Land Cover along the Great Lakes and the St. Lawrence River

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Background

The Food and Agriculture Organization (FAO) of the United Nations defines land cover as "the observed (bio)physical cover on the earth's surface" (FAO 2005). Land cover comprises various classes, including vegetated cover (forest, herbaceous meadow, wetland, etc.) and non-vegetated cover (bare soil, water, rock, snow, etc.). By contrast, land use, a different aspect of the same land, refers to how people use the land surface and the degree to which they do so (e.g. urban development, agriculture). The two concepts should not be confused.

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Land cover along the St. Lawrence River

Land cover and land use are important factors because their state and evolution greatly influence the state of a number of components affecting the St. Lawrence River ecosystem. There are complex relationships between the state of the banks of the St. Lawrence River, the land cover in its valley and the state of the river itself. In monitoring land cover—which includes land use—we were able to draw up an overview and to explore possible connections between land cover and other indicators of the state of the St. Lawrence.

Available map-based data and a classification system for analyzing the evolution of land cover were used to study the Mixedwood Plains Ecozone, which includes the fluvial section, fluvial estuary and part of the Upper Estuary of the St. Lawrence.

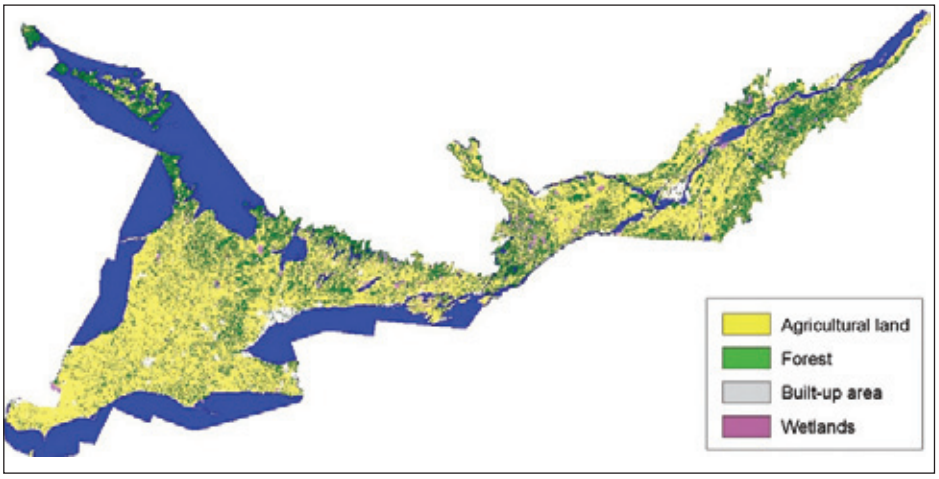
Mixedwood Plains Ecozone

This ecozone encompasses the valley of the lower Great Lakes, known as the southern tip of Ontario, and a significant part of the St. Lawrence River (Figure 1). Its geographic location, navigable waters and combination of gentle topography, fertile soils, abundant rainfall and warm growing season have made it the most intensively used and densely populated area in Canada.

At one time, this ecozone was heavily forested, supporting more species of trees than any other part of Canada. Today, however, the area is mostly agricultural land. Most of the forest has been cleared for farms, orchards, highways and towns.

The ecozone includes aquatic ecosystems, industrial complexes and large recreational areas. Today, service industries and the manufacturing sector are the largest employment sectors. Approximately half of Canada's population, or 14 million people, resides in the ecozone, and 85% of these residents live in the urban centres dotting the Québec–Windsor Corridor, which is home to Canada's two largest cities, Toronto and Montréal.

Figure 1 Land cover mapping in the 1970s



Overview of the Situation

Although there have been significant changes since the beginning of colonization, with severe deforestation in the 18th and 19th centuries, some relatively short-term changes can still be seen today. Analyzing these short-term changes required the use of satellite images from the mid-1970s and the 1990s, with others from around the year 2000. These images have been classified to determine the main classes of land cover and land use, based on Anderson et al. (1976).

Since the mid-1970s, agricultural land and built-up areas seem to have maintained some growth, to the detriment of forests and wetlands (Table 1).

Table 1 Results of analyses of changes in land cover areas between 1970 and 1990–2000

Mixedwood Plains Ecozone			
Class	**Area in 1970 (km²)**	**Area in 1990–2000 (km²)**	**Difference (km²)**
Open water*	48 254	48 858	604
Built-up area	3 745	4 377	632
Bare soil	558	273	-285
Park**	–	183	183
Agricultural land	72 242	77 964	5 722
Forest – regeneration	29 281	23 194	-6 087
Wetland	4 727	3 950	-777
Forested cutovers	–	8	8
Total	**158 807**	**158 807**	

* The size of the open water area depends on how the mapping within the shores of the Great Lakes is divided up; the figures therefore do not include the total area of the Great Lakes.
** The "park" class includes parks, golf courses, airports, industrial lakes and ski trails.

However, when analyzing the changes, it is not enough to simply compare the area statistics alone in order to properly understand the relationship between these classes. To correctly understand the types of changes, a spatial comparison was carried out between maps from the 1970s and those from 1990–2000. Only the main visible changes affecting more than a hectare were retained for analysis, based on riparian strips of various widths.

Making the same observations of riparian strips of various widths by subwatershed allows for a better assessment of the geographic distribution of these changes. If we look at the forest class, which has undergone the most changes in area, the majority of subwatersheds have lost approximately 4% of their forest area in a 30-km riparian strip (Figure 2). However, this percentage represents the change in forest area in relation to all other land cover classes. For this region, the actual forest loss is closer to 40% when the recent forest area is compared to the forest area in the 1970s (Figure 3). This highlights the limited amount of forest cover in the 30-km riparian strip and explains how any loss significantly reduces the remaining area of this class.

Figure 2 **Changes in forest area in relation to total subwatershed area within a 30-km riparian strip**

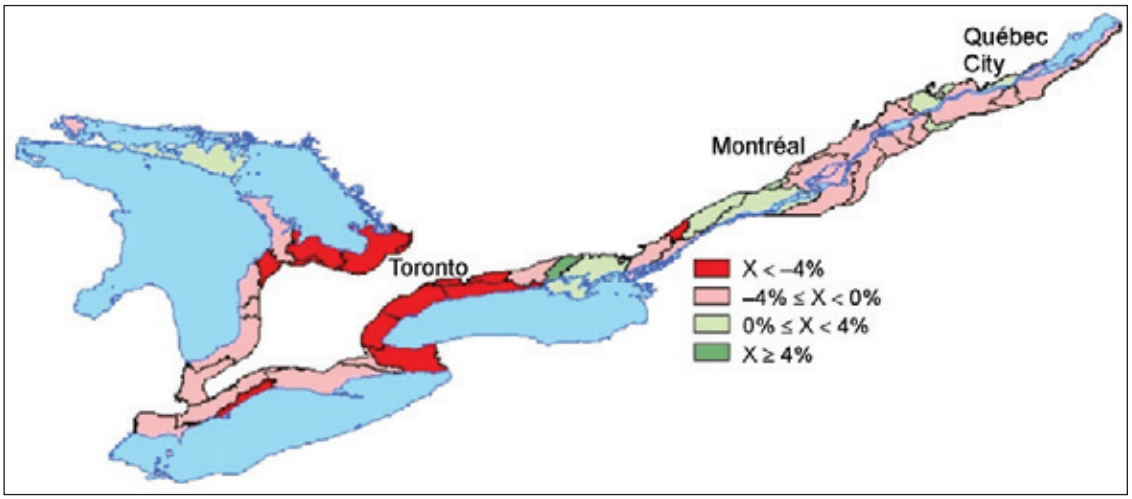
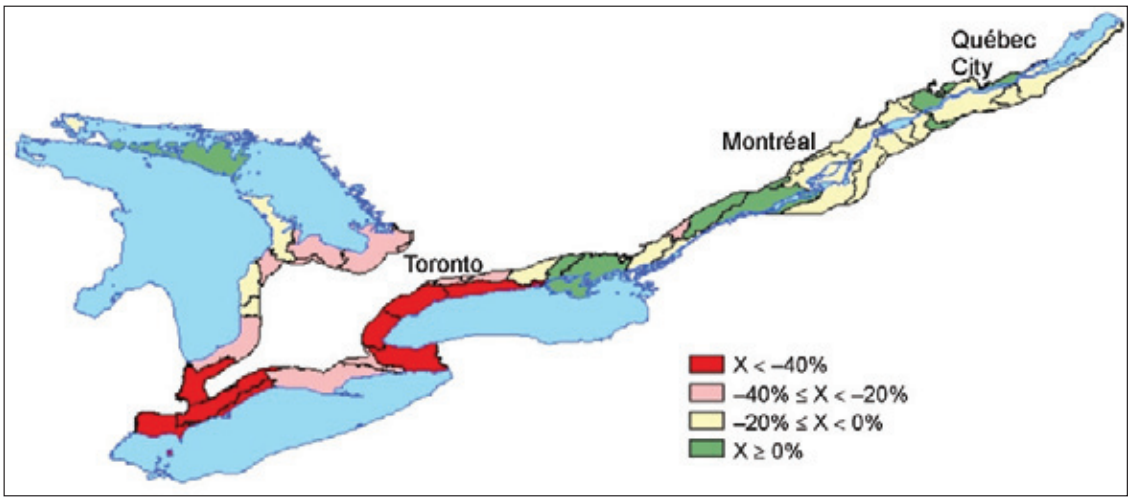


Figure 3 **Changes in forest area in relation to their area in the 1970s within a 30-km riparian strip by subwatershed**



After analyzing the changes within riparian strips measuring 10, 20 and 30 km from shore, respectively, it seems that two thirds of forest losses (107 km²) converted to built-up areas are within the first 10-km strip from shore (Table 2). However, for agricultural land, this same conversion into built-up areas increases linearly with increasing distance from shore. These two types of changes confirm that urban development is occurring inland rather than along the shoreline of the Great Lakes and the St. Lawrence and that wooded areas along the shoreline are becoming increasingly sparse.

Three sectors illustrate land cover changes according to regional realities and their subwatersheds. These three sectors—Montréal, Québec and Toronto—have experienced the largest number of major changes over nearly three decades (Table 3).

Table 2 Main changes in land cover classes for the Mixedwood Plains Ecozone (by riparian strip)

Type of change	Width of riparian strip			Ecozone
	10 km	20 km	30 km	
Agricultural land → Built-up area	328 km² (44%)	485 km² (64%)	578 km² (77%)	754 km² (100%)
Agricultural land → Forest	524 km² (32%)	797 km² (49%)	1002 km² (61%)	1630 km² (100%)
Forest → Built-up area	107 km² (67%)	123 km² (77%)	132 km² (83%)	159 km² (100%)
Forest → Agricultural land	1112 km² (20%)	1898 km² (34%)	2749 km² (49%)	5601 km² (100%)

Table 3 Main changes in area by watershed or region and by width of riparian strip

Changes	Subwatersheds								
	Toronto region[a]			Montréal region[b]			Québec City region[c]		
	Width of riparian strip			Width of riparian strip			Width of riparian strip		
	10 km	20 km	30 km	10 km	20 km	30 km	10 km	20 km	30 km
Agricultural land → Built-up area	103 km²	223 km²	283 km²	114 km²	146 km²	157 km²	28 km²	29 km²	29 km²
Forest → Built-up area	31 km²	43 km²	47 km²	55 km²	58 km²	62 km²	6 km²	8 km²	8 km²
Forest → Agricultural land	76 km²	163 km²	265 km²	89 km²	138 km²	169 km²	2 km²	3 km²	5 km²

a. Credit–Sixteen Mile and Humber–Don watersheds
b. Montréal, Richelieu, L'Assomption, Rouge and Nord and Haut-Saint-Laurent subwatersheds
c. Montmorency subwatershed

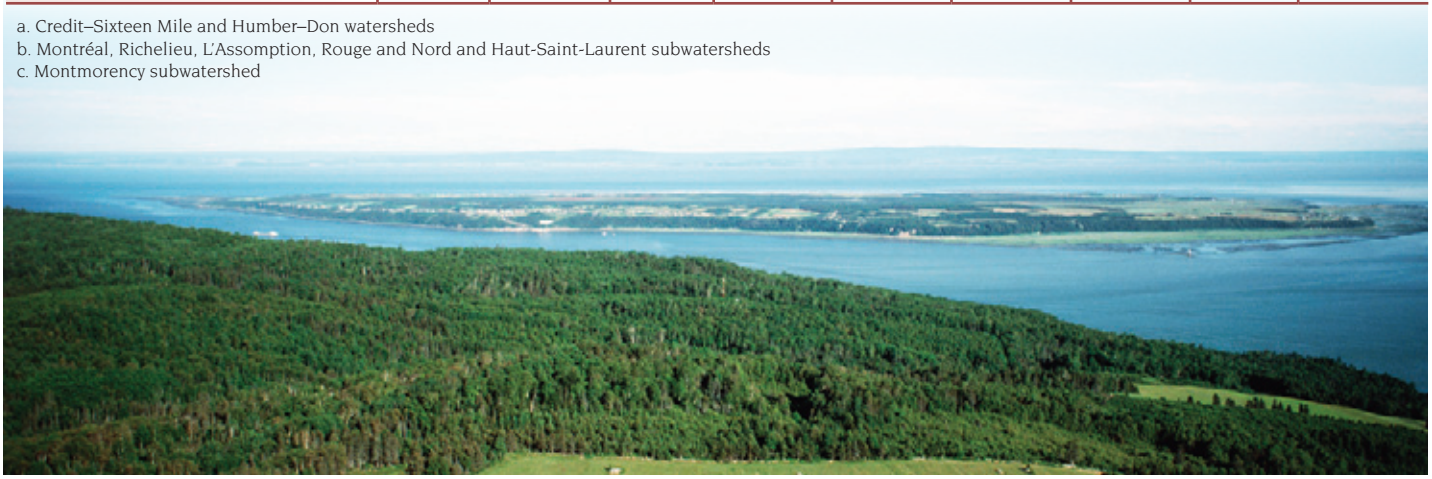


Photo: © Photos.com, 2010

In the Island of Montréal subwatersheds (Figure 4), including the first 10-km wide strips along the north and south shores and the various islands of the Montréal Archipelago, 114 km² of agricultural land have become built-up areas. These changes have occurred mainly in the northern belt and on Jésus Island, just north of the Island of Montréal. Notably, in the southern belt, 55 km² of forested areas have been lost to built-up areas. These results show that the urban development rate in the northern belt has been high since the 1990s. Urban development in the southern belt, which was already highly developed before the 1970s, has continued, but less quickly.

In the Montmorency subwatershed (north shore), including Québec City (Figure 5), 29 km² were converted from agricultural land to built-up areas, whereas 8 km² of forest were converted to built-up areas in the Cap-Rouge area.

Photo: © Photos.com, 2010

Figure 4 **Land cover changes in the Montréal region between 1975 and 2000**

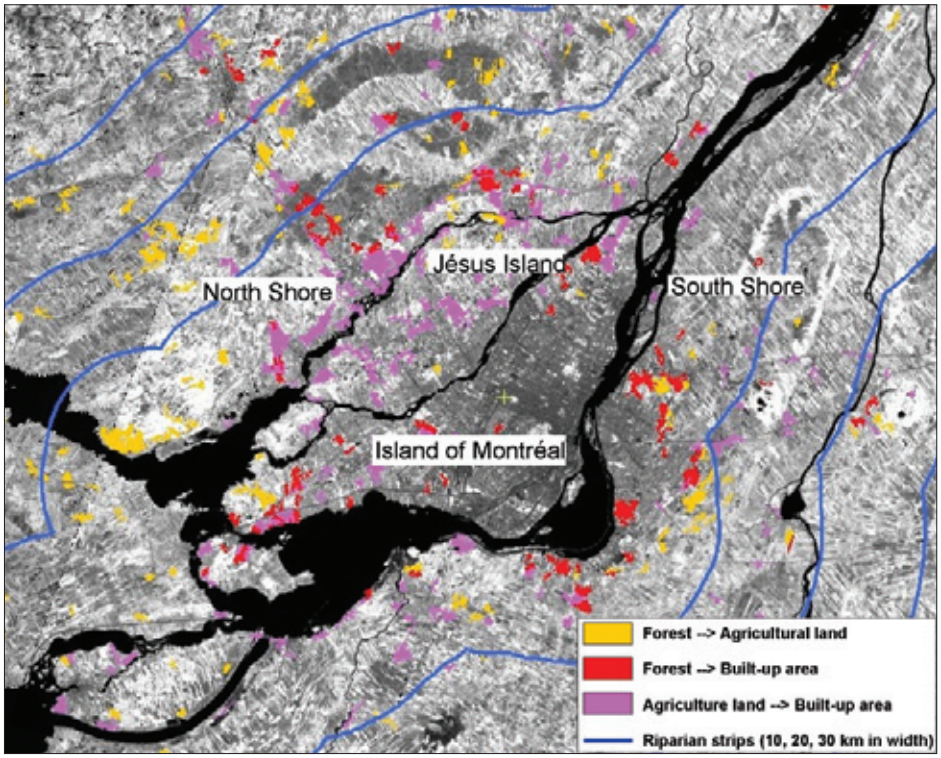


Figure 5 **Land cover changes in the Québec City region between 1975 and 2000**

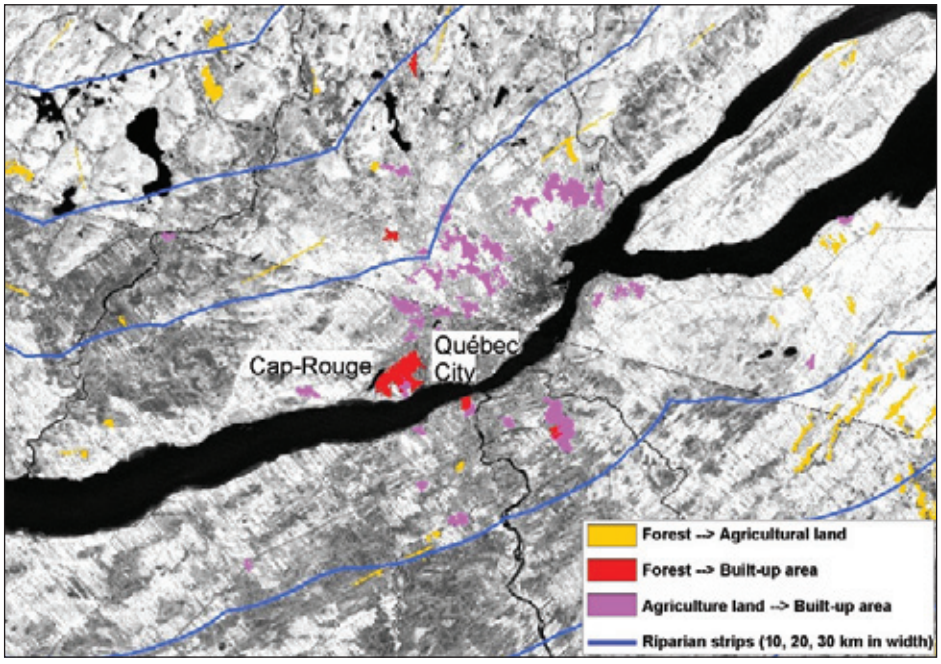
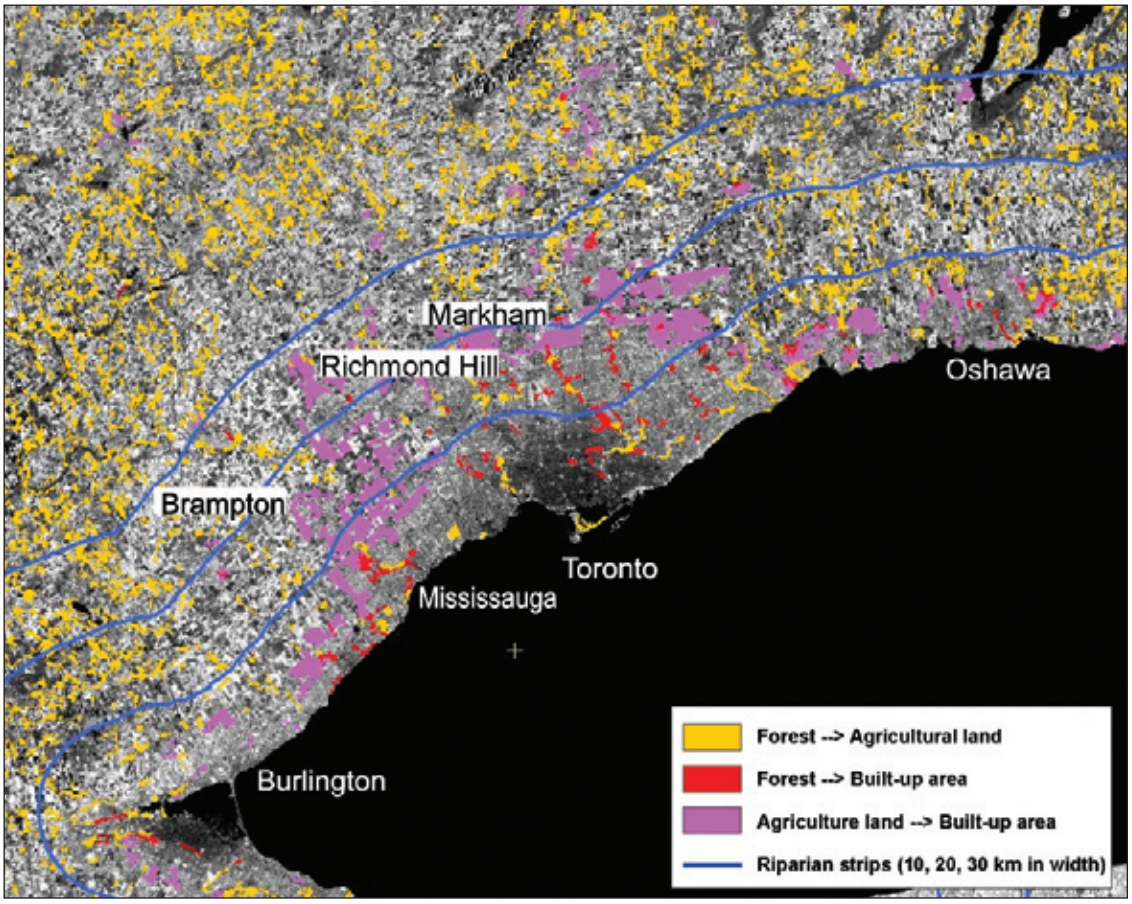


Figure 6 Land cover changes in the Toronto region between 1975 and 1995



On the north shore of Lake Ontario (Figure 6), in the Credit–Sixteen Mile and Humber–Don subwatersheds, 283 km^2 of agricultural land were converted to built-up areas. By comparison, only 47 km^2 of forested areas were converted to built-up areas. Urban development is occurring in the Greater Toronto Area (Mississauga, Brampton, Richmond Hill, Markham). In addition, 265 km^2 of forest have been converted to agricultural land. However, the size of forested areas may have been overestimated in 1970s maps because of the resolution and quality of the Landsat Multispectral Scanner (MSS) images used.

These three sectors account for 55% of the total changes from agricultural land to built-up areas and 65% of the total changes from wooded areas to built-up areas for the entire ecozone.

Since the beginning of the colony, the Mixedwood Plains Ecozone has been significantly modified by mass deforestation to establish agricultural land. Since the beginning of the 20th century, agricultural land area has been growing steadily. Population growth has also led to the expansion of built-up areas, to the detriment of other nearby classes, reflecting the regional reality. The main change that can be considered constant is the expansion of urban development in large centres. This growth is to the detriment of neighbouring forests and agricultural areas. Intensification of urban living has also been observed.

This initial analysis of the evolution of land cover shows that there is a pronounced and continuous shrinking of natural environments along shorelines that is affecting their input to the Great Lakes and the St. Lawrence. Therefore, it is becoming important to take these changes into account when analyzing the changing state of the fluvial ecosystem and the pressures to which it is subject.

Perspectives

Environment Canada is working to develop an integrated approach for environmental monitoring of the Great Lakes–St. Lawrence Basin. To do so, additional work must be done to develop land cover monitoring indicators and activities for this large ecosystem.

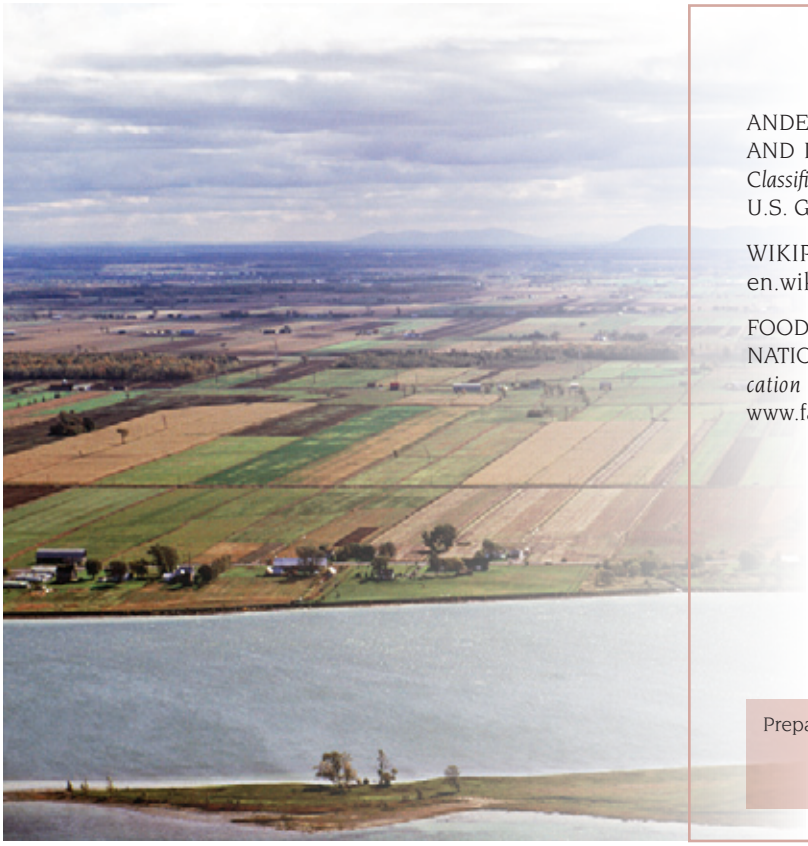
In general, the accuracy of wetland mapping based on past data is still fairly poor. Other studies must be considered to establish the assumption that there have been few changes in the areas occupied by this class over the past 30 years at the ecozone level. Work on certain other areas of the region studied could be necessary.

Even more importantly, the relationship between how the change occurs (density, form, direction) and how it affects the natural environment must be determined. It is especially important to determine the impact of the contaminant loads associated with land use in areas that are particularly sensitive or of high socio-economic value.

KEY MEASURES

Area of Land Use Classes

Through the continual production of land cover maps, the area of classes can be estimated. By comparing these maps, it can be seen how these environments evolve in relation to the area of natural habitats under the influence of urban development.



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To Know More

ANDERSON, JAMES R., ERNEST E. HARDY, JOHN T. ROACH AND RICHARD E. WITMER. 1976. A *Land Use and Land Cover Classification System With Remote Sensor Data*. Washington (D.C.), U.S. Government Printing Office.

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State of the St. Lawrence Monitoring Program

Under the current Canada–Quebec agreement, the St. Lawrence Plan for a Sustainable Development, six government partners—Environment Canada, the Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Fisheries and Oceans Canada, the Ministère des Ressources naturelles et de la Faune du Québec, the Canadian Space Agency, and the Parks Canada Agency—together with Stratégies Saint-Laurent, a non-governmental organization that works actively with riverside communities, are pooling their expertise to provide Canadians with information on the state of the St. Lawrence River at regular intervals.

To obtain the fact sheets and additional information about the State of the St. Lawrence Monitoring Program, please visit our website at:

www.planstlaurent.qc.ca

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