WETLAND DISTRIBUTION AND CONVERSION IN SOUTHERN ONTARIO

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WETLAND DISTRIBUTION AND CONVERSION IN SOUTHERN ONTARIO

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ABSTRACT

Concern over the ongoing conversion of wetlands is growing. Information on the location, extent, and quality of remaining wetlands is needed to assist in developing future policy and management actions aimed at retaining wetland values. In addition, knowledge of wetland conversion rates and trends is important in assessing the current status of wetlands. To date, the availability of such information has been fragmentary and inconsistent. This study used available soil and land use data, supplemented by other information, to map southern Ontario wetlands and wetland conversion on 125 map sheets at a scale of 1:50 000. Analysis has revealed that before 1800, 2.38 million hectares (ha) of wetland were widely distributed throughout southern Ontario. By 1982, 0.93 million ha remained and were more prevalent in the northern parts of the study area. The original wetland area had been reduced by 61% overall, and by 68% south of the Precambrian Shield. Wetland decline since settlement has been most severe in southwestern Ontario where over 90% of the original wetlands have been converted to other uses. Areas in the Niagara Peninsula, along western Lake Ontario and in eastern Ontario have less than 20% of the original wetland area. From 1967 to 1982, 5.2% of the wetland area south of the Precambrian Shield was converted to other land uses. For the same period, some previously converted wetlands were allowed to revert to immature forest and scrubland, reducing the net decline of wetland area in 1982 to 1.8% of the 1967 wetland area. Kent County experienced the greatest reduction in wetland area between 1967 and 1982 with 26% of the 1967 wetland area being converted to other land uses. Conversion to agriculture accounted for most of the recent losses in all areas. Cottage development was a significant factor in the loss of lakeshore wetlands in central Ontario.

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

'While the figures are fragmentary, the general trend is unmistakable: wetlands are a shrinking resource in Ontario'.

(Reid, 1979)

With both the highest population density and best agricultural land in Canada, southern Ontario faces intense land use pressure. Natural areas, including wetlands, often cannot compete economically with other land uses. Over time, this had led to a significant decline in wetland areas.

Wetlands, however, have many important functions and values to society. These include streamflow regulation, water quality improvement, education, recreation, and provision of habitat for numerous species of wildlife and plants. Recognition of these values has caused governments at all levels to respond to concerns over the ongoing conversion of wetlands in Ontario.

The federal and provincial governments have jointly developed a system to rank the value of wetlands (Ontario Ministry of Natural Resources and Environment Canada, 1982). The provincial government has been applying this evaluation system to all southern Ontario wetlands in a major project extending over several years. It has also issued Guidelines for Wetlands Management in Ontario (Ontario Ministry of Natural Resources, 1984) and is preparing a formal policy statement on wetlands under the Ontario Planning Act. Several regional governments have produced reports on Environmentally Sensitive Areas which include some wetlands. These actions are aimed largely towards the retention of the most significant remaining wetlands and represent important progress in wetland conservation.

While concern is growing, little comprehensive, comparative data on land-use change affecting wetlands exists for southern Ontario. Effective action would be strengthened by a better understanding of wetland conversion. Where are reductions occurring, how much has been lost, how quickly and to what land uses? How much remains and where? Are the declines significant? Only with answers to these questions can efforts be targeted to those areas of greatest conversion, be properly moulded to address the processes causing the problem, and then be accurately monitored to assess program performance.

This report presents the methodology and results of a project to map existing southern Ontario wetlands and identify wetlands which have been converted to alternative land uses both since settlement and in recent years. It also identifies those land uses to which wetlands have recently been converted and provides a base for monitoring future wetland change.

This report only covers wetland conversion to other land uses. It is recognized that wetlands can also be degraded by man's actions and yet remain. Changes to processes within a wetland and to its interactions with surrounding areas can affect wetland ecology and values. For example, roads may alter water flow, adjacent drains may change the water regime, upstream erosion may silt in marshes to the detriment of many forms of wildlife. Quality decline within existing wetlands is beyond the scope of this study.

2. WETLAND DEFINITION

Wetland is defined as 'land having the water table at, near or above the land surface or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophilic vegetation and various kinds of biological activity which are adapted to the wet environment' (Tarnocai, 1980).

Four major wetland classes occur in southern Ontario -- marsh, swamp, fen and bog (Ontario Ministry of Natural Resources and Environment Canada, 1982). Marshes are found throughout southern Ontario and contain non-woody vegetation such as rushes, reeds, reed grasses and sedges. Marsh soils can be either mineral or organic. Their waters are usually circum-neutral and can either persist over the soil surface year round or dry up in late summer.

Swamps are wooded wetlands. Surface water can occur seasonally or longer and the substrate is usually saturated. Soils are usually mineral or well decomposed organic. Waters are nutrient-rich and near neutral or slightly acidic. Swamps are the most common wetland class in southern Ontario.

Fens contain sedges, reeds, shrubs and mosses but little or no sphagnum moss. Soils are organic and often poorly to moderately decomposed, at least near the surface. Their waters are less acidic than bogs and, in mineral nutrients, usually poorer than swamps but richer than bogs. The water table is at or close to the surface.

Bogs are generally covered by sphagnum moss and may have trees or shrubs. They have poorly decomposed peat soil. Their waters are strongly acidic and low in mineral nutrients and their water table is at or close to the surface. Bogs and fens are more common in northern Ontario.

3. DATA REQUIREMENTS AND REVIEW OF EXISTING INFORMATION

To produce the maps required for this study, data were required which:

i) could identify the extent and location of existing wetlands and also wetlands which had been converted to other land uses;

ii) were consistent across the 93 300 km^2 southern Ontario study area (Figure 1) to allow valid regional comparisons;

iii) complied with the wetland definition; and

iv) were mappable at a 1:50 000 scale and had a level of accuracy suitable for regional planning.

Table 1, summarizes available wetland mapping and conversion data according to the above data requirements. The table builds on a review by Lynch-Stewart (1983) to summarize wetland conversion studies for southern Canada.

While many sources have mapped current wetlands at regional scales, few adequately covered all classes of wetland. Some exclude or under-represent swamps, the predominant wetland type in southern Ontario. Others omit wetlands with mineral substrate or do not distinguish between existing and converted wetlands. Several comply with the definition of wetlands, but cover only small parts of the study area.

TABLE 1. Assessment Of Wetland Mapping And Conversion Data From Existing Sources.

Existing Data and Sources Map of Current Wetlands	Present Study Requirements (X Indicates Not Met)						Applicable Statistical Findings	Wetlands Converted To:
	Map of Long -term Conversion	Map of Recent Conversion	Land Use Change Statistics	Complete & Consistent Data for all Ontario	Complies with Wetland Definition	Scale at Least as Detailed as 1:50 000		
Wetlands of Canada (Environment Canada, 1981)	X	X	X		X; includes tilled areas	X; 1:7500 000		
Areas of Importance for Migratory Bird Protection in Ontario(Ontario Ministry of Natural Resources,1978)	X	X	X		X; only wetlands important for migratory birds	X; 1:2 235 520		
Organic Soil Maps (Ontario Institute of Pedology)	X	X	X		X; only organic areas; includes tilled areas			
Canada Land Inventory, Present Land Use (Environment Canada, 1967)	X	X	X		X; only non-forested wetlands		185 ha loss to 20 largest cities 1966-1971 (Gierman, 1977)	
Satellite Imagery (Ontario Centre for Remote Sensing)	X	possibly	possibly		X; problems recognizing some wetland types			
Maps Derived from Rational Topographic System (Bardecki; 1981; Ont. M.N.R.,1979)	X	X	X		X; omits many swamps		currently about 0.5 million ha of wetlands	
Sample of 8 NTS Maps in Southern Ontario (Bardecki, 1981)	X			X			317 ha (1.3%) loss from 1966-1978, of which 85% to agriculture	mainly agriculture
Lowdown on Wetlands (Rowntree, 1979) statistic only	X	X	X			X	currently 0.28 million ha of wetlands	
Estimates of Cleared Wetlands in Southern Ontario (Cox,1972)		X	X	few counties missing	X; loss definition a bit crude	X; 1:2 900 000	in 1950, about 1 million ha of wetlands remained; 1.2 million ha (55%) loss from 1800-1950	
Wetland Policies (Reid,1981)X	X	statistics only	X			X	current loss rate 3,650 ha/yr, 1-2% loss per year	mainly agriculture
Lake Ontario and St. Clair Wetlands (McCullough, 1981)				X			L. Ontario:38 km^2 (42%) loss from 1800-1978; L. St. Clair:882 ha (25%) loss from 1965-1978	Western L. Ontario: urban development L. St. Clair: 91% agriculture
Kawartha Lakes Marshlands (Lewies & Dyke, 1973)	X			X	X; only marshes		915 ha (20%) loss from 1960-1969	cottages, docks, marinas
Point Pelee Marsh and Lake St. Clair Marshes (Rutherford, 1979)		X		X	X; only marshes		Point Pelee:28 km^2 (71%) loss from 1800-1975; L. St. Clair: 106 km^2 (39%) loss from 1915-1978	mainly agriculture
Lake Ontario Marshes -- Toronto to Oshawa (Lemay & Mulamoottil,1984)				X	X: only marshes		379 ha (79%) loss of marsh area from 1860-1976	agriculture before 1930; harbours and urban development after 1930
Lake Ontario Marshes -- Toronto to Oshawa (Lemay, 1980)	X			X	X; only marshes		134 ha (44%) loss from 1931-1976	harbours and urban development
St. Lawrence River, Cornwall, Ont. to Matane, Que. (Le Groupe Dryade, 1981)	X			X			42% of wetland area converted from 1945-1975	
Marshes on Lake Ontario (Whillans, 1982)		X	X	X	X; only marshes		19 km^2 (43%) loss of marsh area from 1789-1979	
Lower Great Lakes Shoreline Wetlands (Environment Canada, 1981)	X	X	X	X				
Marshes in Southwestern Ontario (Dubsky, 1982)	X	X	X	X	X; only marshes			
Wetlands Mapped by Some Conservation Authorities	possibly a few	possibly a few	possibly a few					
Environmentally Sensitive Areas Mapped by Some Regional Municipalities	X	X	X	X	X; only those wetlands which are 'environmentally sensitive'			
Maps of Individual Wetlands by Various Agencies	possibly a few	possibly a few	possibly a few	X	X; probably *varies*			

A number of studies did provide maps or estimates of wetland decline, but usually only for a relatively small study area and narrow time span. A study by Cox (1972) provided county and province-wide estimates of wetland conversion statistics but they were very roughly calculated. While each source offered valuable information on some aspect of southern Ontario wetlands as intended, none provided a comprehensive base for all of southern Ontario. It was therefore necessary to create an original data set for this project.

4. METHOD

4.1 Selection of Data Sources and Mapping Methodology

To determine the most cost effective and efficient means of mapping wetlands, several data sources and mapping methodologies were evaluated against the study requirements (Appendix A). The combined interpretation of four existing data sources emerged as the best means for mapping existing wetlands and wetland conversion. Potential wetland soil could be mapped using Canada Land Inventory (CLI) agriculture capability maps and county soil maps. Land use on these areas could be identified using CLI land use maps and Ontario Ministry of Agriculture and Food (OMAF) Land System maps. All data sources used in the production of the maps are listed in Appendix B.

The selection of these data sources was based on two principles derived from the wetland definition:

i) that wetlands occur where near-permanently saturated soils support natural vegetation; and

ii) that "converted wetlands" occur where soil was once saturated but no longer has a natural vegetation cover.

The CLI agriculture capability maps (scale 1:50 000), derived from Ontario soil survey maps, delineate both organic soil and very poorly and poorly drained mineral soils. These soil categories are the areas that were originally saturated (C. Acton, pers. Comm.).

CLI land use and OMAF Land System maps (both at 1:50 000 scale) were found to be suitable for determining land use on wet soil areas. The CLI land use mapping provided land use data circa 1967. The Land System maps documented land use in southern Ontario for 1982.

By overlaying the land use maps onto the saturated soil maps it was possible to provide the data combinations to locate both existing and converted wetlands for 1967 and 1982. Topographic maps (1:50,000 scale) supplemented these overlays by indicating wetlands, largely marshes, that were beyond the resolution of the soil and land use maps.

4.2 Production of Wetland Maps

In 1981, preliminary maps called the 'First Approximation' were generated for southern Ontario. For this initial mapping, wet soils, identified from the CLI agricultural capability maps, were highlighted. These units were considered to indicate the extent of wetlands prior to settlement. The CLI land use maps were then overlaid. Within each wet soil unit, those areas of wet soil with natural cover were identified as being wetland in 1967.

Converted wetlands were identified as those areas of wet soil no longer supporting natural vegetation. Boundaries for both wetlands and converted wetlands were transferred to National Topographic Series (NTS) 1:50 000 base maps. Wetlands were classified for both their vegetation cover and soil characteristics from the two data bases.

The agricultural capability maps were not available on a stable base and some distortion to the paper maps had occurred. The land use map was repeatedly shifted so, as each concession block was mapped, it exactly corresponded to the same block on the underlying map.

In addition to the soil and land use maps, areas identified by a wetland symbol on the NTS maps were considered wetland even if soil data did not show wetness or land use did not show natural cover. This tended to occur only for marshes within lakes and very small wetlands generally below the mapping resolution of the soil and land use maps.

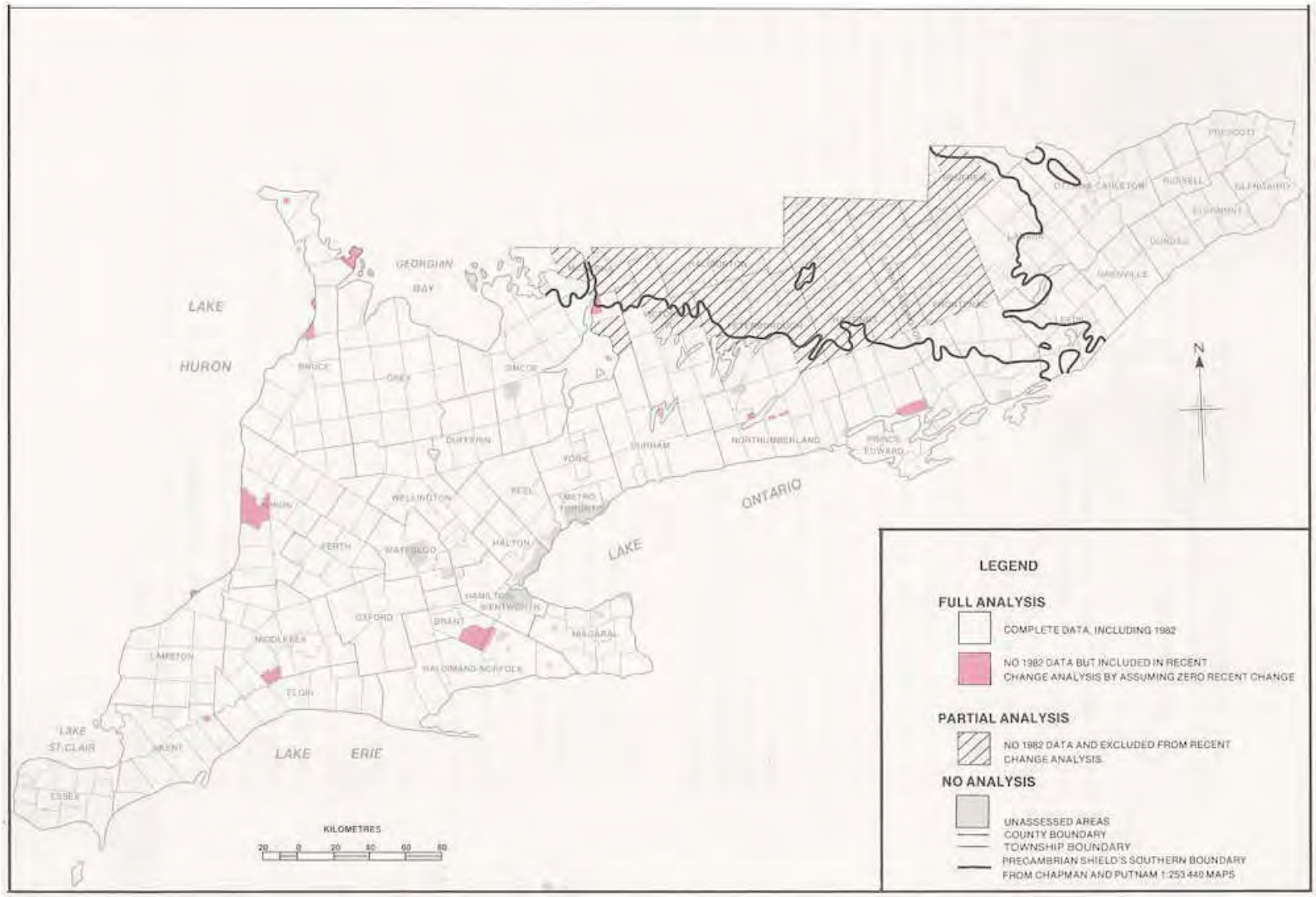
The 'First Approximation' maps were evaluated, both in-house and by a questionnaire to outside users (Appendix B). The maps were compared with known wetland locations established by field mapping, aerial photograph interpretation, or existing detailed maps contained, for example, in regional Environmentally Sensitive Area reports. The evaluation found the maps to be fairly accurate at the 1:50 000 scale for general location purposes, with occasional inaccuracies. Several respondents specifically noted the accuracy of the maps for forested wetlands. Almost all concluded they would use them again with minor revisions. One agency would use them in the future just as they were.

The evaluation results of the 'First Approximation' maps demonstrated the direction for the preparation of the 'Second Approximation' series of maps. Revisions corrected problems associated with the soil and land use data bases, included minor updates, and improved the presentation. The problems and corrective action are summarized in Appendix C. The 'Second Approximation' was produced for use in the first summer of full application of the Ontario wetland evaluation project.

The publication of 1982 Agricultural Land Systems maps, at the 1:50 000 scale, by Ontario Ministry of Agriculture and Food provided an opportunity to update much of the 'Second Approximation' to create a 'Third Approximation'. At the time of mapping no 1982 Land Systems maps were available for much of the Precambrian Shield region of the study area (Figure 1). Consequently wetland locations in this area were largely based on NTS map information.

A comparison of the 'Second' and 'Third Approximations' was used to document changes in wetland area between 1967 and 1982. From this analysis, it was possible to determine the land uses to which wetlands had been converted. It was also possible to identify areas of wetland gain. If an area of saturated soil, which was not under natural cover in 1967, had reverted to a natural cover over 10 years old, it was considered to

FIGURE 1: Southern Ontario Study Area.



represent a wetland gain between 1967 and 1982. Small shifts of the same wetland shape were ignored since there was no basis of knowing which coverage was correct.

Where the 1982 Land System maps did not map within city limits, the Canada Land Use Monitoring Program maps of land use adjacent to urban centres for 1981 were consulted. Nineteen eighty-two data were also not available for Indian Reservations. It was assumed that land use would have changed little since 1967. One exception was the Walpole Island Indian Reservation where data available from McCullough (1981) were incorporated. Finally, 1982 data were not available for Goderich Township.

4.3 Wetland Data Base

Initial estimates of current wetland area and wetland conversion since settlement were produced from the 'First Approximation' maps and published soil area figures (Hoffman and Noble, 1975). This provided general wetland data and trends to policy makers and planners early in the project (Snell, 1982).

Following production of the 'Third Approximation' maps more precise measurements were obtained. Using a digitizing table, the area within each township and conservation authority was determined for: 1967 forested wetlands; 1967 open non-forested wetlands; wetland decline to 1967; and, for those areas with 1982 data, wetland conversion to and from other land uses between 1967 and 1982. The classification for converted wetland uses included: intensive agriculture, low intensity agriculture (hay, pasture and grazing), idle land (abandoned less than 10 years), reforestation, built-up uses, extractive uses, and recreation. The wetland gains were classified as forested wetland, open wetland, shrub wetland (land idle for greater than 10 years), or pastured forested wetland.

These data and township area figures (Ontario Ministry of Intergovernmental Affairs, 1979) were input into a computer. Marsh area within Lake St. Clair was included in area figures for Walpole Island and Dover Township. Where lack of data prevented wetland mapping (Unassessed Areas of Figure 1), the township study area was reduced accordingly. This was the case, for example, with Department of National Defence properties.

The data analysis includes Goderich Township and Indian Reservations by assuming that these areas had no changes in wetlands between 1967 and 1982 (Walpole Island Indian Reservation excepted).

4.4 Accuracy and Future Monitoring

The appraisal of the 'First Approximation' (Section 4.2) showed that this early map set provided approximate wetland location and was particularly suited for the location of forested wetlands. An assessment of the 'Second Approximation' maps by Yatabe (1984) provided a quantitative indication of accuracy for current wetland location. In this study, wetlands of the Credit River watershed were mapped using 1:10 000 aerial photographs, 1:50 000 NTS maps, satellite derived maps from the Ontario Centre for Remote Sensing, and the 'Second Approximation' method. Field checks were also completed.

A comparison of the resulting maps revealed that the 'Second Approximation' provided 85%

accuracy for identifying and locating wetlands. The accuracy of the other methods was far lower, especially for locating swamps. The Credit River Watershed represents a typical area for the 'Second Approximation'. The original soils data are at the scale of 1:63 360, the most common soil map scale in the study area, and the topography includes a range representative of southern Ontario from relative plains to rolling headwater areas. The 'Third Approximation' updates the 'Second Approximation' from 1967 to 1982 to further improve the map accuracy of current wetland distribution.

The extent of wetland conversion since settlement can not be verified since no maps of wetland distribution were made at the time of settlement. It is assumed that the conversion mapping accuracy approaches that of the current wetland distribution mapping, since both use similar data bases.

The 'Third Approximation' represents the most accurate and complete spatial data base of wetland location and conversion now available for southern Ontario and will provide a valuable base for future monitoring of wetland change.[1] However, the maps are at a regional scale. They cannot be enlarged to more detailed scales for site work without sacrificing accuracy.

The limitations of the 'Third Approximation' maps are presented in Appendix D. Most limitations are of minor significance. However, the conversion of lakeshore marshes has been underestimated. Since conversion estimates are conservative and gain estimates are liberal, net wetland decline figures are underestimated.

Future monitoring of wetland decline requires only updated 1:50 000 scale land use mapping which distinguishes natural cover from other land uses. All necessary soil data is already incorporated into the wetland maps.

Monitoring would require the overlay of the 'Third Approximation' on the new land use map and a review of: (a) areas of previous wetlands to find wetland losses (i.e. areas no longer with natural cover): and (b) areas of previous wetland losses to find gains (i.e. areas with new natural cover). Changes can be added directly to the 'Third Approximation' original base maps to minimize drafting requirements.

5. ANALYSIS

5.1 Wetland Distribution and Conversion in Southern Ontario

The following sections present the results of the 'Third Approximation' maps focussing on the county unit. This is an important administrative level for land planning and, with 42 counties in the study area, offers a useful resolution for an analysis of southern Ontario trends. Where greater resolution of change data is of interest, results are presented in a township format.

Several counties in eastern Ontario have been recently amalgamated. To improve the resolution in these areas, the original county units are used. Specifically, the United Counties of Leads and Grenville, the United

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[1] Copies of these maps are available at cost from the Federation of Ontario Naturalists, 355 Lesmill Road, Don Mills, Ontario. M3B 2W8.

Counties of Prescott and Russell and the United Counties of Stormont, Dundas and Glengarry are each considered by their named components. Several counties now form Regional Municipalities, including Durham, Haldimand-Norfolk, Halton, Hamilton-Wentworth, Niagara, Ottawa-Carleton, Peel, Waterloo and York. To simplify the text, both counties and regional municipalities are referred to as 'counties' in the following sections.

5.1.1 Pre-settlement and Current Distribution of Wetlands

Before European settlement, it is estimated there were 2 380 000 ha or 23 800 km^2 of wetland in the southern Ontario study area. This is equal to 25.5% of the total area (Table 2). Much spatial variation in wetland distribution existed (Figure 2). The highest concentration of wetland occurred in south-western and eastern Ontario where 40-80% of the total county area was wetland. Moderate concentrations of 20-40% occurred in the remaining Lake Erie counties, counties to the east of Lake Huron, the Kawartha Lakes counties and several eastern Ontario counties.

Wetlands were originally much less prevalent on the Precambrian Shield compared to areas off the Shield. Over time, lower conversion rates on the Precambrian Shield and higher rates off the Shield have eliminated this difference. The proportion of wetland area to the total area dropped only from 10.8% to 9.6% between 1800 and 1982 for those Precambrian Shield townships with 1982 data. The corresponding figures for counties completely off the Precambrian Shield are 28.2% in 1800 to 8.3% in 1982 (Table 2).

By assuming no recent wetland losses (1967 to 1982) in the areas with no 1982 data (Figure 1), it is estimated that for the whole study area, approximately 933 000 ha of wetland remained in 1982. This represents 10% of the total study area.

The distribution of wetlands in 1982 is a reversal of the pre-settlement condition. In southwestern counties less than 5% of the area remained as wetland (Figure 2). The low proportion extends northeast to Waterloo. Only in Peterborough, Grenville, and Russell does wetland cover more than 20% of the county.

Approximately 86% of the 1982 wetlands were forested. Most were swamps but there were some treed bogs in northern areas. The 14% which were unforested included marshes, fens and open bogs. Of these three classes, marshes predominated in the southern parts of the study area while all three classes occurred along the northern margins.

The distribution of 1982 non-forested wetlands (last column, Table 2) shows a high proportion in counties where major Great Lakes marshes remain: Essex, Kent, Prince Edward, Lambton and Haldimand-Norfolk. Haliburton also has a high proportion of non-forested wetlands. All other counties west of Toronto have a lower percent distribution of non-forested wetlands than that for the total study area. Most counties east of Toronto equal or exceed the average.

Figures 3 and 4 show respectively the original and 1982 wetland distribution by township. Figure 5 shows the proportion of 1982 wetlands which were non-forested.

TABLE 2. County Wetland Area Statistics For c.1800, 1967 And 1982.*

County	Pre-settlement (c.1800) Wetland Area		1967 Wetland Area		1982 Wetland Area		% Open Non-Forested Cover Type
	ha	% of County	ha	% of County	ha	% of County	
Brant	8 530	7.9	4 570	4.2	4 520	4.2	4.3
Bruce	93 530	23.1	41 440	10.3	40 570	10.0	5.9
Dufferin	38 590	25.9	17 610	11.8	16 430	11.0	0.4
Dundas	44 080	43.2	12 830	12.6	12 880	12.6	19.1
Durham	33110	13.3	21 740	8.7	22 060	8.9	15.4
Elgin	44 880	23.9	8 950	4.8	8 860	4.7	1.2
Essex	128 360	68.9	6 400	3.4	5 400	2.9	50.0
Frontenac	48 400	12.7	34 020	8.9	33 840**	8.9	25.2**
Glengarry	56 620	45.4	20 350	16.3	20 410	16.4	9.1
Grenville	49 460	41.3	27 400	22.9	28 480	23.8	10.6
Grey	92 610	20.6	57 830	12.9	57 080	12.7	4.5
Haldimand-Norfolk	89 940	30.9	25 050	8.6	24 140	8.3	31.5
Haliburton***	8 140	6.7	8 130	6.7	8 130**	6.7	61.4**
Halton	14 520	15.9	5 390	5.9	5 250	5.7	1.5
Hamilton-Wentworth	25 030	23.9	5 930	5.7	5 910	5.6	3.5
Hastings***	94 520	18.0	59 470	11.3	59 740**	11.4	12.5**
Huron	77 170	22.7	20 360	6.0	18 810	5.5	4.0
Kent	159 780	63.9	12 550	5.0	9 310	3.7	48.7
Lambton	161 080	52.9	34 550	11.3	30 380	10.0	35.5
Lanark	72 340	23.6	47 430	15.5	46 980	15.3	16.0
Leeds	55 850	25.4	23 810	10.8	23 110	10.5	21.7
Lennox and Addington	62 770	22.1	27 270	9.6	27 660**	9.7	17.9**
Metro Toronto***	3 350	7.5	270	0.6	270	0.6	22.4
Middlesex	46 580	13.9	10 510	3.1	8 960	2.7	1.4
Muskoka***	7 260	6.2	7 200	6.1	7 200**	6.1	29.7**
Niagara	66 560	36.2	11 650	6.3	14 660	8.0	9.6
Northumberland	33 430	15.9	19 800	9.4	19 910	9.5	14.7
Ottawa-Carleton	125 910	45.8	35 260	12.8	34 510	12.6	12.1
Oxford	21 600	10.6	9 820	4.8	9 760	4.8	3.2
Peel	13110	11.1	5 310	4.5	5 330	4.5	4.9
Perth	59 090	27.0	9 120	4.2	9 080	4.1	1.7
Peterborough	129 990	33.1	117 590	29.9	117 010**	29.8	9.8**
Prescott	75 130	60.3	14 740	11.8	15 280	12.3	29.9
Prince Edward	19 900	19.0	11910	11.4	12 230	11.7	41.2
Renfrew***	8 740	4.9	8 130	4.6	8 110**	4.6	27.8**
Russell	44 850	59.1	15 070	19.9	16 290	21.5	1.3
Simcoe	79 720	16.8	44 900	9.5	43 720**	9.2	9.2**
Stormont	44 200	42.1	16 690	15.9	16 830	16.0	4.0
Victoria	60 780	19.8	42 410	13.8	42 110**	13.7	15.4**
Waterloo	9 220	7.0	6 660	5.1	6 480	4.9	8.4
Wellington	42 180	15.8	22 860	8.6	22 090	8.3	3.4
York	29 250	16.7	13 800	7.9	13 140	7.5	10.5
Full Study Area	2 380 160	25.5	946 780	10.1	932 920**	10.0	13.9**

* Percentages and Full Study Area statistics were calculated from the non-rounded numbers. All area statistics are shown to the nearest 10 ha.

** Where no 1982 data, assumed no recent change

*** Study area includes only part of county: for extent see Figure 1.

FIGURE 2: Percentage Of County As Wetland.

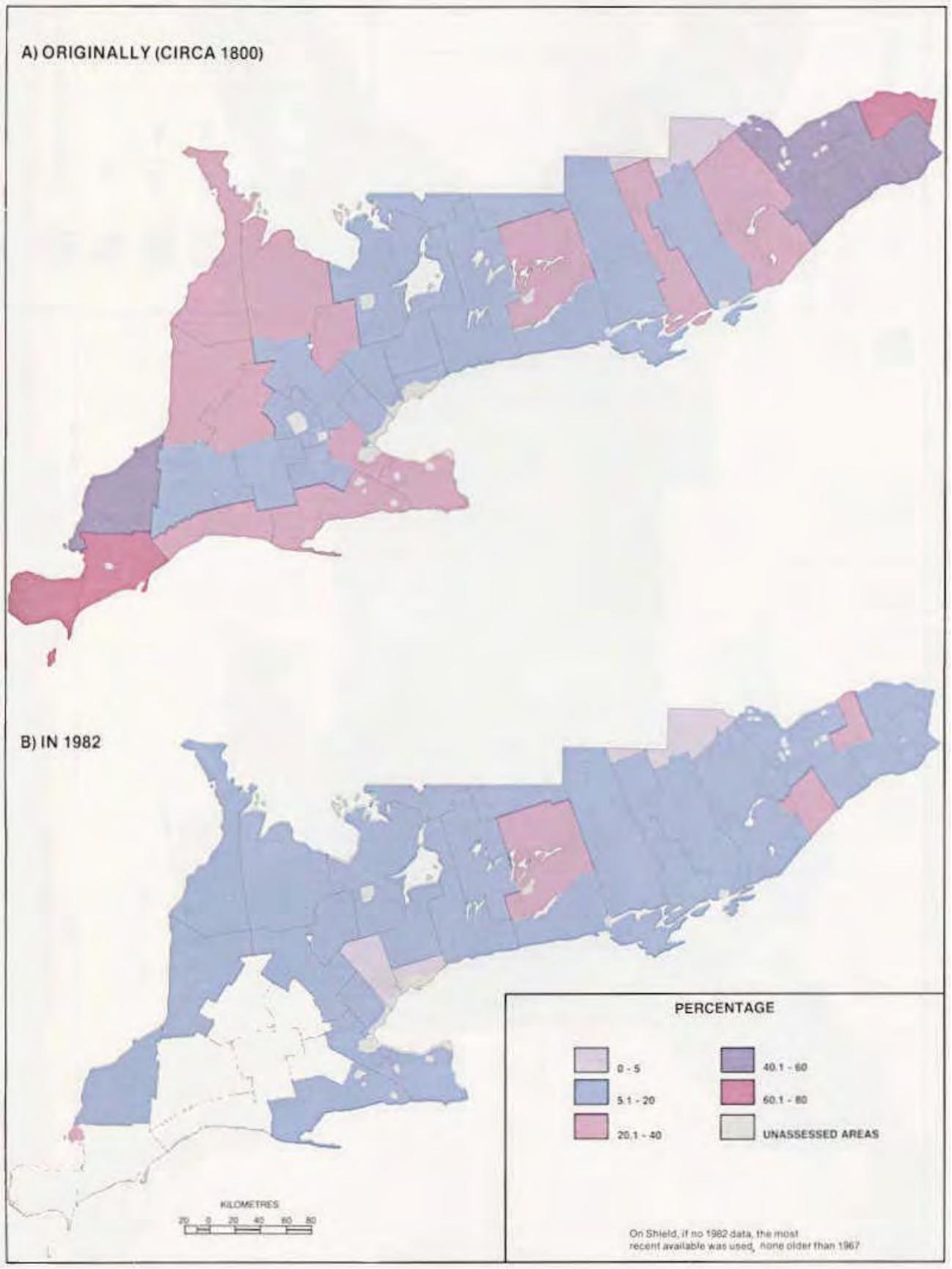


FIGURE 3: Percentage Of Area Originally Wetland By Township.

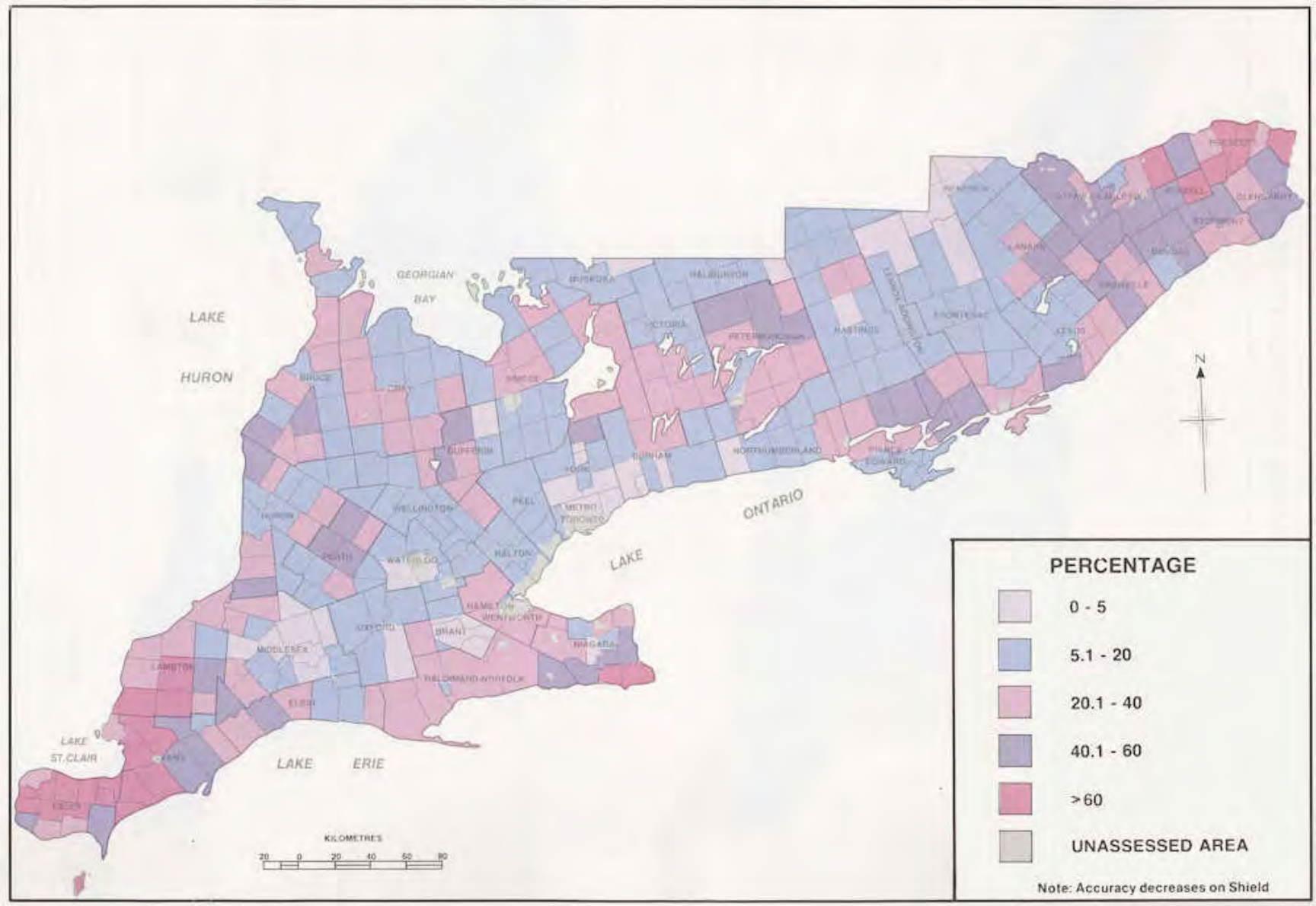


FIGURE 4: Percentage Of Area As Wetland In 1982 By Township.

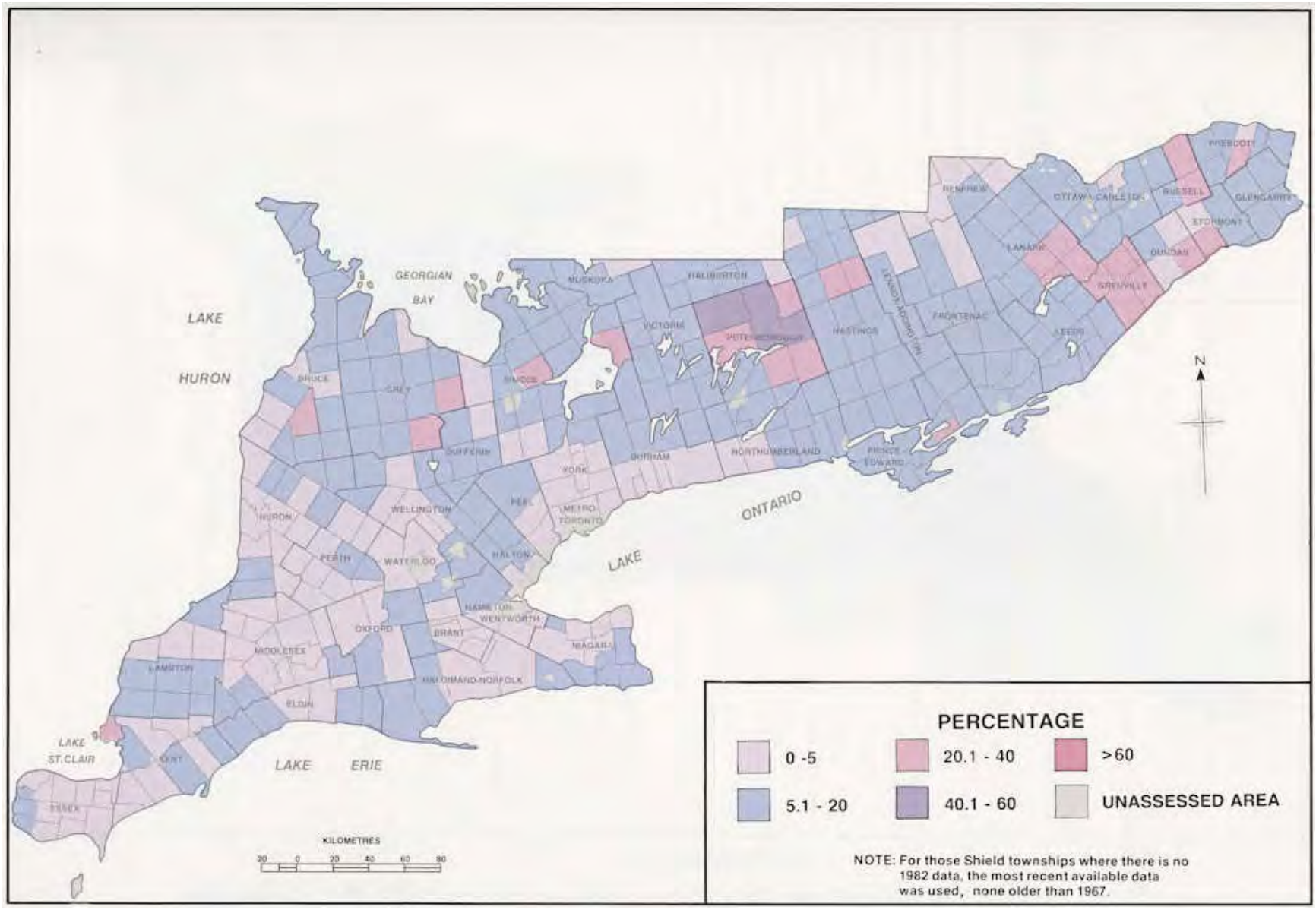
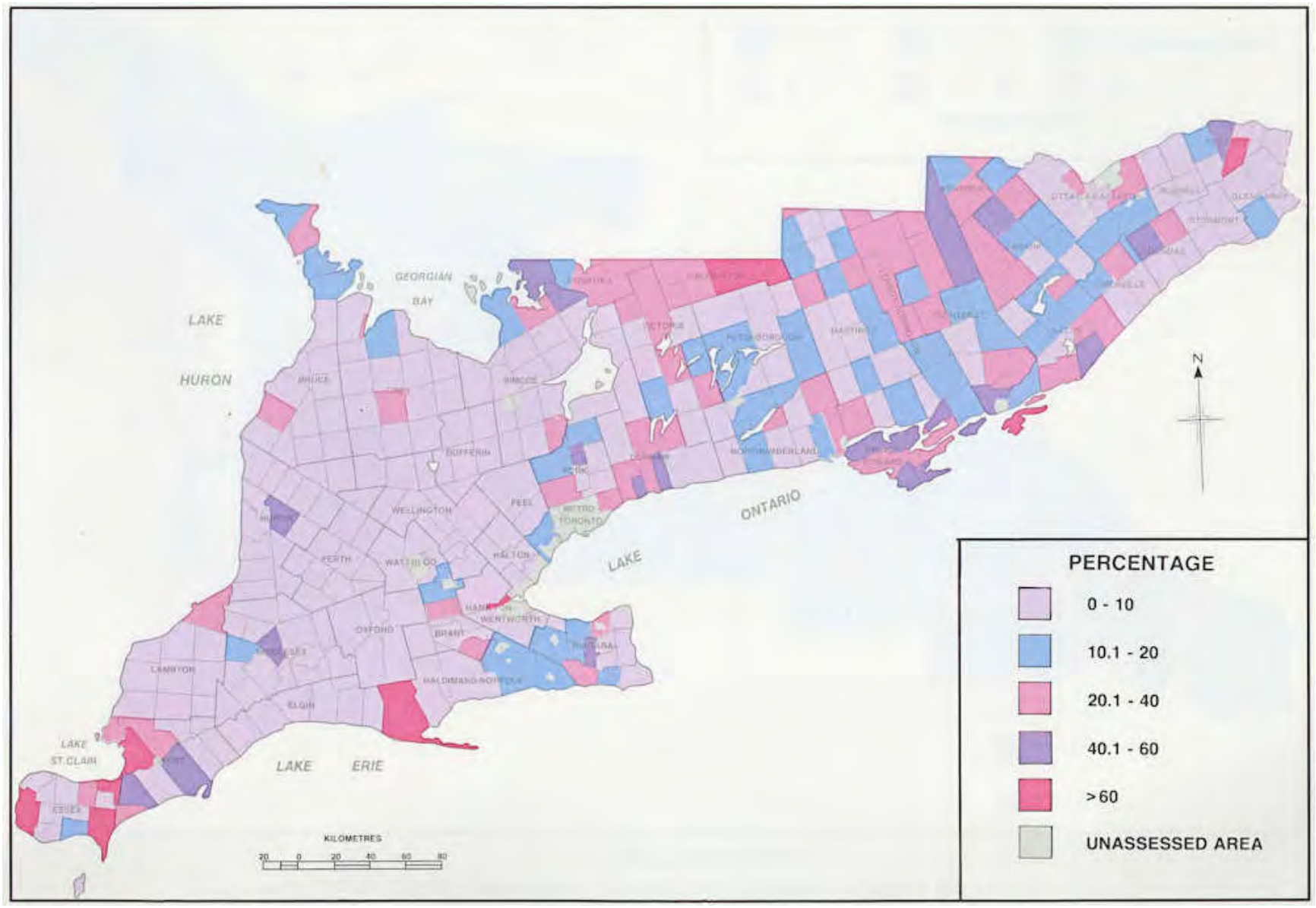


FIGURE 5: Percentage Of 1982 Wetland With Open Cover Type By Township.



5.1.2 Wetland Conversion -- Settlement to 1982

In the two centuries prior to 1982, the wetland area in southern Ontario is estimated to have been reduced by 1 447 000 ha. This is equal to 61% of the total pre-settlement wetland area (Table 3). South of the Precambrian Shield, the change has been 68%. Most conversion occurred where the greatest concentration of wetlands existed under pre-settlement conditions (Figure 6). The extreme southwestern Ontario counties of Essex, Kent and Lambton have undergone the greatest wetland conversion. Large conversions also occurred in the western counties of Bruce, Huron and Perth; the eastern Lake Erie regions of Haldimand-Norfolk and Niagara; and the eastern counties of Prescott and Ottawa-Carleton. Relative to county area, moderate conversion also occurred in Russell, Stormont, Dundas and Glengarry Counties.

Counties in central and west central Ontario, with fewer original wetlands, have experienced smaller conversions. The smallest losses occurred in those counties on the Precambrian Shield. The low area converted in Waterloo and Brant counties may partly be due to the low resolution soil maps used for these counties (Appendix C). County statistics for wetland conversion since settlement are listed in Table 3.

Over 80% of the pre-settlement wetlands in the Metro Toronto area and south and west of Perth County have been converted to alternative land uses (Figure 6). Much of eastern Ontario, the Golden Horseshoe area around western Lake Ontario and eastern Lake Erie, and Huron County show decline in the range of 60-80%. Low conversion rates of less than 20% of the original wetland area are almost exclusively restricted to the Precambrian Shield. Elsewhere, the general trend is for moderate losses of 20 to 60% of the original area. The significance of wetland conversion by township is presented in Figure 7.

5.1.3 Wetland Conversion--1967 to 1982

The following discussion applies to the area updated by the 'Third Approximation'. Between 1967 and 1982, 39 290 ha (5.2%) of wetlands in southern Ontario were converted to other land uses, an average rate of 2 619 ha per year (Figure 8, Table 3). Lambton County experienced the largest conversion, 4 930 ha. Lambton together with Kent, Huron, Simcoe and Middlesex Counties, accounted for 40% of the recent decline. The converted areas consist of a large number of scattered and relatively small wetlands. Very few wetlands greater than 300 ha were completely converted.

There is a great deal of spatial variation in the rate of wetland conversion. Figure 8 shows that southwestern Ontario lost the greatest percentage of wetlands. Kent County lost 30% of its 1967 wetlands in the following 15 years. In addition, Essex, Lambton, Middlesex and Huron Counties showed significant wetland declines. These counties lost 10 to 20% of their wetlands in the 1967-1982 period. In the remaining western part of the study area, most counties experienced a moderate wetland conversion rate of 5 to 10%. In the eastern half of the study area, only Ottawa-Carleton reaches the 5 to 10% conversion class. The rate of wetland conversion in the other counties is below the study area average.

Between 1967 and 1982, 25 430 ha of new wetlands were recorded (Table 3). This

TABLE 3. Wetland Conversion Statistics By County*.

County	Amount of Original Wetland Lost by:				Where 1982 Data Available, 1967 Wetland:					
	1967		1982		Lost by 1982		Gained by 1982		Net Change 1967-1982	
	ha	%	ha	%	ha	%	ha	%	ha	%
Brant	3 960	46.4	4 010	47.1	180	3.9	120	2.6	-60	-1.2
Bruce	52 090	55.7	52 970	56.6	990	2.4	110	0.3	-880	-2.1
Dufferin	20 980	54.4	22 160	57.4	1300	7.4	110	0.6	-1190	-6.7
Dundas	31 260	70.9	31 210	70.8	430	3.4	490	3.8	+60	+0.4
Durham	11 380	34.4	11 050	33.4	470	2.2	800	3.7	+330	+1.5
Elgin	35 940	80.1	36 020	80.3	760	8.5	680	7.6	-80	-1.0
Essex	121950	95.0	122 950	95.8	1260	19.7	260	4.1	-1000	-15.8
Frontenac	14 380	29.7	14 560**	30.1	680	3.8	500	2.8	-180	-1.0
Glengarry	36 270	64.1	36 210	63.9	400	2.0	460	2.3	+60	+0.3
Grenville	22 060	44.6	20 980	42.4	270	1.0	1360	5.0	+1090	+4.0
Grey	34 780	37.6	35 530	38.4	1400	2.4	660	1.1	-740	-1.3
Haldimand-Norfolk	64 880	72.1	65 800	73.2	1710	6.8	790	3.2	-920	-3.7
Haliburton***	10	0.1	10**	0.1	0	0	0	0	0	0
Halton	9 130	62.9	9 270	63.9	230	4.2	80	1.5	-150	-2.7
Hamilton-Wentworth	19 100	76.3	19 130	76.4	570	9.7	550	9.3	-20	-0.5
Hastings***	35 050	37.1	34 780**	36.8	330	1.5	600	2.8	+270	+1.3
Huron	56 810	73.6	58 360	75.6	2420	11.9	870	4.3	-1550	-7.6
Kent	147 230	92.1	150 470	94.2	3760	30.0	520	4.1	-3240	-25.8
Lambton	126 540	78.6	130 700	81.1	4930	14.3	770	2.2	-4160	-12.1
Lanark	24 910	34.4	25 360	35.1	780	1.6	330	0.7	-450	-1.0
Leeds	32 040	57.4	32 740	58.6	1020	4.3	330	1.4	-690	-2.9
Lennox and Addington	35 500	56.6	35 110**	55.9	770	4.3	1160	6.5	+390	+2.2
Metro Toronto***	3 080	92.1	3 080	92.1	0	0	0	0	0	0
Middlesex	36 080	77.4	37 620	80.8	2030	19.3	490	4.7	-1540	-14.7
Muskoka***	60	0.8	60**	0.8	0	0	0	0	0	0
Niagara	54 910	82.5	51 900	78.0	580	5.0	3580	30.7	+3000	+25.8
Northumberland	13 630	40.8	13 520	40.4	550	2.8	660	3.3	+110	+0.6
Ottawa-Carleton	90 650	72.0	91 400	72.6	1850	5.2	1100	3.1	-750	-2.1
Oxford	11 780	54.5	11 840	54.8	520	5.2	460	4.7	-60	-0.6
peel	7 800	59.5	7 780	59.4	10	0.1	30	0.6	+20	+0.4
Perth	49 970	84.6	50 010	84.6	690	7.5	640	7.0	-50	-0.5
Peterborough	12 400	9.5	12 980**	10.0	1190	4.3	610	2.2	-580	-2.1
Prescott	60 400	80.4	59 860	79.7	640	4.3	1180	8.0	+540	+3.7
Prince Edward	8 000	40.2	7 680	38.6	70	0.6	390	3.3	+320	+2.7
Renfrew***	610	7.0	630**	7.2	20	1.4	0	0	-20	-1.4
Russell	29 780	66.4	28 560	63.7	380	2.5	1600	10.6	+1220	+8.1
Simcoe	34 820	43.7	36 000**	45.2	2400	6.2	1220	3.1	-1180	-3.0
Stormont	27 520	62.2	27 380	61.9	370	2.2	510	3.1	+140	+0.8
Victoria	18 370	30.2	18 670**	30.7	480	1.6	180	0.6	-300	-1.0
Waterloo	2 560	27.8	2 740	29.7	340	5.2	160	2.4	-180	-2.7
Wellington	19 320	45.8	20 090	47.6	1160	5.1	380	1.7	-780	-3.4
York	15 450	52.8	16 110	55.1	1350	9.8	690	5.0	-660	-4.8
Full Study Area***	1 433 440	60.21	447 290**	60.8	39 290	5.2	25 430	3.4	-13 860	-1.8

* Percentages, Full Study Area statistics, and calculations of wetland loss used unrounded numbers. All area statistics are shown to be nearest 10 ha.

** Where no 1982 data, assumed no recent change

*** Study area includes only part of county: for extent see Figure 1. Note that the first 4 columns include the whole study area shown on Figure 1; the last 6 columns include only those areas with full analysis.

FIGURE 6: Wetland Conversion By County, c. 1800 - 1982

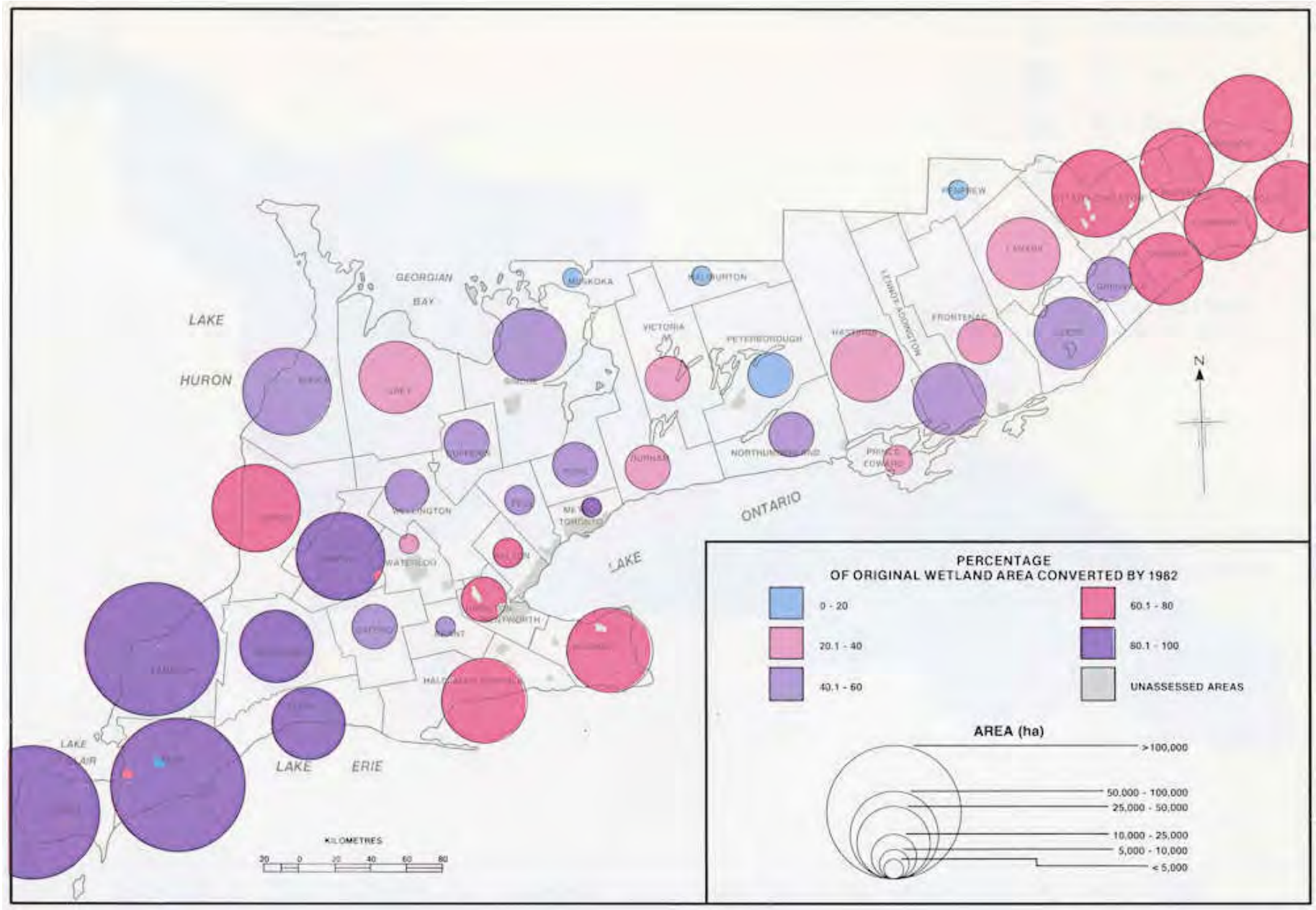


FIGURE 7: Conversion Of Original Wetland Area By Township, c. 1800 - 1992

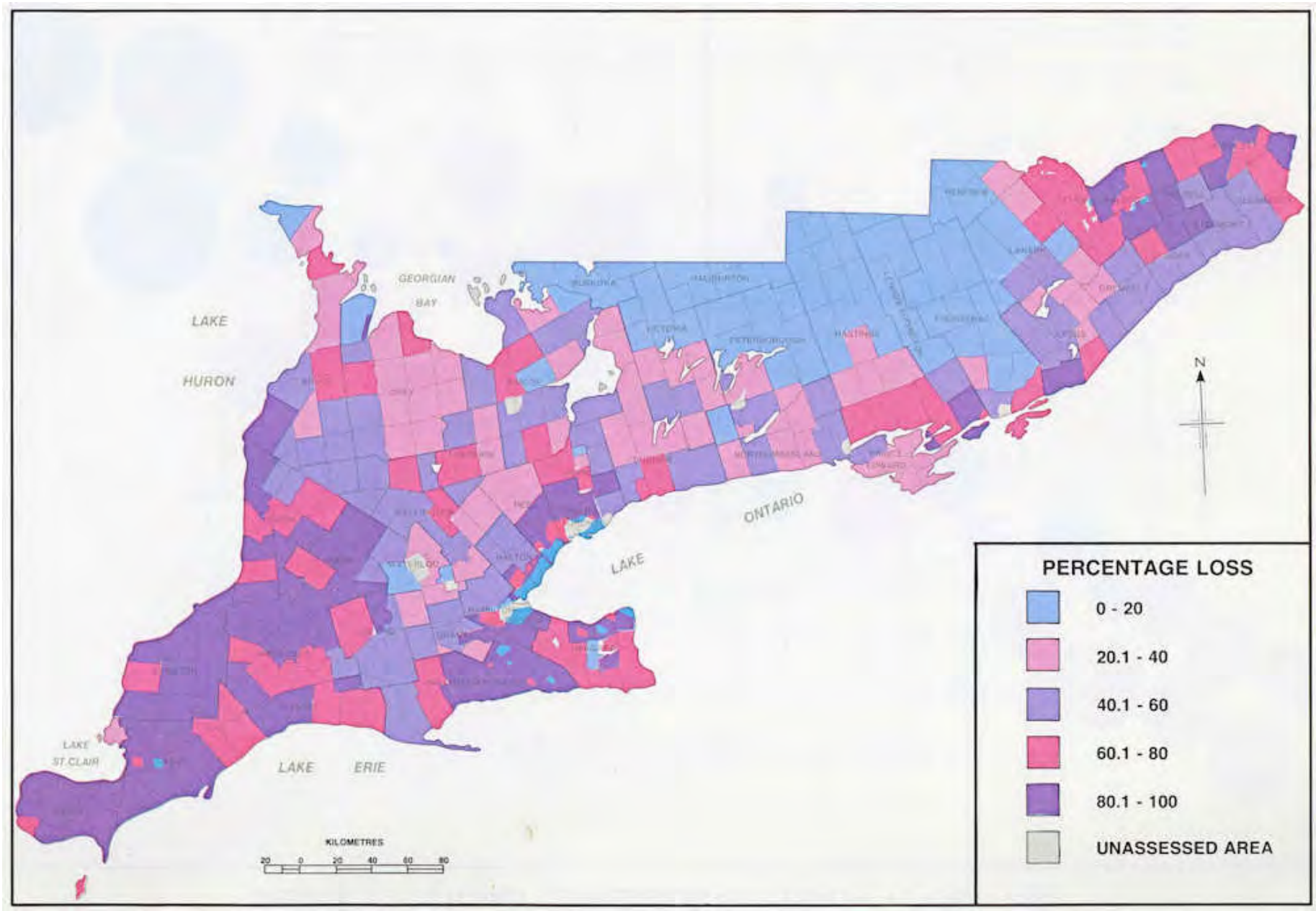
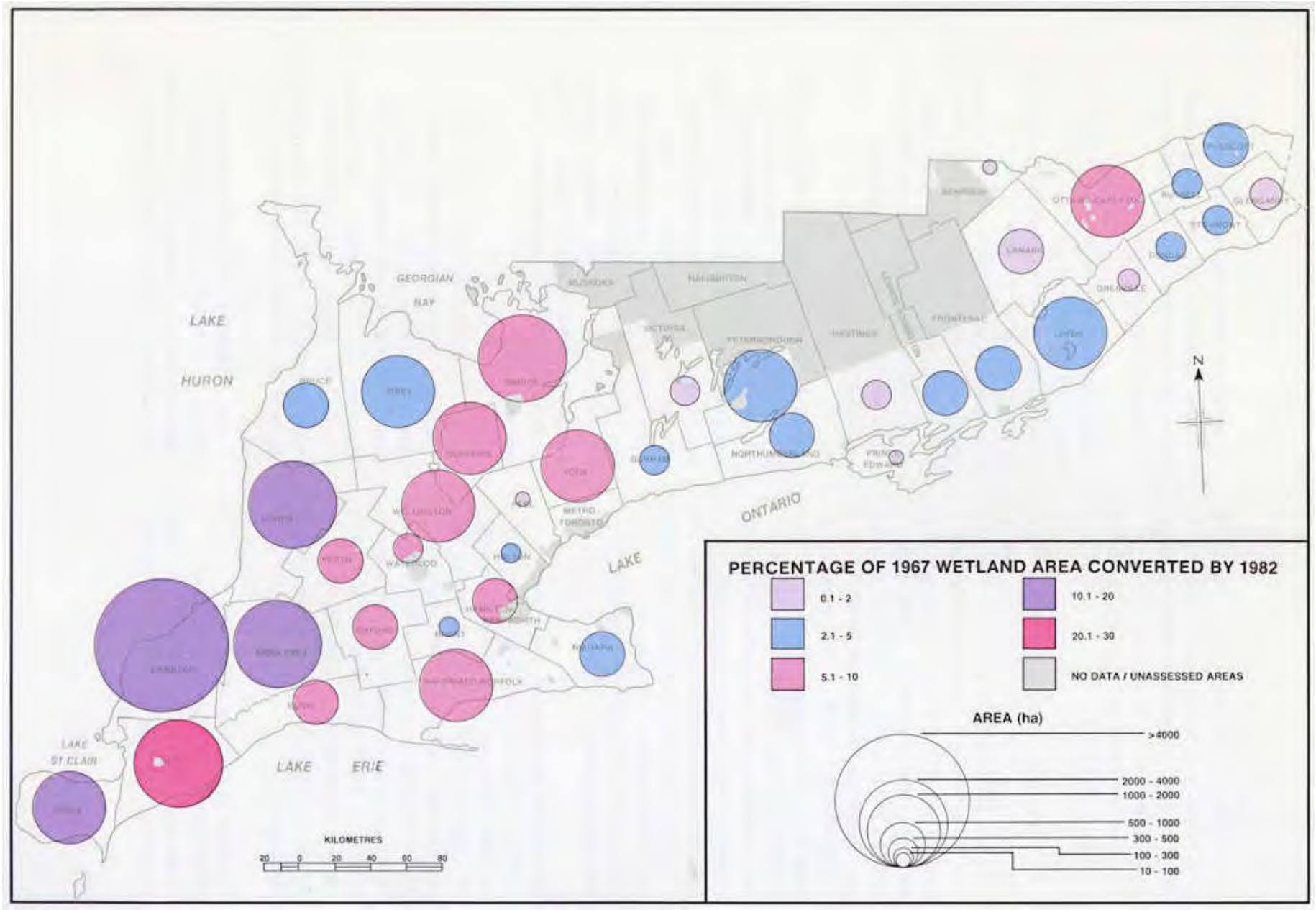


FIGURE 8: Gross Wetland Conversion By County, 1967 - 1982.



averages about 1 695 ha per year. These were areas of wet soil, which had reverted to a natural cover. New wetlands tended to occur in areas where wetlands were already relatively prevalent and where agriculture is of moderate intensity.

The greatest gain, totalling 3 580 ha, was in Niagara County where 14% of the total southern Ontario's gross increase occurred. Most of this new wetland area is abandoned farmland south of Niagara Falls which is being held for land development purposes (R. Stoke, pers. comm.). Gains in eastern Ontario east of and including Ottawa-Carleton and Grenville Counties total 6 700 ha, or 26% of the total study area gross increase. Here, it is probable that some agricultural land was abandoned where soils are difficult to manage. Elsewhere, only Simcoe and Lennox and Addington Counties gained over 1 000 ha. Most of the gain in Simcoe occurred in the northern half of the county. In Lennox and Addington, the increases were concentrated in Ernestown Township.

New wetlands are important since they partially offset wetland conversions. Loss and gain statistics, however, do not present the complete picture. Such wetlands may not have the same value as an undisturbed site. The new wetlands are almost all (94%) immature forest and scrubland abandoned over 10 years ago. It is important to note that some gains may only be temporary, awaiting improved economic prospects in agriculture or urban development.

The gains in wetland area may be overestimated. They were mapped on the assumption that the soils remained wet. While in general, upkeep of drainage installations is unlikely in abandoned agricultural areas, it is not impossible. As well, an abandoned area could be affected by a drain which drains surrounding cultivated land.

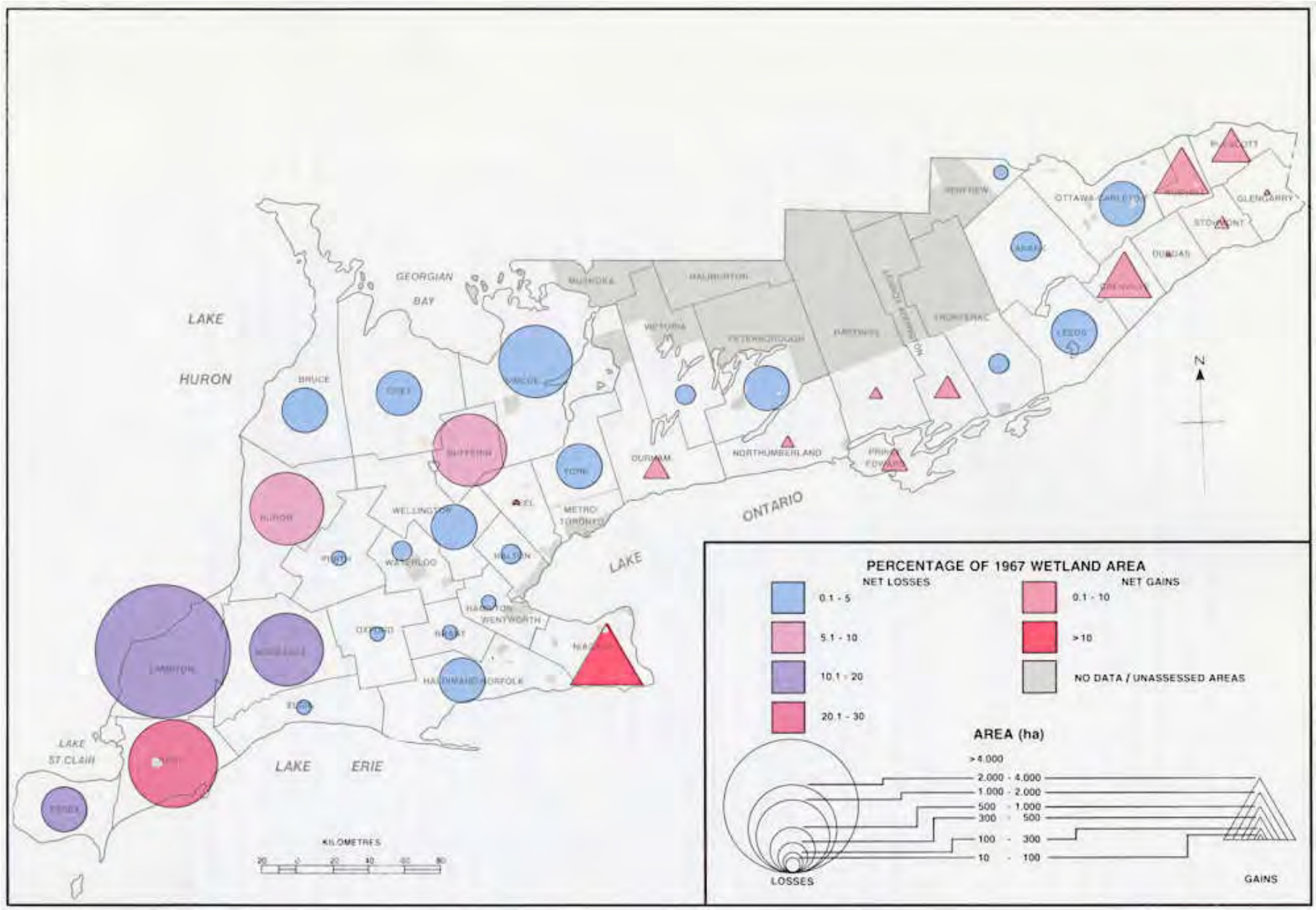
Relatively little expansion of marsh area was noted. One major marsh gain, however, in Hullett Township, Huron County, corresponds to a large Ducks Unlimited (Canada) project. Other projects of this organization were less evident since it has operated in Ontario for only part of the 15 year period under study and has tended to develop projects which were either smaller than 10 ha or involved management of existing wetlands.

The net decline in wetland area over the 1967 to 1982 period was 13 860 ha, an average of 924 ha per year (Table 3). Lambton County experienced the greatest net conversion, 4 160 ha, followed by Kent County, where 3 240 ha were lost (Figure 9). Huron, Middlesex, Dufferin and Simcoe Counties each had a net loss between 1 000 to 2 000 ha while the net loss in Essex was 1 000 ha. West of Toronto, all counties experienced net losses, with the exception of Peel where wetland changes were very small.

A number of counties had net wetland gains (Figure 9). The most significant include Niagara (3 000 ha), Russell (1 220 ha), Grenville (1 090 ha) and Prescott (540 ha). The Niagara net gain represents a 26% increase over its 1967 wetland area. Several other central and eastern Ontario counties had small net gains of less than 500 ha each.

The net decline from 1967 to 1982 represents 1.8% of the 1967 wetland area, an average reduction rate of 0.12% per year. The pattern of net wetland losses is similar to gross

FIGURE 9: Net Wetland Change By County, 1967 - 1982.



losses. Southwestern Ontario shows the greatest reduction, nearly equal to the gross conversion figures. Kent County experienced a 26% net loss of wetlands between 1967 and 1982. Essex, Lambton, and Middlesex also continue to reflect losses in the 10 to 20% range.

5.1.4 Land Use of Converted Wetlands -- 1967 to 1982

The following discussion applies to the area covered by full analysis as shown on Figure 1. It reports on the land uses to which wetlands were converted between 1967 and 1982 (Table 4). The underlying reasons for change are not examined in depth. For example, the results show agricultural land-use change is the major cause of wetland conversion while urban growth directly affects relatively few wetlands. Urban growth, however, is occurring on the better agricultural land in southern Ontario and may contribute to further wetland conversion in rural areas.

Of all southern Ontario wetland converted between 1967 and 1982, 81% became agricultural land; with 57% to farm operations based on cropland (intensive agriculture); and 24% to farms with a hay, pasture or grazing system (low intensity agriculture). Conversions to built-up areas are 5% of the gross total. Included in this figure are cottage and marina developments. Other recreational uses account for approximately 2% of the decline. Wetlands cleared but then abandoned are 6% of the converted wetlands. Extractive uses involve less than 1% of all wetland losses. Reforestation accounts for the remaining 5% wetland change.

In all parts of the study area, agriculture represents the major land use on converted wetlands (Figure 10). Between 1967 and 1982, 31 830 ha of wetland were converted to agriculture. This averages 2 122 ha per year.

Much of this change occurred in southwestern Ontario, but central and eastern Ontario also experienced considerable agricultural conversion (Figure 10).In most counties, agriculture occupies over 70% of the former wetland area. The only counties where less than half the wetland conversion is directly attributable to agriculture are Niagara, York and Russell. Counties with over 1 000 ha of wetlands converted to agriculture include Lambton, Kent, Huron, Essex, Middlesex Haldimand-Norfolk, Simcoe, and Ottawa-Carleton.

Intensive agriculture is the dominant land use to which wetlands were converted in southwestern Ontario. It is of lesser importance in the north and east (Figure 11). Of the 22 320 ha of wetland converted to intensive agriculture, 65% occurred in the seven southwestern counties of Kent, Lambton, Essex, Huron, Middlesex, Elgin, and Haldimand-Norfolk.

While most of the wetland area converted to agriculture were small, scattered sites, several large areas were converted. Examples occur just east of Cookstown in Innisfil Township, Simcoe County; an area just east of Winchester in Winchester Township, Dundas County (recently largely abandoned according to R. Humphries, pers. comm.); Thedford Marsh area in Bosnaquet Township, Lambton County, and a nearby area in McGillivray Township, Middlesex County.

TABLE 4. 1982 Land Uses Of Wetlands Converted Since 1967 By County*.

County***	Agriculture						Idle Land		Built-Up Uses		Reforestation		Recreation Uses		Extractive Uses	
	Intensive		Low Intensity		Total											
	ha	% of Total Change	ha	% of Total Change	ha	% of Total Change	ha	% of Total Change	ha	% of Total Change	ha	% of Total Change	ha	% of Total Change	ha	% of Total Change
Brant	160	88.4	20	11.6	180	100.0	0	0	0	0	0	0	0	0	0	0
Bruce	350	35.4	610	61.9	960	97.3	0	0	20	1.6	10	1.1	0	0	0	0
Dufferin	330	25.8	650	50.0	980	75.8	120	9.1	0	0	200	15.2	0	0	0	0
Dundas	320	73.5	90	20.6	410	94.1	10	3.0	10	2.9	0	0	0	0	0	0
Durham	260	54.7	80	18.0	340	72.7	40	8.1	40	8.0	10	2.0	40	9.2	0	0
Elgin	600	79.1	80	10.3	680	89.4	10	1.2	0	0	70	9.4	0	0	0	0
Essex	1150	90.4	40	3.0	1190	93.4	0	0	40	3.3	0	0	30	2.4	10	0.9
Frontenac**	60	8.2	560	83.3	620	91.5	0	0	50	7.2	10	1.3	0	0	0	0
Glengarry	170	43.1	190	48.0	360	91.1	40	8.8	0	0	0	0	0	0	0	0
Grenville	90	31.4	50	19.3	140	50.7	50	19.0	10	3.9	50	17.4	0	0	20	9.1
Grey	280	20.0	650	46.2	930	66.2	100	7.4	0	0	370	26.4	0	0	0	0
Haldimand-Norfolk	1210	71.1	150	8.7	1360	79.8	20	1.3	90	5.5	110	6.4	120	7.0	0	0
Halton	70	31.2	60	27.4	130	58.6	0	0	60	24.1	0	0	0	0	40	17.3
Hamilton-Wentworth	210	36.7	270	47.7	480	84.4	0	0	0	0	0	0	40	6.7	50	9.0
Hastings**	90	26.8	120	37.5	210	64.3	0	0	100	29.6	0	0	20	6.0	0	0
Huron	1830	75.7	190	8.0	2020	83.7	30	1.1	40	1.5	190	7.9	140	5.8	0	0
Kent	3610	95.9	10	0.4	3620	96.3	100	2.7	40	1.1	0	0	0	0	0	0
Lambton	4400	89.2	130	2.7	4530	91.9	0	0	370	7.4	0	0	20	0.5	10	0.2
Lanark	120	15.9	610	78.4	730	94.3	40	5.7	0	0	0	0	0	0	0	0
Leeds	90	8.4	860	84.3	950	92.7	70	6.6	0	0	0	0	0	0	10	0.7
Lennox and Addington**	200	26.4	530	68.2	730	94.6	10	0.9	30	4.4	0	0	0	0	0	0
Middlesex	1720	84.4	190	9.2	1910	93.6	40	2.1	40	2.1	10	0.7	30	1.4	0	0
Niagara	170	30.2	40	6.1	210	36.8	190	33.5	150	25.3	0	0	10	1.2	20	3.7
Northumberland	120	22.9	180	33.1	300	56.0	150	28.3	60	11.3	0	0	20	4.5	0	0
Ottawa-Carleton	640	34.7	710	38.4	1350	73.1	280	15.4	100	5.2	0	0	100	5.6	10	0.7
Oxford	360	69.9	120	23.1	480	93.0	10	1.8	0	0	0	0	0	0	30	5.2
Peel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	100.0
Perth	410	60.1	230	34.2	640	94.3	20	3.5	20	2.2	0	0	0	0	0	0
Peterborough**	330	27.5	660	55.4	990	82.9	30	2.5	110	9.0	0	0	60	4.6	10	0.9
Prescott	170	25.9	250	39.6	420	65.5	0	0	20	2.6	60	9.3	140	22.5	0	0
Prince Edward	60	85.1	10	14.9	70	100.0	0	0	0	0	0	0	0	0	0	0
Renfrew**	0	0	20	100.0	20	100.0	0	0	0	0	0	0	0	0	0	0
Russell	60	15.1	60	14.7	120	29.8	10	3.8	0	0	250	64.5	0	0	10	2.0
Simcoe**	1170	48.9	210	8.6	1380	57.5	310	13.0	260	11.0	330	13.7	120	4.8	0	0
Stormont	160	44.0	80	20.8	240	64.8	50	14.6	0	0	30	9.3	20	6.0	20	5.4
Victoria**	120	25.1	240	50.2	360	75.3	20	3.4	100	21.3	0	0	0	0	0	0
Waterloo	170	50.5	110	30.6	280	81.1	20	6.7	20	6.1	0	0	20	6.1	0	0
Wellington	620	53.6	310	26.6	930	80.2	80	6.9	50	4.4	90	7.5	10	1.0	0	0
York	440	32.7	120	9.2	560	41.9	560	41.1	100	7.5	80	6.3	10	0.9	30	2.4
Full Study Area	22 320	56.8	9 510	24.2	31 830	81.02	430	6.2	1 920	4.9	1870	4.8	960	2.4	280	0.7

* Percentages and Full Study Area statistics were calculated from non-rounded area statistics. All area statistics are shown to the nearest 10 ha.

** Large part of county not included in 1982 study *area.* Haliburton, Metro Toronto and Muskoka not shown because no 1967-1982 wetland conversion in the limited 1982 research area. *** Only for that part of each county with full analysis: for extent see Figure 1.

FIGURE 10: Wetland Converted To Agriculture By County, 1967 - 1982.

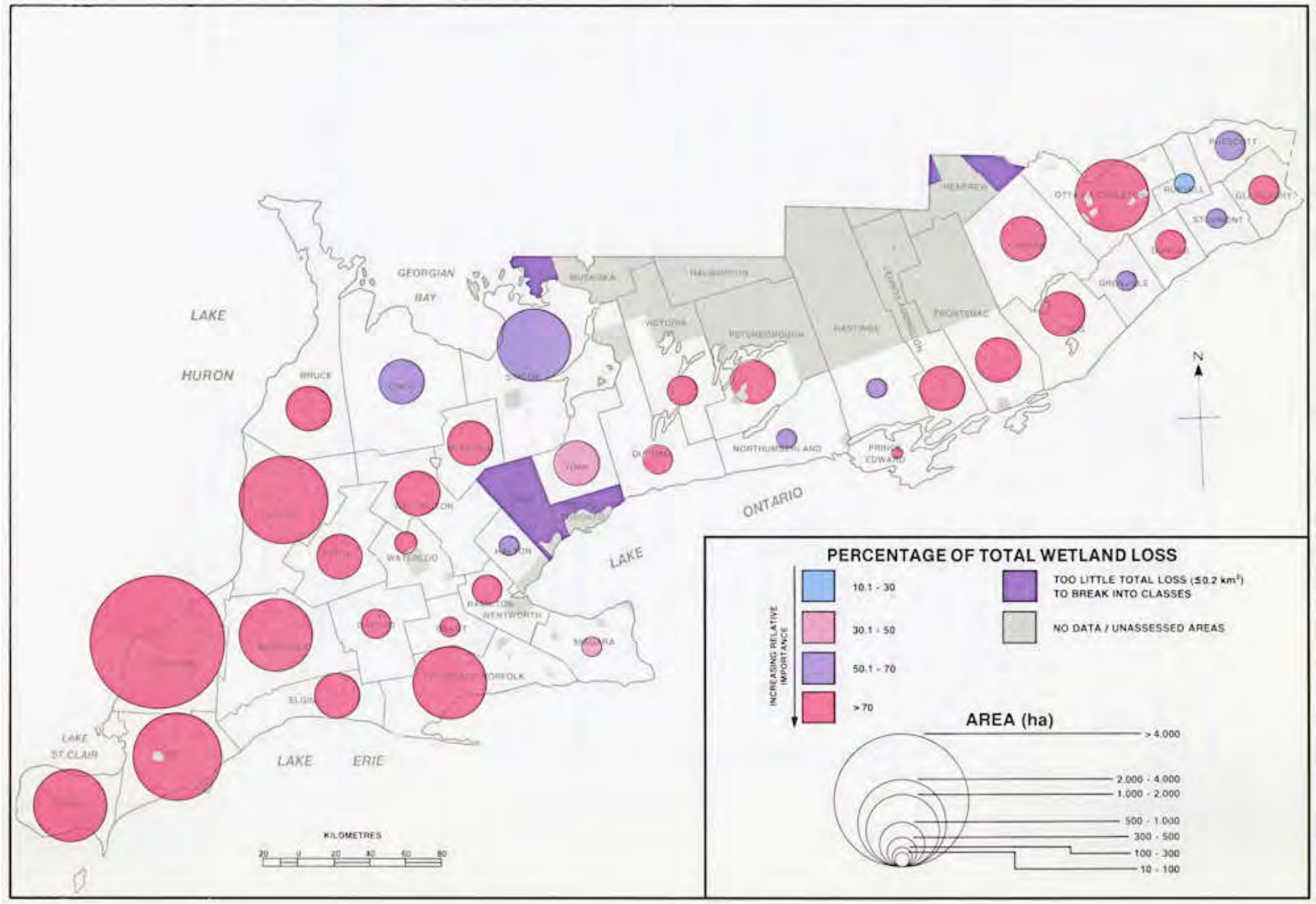
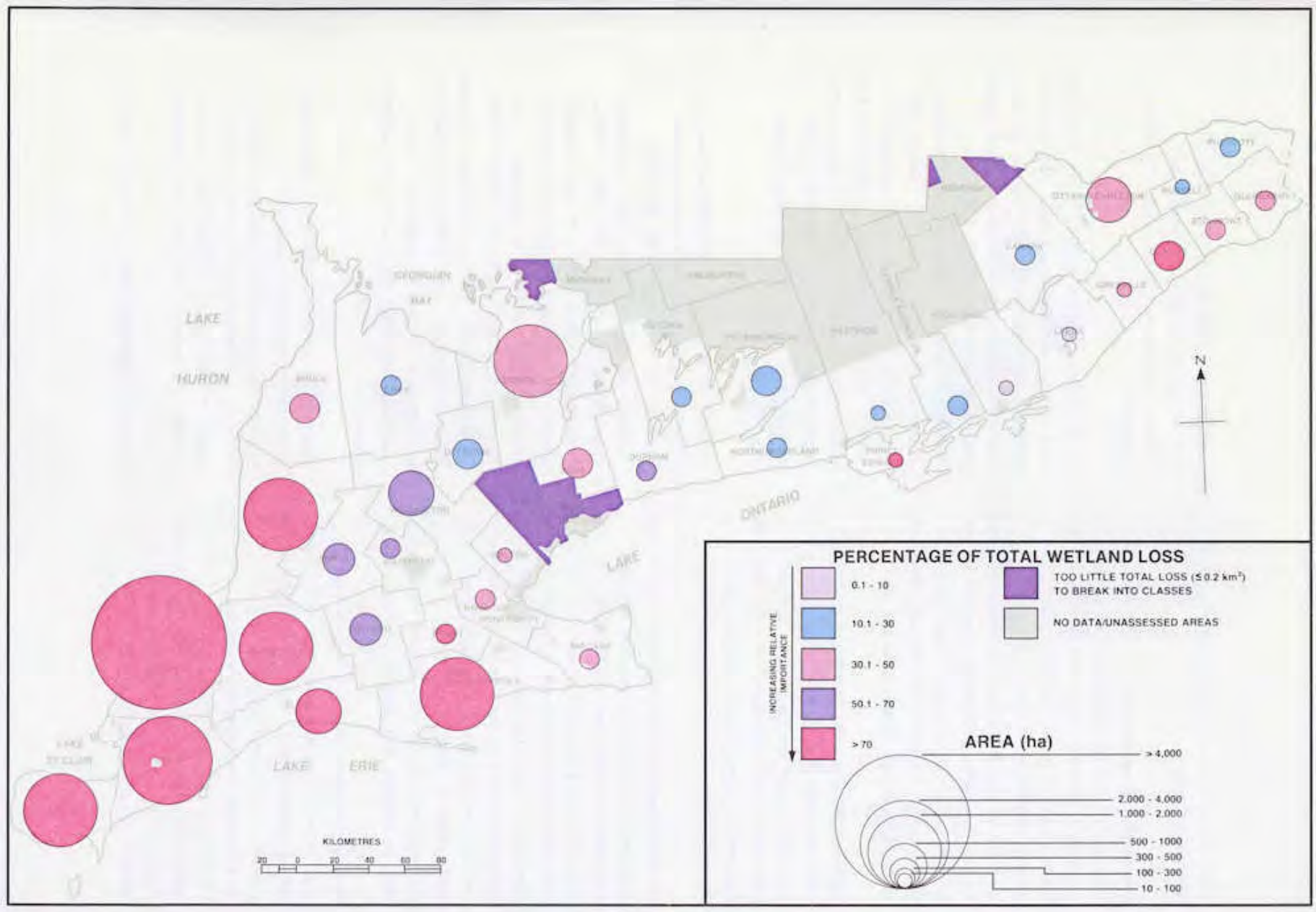


FIGURE 11: Wetland Converted To Intensive Agriculture By County, 1967 - 1982.



Low intensity agriculture was the dominant land use in wetland conversion in several counties bordering the Shield as well as in Bruce County. It is not significant in extreme southwestern Ontario (Figure 12). Over 60% of the 9 510 ha of wetland converted to low intensity agriculture occurred in the northern counties of Bruce, Grey, Dufferin, Peterborough, Lennox and Addington, Frontenac, Leeds, Lanark and Ottawa- Carleton.

Between 1967 and 1982, 2 430 ha of wetland which had been cleared or drained were abandoned to become idle land. Fifty-five per cent of the total conversion to idle land occurred in York, Simcoe, Niagara, and Ottawa-Carleton Counties (Figure 13).

Of these counties idle land was a significant proportion (30-50%) of the total wetland conversion in only York and Niagara. In Simcoe County almost all of the idle land surrounds Barrie in Vespra, Essa and Innisfil townships. The idle land data for York includes an area in Keswick Marsh which has been returned to productive agricultural use since 1982 (M. Valk, pers. comm.).In Niagara, most of the conversions to idle land were in an area just east of Welland.

Between 1967 and 1982, 1 920 ha of wetland were converted to built—up uses, including cottage development. The central Ontario counties of Simcoe, York, Victoria, Peterborough, and Hastings together with the counties of Lambton, Niagara, and Ottawa-Carleton account for 67% of this total (Figure 14). The high figures for central Ontario are due largely to cottage development. Most of the conversions to built-up uses in Lambton, Niagara and Ottawa-Carleton were associated with urban expansion.

In no county does built-up land use exceed 30% of the total wetland converted. For lakeshore wetlands, however, even small losses can be a concern. In the area between the Great Lakes and the Precambrian Shield, lakes and associated lakeshore wetlands are relatively uncommon. This has raised their value both for wildlife and for cottage development sites. The concentration of wetland loss to cottage development in Simcoe, Victoria, and Peterborough Counties corresponds to the proximity of inland lakes to major urban population centres.

Wetland conversions to recreational uses other than cottage or marine development totalled 960 ha between 1967 and 1982. Included are golf courses, picnic grounds, camp grounds and parks. For some of these uses wetlands could remain in their natural state. No distribution pattern of wetland conversion to recreation is apparent. The largest areas (100-140 ha) occurred in Huron, Haldimand-Norfolk, Simcoe, Ottawa-Carleton and Prescott counties. Recreation has played only a minor role in wetland conversion in all counties; totalling only 2.4% of all wetlands converted.

Between 1967 and 1982, 280 ha of wetland were converted to extraction uses with the greatest concentration in Hamilton-Wentworth (50 ha). Incremental harvesting of peat by deeper extraction for horticulture in areas already converted in 1967 was not determined.

The study indicates that 1870 ha of original wetland have been reforested. Unlike the other land uses, this figure cannot be

FIGURE 12: Wetland Converted To Low Intensity Agriculture By County, 1967 - 1982.

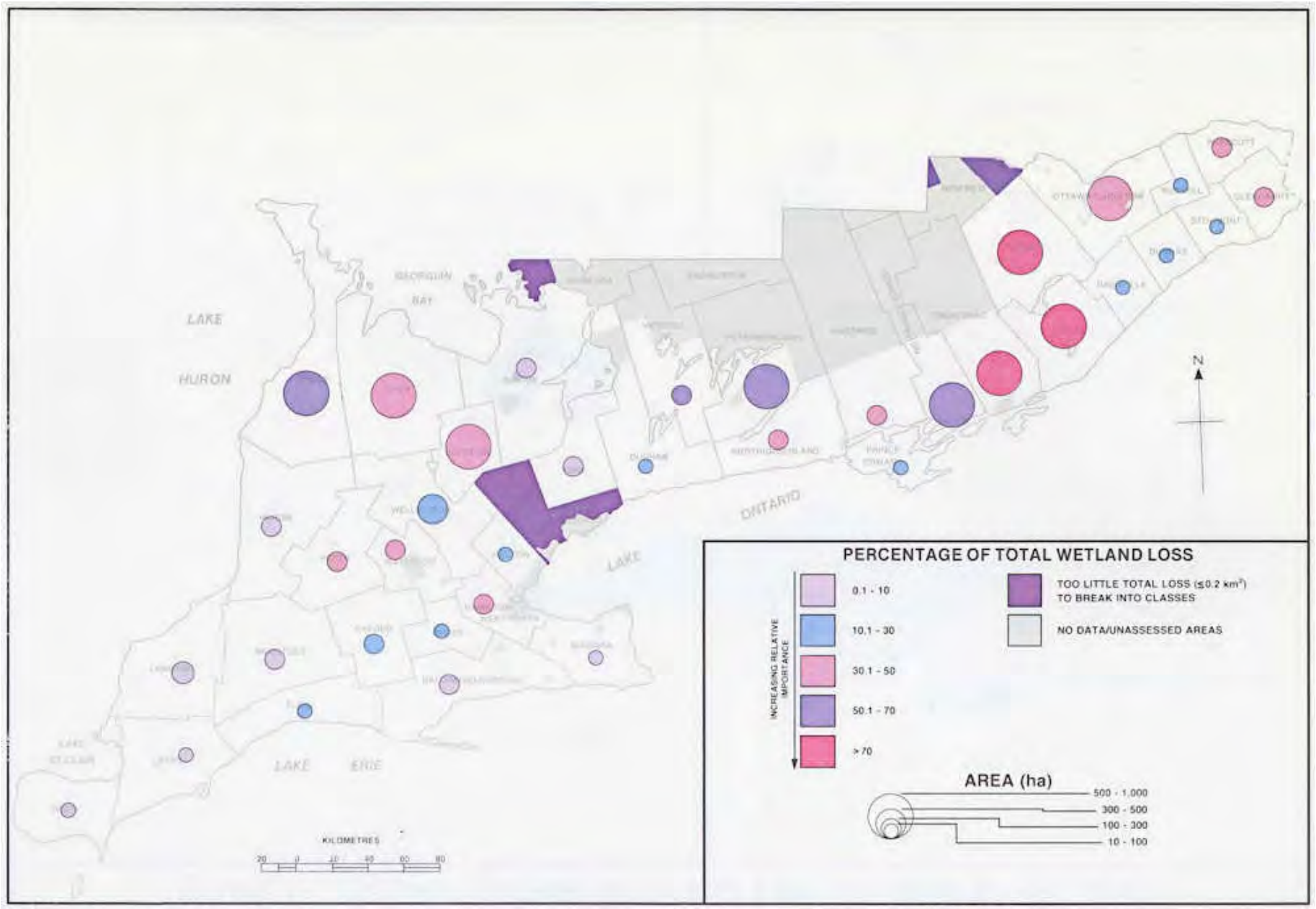


FIGURE 13: Wetland Converted To Idle Land By County, 1967 - 1982.

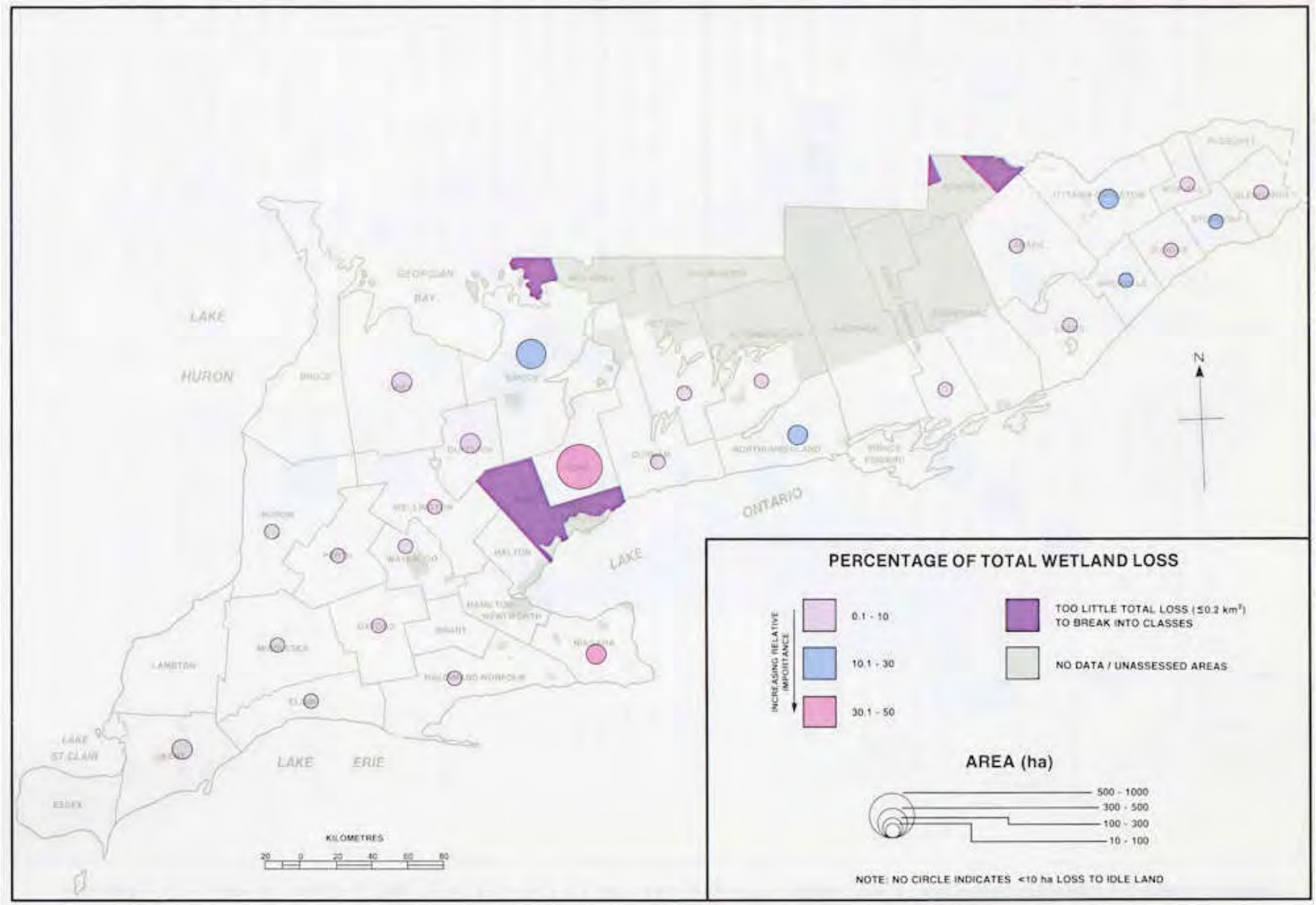
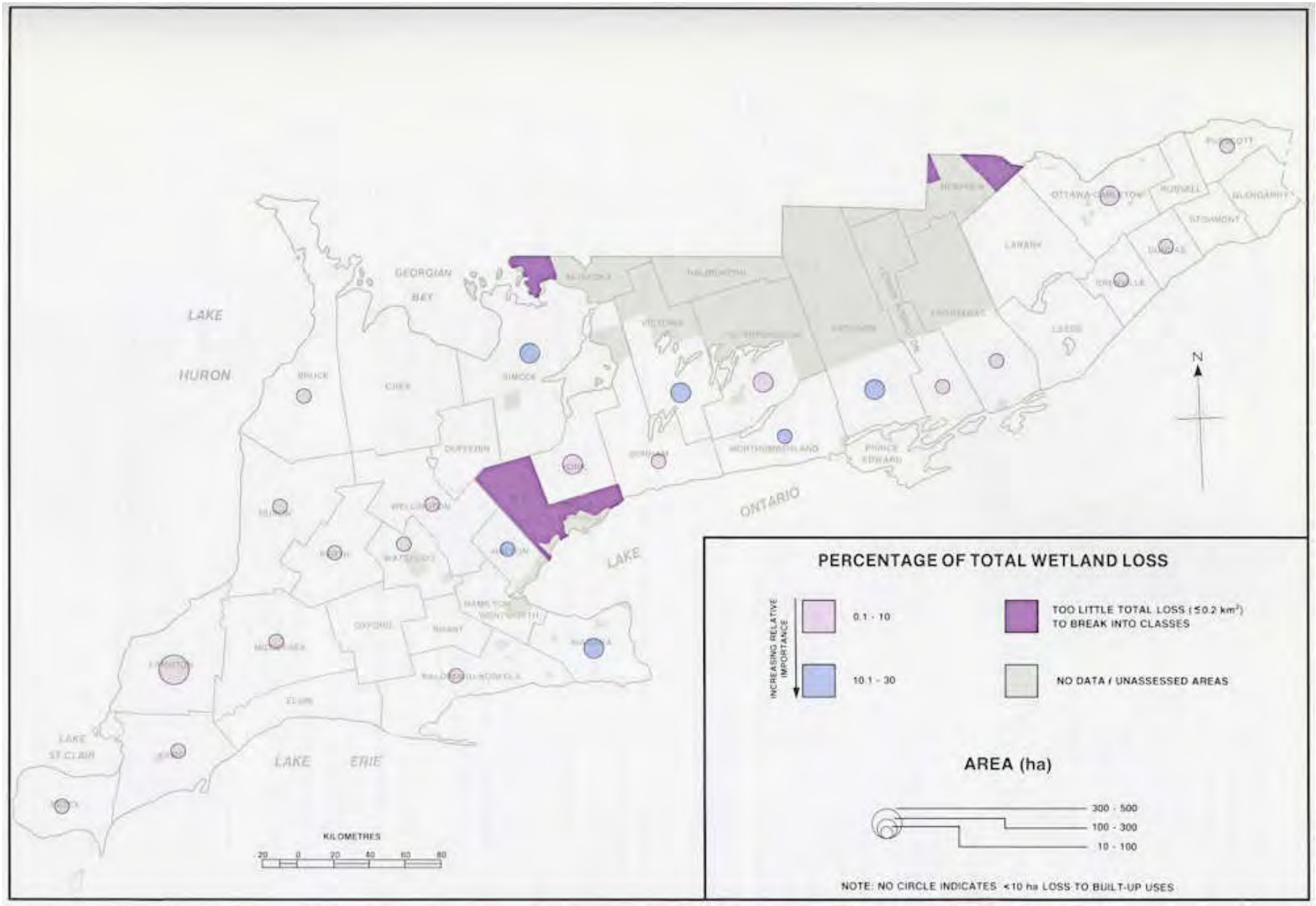


FIGURE 14: Wetland Converted To Built-up Uses By County, 1967 - 1982.



attributed to only the 15 year period 1967 to 1982. The 1967 CLI land use coverage did not have a separate class for reforested areas. Thus, it is not possible to separate pre- and post 1967 reforestation. It is also difficult to distinguish between mature reforestation and natural woodland. In addition, it can be argued that reforestation does not constitute wetland loss provided the area has not been drained.

The largest areas of reforested wetlands occurred in Grey, Simcoe, Huron, Dufferin, Haldimand-Norfolk and Russell counties which collectively account for 78% of the total. About 50% of wetland conversion due to reforestation occurred in Vespra Township, Simcoe County; Cambridge Township, Russell County; and in south Norfolk *of* Haldimand-Norfolk County.

5.2 Comparison of Analysis with Existing Statistics

For estimates *of* the pre-settlement wetland area in southern Ontario, the present study used an approach very similar to that of Cox (1972) and Bardecki (1981). Consequently the 2.38 million ha calculation compares closely to Cox's estimate of 2.32 million ha; and Figure 3, showing the area originally wetland, is very similar to Bardecki's map of areas originally in need of drainage.

There are, however, significant differences in the estimates of the current wetland area for southern Ontario. The results from the present study are 77% of those of Cox (1972) and about twice those of Bardecki (1981) and Rowntree (1979) (Table 5) . County wetland area figures from Bardecki and Cox were found to vary considerably from those of the present study.

TABLE 5. Comparison Of Wetland Area Statistics For Southern Ontario.

Other Source	Study Area	Total Wetland Area from Other Sources (ha)	Wetland Area from Present Study**	
			Hectares	As % of Other Sources
A: Current Wetlands				
Cox (1972) results for c.1950	South of Muskoka-Haliburton Renfrew* except Brant, Haldimand-Norfolk, Middlesex, Northumberland, Peterborough	960 000***	735 000	77
Rowntree (1979)	South of Shield	276 000	647 000****	234
Bardecki(1981)	South of Muskoka-Haliburton-Renfrew*	458 000	909 000	198
B: Converted Wetlands Cox (1972)	South of Muskoka-Haliburton-Renfrew* except Brant, Haldimand-Norfolk, Middlesex, Northumberland, Peterborough	1 145 000***	1 313 000	115

* While Cox and Bardecki each originally included Renfrew, it was excluded from this table to provide compatibility.

** Figures were calculated for the same study area as used by the other source.

*** Calculated using Cox's cleared wetland estimates based on Soil Reports where available; otherwise his Forest Resources Inventory estimate was used.

**** Townships more than 90% off the Shield were included.

Cox's results were intended to be approximate. To estimate remaining wetland area, brief text summaries about the land use on each county soil type were translated into arbitrary percentages. For example, 'much cleared' was set at 50% cleared: 'some cleared' to 10%. Total forest land was used as an estimate of the maximum possible remaining wetland.

In the study by Bardecki (1981) NTS map sheets were used to estimate current wetland area. This method missed over half the wetland area determined by this study. An evaluation of results with those of Rowntree is not possible as his method is not documented.

Cox (1972) estimated long term wetland conversion since settlement at 1.14 million ha. The present study's estimate adjusted to the same area is only slightly higher at 1.31 million ha. Cox's estimate of conversion was 55% of the original area, while the present study documents a 61% loss.

Other wetland conversion estimates have been made for small areas, such as lakeshore perimeters, within the study area. The losses in the Pelee area studied by Rutherford (1979); and also those documented by McCullough (1981) and Whillans (1982) along western Lake Ontario are similar to the conversions of original wetlands documented for the corresponding townships in this study.

Few recent loss estimates exist. Michigan, a state adjacent to southern Ontario, is losing wetlands at 0.2% per year (Tiner, 1984), a figure of the same order of magnitude as 0.12% per year found by the present study. In Ontario, Bardecki's study, covering less than 10% of the present study area, produced a very similar estimate of a 0.11% decrease per year.

Reid (1981) quoted a loss rate of 1-2% per year or 3 640 ha per year. This area figure is only about 40% higher than the current gross loss rate of the present study. Some of the difference may result from the higher area of current wetland (specifically swamps) estimated in the present study compared to earlier studies.

The only study which covered a similar time period to this study is by McCullough (1981) for the Lake St. Clair shoreline. His estimate of a 25% loss from 1965 to 1978 compares well with a 26% loss from 1967 to 1982 estimated by the present study for the corresponding county of Kent.

No study has measured land uses encroaching on wetlands for all of southern Ontario. Bardecki's (1981) results from a small sample area, compare well with those of the present study for southern Ontario. Indeed, by dropping the reforestation class, both studies found that agriculture accounts for 85% of recent wetland loss. This figure is also very close to that of the lower 48 states of the United States where agriculture accounted for 87% of recent wetland losses (Finer, 1984).

Gierman (1977) found the rate of recent wetland loss to urban development to be less than a third of that estimated by this study. His study included only the rural-urban fringe of major cities and is based on CLI land use data within trends to underestimate swamps.

5.3 Wetland Conversion Since 1982

While the study period ends at 1982, activities having the greatest impact on wetland decline may offer clues to current and future trends.

The two types of wetland encroachment of most concern identified by this study are agriculture and lakeshore cottage development.

Since 1982, agricultural profits have generally declined. Operations are over-expanded, land values are falling, and interest payments on past investments are high. Farmers are making fewer investments, including land clearance (B. Fraser, pers. comm.). Some farmers are also seeing more value in their wetlands for fuel wood sources and erosion control (B. Fraser, pers. comm.; R. Humphries, pers. comm.). Market gardening on peat soils has been discouraged by lack of markets and lack of distribution infrastructure in areas far from traditional muck farming centres (M. Valk, pers. comm.).

Some farmers continue to remove small wetland areas for ease of operation of huge farm machinery (B. Fraser, pers. comm.). It is anticipated that agricultural encroachment on wetland has probably slowed since 1982.

Future wetland conversions to agriculture will depend on the farm economy, on farmer and society awareness of wetland values, and on government policy. Some wetland conversions may be risky for farmers. If tobacco farmers switch to vegetable production, expansion of farming on muck soil may be even less promising than today (M. Valk, pers. comm.). Part of the wetland gains on abandoned lands may be lost if old drains are restored (T. Mathers, pers. comm.) or if land speculators offer longer leases (R. Stork, pers. comm.). These areas, however, may tend to be low value wetlands and possibly of greater social benefit under crops.

The pressure to clear established wetlands will probably be greatest for wet mineral soils in southwestern Ontario where soils are very productive and land prices the highest. In this case, those areas which have experienced the most serious past wetland conversions, will continue to be the most threatened.

Cottage development trends seem to be decreasing on lakeshore marshes in central Ontario. There are fewer available new cottage sites and a growing awareness of encroachment problems among both cottagers and permit issuing agencies. The slower conversion trend will probably continue (T. Mathers, pers. comm.).

In the last few years, Ducks Unlimited (Canada) activities have expanded. Part of the effort goes towards maintenance and restoration of waterfowl habitats. As Ducks Unlimited creates more new wetlands, it will influence wetland gain statistics accordingly.

5.4 Summary

Prior to settlement there were about 2 380 000 ha of wetland in southern Ontario, covering 25.5% of the total area. Concentrations occurred in extreme southwestern Ontario and far eastern Ontario. By 1982 about 933 000 ha remained which represents 10% of the study area. Of the original wetland area, 61% had been converted (68% south of the Precambrian Shield) to other land uses. Wetlands are more prevalent now in the northern and eastern half of the study area than in the southern and western portions. Eighty-six percent of the 1982 wetlands were forested.

Since settlement, extensive wetland conversion has occurred in southwestern Ontario, the Niagara Peninsula, sections of the

Lake Ontario shoreline, and parts of eastern Ontario. Precambrian Shield areas show low conversion rates.

Between 1967 and 1982, the southern Ontario study area, where recent analysis was possible (Figure 1), lost 39 290 ha of wetland, and gained 25 430 ha for a net loss of 13 860 ha, or 1.8% of the 1967 wetland area. Some areas, particularly in southwestern Ontario, have undergone significant wetland conversion between 1967 and 1982. For example, the net wetland loss in Kent County was 26% of the 1967 area. These conversion estimates are conservative. They exclude loss of marshes within lakes, of areas smaller than 10 ha, and large areas of degraded but remaining wetlands.

Agriculture accounted for about 85% of the recent conversions across the study area. In southwestern Ontario, conversions to intensive agriculture dominated, while in central Ontario and Bruce County conversion to low intensity agriculture was most prevalent. Wetland decline to cottage development was a significant factor for lakeshore wetlands in central Ontario counties. Recent losses to urban development, idle land, recreation, extractive uses and reforestation were generally minor and localized.

Table 6 summarizes the regional results in decreasing order of original wetland area. Counties are grouped into regions on the basis of past and current wetland status. The Precambrian Shield and Renfrew County did not have enough recent data to be included. The southwest, where the wetland area has dropped from 61% to 6%, shows the most dramatic wetland declines. In 1982, the highest regional wetland occurrence was in Peterborough County.

The 1:50 000 maps provide approximate wetland locations at a regional scale for southern Ontario. They are particularly accurate for swamps, the predominant wetland class. The maps indicate wetland loss since settlement and between 1967 and 1982. Again, they are most accurate for the loss of swamps and inland wetlands. Finally, the maps are a reference point for monitoring future wetland change which will require only new land use information.

This study provides the most comprehensive data available for wetland distribution and conversion in southern Ontario. The results compare well to several detailed local studies for the corresponding areas. This indicates the relative accuracy of the results for all of southern Ontario.

6. CONCLUSIONS

The wetland mapping method presented here demonstrates that appropriate existing data can be interpreted to efficiently derive new information and to help direct effective field research. More wetlands, particularly swamps, are now mapped than had been recognized in the past. Many swamps had been overlooked because of unrecognized values or because of difficulty in identifying them.

The conservative estimates of the rate of wetland conversion for this study are, on average, lower than some other recent estimates.

TABLE 6. Regional Wetland Situation In Southern Ontario.

Regional Grouping	Counties***	Wetland as % of Region		Gross Loss 1967-82		Net Changes 1967-82		Major Conversion Uses
		c.1800	1982	Hectares	% of 1967 Wetland	Hectares	% of 1967 Wetland	
Southwest	Essex, Kent, Lambton	61.1	6.1	9 950	18.6	-8 400	15.7	Intensive agriculture
East	Prescott, Russell, Glengarry, Dundas, Stormont, Grenville, Ottawa-Carleton	47.6	15.6	4 340	3.0	+2 360**	1.6	Intensive and low intensity agriculture
Niagara, eastern Lake Erie	Niagara, Elgin, Haldimand-Norfolk, Hamilton-Wentworth	29.5	7.0	3 620	7.0	+1 980**	3.8	Intensive agriculture
Peterborough	Peterborough*	28.5	23.7	1 190	1.9	- 580	0.9	Low intensity agriculture, localized cottage development
East Central	Lanark,* Leeds, Lennox and Addington*, Victoria*, Hastings*, Frontenac,* Prince Edward	24.6	12.6	4 090	2.4	- 840	0.5	Low intensity agriculture, localized cottage development
Central Lake Huron	Huron, Perth	24.3	5.0	3110	10.5	-1 600	5.4	Intensive agriculture
Northern Lake Huron, southern Georgian Bay	Dufferin, Bruce Grey	22.4	11.4	3 690	3.2	-2 810	2.4	Low intensity agriculture
West Central	York, Northumberland, Wellington, Simcoe*, Durham	15.9	8.7	5 930	4.9	-2 180	1.8	Intensive agriculture, localized built-up uses
West and western Lake Ontario	Middlesex, Oxford, Brant, Waterloo, Halton, Peel, Metro Toronto	11.3	3.9	3 310	7.8	-1 950	2.3	Intensive agriculture, localized urban development

* Townships greater than 90% on Shield are not included in county statistics.

** Gains tend to be low value wetlands located in areas of scrubland and immature forest.

*** Renfrew County not included on table.

Other published estimates have been derived from a study of smaller areas and cannot necessarily be extrapolated to all of southern Ontario.

The net conversion statistics confirm certain areas are experiencing major declines of wetlands. At recent rates, all Kent County wetlands will be gone in 50 to 60 years. Southwestern Ontario, already deficient in wildlife habitat, is rapidly losing scarce wetlands. Lake Erie counties, the Niagara Peninsula and central southwestern Ontario counties have relatively few remaining wetlands. In eastern Ontario long-term losses have been high.

The report does not consider indirect degradation of wetlands. Bardecki (1981) estimated wetland area damaged by partial drainage to involve three times the area of wetland removal. Other actions such as road crossings and siltation from upstream erosion can cause significant loss of wetland value.

In 1800, wetlands were a common feature of the southern Ontario landscape. By 1982, wetlands had become a scarce and critical resource particularly in intensive agricultural regions.

7. RECOMMENDATIONS

i) The 'Third Approximation' maps can be used to locate wetlands and identify wetland conversion at a regional scale. They should be of particular use for provincial and regional planning.

ii) Any further conversion studies should concentrate on wetland types not included in the mapping of this or previous reports. These include bottom land wetlands, wetlands under 10 ha and marsh areas within lakes other than Lakes Ontario and St. Clair.

iii) An update of the wetland maps in ten to fifteen years should be adequate. Updated land use information, preferably showing marsh vegetation in water bodies, would be required for monitoring purposes (see Section 4.4). Monitoring on a five year basis should be considered for areas of serious wetland decline such as Kent, Essex, Lambton, Middlesex and Huron Counties. The county unit will continue to be useful for data summaries. Such monitoring will be essential to effectively assess the impact of federal programs on wetlands.

iv) If complete updated land use is not available, a representative sample could be produced through interpretation of remote sensing products. For example, the 8 NTS maps used by Bardecki (1981) or a representative set of counties would form an appropriate sample. Such samples would allow representative monitoring of wetland conversion trends. Similarly, wetlands evaluated as high value could be monitored.

v) Wetland degradation should be monitored for area, rate, distribution, causes and decline of wetland value, and to determine mitigation measures.

vi) Wetland gains mapped by the 'Third Approximation' should be evaluated using the approach developed by the federal and provincial governments (Ontario Ministry of Natural Resources and Environment Canada, 1982).

vii) The mapping methodology should be considered for other regions in Canada if the scale and precision of soil, land use and topographic maps are comparable and compatible with the wetland sizes of most interest.[1]

viii) It is important that prime resource lands, whether they be wetlands or agricultural lands, be protected for renewable resource production. In addition, greater targetting and evaluation of incentives for land improvements should be achieved to ensure the maintenance of environmental quality and sustainable renewable resource production.

ix) Federally-owned wetlands in southern Ontario should be maintained. Their importance is evident in southwestern Ontario where Point Pelee National Park, and St. Clair, Big Creek, and Long Point National Wildlife Areas ensure minimum wetland protection in these critical areas.

x) Existing federal legislation, policies, and programs should be evaluated to ensure they are used to their full potential to conserve wetlands and limit wetland losses.

xi) Effective and coordinated federal actions would be facilitated by the development of a wetlands conservation policy. Such a policy would cover both use and protection of wetlands from a federal perspective.

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[1] For more information, see Kessel-Taylor (1983)

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APPENDIX A

EVALUATION OF WETLAND DATA SOURCES AND MAPPING METHODS

EVALUATION OF WETLAND DATA SOURCES AND MAPPING METHODS

Wetland conversion studies can be completed by field investigation, remote sensing techniques or by interpretation of existing data bases. These methods were evaluated against the study data requirements of mapping current wetlands and wetland conversion; at a scale close to 1:50 000; consistently across the study area; and in compliance with the wetland definition of Section 2. The need to minimize cost and time for a study covering 93 300 km^2 was also considered.

Several methods were judged not cost and time efficient for the present study:

Field Work: Based on an Ontario Ministry of Natural Resources' estimate of 10 000 wetlands in southern Ontario and an ambitious mapping rate of five wetlands per person per day at $100/day salary and travel expenses, the cost for current wetland maps alone would be $200 000. This approach would not map losses or land use change.

Large Scale Aerial Photography: Interpretation from 1:10 000 aerial photographs costs $1.77/$km^2$ of study area including purchase of existing photography (Yatabe, 1984). At this rate, it would cost $166,000 to cover southern Ontario. If photography must be specially flown, costs would be much higher.

Computer: Costs for soil and land use data input, overlay and output on the Lands Directorate's Canada Land Data System were estimated as $111,000 or $1.19/$km^2$. Distortions in the original maps from the use of unstable base maps would need to be corrected prior to establishing the computer data base. Some methods could not adequately fulfill the wetland definition:

Satellite imagery: The usefulness of satellite imagery for mapping wetlands in latitudes such as northern Ontario has been demonstrated (Telford, 1983). In landscapes similar to southern Ontario, it was concluded that it is not possible, with LANDSAT-D data, to separate all classes of wetlands from other land uses (Ernst-DoHavio et al, 1981). In thickly forested areas, this satellite imagery cannot distinguish between wet and dry soils.

L-band radar imagery, however, can penetrate vegetation. But, while Lyon and McCarthy (1981) found that it provided good potential for wetland mapping, Prout (1980) concluded that this imagery also failed to distinguish between some types of wetlands and other land uses. Satellite imagery alone would also not cover long-term wetland losses.

Soil maps: Soil maps show areas of original pre-settlement wetlands. Wetland conversions and present day wetlands are, however, not distinguishable.

Land use maps: Canada Land Inventory (CLI) Present Land Use maps and Ontario Ministry of Agriculture and Food Land System maps miss most swamps by grouping them with upland forests. These maps alone do not allow interpretation of long-term wetland losses.

National Topographic System (NTS) maps: NTS maps are inexpensive to use but do not allow conversion analysis. They are also seriously limited by the inadequate coverage of swamps. Results of a wetland study of the Credit River watershed (Yatabe,

1984) have been analyzed to show NTS maps missed 65.5% of the wetland area derived from interpretation of 1:10 000 aerial photography. Research work in non-bedrock areas of northwestern Ontario found NTS maps missed 64% of the swamp area (Snell and Cecile, 1985).

Existing wetland maps, both current and historic, cover only small and scattered parts of the study area at various scales. While it is not possible to develop a comprehensive wetland data set from existing maps, they can be used for quality control of other methods. Notes of the first surveyors offer some data on original wetland locations but less than can be interpreted more easily from soil maps.

Method Chosen

The manual overlay of land use and soils maps comes closest to providing all the required wetland data while staying within reasonable cost limits. Yet, this method is not perfect. It misses some marsh areas within lakes where soils or land use are not mapped. Most county soil maps are at a scale comparable to 1:50 000, but a few are mapped at 1:126 720.

Fortunately these two relatively minor weaknesses correspond with NTS maps strengths. The latter recognize marshes better than swamps and a complete 1:50 000 coverage is available.

The method selected used a combination of the manual overlay of land use and soils maps with supplementary information derived from NTS maps. This combination was judged to best fulfill the method requirements of this study.

APPENDIX B

DATA SOURCES FOR PRODUCTION AND VERIFICATION OF THE 1:50 000 WETLAND MAP SERIES

DATA SOURCES FOR MAP PRODUCTION

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APPENDIX C

PROBLEMS AND CORRECTIVE ACTIONS FOR SECOND APPROXIMATION MAPPING OF SOUTHERN ONTARIO WETLANDS

APPENDIX G. Problems And Corrective Actions For Second Approximation Mapping Of Southern Ontario Wetlands

Source	First Approximation Problems	Second Approximation Revisions
Soil Maps & CLI Agricultural Capability Maps	▸ old age and small scale for some counties	▸ counties with new soil maps since CLI were redone with new data: these were Waterloo, Haldimand-Norfolk, Ottawa-Carleton and parts of Niagara
	▸ shifts in map unit boundaries during publication especially in Dufferin but also Bruce, Brant and Prince Edward counties	▸ corrected using NTS contours: wet soils were shifted off hillsides onto low flat areas
	▸ 60% to 80% accuracy of soil units, depending on map scale; small inclusions of other soil types cannot be shown	
	▸ limited recognition of ephemeral wet areas (e.g. beaver ponds)	▸ added by reference to NTS maps
CLI Agricultural Capability Maps	▸ a few wet soil polygons missed	▸ checked every map for omissions
	▸ mistakes by CLI in transfer of lines and interpretations from soil maps	▸ briefly checked each agricultural capability map against corresponding soil maps to catch mistakes
CLI Land Use Maps	▸ lack of data in parks classed as 'recreation'	▸ obtained land use maps from national and provincial parks for wetland extent
	▸ lack of data for various other properties (e.g. Ontario Hydro)	▸ used NTS maps: green on NTS indicates forest; white indicates non-forest
	▸ omission of regenerating meadows because no unique land use class	▸ added by reference to NTS maps
	▸ 15 years out of date - wetland changes since 1967	▸ (this revision was carried out by the Third Approximation update)
	▸ immature forest grown to mature so incorrectly labelled	▸ combined immature and mature forest into one class,'tree and shrub land'
	▸ a few natural land use polygons missed	▸ checked every map for omissions
Final Overlay Maps	▸ anomalies with very small wetlands: both missed wetlands and mapped ones that were not wet. Minimum unit size on soil maps is about 10 ha; a derived overlay can be no more accurate	▸ dropped all wetlands smaller than 10 ha if mapped via the overlay. Small wetlands occur, but are beyond the resolution of this method
	▸ bottom land wetlands often omitted because of lack of wetness data	▸ added by reference to NTS maps and by inclusion of bottom land as potential wetland if adjacent upslope soils were wet
	▸ mistakes by wetland mappers	▸ checked every map for mistakes
NTS Maps	▸ to save time, the First Approximation used NTS base maps on which agricultural capability was mapped. These maps had only sporadic inclusion of the wetland symbol	▸ encircled all wetland symbols on a complete set of NTS maps: when these areas not indicated by overlay, they were added, giving green a forested label, white an open wetland label. The 10 ha minimum area for the overlay was not applicable
	▸ marshes within lakes often omitted because of above problem	▸ added many by above revision; also consulted Canadian Wildlife Service maps (1981) for Great Lakes marshes and CORTS maps (1981) for Rideau-Trent-Severn marshes
General		▸ changes to some specific wetlands from data sent by various users at each step, checked boundaries of all adjacent maps for correspondence
Drafting	▸ hand done and of variable quality	▸ completely redrafted with precise boundary inking and standard drafted labels
	▸ unassessed areas, where one or both data bases missing, not indicated	▸ clearly indicated unassessed areas

APPENDIX D

LIMITATIONS OF THIRD APPROXIMATION MAPS

APPENDIX D. Limitations Of Third Approximation Maps Their Reasons And Significance.

Limitation	Reason	Significance
Current Wetlands		
Wetlands - 10 ha omitted unless mapped by NTS maps	Beyond resolution of original soil and land use maps	Of minor concern for regional studies in southern Ontario, but may underestimate wetland converted to small scattered building lots
Some wetlands - 40 ha omitted in Elgin, Kent, Middlesex, Brant, Welland and Durham counties unless mapped by NTS maps	Beyond resolution of original soil maps	Data for these counties less accurate
Occasional discrepancies at county boundaries	Inconsistencies among county soil maps	Of minor concern - occurred rarely since soil wetness is a basic and consistent feature of soil maps
Underestimated narrow bottom land wetlands between better drained slopes	No data on bottom land wetness and unable to extrapolate using methods outlined in Appendix C	Including the omission of small wetlands, accounted for the 15% missed wetlands in the Credit River Study (Yatabe, 1984)
Uncertain lakeshore marsh boundaries	Extent varies yearly depending on lake levels. Difficult to identify extent of submergent vegetation in 2m of water	Likely underestimates marshes but not serious since compared well with Kawartha Lakes 1:10 000 wetland maps (Lewis and Dyke, 1973)
Different resolution on Precambrian Shield	Soil maps less detailed but NTS maps more accurate	Probably balances out or is insignificant
Losses Underestimated where		
Wetlands retain natural cover but are artificially drained	Assumed all natural land use areas are undrained, due to lack of data	Direct drainage likely very minor but indirect effects from drainage of adjacent areas may be very significant (Bardecki,1981)
Marshes within lakes are lost	Marsh boundaries confused by lake level changes. Since land use coverage does not extend to marshes within lakes, overlay *was* inapplicable. NTS coverage allowed no monitoring of losses	Significance for data on marsh wetland type only
Wetlands lost to historical development in large cities	Soil map coverage does not extend to centre of cities	Minor significance because long-term losses and original wetland estimates are very large compared to wetlands within inner cities
Recent losses in parks	Only one land use coverage available	Probably very minor because parks cover relatively small areas and tend to conserve wetlands
Recent losses on Precambrian Shield	Either no 1982 data to allow recent monitoring or if 1982 data, only 5-7 years monitoring period	Very minor
Large Indian Reservations (Brant, Bruce, Hastings, Middlesex Counties) and in Goderich Township, Huron County	No. c 1982 land use coverage available for Indian Reservations (except Walpole Is.) or Goderich Twp	Very minor. Little recent change on Reservations, and relatively small areas compared to whole county estimates
Waterloo Region	Time constraints prevented full use of extremely detailed soil map for losses	Possibly significant to wetland loss results in Waterloo
Gains Overestimated where		
Drainage maintained on long abandoned land	Due to lack of data, assumed land abandoned10 years had no maintained artificial drainage	Possibly significant where affected by drainage of *adjacent* areas
Gains and Losses		
Possible inconsistencies in distinguishing abandoned wet pasture from marsh between 1967 and 1982 land use maps	Difficult distinction for land use mapping	Minor significance. There may be a few debatable losses and gains between these two land use classes but probably balance out.

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