 million (Figure 7).

Figure 7: Alberta Cropland Acres in Summerfallow, 1961 to 1998



Source: Alberta Agriculure, Food and Rural Development and Statistics Canada

3.3 Risk of Wind Erosion

Wind erosion removes topsoil from cultivated lands, which contributes to a decline in soil health by breaking down soil structure and subsequently reducing soil fertility. Thus, it is an indirect measure of changes in soil quality. The degree to which wind erosion occurs on cultivated croplands depends on soil cover. Reduced tillage leaves more crop residues on the soil surface, which protects against wind and water erosion, conserves soil moisture, maintains soil organic matter, provides a protective cover for growing crops, and improves habitat conditions for soil organisms and wildlife.

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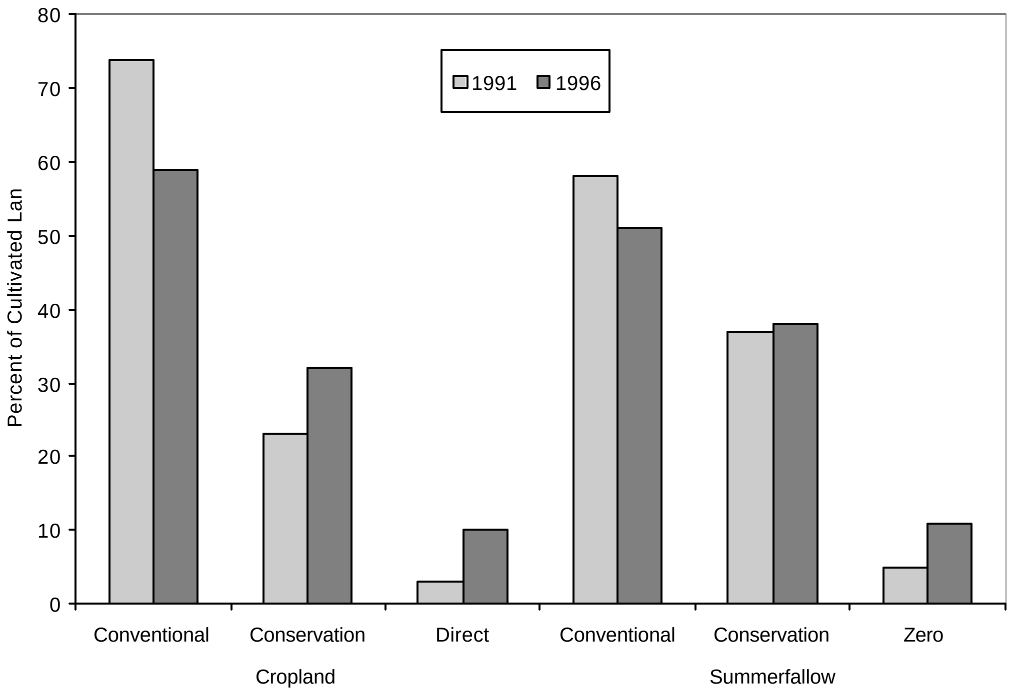
[c] Our approach was to use an annual value of the environmental costs to create annual damage costs as part of the provincial accounts. See our damage costs due to summerfallow below.

Across the prairies, about two-thirds of cultivated lands are at moderate to severe risk of soil erosion when no soil conservation practices are used.[22] However, because of the reductions in the frequency of tillage and the use of summerfallow, a 30-percent decline in the risk of wind erosion occurred between 1981 and 1996. About three-quarters of the reduction is attributed to a change in tillage practice, and one-quarter of the reduction is a result of cropping practices, specifically less summerfallow. During this period, the percentage of cropland at negligible risk increased from 41 to 64 percent. Improvements were greatest where farmers switched from annual crops to perennial forages on sandy, highly erodible lands. The land still at risk (36 percent) is mostly located in the Brown and Dark Brown soil zones of southern Alberta and Saskatchewan.

In Alberta, there has been an overall 31-percent reduction in the risk of wind erosion since 1981 (25-percent reduction due to tillage practice and six percent due to cropping systems used). Between 1991 and 1996, conventional tillage declined (-15 percent) while conservation tillage and direct seeding increased (+9 percent, +7 percent respectively), on the total seeded cropland area in the province (Figure 8). Agriculture Canada attributes much of the improvement to the efforts of soil conservation organizations that have promoted direct seeding.

Figure 8: Alberta's Risk of Wind Erosion: Change in Tillage Practice Between 1991 and 1996

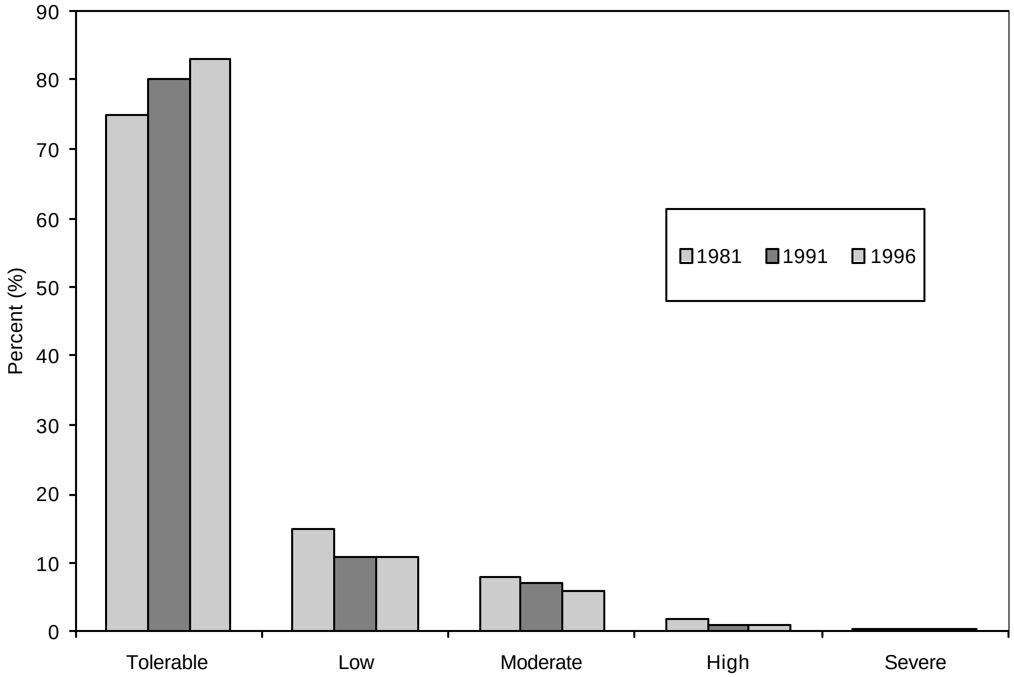


3.4 Water Erosion

Water erosion is caused by various agricultural management practices and results in the loss of topsoil. This causes soil degradation and reduces crop quality and yield on croplands. The eroded sediment is often transported off-site into waterways, where it increases turbidity and sedimentation. In addition, nutrients, pesticides, and bacteria may be attached to the eroded soil particles, contributing to poorer water quality. Therefore, water erosion control measures can protect soil quality as well as water quality. Between 1981 and 1996, changes in cropping measures and the increased use of conservation tillage were responsible for decreases in water erosion risk in several provinces including Alberta.[d] According to Agriculture Canada, the risk of water erosion dropped substantially in Saskatchewan and Alberta because of the increasing use of conservation tillage, the reduction in summerfallow area, and by shifts in the type of crops grown.[23]

The percentage of Alberta's cropland classified at tolerable risk increased from 73 percent in 1981 to 83 percent in 1996, as a result of the decline in percentage of cropland at low, moderate, and high risk (Figure 9). In 1996, about 17 percent (1.8 million ha) of Alberta's croplands (a total of 10.6 million ha) was still at risk due to water erosion: roughly 11 percent of cropland at low risk, six percent at moderate risk, one percent at high risk, and less than one percent at severe risk.

Figure 9: Risk of Water Erosion: Percentage of Alberta's Cropland at Risk, 1981, 1991 and 1996



Source: Agriculture and Agri-Food Canada

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[d] Also, Saskatchewan, Manitoba, Ontario, and New Brunswick.

3.5 Soil Organic Carbon

An important element of soil fertility is the organic content of the soil. "Organic matter in the soil is an essential component of soil that stores and supplies plant nutrients, aids water infiltration into the soil, retains carbon, stabilizes the soil and reduces erosion, and controls the effectiveness of pesticides."[24]

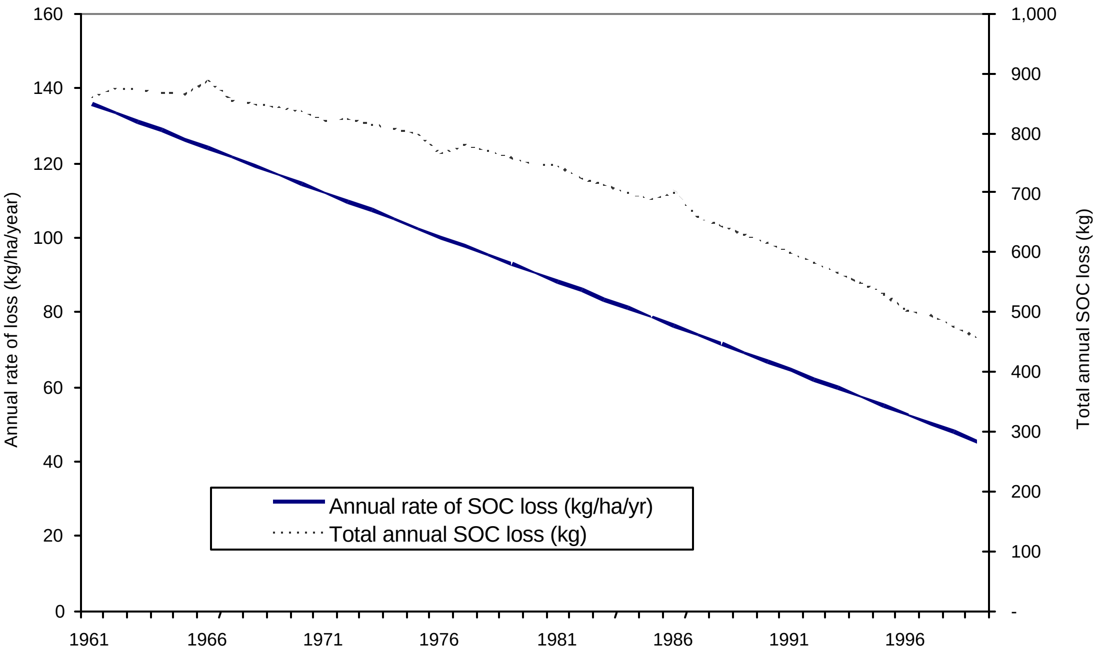
Natural prairie soils contain large reserves of soil organic carbon and there have been some reductions in carbon content with the continued cropping of soils. Studies across the Prairies indicate that the most rapid losses occurred in the early years of cultivation when approximately 25 percent of the soil organic carbon was lost to the atmosphere.[25] However, findings from long-term research sites indicate that this loss of soil organic carbon has abated and the long-term application of manure restores lost carbon and maintains soil structure.[26]

Soil organic matter comprises five to ten percent of most agricultural soils. The terms "soil organic matter" and "soil organic carbon" are often used interchangeably. According to Agriculture and Agri-Food Canada, soil organic matter typically contains about 50 percent carbon, 40 percent oxygen, five percent hydrogen, four percent nitrogen, and one percent sulphur.

Carbon is, therefore, an essential indicator of soil quality. Losses in soil organic matter result in lower fertility and a loss in soil structure, which leads to greater vulnerability to erosion. All of these effects lead to lower productivity, reduced yields and an unsustainable soil resource.[27]

A recent report by Agriculture and Agri-Food Canada includes data on the rate of change for Canada's agricultural soils.[28] The researchers used a computer simulation model (the Century model) to estimate the change in soil organic carbon levels from 1970 to 2010. Alberta's rate of loss of soil organic carbon is one of the highest rates in Canada, but the rate of loss is slowing (Figure 10). In 1970, Alberta's estimated rate of loss of soil organic carbon was 116.3 kg per hectare per year, whereas in 2000, the estimated rate of loss of soil organic carbon is about 40 kg per hectare per year and, in 2010, the predicted rate of loss is 23.6 kg per hectare.

Figure 10: Estimated Annual Rate of Soil Organic Carbon Loss in Agricultural Soils in Alberta, 1961 to 1999

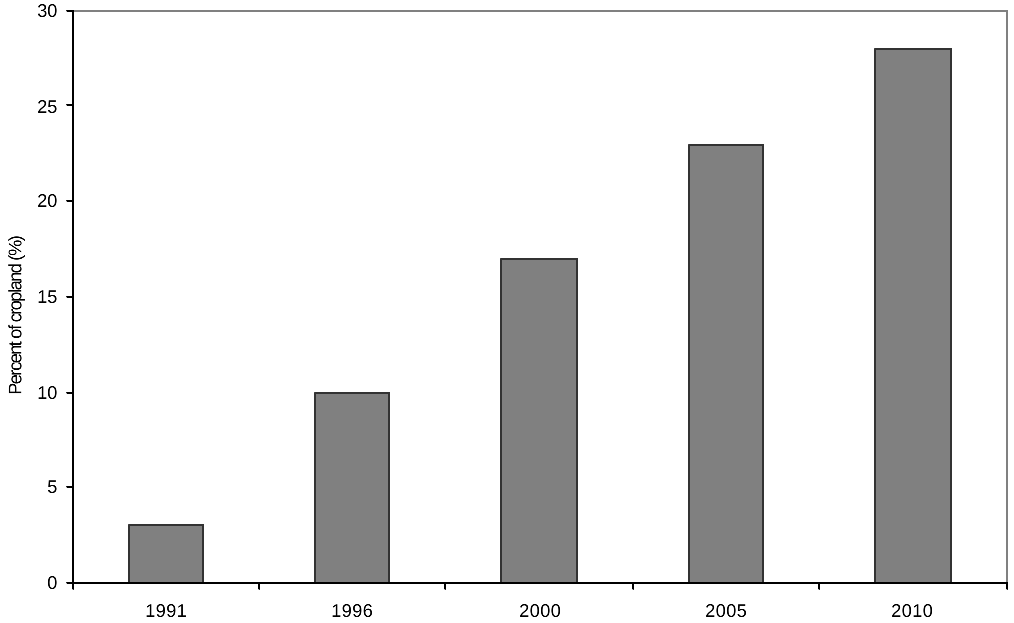


Source: Original data from Agriculture and Agri-Food Canada. Calculations by authors. Data prior to 1970 are extrapolated using regression

It estimated that Canadian agricultural soils lost organic carbon at an average rate of 70 kg per hectare in 1970 and 43 kg per hectare in 1990, but by 2000, it is estimated that the average rate will approach zero. This is a result of some soils (e.g., Saskatchewan's soils) reportedly accumulating organic carbon. Much of the declining rate of loss is attributed to the increasing use of soil conservation practices such as no-till, less summerfallow, and greater amounts of crop residues.

The predicted improvements in Alberta are based on expected increases in the use of conservation practices (Figure 11). In the past decade the percentage of cropland under no-till has risen from three to 17 percent. However, to achieve the lower rates of soil carbon loss, the share of cropland under no-till needs to increase to 28 percent by 2010.

Figure 11: Alberta's Actual and Predicted Use of No-Till on Cropland

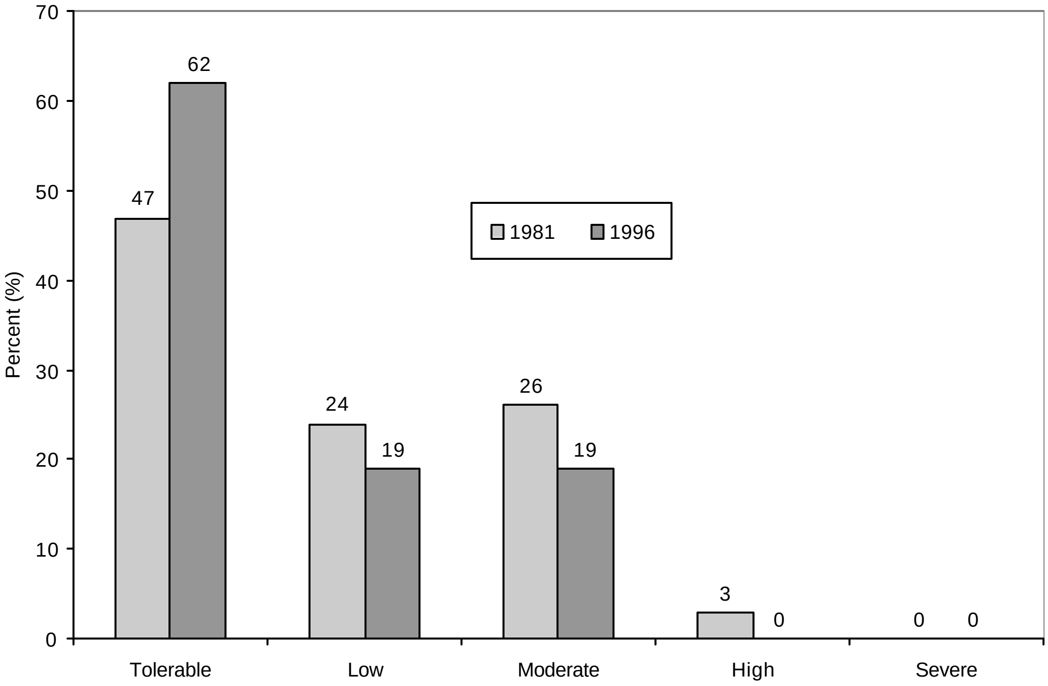


Source: Agriculture and Agri-Food Canada

Tillage erosion is caused when tillage implements loosen the soil, causing it to move down slope. Over time, this movement results in large losses of soil from higher ground and accumulation of soil down slope. Therefore, tillage erosion is a measure of the amount of soil lost from these upper slope areas. Between 1981 and 1996, the overall risk of tillage erosion on agricultural croplands across Canada dropped by 24 percent. The Prairie Provinces' risk also dropped about 24 percent over the same time period, with Alberta improving by 25 percent. However, some regions showed limited improvement or an increase in risk on at least five percent of their cropland, including Alberta's Parkland and Mid Boreal Upland (six percent).[29]

In general, the risk of tillage erosion in Alberta has decreased since 1981. The percentage of cropland classified as low risk (-5 percent), moderate risk (-7 percent) and high risk (-3 percent) has decreased, and the percentage of cropland considered at tolerable risk has increased by 15 percent (Figure 12). The overall improving trend is a result of a change in the type of tillage equipment used by farmers and a reduction in the frequency of tilling. These improvements indicate a good trend in soil conservation practices but, as of 1996, 38 percent of Alberta's cropland (that is, 3.6 million hectares or 8.96 million acres) remained at risk (i.e., not classified as tolerable). This indicates that increased land stewardship attitudes, crop production practices, and the availability of conservation management strategies need further promotion.[30] Such measures include encouraging the adoption of conservation practices and management strategies, developing new technologies for erosion control, improving the delivery of information to producers, monitoring changes in erosion risk, and directing policy to this issue. Tillage erosion has only recently been recognized as a significant cause of erosion; thus soil erosion control programs that have targeted water and wind erosion need to consider tillage erosion as well.

Figure 12: Alberta's Risk of Tillage Erosion on Cropland: Percentage/Share of Cropland in Tolerable to Severe Risk Classes



Source: Agriculture and Agri-Food Canada

Attention has recently focused on the role that soil carbon can play in acting as a sink for atmospheric carbon dioxide, the major contributor to global climate change. If the international community decides that soil sequestration of carbon is eligible for carbon credits there will be an additional reason to increase soil carbon levels, which will also benefit the long-term sustainability of agriculture in Alberta.

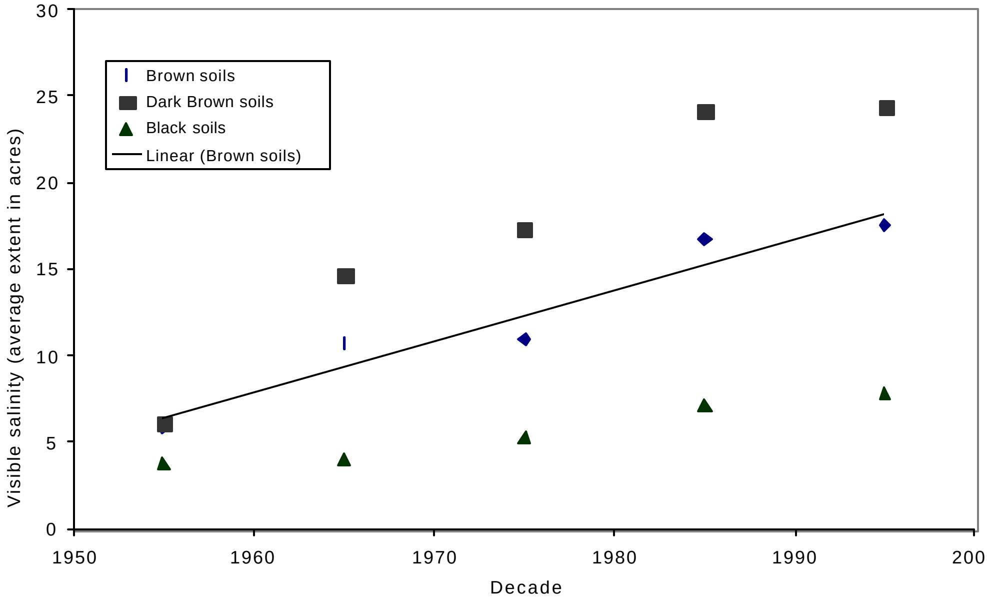
3.6 Salinity

Salinity is another factor that limits crop growth. The problem occurs in both dryland farming and in irrigation agriculture. Dryland salinity is a major soil degradation problem on the Canadian prairies. The problem occurs in coulee bottoms and in depressions and sloughs, where groundwater redistributes salts in the soil and they accumulate at the surface. Salinity becomes more severe after a few wet years.

In irrigated agricultural areas, salinity results from excess water, which causes salts to leach out of the soil and then be left on the surface as the water is used by plants or evaporates. Canal seepage has been a major cause of soil salinity, although poor water management practices, such as over-irrigation and poor drainage are also factors. Soil salinity hinders plant growth. High levels of salt in the soil have the same effect as drought, making less water available for uptake by plant roots and lowering crop yields. In areas of high salinity, plants will not grow at all, and in areas affected by moderate to severe salinity, annual yields of most cereal and oilseed crops are reduced by up to 50 percent.[31] However, even beyond the range of visible salinity, there are still considerable impacts on crop yields. Taking this range into consideration, average reductions in yields across the province are estimated at 25 percent on saline soils.[32]

It appears that saline areas are increasing in extent**.** In their paper, *Determination of Historical Changes in Salinity*, Cannon and Wentz report on their examination of air photos for visible salinity in both dryland and irrigated areas of central and southern Alberta.[33] Between the 1950s and the 1990s, they found a three-fold increase in the average area of visible salinity identified on the photos. The increase in area was greatest on the dark brown soils and least on the black soils, where there were no irrigated sites (see Figure 13). The increase in the extent of salinity occurred irrespective of whether an area drained locally, was part of a regional drainage system, or was within an irrigated area. It appears from this study that the area affected by salinity has been increasing at about six percent per year when averaged over the whole period.

Figure 13: Visible Changes in Salinity in Central and Southern Alberta, 1950s to 1990s



Source: "Determination of Historical Changes in Salinity" (see text)

A study on dryland salinity conducted in the 1980s found that salinity caused by human activities had affected approximately 1.6 million acres (647,485 ha) in Alberta.[34] If the area affected by salinity has been increasing at the rate suggested by the data shown in Figure 13, it is probable that the total area affected by salinity has increased from 1.6 million acres in the mid-1980s to 1.68 million acres in the mid-1990s.[e] To calculate the impact that dryland salinity has had on agricultural returns, it is assumed that salinity causes an average reduction in crop yields of 25 percent[35] and that the entire cultivated area affected by dryland salinity is sown to barley. Barley is more tolerant of salinity than wheat, canola, beans or peas, so it is most likely to be grown on saline land. The value of lost production due to salinity in dryland agriculture at current prices may be about $55-million per year at the present time.[f]

Of course, salinity problems do not affect all farms equally and on most prairie farms, less than one percent of the farm area is affected. However, 36 percent of farms have 1 to 15 percent of their land affected by salinity and on two percent of farms more than 15 percent of the land is affected.[36]

Salinity on irrigated land needs to be considered separately. On average, the percentage of irrigated land affected by salinity is higher than in dryland farming. Of the 1.25 million acres irrigated within the province's 13 irrigation districts, about 12 percent (144,000 acres) was affected by salinity in the 1980s, although the actual amount varied from 4 to 25 percent across the region.[37] The lowest values were in St. Mary's Irrigation District, where land is flat and well drained and the highest in the Raymond and Western Irrigation Districts, where land is hillier. If it is assumed that the area affected by salinity has increased over the entire area, at the same rate as indicated by the visible salinity increases shown in Figure 13, the area affected by salinity would have increased to about 151,225 acres by the mid-1990s.[g] Assuming that the saline land is used to grow barley and that yields are reduced by 25 percent, the annual cost of salinity due to lost production at current prices would be about $8-million.[h] If average crop yields are reduced by more than 25 percent (due to moderate to severe salinity) or if other crops with a higher value per acre than barley are grown, the annual losses could be higher.

By the mid-1990s it is estimated that salinity was affecting about 1.83 million acres (1.68 million in dryland farming and 151,000 on irrigated land), and was having a considerable effect on both yields and returns. Based on the above estimates, it could be costing Alberta farmers about $63-

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[e] While it is likely that salinization has continued to increase since the mid 1990s, the data were not extrapolated to the present day. However, the financial calculations were made using current prices for barley.

[f] The average barley yield in Alberta is 55 bushels/acres x 1.68 million acres affected by salinity = 92.4 million bushels, assuming average yields. The price of barley in 2000 is taken as $2.4 per bushel ($110 per tonne/45.93 bushels per tonne). The total value of barley produced from 1.68 million acres is 92.4 million bushels x $2.4 per bushel = $222-million. If production declines by 25 percent due to salinity, the lost value is $222-million x 25 percent, which is $55-million per year.

[g] It should be noted that some irrigation farmers have the impression that salinity problems are declining. The land lost to seepage has been dramatically reduced, as a result of canal rehabilitation, but salinity is still a problem in areas where there would be seepage under natural conditions, as indicated by the increases in visible salinity in the study by Cannon and Wentz.

[h] Area irrigated = 1.25 million acres of which 12 percent (144,000 acres) was affected by salinity in the mid-1980s. Assuming that the area has increased by the same amount as found in the study by Cannon and Wentz, the saline area of irrigated lands would have increased to 151,225 acres by the mid-1990s. The average barley yield on irrigated land is about 90 bushels an acre, which would yield 13.6 million bushels (151,225 x 90). The value of barley production would be $32.6-million ($2.4/bushel x 13.6 million bushels). If yields are reduced by 25 percent due to salinity the lost production is worth $8.16 million ($32.6-million divided by 4).

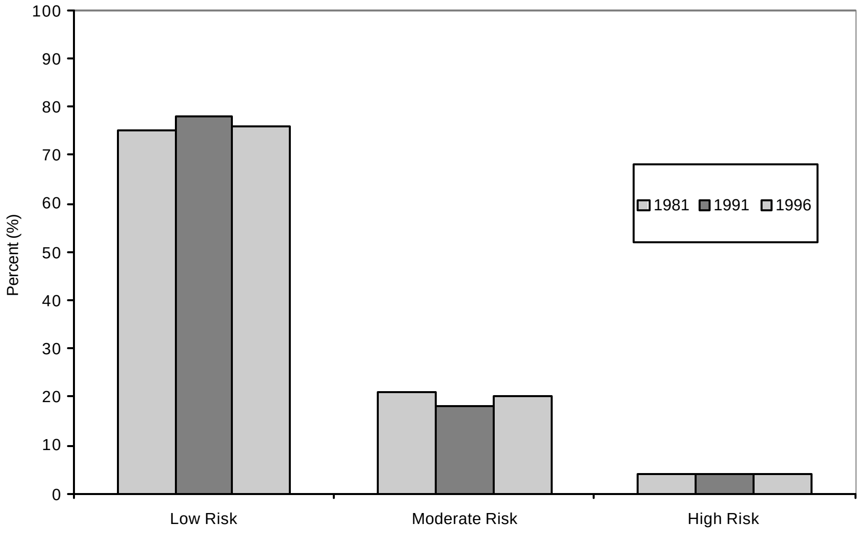
million a year in lost production (assuming that salinity causes an average 25-percent reduction in yield and aggregating figures for dryland and irrigation agriculture). Assuming that the trends seen between the 1950s and mid-1990s are continuing, salinity now affects about 6.5 percent of the total dryland arable acreage and slightly more than 12 percent of the irrigated area. It raises concerns about the long-term sustainability of agriculture on a significant area of land.

3.7 Risk of Increase in Soil Salinity

While soil salinity in areas that are already saline is spreading, it seems that the risk of soils becoming saline has not increased. The risk of soil salinity considers the risk of new land becoming saline rather than the spread of existing saline areas. In a recent study Eilers et al. assessed the risk of cropland soils becoming more saline based on current land use.[38] Permanent cover is associated with the lowest risk of salinization because plants are in place all year, whereas land under summerfallow is considered to be at the highest risk, and land under annual cropping is at moderate risk.

Between 1981 and 1996, there was little change in the risk of soil salinization in Alberta (Figure 14). In 1996, 76 percent of the province's cropland soils were at low risk of increasing salinization, 20 percent were at moderate risk, and four percent at high risk. Thus, the risk of salinization has remained stable over the past two decades. However, with the total land in crops being 23.6 million acres, 5.7 million acres are classified as being at a moderate or high risk of salinization. This does not mean that salinization will actually occur. Strategies that emphasize the efficient use of soil water are thought to be the most important factor in reducing soil salinization. For example, maintaining permanent cover or a continuous crop helps prevent salinization because the plants are able to soak up some of the water that is carrying excess salts. The reduction in summerfallow, noted above, will also help reduce the risk of salinity. However, the fact that the risk of soil salinity is not changing does not alter the concern about existing saline areas, where saline seeps continue to grow, affecting a larger area of land.

Figure 14: Alberta's Risk of Soil Salinization on Cropland: Percentage/Share of Cropland in Low to High Risk Classes, 1981 to 1996



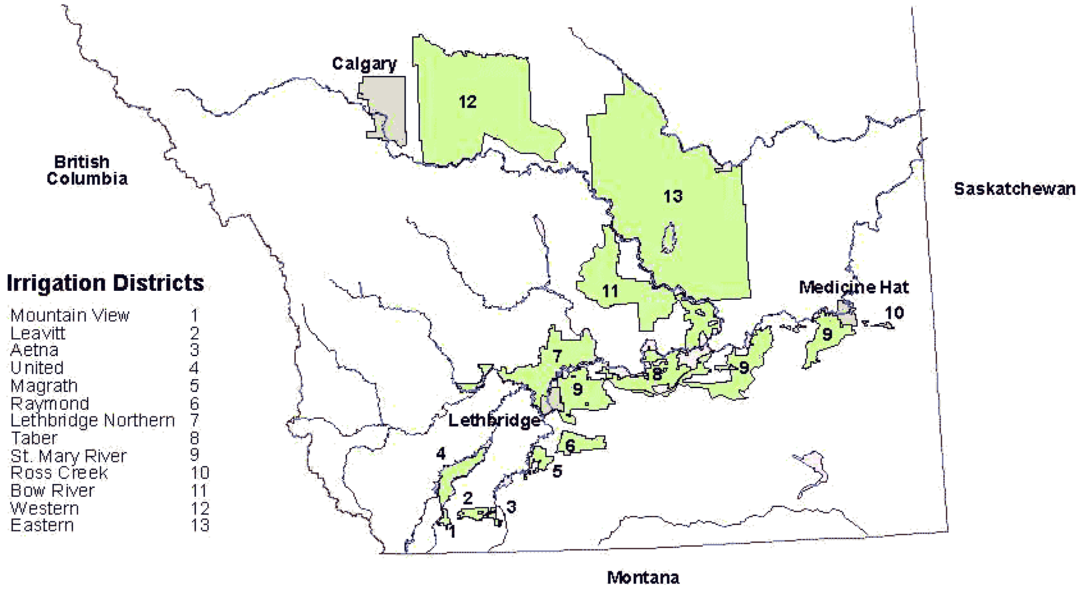
Source: Agriculture and Agri-Food Canada

Next we look at two specific types of agriculture that are also relevant to the long-tern sustainability of agriculture in Alberta. Then, having looked at the physical state of agriculture, we will examine its economic sustainability.

4 Irrigation Agriculture

Irrigation agriculture continues to expand, beyond the 1.25 million acres that are currently serviced by the 13 irrigation districts in southern Alberta (Figure 15), with individual farmers irrigating parcels of land across central Alberta. Crops produced under irrigation account for about 12 percent of Alberta's agricultural production, even though irrigated land constitutes only five percent of the total cultivated acreage.[39]

Figure 15: Irrigation Districts in Southern Alberta



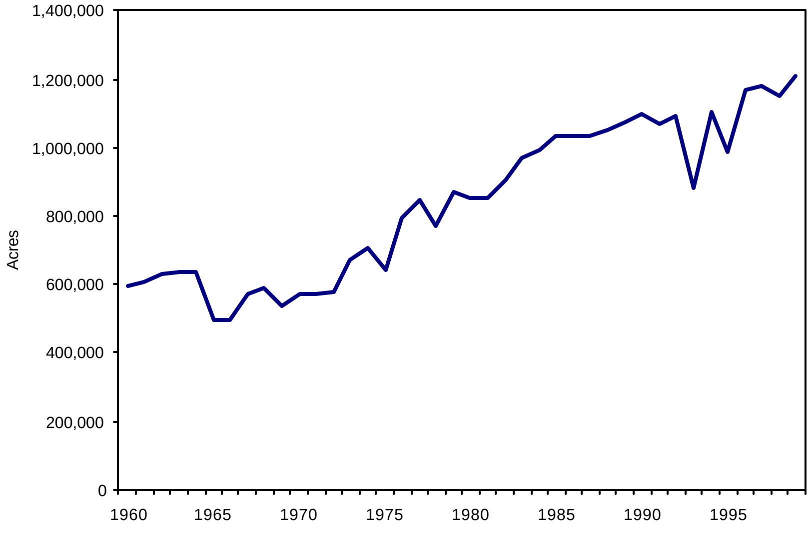
Source: Alberta Agriculture, Food and Rural Development

Irrigation development began in Alberta in the 1880s to attract settlers to the area. Currently, all 13 irrigation districts are located in the South Saskatchewan River basin. Most (84 percent) of the province's irrigated lands are in this river basin. Irrigation districts are cooperatively owned by water users and operated by an elected board of directors. However, the provincial government provides support, including construction and maintenance of headworks and canals.

Agriculture on a national level, withdraws relatively small amounts of water (6 percent) compared with thermal power generation (63 percent) and manufacturing (16 percent). However, agriculture does consume a larger proportion of the water that is withdrawn, returning less than 30 percent to its source. About 75 percent of agriculture withdrawals occur in the semi-arid prairie region.[40]

In 1911, the area of irrigated farmland in Alberta was 47,500 acres. Since then, the area of irrigated farmland has increased by about 400 percent to 1,211,673 acres in 1999, an increase of 1,164,173 acres. The area under irrigation grew by approximately 100 percent between 1960 and 1999 (from approximately 600,000 acres to 1.2 million acres; Figure 16).

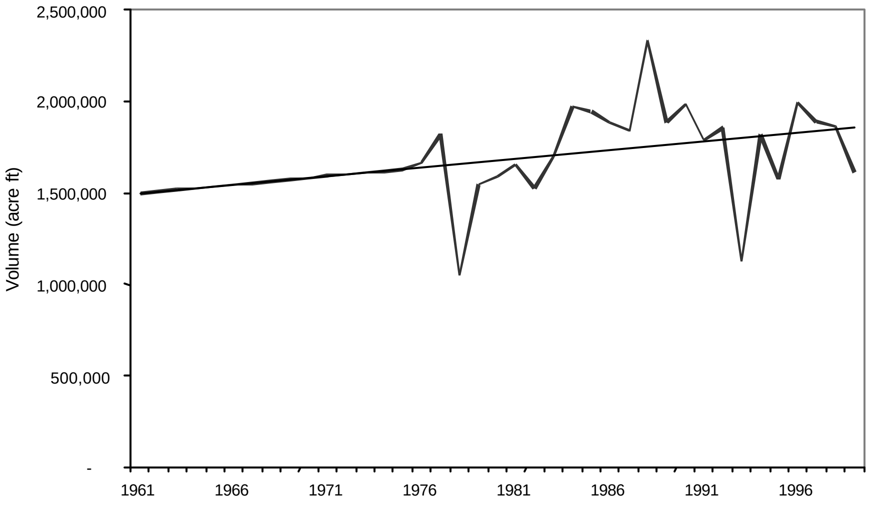
Figure 16: Actual Area Under Irrigation in Alberta, 1960 to 1999



Source: Alberta Agriculture, Irrigation Branch

Annual diversions have increased from about 1.5 million acre-feet in 1961 (projected by regression), to an average of 1.75 million acre-feet during the 1990s. Although there are wide fluctuations in the data recorded (Figure 17), the trend line indicates an increase in the annual volume diverted from the South Saskatchewan River basin.

Figure 17: South Saskatchewan River Basin Annual Irrigation Diversions, 1961 to 1999

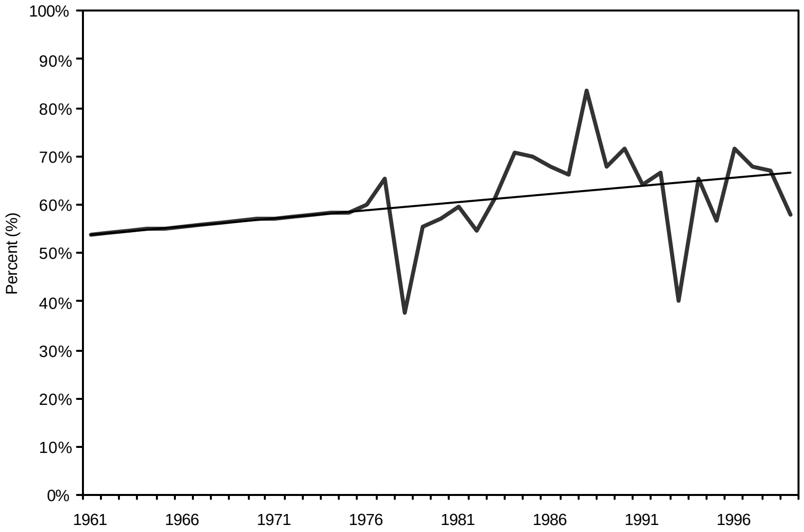


Sources: Water Survey of Canada, Alberta Environmental Protection

Each irrigation district has a licence for a specified volume of water that can be diverted for irrigating crops. In 1999, the water diversions for irrigation, in relation to the licence for water use in each irrigation district, ranged from 30 percent to 95 percent. The average percentage of water diverted for irrigation across all districts was 58 percent.

The annual percentage use of the total volume allocated for irrigation licences is recorded for the years 1976 to 1999. The annual percentage use prior to 1976 has been extrapolated. Although the annual percentage of irrigation licences used fluctuates greatly over the time period recorded, the trend line indicates that the percentage use of allocated diversions for irrigation is increasing.

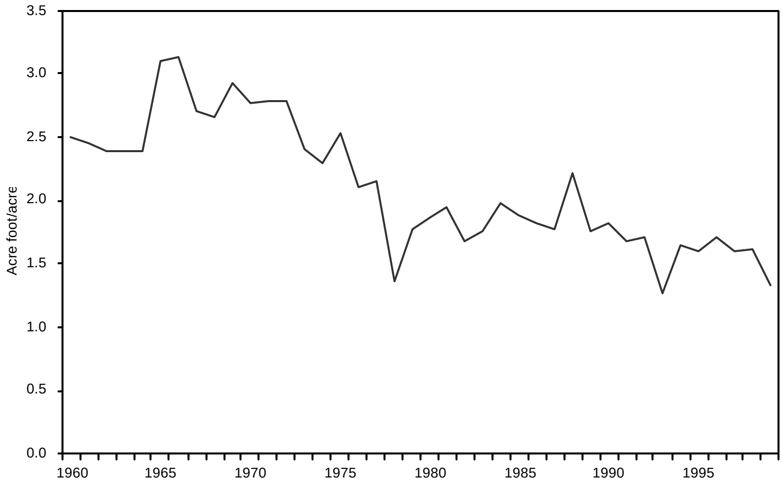
Figure 18: Percentage of Total Irrigation Licences in Use in Alberta, 1960 to 1999



Sources: Water Survey of Canada, Alberta Environmental Protection

However, since 1960, the volume of water used per acre irrigated has declined indicating that irrigation practices have become more efficient in the use of water (Figure 19).

Figure 19: Volume of Water Used Per Irrigated Acre in Alberta, 1960 to 1999

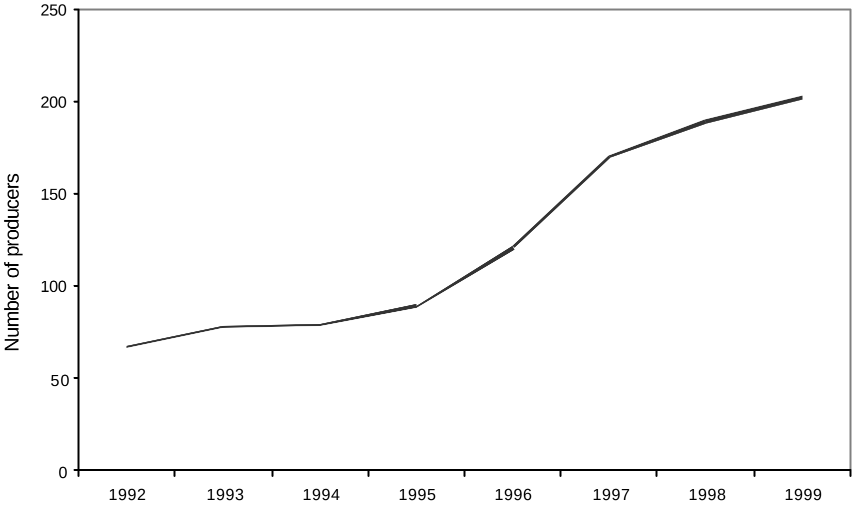


Sources: Water Survey of Canada, Alberta Environmental Protection

5 Organic Agriculture

In North America the organic market is growing at a rate of about 20 percent a year and the number of organic farmers is increasing rapidly. Alberta currently has about 250 organic farmers and the total organic acreage is estimated to be 333,520 acres, with nearly two-thirds in pasture and native range, and 133,000 acres in crops.[41] The area being farmed organically is less than one percent of the total cropped acreage in Alberta, but more farmers are converting to organic agriculture. One of the four certifying bodies in the province, the Sustainable Agriculture Association, Calgary-based chapter, reported 20 farms wishing to join their Association in 2000, a 40-percent increase over 1999 membership.[42] The numbers of certified organic producers recorded by Canadian Organic Growers Inc. is shown in Figure 20, but this does not include farmers in transition.

Figure 20: Number of Certified Organic Producers in Alberta

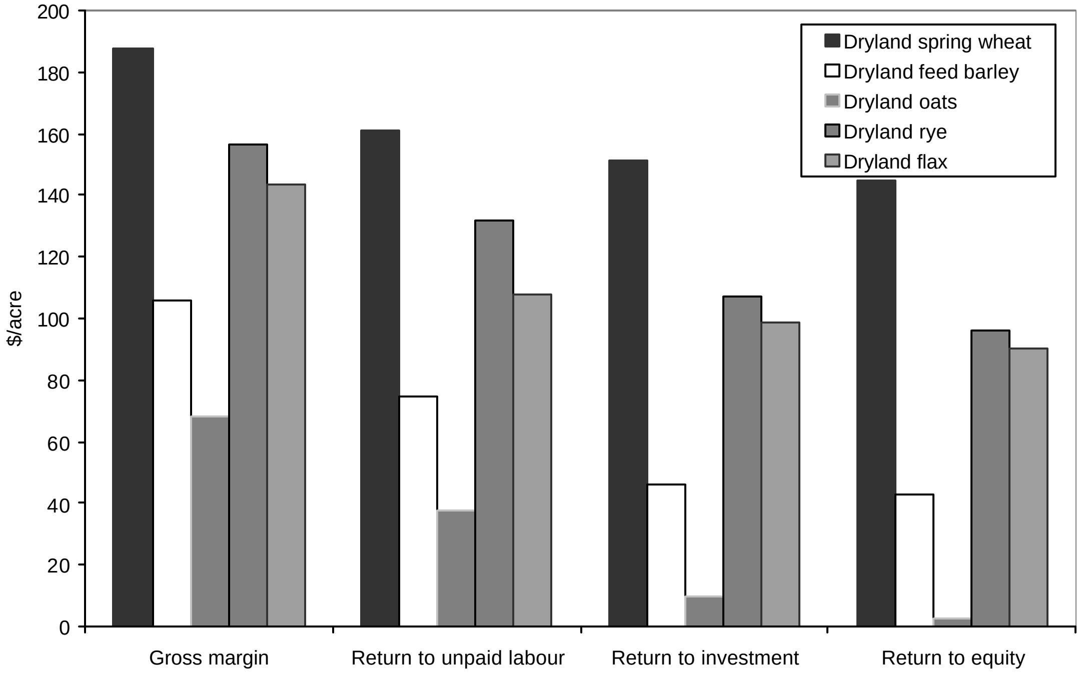


Source: Canadian Organic Growers Inc.

Alberta has more than half the organic acreage in Canada according to statistics from Canadian Organic Growers Inc. Their data show that in 1998 Alberta had more than 227,850 acres in organic production, which was 56 percent of the total Canadian organic acreage reported to them. These provisional figures indicated that there were 185 certified organic producers in Alberta in 1998.[43] These figures are obtained by sending an annual questionnaire to all certifying agencies across Canada, so only the respondents would be included and thus the data may underestimate the total number of organic producers. They do, however, provide an indication of the relative importance of organic agriculture in Alberta compared with the rest of Canada.

It seems that organic agriculture can be profitable, as least where price premiums prevail for organic produce. Alberta Agriculture, Food and Rural Development's crop enterprise analysis studied a number of dryland organic enterprises across the province for 1999.[44] The number of farms supplying data varied from 15 (for wheat) to four (for rye). As shown in Figure 21, all crops provided positive results, with dryland spring wheat giving the best returns per acre and oats the poorest. However, there has been little study on the long-term sustainability of organic farms in Alberta. A 12-year project is being conducted by Agriculture and Agri-Food Canada, but the preliminary results were not yet available when this report was prepared.

Figure 21: Organic Crop Enterprise Returns for Alberta in 1999



Source: Alberta Agriculture, Food and Rural Development

Organic farming is considered a “natural” system that maintains the quality and productivity of the land over the long term and is thus deemed sustainable. Some experience suggests there may be problems in ensuring a balanced nutrient cycle in organic farming. A Manitoba study found that although 40 percent of the land on organic farms is dedicated to soil-building crops such as alfalfa, pasture and sweet clover green manure, in some cases there were deficiencies in soil phosphorous (P) and sulphur (S). “The limiting factor to profitable organic cropping in the long term appears to be reduced soil nutrient status, especially for P and S, and weeds.”[45]

Another Manitoba study found that the only organically-grown crops that were profitable at conventional commodity prices were durum wheat, soft white spring wheat and alfalfa hay.[46] However, when the price premiums obtained for organic products were factored in, net returns were always positive and could be good. Indeed, a comparison of full input (fertilizer and herbicide), low input (fertilizer but no herbicide, or herbicide but no fertilizer) and organic systems showed that the organic systems had the lowest production costs and the highest net returns over an eight-year period (for rotations involving wheat, peas and flax, or wheat, alfalfa and flax).

Similar results have been found in Saskatchewan where provisional figures from the first four years of a long-term study indicate that, “The use of Organic Input management was more profitable than the High Input or Reduced Input management systems under the 1996/97-1998/99 price premiums levels that existed for organic grains.”[47]

From experience in the other Prairie provinces it would appear that organic agriculture in Alberta should be able to maintain the carbon levels in the soils and provide a profit, at least where there is a price premium for the products. It is thus a viable option to high-input, high-cost agriculture that can also be sustainable.

6 The Agricultural Land Base

One final factor that affects the sustainability of agriculture is the size of the agricultural land base. The total area of farms in Alberta increased from 47 million acres in 1961 to nearly 52 million acres in 1996.[48] Despite this apparent growth, the area of most productive land is slowly declining. From 1971 to 1995 the province experienced a net loss of 253,000 acres of land (about one percent of the total cropped area), half of which was high capability land suitable for annual cropping and horticultural crops.[49] This productive land, which falls in classes 1-3, constitutes only 17 percent of the soils in the province[50] and is primarily located in the corridor between Edmonton and Lethbridge where urban pressures are greatest.

Over two-thirds of the additions to the agricultural land base have been poorer soils, primarily in the Peace River region in northern Alberta where, until 1992, the government had an active policy of selling vacant public land. Urban annexation, residential subdivisions and oil and gas activity are the main causes for the loss of better quality lands. Although the land base deletions between 1971 and 1995 represent only 0.5 percent of the total agricultural area, such deletions will undermine the long-term sustainability of Alberta's agriculture. The area of good quality farmland has decreased by nearly two percent in the 25-year period (that is, land in classes 1 and 2, which have no limitations or moderate limitations for agriculture). The loss of prime farmland was a concern to the Agriculture Summit held in June 2000 and Summit co-chair, Brian Heidecker suggested that outside experts could help find ways "to allow prime agricultural land to stay in agriculture and direct other development to lesser productive land."[51]

7 The Long-Term Environmental Sustainability of Agriculture

Earlier in this report we asked whether agriculture in Alberta is sustainable. We see that crop yields are increasing and that the numbers of livestock in the province have risen rapidly but this has come with costs to the environment. There have been some major improvements in agricultural practices, but some negative features have offset these improvements.

On the favourable side, we see the dramatic reduction in summerfallow. Whereas extensive areas were traditionally fallowed each year in Alberta, recent trends to eliminate summerfallow and reduce tillage intensity, including zero tillage, will help maintain and restore soil carbon levels. Research on long-term plots shows that, with good management, organic matter can be maintained or even enhanced to some extent, and yields should be maintained indefinitely.[52] Even the practice of removing straw for non-agricultural uses is acceptable in areas where manure is used to replenish nutrients, although on light soils it is both better and more economic to keep the straw rather than to replenish the lost nutrients with artificial fertilizers. Thus, with good management practices (manure and fertilizers) to restore the elements that crops removed from the soil, it should be possible to maintain high yields in perpetuity. Farmers who do not manage their land well will go out of business, leaving others to restore the fertility of the soil and ensure sustainability.[53]

Also on the favourable side, we see the increasing efficiency in the use of irrigation water, both in its transport and in on-farm use. The rapid increase in organic farming, which avoids the problems associated with the use of pesticides and artificial fertilizers, is also a positive sign.

However, against these improvements in agricultural practices that assist sustainability must be set a number of negative influences. The physical loss of farmland to non-agricultural uses is a concern due to the fact that losses are mostly of better quality land. While it will not have an immediate effect on agricultural production, it is important to remember that land is a finite resource and must be retained in agricultural production for full agricultural sustainability.

The increase in soil salinity in both dryland farming and irrigation agriculture is another factor on the negative side that is reducing the land available for farming or the productivity of some areas. While seeps in dryland agriculture may have a natural cause, their extension is certainly a concern for sustainability. Salinity is reducing yields in both dryland and irrigation agriculture and additional efforts should be made to find ways to reduce its impact.

The most widespread problem, however, is the environmental degradation that is being caused by some current farming practices. Groundwater and surface water are being polluted by runoff from pesticide and fertilizer applications and from livestock operations. We have to repeat the conclusion of the CAESA study on *Agricultural Impacts on Water Quality in Alberta* that "current agricultural management practices on many farms are not adequate to sustain water quality, particularly in the high and moderate intensity agricultural areas of Alberta."[54] This leads us to the conclusion that, despite the improvements outlined above, current agricultural practices are not sustainable from an environmental perspective.

This does not mean that the situation cannot change. Agriculture and Agri-Food Canada, various universities and the Alberta government have a network of long-term monitoring sites across the province that are examining crop quality and soil health. Hopefully, they will obtain data to show how high crop yields can be maintained without causing negative environmental impacts. Research is also ongoing into ways to reduce problems associated with manure from livestock operations. However, even if answers are found, more stringent regulations and monitoring will be necessary to ensure that state-of-the-art standards are implemented and maintained. Certainly, the current Code of Practice for livestock operations must be updated and enforced.

In the immediate future, however, it is likely that farmers will be forced to change some practices due to the economic difficulties that many are facing.

8 Economic Sustainability

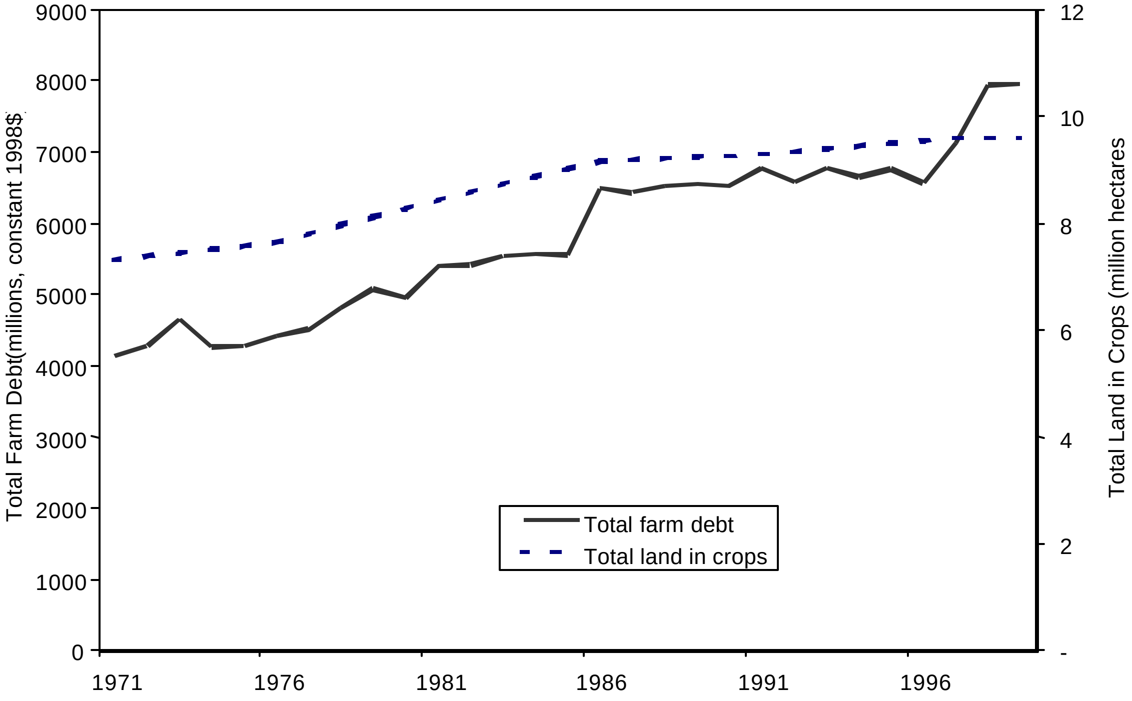
In addition to concerns about environmental sustainability, farmers are also concerned about economic sustainability. It has been shown above that expenditure on things such as fertilizer, herbicides and pesticides has been increasing at a far greater rate than the increase in the area of land to which these inputs are applied. Grain and oilseed yields have continued to increase, but world prices for grain and oilseeds have remained low, while the cost of inputs has soared.

For various reasons, smaller family farms are in decline. Unless they serve a niche market, as in the case of organic agriculture and a variety of specialty crops and livestock, smaller units do not have the financial resources to weather downturns in the agricultural economy. Even with government disaster assistance programs, a series of years with bad weather can bring operations to bankruptcy. Farmers who take on debt to expand are often the first to lose when lower prices or poor yields make it impossible to meet their debt obligations. As some farmers left agriculture, farms grew. Between 1961 and 1996, the number of farms in Alberta declined by nearly one-fifth, from 73,212 to 59,007. As a result the average farm size increased. In 1961 the average farm had

645 acres with 223 acres in crops. By 1996, average farm size had increased by over one-third, to 881 acres, while the area in crops had more than doubled, to an average of 469 acres per farm.

Not only did farms grow in size, but so did farm debt. As Figure 22 shows, total farm debt in Alberta almost doubled between 1971 and 1996 from under $4,000-million to nearly $8,000-million in constant 1998 dollars. During the same period the total land in crops increased from 7.3 million hectares to 9.5 million hectares, or 30 percent. Thus farm debt per hectare of cropland increased, from $565 per hectare in 1971 to $829 per hectare in 1996. It is recognized that not every hectare of land carries this much debt. Some of the debt will be associated with intensive livestock operations that will carry much higher debts per hectare. More work, beyond the scope of the current project, would be required to determine what the actual debt is per unit of cropland and what proportion is due to the increase in intensive agricultural activities. However, these figures suggest that farm debt (in constant dollars) may be increasing at a faster rate than the actual growth in farming. This increasing debt is inevitably a matter of concern and will probably lead to a further reduction in family farms, with associated impacts on the rural economy.

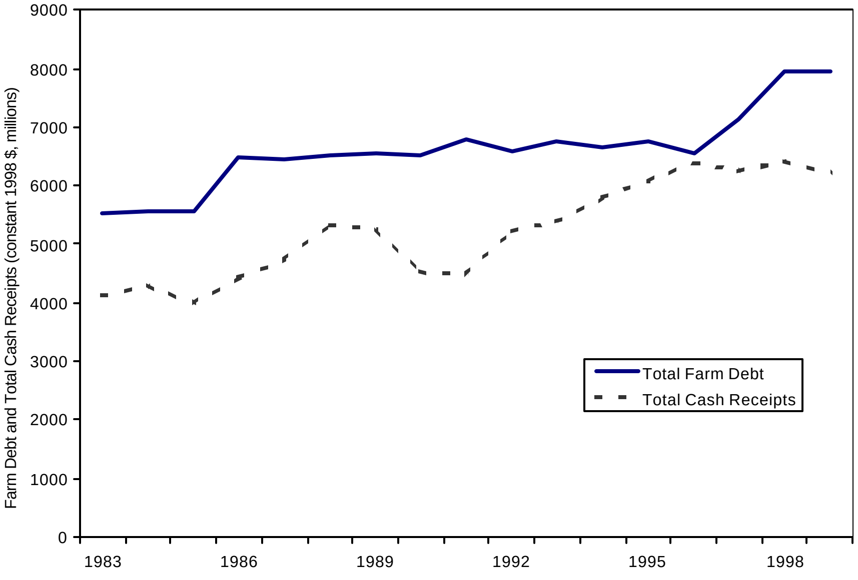
Figure 22: Growing Farm Debt and Total Land in Crops in Alberta, 1961 to 1996



Source: Statistics Canada CANSIM v 383139, Table 002-0008 and Historical Overview of Canadian Agriculture, Cat. No. 93-358-XPB, Table 1

While farm debt has been increasing due to the costs of purchasing land and ever more expensive farm equipment, the prices obtained for agricultural products have declined relatively. Although at the beginning of the 1990s, the gap between total cash receipts and farm debt was shrinking, since 1996 it has again been growing, as debt increased and receipts held constant (Figure 23).

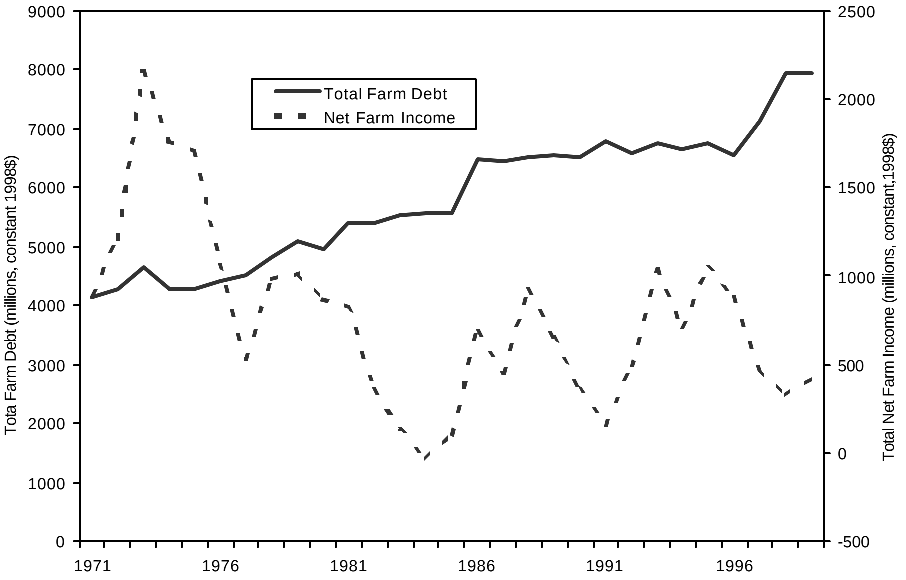
Figure 23: Farm Debt and Total Farm Cash Receipts in Alberta, 1983 to 1999



Source: Statistics Canada, Cat. No. 21-603-UPE

The truly serious decline in the economic position of Alberta agriculture is seen by comparing the increase in farm debt and the decline in net farm income from 1971 to 1999, in constant 1998$ (Figure 24). While farm debt has climbed, net farm income has, on average, been falling since the early 1970s. This certainly brings into question the economic sustainability of Alberta agriculture if such trends continue. This in turn will have implications for agricultural practices.

Figure 24: Farm Debt and Total Net Farm Income in Alberta, 1971 to 1999

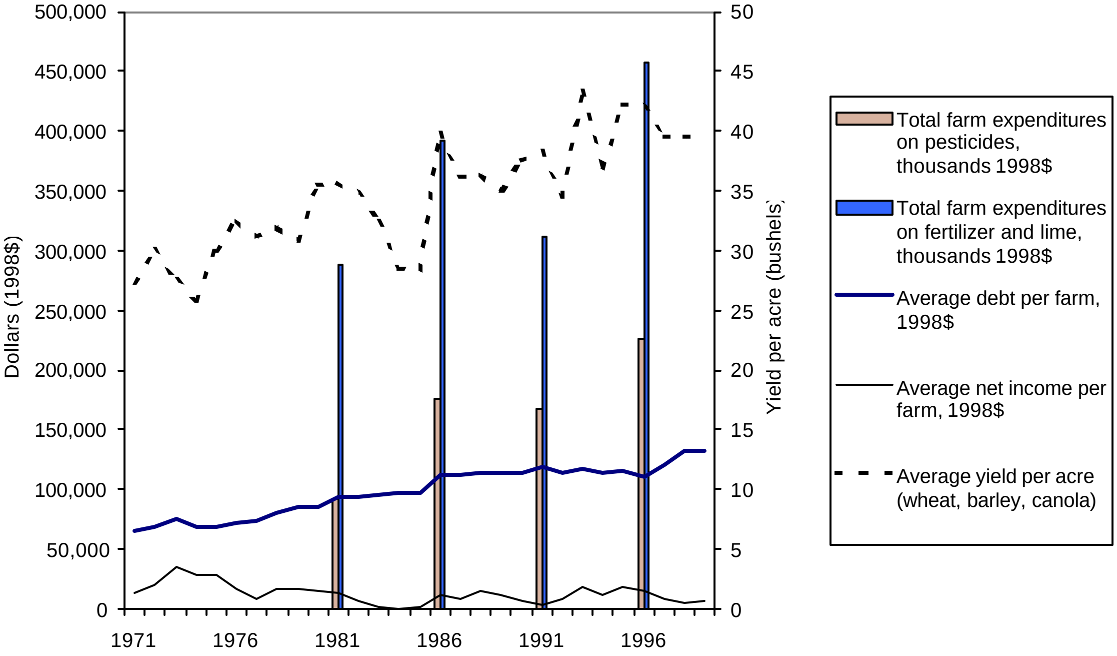


Source: Statistics Canada, Catalogue No. 21-603-UPE

Due to the fact that a large proportion of Alberta's agricultural production is exported, Alberta exports have to compete on the world market. And because export production is so large, it is impossible for the federal or provincial governments to subsidize output as is done in many European countries. Thus farmers are subject to the vagaries of the international marketplace.

In summary, as the use of inputs such as fertilizers and pesticides has increased, yields have increased, but so too has the average debt per farm, while at the same time the average net income per farm has declined (Figure 25). On a per-farm basis the real debt burden has increased 101 percent since 1971—an annualized rate of 3.5 percent from an average $65,973 (1998$) per farm in 1971 to $132,421 (1998$) in 1999. Net income per farm has declined 50 percent from approximately $14,000 in 1971 to $7,000 in 1999 (1998$). Expenditures on pesticides have more than doubled since 1981, and expenditures on fertilizer and lime have increased by 44 percent. It is possible that the trend in increasing yields may be depleting the productivity of cropland. In addition, it is doubtful that farmers will be able to continue covering the cost of increasing inputs, given the rapidly increasing costs of fuel, fertilizers and herbicides, increasing farm debt, declining net income, and the current prices for grain on world markets. The burden of debt is significant given the shrinking size of farm households in the province and continues to weigh heavily on the long-term viability of farming operations.

Figure 25: Total Farm Expenditures on Pesticides, Fertilizer and Lime, Average Yield per Acre, Average Debt per Farm, and Average Net Income per Farm, 1971 to 1999

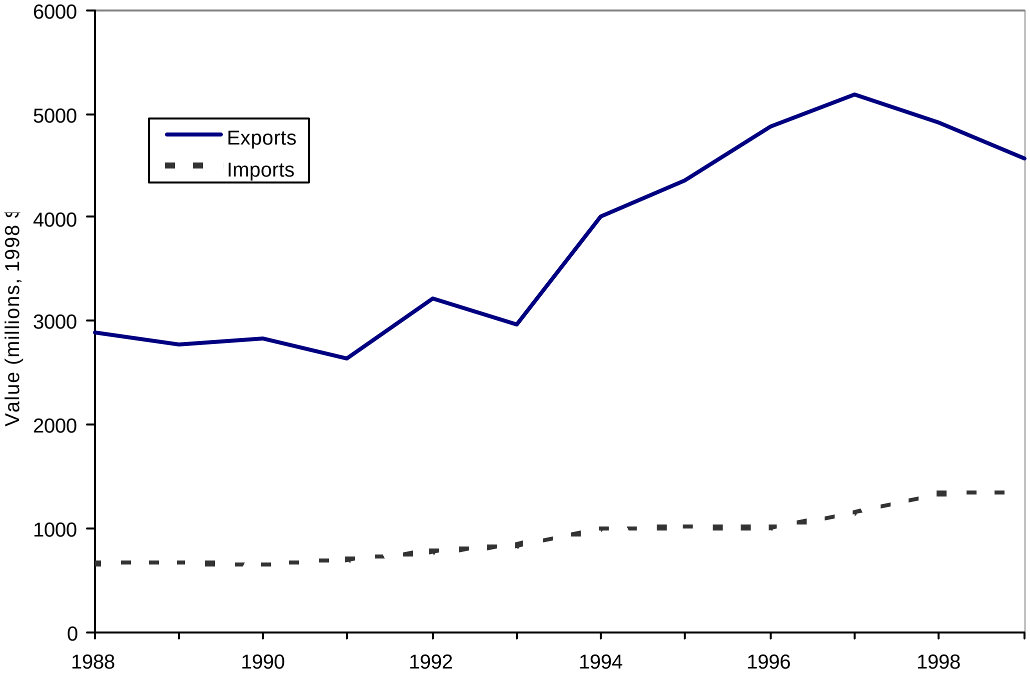


Source: Data for 1971 to 1999 from Statistics Canada Catalogue No. 21-603-UPE and Alberta Agriculture. Number of farms were estimated between survey years by overall average percent change. Calculations by authors.

9 Trade in Agricultural Products

Alberta's agricultural-based exports are an important element in provincial trade. As Figure 26 shows, in 1999 international exports of primary agriculture and food, feed and beverages totaled $4,387-million, or nearly 13 percent of the province's total commodity exports.[55] Alberta's total agri-food exports increased by 58 percent between 1988 and 1999 when measured in constant 1998 dollars. During the same period, the value of agri-food imports doubled (in 1998$) but even in 1999 the total value of agri-food imports was only 30 percent of the value of exports (although up from 23 percent in 1988). Some caution is required when interpreting the import figures for it is not certain exactly what proportion of the imports that cross the provincial border stay within the province.[i] It appears that the most important agri-food imports were products and by-products of manufacture, which accounted for 63 percent of total agricultural imports in 1999. Foods and food materials made up 28 percent of the value of the products of manufacture sub-category in 1999 (see Figure 27).

Figure 26: Alberta's Agri-Food Exports and Imports, 1988 to 1999



Source: Statistics Canada and Alberta, Agriculture, Food and Rural Development

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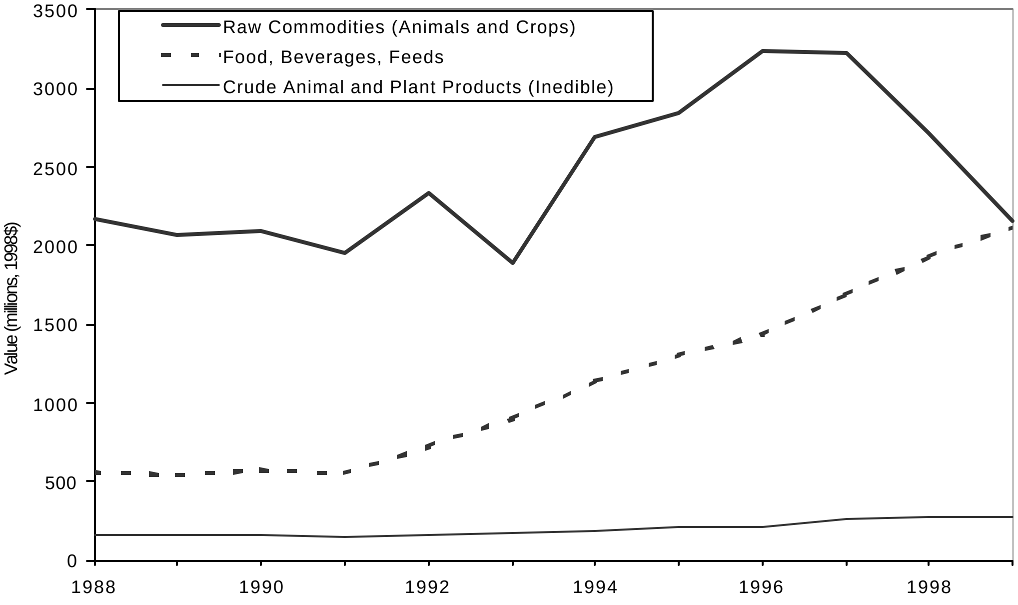
[i] Imports statistics are gathered by Revenue Canada at border entry points and reported by Statistics Canada on a province-of-clearance basis. Often, the province of clearance is not the province of final destination for imported goods. Thus, imports at the Alberta level could be portrayed incorrectly. For this reason, Statistics Canada's data are, in some cases, adjusted to account for inter-provincial movements of imported goods. (Information provided by Alberta Agriculture, Food and Rural Development.)

Figure 27: Alberta's Total Agri-Food Exports by Category, 1988 to 1999



Source: Statistics Canada and Alberta Agriculture, Food and Rural Development

As raw commodity prices have stayed relatively low, one of the best ways to increase the returns for Alberta farmers is to increase the value of agricultural products before they are exported. Thus the composition of Alberta's agri-food exports has been changing, with a dramatic growth in the export of value-added products. The value of food, beverage and feed exports was nearly four times as high in 1999 as in 1988, when measured in constant 1999 dollars and almost equaled the value of raw commodity exports for the first time. Exports of crude animal and inedible plant products (mainly raw hides and skins, seeds for sowing and peat moss) increased by 70 percent in value (1998$) over the period, but still only accounted for six percent of total agri-food exports in 1999. Within the raw commodity category, wheat, live cattle and canola seed were the most important exports, accounting for 80 percent of the total. Meat products accounted for two-thirds of the exports in the food, beverage and feeds category in 1999, with beef and veal alone being responsible for 57 percent of the exports in that category. Animal feeds made up a further 11 percent of the "food, beverages, and feeds" category, with oilseed cake and meal responsible for nearly half the total value of animal feed exports.

10 Environmental Costs of Agriculture

In the original 1995 GPI study for the U.S.,[56] estimates of the cost of loss of agricultural farmland due to urbanization, soil erosion and compaction were calculated as net deductions from U.S. GDP to derive a net sustainable economic welfare estimate (see Appendix C). The Australian GPI estimates for 2000[57] include estimates of the economic cost of land degradation and irrigation water use (see Appendix D). GPI Atlantic, headed by Dr. Ron Colman, has also developed methodologies for assessing the full costs of agricultural land use practices and the relationship of agricultural soil degradation to economic growth (see Appendix E).

Our Alberta GPI accounts for agriculture attempt to estimate the environmental costs associated with agriculture. It was not possible in the current study to put a cost to water pollution caused by agricultural activities; although the costs were not quantified, they should not be overlooked.

The cost of wind erosion on bare soil was estimated using the area of Alberta's cropland that was in summerfallow on an annual basis between 1961 and 1999. Although 24 percent of cultivated land has a moderate inherent risk of wind erosion of bare soil (11 to 22 tonnes/ha/year), only 12 percent was included as at risk because the model used[j] applied to areas with an erosion rate greater than 15.4 tonnes/ha/year.[58] In addition, 27 percent of cultivated land has inherent high risk (22.0 to 32.9 tonnes/ha/year), and four percent has severe inherent risk (over 32.9 tonnes/ha/year), for a total of 43 percent. Therefore, on-site and off-site costs were calculated based on 43 percent of the total hectares of summerfallow (i.e., 43 percent of bare soil on cultivated land). The costs of wind erosion are from Pimentel et al., converted to CDN1998$.[59] The water erosion costs were not included because only wind erosion statistics were readily available. On-site costs are an estimated $7.41/ha/year (1998$) reflecting the replacement cost of losses in phosphorus and soil depth, and off-site costs are an estimated $1.60/ha/year (1998$), including damages by wind erosion to exterior paint, landscaping, health, recreation, etc. Figure 28 indicates that wind erosion costs are declining, which is a result of farmers reducing the amount of cultivated land in summerfallow. Costs have fallen from $28.9-million in 1961 (1998$) to $12.8-million. This is a clear demonstration of how changes in behaviour and best practices have direct economic and environmental benefits. However, other externalized costs are associated with agriculture such as contaminated runoff from livestock farms and cropland, irrigation use of water, and water erosion costs. For example, the costs of salinity are estimated to be $55-million per year for dryland agriculture and at least $8-million with irrigation agriculture.

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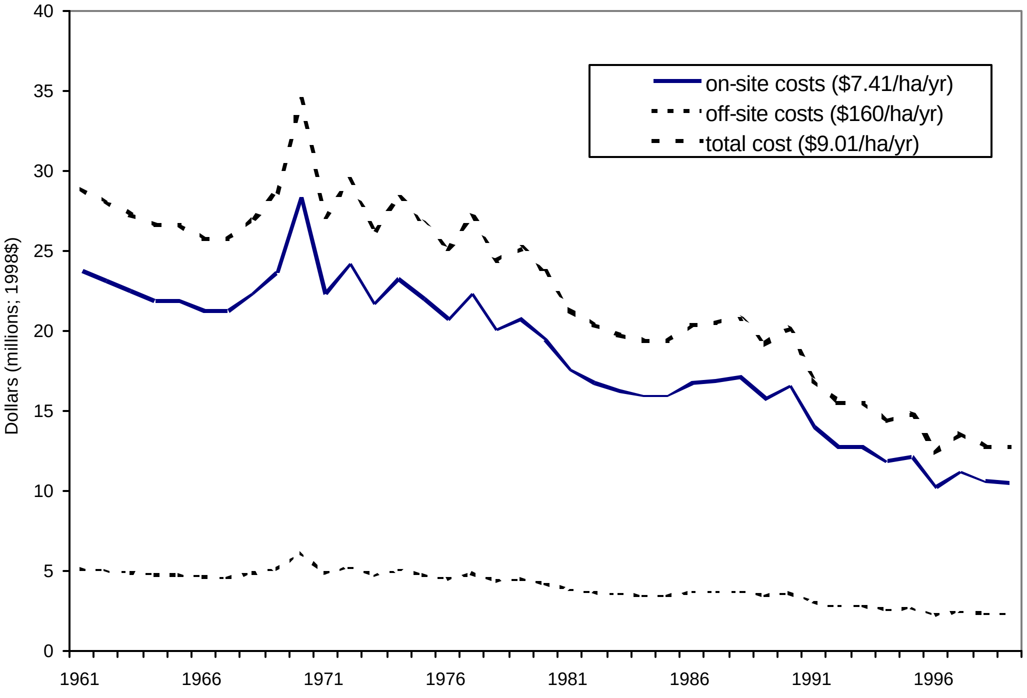
[j] The Century model was used; see section 3.5 of this report for more information.

Figure 28: On-site and Off-site Wind Erosion Costs based on Wind Erosion Risk and the Area of Cultivated Land in Summerfallow, 1961 to 1999



Source: "Cost of Wind Soil Erosion," Pimentel et al. (1995)

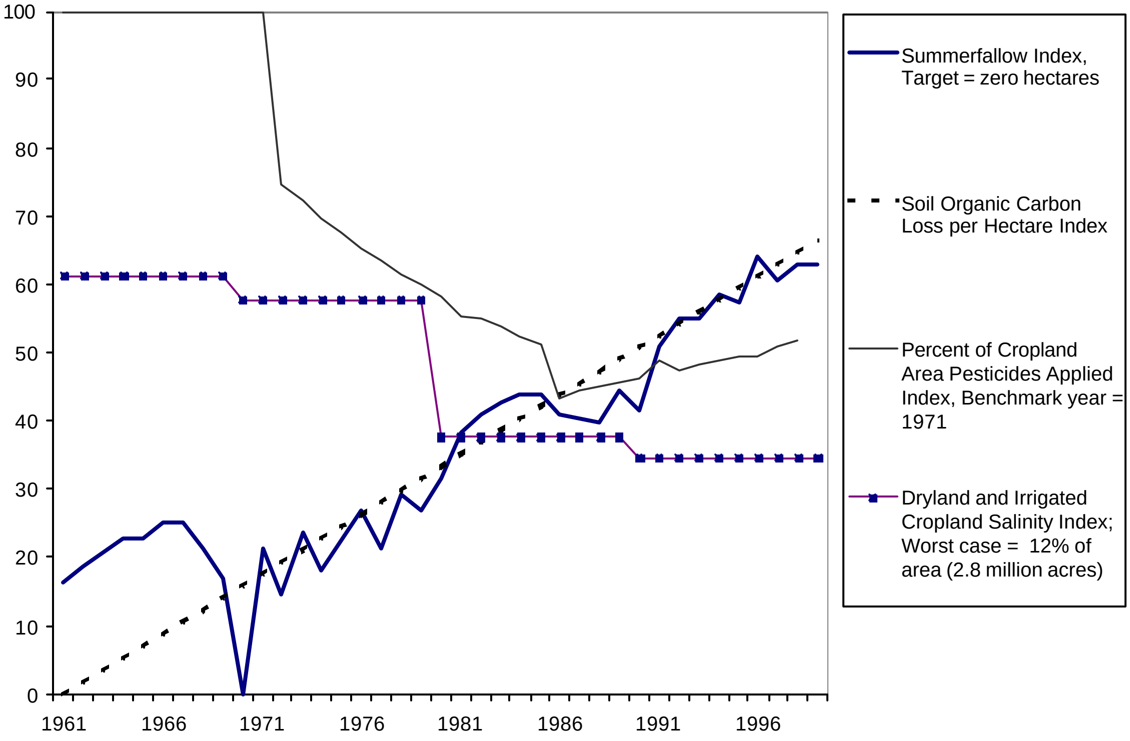
11 Agriculture Index

Six indices were determined to assess agricultural sustainability including:

1) the cropland area in summerfallow (target = 0 ha; improving);
2) the percentage of cropland on which pesticides are used (best year benchmark = 32.6 percent; increasing);
3) dryland and irrigated land salinity (target = 0 ha, with worst case scenario twice the current area; worsening);
4) the rate of loss of soil organic carbon (target = 0 kg/ha/yr; improving);
5) average yield per acre for wheat, barley, and canola as a proxy for productivity (best year benchmark = 109 bushels/acre; increasing); and,
6) average farm debt per farmer (best year benchmark = $37,400; worsening).

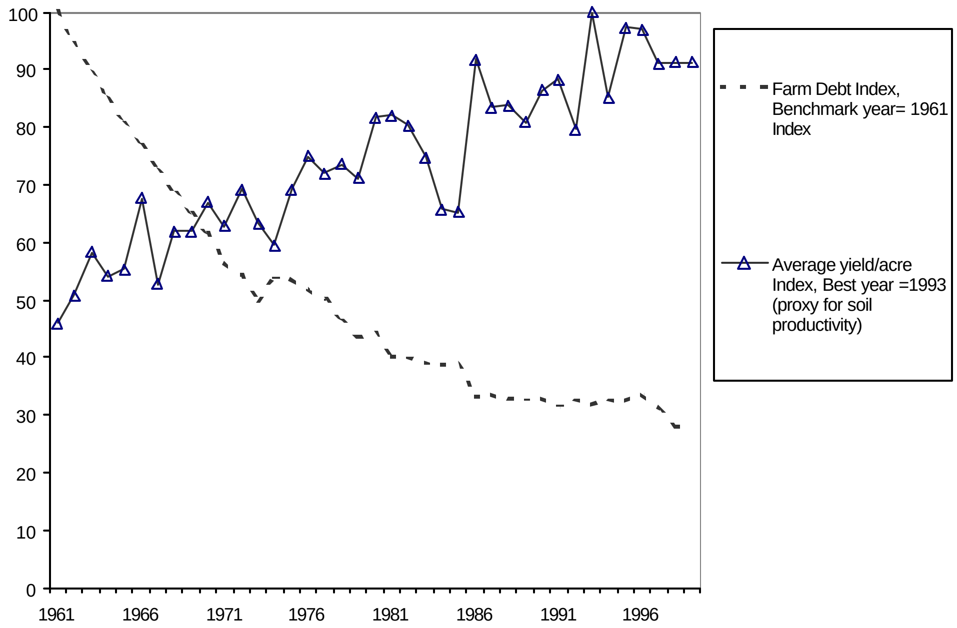
In Figure 29, the rate of loss in soil organic carbon on agricultural land, and the amount of cropland area in summerfallow have improved since 1961. On the other hand, the percentage of cropland area to which pesticides are applied, and the area affected by salinity have both worsened.

Figure 29: Indices for Summerfallow, Salinity, Loss of Soil Organic Carbon, and the Percentage of Cropland upon which Pesticides are Applied, 1961 to 1999



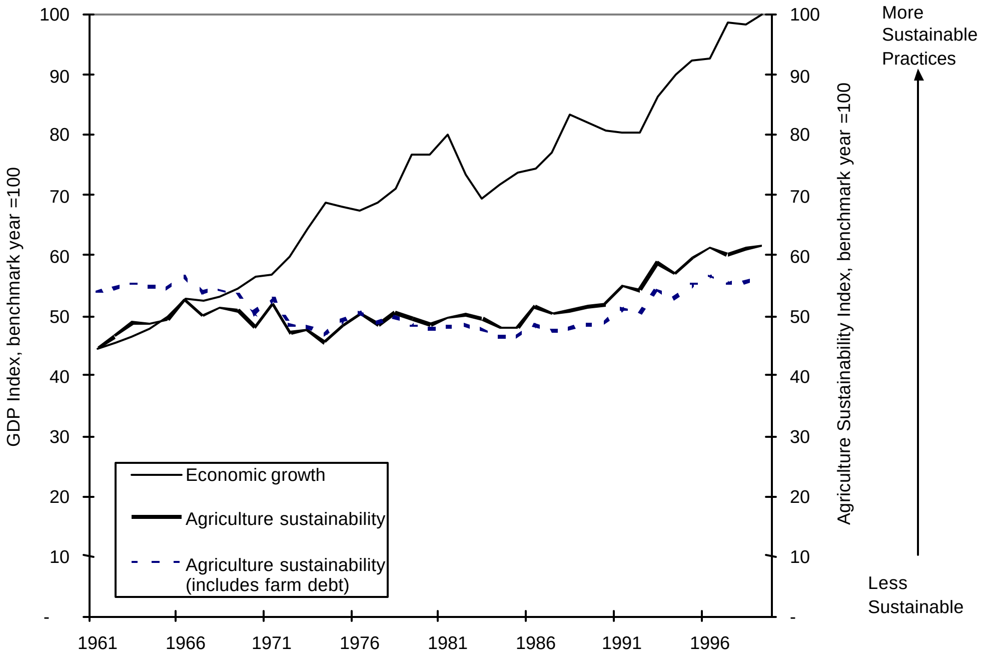
In Figure 30, the farm debt benchmark is 1961 and the best year for average yield per acre is 1993. Since 1961, the farm debt index has declined steadily indicating a worsening trend, reaching 28 in 1999. In contrast, the average yield per acre index has been climbing since 1961; it peaked in 1993 but has since remained high at 91 on the index in 1999.

Figure 30: Average Yield per Acre and Farm Debt Indices, 1961 to 1999



Two indices are presented in Figure 31. One includes the average of the first five indices above (excluding the farm debt index), and the second includes all six indices. In 1999, the former aggregate index scores 61.5 (an increase from 44.7 in 1961), and the latter aggregate index scores 55.9 (an increase from 53.9 in 1961).

Figure 31: Alberta Agricultural Sustainability Indices, 1961 to 1999



Appendix A. List of Alberta GPI Background Reports

A series of Alberta GPI background reports accompanies the *Alberta Sustainability Trends 2000* report and this report. These documents are being released in late 2001 and early 2002 and will be available on the Pembina Institute's website at www.pembina.org.

Alberta GPI Background Reports and Sustainability Indicators

GPI Background Reports	**GPI Accounts Covered by Report**
1. Economy, GDP, and Trade	• Economic growth (GDP) • Economic diversity • Trade
2. Personal Consumption Expenditures, Disposable Income and Savings	• Disposable income • Personal expenditures • Taxes • Savings rate
3. Money, Debt, Assets and Net Worth	• Household debt
4. Income Inequality, Poverty and Living Wages	• Income distribution • Poverty
5. Household and Public Infrastructure	• Public infrastructure • Household infrastructure
6. Employment	• Weekly wage rate • Unemployment • Underemployment
7. Transportation	• Transportation expenditures
8. Time Use	• Paid work time • Household work • Parenting and eldercare • Free time • Volunteerism • Commuting time
9. Human Health and Wellness	• Life expectancy • Premature mortality • Infant mortality • Obesity
10. Suicide	• Suicide
11. Substance Abuse; Alcohol, Drugs and Tobacco	• Drug use (youth)
12. Auto Crashes and Injuries	• Auto crashes
13. Family Breakdown	• Divorce
14. Crime	• Crime
15. Gambling	• Problem gambling
16. Democracy	• Voter participation
17. Intellectual Capital and Educational Attainment	• Educational attainment
18. Energy (Oil, Gas, Coal and Renewable)	• Oil and gas reserve life • Oilsands reserve life
19. Agriculture	• Agricultural sustainability
20. Forests	• Timber sustainability • Forest fragmentation

GPI Background Reports	**GPI Accounts Covered by Report**
21. Parks and Wilderness	• Parks and wilderness
22. Fish and Wildlife	• Fish and wildlife
23. Wetlands and Peatlands	• Wetlands • Peatlands
24. Water Resource and Quality	• Water quality
25. Energy Use Intensity, Greenhouse Gas Emissions and Air Quality	• Energy use intensity • Air quality-related emissions • Greenhouse gas emissions
26. Carbon Budget	• Carbon budget deficit
27. Municipal and Hazardous Waste	• Hazardous waste • Landfill waste
28. Ecological Footprint	• Ecological footprint

Appendix B. Agricultural Sustainability Index Data

	Cultivated Land in Summerfallow (Millions ha)	Index	Soil Organic Carbon Loss (kg/ha/year)	Index	Cropland where Pesticides Applied (percent)	Index	Average Yield per Acre (bushels)	Index	Debt per Farmer (1998$)	Index	Overall Index (excludes farm debt included in debt index)
1961	7.5	16.3	135.902	0.0	33%	100.0	1.09	46.0	$ 37,377.19	100.0	44.7
1962	7.2	18.6	133.524	1.7	33%	100.0	1.09	50.8	$ 39,539.42	94.5	46.5
1963	7.1	20.8	131.146	3.5	33%	100.0	1.09	58.4	$ 41,742.90	89.5	48.8
1964	6.9	22.9	128.768	5.2	33%	100.0	1.09	54.2	$ 43,988.27	85.0	48.7
1965	6.9	22.7	126.39	7.0	33%	100.0	1.09	55.4	$ 46,276.17	80.8	49.3
1966	6.7	25.2	124.012	8.7	33%	100.0	1.09	67.6	$ 48,661.94	76.8	52.6
1967	6.7	25.3	121.634	10.5	33%	100.0	1.09	52.9	$ 51,505.19	72.6	50.0
1968	7	21.3	119.256	12.2	33%	100.0	1.09	62.0	$ 54,441.62	68.7	51.4
1969	7.4	16.9	116.878	14.0	33%	100.0	1.09	62.0	$ 57,473.81	65.0	50.8
1970	8.9	0.0	114.5	15.7	33%	100.0	1.18	67.1	$ 60,604.38	61.7	48.1
1971	7.0	21.2	112.122	17.5	33%	100.0	1.18	63.0	$ 65,973.14	56.7	51.9
1972	7.6	14.6	109.744	19.2	44%	74.7	1.18	69.3	$ 68,737.64	54.4	47.1
1973	6.8	23.6	107.366	21.0	45%	72.2	1.18	63.4	$ 75,046.56	49.8	47.6
1974	7.3	18.0	104.988	22.7	47%	69.8	1.18	59.6	$ 69,125.56	54.1	45.6
1975	6.9	22.5	102.61	24.5	48%	67.5	1.18	69.3	$ 69,560.45	53.7	48.3
1976	6.5	27.0	100.232	26.2	50%	65.4	1.18	75.0	$ 72,244.98	51.7	50.3
1977	7	21.3	97.854	28.0	51%	63.4	1.18	71.9	$ 74,555.11	50.1	48.5
1978	6.3	29.2	95.476	29.7	53%	61.6	1.18	73.7	$ 80,509.00	46.4	50.4
1979	6.5	27.0	93.098	31.5	54%	59.8	1.18	71.1	$ 85,692.58	43.6	49.4
1980	6.1	31.5	90.72	33.2	56%	58.2	1.74	81.8	$ 84,432.91	44.3	48.5
1981	5.5	38.2	88.342	35.0	59%	55.4	1.74	82.1	$ 92,960.77	40.2	49.7
1982	5.3	41.0	85.964	36.7	59%	55.1	1.74	80.3	$ 93,332.62	40.0	50.2
1983	5.1	42.7	83.586	38.5	61%	53.7	1.74	74.7	$ 95,641.19	39.1	49.5
1984	5	43.8	81.208	40.2	62%	52.4	1.74	65.8	$ 96,125.98	38.9	48.0
1985	5	43.8	78.83	42.0	64%	51.1	1.74	65.3	$ 96,205.06	38.9	48.0
1986	5.3	41.0	76.452	43.7	75%	43.3	1.74	91.8	$ 112,393.45	33.3	51.5
1987	5.3	40.4	74.074	45.5	73%	44.6	1.74	83.5	$ 111,580.37	33.5	50.3
1988	5.4	39.9	71.696	47.2	72%	45.2	1.74	83.9	$ 113,476.79	32.9	50.8

	Cultivated Land in Summerfallow (Millions ha)	Index	Soil Organic Carbon Loss (kg/ha/year)	Index	Cropland where Pesticides Applied (percent)	Index	Average Yield per Acre (bushels)	Index	Debt per Farmer (1998$)	Index	Overall Index (excludes farm debt included in debt index)
1989	5.0	44.4	69.318	49.0	71%	45.7	1.74	80.9	$ 114,110.44	32.8	51.5
1990	5.2	41.6	66.94	50.7	70%	46.3	1.83	86.5	$ 113,878.00	32.8	51.9
1991	4.4	50.8	64.562	52.5	67%	48.7	1.83	88.4	$ 118,555.09	31.5	55.0
1992	4	55.1	62.184	54.2	69%	47.6	1.83	79.6	$ 114,273.74	32.7	54.2
1993	4	55.1	59.806	56.0	68%	48.2	1.83	100.0	$ 116,812.13	32.0	58.8
1994	3.7	58.4	57.428	57.7	67%	48.9	1.83	85.2	$ 114,058.27	32.8	57.0
1995	3.8	57.3	55.05	59.5	66%	49.6	1.83	97.3	$ 115,346.87	32.4	59.7
1996	3.2	64.0	52.672	61.2	66%	49.3	1.83	96.9	$ 111,306.36	33.6	61.2
1997	3.5	60.7	50.294	63.0	64%	51.0	1.83	91.1	$ 120,150.58	31.1	60.1
1998	3.3	62.9	47.916	64.7	63%	51.7	1.83	91.2	$ 133,113.41	28.1	61.0
1999	3.3	62.9	45.538	66.5	62%	52.5	1.83	91.2	$ 132,421.59	28.2	61.5

Appendix C. U.S GPI Methodology for Loss of Agricultural Soils

The U.S. GPI estimates include an estimate of the cost of the loss of agricultural productivity by estimating: 1) losses due to urbanization, 2) losses due to erosion, and 3) losses due to compaction. These and other detailed GPI methodological descriptions for the U.S. GPI analysis can be found in Anielski and Rowe (1999).[60]

Economic Cost of Loss of Farmland in the U.S. GPI

Sustaining the productive capacity of farmland is fundamental to sustaining the basic need for food for American households. The productive capacity of farmland has been reduced in two ways. On one hand, urban expansion permanently removes land from production by paving it over. On the other hand, poor land management destroys the soil: erosion, compaction, and decomposition of organic matter all remove land from production gradually by lowering its productivity. The decline in soil quality over the past forty years has been masked by higher inputs of fuel and fertilizer. In addition, soil depletion is not necessarily linear. It may not show up gradually in yield reductions, but rather in a sudden and irreversible decline.

The contention that we can compensate for paving or mismanaging farmland by bringing new land into production is misguided. Most of the land that economists point to in this regard is now idle because it is “dangerously erodible when in crop production” (Healy, 1982, p. 115).

Another contention is that the costs of losing farmland can be safely ignored because the resulting losses will occur in the distant future when people will be far richer than today, and technology far more advanced. This is a *reductio ad absurdum* of conventional economic theory, which suggests that future gains and losses should be “discounted” at the prevailing interest rate to determine the “present value” of an action: in this case, the loss of soil. A century or so from now, Americans are not likely to be impressed at our foresight and wisdom in discounting their needs and well-being to zero.

Production should be regarded as genuine progress only to the extent that it is *sustainable*. Otherwise, it is simply the conversion of capital to current income. The GPI therefore subtracts the cumulative damage to long-term productivity of land that results from urbanization and poor land management (deteriorating soil).

According to the 1997 National Resources Inventory by the U.S. Department of Agriculture, there were 380.5 million acres of cropland in the United States. Of this area, roughly 108.9 million acres were considered “highly erodible.” According to the U.S. Department of Agriculture (1997), total erosion on all cropland, between 1982 and 1997, decreased by 42 percent. In 1982, erosion totaled 3.4 billion tons; by 1997 it had been reduced to 2 billion tons. Total erosion on highly erodible cropland declined by 38 percent between 1982 and 1997. In 1982 there were 1.9 billion tons of erosion occurring on highly erodible land. By 1997, erosion fell to 1 billion tons on this land. Despite substantial changes from 1982 to 1995, there was virtually no change in the total amount of erosion or in the rate of erosion from 1995 to 1997.

According to the U.S. Department of Agriculture, despite gains in the fight against soil erosion, agricultural producers continue to face the challenge brought about by changing weather and market conditions of managing, maintaining, and enhancing the productivity of their lands. Soil erosion is a problem that must be continuously addressed through the enhanced development and application of conservation practices.

Losses due to urbanization

Approximately 40 million acres of farmland had been urbanized or transformed into highways and rights-of-way, by 1950 (Economic Research Service (ERS), 1982). At present, urbanization destroys approximately 300,000 acres of cropland per year. This is a conservative estimate, based on the 1981 National Agricultural Lands Study.

The value of an average acre of converted cropland, based on its productivity without high applications of fertilizers and other energy-intensive inputs, is estimated to be $329 per acre per year in 1992 dollars. To estimate the accumulated annual loss of services from farmland that had already yielded to urbanization by 1950, we used an average annual value of $71 per acre, in 1992 dollars. (As in the case of wetlands, the marginal utility (or value) of the first acres removed from agriculture is lower than the value of the land most recently urbanized.)

According to the USDA 1997 State of the Land inventory, between 1992 and 1997, total U.S. cropland—both cultivated and non-cultivated—declined from 382.3 million acres to 380.5 million acres. Of this 1.8 million-acre net reduction, 1.1 million acres came out of production between 1995 and 1997. This land was converted to other uses such as pastureland and some urban development. The 1.8 million-acre net reduction would amount to 360,000 acres per year from 1992 to 1997; how much of this total is urban development not available in the report). Thus our original 300,000 acres per year loss estimates may still be reasonable.

The cumulative cost of urbanization up to 1950 is estimated at $2.85-billion. This is based on an average value of $71 per acre for the approximately 40 million acres that have been urbanized or transformed into highways and rights-of-way. (ERS, 1982). As in the case of wetlands, the marginal utility (or value) of the first acres removed from agriculture is lower than the value of the land most recently urbanized.

Urbanization thus removes annually from the cropland base, the biological services worth $2.85-billion in 1950, plus $98.7-million (300,000 acres times $329 per) acre for each subsequent year. These costs are cumulative. For 1997 we estimate the economic costs due to urbanization at $7.5-billion, in 1992 dollars.

Losses due to deteriorating soil condition

Urbanization removes the productive potential of farmland in a highly visible way. But it may not be as serious in the long run as the deterioration of soil due to poor management. The decline of soil quality over the past forty years has been masked by higher inputs of fertilizer, pesticides, and fuel. In addition, soil depletion is not necessarily linear. It may not show up gradually in yield reductions, but rather in a sudden and irreversible decline. Agricultural productivity losses from erosion have been estimated at $1.3-billion, or $2.15-billion in 1992 dollars (Soil Conservation Service, 1980).

This series actually starts in 1949, with cumulative damage or lost productivity due to erosion equal to $14.5-billion (in 1992 chained dollars). The rate of erosion is assumed to have grown by one percent per year from 1950 to 1972. According to the recent 1997 State of the Land Report (USDA) the rate of erosion has declined from 8.0 tons/ac/yr in 1982 to 5.2 tons/ac/yr in 1995, then levels off. This amounts to a net reduction in erosion rates of 2.7 percent per annum through to 1995 which we use to extrapolate through to 1995, then assume no change in erosion rates from 1995 to 1997. We assume that the annual value of the cumulative damage prior to 1950 was $14.5-billion, with further costs added to that. By 1997 the estimated total cost due to soil erosion was $112.1-billion, in 1992 dollars.

The damage to soil from compaction by heavy machinery in 1980 was estimated at $3.0-billion in 1980 dollars (Sampson, 1981) or $4.97-billion in 1992 chained dollars. The above estimate converted to 1992 chained dollars using 1992 GDP chain-type price index yielding $4.97-billion. We assumed a 3 percent increase in the losses due to compaction for years prior to and following 1980. We were unable to find newer estimates of the cost of soil compaction. The 1997 estimate of the cost of soil compaction is $8.2-billion, in 1992 dollars.

The total economic costs of the loss of farmland to urbanization, soil erosion and soil compaction in the GPI is estimated at $127.8-billion in 1997 (in 1992 dollars) having risen steadily from an estimated $21.1-billion in 1950 (in 1992 dollars).

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Appendix D. Australian GPI Methodology for Loss of Agricultural Soils and the Cost of Irrigation Water Use

The Australian GPI for 2000 estimated by Hamilton and Denniss estimate the cost of land (soil) degradation and the cost of irrigation water use, which they deduct against GDP to derive the GPI estimates. The following outlines their methodology taken directly from Hamilton and Denniss (2000).[61]

Costs of land degradation

Soil is a resource for which there is no substitute. Moreover soil loss and changes in soil structure are effectively irreversible. As such the soil may be classified as 'critical capital' (Diesendorf 1997: 90). Current agricultural practices are unsustainable; the current generation is leaving a depleted and less productive resource for future generations, a resource that is essential for maintained living standards and ecological processes. The Standing Committee on Agriculture defined sustainable agriculture as 'the use of farming practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities' (quoted in Derrick and Dann 1997:189).

While there is a continuing debate over the economic viability of some types of farms, it is clear that the natural resource base is being depleted and other ecosystems have been seriously degraded.

The principal environmental problems associated with the land use in Australia are soil structure decline, salinity and waterlogging, acidification, nutrient loss, weed infestation, habitat loss and various forms of erosion. Some of the environmental impacts have already been assessed in our evaluation of the environmental costs of irrigation water use. The costs of degradation of native forests are also assessed elsewhere (Column S).

Some of the environmental costs associated with land use are reflected directly in lower agricultural outputs and higher costs of inputs—the on-farm costs. For example, weed infestation costs around $3.3-billion annually (excluding the health and environmental costs associated with weeds), mainly due to lost production and control costs (DEST 1996b: 6-23). The control costs are intermediate inputs that are reflected in final prices.

The off-farm costs include both costs imposed on other farmers—through, for example, the spread of weeds or salinisation of waterways—and damage to natural systems.

The question of how to value the loss of natural capital of the land is difficult. There are two types of costs: loss of productive potential, and environmental damage. One method of estimating the loss of productive potential would be to use the proportion of the value of agricultural output that is denied future generations through irreplaceable soil loss. Estimates of the annual losses have been made in the form of the production equivalent of land degradation. In a recent review, the Industry Commission reports a number of studies for the early to mid-1990s which indicate that land degradation across Australia results in an annual loss of output equivalent to around 5-6 percent of the value of agricultural production (Gretton and Salma 1996:E4-E7). This amounted to around $1.2-billion in 1992-93 (RBA 1996: Table 5.18). The figure of 5-6 percent is an underestimate because it takes account of only some forms of land degradation—acidification, soil structure loss and erosion—and accounts only for production losses and not ecological damage. We therefore estimate total damage at double that amount; i.e., $2.4-billion in 1992-93 (although farm prices and output were low in that year due to recession). The figure is $2.6-billion in our base year 1989-90.

More recently, a study by the ACF and NFF estimated that the cost of land and water degradation amounts to $1.4-billion annually, made up mainly of the costs of salinity, acid soils and poor water quality. Adding some more difficult to quantify impacts, such as degradation of ecosystems and coastal sedimentation, brings the figure to more than $2-billion (Virtual Consulting 2000).

In addition to the annual loss of environmental quality experienced by the current generation, we need to account for the losses imposed on future generations by the irreversible depletion of a critical resource. The costs imposed on future generations are estimated by the present value of the future losses, which at a discount rate of 5 percent amount to 20 times current losses ($52-billion), distributed back over the years according to the contribution of each year to the current level of depletion. Very little data exist to indicate the trends over time in land degradation. In the absence of data, we assume that land degradation has proceeded at a rate of two percent per annum over the study period, so that for each year of the study period the capitalized future costs of land degradation amount to $1.04-billion at 1989-90 prices. This can be thought of as the amount that the population would have needed to set aside each year to compensate future generations for losses due to land degradation. This same rate of change of land degradation is used to estimate the losses in each year to the current generation.

We saw above that weed infestation costs around $3.3-billion annually (1986 data). Around $3-billion of this is reflected in lost or contaminated production (DEST 1996b: 6-23). This represented 19.4 percent of gross farm production in 1986. Since weed infestation does not represent an irreplaceable loss, its costs represent annual costs only. In addition, the cost of weeds is already reflected in the national accounts through a lower value of output. Weed control expenditures are defensive, but since they are intermediate inputs they too are reflected in the accounts.

Costs of irrigation water use

The costs of water use measured here are those associated with environmental damage due to diversions of water for irrigation purposes from Australia's river systems, particularly the Murray-Darling Basin which accounts for 75 percent of irrigation water in Australia (ABS 1996a, Table 6.5.3). The costs of water pollution included in the next component (Column P) are those associated with wastewater disposal in urban areas.

The environmental impacts of water diversions from Australia's rivers include:

- loss and degradation of habitat resulting in disturbance to flora and fauna;
- declining conservation and recreational values associated with riverine ecosystems;
- downstream impacts of salinisation on household water users; and
- downstream impacts on industrial and other agricultural water users.

The last-mentioned set of costs includes loss of forest growth and grazing productivity, and additional costs due to salt build-up in industrial boilers, reduced service life of pipes, fittings and machinery and the costs of softening and demineralising water. These are intermediate costs that will be reflected in the prices of final goods produced.

Downstream impacts of salinisation on households include reduced service lives of pipes, fittings and machinery, increased use of household cleaning products (soaps, detergents and water softeners), and reduction in yields of garden produce (River Murray Commission 1984). These require defensive expenditures that in principle should be deducted from the estimate of the GPI.

The only feasible way of estimating the environmental costs of water use and salinisation is by use of the control cost method. This involves estimating the loss in agricultural output from reductions in water diverted to irrigation. The rationale behind the control cost method is that by agreeing to spend a given amount on controlling an environmental problem society 'effectively' demonstrates a willingness to pay for a certain amount of reduction in environmental damage. One implication of this is that amelioration measures will be adopted from an array of possibilities from the cheapest to the most expensive up to the point where the control cost is equal to the damage avoided.

In this case the argument is that the value of the environmental damage done by the diversion of the last gigalitre of water is equal to the value of the additional agricultural output. This would be a far-fetched interpretation since in the past the environment has been treated effectively as a free good, so that the environmental costs greatly exceed the economic benefits. Nevertheless, the control cost approach may be considered to provide a lower bound to the environmental costs of excessive water use.

In order to provide for adequate environmental flows in the Murray-Darling Basin, it is estimated that current diversions will need to be reduced by around 30 percent, from 10 684 GL/year (the mean for 1988-89 to 1992-93) to 7500 GL/year (Hamilton, Hundloe and Quiggin 1997:22-3). If diversions are reduced to around 7500 GL/year (along with some changes to the seasonal flows to make them more in harmony with natural cycles) then a high proportion (perhaps 80 percent) of the environmental damage will in time be ameliorated. We thus assume that environmental costs began to exceed 'acceptable' levels (a form of safe minimum standard) when diversions began to exceed 7500 GL/year, an event that occurred for the first time in 1968.

Using farm budgets, the Murray-Darling Basin Commission estimated the value of water to irrigators at $56.40/ML in 1988 (MDBC 1989: 4). To estimate the costs of water use we apply this figure, adjusted for inflation, to each megalitre in excess of 7500 gigalitres for each year since 1967. Using this procedure, the cost of environmental damage from excessive water use for 1996 is estimated at $233-million. This is a very low figure.

In order to obtain a better approximation we make two adjustments to our estimate so far. First of all, since the Murray-Darling Basin accounts for only 75 percent of total irrigation water in Australia, we scale up our estimate by 33 percent. Secondly, since the control cost method is likely to seriously underestimate the environmental damage (for the reason given above) we arbitrarily double our estimate. This gives an estimated cost of environmental damage from irrigation water diversions in 1996 of $621-million. As a justification for the doubling of the initial estimate it might be pointed out that one study which evaluated the costs and benefits of reduced diversions in the Barmah-Millewa red gum forests of the Murray-Darling Basin concluded that the costs to agriculture from managed floods involving additional dam releases are exceeded by the benefits to the timber industry *alone* (MDBC 1992). In other words, using our control cost valuation, the increase in the health of forests reflected in higher timber yields—without any account of ecological and recreational values—is alone enough to account for the forgone agricultural output.

Appendix E. GPI Atlantic Estimates of Costs to Agriculture

Researchers at GPI Atlantic, headed by Dr. Ron Colman, are also advancing the methodological framework for assessing the full costs of agricultural land use practices as part of constructing a set of GPI accounts for Nova Scotia. Their reports pertaining to agriculture can be purchased at www.gpiatlantic.org and include:

- Farm Viability and Economic Capacity in Nova Scotia
- Introduction to the GPI Renewable Resource Accounts

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