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**ESTIMATING AGRICULTURAL SOIL EROSION LOSSES FROM CENSUS OF AGRICULTURE CROP COVERAGE DATA**

by

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## A B S T R A C T

This paper deals with the technical aspects of quantifying soil erosion on farms in Canada. Statistics Canada crop coverage information is overlaid with physiographic data from Agriculture Canada, in a large scale soil erosion model, using the ARC/INFO Geographic Information System. This combination of data sources and technology, make the implementation of long term soil erosion monitoring a realistic objective before the year 2000.

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CONTENTS

## 1. Introduction

Land degradation processes in Canada cost farmers more than 1 billion dollars annually.[1] The impacts on agriculture arising from reduced soil quality include, declines in crop quality, reductions in crop yield and increased expenses for the inputs required to maintain productivity. From an environmental perspective, land degradation impacts are not as clearly defined, and are felt on a much broader scale. The environmental impacts of land degradation can be summarized briefly: water quality declines, wildlife habitat destruction, wildlife poisoning, increased soil water run-off and air pollution resulting from wind erosion. It is difficult to isolate and estimate the cost of these environmental impacts, because they are widespread and vary substantially from place to place.

The long run implications of continued land degradation may prove to be even costlier to Canadians. If Canada had an abundant supply of cropland to be constantly rotated as it degraded from overuse then land degradation would cease to be a long term economic problem. However, of Canada's total land area of approximately 10,000,000 square kilometers, only 8 percent or 810,000 square kilometres is suitable for dependable agricultural production.[2] For the most part, all of Canada's suitable agricultural land is being utilized and no new significant reserves remain to be brought into production. Roughly half of this suitable agricultural land is being used for other purposes and will not be returned to agriculture in the forseeable future. It should also be noted that Canada's primary agriculture industry and the food processing sector collectively account for over 14 percent of annual gross domestic product. The loss of productivity from our agricultural land would have strong impacts both environmentally and economically. This makes the need for close monitoring of remaining productive land essential.

Current farming practices and the policy framework which supports them are contributing to land degradation in Canada.[3] Reducing this degradation is a task which requires immediate action. Federal agencies are already collecting a substantial amount of useful information which would contribute to the understanding and amelioration of the land degradation problem if it were applied in a consistent manner over a period of years. Efforts to improve the information base on land degradation have been made in past, however the opportunity now exists to intensify this work in light of technological developments and the persistence of the degradation problem.

This paper presents current initiatives towards the development of new improved information on the rates of soil erosion by water. Information presented here also details efforts between Statistics Canada and Agriculture Canada who cooperated on the Land Degradation Task Force in 1985/86.[4] This work provided the first real estimates of the costs of land degradation to Canadians.

Part of the modelling methodology used for the task force project will be presented in this paper in conjunction with some new, time saving technological enhancements that speed up earlier estimation procedures. This paper then goes on to present research results for a soil erosion pilot study conducted for the Maritime Provinces using these techniques.

It is hoped that the improved information and supporting tools coming from this research will allow decision makers to formulate policies that more effectively address land degradation problems, and that new insights might be gained into degradation problems.

## 2. Background

### 2.1 Erosion - A Natural Process ?

Erosion is one of the most common of geologic phenomena. It is a process that is constantly taking place. The entire surface of the earth is exposed to varying degrees of erosion, be it from wind or water. For the most part geologic erosion of this type could be viewed as normal because it has always operated in a steady and inexorable manner without direct human interference. For example, sedimentary rocks are formed from erosion products over a time period of a million years or more. Fluctuations in these erosional / depositional rates are functions of topography, climatic factors and parent material physiography.

Erosion which takes place more rapidly than geologic erosion could be referred to as accelerated erosion. With this type of erosion, external human factors accelerate the action of topography, climate and physiography. In modern agricultural areas soil erosion is often rapid and severe. Agricultural practices hasten the rate at which natural erosion occurs by exposing more soil surface to wind and water than would otherwise be the case. As a result, the amount of material running off the land is significantly higher than under strictly natural conditions where soil surfaces are protected by continuous vegetation such as natural grasslands or forests. Quantifying accelerated soil erosion and assessing its economic/environmental impact is a challenge that is only beginning to be met as we become more aware of the urgency of the situation.

## 2.2 Estimating Water Erosion Losses

In Soil Science there are several ways of estimating soil losses on land. The scale of the project largely determines the method used. At the smallest and most detailed scale soil scientists actually make measurements in the field using specialized equipment to determine the soil removal rates from given parcels of land. Studies for larger areas require models that allow the researcher to simulate events taking place in the field. The modelling methods lack the precision of actual field sampling methods but results are generally consistent with smaller scale sampling. Given the size of Canada, the only practical way to estimate broad soil erosion losses is through the application of a generalized model.

## 2.3 The Universal Soil Loss Equation

The development of soil loss models began as long ago as 1940 when soil erosion was recognized to be a problem in the American Corn Belt. From this early research, scientists at various universities have developed today's "Universal Soil Loss Equation" (**USLE**).[4] This Equation is made up of 4 basic physical parameters which, when assessed collectively, determine the erosion potential from water on any parcel of land. The equation and physical parameters are as follows:

$$A = R\ K\ LS\ CP$$

**A** is the computed soil loss per unit area per year measured in tonnes per year.

**R** is the rainfall and run-off factor converted to an index unit which includes a factor for run-off from snowmelt or irrigation. It is derived from rainfall intensity expressed as kinetic energy per acre per hour of rainfall.

**K** is the soil erodibility factor as determined by the particle size distribution and organic matter content of a specified soil. This value is based on experimental observations where fine textured soils have maximum values close to 1.0 and coarse textured soils have minimum values close to 0.0.

**LS** is the topographic factor as determined by slope length and steepness. A value of 1.0 represents a standard field of 9% slope and a length of 72.6 feet. Slope combinations above 1.0 represent greater erosion potential than the standard field while slopes below 1.0 represent lesser erosion potential.

**CP** is the crop cover and management factor as determined by the type of vegetation, and the cultivation method used. An index value of 1.0 represents the maximum erosion potential of a fallow field.( no protective cover at all )

Three of these four factors, rainfall, soil erodibility, slope length, and slope steepness **RKLS** are fixed and cannot be readily adjusted by typical agricultural practices in the short term. In other words, the farmers cannot readily adjust the amount of rainfall they receive, or the particle size distribution of their soil, or the steepness or length of the slopes on their fields.

However, the final factor - the Crop Cover and Management Factor **CP**, is in fact largely determined by the farmers as they decide what crops to plant and what culturing practices they employ. Because the Crop Cover Factor and Management Factor is determined by individuals, it is extremely subject to variations and is not as static as the other four parameters **RKLS** which are determined by nature alone. This does not mean that the physical parameters - **RKLS** are easier to assess than the**CP** factor. Information availability on these physical properties is sparse and often in a format requiring extensive manipulation before it can be used for quantitative analysis. (i.e. slopes have to be derived from maps and then converted into regional averages for calculation purposes)

The situation is somewhat different in the calculation of the CP factor. A wealth of information on crops from the Census of Agriculture and other sources exists; therefore, the decision is largely a question of how in depth should the analysis be, in order to effectively provide useful information on the problem? Should farm micro-data be used or would county level aggregates suffice for the type of analysis sought? Farm micro data allows farm by farm assessment of cropping practices and land use intensity. When reaggregated the derived information provides the most accurate and revealing USLE results possible from Census of Agriculture data. While regional aggregate data lack the resolution of the micro data, it is easier to analyze and will provide generalized results in a shorter time frame.

Agriculture Division at Statistics Canada has conducted the Census of Agriculture every fifth year since 1901. The output of this survey provides an accurate picture of farmland allocation across the entire country. If one were to apply the USLE to each census year an historical picture of agricultural soil erosion could be developed. In brief, each crop type from the census would be assigned a CP factor value, which when coupled with the other physiographic parameters in the USLE, would give us national soil erosion estimates.

## 3. Methodological Elements

This section describes how Census of Agriculture crop coverage data can be used to calculate one of the components in the Universal Soil Loss Equation.

### 3.1 Crop Cover and Management Factor CP

This factor in the Universal Soil Loss Equation is defined as the ratio of soil loss from land under specified cover and condition to the corresponding loss from a hypothetical clean tilled continuously fallow parcel of land. Census of Agriculture data are ideally suited to the calculation of the CP factor. Every farmer in Canada provides a complete picture of his/her individual land use pattern. This allows each farmers' particular cropping practices to be assessed which, in turn, yields details about the condition and cover of soils and vegetation on each land parcel. After individual cropping practices have been assessed, it is possible to assign CP factors to individual farm crops and then aggregate these values to a set of larger scale geographic units such as Census Divisions or Agricultural Watersheds.

### 3.2 Soil Loss Ratios

In order to estimate the ratio of soil lost under one cropping system as it relates to continuous fallow, it is necessary to observe soil loss rates under various crop conditions. The United States Department of Agriculture has compiled a detailed set of soil loss ratios from more than a quarter of a million soil plot samples.[5] Canadian soil loss ratios can be extrapolated from these by taking soils in Canada with similar characteristics and applying the corresponding soil loss ratios from the American historical data.

Soil loss ratiös range from a low of 0 (dense forest) to a high of .85 (wide-row crop). The soil loss ratio depends not only on current crop type but on many other factors as well - the previous crop, the type of tillage, the canopy cover, the plant rooting system, the type and density of crop residue, soil structure, organic matter levels, microbial activities and many others. Many of these are difficult to measure in soil test plots so information on their effects is limited. For example, measuring microbial activity is difficult in a laboratory setting and is next to impossible in the field. Therefore, the effects of microbial population changes are not well supported by field sample results.

## 3.3 Crop Growth Stages and Soil Erosion

Since the **CP** factor is determined by crop cover, crop growth stages for each Census crop have to be assessed to indicate the times of year the soil was exposed to the varying levels of rainfall erosivity. For example, seedbeds are very vulnerable to erosive forces because no cover crop has grown to protect the soil surfaces from the impact of raindrops, and no vegetation exists to slow run-off and allow infiltration of water. At this stage erosional conditions are at a maximum. Conversely, during full crop canopy in July, erosion forces are minimized because the thick canopy intercepts and slows raindrops to allow infiltration and reduce subsequent run-off. Because rainfall varies geographically, crop stages have to be approximated on a regional basis to allow for the conditions associated with each crop type and corresponding climatic conditions.

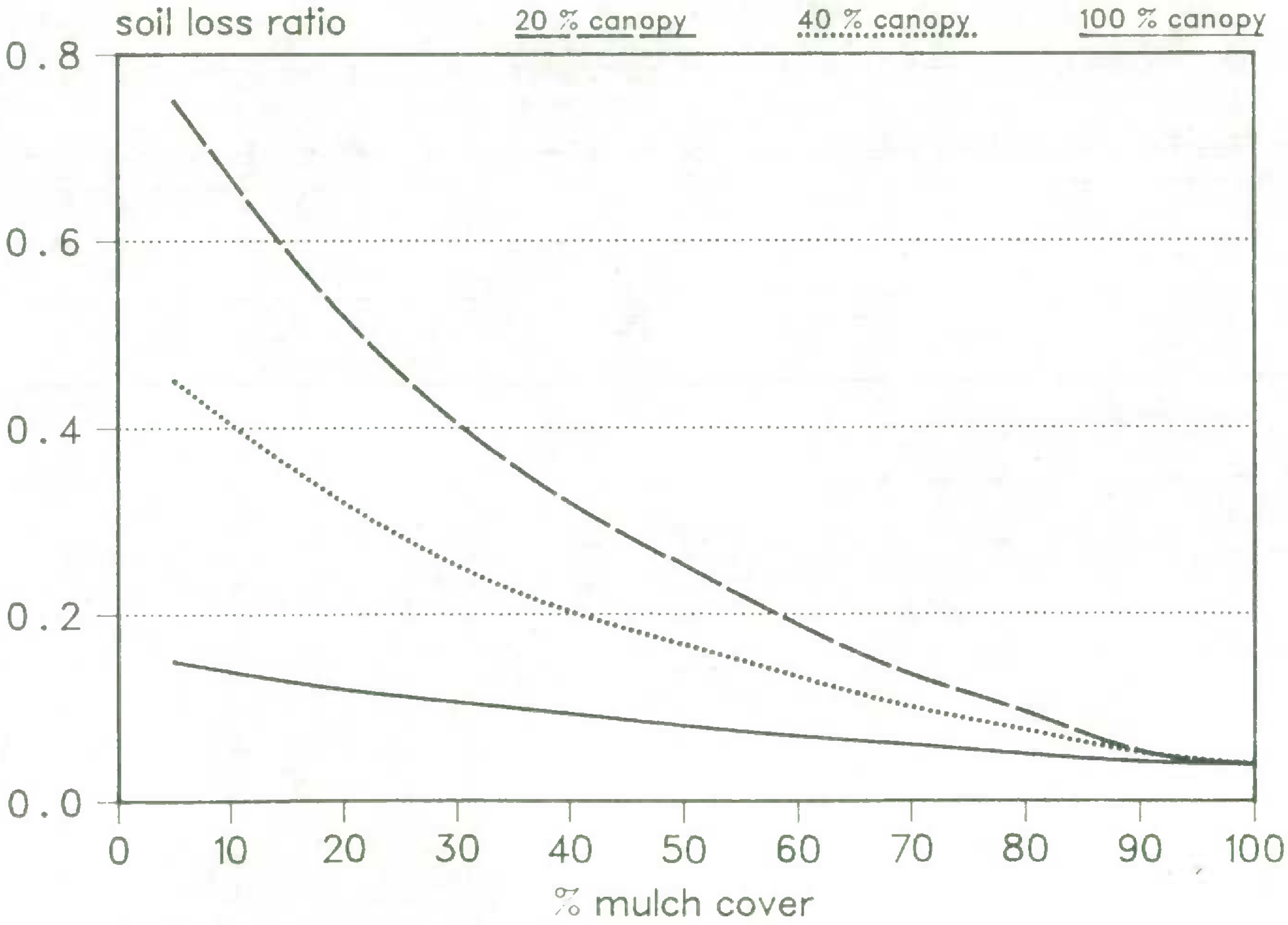
### 3.4 Residue Mulches and Soil Erosion

Residue mulches (crop remnants) are even more effective at preventing soil loss than high density crop canopies. This was proven in the USDA studies on relative soil loss rates.[6] Because mulches intercept raindrops much closer to the ground, the drops are unable to recapture their fall velocities the way raindrops falling from elevated crop canopies can.(see graph 1) The amount of residue mulch in a field depends on the cropping practices employed by the individual farmer. Residue levels can be determined by examining crop types, as well as by looking at cropping practices from Census micro-data.[7] For example, ensilage corn leaves very little organic residue because the whole plant is harvested for feed. On the other hand, grain corn harvesting leaves more organic residues in the form of leaves and stalks in the field because only the corn cobs or kernels are harvested. A further refinement can be introduced when Census micro data are used to differentiate between monocultural and rotational cropping practices.[8] Monoculturing is the continuous planting of one crop type year after year. Corn grown in monoculture leaves smaller amounts of organic residue than a corn crop grown in rotation with an organic matter building crop such as alfalfa. The intensity of cropping and the expected levels of crop residues can be estimated by analyzing crop area distributions reported on each Census of Agriculture Questionnaire.

### 3.5 **Tillage and Soil Erosion**

The effects of tillage on soil loss ratios are quite significant. The type of tillage and how frequently it is carried out, influences the porosity and structure of the soil. This in turn affects the run-off and water status of the soil. In general, the more frequently land is tilled, the greater the resulting structural degradation. Tillage rates are difficult to assess since no quantitative data exists to indicate the number of cultivations taking place or type of tillage patterns. It is possible to derive estimates of these by assessing the volume of machinery fuel consumed on farms from Census questionnaires, combined with a knowledge of typical cropping/tillage operations.

## GRAPH 1 – SOIL LOSS RATIOS AS AFFECTED BY CROP CANOPY AND MULCH COVERS




Source: Agriculture Canada, An Assessment of Agricultural Land Degradation In Canada 1986.

### 3.6 **Rainfall Intensities and Soil Erosion**

The rainfall factor **R** in the **USLE** does not completely account for local differences rainfall effects on soil erosion. It is important to know the distribution of erosive rainfall between the various crop stage periods so that soil loss ratios can be weighted by the actual amount of rainfall occurring within the crop stage period. If all other factors affecting the **CP** value were held constant the **CP** value would still vary geographically simply due to the natural climatic variation of rainfall intensity through-out the crop year. Rainfall intensity as it relates to soil erosion is measured in terms of erosion index units or (EI). This is defined as the storm energy (E) multiplied by the maximum 30 minute rainfall (I).[9] This index value provides a measure of the potential erosion energy. In general, the distribution of (EI) in Canada is seasonal and goes from a low during snow cover months to a high occurring in the summer when rainfall intensity is at a maximum because of intense cyclonic activity encountered in those months.

In summary, the **CP** value quantifies the erosion control effectiveness of any crop/management combination, by linking the erosive rainfall periods to crop growth stages. To best quantify consistent **CP** values, the most detailed and comprehensive set of crop cover and management statistics is essential.

## 3.7 Accuracy of USLE Predictions

Most of the development behind the **USLE** was done on medium textured soils, on slopes between 3 and 18 percent and of lengths of under 400 feet. These conditions describe the majority of farms, however,the more these limits are exceeded the greater will be the probability of significant error. The USDA has tested the accuracy of **USLE** by comparing actual field sampling testplot results to modelled **USLE** runs on the same plots.[10] (i.e. equation results are only as good as the data being extrapolated from) In general, model results are within 10% of actual observations if the above mentioned bounds are not exceeded.

# 4. Applications

## 4.1 Tabular CP factor Calculation

The United States Department of Agriculture USDA has designed a tabular method of assessing **CP** factors by crop type. It incorporates all of the previously mentioned contributing factors and can be calculated on a micro-computer with relative ease for various crop and soil conditions. Table 1 shows an example tabulation for a highly erosive tobacco crop in Southern Ontario.

**TABLE 1 Tobacco Annual CP factor Calculation**

| EVENT | DATE | % ANNUAL EI BY DATE | CROP STAGE | EI IN PERIOD | SOIL LOSS RATIO | CROPSTAGE CP VALUE |
|---|---|---|---|---|---|---|
| Plow | OCT 15 | 78.17 | F | 0.43 | 0.77 | .334 |
| Disk | MAY 5 | 21.50 | SB | 0.02 | 0.83 | .018 |
| Plant | MAY 20 | 23.61 | SB | 0.05 | 0.83 | .045 |
| 10% canopy | JUN 15 | 29.00 | 1 | 0.13 | 0.71 | .091 |
| 50% canopy | JUL 10 | 41.87 | 2 | 0.04 | 0.50 | .019 |
| 75% canopy | JUL 30 | 45.61 | 3 | 0.11 | 0.25 | .029 |
| Harvest | AUG 30 | 57.02 | 4 | 0.21 | 0.40 | .085 |
| Annual CP value | | | | | | 0.62 |

In the left column crop activities are listed showing the sequence of events in the field. Each one of these events has an impact on the erosivity index at the ground level and the subsequent soil loss ratios. The crop year ends on October 15 when the soil is plowed under. At this point of the crop year 78.17 percent of the calendar year EI has occurred and it can be assumed that by December 31, the remaining 22.83 percent of the EI will occur. During the fallow (F) crop stage 43% (.43) of the crop year erosivity index occurs while the field has a relatively vulnerable soil loss ratio of .77. The resultant CP value is simply the product of these two values which amounts to a crop stage CP value of .334.

During the seedbed crop stage (SB) between May 5th and June 15th, 7% (.02 + .05) of the annual erosivity index occurred. At this stage the soil loss ratio was at its highest with a value of .88. The soil properties which enhance small plant propagation are also the properties which maximize soil erosion. The optimum growing conditions for most young plants is a finely disked surface allowing easy root penetration. Disking reduces structural stability by breaking up soil clods and allowing water to detach and transport the finer soil granules that are lighter and lack the cohesion to remain fixed in the field. As a result, the seedbed crop stage is not a great deal different from the highly erodible conditions encountered with continuous clean tilled fallow. The high value of 88% (.88) reflects this.

As shown in Table 1, tobacco planting was estimated to begin on May 20. At this stage, the seedbed was quite vulnerable to erosive forces because no cover was present. By June 15, 10% of the field was covered by crop canopy. This offered some protection to the soil and reduced the soil loss ratio to .71 from the seedbed stage high of 75% and the soil loss ratio had further declined to a low of .25. Tobacco is planted in wide rows. This means that canopy coverage can never reach a value of 90% or higher that is attainable with a forage crop such as clover. On August 30, the tobacco was harvested and crop residues were left until plowing was performed on October 15. During this period soil loss ratios remained reasonably low because crop residues were present and the soil surface was undisturbed. After plowing, crop residues were buried and no longer provided protection, at the same time the soil structure was disturbed. This is reflected by an increase in the soil loss ratio to .40 for the period.

This type of CP value calculation can be done for any type of crop in any location providing we have the available Census data and the required agronomic expertise to define crop growth stages, EI periods and rotations. It is also possible to estimate historical soil erosion from Census micro-data as far back as 1966, the earliest year available digitally.

## 4.2 Task Force on Land Degradation Study Results

In 1985 after the release of the Senate Task Force Report - "Soil at Risk" it was recognized that no national Canadian efforts had been made to estimate the impacts of land degradation. This prompted the first Canadian efforts in conducting a large scale assessment of Agricultural Land Degradation. The task of estimating the impacts of land degradation was undertaken by Agriculture Canada. The four major objectives of the study were as follows:

1.) To estimate the area, extent and severity of water erosion, wind erosion, acidification and soil compaction in agricultural areas.

2.) To quantitatively estimate how crop yields and inputs are affected by varying levels of soil degradation.

3.) To estimate annual off-farm and on-farm economic impacts of soil degradation.

4.) To assess the confidence level of the study results and priorize actions to be taken in filling the research gaps.

Statistics Canada participated in this study by providing crop coverage data for the 1981 Census Year and contributing to the calculation of the CP factor. In brief, a sorting program was used to help determine generalized crop rotations for each agricultural region in Eastern Canada. This procedure used Agricultural Census information to look closely at regional crop distributions, which provided an assessment of common crop rotations. After determining the common crop rotations and acreages of crops under each croptype/rotation, an aggregate CP value for each crop in each region was calculated. This data was used in conjunction with meteorological observations and soil properties data to estimate CP values for the six agricultural regions of Eastern Canada. Agriculture Canada was responsible for providing all of the physical parameters for input into the USLE. These were later incorporated into the USLE calculations being carried out at Agriculture Canada. The table below depicts the final CP factor results for each crop region in Eastern Canada.

**TABLE 2 - CP Factors by Agricultural Crop Region 1981**

| | Region 1 | Region 2 | Region 3 | Region 4 | Region 5 | Region 6 |
|---|---|---|---|---|---|---|
| grain corn | .44 | .31 | .36 | .28 | .28 | .28 |
| silage corn | .57 | .46 | .48 | .43 | .38 | .39 |
| soybeans | .48 | .49 | .49 | .50 | .49 | .51 |
| spring grain | .35 | .21 | .29 | .26 | .26 | .28 |
| fall grain | .29 | .25 | .34 | .22 | .20 | .22 |
| tobacco | .64 | .62 | .65 | .65 | .65 | .66 |
| potatoes | .45 | .43 | .37 | .36 | .35 | .36 |
| vegetables | .70 | .68 | .71 | .71 | .70 | .72 |
| summerfallow | 1:00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| alfalfa | .02 | .02 | .02 | .02 | .02 | .02 |
| sugarbeets | .36 | .43 | .37 | .36 | .35 | .36 |
| rootcrops | .36 | .43 | .37 | .36 | .35 | .36 |
| nursery | .20 | .20 | .20 | .20 | .20 | .20 |
| tree fruit | .05 | .05 | .05 | .05 | .05 | .05 |
| grapes | .05 | .05 | .05 | .05 | .05 | .05 |
| small fruit | .10 | .10 | .10 | .10 | .10 | .10 |
| sod | .02 | .02 | .02 | .02 | .02 | .02 |
| grass hay | .00 | .00 | .00 | .00 | .00 | .02 |
| imp. pasture | .00 | .00 | .00 | .00 | .00 | .00 |
| other improved | .00 | .00 | .00 | .00 | .00 | .00 |
| woodland | .00 | .00 | .00 | .00 | .00 | .00 |

The results indicate that in region 1 **CP** values are somewhat higher than in adjacent crop regions. This fact can be attributed to two main reasons. First, monoculturing practices are prevalent in region 1 and this affects soil loss ratios through increased tillage and subsequent low residue mulches. Second, rainfall is more intense in this region which increases local **CP** values. The other cropping regions showed some variability between individual crop **CP** values but were generally similar to one another. In summary, results proved that more intense cropping practices are affecting the potential for soil erosion on farmland.

### 4.3 **Maritime Provinces - 1988 Pilot Erosion Study**

The Maritime Provinces were the site chosen to test the applicability Geographic Information System (GIS) technology for modelling soil erosion on farmland. The standardized **USLE** components were calculated from a variety of data which were then stored in the GIS, using drainage sub-basins as the standard geographic unit of analysis.[12] The individual Factor results are mapped in Figures 1 to 4.

**Figure 1**: Rainfall intensity is measured at weather stations throughout the Atlantic region. From these station values long term averages are developed by Environment Canada and, ultimately, contour maps which indicate probability of rainfall erosivity (R) are derived.[13] A snowmelt factor is also included to account for spring run-off. Each watershed was assigned an average rainfall erosivity value based on its location with respect to the contoured rainfall intensity values. In general, coastal areas appear to receive more precipitation and thus have higher erosivity potential. Once the data was aggregated to sub-basins, the boundaries of adjacent sub-basins having similar rainfall measurements were dissolved. (This dissolve was performed for all the Figures.)

**Figure 2**: Soil erodibility (K) values by sub-basin were developed from data [14] on particle size distribution and organic matter content where available - when not available, data from adjacent soil polygons were used. In general, the smaller the soil particle size and the lower the organic matter content, the higher the K value and consequent erodibility.

**Figure 3**: Slope length and steepness LS were derived from Canada Soil Survey maps.[15] In deriving this factor, the mid-point of the individual soil polygon slope distribution was chosen to represent each polygon. The weakness in this method is that the slope distribution in classes above and below the median is not represented. In response to this problem, work has been carried out on our behalf to apply GIS technology to slope estimation problems. technology for slope estimation.(Students at the Nova Scotia College of Geographical Sciences tackled this problem.) The methodology developed calculates slope by overlaying land use and topography (from digital topographic map sheets) to derive slope length and slope steepness on individual parcels of land.

**Figure 4**: The fourth factor, crop cover and management CP, was determined from the distribution of crops measured in the 1986 Census of Agriculture (this Census records the geographic location of each farm in Canada and the crops grown). The crop cover and management factor for any given crop is the expected soil loss for that crop expressed as a proportion of that which would occur on bare fallow - the longer soil is exposed to the elements the

greater the likelihood of erosion occurring, so that, for example, a wide-row crop would have a high **CP** value and a forage crop, which grows to form a continuous vegetative mat, would have a low value.

The final product of this analysis, **Figure 5**, maps the low, medium and high soil loss areas of Atlantic Canada. It was produced by combining the data for the component factors to arrive at the approximate soil loss per hectare from water erosion. The analysis shows areas of northern and southern New Brunswick, central Nova Scotia, and eastern Prince Edward Island to be at highest risk from soil erosion. These areas have the most erodible soils combined with a high proportion of wide row crops and slopes of considerable length and steepness. Ground truthing these results, by looking at areas where erosive potatoe crops are grown, seems to prove that the model's predictions are fairly accurate.

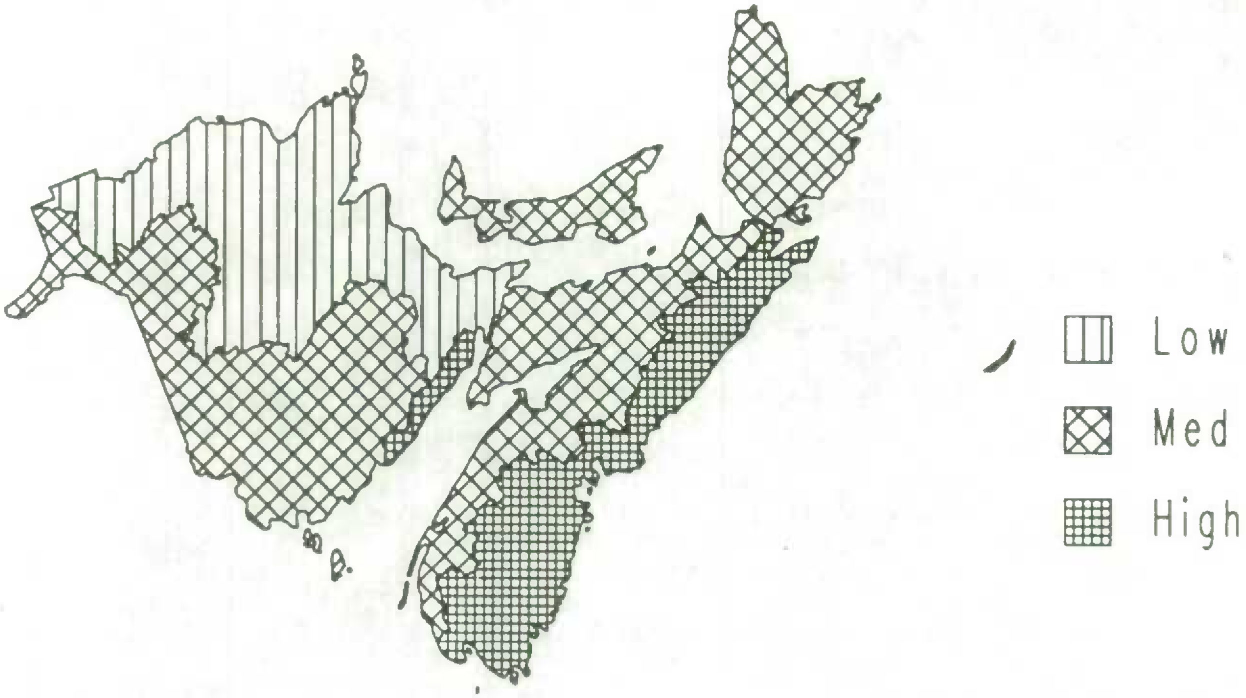
## 5. Conclusions

Attempts to quantify national water erosion losses proved a significant challenge to soil scientists and statisticians alike. Provincial data sources were disparate and data collected in one format in one province was not available in the same format in next province. The reconciliation exercise to make the various data sources consistent for statistical analysis proved to be a cumbersome task. It was clear that the existing tools for data analysis lacked the flexibility to analyze complex geographic distributions. New technology in the form of Geographic Information Systems (GIS) are now ready to provide a set of implements well suited to joining and manipulating data files from various administrative/physiographic sources. For example, one can use point sampling values from one area, then derive areal estimates from these (by rolling the data up to polygons and calculating averages) which can then be compared to existing polygon data from an adjacent administrative/physiographic region. The number of steps required to make data geographically comparable is greatly reduced by using a GIS to transform data to a consistent spatial frame.

Since 1986 Agriculture Canada and Statistics Canada have both adopted the ARC/INFO GIS software for use in their respective programs. This will facilitate future land degradation assessments.

Figure 1

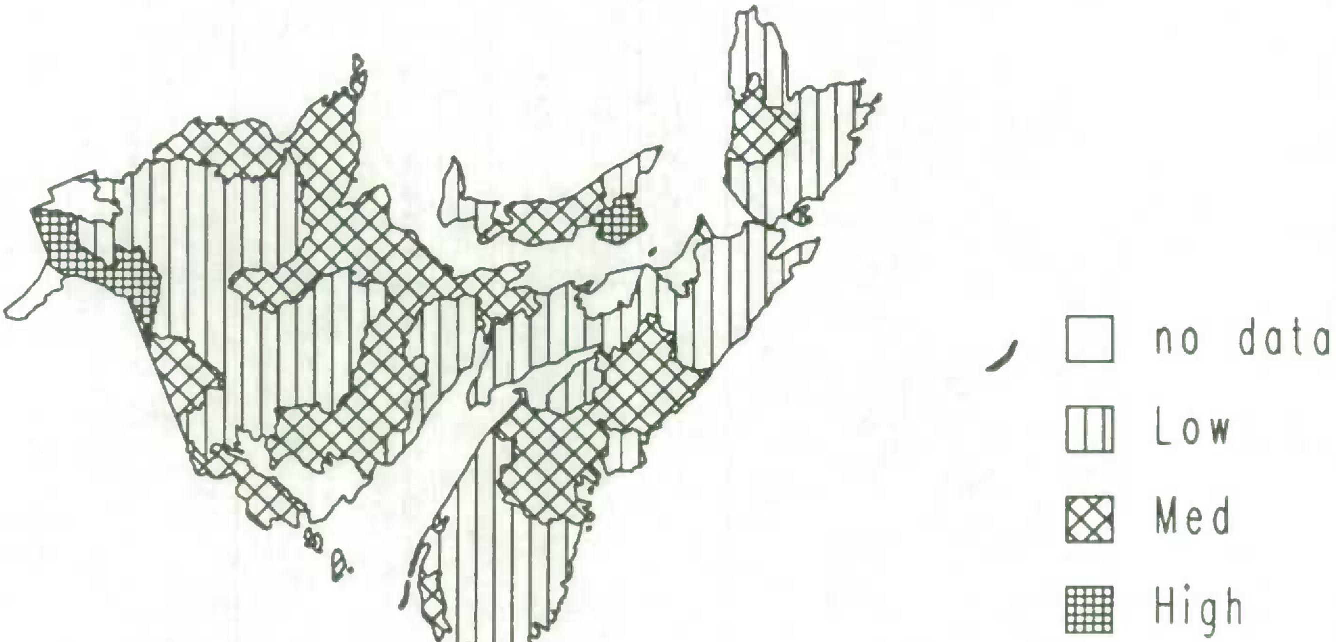
# SOIL LOSS IN ATLANTIC CANADA
## Rainfall and Runoff factor




Source: Agriculture Canada, Land Resource Research Center

Figure 2

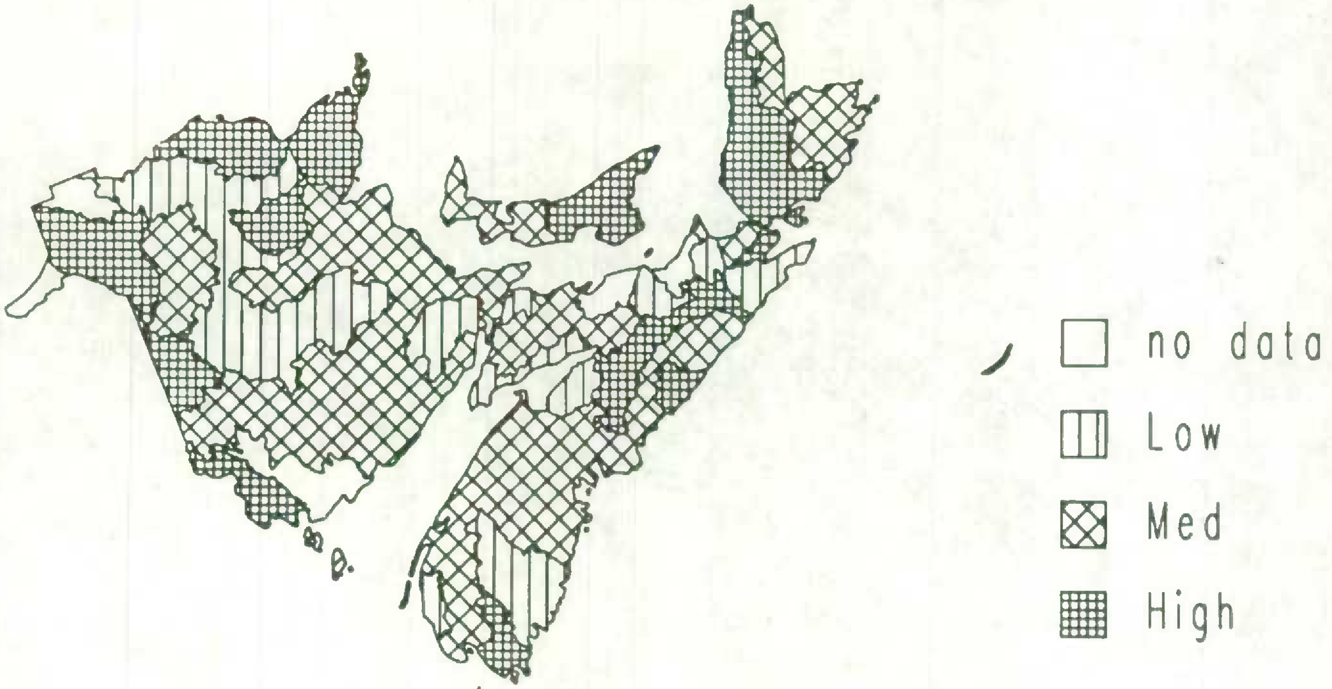
# SOIL LOSS IN ATLANTIC CANADA
## Soil Erodibility factor .




Source: Agriculture Canada, Land Resource Research Center

Figure 3

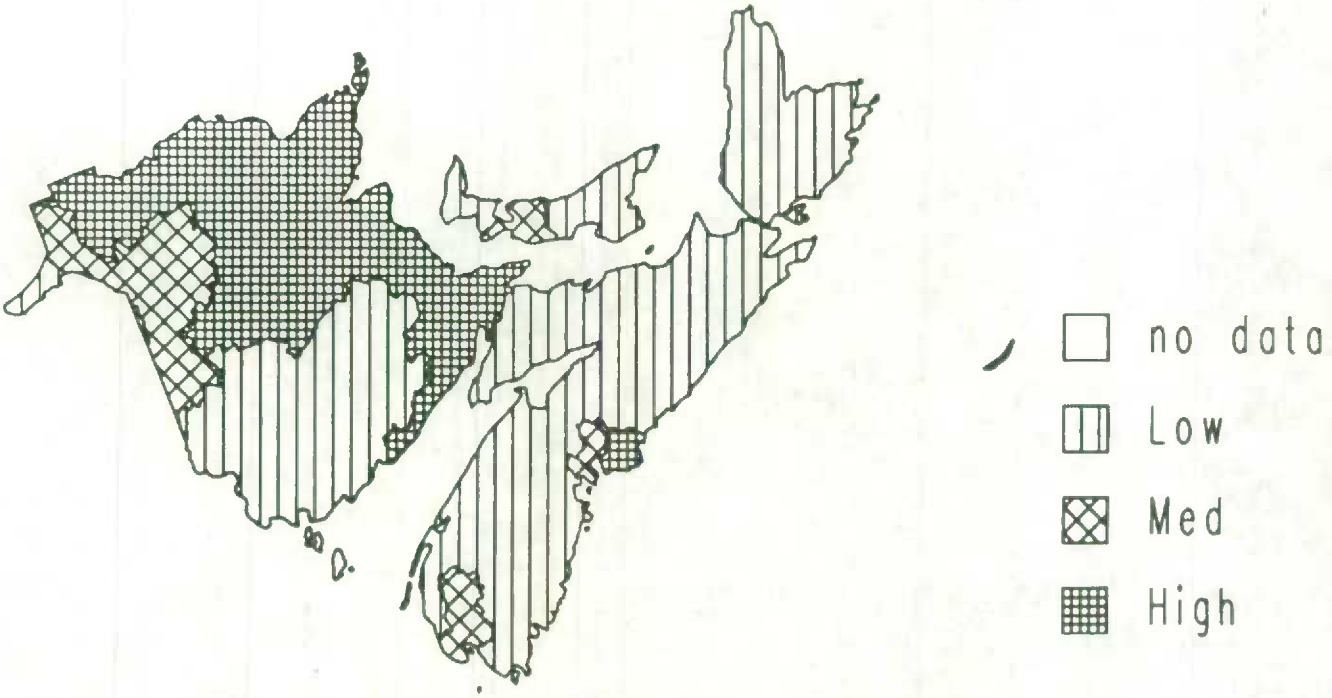
## SOIL LOSS IN ATLANTIC CANADA
### Crop cover and management factor




Source: Agriculture Canada, Land Resource Research Center
Statistics Canada, Census of Agriculture

Figure 4

## SOIL LOSS IN ATLANTIC CANADA
### Slope length and steepness factor

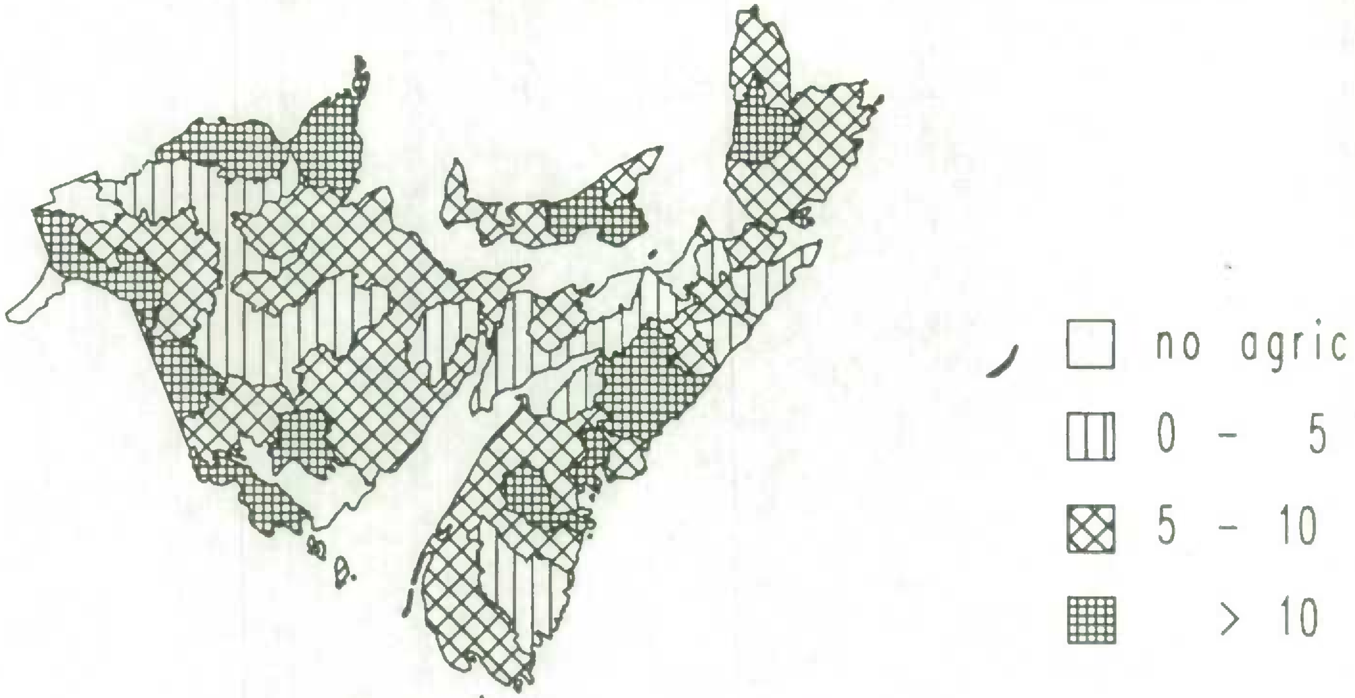



Source: Agriculture Canada, Land Resource Research Center

Figure 5

# SOIL LOSS IN ATLANTIC CANADA

Total soil loss, tonnes/ha of farmland, 1981




Source: Agriculture Canada, Land Resource Research Center
Statistics Canada, Census of Agriculture

## 6. References

1.) Bailey R.C. "Strategic Priorities For Agricultural Natural Resource Use" Agriculture Canada, Proceedings of the Canadian Agricultural Outlook Conference - December 1986.

2.) Standing Committee on Agriculture, Fisheries and Forestry, "Soil at Risk", A Report on Soil Conservation, Senate of Canada, H.O. Sparrow (CHMN), 1984.

3.) Bailey R.C. "Strategic Priorities For Agricultural Natural Resource Use"

4.) Wischmeier, W.H., and D.D. Smith, "Predicting rainfall-erosion losses. A guide to conservation planning.", USDA Agricultural Handbook # 537, 1978.

5.) Wischmeier, W.H., and D.D. Smith, "Predicting rainfall-erosion losses. A guide to conservation planning."

6.) Wischmeier, W.H., and D.D. Smith, "Predicting rainfall-erosion losses. A guide to conservation planning."

7.) Trant, D. "Cropping Practice Pilot Project: A Methodology to Enhance Agricultural Statistics For Environmental Assessment", unpublished Working Paper, Statistics Canada, September 1983.

8.) Trant, D. "Cropping Practice Pilot Project: A Methodology to Enhance Agricultural Statistics For Environmental Assessment"

9.) Wischmeier, W.H., and D.D. Smith, "Predicting rainfall-erosion losses. A guide to conservation Planning."

10.) Wischmeier, W.H., and D.D. Smith, "Predicting rainfall-erosion losses. A guide to conservation planning."

11.) Shields, K. et al. "Group Co-operative Project - Using Digital Map Sheets for USLE Slope Estimation" Un-published working paper, Nova Scotia College of Geographical Sciences, 1988.

12.) Hamilton, K. and D. Trant "The Application of Geographic Information Systems in Canadian Environment Statistics" Statistics Canada, Un-published Working paper, 1988.

13.) "Depth, Duration and Frequency of Point Rainfall" (Rainfall maps), Atmospheric Environment Service, Climatological Applications Branch, Environment Canada, 1984.

14.) "CANSIS" (Canadian Soil Information System), Research Branch, Land Resource Research Center, Agriculture Canada, 1984.

15.) "CANSIS" (Canadian Soil Information System), Research Branch, Land Resource Research Center, Agriculture Canada, 1984.

## 7. Bibliography

Agriculture Canada "A Preliminary Economic Assessment of Agricultural Land Degradation In Atlantic, Central Canada and British Columbia", 1986.

Bailey R.C. "Strategic Priorities For Agricultural Natural Resource Use" Agriculture Canada, Proceedings of the Canadian Agricultural Outlook Conference - December 1985.

Collins, T.G. and J.C. Hendley "Optimal Investment to Reduce The Rate of Decay of an Income Stream : The Case of Soil Conservation", Journal of Environmental Economics and Management, March 1983.

Coote, D.R., J. Dumanski and J. Ramsey, "An Assessment of Degradation of Agricultural Lands in Canada" Agriculture Canada, Research Branch, LRRI-118, 1981.

Hamilton, K. and D. Trant "The Application of Geographic Information Systems in Canadian Environment Statistics" Statistics Canada, Un-published Working paper, 1988.

Jackson, M.J., W.J. James and A. Stevens, "The design of environmental geographic information systems", Phil. Trans. R. Soc. Lon. A 324, 373-380, 1988.

Land Evaluation Group, "Land Evaluation under Alternative Erosion Control Policies", University of Guelph, report 4/81-83, 1983.

Ontario Ministry of Agriculture and Food, Cropland Soil Erosion - Estimated Cost to Agriculture in Ontario, 1982.

Rennie, D,A, "Implications of Present Situation and Outlook for Agricultural Natural resources in Canada". Agriculture Canada, Proceedings of the Canadian Agricultural Outlook Conference - December 1986.

Senate of Canada, "Soil At Risk", Standing Committee on Agriculture, Fisheries, and Forestry, Senate of Canada, 1984.

Statistics Canada, "Human Activity and the Environment", catalogue 11-509E, 1986.

Trant, D. "Cropping Practice Pilot Project: A Methodology to Enhance Agricultural Statistics For Environmental Assessment", unpublished Working Paper, Statistics Canada, September 1983.

Wischmeier, W.H., and D.D. Smith, "Predicting rainfall-erosion losses. A guide to conservation planning.", USDA Agricultural Handbook # 537, 1978.

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