SOIL EROSION

THE THREAT TO FOOD PRODUCTION

A Statement on the Soil Erosion Situation and Soil Conservation Needs

by the
ONTARIO INSTITUTE OF AGROLOGISTS

SOIL EROSION

The Threat To Food Production

1983

This publication is authorized by the Provincial Council of the Ontario Institute of Agrologists.

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The Ontario Institute of Agrologists acknowledges, with appreciation, the significant use of the source material as documented in this publication.

Appreciation is also extended to the following for their constructive reviews of this publication: — Charles Baldwin, P.Ag., Chairman, OIA Soil Conservation Committee; Gregory Wall, P.Ag., Ontario Institute of Pedology; Galen Driver, P.Ag., Ontario Ministry of Agriculture and Food; Lee Battiston, P.Ag., Department of Land Resource Science, Professor Bev Kay, P.Ag. Chairman, Department of Land Resource Science and Professor Peter Stonehouse, School of Agricultural Economics and Extension Education — all of the University of Guelph.

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Summary

Soil erosion is costing millions of dollars each year and jeopardizing agriculture's long-run food production capability.

Annual cropland soil erosion costs in Ontario are estimated at $74 million. The main losses occur in southern and western Ontario with localized damage in the central and eastern regions of the province.

Soil erosion occurs on all cropland, but row cropland is the most serious source of water and wind erosion. Yield reduction and soil nutrient losses are the major cost factors.

The major causes of soil erosion and associated soil degradation are the technological changes related to the massive expansion in intensive and continuous row crop production in recent decades. Shrinking profit margins among farmers have been a powerful motivating force in this direction.

Only limited recognition and support has been given to correcting the situation. Awareness, education, research, technical assistance and financial support are the elements of the program that is required to halt the devastating inroads of soil erosion and its threat to the food production base.

"History shows land deterioration has nation destroying potential."[1]

1) Dr. C. Fred Bentley, FAIC, P.Ag., Professor Emeritus of Soil Science, University of Alberta, 1981-82 Klinck Lecture.

The Situation

Soil degradation by wind and water erosion is a natural on-going process. While some forms of erosion, such as stream-bank and gully erosion are obvious and their environmental impacts are understood, other forms, such as sheet-rill and wind erosion are less obvious and far more insidious.

Soil erosion occurs on all cropland. However, row cropland[2] is the most serious source of water and wind erosion in Ontario. Erosion of soil by water is of greater concern and has more serious effects than wind erosion.[3]

Until recently, the ability of professionals to address the erosion problem has been hampered by the lack of information on the extent, effects and cost of soil erosion. Three studies were initiated in 1982 in response to this need for information. The results provide much of the information in this publication.

Annual cropland soil erosion costs in Ontario are estimated to be $68 million from yield reductions and nutrient pesticide losses.[4] An additional $6 million is estimated as the annual cost of maintaining surface and subsurface drainage systems.[4] This brings the total yearly cost to $74 million for the factors which have been quantified in this study. The costs would be much higher if other soil degradation factors such as soil structure deterioration and reduced water-holding capacity were included.

Detailed field trials[5] in Waterloo County in 1982 and 1983 indicate that grain corn production was not profitable on eroded soils. Careful extrapolation of plot losses to a field level indicated that even when erosion affected only a portion of the field, the average losses on a field basis ranged from $61 to $101 per ha in 1982. In 1983, dry conditions resulted in even greater productivity losses on eroded trial plots than was observed in 1982.

Wind erosion, although less extensive than water erosion, can be equally as damaging in some areas. In field trials conducted near Hillsburg, Ontario in 1979[5] as much as one cm of soil was removed by a single wind storm. Corn yields on severely wind eroded plots at this site were, on average, 44 per cent of their non-eroded counterparts.

Clearly, soil erosion by wind and water has a significant, negative influence on both soil productivity and profitability of crop production.

Effects of Soil Erosion on Productivity

Soil erosion affects productivity both directly and indirectly. Direct effects include washing out of seeds and nutrients, deposition of sediment on newly established seedings, gullying and other processes which affect crop production on an annual basis. A far more serious problem is the indirect or long-term effects of erosion on soil productivity. Erosion removes the organic matter rich surface horizon of a soil, leaving subsoil as the cultivation media. Subsoils, by nature, have lower water storage capacities, poorer infiltration, poorer structure, lower fertility and generally less desirable characteristics as a rooting medium than the original surface soil.

Research has shown that the magnitude and the specific causes of erosion-related yield reduction are quite variable.[5] Each of the characteristics varies from site to site. This variability has far-

2) Row cropland is identified as corn, beans, tobacco, tomatoes, potatoes, peas, small grains, sweet and seed corn, grapes and other garden vegetables when more than 200 hectares is grown in a county (per Cropland Soil Erosion study — see footnote 4).

3) From 'Soil Conservation Survey, 1982-83' by the Soil Conservation Committee of the Ontario Institute of Agrologists. For more detailed information, see Appendix 1.

4) 'Cropland Soil Erosion — Estimated Cost to Agriculture in Ontario', 1982 study by the Ontario Institute of Pedology and the Ontario Ministry of Agriculture and Food. For details of study methodology, see Appendix 2.

5) Battiston, L.A. and M.H. Miller, 1983. The nature and extent of corn yield reduction due to erosion. Unpublished reports. Department of Land Resource Science, University of Guelph.

reaching implications. No single remedial measure will be equally effective in restoring productivity to all eroded soils. Erosion control programs will have to be tailored to individual soils and management systems. For example, productivity can be restored simply by increasing fertilizer inputs on those eroded soils on which fertility is the only yield limitation. Unfortunately, this is rarely the case. Other factors such as lower available water holding capacity, lower infiltration rates and poorer structure than their non-eroded counterparts represent continuing long-term limitations to productivity that are difficult to correct.

Determination of the specific causes of yield reductions on eroded soils is further hampered by climatic variability. In 1982, the growing season was unusually wet. Consequently, plant-water relations in eroded soils were not as large a problem as in the 1983 growing season, when unusually dry growing conditions resulted in considerably greater yield losses. (The mean yield reduction at twelve sites in 1983 was 47 percent, with a range of 13 to 83 per cent[5]). In some eroded soils, reduced fertility was the major cause of yeild reduction in 1982. Moisture stress was the major cause in 1983.[5]

The significance of this response is that, while there is now research that indicates erosion is a very real problem in Ontario, not all the relationships between erosion and yield loss are fully understood. At this point in time, erosion research is in the early stages in Ontario. Considerably more work is required in order to develop a comprehensive understanding of the mechanisms which reduce yields on eroded soils.

Location and Categories of Soil Erosion Losses

A. ***By Geographic Area***[4]

More than 80% of the annual agricultural cost of soil erosion occurs in the southern and western regions of the province ($35 million and $22 million respectively). Annual losses are calculated at $8 million in the central region and $4 million in the eastern region.

The greatest costs on a county basis occurred in Elgin, Kent, Huron, Middlesex, and Oxford counties. These were closely followed by Brant, Haldimand-Norfolk, Lambton, Perth, Simcoe, Waterloo, Wellington and York counties. Costs on a per county basis appear in Appendix 3.

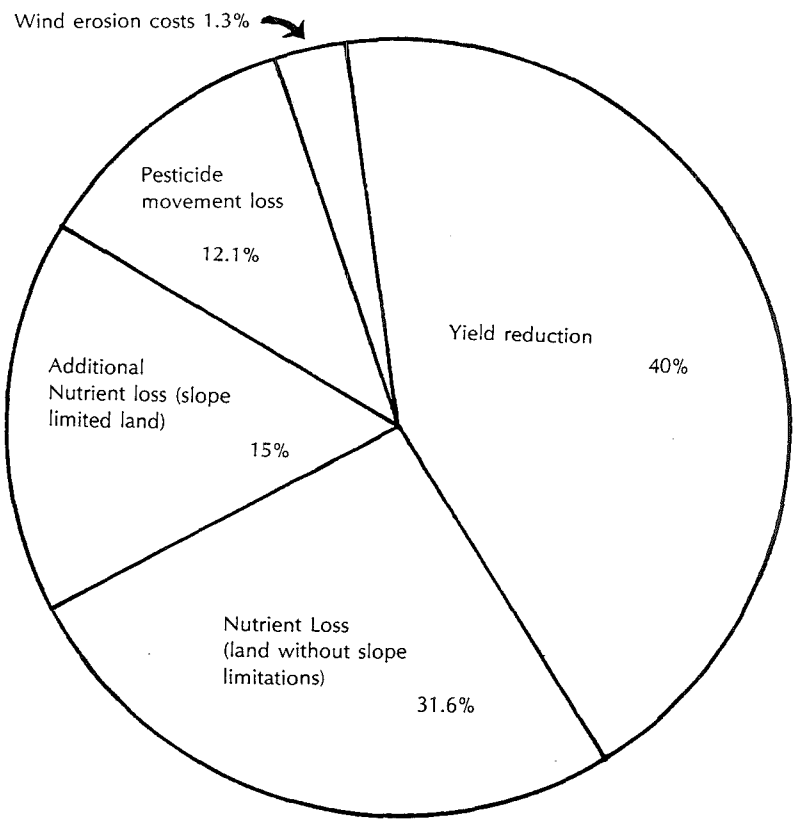
On the basis of erosion costs per hectare of row cropland — Brant, Elgin, Middlesex, Oxford and Waterloo counties show the highest values.

B. ***By Categories of Losses***[4]

The following chart shows that 40% of cropland soil erosion costs result from yield reductions on row cropland with slope limitations.[6] This is followed by more than 30% nutrient losses on land without slope limitations and an additional 15% on land with slope limitations. Pesticide movement and wind erosion losses account for the balance.

6) 'Slope Limitations' in the study refers to Class 2, 3, 4 cropland with slopes of 2% and greater, depending on the land classification and the complexity of the slope.

Distribution of Cropland Soil Erosion Costs



Reasons for the Soil Erosion Problem

The on-going degradation of our soil is a product of the rapid technological changes in agriculture during the 60's and 70's. These changes resulted in a massive expansion of row crop production, especially corn and soybeans.

There are several reasons for this changing thrust in food production. Research and production emphasis has been directed toward greater productivity. This has resulted in the development of faster maturing and higher yielding varieties, increased use and effectiveness of pesticides and chemical fertilizers (especially nitrogen), and better storage and drying facilities. This has been accompanied by larger and more specialized field equipment, changing and sometimes excessive tillage operations, the tillage of wet soil, and larger fields with longer slopes — all of which have compounded the soil erosion and other soil degradation problems.

Technological developments have not been as great for soil structure - building crops such as forages, pastures and small grains. The de-emphasis on these crops, along with the lack of adequate soil conservation practices, has resulted in an apparent decline in overall natural fertility and soil organic levels with consequent structural damage and increasing vulnerability to erosion

on Ontario soils. An extended study at the University of Guelph demonstrated that soil organic matter content was maintained with crop rotation and strip cropping, but declined significantly when soil conservation practices were not followed.[7]

Another major factor has been the generally higher level of financial returns from row crops, especially during the 70's. This accelerated the expansion of row crop production. In some cases, economic necessity dictated this production system in order to achieve and maintain financial stability — sometimes at the expense of mining the soil.

There has also been a lack of recognition and serious attention given to the soil erosion problem — at all levels. Short-run expediency and higher profile and more pressing issues have taken precedence over the fundamental issue of the care and maintenance of an essential resource — our soil.

Progress Toward Improvement

A. *Recognition and Support*

Most farmers are stewards of the land and want to protect and maintain the heritage of our soil. They are becoming more aware of the disastrous effects of soil erosion. This is illustrated by the response to the Soil Conservation Survey conducted by the Ontario Institute of Agrologists.[3] 89% of the respondents indicated that soil erosion is a concern. The Ontario Institute of Pedology study, by quantifying the economic loss, brought the magnitude of the problem into focus.

Assistance in soil erosion control is limited. Government ministries and conservation authorities are providing some advice on soil conservation practices such as crop rotations, strip cropping, tillage techniques and planting windbreaks and shelterbelts. In April 1983, the Ontario Ministry of Agriculture and Food established a five year $25.5 million program for on-farm erosion control projects and manure storage facilities. The major portion of this funding is currently being applied to the manure storage component.

Economic conditions are having both a negative and positive effect on improved soil conservation practices. On the one hand, difficult financial positions result, in some cases, in extracting maximum returns from the land — often at the expense of soil quality. On the other hand, the economic situation has created a trend to more diversified farming with the inherent broadening of the crop rotation program.

B. *Whose Responsibility?* [8]

We can surely accept the thesis that soil conservation and a sustainable agricultural system are necessary goals. This raises the question — Is maintaining long-term productivity a public or private cost? As a private cost, solely to farmers, the effectiveness may be questionable and the added costs would have to be reflected in some form of added return.

Is society, through government, willing to accept the costs of ensuring the maintenance of soil productivity and an adequate food production base? Even if the answer is yes, what methods should be used? Should financial inducements be offered to farmers for soil conservation practices such as the use of more rotational systems with pasture, hay and other non-row structure-building crops? Or should compulsory programs be introduced to achieve desired results? Compulsion is not looked on with favour in the agricultural sector and tends to be ineffective.

7) 'Effects of Long-Term Erosion on Soil Properties and Productivity" — J.W. Ketcheson, P.Ag. and P.H. Groenevelt, Department of Land Resource Science, University of Guelph — Paper presented at American Society of Agronomy, Washington, D.C., 1983.

8) Significant parts of the information in this section are adapted from a paper 'To Whom Should God Send the Soil Conservation Bill?" by D. Peter Stonehouse, School of Agricultural Economics and Extension Education, University of Guelph, September 1983.

C. *Action*

The fundamental questions of responsibility and program leadership must first be answered. Once these are established, specific actions centering on **education *and* financial support** can be undertaken. The O.I.A. study[3] indicates several directions for each of these thrusts:

Education:
- Improved land stewardship attitudes.
- Better tillage practices.
- Better crop rotations (that include forage).
- Promotion of soil conservation practices such as grassed waterways, sod buffer strips, cover crops, fencing livestock out of streams and ditches, and better crop residue management.

Financial Support:
- More demonstration projects.
- Increased co-operative projects such as between the Ministries of Natural Resources and Agriculture and Food.
- Additional technical support from soil management specialists.
- Expanded applied research.

Concerted action is required. **The Ontario Institute of Agrologists recommends an integrated program of education, research, technical assistance and financial incentives to achieve necessary results.**

Action is a responsibility of everyone — farmers, consumers, governments, educational institutions, conservation agencies and agricultural organizations. Agrologists have a key role. Dr. Bentley[1] states that it is a fundamental professional responsibility and obligation of agrologists to lead the way in finding answers to maintaining or enhancing the productivity of farmlands on an enduring basis. He suggests that 'agrologists should press by every means at their disposal — on every imaginable occasion — to all agencies and organizations likely to have any influence related to food and agriculture — to inform Canadians and the responsible elected officials that Canada's land resource base is: not abundant; not secure, indeed in jeopardy.'

"The food security of future generations of Canadians is at stake. Actions are needed — starting now."[1]

"I worry: What kind of future are we building for our grandchildren?...and theirs?"[1]

Appendix 1

Soil Conservation Survey

This survey was conducted in 1982/83 by the Soil Conservation Committee of the Ontario Institute of Agrologists. Those surveyed included all the County Presidents of the Ontario Soil and Crop Improvement Association, General Managers of the Conservation Authorities, and Agricultural Representatives, Agricultural Engineers and Plant Industry Branch Specialists of the Ontario Ministry of Agriculture and Food. There was an 82% response rate among the 164 persons contacted in the survey.

Summary of Questionnaire Results

Question #1 — Is soil erosion a concern in your area?
89% replied YES

Question #2 — To what extent is soil erosion by WATER a concern in your area?

	% Answering Moderate-Severe
Streams, drains, etc.	67
Ditchbanks	66
Gully	56
Sheet and Rill	52

Question #3 — What effect is soil erosion by WATER having on:

	% Answering Moderate-Severe
Increasing ditch maintenance costs	63
Downstream sedimentation concerns	62
Degrading fish and wildlife habitat	37
Increasing crop production costs	31
Lowering crop yields	29

Question #4 — To what extent is soil erosion by WIND a concern in your area?

	% Answering Moderate-Severe
On sandy soils	43
On loam soils	24
On organic soils	15
On clay soils	9

Question #5 — What effect is soil erosion by WIND having on:

	% Answering Moderate-Severe
Lowering crop yields	16
Increasing ditch maintenance costs	10
Increasing crop production costs	10
Downstream sedimentation concerns	7
Degrading fish and wildlife habitat	4

Question #6 — What are some of the major factors of concern in your area with soil erosion by WATER? (listed in order of importance i.e. #1 most important)

1 Lack of erosion control measures
2 Unwise tillage practices (excessive, too deeply, etc.)
3 Inadequate crop rotations
4 Lack of financial incentive
5 Field enlargement
6 Decrease in forage crop acreage
7 Lack of policy direction
8 Lack of technical help
9 Land rental systems (eg. short-term leases)
10 Increase in row-crop acreage
11 Lack of research data
12 Land rental by intensive large-scale units
13 Reduction in the number of livestock farms
14 Excessive land prices

Question #7 — What are some of the major factors of concern in your area with soil erosion by WIND? (listed in order of importance, i.e. #1 most important)

1 Lack of erosion control measures
2 Unwise tillage practices (excessive, too deeply, etc.)
3 Inadequate crop rotations
4 Field enlargement
5 Lack of financial incentive
6 Lack of policy direction
7 Reduction in the number of livestock farms
8 Increase in row-crop acreage
9 Decrease in forage-crop acreage
10 Lack of technical help
11 Land rental systems (eg. short-term leases)
12 Land rental by intensive large-scale units
13 Lack of research data
14 Excessive land prices

Question #8 — ***Remedial Measures:*** What, in your opinion, is needed to assist farmers in your area to manage soils for food and fibre production on a long-term basis?

	% Answering High — Very High
A Improve their land stewardship attitude	83
Use of better tillage practices	80
Use better crop rotations (that include forage)	77

B Conservation Practices that should be promoted (listed in order of importance i.e. #1 is most important)

1 Grassed waterways
2 Sod buffer strips
3 Cover crops
4 Fencing livestock out of streams and ditches
5 Better crop residue management
6 Gully control
7 Windbreaks
8 Green manure crops
9 Contour and strip cropping

C Programs that should be promoted (listed in order of importance)

1 More demonstration programs
2 Increase in co-operative projects (eg. between MNR and OMAF)
3 Increased technical help (soil management specialists)
4 Increased concern and action from policy makers
5 Increase in applied research
6 Increased financial assistance

Appendix 2

'Cropland Soil Erosion' — Study Methodology

The Ontario Institute of Pedology is a co-ordinating agency supported by Agriculture Canada, Ontario Ministry of Agriculture and Food, and the University of Guelph with responsibility to undertake soil resource inventories and associated research on soil formation, soil mapping and interpretation of soils in Ontario.

The Study

Soil Scientists and other agricultural and conservation specialists throughout Ontario participated in the study. Extensive review procedures were established to carefully establish and validate the methodology and results of the study. In order to determine realistic cost estimates, the study used only those costs which could be justified and quantified, and data and assumptions which would not overstate the estimated costs.

Base Data Used

Soil Erosion Rates

- 6.7 tons per hectare per year* (6.7t/ha/yr) from row cropland without slope limitations. This is considered a tolerable level for sustained agricultural production.
- 22.4t/ha/yr* for row cropland with slope limitations. At this rate, most topsoil would be lost in about 60 years.

Yield Reduction Rates

- These damages were calculated only for row cropland with slope limitations on class 2T, 3T and 4T land where soil erosion problems are commonly observed in Ontario. The following average yield reductions were used, based on current research results at the University of Guelph:
  - 25% annual yield reduction for continuous corn crops (more than 10 years) and bean crops.
  - 15% annual yield reduction for remaining corn crops.

Nutrient Value Loss Rates

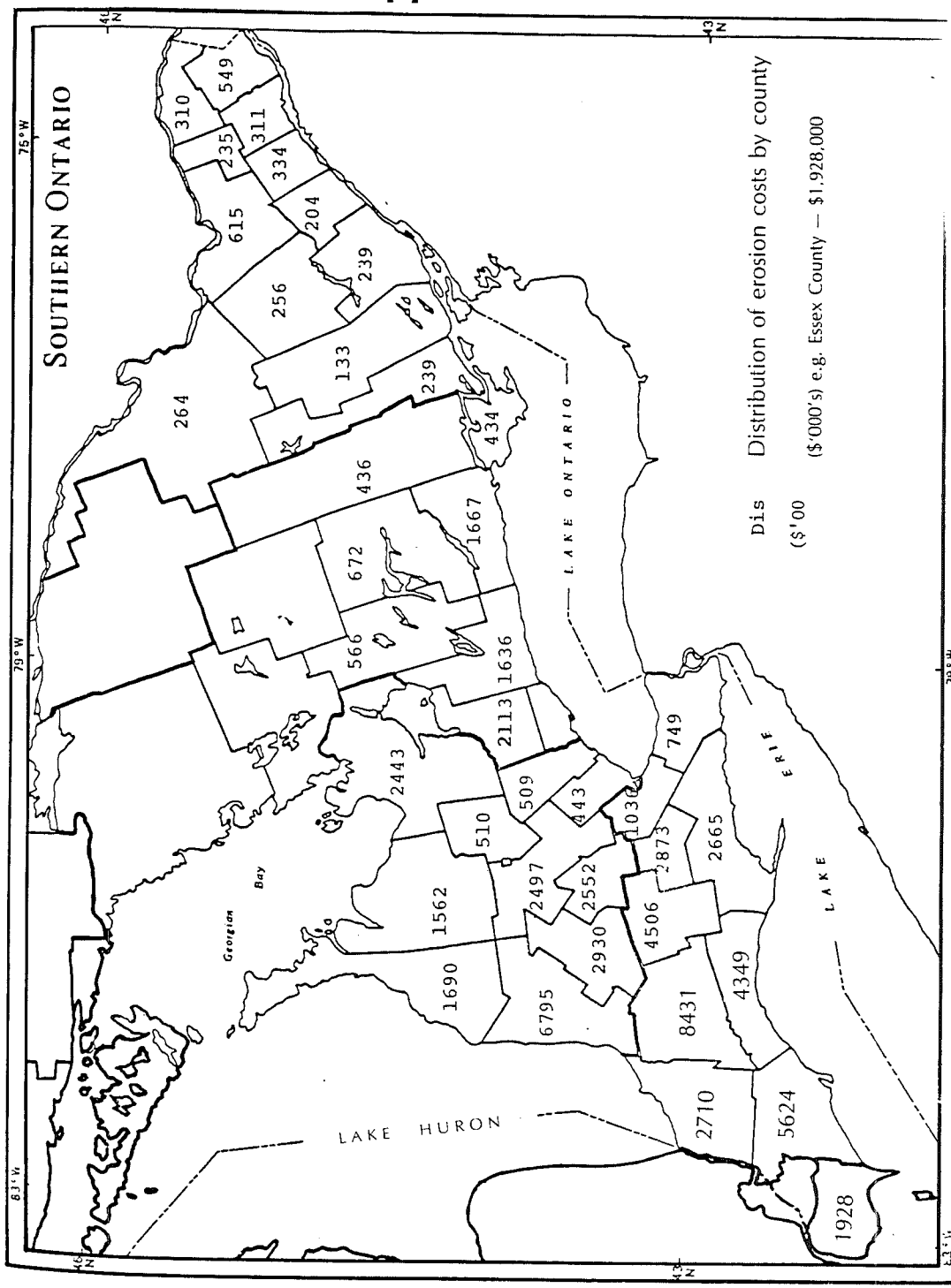
- Considered for all row cropland. The loss associated with a tonne of topsoil was calculated at $1.50 with a relative value of N, P, and K at 75%, 15% and 10% respectively.

Pesticide Movement Rates

- Estimated movement loss for all row crops on the basis of 10% of the average value of applied pesticides. An additional $15/ha/yr loss was included for tomato, potato, and tobacco crops.

*Studies by Van Vliet et al. (1976) reported mean annual rates of soil erosion for many row crops in Ontario from less than 1t/ha/yr to more than 50t/ha/yr.

Appendix 3



THE ONTARIO INSTITUTE OF AGROLOGISTS

The Ontario Institute of Agrologists (OIA) is the organization of professional agriculturists in Ontario. There are 1300 members affiliated with 12 branches across the province. The OIA is affiliated with the Agricultural Institute of Canada.

The general purposes of the Institute are:

1. To contribute to the improvement of the agriculture and food industry through making the Ontario Institute of Agrologists of increasing value and service to the industry, to society, and to the members of the Institute.
2. To increase the knowledge, skill and proficiency of its members in the practice of their profession.

Provincial Council of the Ontario Institute of Agrologists 1983-84

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