AGRI-ENVIRONMENTAL INDICATOR PROJECT

Agriculture and Agri-Food Canada

REPORT NO. 18

FARM RESOURCE MANAGEMENT INDICATOR: SOIL COVER AND LAND MANAGEMENT COMPONENT

TECHNICAL REPORT

by

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PREFACE

The Agri-Environmental Indicator (AEI) Project of Agriculture and Agri-Food Canada (AAFC) was initiated in 1993 in response to recommendations made by several agencies, organizations and special studies. The overall objective of the project is to develop and provide information to help integrate environmental considerations into decision-making processes of the agri-food sector.

The project aims to develop a core set of regionally-sensitive national indicators that build on and enhance the information base currently available on environmental conditions and trends related to primary agriculture in Canada. The soil cover and management component of the Farm Resources Management indicator is an important part of the agri-environmental indicator set. Indicators are also being developed for other aspects of farm resources management and in relation to issues of water quality, agroecosystem biodiversity, soil quality, agricultural greenhouse gases and agricultural production efficiency.

Research results in the form of discussion papers, scientific articles and progress reports are released as they become available. A comprehensive report is planned for fiscal-year 1998-1999.

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1. INTRODUCTION

1.1 ENVIRONMENTAL INDICATORS

Over the past two decades, concern for the state of the environment and the prospects for sustainable development has focussed considerable attention on the effects of agricultural activities on soil quality. As a result, considerable adjustment of land use and production activities has occurred, but there is continuing concern that more changes are required in order to maintain the long-term health of our soils and farming industry. One of the primary concerns at the present time, after 10 - 15 years of conservation promotion, education and implementation, is to provide some answers to the question "How are we doing?" In other words, we need to assess our progress toward environmentally sustainable agricultural production practices. One method of monitoring broad-scale changes is through development of 'indicators' which focus on different aspects of the agriculture/environment interface.

The concept of using 'indicators' as a method of tracking changes in a broad and varied industry arises as a result of the impracticality of repeatedly measuring a wide range of specific and precise conditions. By carefully assessing the suite of agricultural activities that affect environmental quality, a few key variables that can be monitored efficiently and that reflect a wider range of changes can be identified. For example, since one of the primary factors influencing the amount of wind and water erosion of agricultural soil is the amount of bare soil exposed to erosive weather, measuring or estimating changes in soil cover over time can serve as an 'indication' of movement toward or away from environmental sustainability. A key issue in the choice of an indicator is to identity a measure which has a consistent implication for a variety of environmental issues. In this case, for example, a greater amount of soil cover (particularly crop residue) not only helps prevent erosion, but helps build soil carbon levels, thereby sequestering atmospheric carbon dioxide as well. In addition, soil cover can provide habitat benefits to a variety of wildlife, thus having positive implications for biodiversity.

1.2 SOIL COVER

The assessment of changes in soil cover must consider two factors. First, changes in the area of crops which provide different types and amounts of vegetative and residue cover represent an important determinant of the overall level of, and changes in, soil cover. For example, a shift from hay to corn or soybeans constitutes a decrease in soil cover due to the tillage routines involved in cultivating an annual row-crop versus a perennial sod crop. This particular example therefore represents a negative impact. At the same time, however, changes may have been occurring in the tillage practices being used and, particularly in the case of erosion-prone crops and soil types, the level of soil cover afforded by a specific crop may have changed. For example, the implementation of conservation tillage in corn production would provide a positive impact by increasing soil cover. The problem is to determine whether the environmental impact of, for example, a minor shift from hay to corn is compensated for by widespread improvement in residue levels in corn production. In other words:

> What has been the cumulative affect of changes in crop area and residue management on soil cover over the history of agriculture in Canada? Is the situation improving or becoming worse?

This report outlines a study which addresses these issues at the level of national and provincial trends in crop production and land management. Findings are presented with specific reference to the impact of these changes on the relative amount of soil cover provided by the various crops and agricultural activities. This report constitutes the first 'overview' of soil cover as an agro-environmental indicator and presents the framework for the development of a more rigorous 'composite' indicator that combines land use and management information.

1.3 LAND USE AND MANAGEMENT DATA

Since the amount of soil cover provided by an agricultural system is a function of the type of crop(s) grown, as well as the management of crop residue between growing periods, data pertaining to land use and management is of primary concern. Soil scientists, geographers and specialists in land evaluation, land degradation and rural planning have for some time been promoting the need for current and accurate land use and management data in order to support efforts to manage resources (Halstead and Dumanski, 1977; University of Guelph, 1978; Coote *et al.*, 1981; Huffman and Dumanski, 1985; Hiley and Wehrhahn, 1991; Jeck *et al.*, 1990). As a result, a number of different land use inventory techniques based on airphotos, field survey, census data and satellite imagery have been developed to address the issue.

However, current efforts to analyze and monitor agricultural land use activities find these techniques lacking in several ways. Air photo interpretation (API), or API combined with site inspection has been used extensively in regional studies and is accurate and detailed, but it is also slow, expensive and oriented to land cover, with little opportunity for interpretation of socioeconomic or farm structural characteristics. An adaptation that provides socioeconomic and farm activity information has been successfully demonstrated in several regions of Canada (Huffman and Dumanski, 1985), but again the expense and time required restricts its use to small areas and infrequent time intervals.

Classification of satellite imagery is a versatile approach, with a variety of image types and spatial resolutions and a product suitable for digital manipulation in Geographic Information Systems (GIS). However, remote sensing suffers from a lack of socioeconomic interpretability and is therefore low in analytical potential. Remote sensing has been employed successfully throughout the agricultural regions of Canada (Ryerson *et al.*, 1979; Wilson, 1986; Energy, Mines and Resources Canada, 1987) for specific purposes, but in the context of land use analysis for the whole country, the cost renders it impractical.

The national Census of Agriculture conducted by Statistics Canada, with its wide variety of variables and coverage of all farms every 5 years (1961, 1966, 1971, 1976, etc.) has tremendous potential for analytical studies over large areas. For detailed, local studies the Census is somewhat restricted by a lack of locational accuracy and the fact that it is generally available only on the basis of cultural units such as Enumeration Areas (EA's), Census Subdivisions or Crop Reporting Districts. For national and provincial-level evaluations, however, the Census can provide reasonably consistent data over a fairly long time period (1901 - 1991) and is probably the best source of the information necessary for developing and reporting on soil cover as an agro-environmental indicator.

2. METHODOLOGY

2.1 THE 'CENSUS OF AGRICULTURE' DATABASE

The Census of Agriculture database can be subdivided into four sections: 1) farm structure, 2) crops and land use, 3) livestock and 4) economics. The crops and land use section is of most relevance to assessments of land management and this is comprised of approximately 30 variables relating to the area of land use types, field crops and specialty crops. There have been some changes to the specific questions asked of farmers over the years, but for the most part variables such as crops can be reliably tracked over time. Especially at the provincial and national levels, where a certain amount of generalization is necessary, the data is comparable. The 1991 (and subsequent, we presume) Censuses have the addition of a 'land management' section dealing with tillage practices such as conventional, conservation and no-till and the use of conservation structures such as windbreaks and grassed waterways.

Census data at various levels of aggregation has only become available in electronic format since 1986, so data preparation involved extracting pertinent numbers for selected crops and land use types from archived hardcopy publications. The data was collected at the provincial level for all provinces except Newfoundland/Labrador (due to incomplete historical records), entered into a spreadsheet format and analyzed at the provincial and national levels. Information was extracted for ten-year intervals for the period 1901 to 1991. The raw data, presented in Appendix 1, details the area of land associated with each of the following variables:

1) Total Farmland (crops + hay + pasture + treed land + buildings, lanes, etc.)
2) Average Farm size (Total farmland / number of farms)
3) Cropland (sum of all crops)
4) Pasture (Improved pasture only, no rangeland)
5) Summerfallow (cropland not cropped for one year for moisture and weed control)
6) Fruit & Berries (tree fruit, blueberries, strawberries, grapes, etc.)
7) Hay
8) Potatoes
9) Wheat
10) Oats & Barley
11) Corn
12) Soybeans
13) Tobacco
14) Canola

The choice of crops as listed above reflects their importance in Canadian agriculture, their significance with respect to soil cover and their consistent reporting in the Census. Some are of more importance at a regional level than nationally (eg. potatoes and summerfallow), but they are all significant at the provincial level of analysis. The values presented in Appendix 1 have been collected from various census documents and are tabulated for the years 1901, 1911, 1921, 1931, 1941, 1951, 1961, 1971, 1981, and 1991. The values for several of the crops (hay, potatoes, wheat, oats & barley and corn) for the years 1901 through 1951 represent the area for the year following or the year preceding the tabulated reference year. However, since this data is used only for a long-term trend analysis, and crop areas would not be expected to vary widely from year to year, this inconsistency was ignored.

There is some question as to the reliability of the Census data available for the years prior to 1931, and for certain variables and regions in subsequent years. For example, the values for 'summerfallow' in Eastern Canada are generally inflated due to a misunderstanding of the meaning of the term, and there is some concern about the interpretation of the description of 'conservation tillage', especially in Atlantic Canada. However, since this is a general overview, and much of the problem data is not used (i.e. no analysis of summerfallow in the East), these issues are not addressed in this report. The descriptions of Canadian agriculture provided here should only be considered as indicative of a general trend. In the meantime,

Agriculture and Agri-Food Canada has a study underway to assess and validate these concerns.

2.2 SELECTION OF INDICATORS

2.2.1 LAND USE

The first factor to be considered in an assessment of the impact of agriculture on the environment, and specifically in the amount of soil cover provided by agricultural activities, pertains to the amount of land in agriculture. All other things being equal, the less farmland there is, the less likely there is apt to be bare soil due to farming activities. In reality, any change in agricultural soil cover afforded by a change in farmland area may be more than offset by a shift to more or less bare soil within the farmland that is utilized, but the first 'indication' of agricultural soil cover relates to the amount of agricultural land in use.

Within the farmland sphere, different crops and land use types have different propensities for leaving soil exposed to erosive conditions and trends in the area of different crops over time must be interpreted individually with reference to soil cover. For example, a trend of increasing rowcrops such as potatoes or corn, or of summerfallow, generally indicates a movement toward higher risk of soil erosion, while a trend of increasing hay acreage indicates the opposite. That risk may be altered (either increased or decreased) by the specific management practices used, but for general purposes and under a consistent tillage routine, crop areas and trends can be informative with respect to the amount of soil cover. In order to present an overview of long-term trends in soil cover in Canada, by province and nationally, five variables in the realm of 'land use' were identified as being important. These are: 1) the area of farmland, 2) the proportion of farmland cultivated, 3) the proportion of farmland in hay and pasture, 4) the proportion of cropland in rowcrops and 5) the proportion of cropland in summerfallow. The rational for the use of each of these is presented below.

1) **The area of farmland.** A region or a time period in which there is a greater amount of farmland is likely to have a greater impact on agricultural soil cover than one with less farmland. That comparison must be tempered by a consideration for the type of agriculture that is carried on in the respective areas or time periods, since one farming system can have considerably different soil cover characteristics than another, but it is of paramount concern in a comparison of similar regions. In an evaluation, more farmland can be considered as an indication of less soil cover.

2) **The proportion of farmland cultivated.** A cropping system which includes recurrent soil cultivation represents, by virtue of the tillage activities involved, a lower level of cover over the course of a year than a perennial system of grass or trees. As a general rule, the potential for degradation by erosion can be considered to increase as the amount of bare soil (among individual plants and during non-growing seasons) increases. There is a considerable amount of variability in the amount of cover provided by different classes of cultivated land (i.e. rowcrops such as corn, vegetables, potatoes and tobacco provide less cover than grain and

oilseeds, which in turn provide less than hay), but in general a higher proportion of farmland under cultivation indicates a higher probability of bare soil. Thus this variable correlates negatively with soil cover and indicates the extent and/or the trend to which a particular region may be susceptible to soil degradation by erosion.

3) **The proportion of farmland in hay and pasture.** Soil erosion on sod (hay and pasture land) is generally restricted to localized areas of bare soil immediately after harvest or on cattle paths and at watering holes. In addition, maintenance of high yields and high quality in a hay crop generally relies on periodic plough-down and reseeding, and at that time there is considerable bare soil. However, the potential for soil degradation by erosion due to a lack of soil cover is considered to be low for lands in these uses, and the trend and extent to which a region may be susceptible to soil degradation will be revealed by the proportion of farmland in hay and pasture.

4) **The proportion of cropland in rowcrops.** Since 'row crops' such as potatoes, corn, tobacco and vegetables tend to have more space between rows than other crops such as grain and oilseeds, and may be subject to more intensive cultivation, the area in these crops can be considered as an indicator of soil cover. Trends in the area of potatoes and corn, crops with longterm records in the Census, can therefore serve to reveal changes over time and differences between regions in the amount of soil cover.

5) **The proportion of cropland in summerfallow.** The practice of summerfallowing, which is most common in the prairies, represents a lower level of soil cover than cropping, since the soil is usually without plant canopy for the entire growing season. In addition, the tradition of repeatedly cultivating summerfallow fields for weed control buries the previous year's crop residue, thus leaving the soil essentially bare for much of the year. Therefore, a trend in the proportion of cropland in summerfallow indicates a trend in the amount of soil cover and a trend in susceptibility to soil degradation through erosion.

2.2.2 TILLAGE PRACTICES

As noted earlier, the interpretation of land use trends with respect to soil cover is complicated by management practices employed by farmers. Tillage practices for residue maintenance are being developed and used to a growing extent and other approaches such as high plant densities and fast-growing crop varieties reduce the potential for soil degradation by erosion, especially in high-risk cropping systems. A reflection of the interest in soil conservation is contained in the 1991 Census data, which reports on the adoption of various agricultural conservation practices. In that edition of the national survey, farmers were asked to report on the area under conventional, conservation and no-till, the amount of summerfallow with weed control through tillage only, chemicals only and both tillage and chemicals and whether or not they used forage rotations, winter cover crops, strip-cropping, contour cultivation or grassed waterways.

A national review of the information contained in the 'conservation module' of the 1991

Census, cross-referenced with the size of farms, farm type, off-farm work, farm ownership and total sales levels has been published previously (Dumanski *et al.*, 1994). In the current study the information on tillage practices was used to identify the amount of cropland subject to conservation practices and thus enhanced soil cover. In this way, crop areal changes as well as changes in management practices can be incorporated into a 'composite soil cover index'. The information utilized, and the methodology of developing the soil cover indicator, is outlined below. This indicator is intended to reveal trends towards or away from sustainable farming practices by indicating changes to soil cover, a key factor influencing the risk of soil erosion. No interpretations concerning acceptable limits are provided.

The farm management practices considered in this report are those which are employed to provide a greater degree of soil cover over the course of a year. For example, the degree of soil cover on summerfallow land varies depending on the technique employed to control weed growth. Weed control with tillage only, by relying on repeated cultivations, can be considered to result in a low level of cover, while the use of tillage plus chemicals leaves intermediate levels and the use of chemicals only eliminates the need for cultivation and leaves the highest level of cover. For cropland, the degree of soil cover varies under different cultivation practices; 'conventional' tillage generally refers to the use of mouldboard plows and discs to bury crop residue and therefore represents low levels of soil cover, 'conservation' tillage refers to the use of implements designed to maintain residue on the surface and thus represents medium levels and 'no-till' represents the highest level of soil cover.

The variables of the 1991 Census referring to these management practices are as follows:

i) **Area of summerfallow maintained by tillage weed control.** Traditionally, the practice (primarily in the prairies) of fallowing the land for one year in order to build moisture reserves and control weeds required that routine tillage be carried out periodically throughout the growing season. However, the tillage tended to bury crop residue and thus exposed the surface (Neave *et. al.*, 1995) which increased the potential for soil degradation by erosion. In the past 10 - 15 years, however, there has been a growing recognition of this fact and new methods of summerfallowing. including reduced tillage, conservation tillage and chemical weed control have been increasing. Therefore, it is expected that as the proportion of fallow land maintained by tillage only declines, the potential for soil degradation by erosion also declines.

Ii) **Area of summerfallow land maintained by chemical-only weed control.** Chemical-only weed control is a management practice which represents a marked improvement towards maintaining soil cover. The improvement results from maintaining the soil aggregates and cover through the elimination of tillage. Therefore, an increase in the proportion of fallow land maintained by chemical-only weed control indicates an increase in the level of soil cover.

iii) **Area of summerfallow land maintained by a combination of chemical and tillage weed control.** Chemical and tillage weed control is a management practice which represents a moderate improvement towards sustaining soil cover by reducing the amount of tillage involved in weed control, through either reduced frequency or 'spot cultivation'.

Therefore, the proportion of fallow land maintained by a combination of chemical and tillage weed control represents a level of soil cover between that of tillage only and chemical only.

iv) **Area of cropland prepared for seeding using conventional tillage practices.** "Conventional" tillage practices involve the use of tillage implements which turn over the top 15 to 20 cm of soil, burying plant residues and exposing the soil. This is complemented with secondary tillage designed to break down soil aggregates and produce a smooth, even seedbed (Brady, 1990). The Census definition of conventional is "incorporates most of the crop residue (trash) into the soil. The proportion of land under conventional tillage thus provides an indication of the amount of bare soil, particularly over the winter.

v) **Area of land prepared for seeding using conservation tillage practices.** "Conservation" tillage is a management practice which makes use of implements which break up the soil and kill weeds but do not turn the soil over. It is designed to maintain crop residue on the surface and represents an improvement towards maintaining soil cover. The Census definition reads "retains most of the crop residue (trash) on the surface (include minimum tillage practices)". Although the degree of protection offered is crop dependent, the proportion of land under conservation tillage indicates a reduction in the amount of bare soil compared to conventional tillage.

vi) **Area of land prepared for seeding using no-till.** No-till is a management practice which maintains all plant residue on the surface. This practice represents the highest level of soil protection attainable through cover management. The Census definition defines it as "no tillage prior to seeding (include direct seeding into stubble or sod and ridge tillage). The level of soil protection varies between crops (i.e. some crops produce more residue than others), but for a specific crop no-till provides more cover than either conventional or conservation tillage.

2.2.3 COMPOSITE SOIL COVER INDICATOR: LAND USE + TILLAGE PRACTICE

As discussed above, the type of crop, the tillage practices and the weed control methods all affect the amount of soil cover provided by cropping activities within a region. Trends in soil cover can, therefore, be affected by changes in all of these factors simultaneously, indicating the need for a composite index. With such an index, crop area and farm management information was used to provide a regional estimate of changes in soil cover over the period 1901 - 1991.

The composite crop/tillage indicator developed for this assessment rates soil cover as high, medium or low based on the type of crop and tillage practice, or, in the case of summerfallow, the weed control method. Advice from regional crop and farm management experts was used to designate each combination of crop and management practice into one of those categories, based on information similar to that used in developing C-factors in the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). For example, for this study we consider grain corn grown under conventional tillage to provide low soil cover, under conservation tillage medium cover and under no-till high cover. These cover estimates are based on the prevalent

tillage practice for each crop in a Canadian context. For example, conventional tillage for corn assumes fall moldboard plowing, while conventional grain tillage assumes one fall pass with a field cultivator. The crops identified as being of primary importance in Canadian agriculture, and which have good long-term Census records (presented in Appendix 1) are outlined with their respective soil cover categories in Table 1.

Table 1. Categorization of crop/tillage practices into soil cover categories.

CROP	TILLAGE PRACTICE		
	Conventional	Conservation	No-till
Corn	low	medium	high
Potatoes	low	medium	medium
Wheat, Barley, Oats	medium	high	high
Hay	high	high	high
Fruit & Berries	medium	high	high
Tobacco	low	medium	medium
Canola	low	medium	medium
Soybeans	low	medium	high
	WEED CONTROL		
	Tillage	Tillage/Chemical	Chemical
Summerfallow	low	medium	high

In order to assess soil cover with the composite index as presented above, the area of each tillage practice as reported in the 1991 Census is calculated as a proportion of the total cropland area, and those proportions are used to calculate the area of each crop in each soil cover category. The area in each soil cover category is then summed to provide a single provincial and national figure for each year documented (Table 2). Since widespread use of conservation tillage has only occurred within the last 10-15 years, for 1981 and previous Censuses, all summerfallow land was considered to be `tillage only' and all cropped land was considered to be conventionally tilled.

Table 2. Example of calculations used to develop soil cover category totals, 1981 and 1991.

Crop	Area (ha)		Soil Cover Category Under:		
	1981	1991	Conventional	Conservation	No-till
Wheat	1000	1000	medium	high	high
Potatoes	1000	1000	low	medium	high
Proportion of land in 1981:			1.0	0.0	0.0
Proportion of land in 1991:			0.6	0.4	0.0

Area in 1981 Under:

Low Cover	(0.0 x 1000 ha wheat) + (1.0 x 1000 ha potatoes) **= 1000 ha**
Medium cover	(1.0 x 1000 ha wheat) + (0.0 x 1000 ha potatoes) = **1000 ha**
High cover	(0.0 x 1000 ha wheat) + (0.0 x 1000 ha potatoes) = **0 ha**

Area in 1991 Under:

Low Cover	(0.0 x 1000 ha wheat) + (0.6 x 1000 ha potatoes) = **600 ha**
Medium cover	(0.6 x 1000 ha wheat) + (0.4 x 1000 ha potatoes) = **1000 ha**
High cover	(0.4 x 1000 ha wheat) + (0.0 x 1000 ha potatoes) = **400 ha**

Since there is no quantifiable relationship between the 'high', 'medium' and low' soil cover categories, results are presented in the form of charts with three components rather than as a single soil cover estimation. The analysis presented in the 'land use' section, in which farmland area, cultivated land, hay and pasture, rowcrops and summerfallow proportions are tracked, helps to provide an explanation of the relationships amongst the following three components:

i) **The area of land with low cover.** Land under low cover represents the highest potential for soil degradation as a result of soil exposure. Therefore, the extent to which a particular region may be susceptible to soil degradation will decrease as the area of cultivated land under low cover decreases.

ii) **The area of land with medium cover.** Land under medium cover represents a moderate risk of soil degradation due to lack of soil cover. Therefore, the extent to which a particular region may be susceptible to soil degradation will increase if land shifts from high cover to medium, or decrease as land is shifted from low cover to medium.

iii) **The area of land with high cover.** Land under high cover represents the lowest risk of soil degradation due to cover. Therefore, the extent to which a particular region may be susceptible to soil degradation will decrease as the proportion of the total land base under high cover increases.

3. RESULTS

3.1 LAND USE

3.1.1 AMOUNT OF FARMLAND

The national data for farmland area as presented in Appendix 1 shows a dramatic increase in total farmland in Canada from approximately 25.6 million ha in 1901 to more than double that (56.9 m ha) by 1921 and then to 67.6 m ha by 1991. The area has varied very little since 1931, although it reached a peak in 1951 and has declined slightly since then. However, the distribution of farmland, and the trend over time, is quite different from province to province (Figure 1).

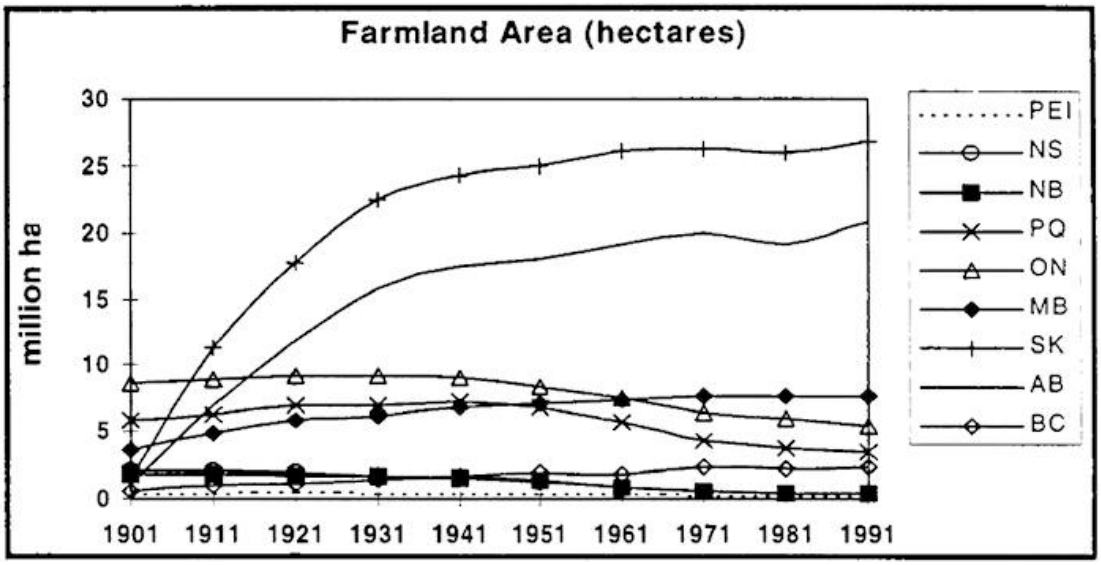

Figure 1. Total Farmland Area in Canada; 1901 - 1991.

Saskatchewan and Alberta have by far the greatest farmland area of all provinces, with 40% and 31% of the country's total in 1991. Manitoba, Ontario and Quebec follow, but with only 11%, 8% and 5%, respectively. All three prairie provinces show a rapid increase in farm area between 1901 and 1931, and a gradual increase since then, while Ontario and Quebec show a gradual increase to a peak in 1941, followed by a steady decline to 1991. Prince Edward Island, Nova Scotia and New Brunswick peaked around 1921 and have declined slowly since then, while British Columbia has undergone a steady increase in farmland area throughout the 90 year period.

In terms of the potential for bare soil within the agricultural area, all provinces east of and including Ontario show an improvement (i.e. a decline in farm area) in the period 1901 - 1991, while the four western provinces show an increasing area with potential for soil degradation due to agricultural activities. However, the area of farmland per se is not a good indication of the actual trend in soil cover, as evidenced by the following parameters.

3.1.2 PROPORTION OF FARMLAND CULTIVATED

The proportion of total farmland that is cultivated (all annual crops plus orchards, berries, specialty crops, hay and summerfallow) gives an indication of the degree to which agricultural soils are at risk of being exposed to erosion by weather. The national summary data indicate that the proportion of total farmland cultivated has increased steadily from approximately 32% in 1901 to 61% in 1991 (Figure 2). During this time, the absolute area of land in crops increased by 41 percent (Appendix 1). The provincial summaries indicate considerable variability, with Manitoba and Saskatchewan having the highest proportion of farmland cultivated throughout the 90 years and Ontario, undergoing a rapid increase in the period 1961 1981, rising above the national average by 1991. Prince Edward Island, Quebec and Alberta have followed the general trend of a gradual increase, but are slightly below average, while New Brunswick, Nova Scotia, and British Columbia have the lowest proportion of cultivated land.

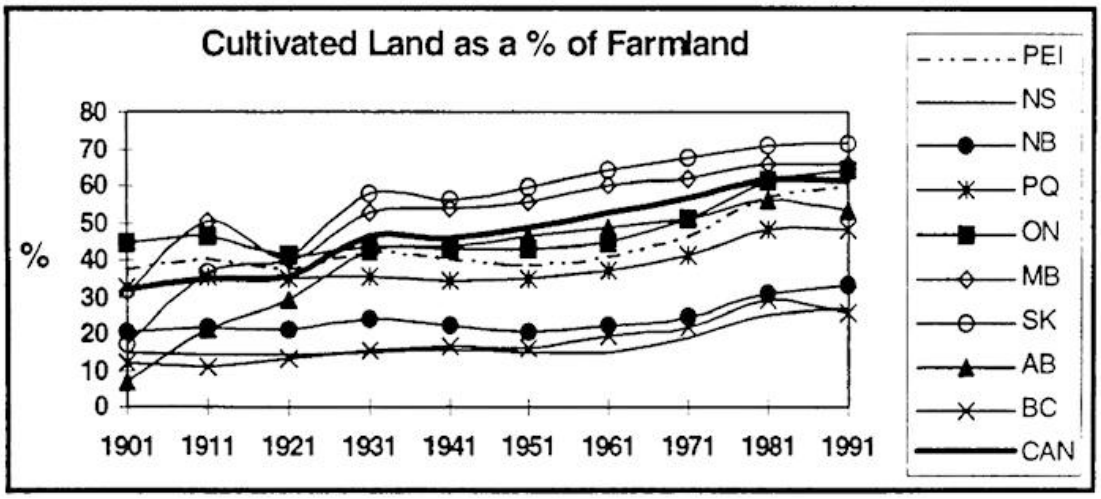

Figure 2. Proportion of Total Farmland in Cultivated Land; 1901 - 1991.

A national trend that corresponds to that of the prairie provinces shows a gradual increase in proportion of farmland cultivated over the first 20 years of this century, followed by a rapid increase between 1920 and 1930, then a period of stability for 10 years followed by a steady increase until the early 1980's, when the trend to increased cultivated land began to level off. Between 1981 and 1991 British Columbia and Alberta registered a decline in the proportion of farmland cultivated, Manitoba, Saskatchewan and Quebec remained virtually stable and Ontario, Prince Edward Island, New Brunswick and Nova Scotia showed marginal increases. Nonetheless, all provinces have shown considerable increases in cultivated proportion since the turn of the century, suggesting that, based on land use distributions within Canadian farms, there has been a considerable increase in the risk of soil degradation due to a lack of cover.

The increasing proportion of farmland that is cultivated has implications for environmental stress, but the degree of impact is dependant on the actual changes. For example, if 'other' farmland such as forest and pasture has been converted to cultivated land at the same time as there has been a shift from hay and cereals to rowcrops, then the increase in stress will have been even greater than the 'cultivated' trend suggests. However, if the increase in cultivated land was accompanied by a shift from rowcrops, which provide a low amount of soil cover to crops with greater cover, such as cereals and hay, the impact could be generally positive. As it is, based on only cultivated land data, it appears that the risk of soil degradation by erosion increased between 1901 and 1991. More information may be obtained through analysis of different crop and land use types.

3.1.3 PROPORTION OF FARMLAND IN HAY AND PASTURE.

The proportion of farmland that is devoted to hay and pasture provides an indication of the extent to which agricultural soils are protected from erosion. Land in hay and pasture can be considered to have low susceptibility to bare soil, and therefore as the proportion of farmland in these uses changes the potential for soil degradation will change inversely. At the national level, the proportion of farmland in hay and pasture has increased from approximately 10% in 1901 to 15% in 1991 (Figure 3). This indicates that a relatively small proportion of Canada's farmland falls into the category at low risk of bare soil, but that proportion has increased relative to more intensively cropped land over the 90 year period. However, there is a great deal of variation between provinces.

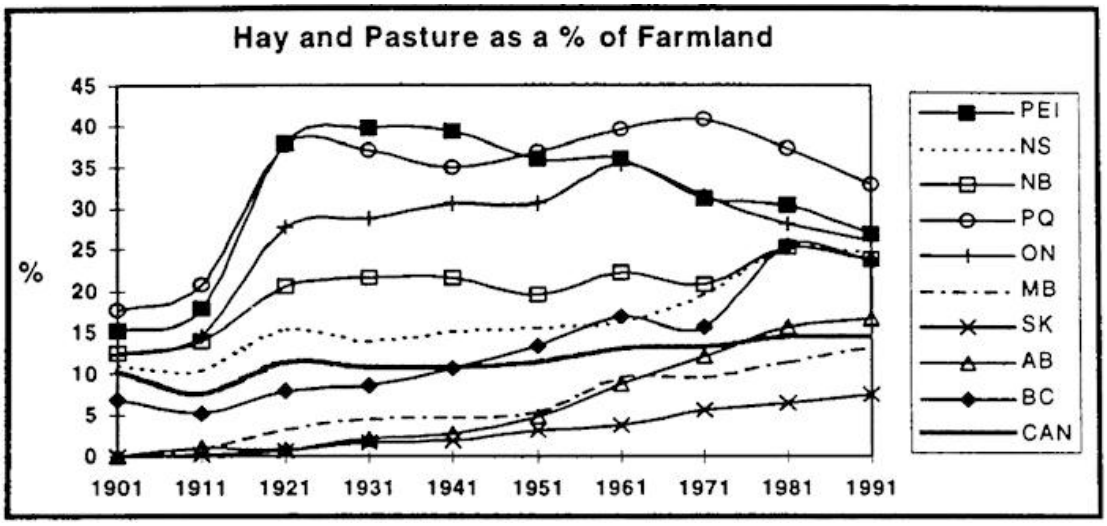

Figure 3. Proportion of Total Farmland in Hay and Pasture; 1901 - 1991.

The provincial trend lines indicate that the national result is largely due to the prairie provinces, which have a large share of the Canadian farmland area and low proportions of land in sod (consistently less than the national average). Prince Edward Island, Quebec and Ontario have the highest proportions, while New Brunswick, Nova Scotia and British Columbia have moderate proportions and slightly above the national average. Of particular note with reference to bare soil trends is the decline in hay and pasture proportions in provinces with the highest levels. Prince Edward Island has shown declines since 1931, Ontario since 1961, Quebec since 1971 and Nova Scotia, New Brunswick and British Columbia since 1981. This indicates that in the most intensive regions of the country, the proportion of farmland under low risk of being bare is declining. However, a positive trend is apparent in the prairies, where the proportion of farmland in sod crops continues to rise.

3.1.4 PROPORTION OF CROPLAND IN ROWCROPS

The planting, tillage and harvesting practices used in growing rowcrops such as corn, potatoes and tobacco tend to leave the soil with less surface protection than those used with perennial hay and close-row crops such as grain. The amount of cropland devoted to these crops is, therefore, an indication of the risk of soil degradation due to land use within the agricultural sphere. The statistic "proportion of cropland in rowcrops", tracked over the time period 1901 - 1991 (Figure 4) shows a relatively stable value of around 3-4% for Canada as a whole, with a low value of 1.3% from 1931 to 1961 and a peak of 4.2% in 1981. The implications are that the low soil cover level associated with rowcrops does not present a large or growing

environmental hazard for Canada. However, the very low proportion of rowcrops in the prairie provinces (generally <1%), coupled with their high amount of cropland, gives a national result that masks much higher, and potentially significant, rates in the eastern provinces.

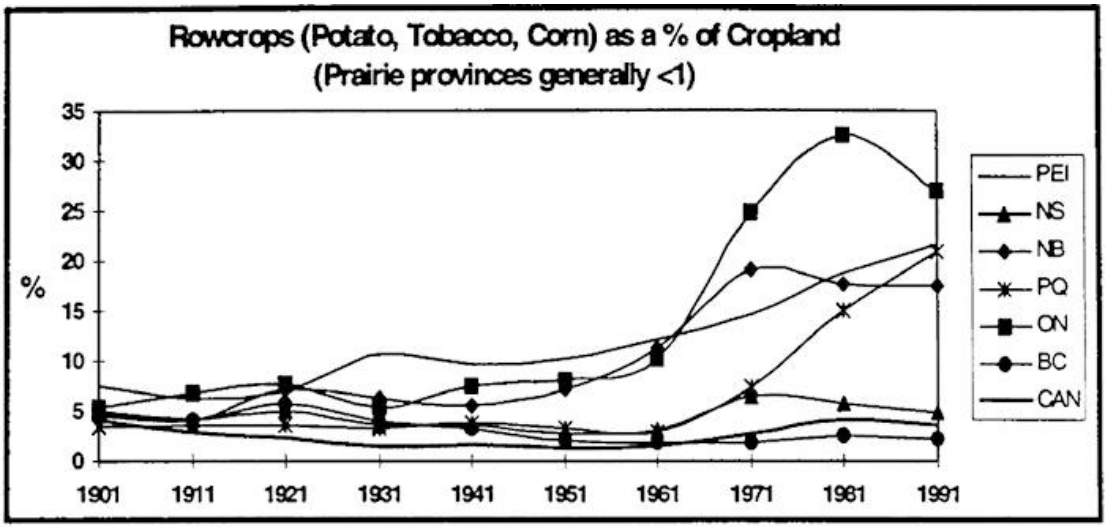

Figure 4. Proportion of Cropland in Rowcrops; 1901 - 1991.

Figure 4 reveals a dramatic increase in the proportion of cropland devoted to rowcrops, starting in the early 1960's, for Ontario, Quebec, New Brunswick and Prince Edward Island. In Ontario, massive increases in corn area and declines in tobacco and potatoes result in a trend that reached a peak of 33% in 1981 and then declined to 27% by 1991. The recent decline is due to a reduction in tobacco and a shift from corn to soybeans. New Brunswick, with potatoes dominating the rowcrop area, peaked at 19% in 1971, declined to 17.5% by 1981 and has remained essentially constant since then. In Quebec, corn area increased 13 -fold between 1961 and 1991, while potato area declined and tobacco remained essentially constant to give a rowcrop area that increased from 3% in 1961 to 21% in 1991. PEI shows a steady increase in potatoes, corn and tobacco, for a combined increase in rowcrops from 7% of cropland in 1901 to 22% in 1991. The upward trend in both PQ and PEI appears to be continuing. In Nova Scotia, a decrease in potato area and total cropland since 1901 and a significant increase in corn since 1971 results in a fairly stable trend of about 5-6% rowcrops, while BC shows a general decline from 5% in 1901 to 2% in 1991.

The impact of rowcrop cultivation (*per se*) on soil cover levels appears to be of concern in Eastern Canada, especially in ON, NB, PEI and PQ. As an agri-environmental indicator, the proportion of cropland under rowcrops highlights a worsening situation in these regions and reveals the need for conservation practices to reduce the risk of soil degradation. Even with the adoption of conservation tillage on these crops, one must assume that the soil is under more stress than under a perennial or grain crop system.

3.1.5 PROPORTION OF CROPLAND IN SUMMERFALLOW.

The amount of summerfallow in the Canadian prairies is of considerable interest in bare soil assessments, not only because of the large area in agriculture in the prairie provinces, but also because that practice has traditionally involved recurrent cultivation throughout the growing season, leaving the soil surface essentially uncovered for several months. All three provinces follow a trend of summerfallow proportion that is embodied in the summary curve, with peaks in 1941 and 1961 and a general decline since 1961 (Figure 5). The 1991 value is lower than at any point since 1931, even though there has been a 15% increase in the absolute area in summerfallow (Appendix 1). This discrepancy reflects the overall increase in total cropland in the prairies over that period.

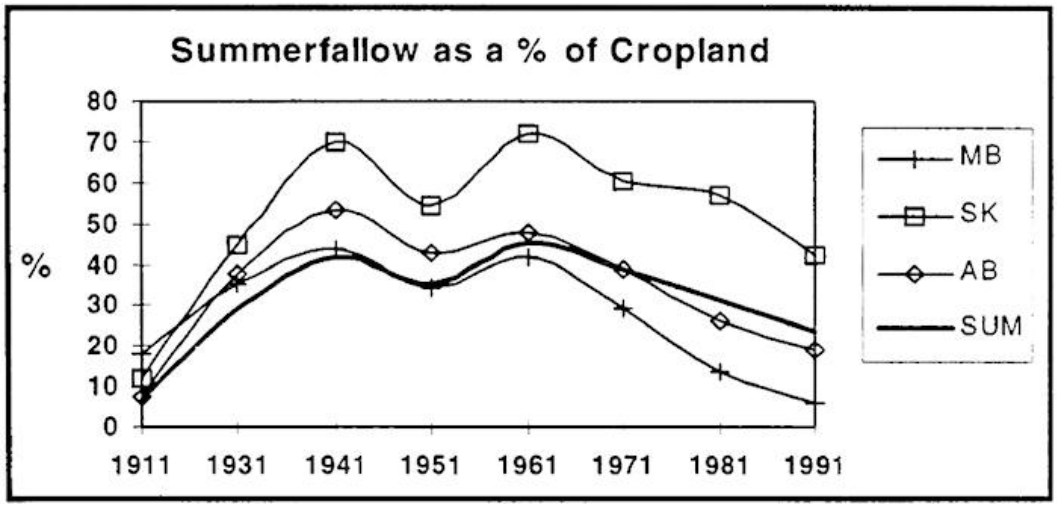

Figure 5. Proportion of Cropland in Summerfallow: 1911 - 1991 (Data not available for 1901 & 1921).

The summary suppresses some regional variability, even though provincial trends mirror the national pattern. Saskatchewan has consistently had the highest proportion of cropland in summerfallow, reaching peaks of 70% and 72% in 1941 and 1961 respectively. Manitoba has had the lowest proportion of cropland in summerfallow throughout the study period and by 1991 reported only 6%. The rate of decline in summerfallow levels in Alberta and Manitoba has been steady and greater than in Saskatchewan, which showed a maintenance of levels between 1971 and 1981. By 1991 the proportion of cropland in summerfallow had declined

to the lowest level ever for Manitoba, while in Saskatchewan the 1991 value was roughly the same as in 1931.

The decline in the proportion of cropland in summerfallow in recent years, in all three provinces, can be considered as an indication of improvement in terms of soil cover, providing changes in management practices have not increased the extent or duration of bare soil on summerfallow.

3.2 TILLAGE PRACTICES

Throughout the discussion of trends in agricultural land use and their implications for soil cover levels presented above there is an underlying assumption that the amount of residue provided by a crop, and the management of that residue by farmers, has been consistent over time. We know that this is not the case. Crop yields (and thus straw production) varies from year to year, while at the same time many farmers have recently adopted conservation tillage in order to retain residue on the surface. For the purposes of long-term and provincial level reporting we can ignore the year to year fluctuations in the amount of straw produced, but the adoption of conservation tillage is a relatively recent and permanent characteristic that should be incorporated into the analysis.

As noted earlier, the 1991 Census data contains information pertaining to the use of on-farm conservation practices. Specifically, data available are: the area of summerfallow weed control by tillage only, tillage plus chemicals and chemicals only; the area of seedbed preparation using conventional tillage (incorporates most of the crop residue), conservation tillage (retains most of the crop residue on the surface) and no tillage; and the number of farms using winter cover crops to control soil erosion. Since the adoption of these practices has occurred primarily since 1981, we can assume that production reported by the Census for all years up to and including 1981 was under 'conventional' practices. Thus the incorporation of high, medium and low soil cover depending on tillage practice will indicate the effect of conservation practices on long-term soil cover. Since there are no common 'conservation' or 'no-till' practices associated with potato and tobacco production, we have used the percentage of farms using winter cover crops as a surrogate for conservation and no-till for these crops. Table 3 provides the proportions of area and farms using conservation practices as determined from the 1991 Census.

Table 3. Proportion of area and farms using various conservation practices, by province, 1991.

PRACTICE	PEI	NS	NB	PQ	ON	MB	SK	AB	BC	CAN
SF: Tillage only*	n/a	n/a	n/a	n/a	n/a	73	57	58	66	58
SF: Tillage + Chemicals*	n/a	n/a	n/a	n/a	n/a	24	39	37	31	38
SF: Chemicals only*	n/a	n/a	n/a	n/a	n/a	3	4	5	3	4
Conventional Tillage*	91	88	85	85	78	66	64	73	83	69
Conservation Tillage*	8	8	13	12	18	29	26	24	12	24
No Tillage*	1	4	2	3	4	5	10	3	5	7
Winter Cover Crops**	9	12	10	4	20	7	6	7	11	10

* = % of area ** = % of farms

3.3 COMPOSITE SOIL COVER

The combined effect of changes in crop areas and tillage practices can be cumulative or counteractive. For example, the adoption of conservation tillage on corn (which increases cover) may be accompanied by an areal shift from corn to soybeans that is sufficient to result in an overall decrease in cover. At the opposite extreme, a reduction in the area of summerfallow may be accompanied by the adoption of chemical weed control to give a dramatic improvement in overall soil cover. Although this study has not quantified the amount of soil cover more precisely than 'low, medium and high', regional trends in each of these parameters, taking into consideration both crop areal changes and the adoption of conservation practices, are shown in Figures 6, 7 and 8.

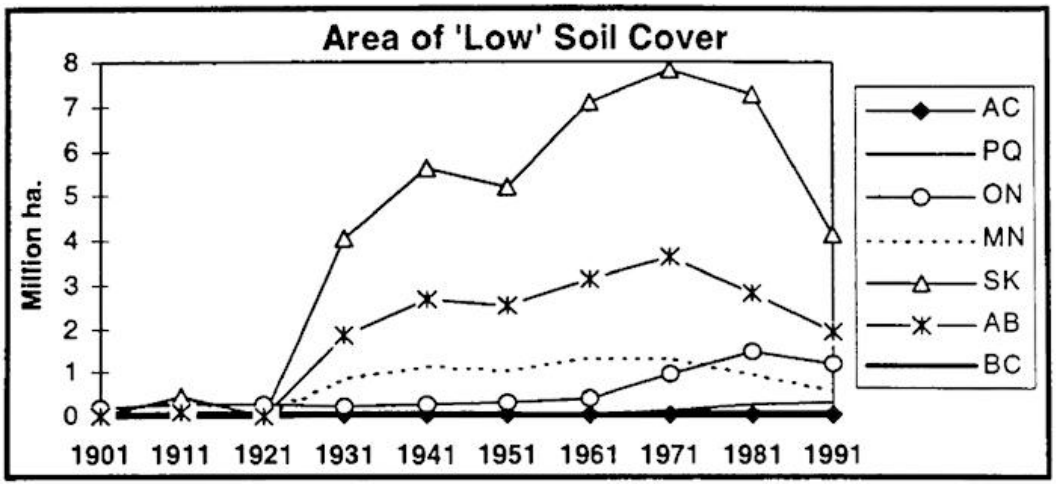

Figure 6. Area of Cropland under 'Low' Cover, 1901 - 1991.

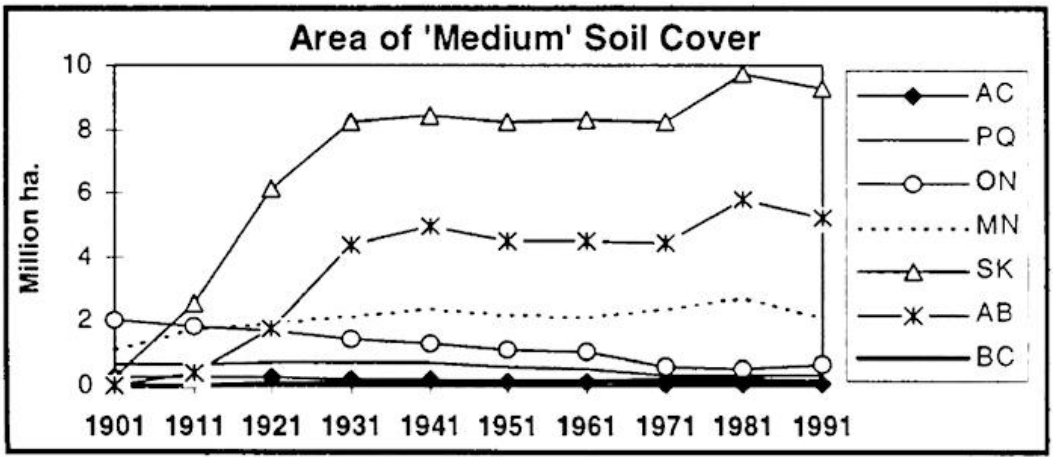

Figure 7. Area of Cropland under 'Medium' Cover, 1901 - 1991.

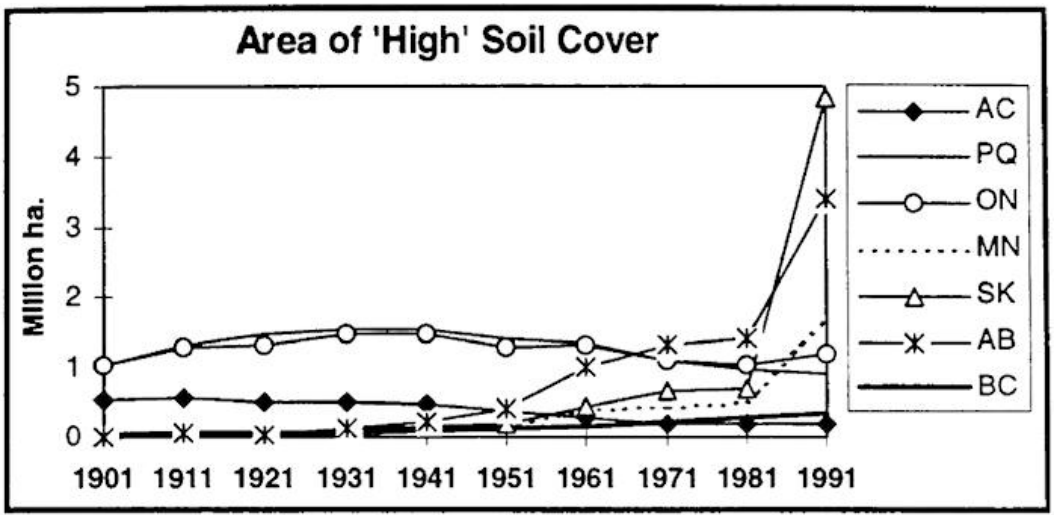

Figure 8. Area of Cropland under 'High' Cover, 1901 - 1991.

Compilation of these regional trends at a national level (Figure 9) shows: 1) a fairly sharp increase in the amount of farmland under low cover between 1921 and 1971, followed by a decline to 1991, 2) an increase in medium cover between 1901 and 1941 and a fairly level trend since then, and 3) a very minor increase in high cover between 1901 and 1981, followed by a dramatic increase between 1981 and 1991.

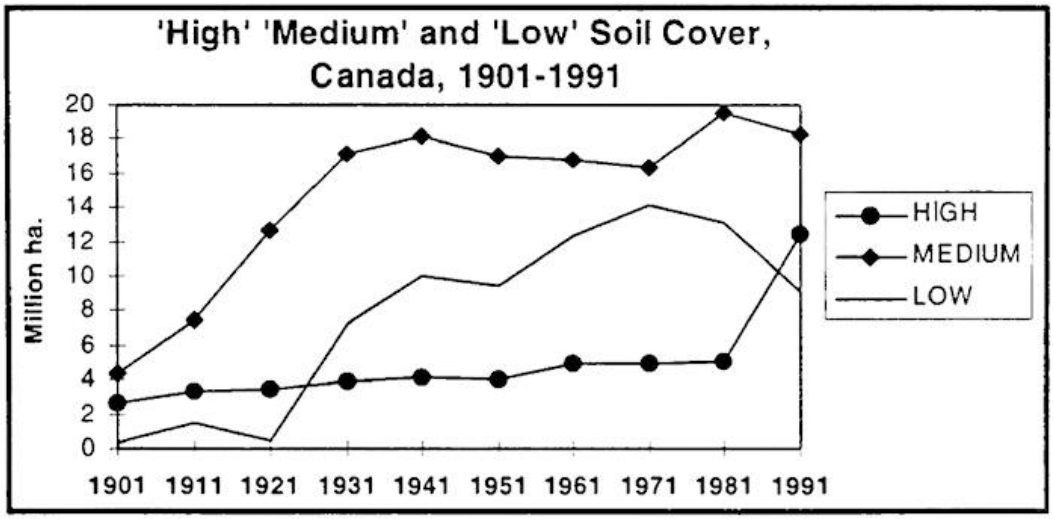

Figure 9. Area of High, Medium and Low Soil Cover in Canada, 1901 - 1991.

4. DISCUSSION

4.1 NATIONAL PERSPECTIVE

In Canada, most land use trends indicate a negative situation in terms of soil cover between 1901 and 1991. The area of farmland increased, the proportion of that farmland that is cultivated increased, the proportion of cultivated land under annual crop production increased and the proportion of cropland devoted to rowcrops increased. On the other hand, two trends; a decline in summerfallow levels and an increase in the amount of cultivated land under conservation and no-tillage systems, have positive implications for soil cover levels. These two indications of a move to improve soil cover levels are particularly important in that they occur in the latter part of the time period, between 1961 and 1991, and especially between 1981 and 1991.

Although it is fairly clear that the expansion of crop production in Canada in this century has exposed a great deal of soil to environmental degradation processes, it is difficult to make a definitive judgement of whether that trend is continuing or not. Farmland expansion has levelled off and summerfallow levels have declined, while conservation tillage is expanding greatly, but the proportion of farmland cultivated and the proportion in rowcrops is still on the rise. The analysis is hindered by the use of the 'qualitative' measures high, medium and low, but for the first time since the mid 1920's there is more high cover than low cover in Canada. With a fairly stable medium cover component it seems that the decade of the 1980's was very positive in terms of soil cover. As a result, it is apparent that the risk of soil degradation by erosion has declined between 1981 and 1991 and the improvement is clearly the result of the adoption of management practices rather than a shift towards crops which provide a naturally higher level of soil cover.

4.2 REGIONAL PERSPECTIVE

The national perspective hides a considerable amount of regional variability. For example, in all three provinces in Atlantic Canada (excluding Newfoundland), the amount of farmland declined between 1901 and 1991, and even though cultivated land as a proportion of farmland increased, the actual amount decreased. In addition, in PEI and NB, potatoes have replaced other crops to a considerable extent, thereby increasing the risk of bare soil on the cultivated area. To compound matters, the production of potatoes does not lend itself easily to increased residue levels through management, and the adoption of conservation practices to improve soil cover is less dramatic than in other parts of the country. In NS the proportion of farmland in hay and pasture has increased and the proportion of cultivated land in rowcrops has increased only slightly.

In summary, even though the area of farmland and cultivated land in Atlantic Canada has declined significantly over the period 1901 - 1991, other land use changes have occurred such that the absolute area of both high and medium cover has declined and the amount of low cover has doubled in PEI, increased slightly in NB and declined in NS. The implications are that increased soil cover under potato production is a priority to improve overall soil cover levels in Atlantic Canada.

Quebec and Ontario have both undergone a decline in farmland area at the same time as the proportion cultivated has increased slightly. The high-cover land uses of hay and pasture increased as a proportion of farmland from 1901 to about 1971, but declined thereafter, while rowcrops (mainly corn) increased dramatically between 1971 and 1991. As a counteraction for the bare soil traditionally associated with rowcrops, there has been a moderate level of adoption of conservation and no-till, with Ontario showing greater gains in that aspect. The net result of both positive and negative changes has been a decline in high and medium cover conditions and an increase in low cover. Increased adoption of conservation practices, especially for rowcrop production, would benefit soil cover in central Canada.

In the prairie provinces the total area of farmland has increased dramatically, especially in Saskatchewan and Alberta. In addition, the proportion of farmland that is cultivated has increased, leading to a complementary increase in the area of land at risk of low soil cover. Rowcrops are not a significant issue in the prairies, but the practice of summerfallowing has traditionally left the soil bare for significant portions of the year. Summerfallow proportion increased in all three provinces between 1901 and 1961, but has been declining since then. Overall, through most of this century, the prairies have been in a situation of increasing low and medium soil cover and decreasing high cover, but widespread adoption of conservation tillage and reduction in summerfallow since the early 1980's has reversed those trends. However, the continuing large area of medium levels of soil cover leave room for improvement that will probably be gained through residue management and cover crops.

In British Columbia farmland area increased steadily between 1901 and 1991, the proportion of farmland cultivated increased, hay and pasture proportions increased, summerfallow area (in the Peace River area) increased and rowcrop proportions increased. The 1991 Census shows moderate levels of adoption of conservation and no-till land management in BC. In summary, the history of expanded farming in BC in this century has lead to increased levels of high, medium and low soil cover. All factors together have, however, favoured an increase in high levels of soil cover. From the data available to this study, it appears that increased adoption of conservation practices would further enhance this trend.

The results from the regional summaries show a wide degree of variability, in that the values of soil cover differ from province to province, as does the relative importance of changing management practices and changing crop distributions. In 1981 four provinces (Alberta, Saskatchewan, Manitoba and Ontario) showed a larger area of cultivated land classified as

low cover than as high cover, whereas by 1991 no provinces showed that situation (Ontario showed equal areas in both classes). For Canada as a whole the shift was from twice the area in low cover as in high cover in 1981 to 25% less by 1991. All provinces except PEI and PQ show a decline in the area of land in low cover between 1981 and 1991 and all except NS, NB and PQ show increases in the area under high cover.

5. CONCLUSIONS

Changes documented in Census of Agriculture data indicate that since 1901 there has been an overall decrease in the level of soil cover on farmland in Canada. The area of farmland and of land in crops has steadily increased, the proportion of farmland in hay has decreased and the proportion in summerfallow in 1991 is higher than in 1901. This decrease in soil cover indicates an increased risk of environmental degradation through soil erosion at both the national and provincial levels. However, adoption of conservation management practices, a reduction in summerfallow levels and some crop changes indicate that during the more recent decades there has been a shift to increased soil cover.

Our analysis indicates that the agricultural industry in the prairie provinces, Ontario and Prince Edward Island had the poorest performances, but by 1991 the quality of soil cover had improved in these five provinces, especially in the prairies. The significance of this result is highlighted by the large share of Canadian agricultural land represented by these five provinces (89.5 percent). The remaining provinces each registered a large proportion of cultivated land under high cover in both 1981 and 1991.

Reference to the management and crop change data indicates that the improvements in soil cover have been attained primarily through the adoption of conservation management practices such as chem-fallow, reduced summerfallow and conservation tillage. However, in most cases these improvements have been significantly negated by shifts to crops which provide less cover, such as potatoes, corn, soybeans and canola. These results indicate that it is critical to identify, at least at the provincial level, parts of the country that should be monitored, and where increased efforts to address soil degradation through conservation and crop choices should be made.

6. FURTHER WORK

Work on a soil cover / land management indicator is ongoing, with the emphasis on improved crop specificity and spatial stratification. The data and analysis presented above show that there is a variety of forces and reactions at work and we could do well to explore these issues in more detail.

Currently, we are developing "bare soil days" (BSD) indices for each crop and region in order to quantify and provide more precision for the high-medium-low cover designation. Under the BSD concept, an index is developed which shows the cumulative number of days that would likely be bare soil under each crop and 'typical' management scheme. These values will be multiplied by the appropriate crop areas at sub-provincial 'Ecodistrict' levels in order to define regional trends and characteristics. This will allow much more precise identification of soil cover changes and will enable us to pinpoint contributing factors.

7. REFERENCES

Coote, D.R., J. Dumanski and J.F. Ramsay. 1981. An assessment of the degradation of agricultural lands in Canada. Agriculture Canada. Ottawa. 86 pp.

Dumanski, J., L.J. Gregorich, V. Kirkwood, M.A. Cann, J.L.B. Culley and D.R. Coote. 1994. The Status of Land Management Practices on Agricultural Land in Canada. Agriculture and Agri-Food Canada, Ottawa. CLBRR Technical Bulletin 1994-3E, 46 pp.

Energy, Mines and Resources Canada. 1987. Remote Sensing for Agriculture. User Assistance and Marketing Unit. Ottawa. 7pp.

Halstead, R.L. and J. Dumanski (eds.). 1977. Land evaluation and systematic data collection. Agriculture Canada. Ottawa.111 pp.

Hiley, J.C. and R.L. Wehrhahn. 1991. Evaluation of the sustainability of extensive annual cultivation within selected resource areas of Alberta. Agriculture Canada. Edmonton. LRRC Contribution No. 91-18. 88 pp.

Huffman, E. and J. Dumanski. 1985. Agricultural land use systems: An economic approach to rural land use inventory. J. Soil & Water Cons., 40:3 pp 302-306.

Jeck, S.C., D.E.Moon and C.J.Selby. 1990. The LANDS system user's manual - Vol I - Procedures (1st ed.). Agriculture Canada. Vancouver. 149 pp.

Ryerson, R.A., P. Mosher, V.R. Waller and N.E. Stewart. 1979. Three tests of agricultural remote sensing for crop inventory in Eastern Canada. Can. J. Rem. Sens., Vol.5, No.1:53-66.

University of Guelph. 1978. Methodology study and development of a data base for rural land evaluation in Ontario. Centre for Resources Development. Guelph. 60 pp.

Wilson, D.A. 1986. The role of remote sensing in the Canada Land Use Monitoring Program (CLUMP). Proc. of the 10th Can. Symp. on Rem. Sens. Edmonton. pp.947-956.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses. U.S. Department of Agriculture, Agricultural Handbook 537. 58pp.

APPENDIX 1.

Farmland and Crop Areas, by Province and National Census of Agriculture, 1901 - 1991.

Census of Agriculture, 1901 -1991 (Hectares)

N/D = No Data Available

Prince Edward Island

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	482,708	35	182,233	N/D	N/D	1,300	73,546	13,499	17,101	68,308	15	N/D	7	N/D
1911	485,878	34	197,458	N/D	360	1,807	86,904	12,370	11,614	75,199	89	N/D	0	N/D
1921	491,588	36	186,380	101,970	N/D	1,075	84,678	13,045	12,671	67,016	62	N/D	0	N/D
1931	481,372	37	200,887	97,872	3,525	948	93,654	21,679	7,781	60,635	131	N/D	0	N/D
1941	472,346	39	190,072	95,798	1,593	106	90,413	18,380	3,350	57,953	271	N/D	0	N/D
1951	442,619	44	172,234	79,987	730	247	79,298	17,370	1,465	39,709	267	0	0	2
1961	388,005	53	158,051	67,855	1,023	669	72,155	18,659	1,639	39,955	557	0	40	0
1971	313,032	69	141,996	46,178	3,712	344	51,891	18,893	2,671	33,317	1,143	0	1307	0
1981	282,618	90	158,053	36,176	3,023	457	50,010	25,813	3,284	34,900	2,668	41	1614	1
1991	258,504	110	153,882	19,250	996	842	50,295	31,443	4,770	41,107	1,355	2360	755	0

Nova Scotia

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	2,053,221	38	308,912	N/D	N/D	13,852	224,024	15,137	6,601	39,924	72	N/D	0	N/D
1911	2,125,780	40	306,339	N/D	192	16,595	218,455	12,457	4,929	41,083	253	N/D	0	N/D
1921	1,908,814	40	277,722	101,799	N/D	16,536	190,310	13,944	5,904	41,279	112	N/D	0	N/D
1931	1,738,475	44	252,046	68,012	3,729	19,348	172,862	8,918	1,137	34,659	258	N/D	0	N/D
1941	1,542,328	47	232,738	70,814	1,515	15,664	161,477	8,266	764	33,576	259	N/D	0	N/D
1951	1,282,507	55	192,944	62,680	1,020	9,048	138,083	4,822	383	24,405	278	0	0	0
1961	901,315	72	132,997	51,511	1,072	8,535	94,514	3,289	549	15,579	775	0	28	0
1971	537,006	89	98,181	43,397	2,535	7,653	61,650	1,409	1,964	10,701	4,606	48	507	0
1981	465,355	92	112,620	46,040	5,146	10,818	71,003	1,543	2,882	10,202	4,965	80	247	7
1991	396,462	100	106,079	30,679	1,184	14,961	67,381	1,772	1,531	9,622	3,210	184	127	39

New Brunswick

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	1,795,603	49	366,260	N/D	N/D	3,606	222,071	16,298	10,907	77,391	105	N/D	1	N/D
1911	1,833,831	49	402,659	N/D	263	3,826	254,710	16,339	5,425	82,340	122	N/D	0	N/D
1921	1,725,354	47	365,779	129,632	N/D	3,295	223,332	26,079	6,494	82,755	223	N/D	0	N/D
1931	1,677,684	49	391,311	118,276	6,584	3,837	243,211	24,418	2,796	85,808	238	N/D	1	N/D
1941	1,601,919	50	349,921	119,929	3,424	1,234	225,226	19,162	1,731	82,280	449	N/D	0	N/D
1951	1,402,341	53	287,581	98,550	2,799	1,770	174,313	20,704	981	68,216	284	6	0	0
1961	888,901	75	195,000	80,840	2,282	2,453	116,007	21,888	1,021	43,356	410	2	7	0
1971	541,151	99	130,247	46,446	3,473	2,154	66,315	24,012	2,495	23,762	1,504	7	140	0
1981	437,261	107	130,339	41,420	5,175	3,792	69,168	21,738	3,499	18,715	1,912	21	192	2
1991	375,093	115	122,072	25,013	1,549	4,897	64,457	20,456	2,210	21,580	1,148	18	67	6

N/D = No Data Available

Quebec

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	5,836,974	42	1,914,978	N/D	N/D	13,856	1,029,843	51,404	56,504	587,637	11,519	N/D	3478	N/D
1911	6,309,410	42	2,228,789	N/D	1,685	14,746	1,305,038	50,871	25,411	602,240	24,136	N/D	4873	N/D
1921	6,973,657	51	2,421,557	1,154,807	N/D	11,966	1,474,510	59,331	46,190	666,848	24,149	N/D	3999	N/D
1931	6,992,712	51	2,481,330	1,050,981	11,376	14,683	1,538,168	53,730	14,884	668,739	19,936	N/D	4920	N/D
1941	7,299,185	47	2,480,207	1,018,085	2,738	10,796	1,535,640	60,106	7,323	672,292	26,375	N/D	5537	N/D
1951	6,783,482	51	2,339,917	1,085,112	19,027	14,596	1,420,840	37,890	3,976	561,877	34,646	128	3737	1
1961	5,737,692	60	2,106,725	934,676	18,728	12,875	1,338,478	32,457	4,285	533,302	24,569	27	4351	0
1971	4,364,793	71	1,752,702	691,872	33,004	12,635	1,090,566	19,209	15,801	296,234	108,610	496	3959	345
1981	3,773,754	78	1,753,521	442,924	53,000	13,230	964,071	17,147	40,845	255,694	249,480	1428	3541	5
1991	3,424,695	90	1,636,105	270,535	14,691	21,591	860,419	17,490	37,407	253,372	325,048	25078	2091	745

Ontario

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	8,627,465	42	3,832,955	N/D	N/D	107,941	1,053,227	71,191	601,161	1,330,868	134,018	N/D	1263	N/D
1911	8,959,745	42	4,029,282	N/D	100,168	121,444	1,299,660	63,996	351,715	1,363,633	210,181	N/D	5458	N/D
1921	9,144,468	46	3,779,513	1,229,107	N/D	79,494	1,314,609	63,074	343,702	1,278,552	224,395	N/D	2676	N/D
1931	9,230,137	48	3,875,671	1,189,512	139,269	65,529	1,470,184	57,376	255,524	1,122,190	142,391	N/D	18420	N/D
1941	9,047,111	51	3,742,676	1,308,440	129,623	41,852	1,465,852	53,539	318,664	957,682	216,783	N/D	23103	N/D
1951	8,437,749	56	3,493,616	1,307,421	134,876	44,636	1,278,423	23,704	319,948	748,166	227,338	53744	37744	23
1961	7,507,681	62	3,228,949	1,331,774	98,942	39,577	1,326,045	20,796	234,939	756,404	268,633	85078	51651	146
1971	6,450,762	68	3,174,610	944,171	96,143	36,271	1,093,918	16,186	143,788	403,100	759,210	155496	35025	0
1981	6,030,583	73	3,627,521	656,068	63,218	32,067	1,040,620	15,807	212,981	301,914	1,137,557	276731	48363	857
1991	5,443,568	79	3,406,778	389,653	63,566		1,034,118	14,172	180,508	272,019	896,578	565889	26732	25842

Manitoba

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	3,573,647	111	1,114,022	N/D	N/D	263	0	10,592	794,149	288,342	25	N/D	4	N/D
1911	4,923,747	113	2,086,772	N/D	379,370	886	55,634	10,704	1,115,107	656,748	1,954	N/D	18	N/D
1921	5,906,346	111	2,367,141	168,645	N/D	43	23,151	10,847	1,013,139	977,465	2,733	N/D	1	N/D
1931	6,114,800	113	2,362,414	166,461	836,476	261	111,187	13,485	868,977	1,262,634	3,631	N/D	7	N/D
1941	6,826,041	118	2,557,168	184,065	1,118,296	294	138,839	13,095	1,438,677	961,443	29,326	N/D	3	N/D
1951	7,164,953	137	2,964,190	236,290	1,018,049	200	145,285	7,138	949,934	1,269,903	15,155	1	0	17
1961	7,342,581	170	3,107,059	290,883	1,305,300	247	405,630	7,402	1,177,481	981,428	14,273	322	0	11780
1971	7,681,346	219	3,686,444	295,199	1,072,980	164	438,084	13,205	1,018,096	1,393,776	7,609	535	0	233240
1981	7,605,013	258	4,414,035	352,002	597,481	208	508,182	16,534	1,590,589	1,180,535	109,030	2282	0	241160
1991	7,713,921	300	4,754,228	340,802	296,573	449	689,155	119,994	2,170,897	698,853	52,089	50	0	503912

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N/D = No Data Available

Saskatchewan

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	1,549,113	115	264,942	N/D	N/D	36	0	2,478	196,884	62,089	0	N/D	1	N/D
1911	11,355,050	119	3,692,599	N/D	440,069	413	15,232	9,717	1,708,649	815,477	311	N/D	1	N/D
1921	17,789,908	149	7,202,169	86,985	N/D	12	6,644	12,714	4,117,317	2,051,018	1,971	N/D	1	N/D
1931	22,497,963	165	8,942,436	287,873	4,017,359	168	81,700	16,028	5,945,879	2,274,720	2,440	N/D	2	N/D
1941	24,230,553	175	7,988,095	316,779	5,577,907	183	149,986	14,574	6,737,067	1,708,810	5,619	N/D	1	N/D
1951	24,918,449	222	9,579,558	582,322	5,194,938	129	200,329	6,314	6,348,351	1,909,169	1,219	4	0	93
1961	26,030,679	277	9,667,499	563,437	6,942,363	122	425,112	4,822	6,498,850	1,825,340	803	22	0	150271
1971	26,289,855	341	11,047,906	791,317	6,691,920	107	665,304	1,315	5,222,305	3,029,598	802	301	0	1099018
1981	25,909,905	385	11,724,040	973,966	6,694,857	40	705,555	1,009	7,827,517	1,936,058	4,237	69	4	542553
1991	26,826,992	441	13,439,629	1,074,114	5,704,644	235	928,821	1,803	8,583,871	1,676,504	1,642	0	0	1349009

Alberta

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	1,105,484	117	76,184	N/D	N/D	19	0	1,532	17,402	4,477	9	N/D	4	N/D
1911	7,015,006	116	1,365,362	N/D	101,353	172	65,631	8,117	362,788	49,610	537	N/D	1	N/D
1921	11,837,490	142	3,444,311	63,631	N/D	48	42,421	9,665	1,648,542	148,296	925	N/D	0	N/D
1931	15,751,013	162	4,865,154	211,988	1,837,544	111	116,411	12,111	3,209,817	1,156,322	1,262	N/D	1	N/D
1941	17,488,602	175	4,964,084	252,800	2,645,248	151	227,950	10,121	3,585,046	1,412,181	1,315	N/D	2	N/D
1951	17,966,391	213	5,830,288	449,699	2,503,425	94	414,566	8,220	2,736,411	1,803,984	794	0	0	11
1961	19,085,369	261	6,310,046	675,015	3,010,490	99	1,001,164	8,454	2,276,264	2,226,545	1,043	0	1	123149
1971	20,005,773	319	7,311,300	1,109,246	2,832,261	129	1,317,526	10,563	1,391,462	3,052,139	2,406	69	0	798243
1981	19,081,132	329	8,429,146	1,579,176	2,202,308	87	1,406,559	6,719	2,709,705	3,129,410	14,685	109	0	584420
1991	20,781,181	363	9,278,729	1,739,982	1,768,856	465	1,720,054	11,452	3,117,672	2,703,368	11,896	320	0	1197643

British Columbia

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	605,116	93	72,322	N/D	N/D	3,032	41,523	3,316	6,452	14,789	21	N/D	24	N/D
1911	1,026,668	61	110,554	N/D	2,164	14,250	53,612	4,394	3,836	14,177	151	N/D	19	N/D
1921	1,155,982	53	154,668	35,274	N/D	17,606	55,480	7,343	13,560	23,013	1,374	N/D	0	N/D
1931	1,431,157	55	204,257	46,604	16,876	17,925	75,147	6,799	24,141	31,774	1,697	N/D	73	N/D
1941	1,629,989	62	238,072	69,350	30,327	16,001	103,909	6,376	44,803	41,031	1,882	N/D	218	N/D
1951	1,900,216	72	271,740	138,687	28,416	18,976	114,952	4,440	42,798	39,069	1,406	0	29	0
1961	1,821,123	91	318,797	143,389	33,050	17,314	162,865	4,967	35,278	61,391	1,494	1	0	217
1971	2,353,201	128	441,523	160,779	69,836	17,257	207,269	3,670	44,174	115,273	5,452	0	0	7868
1981	2,175,474	109	567,427	266,501	63,437	17,072	289,812	3,505	42,876	121,165	11,793	2	0	25186
1991	2,388,913	124	555,998	240,659	57,394	18,428	325,687	3,364	44,177	72,732	9,689	2	0	40224

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Canada

Year	Farmland	Farm Size	Cropland	Pasture	Summer Fallow	Fruit & Berries	Hay	Potatoes	Wheat	Oats & Barley	Corn	Soy-Beans	Tobacco	Canola
1901	25,629,329	50	8,132,808	N/D	N/D	143,904	2,644,235	185,449	1,707,161	2,473,826	145,784	N/D	4782	N/D
1911	44,035,116	65	14,419,813	N/D	1,025,624	174,140	3,354,877	188,965	3,589,475	3,700,506	237,735	N/D	10372	N/D
1921	56,933,607	80	20,199,241	3,071,850	N/D	130,075	3,415,135	216,043	7,207,518	5,336,242	255,944	N/D	6678	N/D
1931	65,915,313	90	23,575,506	3,237,580	6,872,738	122,810	3,902,524	214,545	10,330,938	6,697,482	171,982	N/D	23425	N/D
1941	70,138,075	96	22,743,033	3,436,060	9,510,671	86,282	4,099,292	203,619	12,137,425	5,927,248	282,279	N/D	28864	N/D
1951	70,298,708	113	25,132,068	4,040,748	8,903,280	89,696	3,966,089	130,601	10,404,246	6,464,499	281,388	53883	41510	147
1961	69,703,346	145	25,225,123	4,139,379	11,413,251	81,892	4,941,968	122,734	10,230,306	6,483,300	312,556	85452	56079	285564
1971	68,536,920	188	27,784,909	4,128,604	10,805,864	76,715	4,992,523	108,464	7,842,755	8,357,901	891,343	156951	40938	2138714
1981	65,761,095	207	30,916,704	4,394,273	9,687,646	77,771	5,104,981	109,816	12,434,178	6,988,593	1,536,327	280763	53959	1394191
1991	67,609,329	242	33,453,500	4,130,686	7,909,453	91,157	5,740,388	121,946	14,143,043	5,749,157	1,302,655	593900	29771	3117419