

**MAPPING THE WETLANDS OF THE ST. LAWRENCE  
USING REMOTE SENSING (1990–91)**

Scientific and Technical Report ST-232E



# **Mapping the Wetlands of the St. Lawrence using Remote Sensing (1990-91)**

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State of the St. Lawrence

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September 2005

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Correct citation for this publication:

Létourneau, G. and M. Jean. 2005. *Mapping the Wetlands of the St. Lawrence using Remote Sensing (1990–91)*. Scientific and Technical Report ST-232E. Environment Canada – Quebec Region, Environmental Conservation, St. Lawrence Centre. 98 pages.

Published by authority of the Minister of the Environment

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Catalogue No. En 152-1/232-2005E

ISBN 0-662-42415-8

## **Management Perspective**

This document is published under the Data Integration and Access to Information Program of St. Lawrence Vision 2000 (SLV 2000), in partial fulfilment of its objective to acquire comprehensive cartographic knowledge of the St. Lawrence River through the collection, display and processing of remote sensing data. This project was initiated under the St. Lawrence Action Plan.

The surface area occupied by wetlands is a source of constant concern for researchers and stakeholders working in this environment. This latest mapping serves to update old maps of riparian wetlands and present a uniform mapping of a large section of the St. Lawrence River.

## **Perspective de gestion**

Le présent document est publié dans le cadre du programme Intégration des données et accès à l'information du plan d'action fédéral-provincial Saint-Laurent Vision 2000 (SLV 2000), sous l'objectif Acquisition de connaissances cartographiques globales par le prélèvement, l'affichage et le traitement de données de télédétection. Ce projet a été initié au cours du Plan d'action Saint-Laurent (PASL).

La superficie occupée par les milieux humides est l'objet de préoccupations constantes de la part des chercheurs et des intervenants du milieu. La cartographie présentée dans les pages qui suivent met à jour les anciennes cartes sur les milieux humides du fleuve et procure une présentation uniformisée d'un grand tronçon du fleuve

## **Acknowledgments**

We thank the Canadian Wildlife Service, especially Pierre Laporte and Michel Robert, for validating the mapping of the Ile aux Grues sector.

We are also grateful to Jean Bachand of the Société de conservation de la baie de L'Isle-Verte for validating the mapping of the L'Isle-Verte sector.

Lastly, we wish to acknowledge the collaboration of the St. Lawrence Centre's ZIP Team, whose comments allowed us to refine the mapping of certain sectors.

# **Abstract**

Close to 10% of the province of Quebec is made up of wetlands. They are preferred habitats for the establishment and maintenance of particularly diversified plant and animal life. The location, characterization and precise calculation of the area occupied by marshes and swamps are vital to monitoring animal species and habitats. The last comprehensive mapping of St. Lawrence River wetlands dates back to the Dryade Group's 1980 work on migratory bird habitats. Other studies were also conducted in the 1980s, but they are too limited in scope to apply to the entire St. Lawrence River. A more recent look at St. Lawrence wetlands was therefore necessary to assess the present state of these habitats.

The objective of this project was to map the different land-use categories over a 1-km-wide riparian strip, including the water. Emphasis was placed on distinguishing among the various groupings of marshes and swamps, and on a sound estimate of submerged aquatic plants.

Using a MEIS-II airborne sensor, we were able to discern 64 land-use categories, out of which we found 46 wetland classes. The latter include two classes in open water, two classes of aquatic vegetation over more than 28 100 hectares, 20 classes of low marshes covering more than 17 450 ha, 16 classes of high marshes over more than 9500 ha, and five classes of swamps over more than 6470 ha. For logistical reasons, only the areas from Cornwall to Cap Tourmente, on the north shore, and from Lake Saint-Francois at Dundee up to Trois-Pistoles, on the south shore, were covered by MEIS-II airborne images. Our results demonstrate that remote sensing is an efficient and useful tool for surveying vast areas of wetlands.

## Résumé

Les milieux humides représentent près de 10 p. 100 des terres du Québec. Ils constituent des endroits privilégiés pour l'établissement et la conservation d'une faune et d'une flore particulièrement diversifiées. La localisation, la caractérisation et le calcul précis de la superficie occupée par les marais et les marécages ont une grande importance pour le suivi des habitats et des espèces animales. La dernière cartographie globale des milieux humides du Saint-Laurent remonte aux travaux du Groupe Dryade (1980) sur les habitats propices aux oiseaux migrateurs. D'autres études ont aussi été effectuées dans les années 1980, mais les superficies étudiées sont trop limitées pour permettre un bilan de l'état des habitats à l'échelle fluviale. Un portrait plus récent de l'état des milieux humides était donc nécessaire pour dresser un bilan précis de la situation actuelle.

Ce projet consistait à acquérir la cartographie des différentes classes d'occupation du territoire sur le premier kilomètre de rive, incluant les eaux du fleuve. Une importance particulière a été accordée à la distinction des différents groupements de marais et marécages, ainsi qu'à une estimation adéquate des herbiers submergés.

Les résultats obtenus à l'aide du capteur aéroporté (MEIS-II) ont permis de distinguer 65 classes d'occupation, dont 46 classes de milieux humides. Ces dernières comprennent deux classes d'eau libre, deux classes d'herbier couvrant plus de 28 100 ha, 20 classes de bas marais pour plus de 17 450 ha, 16 classes de haut marais pour plus de 9500 ha et cinq classes de marécages totalisant plus de 6470 ha. Pour des raisons de logistique, seuls le territoire de Cornwall jusqu'au cap Tourmente sur la rive nord et celui partant de la Réserve nationale de faune du lac Saint-François, à Dundee, jusqu'à Trois-Pistoles sur la rive sud ont été couverts par les images aéroportées MEIS-II. Les résultats montrent que la télédétection constitue un outil efficace et avantageux pour inventorier les milieux humides sur de vastes territoires.



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# 1 Introduction

In monitoring plant and animal species and their habitats, the location and characterization of swamps and marshes and the accurate calculation of their area are essential. The most recent comprehensive mapping of the St. Lawrence shoreline was carried out by Groupe Dryade (1980), in order to map migratory bird habitats. Other, more local, mapping studies were conducted in the 1980s (Jacques 1985, Pilon et al. 1980), but the areas mapped were too limited to evaluate the state of habitats along the entire St. Lawrence. An up-to-date picture of St. Lawrence wetlands will allow for a more accurate assessment of the current situation.

In this document, land-use classes within the first kilometre inland from the shoreline on both sides of the St. Lawrence were mapped, along with the waters of the river itself. Particular attention was paid to distinguishing between the various marsh and swamp plant communities and to adequately estimating areas of submerged aquatic vegetation. The scientific names of vascular plants were taken primarily from Marie-Victorin (1997).

The firm Aménatech, part of the SM Group, was commissioned in 1992 to map the section of the river from Cornwall to Montmagny, while the St. Lawrence Centre (SLC) was responsible for the section of the shoreline from Montmagny to Trois-Pistoles, with assistance from the Canadian Wildlife Service and the Société de conservation de la baie de L'Isle-Verte. Some modifications were made to Aménatech's results to better meet the requirements of the SLC's State of the St. Lawrence Section. A portion of Aménatech's results were corrected and completed.

This document is an updated version of the report by Létourneau and Jean (1996) using more recent mappings of the same area. To ensure the consistency of map legends, Quebec's wetland classification system (Buteau et al. 1994) was used, with the "deep marsh" and "shallow marsh" classes combined in the "low marsh" class, and the "wet meadow" and certain other marsh classes combined in the "high marsh" class. In addition, refinements were carried out to the mapping of some areas. These modifications also required the complete revision of the original texts and wetland area statistics.

## 2 Study Area

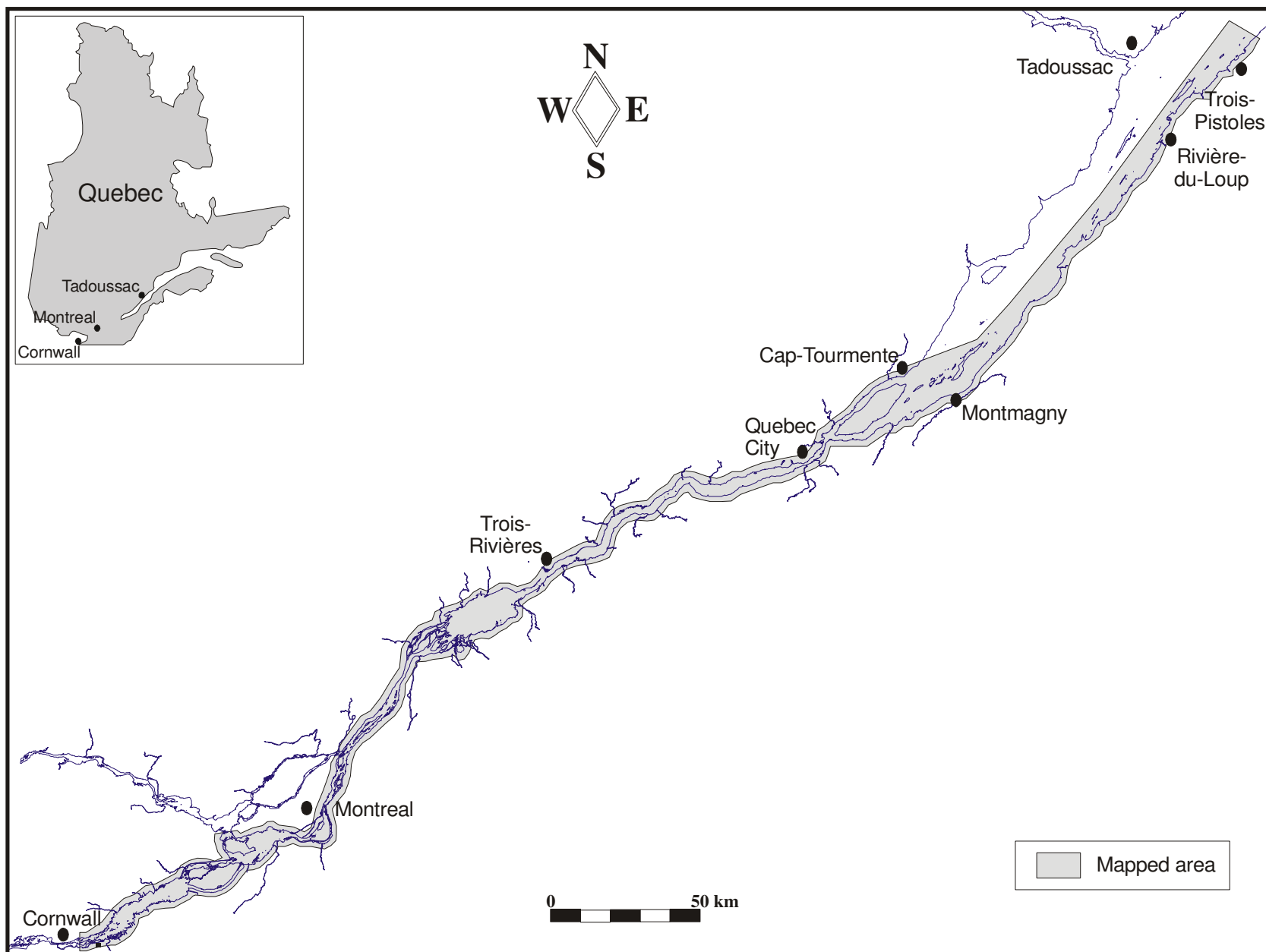
The maps shown here cover the St. Lawrence River from Cornwall, Ontario, to Cap Tourmente, Quebec, on the north shore, and from the Lac Saint-François National Wildlife Area in Dundee to Trois-Pistoles on the south shore. In Figure 1, the sections of the river that have been mapped are shaded. Readers should note that, in the Montreal area, only the south shore of the Island of Montreal was mapped. The Rivière des Prairies and Rivière des Mille Îles were excluded because they are not associated with a ZIP (*zone d'intervention prioritaire*, or Priority Intervention Zone). To better meet the needs of St. Lawrence Centre (SLC) researchers, we adopted the scheme used by the SLC, which divides the study area into study sectors (formerly called ZIPs). Each study sector corresponds to a specific ecosystem or at least a region with fairly homogeneous biophysical and socio-economic characteristics. Figure 2 shows the division of the river into 13 sectors (originally 23 ZIPs). As Burton (1991) explains:

The main goal of dividing the territory into subunits is to facilitate the understanding of local phenomena that may be associated with local human activities. This division facilitates the identification of uses and resources near riverside communities. . . .

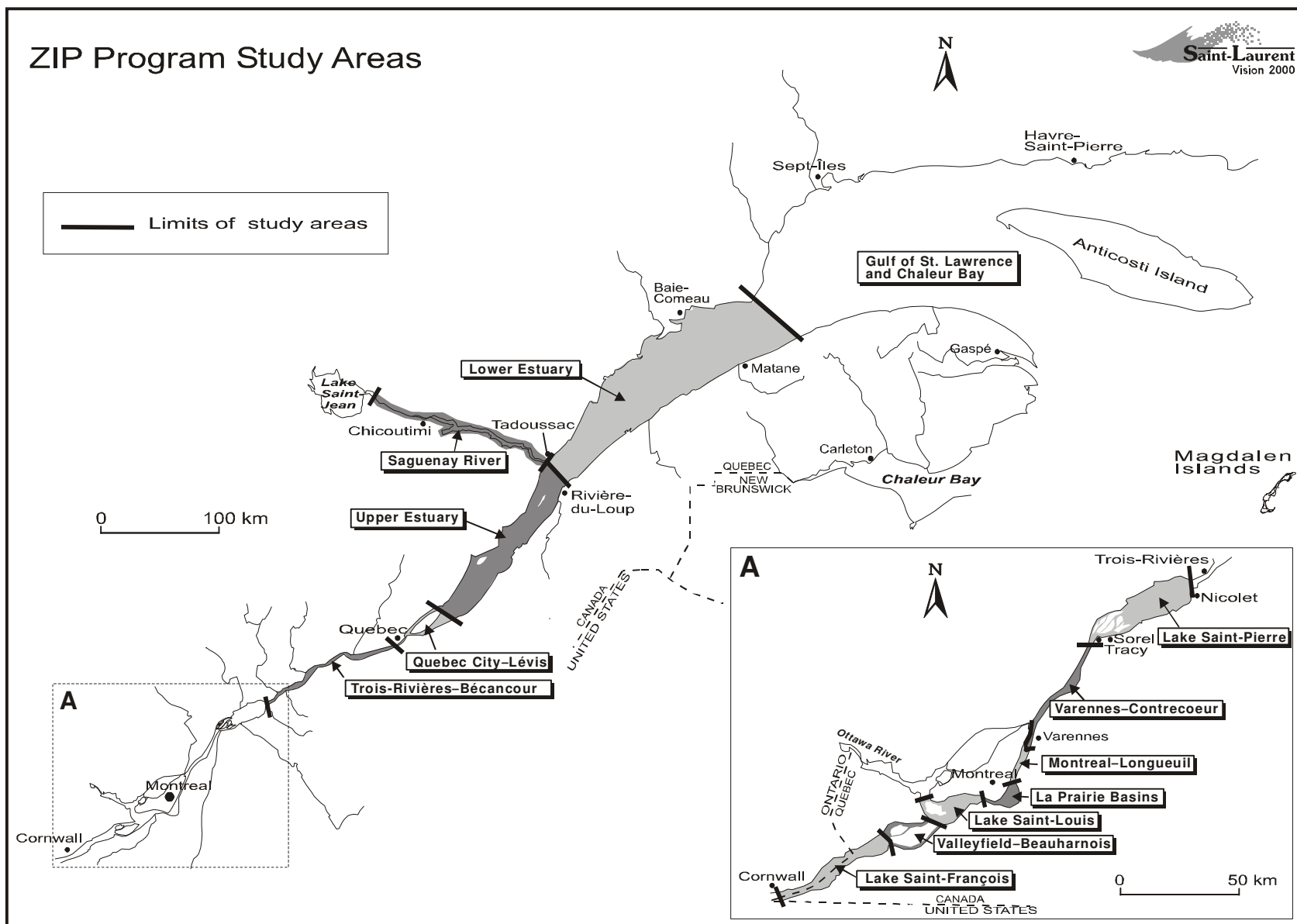
The ZIP program not only pays special attention to the local sources of environmental degradation and contamination, but aims to highlight valued elements (uses and resources) of the area to encourage commitment from riverside partners in acting cooperatively to recover uses and conserve resources as well as implement preventive measures. The ZIP program is a key component of the Great Lakes/St. Lawrence Pollution Prevention Initiative under Canada's Green Plan. [translation]

Some very small areas may not have been mapped because of the presence of clouds or because of insufficient aerial coverage during image acquisition. They include the north shore of Lake Saint-François between Cornwall and Lancaster, a portion of the Beauharnois Canal, Saint-Lambert, a section between the Îles de Contrecoeur and Saint-Ours Island, and part of the south shore between Sorel and Baie de Lavallière.





**Figure 1** Area mapped



**Figure 2** Study areas in the ZIP Program

Cartographic data on the study area were not all acquired in the same year. The data from July 26 and August 21, 1990, cover the region from Cornwall to Trois-Rivières, while the data from September 3, 1991, cover the area between Trois-Rivières and Trois-Pistoles.

### **3 Methodology**

Wetlands were mapped using MEIS-II images acquired on July 26 and August 21, 1990, and September 3, 1991. The near-IR (1 and 3), red (4) and green (8) bands were used to distinguish among the various plant species using supervised classification.<sup>1</sup>

Several steps were required to achieve this objective.

#### **3.1 IMAGE VIEWING AND ENHANCEMENT**

This first step enables the interpreter (biologist) to visually identify the various land-use elements shown in the image by comparing them with information already gathered on the ground and to select the best image-enhancement methods to obtain images with maximum contrast.

#### **3.2 DIFFERENTIATING BETWEEN WETLANDS AND UPLAND AREAS**

Wetlands must be differentiated from upland areas to obtain accurate results. Some wetland classes may be confused with upland classes, which is easily understandable since some wetlands such as high marshes have been previously cultivated or used as pastureland. To prevent this problem, the 20-year floodline must be taken into account during image interpretation.

#### **3.3 SELECTION OF TRAINING AREAS**

Classification accuracy depends, among other things, on the selection of training areas.<sup>2</sup> Maximizing the use of ground information and frequently consulting plant ecologists specialized in wetlands are essential to the process.

A uniform selection of training areas throughout the image allowed grey scale values representing the spectral properties of the various types of vegetative cover to be obtained. Next, undesirable values or values outside the wetland class selected were eliminated from the training

---

<sup>1</sup> Automatic classification process using the a posteriori distribution of known pixels into a certain number of classes (Paul et al. 1982).

<sup>2</sup> A training area is a portion of the study area whose characteristics are accurately known and where special equipment has been installed, above which aerial remote sensing missions are flown to study and fine-tune or check the results of missions carried out in other regions (Paul et al. 1982).

areas. The range of characteristics in the classes was sufficiently broad to reduce the number of unclassified pixels.

### **3.4 EVALUATION OF SPECTRAL CHARACTERISTICS OF WETLAND CLASSES**

The spectral characteristics<sup>3</sup> of wetland classes were used to clearly define each class, in order to prevent any confusion and ensure that training areas were accurate. Some training areas were readjusted as required to satisfy criteria for spectral differences between classes. Statistical differences between classes were evaluated using discriminant analysis. Overall, differences were great enough to allow for the correct classification of wetland classes.

### **3.5 IMAGE CLASSIFICATION**

Supervised classification using a Bayesian maximum likelihood classifier was used to process the remote sensing images. In this type of classification, a unique pixel value, defined during the evaluation of spectral characteristics, is assigned to all pixels in the image identified as representing a specific wetland class. Using a colour chart employed in conventional wetland mapping, a colour can then be associated with this pixel value to identify the class on the maps. The classification is evaluated by comparing it with existing data (maps and reports) on the area. The wetland classification system developed by Jacques and Hamel (1982) was used as the basis for most of the initial vegetation mapping. In this report, however, these classes were redefined to correspond to the Quebec wetland classification scheme (Buteau et al. 1994). Incorrect results for one or more classes or conflicts between two classes may require the modification of training areas or reclassification.

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<sup>3</sup> Set of characteristics, in one or more spectral bands, required and sufficient to identify an area, determined based on the ambient conditions of the natural environment. Note: The use of the term *spectral signature* to designate a target's characteristic is inappropriate, since the spectral properties of the targets in a scene do not exhibit the same spatial and temporal invariance as the spectral lines of simple chemical elements (Paul et al. 1982).

### **3.6 INTEGRATION OF CLASSIFICATIONS OF WETLANDS AND UPLAND AREAS**

Once each environment was classified according to the corresponding legend, the results of the classification of wetlands and upland areas were integrated to provide a comprehensive map of both environments.

### **3.7 POSTCLASSIFICATION SMOOTHING OF IMAGES**

After classification, the data were smoothed to homogenize the result of the integration of the wetland and upland classifications. A modal filter ( $3 \times 3$  pixels) was used to “clean up” the thematic information and give it a more uniform appearance. This operation decreases data variance in each class and reduces the overlap (confusion) between the spectral characteristics of one class and other classes.

## 4 Legend Elements

The mapping of marshes, swamps and shallow water (including the first kilometre inland from the shoreline) allowed 65 plant community and land-use classes to be identified. Of these, 46 were wetland classes; the other 19 were either land-use classes associated with upland environments or classes involving physical constraints such as clouds and unclassified pixels. Classes are described individually below to ensure readers understand the differences between them. Tables 1 and 2 show all classes identified between Cornwall and Trois-Pistoles. Many of the classes were only found in very specific parts of the St. Lawrence River.

**Table 1**  
**Wetland classes between Cornwall and Trois-Pistoles**

Wetland classes
Denuded substrate
Open water
Shallow open water
Shallow water dominated by submerged vegetation
Shallow water dominated by floating vegetation
Low marsh
Low marsh dominated by narrow-leaved vegetation
Low marsh dominated by dense narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Scirpus</i> sp.)
Low marsh dominated by sparse narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Scirpus</i> sp.)
Low marsh dominated by <i>Typha</i> sp.
Low marsh dominated by emergent and floating vegetation
Low marsh dominated by <i>Schoenoplectus pungens</i> and other emergent plants
Low marsh dominated by <i>Schoenoplectus pungens</i> and <i>Scirpus lacustris</i>
Low marsh dominated by <i>Sagittaria</i> sp.
Low marsh dominated by <i>Spartina alterniflora</i>
Low marsh dominated by <i>Spartina alterniflora</i> and <i>Salicornia europaea</i> L. (S.L.)
Submerged low marsh dominated by <i>Schoenoplectus pungens</i>
Low marsh dominated by <i>Schoenoplectus pungens</i>
Low marsh dominated by sparse <i>Schoenoplectus pungens</i> and/or other emergent plants
Low marsh dominated by robust emergent vegetation
Low marsh dominated by robust emergent vegetation and other herbaceous plants
Low marsh dominated by <i>Bolboschoenus fluviatilis</i>
Low marsh dominated by <i>Typha</i> sp. and <i>Zizania</i> sp.
Low marsh dominated by narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Sparganium</i> sp.)
Low marsh dominated by dead vegetation

Wetland classes	
	High marsh High marsh dominated by tall grasses High marsh dominated by short grasses High marsh dominated by <i>Taraxacum officinale</i> High marsh dominated by <i>Carex</i> sp. High marsh dominated by <i>Lythrum salicaria</i> or other broad-leaved vegetation High marsh dominated by broad-leaved vegetation High marsh dominated by <i>Phragmites australis</i> High marsh dominated by <i>Salicornia europaea</i> L. (S.L.) and <i>Spergularia canadensis</i> High marsh dominated by <i>Spartina patens</i> High marsh dominated by <i>Spartina patens</i> and <i>Bolboschoenus maritimus</i> var. <i>paludosus</i> High marsh dominated by <i>Spartina patens</i> and <i>Hierochloa odorata</i> High marsh dominated by <i>Spartina patens</i> and <i>Plantago maritima</i> High marsh used for agriculture High marsh dominated by <i>Spartina pectinata</i> High salt marsh
	Shrub swamp Forested swamp Forested swamp dominated by <i>Acer saccharinum</i> Forested swamp dominated by <i>Acer rubrum</i> Forested swamp dominated by <i>Larix laricina</i>

Source: Marie-Victorin (1997).

**Table 2**  
**Upland classes between Cornwall and Trois-Pistoles**

Upland classes	
Outside study sector	Mixed forest
Unclassified	Plantation
Dry meadow	<i>Acer rubrum</i> on poorly drained soil
Plowed land	Semi-denuded soil with regenerating deciduous trees
Agriculture	Built-up area
Fallow land	Sedimentation basin
Harvested peatlands	Clouds and shade
Forest with no dominant species	Logs
Deciduous forest	Quarries, bare soil in urban setting
Coniferous forest	



#### **4.1 BEYOND THE STUDY AREA**

The study area was defined as ending one kilometre from the high water mark. The “beyond study area” class contains no elements and represents an absence of information on a sector not included in the study area.

#### **4.2 UNCLASSIFIED PIXELS**

Unclassified pixels generally result from confusion between classes, when the classification algorithm is unable to decide what class to put the pixel into. Because of the standard deviation for some spectral signatures, a pixel may belong to several classes. As a result, the algorithm is not able to identify the single most likely class to which the pixel belongs and creates a special class for these pixels.

Unclassified pixels often occur at the land/water boundary, where the bare soil of the shoreline and the shallow open water may be confused during classification. Clouds and the shadows they cast on the ground may also create confusion between classes. Clouds may either hide ground features completely or alter their spectral characteristics so that the pixels are not associated with the class in which they actually belong.

#### **4.3 DENUDED SUBSTRATE**

Jacques and Hamel (1982, p. 26) define denuded substrate as an area with no vegetation or, in some cases, with vegetation covering less than 25% of its surface, often found within wetlands belonging to other classes. These authors identified seven subclasses of substrates: rocky, stony, pebbly, gravely, sandy, silty and organic. On the maps, this class often corresponds to a bare space within some plant communities (such as marshes) or a sandy beach.

#### **4.4 OPEN WATER**

Open water is the convergence of water masses with no submerged or emergent vegetation. This class may be confused with the “shallow water” class in the case of a dark-coloured water mass such as the Ottawa River or a water mass with high concentrations of dissolved matter such as the Saint-François River (south shore of Lake Saint-Pierre).

#### 4.5 SHALLOW OPEN WATER

The National Wetlands Working Group (1988) defined “shallow open water” — not to be confused with “shallow water” — as follows:

[...] intermittently or permanently flooded or seasonally stable water regimes, featuring open expanses of standing or flowing water which are variously called ponds, pools, shallow lakes, oxbows, reaches, channels or impoundments. Shallow water is distinguished from deep water by mid-summer water depths of less than 2 m [...].

In this study, the “shallow open water” class designates a water mass with no submerged or emergent vegetation and where the bottom (bare soil or substrate) can be easily identified due to the shallowness of the water. This habitat is generally found around islands, at the far end of bays or off gently sloping shoreline. Tributaries can also be classified as “shallow open water,” due to their shallow depth or their high suspended-matter content. It is difficult to distinguish a clear water mass over a bottom with no vegetation from a water mass with high concentrations of suspended particulate matter.

#### 4.6 SHALLOW WATER

Synonymous with “aquatic vegetation,” Jacques and Hamel (1982, p. 30-31) defined the “shallow water” class as follows:

This class is characterized by the dominance of floating vegetation and/or leaves and/or algae and/or submerged vegetation. . . . Certain emergent plants may be present but cover less than 25% of the surface area . . . . Typical plants include such genera as *Nymphaea*, *Nuphar*, *Brasenia* Schreb., *Potamogeton*, *Polygonum*, *Vallisneria*, *Elodea*, *Myriophyllum* and *Chara*. [translation]

Grandtner (1975) associates shallow salt water with *Ruppia maritima* and *Zostera maritima*, while Reed and Moisan (1971) associate this zone with *Fucus* sp. and *Ascophyllum* sp. In the original report (Létourneau and Jean 1996), several classes of shallow water dominated by algae (*Fucus* sp., *Zostera maritima* and *Laminaria* sp.) were identified. To take account of the discrepancy with more recent mapping efforts, these classes were eliminated, with the authors preferring to have incomplete information rather than overestimate the area occupied.

#### 4.6.1 Shallow water dominated by submerged vegetation

These shallow-water habitats are characterized by the permanent presence of water and plant species with submerged leaves. Although 27 580 ha of this habitat were identified between Cornwall and Quebec City, over 80% was found in the three fluvial lakes: Lake Saint-François (5483 ha), Lake Saint-Louis (3965 ha) and Lake Saint-Pierre (12 898 ha).

#### 4.6.2 Shallow water dominated by floating vegetation

These shallow-water habitats are characterized by the permanent presence of water and plant species with emergent floating leaves. Between Cornwall and Trois-Rivières, 470 ha were identified in rivers and channels. This floating vegetation also covers some pools inside bays in Lake Saint-Pierre.

### 4.7 LOW MARSH

Low marshes are wetlands that are periodically flooded, but whose substrate is permanently saturated or covered with water during most of the growing season. They are characterized by emergent herbaceous vegetation composed of reeds, rushes and sedges (Jacques and Hamel 1982, National Wetlands Working Group 1988, Buteau et al. 1994). On the gradient running from open water to dry land, low marshes occur between shallow water and high marshes. In the first version of this report (Létourneau and Jean 1996), the “low marsh” class was subdivided into “deep marsh” and “shallow marsh” classes. To harmonize the existing datasets, a single nomenclature was adopted and the term “low marsh” was chosen. In many cases, similar classes (such as “deep marsh dominated by *Typha* sp.” and “shallow marsh dominated by *Typha* sp.”) were merged into a single class.

The classes identified can be differentiated by the type of dominant vegetation found: narrow-leaved emergent plants (*Typha* sp., *Sparganium eurycarpum*, *Butomus umbellatus*, *Eleocharis palustris*, *Schoenoplectus pungens*, *Scirpus lacustris*), *Bolboschoenus fluviatilis* (whose spectral characteristics are affected by the long involucre, or involucral bract, at the tip) and broad-leaved emergent plants (*Sagittaria* sp. and less commonly *Pontederia cordata*, which is only found in Lake Saint-Pierre).

Aménatech (1992a) used a class called “low shallow marsh dominated by emergent vegetation,” which we have renamed “low marsh.” This class is found chiefly in the Trois-

Rivières and Gentilly region (353 ha), consisting mainly of narrow-leaved emergent plants. A small area (40 ha) was also found in Lake Saint-Pierre.

#### **4.7.1 Low marsh dominated by narrow-leaved vegetation**

This class is represented by the extensive *Scirpus lacustris* and *Schoenoplectus pungens* marshes along the south shore of Lake Saint-Pierre. The distribution of these marshes is indicative of their tolerance to wave action. Their relatively homogeneous features stand out well in the classification due to their characteristic blue hue in colour composite images<sup>4</sup> involving the infrared, red and green bands.

The class also occurs at two locations along the north shore of the river, east of the Berthier–Sorel islands and at the mouth of the Baie de Maskinongé. The composition of the marshes in the bay seems more diversified than in those on the south shore, since they consist, according to Jacques (1985), of marshes dominated by tall, narrow-leaved emergent plants such as *Scirpus acutus*, *Typha angustifolia* and *Scirpus fluviatilis*, as well as broad-leaved emergent plants (*Sagittaria* spp.). Along the shorelines of the Îles de la Girodeau and Île de Grâce, *Scirpus acutus* is also accompanied by *Typha angustifolia* and *Scirpus fluviatilis*. Here, the plants form smaller, more heterogeneous mosaics than in the extensive marshes of the south shore. These marshes cover close to 3000 ha in Lake Saint-Pierre alone.

#### **4.7.2 Low marsh dominated by dense narrow-leaved vegetation (*Typha* sp. and *Scirpus* sp.)**

This class is found mainly in Lake Saint-Louis, more specifically around the Îles de la Paix. On the maps, this class also occurs around the small islands north of Île Perrot, south of Île de Tekakwitha (downstream of Châteauguay) and in the former riverbed, just off Melocheville. Over 60 ha of this class were mapped in all.

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<sup>4</sup> Colour image that results from combining the monochrome images of a single scene (Paul et al. 1982).

#### **4.7.3 Low marsh dominated by sparse narrow-leaved vegetation (*Typha* sp. and *Scirpus* sp.)**

This class, like the previous one, is found around the Îles de la Paix in Lake Saint-Louis. A large area also occurs near the mouth of the Châteauguay River (over 10 ha).

#### **4.7.4 Low marsh dominated by *Typha* sp.**

This class occurs in Lake Saint-François, around the Îles de Boucherville, in the Varennes–Contrecoeur region and in Lake Saint-Pierre. In Lake Saint-François, where over 330 ha were mapped, this type of marsh is found mainly around the islands and on the south shore (near the Cornwall–Dundee sector). Roughly 144 ha of these marshes were mapped around the Îles de Boucherville. Slightly over 200 ha were found in Contrecoeur and along the shoreline of Île de Verchères, while over 700 ha were found in Lake Saint-Pierre. Low marshes dominated by *Typha* sp. occupy close to 450 ha in Saint-François Bay, while there are a few large areas around the Îles de la Girodeau and Île du Moine and close to 250 ha at the far end of Baie de Lavallière.

#### **4.7.5 Low marsh dominated by emergent and floating vegetation**

This class is only found in Lake Saint-Pierre, which has slightly over 385 ha (mainly in Saint-François Bay). Although it is different spectrally from the “low marsh dominated by narrow-leaved emergent vegetation” class, this class may also be associated with *Schoenoplectus pungens* and *Scirpus lacustris*.

#### **4.7.6 Low marsh dominated by *Schoenoplectus pungens* and other emergent plants**

This class, which comprises communities of *Schoenoplectus pungens* and other unidentified emergent plants (heterogeneous plant community), occurs between Trois-Rivières and Cap Tourmente. According to the maps, there are an estimated 1477 ha or more of this class in the Trois-Rivières–Bécancour sector, over 722 ha in the Quebec City–Lévis sector and over 266 ha in the Upper Estuary. In the Quebec City region, Aménatech (1992a) abandoned the designations of “deep marsh” and “shallow marsh” to take account of the tidal regime, as well as the wide variety of plants in formations dominated by *Schoenoplectus pungens*. Aménatech (1992a) assumed that the other emergent plants were those species described by Doran (1981),

such as *Zizania aquatica* var. *brevis*, *Sagittaria latifolia*, *Sagittaria cuneata* and *Eleocharis erythropoda*.

#### **4.7.7 Low marsh dominated by *Schoenoplectus pungens* and *Scirpus lacustris***

*Scirpus lacustris*, which is very common in Lake Saint-Pierre, occurs along with *Schoenoplectus pungens*. *Eleocharis palustris* may also be mixed in with this class and confused with *Scirpus lacustris*. This type of marsh is found mainly in the Trois-Rivières region, where it covers over 330 ha.

#### **4.7.8 Low marsh dominated by *Sagittaria* sp.**

Low marsh dominated by *Sagittaria* sp. is found in Lake Saint-Louis (nearly 115 ha), the Îles de Contrecoeur (just under 75 ha) and Lake Saint-Pierre, where 900 ha are spread between Saint-François Bay and the Baie de Maskinongé, including the far end of the bays in the Îles de la Gironde. Another 20 ha are found near Trois-Rivières.

#### **4.7.9 Submerged low marsh dominated by *Schoenoplectus pungens***

This class is unusual in that it is made up exclusively of completely submerged plants, and is found mainly in regions between Portneuf and Saint-Nicolas, where the water depth is greater at high tide. It covers an estimated 500 ha in this sector and 70 ha in the Quebec City sector.

#### **4.7.10 Low marsh dominated by *Schoenoplectus pungens***

*Schoenoplectus pungens* communities are found in fresh water from Pointe-du-Lac and Nicolet as far downstream as the brackish water at the eastern tip of the Île d'Orléans, including Cap Tourmente on the north shore and Saint-Michel-de-Bellechasse on the south shore. At Saint-Roch-des-Aulnaies, the species is replaced by *Spartina alterniflora* and *Spartina patens*. This community competes with other *Schoenoplectus pungens*-dominated communities, and area statistics should be compiled together rather than separately. However, 64 ha are found in Lake Saint-Pierre, 368 ha in the Fluvial Estuary, 194 ha around Quebec City and 2040 ha in the Upper Estuary.

#### **4.7.11 Low marsh dominated by sparse *Schoenoplectus pungens* or other emergent plants**

This class can be distinguished from the previous one by the less dense plant cover. It covers 710 ha along the shoreline of the Côte de Beaupré and the Île d'Orléans.

#### **4.7.12 Low marsh dominated by robust vegetation**

This class covers close to 24 ha in the Îles de Boucherville. Although it is more local in nature, it is similar to the following class.

#### **4.7.13 Low marsh dominated by robust vegetation and other herbaceous plants**

This class is found around Saint-Ours Island (downstream of the Îles de Contrecoeur), where it covers roughly 10 ha. Due to the poor radiometric quality of the images of this part of the St. Lawrence, a more detailed identification of the plants could not be carried out. In addition, in Lake Saint-Pierre, some zones in the low marsh can be distinguished from the previous classes and seem to be associated with an absence of *Scirpus lacustris* and *Schoenoplectus pungens* and the greater dominance of robust emergent plants such as *Typha* sp. on Île de Grâce and in Saint-François Bay and of broad-leaved plants such as *Sagittaria* sp. at the outlet of this bay and in less exposed sites such as the south shore and the far end of the Baie de Maskinongé, and the area around the Îles de la Girodeau. These marshes are greater in plant diversity than those dominated by *Scirpus lacustris* and it is difficult to distinguish among the many mosaics of different sizes that comprise the vegetation. Consequently, these units tend to be grouped together during classification, making it difficult to associate a specific community of species with this category, unlike the “low marsh with emergent narrow-leaved plants” class, which has a more homogeneous appearance. Over 1100 ha of these heterogeneous habitats were found in Lake Saint-Pierre and nearby bays.

#### **4.7.14 Low marsh dominated by *Bolboschoenus fluviatilis***

Low marsh dominated by *Bolboschoenus fluviatilis* is found in Lake Saint-Louis around the Îles de la Paix (22 ha), as well as around the Îles de Boucherville (32 ha) and Îles de Contrecoeur (150 ha). It also occurs in Lake Saint-Pierre at the far end of Saint-François Bay and the Baie de Lavallière (2070 ha).

#### **4.7.15 Low marsh dominated by *Typha* sp. and *Zizania* sp.**

This class is found exclusively in Lake Saint-Pierre, in the shelter of Longue Pointe, where close to 160 ha were mapped.

#### **4.7.16 Low marsh dominated by narrow-leaved vegetation (*Typha* sp. and *Sparganium* sp.)**

This class was only identified on our maps in Lake Saint-Louis, where over 240 ha were found around the Îles de la Paix and in the Châteauguay region.

#### **4.7.17 Low marsh dominated by dead vegetation**

The “low marsh dominated by dead vegetation” class was created to describe an area of denuded substrate with sparse vegetation in the Baie de Lavallière sector. Human activities that occurred before the reference documents (Jacques 1986) were written could be the source of these changes. According to Dryade (1980), this sector had a swamp in the past. An area of over 240 ha along the bay seems to have been disturbed.

#### **4.7.18 Low marsh dominated by *Spartina alterniflora***

Buteau et al. (1994) defined low salt marsh as follows:

Salt marshes, which are under a tidal regime, are flooded during fairly variable periods, depending on their topographic location. Plant communities flooded daily form low marshes, while all other formations correspond to high marsh. The *Spartina alterniflora* formation is typical of low marshes, while high marshes are characterized by communities dominated by *Spartina patens*, *Juncus arcticus* var. *balticus* or *Carex* sp. [translation]

Jacques and Hamel (1982, p. 38) described this class as follows:

This habitat is colonized almost exclusively by *Spartina alterniflora*, since often no other species is able to compete with it (Blouin and Grandtner 1971). It is sometimes accompanied by certain rockweeds (*Fucus vesiculosus*, *Fucus edentatus*, *Ascophyllum nodosum*) (Cantin 1974) and *Zostera marina* (Reed and Moisan 1971). The *Spartina alterniflora* zone is subject to an immersion gradient ranging from 9 to 100% of the time due to altitudinal variations, and is crisscrossed by a series of more or less interconnected channels and pools (Gauthier et al. 1980). [translation]



Low marsh dominated by *Spartina alterniflora* begins at Saint-Roch-des-Aulnaies, where it replaces low marsh dominated by *Schoenoplectus pungens*. Over 1050 ha of this class were mapped in the Upper Estuary and just under 640 ha in L'Isle-Verte and Trois-Pistoles.

#### **4.7.19 Low marsh dominated by *Spartina alterniflora* and *Salicornia europaea* L. (S.L.)**

According to a mapping study carried out by Garneau (1984), there seems to be a transition zone between *Spartina alterniflora*- and *Spartina patens*-dominated marshes between Cacouna and Pointe à la Loupe, downstream of L'Isle-Verte, consisting of a mixture of the two species. In the remote sensing images, this mixture can be clearly distinguished from communities dominated by *Spartina alterniflora* or *Spartina patens* alone. Over 200 ha were identified on the airborne images.

### **4.8 HIGH MARSH**

High marsh is characterized by a closed herbaceous cover, often of grass-like plants, with few or no openings filled with water (Jacques and Hamel 1982). On the gradient between open water and dry land, this type of wetland generally succeeds low marshes and precedes shrub swamps. The dominant vegetation consists mainly of grasses, generally not as tall as the tall emergent plants in the preceding classes (low marsh). Four species dominate this formation in Lake Saint-Pierre: *Phalaris arundinacea*, *Calamagrostis canadensis*, *Spartina pectinata* and *Lythrum salicaria* (Jacques 1986). Trees or shrubs may be interspersed here and there in the high marsh. Although water depths may be as great as 15 cm in spring and fall (up to 30 cm in high flood years), during the growing season, the substrate is saturated with water but the surface is dry.

Cattle producers may use high marshes as pastureland. The distinction between high marshes and agricultural fields can only be made by separating upland areas from wetland areas before classification.

The “high marsh” class was also used as a general class in some sectors: Lake Saint-François (11 ha), Varennes–Contrecoeur (45 ha), the Quebec City region (40 ha) and the Upper Estuary (58 ha).

#### 4.8.1 High marsh dominated by tall grasses

High marshes dominated by tall grasses are most abundant in the freshwater section and Fluvial Estuary. According to Aménatech (1992b, p. 37):

In Lake Saint-Louis, Lake Saint-Pierre and the freshwater stretch, the *Phalaris arundinacea*, *Calamagrostis canadensis* and *Spartina pectinata* dominating the cover cannot be differentiated.... In Lake Saint-Pierre, the broad-leaved species *Lythrum salicaria* is sometimes very abundant in tall-grass wet meadows . . . [translation]

This class first appears in Lake Saint-Louis (57 ha), and also occurs in the sectors of Montreal–Longueuil (133 ha), Varennes–Contrecoeur (380 ha), Lake Saint-Pierre (3384 ha), Trois-Rivières–Bécancour (171 ha), Quebec City–Lévis (110 ha) and the Upper Estuary (100 ha).

#### 4.8.2 High marsh dominated by short grasses

High marshes with short grasses are found mainly in the Boucherville (15 ha) and Verchères–Contrecoeur (135 ha) islands. According to Aménatech (1992b, p. 37):

Short-grass wet meadows, although dominated by the true grasses (*Agrostis stolonifera*, *Agropyron repens*, *Poa pretensis*, etc.), usually have greater species diversity than tall-grass wet meadows. They are rare in the study area as a whole. [translation]

#### 4.8.3 High marsh dominated by *Taraxacum officinale*

Several communities were identified by Aménatech (1992b) in the Verchères and Contrecoeur islands (a little over 20 ha). In the Aménatech report (1992b), this class appears under the name of “wet meadow dominated by *Taraxacum*.” No explanation was given as to why *Taraxacum* was designated as the dominant species of a high marsh.

#### 4.8.4 High marsh dominated by *Carex* sp.

According to Aménatech (1992b, p. 37), *Carex aquatilis* and *Carex lacustris* occupy this type of habitat in Lake Saint-François (1326 ha). In the Lower St. Lawrence region, according to Jacques and Hamel (1982, p. 42), “further inland, this zone often succeeds the previous one (high salt marsh dominated by *Spartina patens*). The dominant stratum is represented by *Carex paleacea*....”[translation] *Carex* sp. grow in the developed area of the Port of Cacouna (38 ha) and also further downstream, past L’Isle-Verte (21 ha).

#### **4.8.5 High marsh dominated by *Lythrum salicaria* or other broad-leaved vegetation**

According to Aménatech (1992b), this class is found only in Lake Saint-Louis. It occurs on the Îles de la Paix and in wetlands in the Châteauguay region (close to 37 ha).

#### **4.8.6 High marsh dominated by broad-leaved vegetation**

The refinement of the results reduced the area of this class to under 1 ha. It is located along the upstream end of Sainte-Thérèse Island.

#### **4.8.7 High marsh dominated by *Phragmites australis***

*Phragmites australis* is found along the edge of the Beauharnois Canal, where its marked presence allowed the species to be identified (894 ha).

#### **4.8.8 High marsh dominated by *Salicornia europaea* L. (S.L.) and *Spergularia canadensis***

According to Jacques and Hamel (1982), *Salicornia europaea* L. (S.L.) may dominate in shallow, very salty bays. According to Blouin and Grandtner (1971), this species may occur along with *Spergularia canadensis*. On the maps by Garneau (1984), these two species form a community along the shoreline between L'Isle-Verte and Pointe à la Loupe. We were able to easily identify them in the remote sensing images (75 ha).

#### **4.8.9 High marsh dominated by *Spartina patens***

According to Jacques and Hamel (1982, p. 36), “the second zone, for example, is the zone dominated by *Spartina patens* which, in the marshes studied by Gauvin (*loc. cit.*), is located between the daily high tide line and spring tide line.” [translation] Dryade (1980) found the class along the shoreline between Kamouraska and Trois-Pistoles, and its presence was confirmed by Garneau (1984) between Cacouna and Pointe à la Loupe. Roughly 458 ha were mapped between Cacouna and Trois-Pistoles.

#### **4.8.10 High marsh dominated by *Spartina patens* and *Bolboscoenus maritimus* var. *paludosus***

This class mainly occurs near L'Isle-Verte and Pointe à la Loupe, where thin strips of it were found sandwiched between *Spartina patens* communities and *Spartina patens* and *Hierochloe odorata* communities. Other communities were found in the Baie de Cacouna. On the

maps generated from the remote sensing images, the class appears mainly in the L'Isle-Verte area, at the mouth of the Verte River, where roughly 125 ha were found.

#### **4.8.11 High marsh dominated by *Spartina patens* and *Hierochloe odorata***

This community is found in the L'Isle-Verte area between Ronde Island and the mouth of Verte River (roughly 55 ha), where it is associated with *Spartina pectinata*-dominated communities. It can be easily distinguished from other classes by its characteristic colour; its distribution corresponds well to its occurrence on the maps by Garneau (1984).

#### **4.8.12 High marsh dominated by *Spartina patens* and *Plantago maritima***

According to the maps by Garneau (1984), *Plantago maritima* is very common at the far end of the Baie de Cacouna, although it can be found nearly everywhere between Cacouna and Pointe à la Loupe. In the L'Isle-Verte area, this formation occurs beside high marshes dominated by *Spartina patens* and *Bolboschoenus maritimus* var. *paludosus*. For the purposes of this mapping study, a class was created combining *Spartina patens* and *Plantago maritima*, because of the impossibility of clearly distinguishing between them. However, *Spartina patens* and *Plantago maritima* communities can be distinguished visually from adjacent communities. The class, which occurs over a total of 65 ha, is particularly abundant in the Baie de Cacouna (roughly 29 ha).

#### **4.8.13 High marsh used for agriculture**

This class was created for the specific case of Île aux Grues, where the wet meadows are used extensively for agriculture (894 ha). It also appears in areas further downstream such as Cacouna (2 ha). An area in the Port of Cacouna does not seem to correspond to either wetland or upland habitat and, although it is most likely high marsh, does not fit into the two other high marsh classes.

#### **4.8.14 High marsh dominated by *Spartina pectinata***

This class is found mainly in the Anse de L'Isle-Verte (55 ha). A few communities were also identified in the Port of Cacouna (10 ha), but should be assigned to the class of *Carex* sp. In

some small areas, flooding may have modified the spectral response of *Carex* sp. so that they were mistaken for *Spartina pectinata*.

#### 4.8.15 High salt marsh

Jacques and Hamel (1982, p. 42) commented about salt meadows (high salt marshes):

Cantin (1974) identified an area dominated by *Hordeum jubatum* as representative of salt meadows in the Kamouraska region. The meadow is next to an area of *Spartina patens*, *Carex paleacea*, *Scirpus maritimus*, *Spartina pectinata*, *Atriplex hastata* and *Glaux maritima*, which are some of the species associated with *Hordeum jubatum* in salt meadows. [translation]

This class appears throughout the Upper Estuary study sector (721 ha) and continues into the Lower Estuary (60 ha) as far as Trois-Pistoles.

### 4.9 SWAMP

Swamps are wetlands dominated by ligneous, treed or shrubby vegetation and still or slow-moving water, with seasonal or long periods of flooding (Buteau et al. 1994).

#### 4.9.1 Shrub swamp

This class is dominated by shrubs, which make up over 25% of the cover; openings may be occupied by emergent marsh plants (Jacques and Hamel 1982). Around Lake Saint-Pierre, dominant species in this class include *Salix* sp. and *Alnus incana* ssp. *rugosa* (Jacques 1986). No species distinctions were employed in the classification and all species were included in the shrub swamp class. Sparse shrub swamps may be confused with high marsh on the maps.

Extensive shrub swamps were found around Lake Saint-François (481 ha), mostly in the Lac Saint-François National Wildlife Area. Roughly 58 ha were identified in Lake Saint-Louis on the Îles de la Paix and Saint-Bernard Island. The Îles de Boucherville also have a small area of shrub swamp (slightly over 38 ha). In addition, 12 ha can be found next to a forested swamp on Saint-Ours Island, near the Îles de Contrecoeur. Lake Saint-Pierre has the greatest concentration (903 ha) and also the widest distribution of shrub swamps. This habitat is found along the shoreline of the lake, but particularly in Lavallière and Saint-François bays and on the less agricultural islands in the Berthier–Sorel islands. In the Fluvial Estuary, a small area (43 ha) is found near Nicolet and the boundary of the Lake Saint-Pierre study sector. In the Quebec City–

Lévis sector, shrub swamps can be found along Côte de Beaupré and the north shore of Île d'Orléans (174 ha) next to forested swamps. The only shrub swamps found in the Upper Estuary were along the upper end of the gradient on the Cap Tourmente flats (56 ha).

#### 4.9.2 Forested swamp

Forested swamp is dominated by tree species, which make up over 25% of the cover. In such swamps, the vegetation forms a relatively dense forest of tall conifers or hardwood species (Jacques and Hamel 1982, National Wetlands Working Group 1988).

In the Lake Saint-Pierre floodplain, forested swamps are typically dominated by *Acer saccharinum* (Jacques 1986). We could only distinguish one category of forested swamp in the remote sensing images. We preferred therefore to retain the “forested swamp” class rather than to create a new class, “forested swamp dominated by *Acer saccharinum*.”

Aménatech (1992a, p. 29) describes the species found in swamps between Trois-Rivières and Montmagny:

However, in the rare areas with well-developed forested swamps such as Bécancour and Gentilly, *Acer saccharinum* is known to be dominant. Further east, the nature of the shoreline creates conditions that generally favour other species such as *Fraxinus americana*, *Fraxinus pennsylvanica*, *Populus deltoides* and *Ulmus americana*. *Salix nigra* and *Salix fragilis* often form a discontinuous fringe at the water's edge. [translation]

As in the case of high marshes, forested swamp is distinguished from forest by separating wetlands from uplands before classification; however, the two classes can still be confused. Forested swamp could also be confused with dense shrub swamps. In the field, it is possible to distinguish these two classes by examining the herbaceous species growing beneath trees.

This class was used generically and does not necessarily include the other classes of forested swamps identified. While 38 ha of forested swamps were identified in Lake Saint-François, more specific classes of forested swamps covered 435 ha there. In the Îles de Boucherville, only 17 ha of this class were found. On the Île de Verchères and Saint-Ours Island, 54 ha of this habitat occur next to the high marshes. All the forested swamps in Lake Saint-Pierre were combined in this single class, covering a total area of 3096 ha. In the Fluvial Estuary (703 ha), most of this habitat is located between Nicolet and Portneuf. In the Quebec City region,

forested swamps (141 ha) are found alongside shrub swamps along the Côte de Beaupré and the north shore of the Île d'Orléans. In the Upper Estuary, this habitat is found only at Cap Tourmente (29 ha).

#### **4.9.3 Forested swamp dominated by *Acer saccharinum***

Since this class was found to be dominant around Lake Saint-Louis, all forested swamps there were included in it. Most of the 188 ha were found on Saint-Bernard and Dowker islands and the Kahnawake Mohawk Reserve.

#### **4.9.4 Forested swamp dominated by *Acer rubrum***

This class was created to distinguish it from forested swamps dominated by *Larix laricina*, which are found next to it in the Lac Saint-François National Wildlife area (Dundee) on the south shore of Lake Saint-François (322 ha).

#### **4.9.5 Forested swamp dominated by *Larix laricina***

This class was created to distinguish it from forested swamp dominated by *Acer rubrum*, which is found next to it in the Lac Saint-François National Wildlife area (113 ha).

### **4.10 HARVESTED PEATLANDS**

A few peatlands were identified in the Rivière-du-Loup and L'Isle-Verte regions. The colour and shape of these exploited areas make them easy to distinguish from adjoining features. Unfortunately, once data from outside the one-kilometre-wide inland strip were eliminated, only 34 ha of these peatlands remained.

### **4.11 DRY MEADOW**

The “high marsh dominated by tall grasses” class was found on all the islands in the study area, and dominated in the mapping study by Aménatech (1992b). The St. Lawrence Centre made some modifications to this class using information from the report by Pilon et al. (1980), including adding the “dry meadow” class, which was obtained by masking the portions of presumed high marshes outside the floodplain. Therefore, no classification per se was carried out to obtain this new class; instead, a mask representing areas of dry meadows was applied. The

areas most affected comprise the group of islands downstream of Sainte-Thérèse Island and Île de Verchères.

#### **4.12 PLOWED LAND**

Plowed fields usually appear as denuded substrate or very short vegetation through which the soil is visible. This class was sometimes confused with the “agriculture” or “built-up area” classes.

#### **4.13 AGRICULTURE**

Pastureland and forage crops stand out well due to their uniform colour and are easily distinguished by their physical appearance. Although a number of crops can be identified, there is not enough information to distinguish hayfields from oat fields. During the period in summer when these images were acquired, there may have been occasional confusion between the “agriculture” class and the “plowed land” or “fallow land” class.

#### **4.14 FALLOW LAND**

Fallow fields generally have a less uniform surface than forage fields and pastureland. This class was less prevalent than cropland (forage), pastureland and plowed land.

#### **4.15 FOREST WITH NO DOMINANT SPECIES**

This class involves forest present on islands that is not precisely identified on the ecoforest maps of Quebec’s Ministère des Forêts and can thus contain deciduous or coniferous trees. It is found on islands in the Kamouraska–Trois-Pistoles section.

#### **4.16 DECIDUOUS FOREST**

Deciduous forests are prevalent along the shores of the St. Lawrence River. Aménatech (1992a, 1992b) found this forest exclusively in the area between Cornwall and Montmagny. Forested swamps also contain deciduous trees (*Acer saccharinum*, *Acer rubrum*). These forests also occur between Montmagny and Trois-Pistoles, although coniferous forests are more abundant.



#### **4.17 CONIFEROUS FOREST**

Coniferous forests are very easily distinguished from deciduous forests by their distinctive colour. This class is found mainly downstream of Montmagny as far as Trois-Pistoles. Quebec's Ministère des Forêts ecoforest maps aided in distinguishing between coniferous and deciduous forests. We did not attempt to identify species.

#### **4.18 MIXED FOREST**

Mixed forests are easily distinguished from deciduous and coniferous forests by their distinctive colour. This class occurs mainly downstream of Montmagny as far east as Trois-Pistoles. Quebec's Ministère des Forêts ecoforest maps aided in distinguishing these forests from coniferous and deciduous forests.

#### **4.19 PLANTATION**

A plantation of trees (probably conifers), roughly 36 ha in size, was identified by Aménatech (1992a) on the south shore of the St. Lawrence opposite the mouth of the Saint-Maurice River.

#### **4.20 ACER RUBRUM FOREST ON POORLY DRAINED SOIL**

According to Aménatech (1992b), the "*Acer rubrum* forest on poorly drained soil" class occurs mainly along the Beauharnois Canal. There does not seem to be any difference between this class and the "forested swamp dominated by *Acer rubrum*" class, although Aménatech (1992b) did make a distinction between the two classes.

#### **4.21 SEMI-DENUDED SOIL WITH REGENERATING DECIDUOUS TREES**

This class also came from Quebec's Ministère des Forêts ecoforest maps. It is found mainly between La Pocatière and Rivière-du-Loup in the midst of other forest classes.

#### **4.22 BUILT-UP AREA**

The "built-up area" class may include, along with urban spaces (dominated by concrete and asphalt), highways, plowed fields (where the very light tone of the signal for bare soil can be confused with that for urban spaces), areas of landfill and bridges.

**4.23 SEDIMENTATION BASIN**

This class was created to encompass the sedimentation basins constructed along the Beauharnois Canal. These shallow basins emit a spectral response different from other water masses and can therefore be mapped.

**4.24 CLOUDS AND SHADOW**

The presence of clouds and shadows is a major disadvantage in remote sensing. Areas hidden by clouds cannot be analysed, while the poor radiometric quality of images acquired when atmospheric haze is present makes classification somewhat less accurate.

**4.25 LOGS**

This class was created to represent the floating log booms at the western outlet of the Saint-Maurice River (Trois-Rivières).

**4.26 QUARRIES, BARE SOIL IN URBAN SETTING**

This class was created for a very localized phenomenon: 11 ha near the municipalities of Portneuf and Jacques-Cartier. Aménatech (1992a) provided no justification for the creation of this class.

## 5 Results

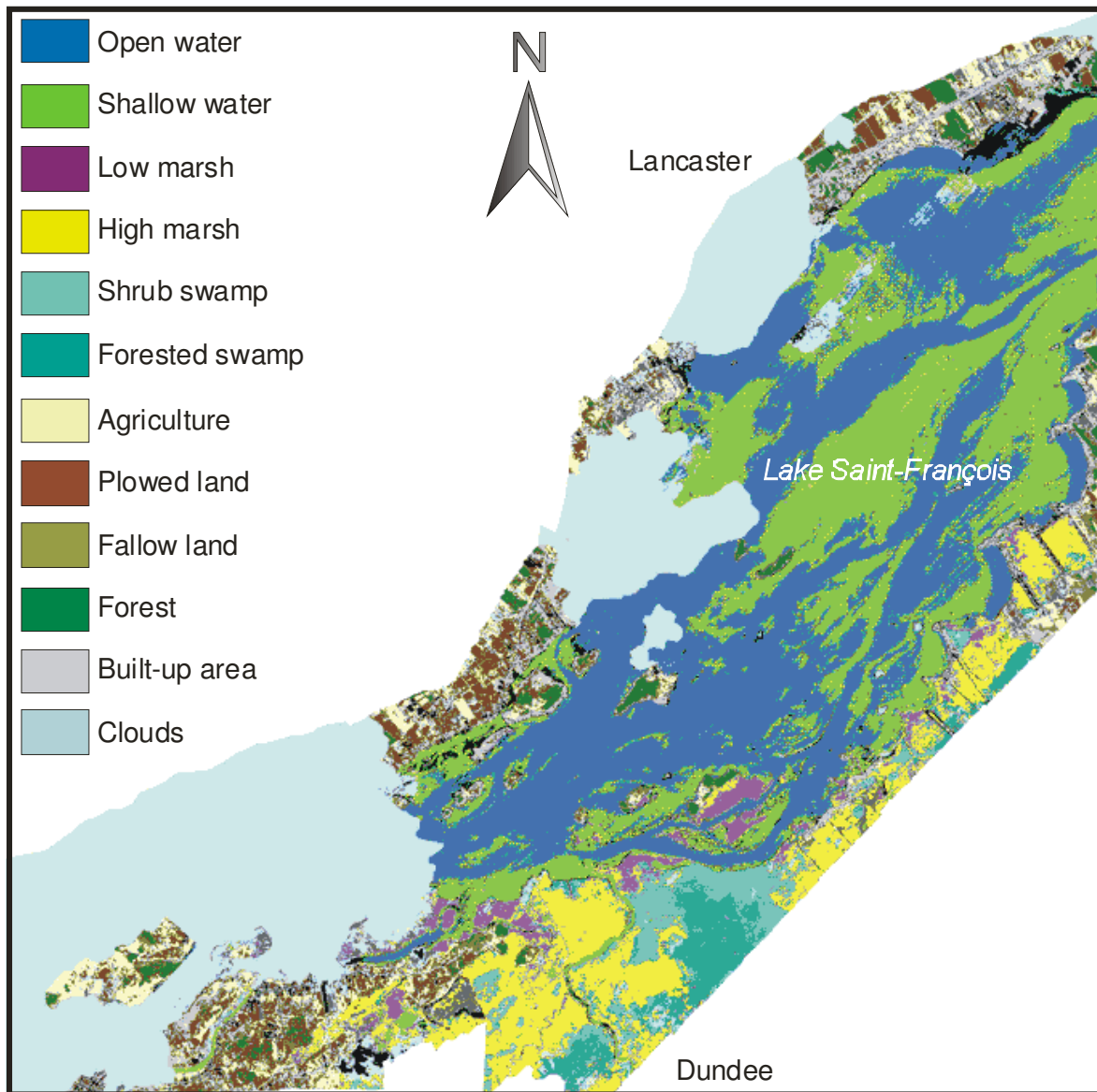
After the mapping of the one-kilometre-wide inland strip between Cornwall and Trois-Pistoles, classes were merged in the figures displayed in this chapter to optimize the viewing of the vegetation characteristics of each region at a small scale. The tables that follow the figures show the maximum number of classes obtained per region, along with their area in hectares. Areas were calculated based on the boundaries of the respective ZIPs and therefore may differ from data in the reports cited as a reference, which provide statistics by processed file.

In all, between Cornwall and Trois-Pistoles, there are roughly 28 141 ha of shallow water, 17 468 ha of low marshes, 9507 ha of high marshes and 6470 ha of swamps.

### 5.1 CLASSIFICATION OF THE LAKE SAINT-FRANÇOIS STUDY SECTOR

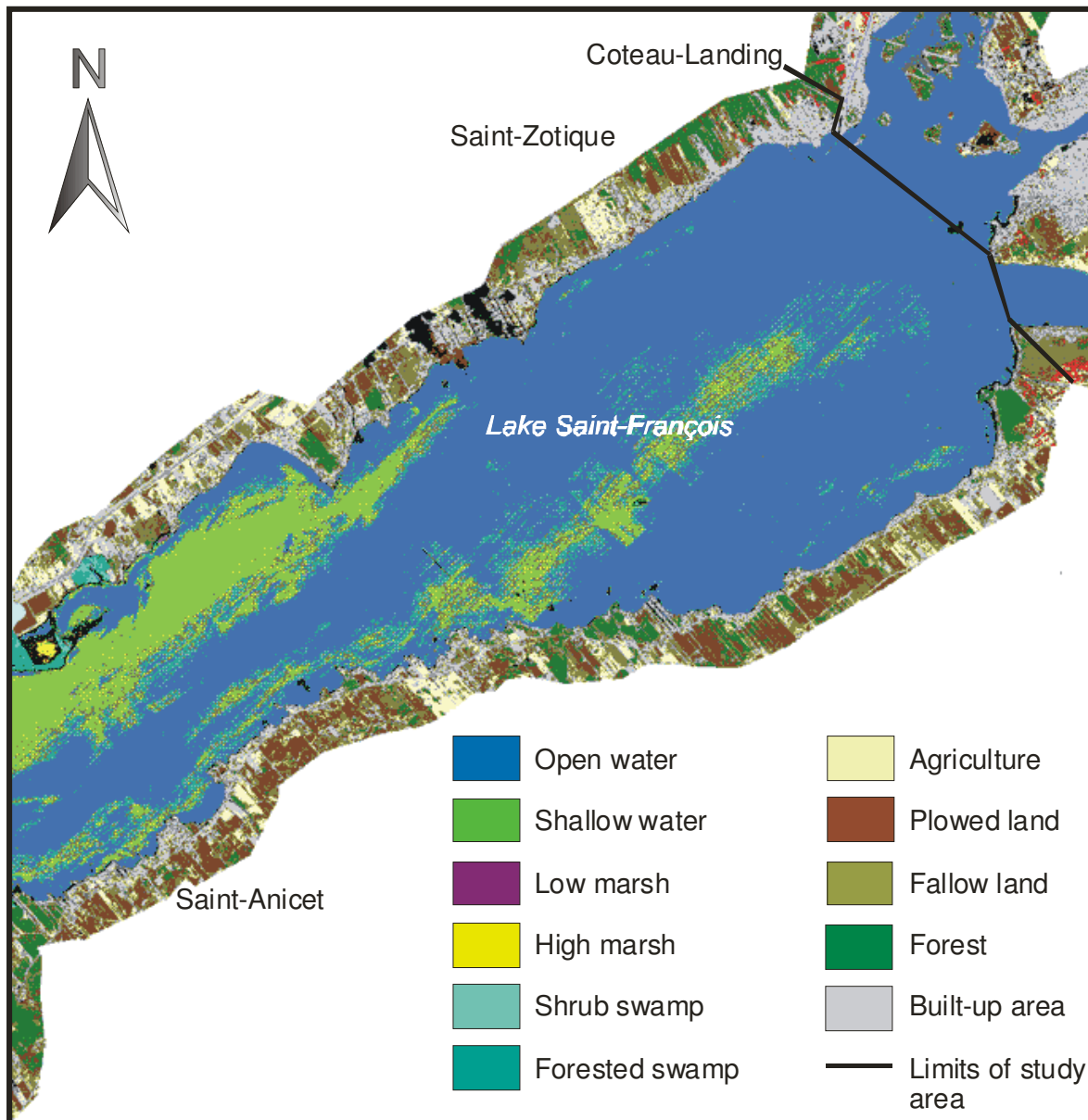
Figure 3 shows the distribution of the various wetland classes in the upstream portion of the Lake Saint-François study sector. Extensive wetlands occur on the south shore of the lake. In the downstream portion of the lake, however, wetlands are more common on the north shore (Figure 4). The cloud cover present during image acquisition on July 26, 1990, masked the north shore of the lake (30% of the territory or 5400 ha).

Despite the presence of clouds and atmospheric haze, close to 5480 ha of shallow water was identified. The Lac Saint-François National Wildlife Area, on the south shore (Figure 3), supports close to 330 ha of low marshes, nearly 1250 ha of high marshes and close to 825 ha of swamps. Low marshes are abundant around islands, occupying over 330 ha in the sector, where they are dominated by *Typha* sp. The high marshes are dominated by *Carex* sp. The swamps can be divided into shrub swamps, forested swamps dominated by *Larix laricina* and forested swamps dominated by *Acer rubrum*, these three classes occurring together in the Dundee area. The north shore contains roughly 74 ha of swamps (general class) (Figure 4). In this area, the predominant land-use type along the shoreline is agriculture.



**Figure 3 Mapping (July 26, 1990) of wetlands in the Lake Saint-François study sector (western portion)**

In its first mapping project, Aménatech (1992b) identified shallow water as occupying a smaller area. Reclassification based on new sampling sites allowed new plant communities in the centre of the lake to be identified. Image processing focused on shallow water only and not all classes. The result was superimposed on the earlier map.



**Figure 4 Mapping (July 26, 1990) of wetlands in the Lake Saint-François study sector (eastern portion)**

Aménatech (1992b) issued various warnings in its report on the radiometric quality of images and the limitations of interpreting various classes:

- The marked presence of clouds adversely affected the radiometric quality of the images and resulted in decreased classification accuracy. The presence of clouds resulted in the elimination of a large part of the area on the north shore.

- This lack of accuracy resulted in a certain degree of confusion between open water and the shallow water classes. The lack of recent information on aquatic plant communities makes the assessment of their spatial distribution difficult. One area of confusion was between areas of sparse aquatic vegetation and sections of the river with calmer hydrodynamics. More specifically, the area occupied by the “shallow water with floating leaves” class is overestimated for the Rivière aux Saumons, in the middle of the Lac Saint-François National Wildlife Area. This can be explained by the narrowness of this river, which, during this time of year, is in its period of minimum flow. On the north shore, the presence of clouds led to an overestimation of this class as well.
- Unclassified pixels in wetlands are mainly mixed pixels and unsampled pixels in the area west of the Rivière aux Saumons. Unclassified pixels in the one-kilometre-wide inland strip consist of pixels whose signal was influenced by atmospheric conditions and variations in the moisture content or density of agricultural fields.

**Table 3**  
**Wetlands in the Lake Saint-François study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	5483.46
Shallow water dominated by floating vegetation	11	267.72
Low marsh dominated by <i>Typha</i> sp.	38	333.78
High marsh	80	11.39
High marsh dominated by <i>Carex</i> sp.	83	1326.40
High marsh dominated by <i>Phragmites australis</i>	84	32.79
Shrub swamp	110	481.00
Forested swamp	130	38.59
Forested swamp dominated by <i>Acer rubrum</i>	132	321.96
Forested swamp dominated by <i>Larix laricina</i>	133	113.12
Total		8410.21

Aménatech (1992b) also reports confusion between shallow water and open water, mainly in the central part of Lake Saint-François, at the entrance to the Beauharnois Canal and around the islands northwest of Valleyfield, due to radiometric variations in and between flight lines. This misalignment, which resulted from the merging of files for the areas upstream and downstream of Lake Saint-François, is apparent in Figure 4 among the shallow water plant communities. In addition, the misalignment is also due to the fact that the two mosaic files were

processed, or classified, independently of one another, since each file had its own training areas and spectral characteristics from which the image classification was carried out.

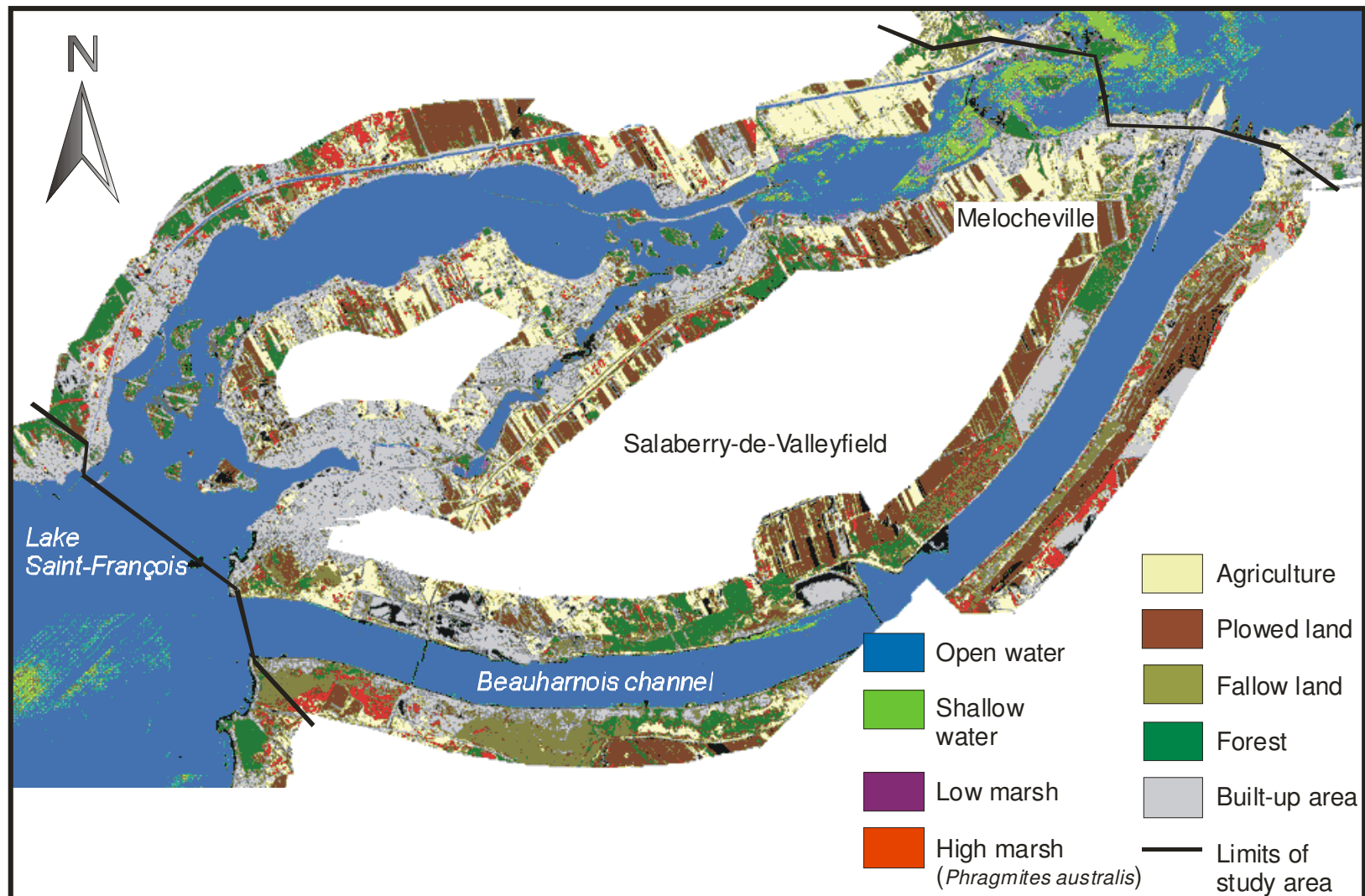
Moreover, according to Aménatech (1992b), the “high marsh” class basically corresponds to the wetlands managed by Ducks Unlimited Canada in the northwestern part of the study sector. Unclassified pixels in wetlands are mainly mixed pixels along the water’s edge. The “agriculture” class partially overlaps the “plowed land” class. Unclassified pixels in upland areas basically correspond to areas with shadows or clouds and sections of open water that were not identified during classification.

## **5.2 CLASSIFICATION OF THE VALLEYFIELD–BEAUHARNOIS STUDY SECTOR**

Figure 5 results from the merging of images obtained on two different dates: July 26, 1990 (images of the western end of the Beauharnois Canal) and August 21, 1990 (images of the rest of the region).

A new class entitled “high marsh dominated by *Phragmites australis*” emerged in the classification. It covers an area of roughly 860 ha (Table 4), nearly 50% of which is located on the south shore of the Beauharnois Canal, with the rest distributed along the north shore of the river. Since this class can be confused with the “agriculture” class, caution is required in interpreting the total area.

The “built-up area” class is omnipresent, representing over 3720 ha in the one-kilometre-wide inland strip. In addition to the urban areas, this class includes residential and rural areas with their accompanying areas of shrubs and bare soil. This class is easily confused with classes of denuded substrates, which appear in very light tones on the images, resulting in overestimates of the area covered, mainly along the south shore of the Beauharnois Canal.



**Figure 5 Mapping (July 26 and August 21, 1990) of wetlands in the Valleyfield-Beauharnois study sector**



Agriculture, which is even more common, occupies close to 4420 ha when the “plowed land” and “agriculture” classes are combined. The white area that can be seen in the middle of the Beauharnois Canal and part of the south shore is associated with unclassified pixels, but corresponds to areas not covered by overflights rather than unclassified pixels.

**Table 4**  
**Wetlands in the Valleyfield–Beauharnois study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	236.11
Shallow water dominated by floating vegetation	11	3.05
Low marsh dominated by <i>Sagittaria</i> sp.	25	1.07
Low marsh dominated by <i>Typha</i> sp.	38	2.07
Low marsh dominated by narrow-leaved vegetation	44	25.71
Low marsh dominated by dense narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Scirpus</i> sp.)	45	23.24
Low marsh dominated by sparse narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Scirpus</i> sp.)	46	11.74
Low marsh dominated by narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Sparganium</i> sp.)	57	4.97
High marsh dominated by <i>Phragmites australis</i>	84	861.22
Forested swamp dominated by <i>Acer saccharinum</i>	131	3.95
Total		1173.13

According to Aménatech (1992b), many of the unclassified pixels represent water treatment sedimentation basins located near the Beauharnois power plant. The other unclassified pixels consist of mixed pixels representing habitat at the water’s edge and localized aquatic plant communities.

### **5.3 CLASSIFICATION OF THE LAKE SAINT-LOUIS STUDY SECTOR**

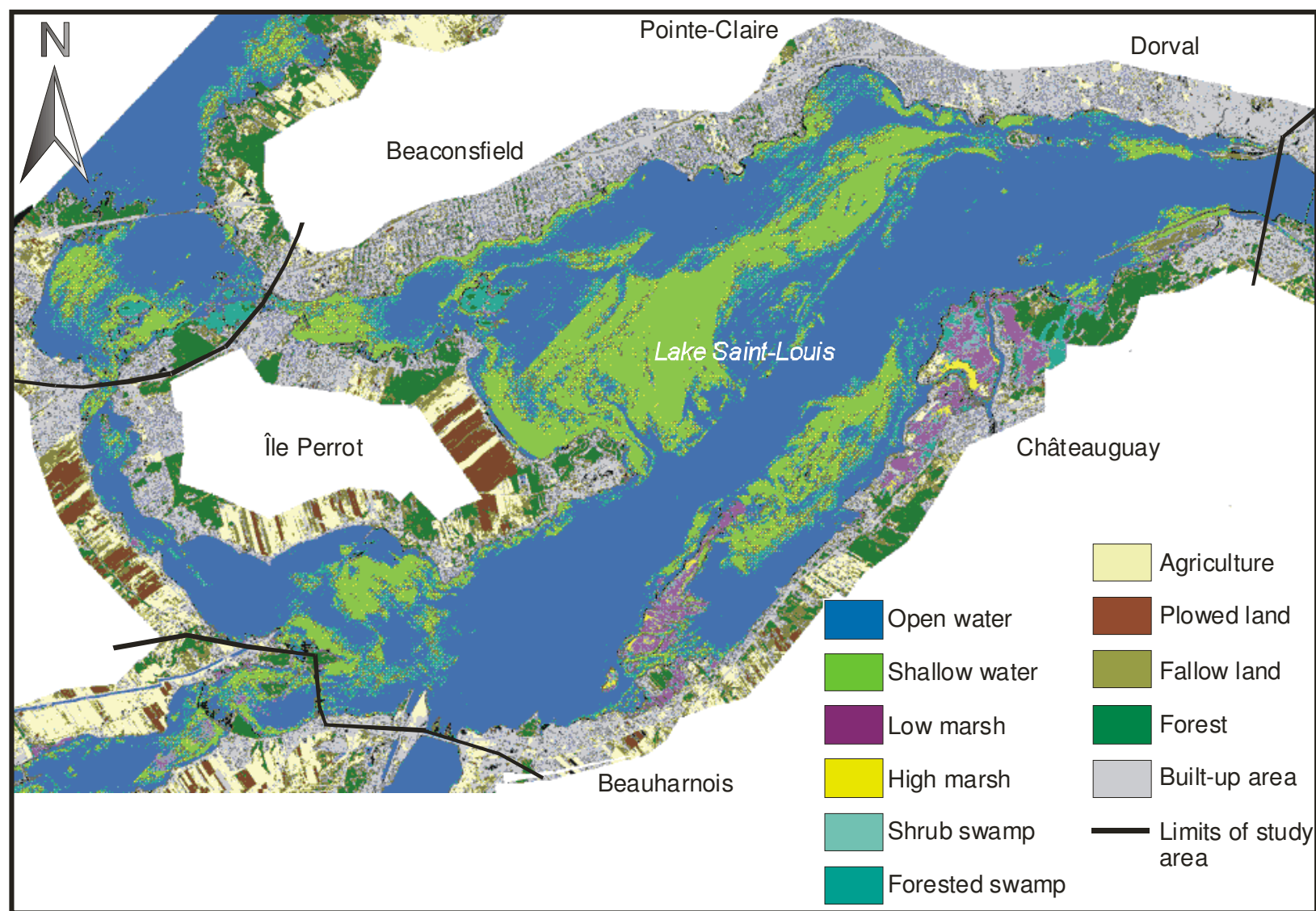
As Figure 6 shows, the south shore of Lake Saint-Louis is fairly wooded with extensive farmland. There are also many marshes and swamps along the shoreline. In contrast, the north shore, on the Island of Montreal, is highly urbanized. The Lake Saint-Louis study sector contains over 3900 ha of shallow water, 510 ha of low marshes, close to 100 ha of high marshes and over 240 ha of swamps (Table 5). In upland areas, it also includes 1235 ha of forests, 2800 ha of

agricultural land and over 3400 ha of built-up areas within the one-kilometre-wide inland strip. Despite the presence of expanses of shallow water, there is over 10 680 ha of open water.

In this sector, according to Aménatech (1992b), the classification of shallow water and open water is particularly difficult because of the different types of open water found in the region. The brown water of the Ottawa River and clear green water of the Great Lakes make it difficult to distinguish among shallow waters using the maximum likelihood algorithm. The “low marsh dominated by *Sagittaria* sp.” class was slightly overestimated, particularly around Dowker Island, where *Lythrum salicaria* is mixed in with this class. In addition, the “shallow open water” class was overestimated in relation to the “open water” class.

**Table 5**  
**Wetlands in the Lake Saint-Louis study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	3965.43
Shallow water dominated by floating vegetation	11	40.79
Low marsh dominated by <i>Sagittaria</i> sp.	25	114.35
Low marsh dominated by <i>Bolboschoenus fluviatilis</i>	27	22.30
Low marsh dominated by dense narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Scirpus</i> sp.)	45	39.74
Low marsh dominated by sparse narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Scirpus</i> sp.)	46	92.03
Low marsh dominated by narrow-leaved vegetation ( <i>Typha</i> sp. and <i>Sparganium</i> sp.)	57	243.87
High marsh dominated by tall grasses	81	57.37
High marsh dominated by <i>Lythrum salicaria</i> or other broad-leaved vegetation	86	37.21
Shrub swamp	110	57.95
Forested swamp dominated by <i>Acer saccharinum</i>	131	183.86
Total		4854.90



**Figure 6 Mapping (August 21, 1990) of wetlands in the Lake Saint-Louis study sector**

In addition, according to Aménatech (1992b), the “built-up area” class covers a large area in the one-kilometre-wide inland strip. This is due to the heavy urbanization of the sector and the presence of residential and rural areas with a high percentage of vegetation. In addition, built-up areas and fallow land alternate to some extent, so that the area appears fragmented, representing areas under development. Unclassified pixels consist mainly of mixed pixels and pixels that were not defined spectrally in the sampling.

#### **5.4 CLASSIFICATION OF THE LA PRAIRIE BASINS STUDY SECTOR**

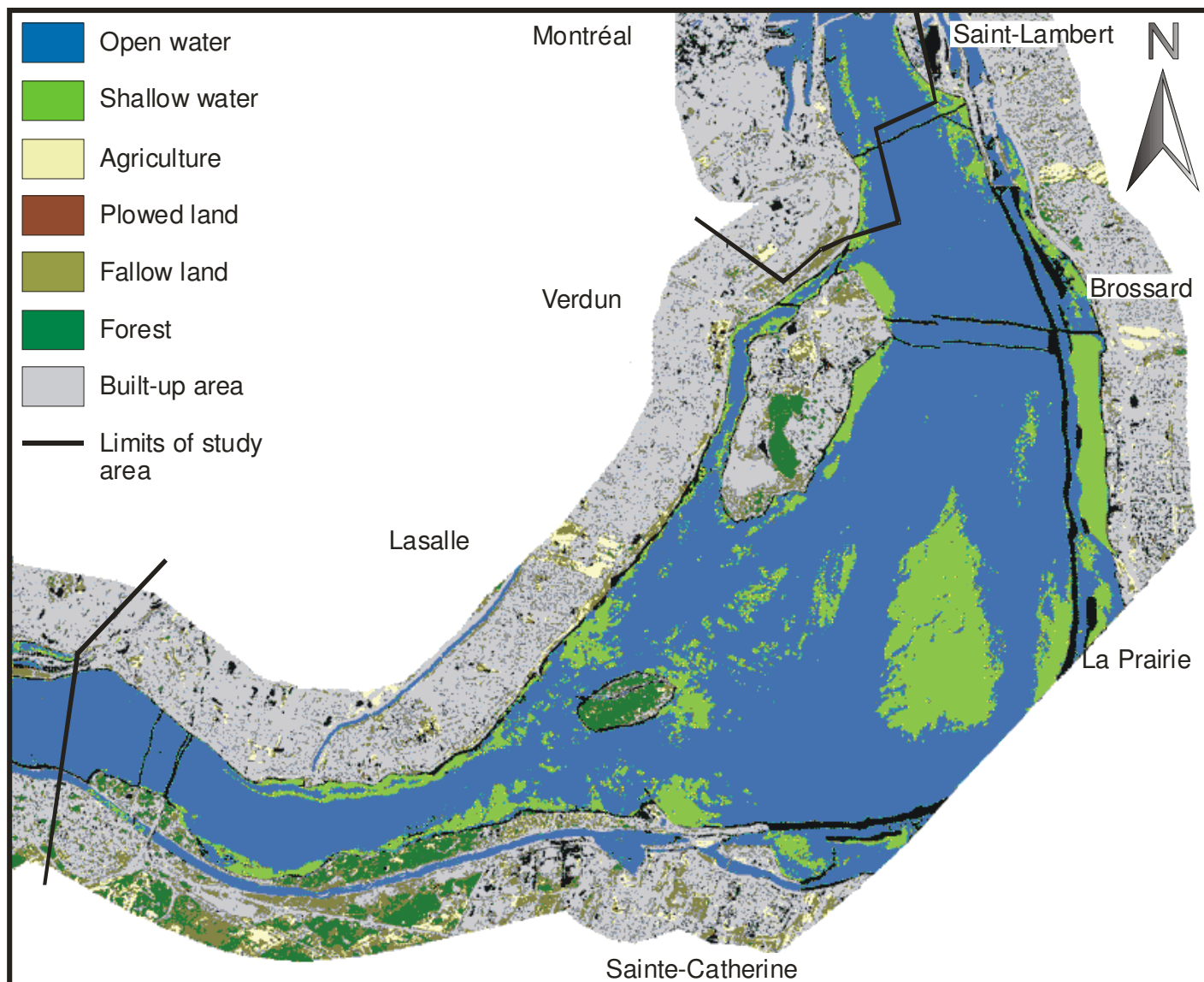
This sector of the St. Lawrence is notable for the low incidence of marshes and swamps. As Figure 7 shows, most of the land on both sides consists of built-up areas. On the south shore, agricultural and forested areas tend to be localized. There are slightly over 950 ha of shallow water (Table 6). Although the high degree of urbanization results in over 3080 ha of built-up areas, there are still close to 410 ha of forest and close to 1110 ha of agricultural land.

**Table 6**  
**Wetlands in the La Prairie Basins study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	955.58

No images are available of the eastern part of the La Prairie Basins sector and an additional flight line would be required to acquire them (unfortunately, accidentally omitted by the aviation company).

In addition, the area occupied by shallow water along the Island of Montreal was overestimated, to the detriment of the “open water” class. The problem appears to be a conflict between the spectral characteristics of the brown water mass from the Ottawa River and those of the shallow water.



**Figure 7 Mapping (August 21, 1990) of wetlands in the La Prairie Basins study sector**

Refining the classification allowed the area occupied by aquatic plant communities to be reduced to a more realistic figure. The “agriculture” class was found in some urbanized sectors such as Verdun and Saint-Lambert and probably consists of abandoned fields.

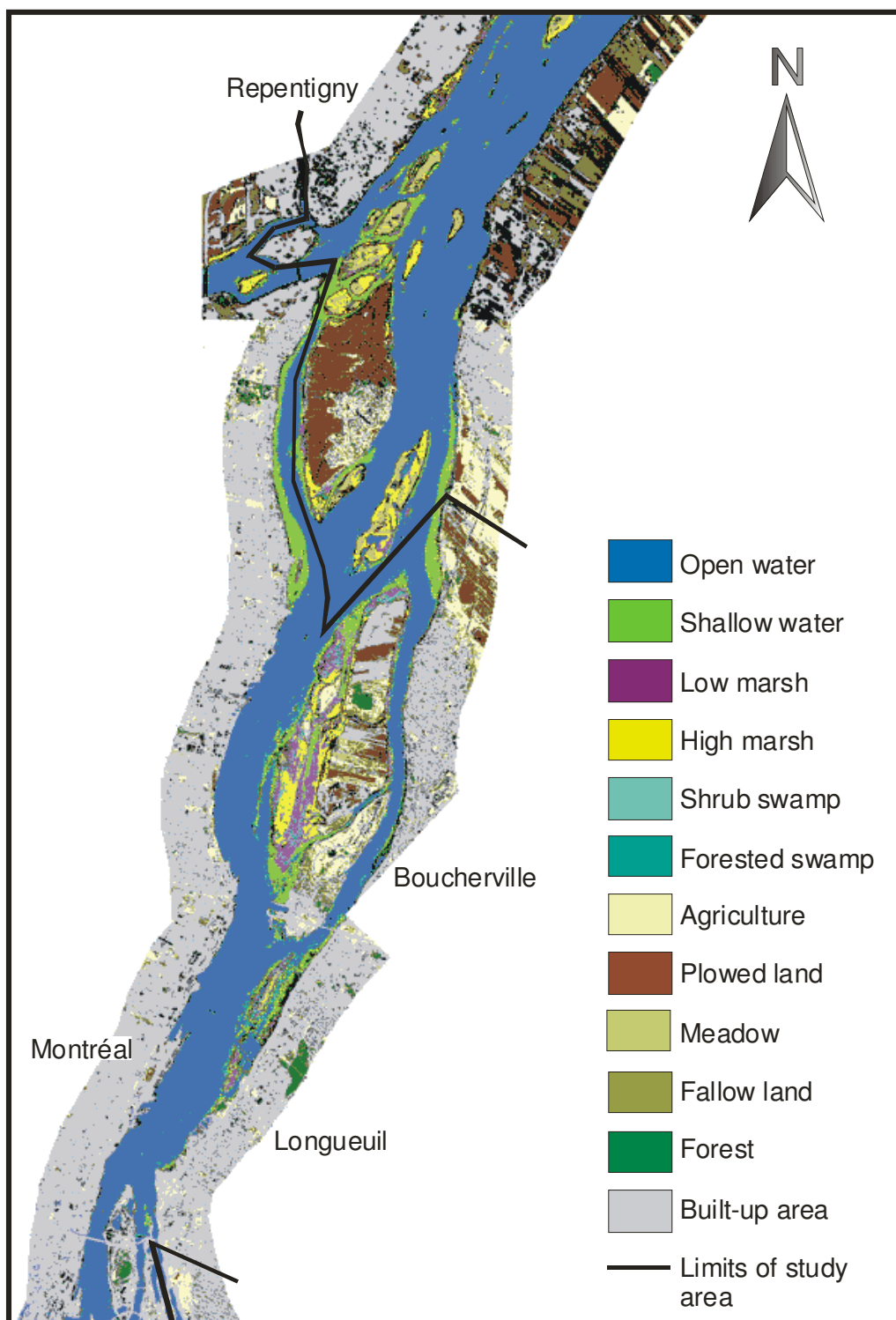
Unclassified pixels in wetlands included shallow water in the southwest portion of the sector, mainly off Kahnawake and the marina near Lachine. Other unclassified pixels correspond mainly to upland areas (bridges, dikes, islets, etc.) that were not sampled and turbulent water masses in the rapids. Unclassified pixels in the one-kilometre-wide inland strip are mainly mixed pixels or pixels undefined in sampling.

## 5.5 CLASSIFICATION OF THE MONTREAL–LONGUEUIL STUDY SECTOR

The Montreal–Longueuil study sector is one of the most highly urbanized regions, as seen in Figure 8. Municipalities located along the shoreline include Montreal, Montréal-Est, Tétraultville, Pointe-aux-Trembles, Boucherville and Longueuil. As Table 7 shows, the Îles de Boucherville contain extensive wetlands, including over 500 ha of shallow water, close to 200 ha of low marshes, 150 ha of high marshes and only 55 ha of swamps.

**Table 7**  
**Wetlands in the Montreal–Longueuil study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	502.86
Shallow water dominated by floating vegetation	11	1.48
Low marsh dominated by <i>Bolboschoenus fluviatilis</i>	27	31.84
Low marsh dominated by <i>Typha</i> sp.	38	144.03
Low marsh dominated by robust vegetation	54	23.91
High marsh dominated by tall grasses	81	133.59
High marsh dominated by short grasses	82	15.34
Shrub swamp	110	38.51
Forested swamp	130	17.08
Total		908.64



**Figure 8 Mapping (August 21, 1990) of wetlands in the Montreal–Longueuil study sector**

The “high marsh dominated by tall grasses” class was overestimated in relation to low marshes in the Taillandier Flats area opposite the Îles de Boucherville. Low marshes in this area were classified as shrub swamps and forested swamps, due to the fact that the two latter classes had poor spatial coverage, resulting in inadequate sampling.

The one-kilometre-wide inland strip in the sector is highly urbanized and has a number of built-up areas within a rural setting. This is accurately reflected in the “built-up area” class, which covers a complete range of variations within these areas. On the other hand, this class was overestimated to the detriment of the “plowed land” class, particularly the subclass of denuded substrate.

Unclassified pixels were mainly mixed pixels located at the water’s edge.

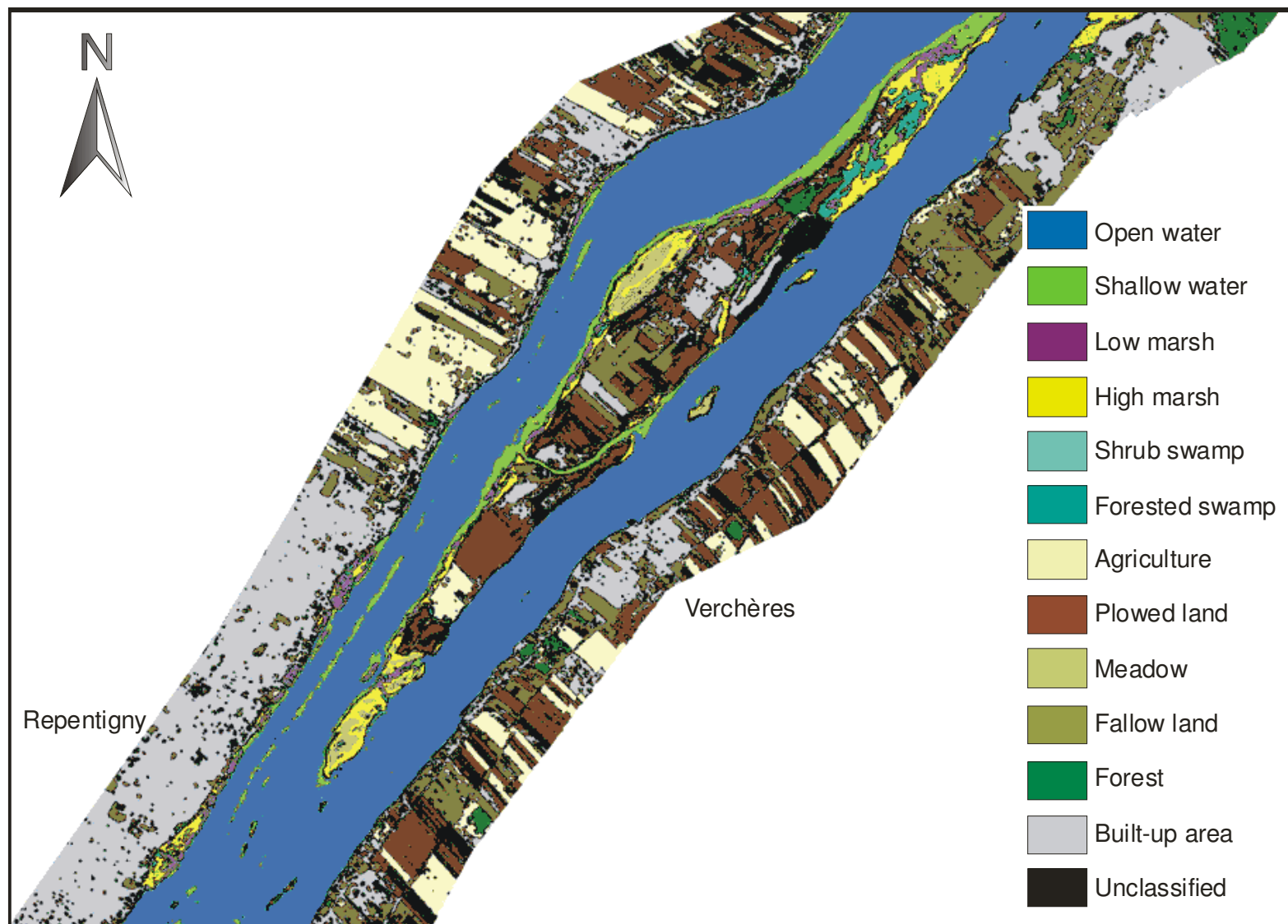
## **5.6 CLASSIFICATION OF THE VARENNES–CONTRECOEUR STUDY SECTOR**

As figures 9 and 10 show, the Varennes–Contrecoeur study sector takes in Sainte-Thérèse Island, Île de Verchères and the Îles de Contrecoeur. The sector contains close to 860 ha of shallow water, close to 440 ha of low marshes, over 580 ha of high marshes and 66 ha of swamps (Table 8). In upland areas, the sector has over 3000 ha of built-up area, over 1200 ha of forests and over 4770 ha used for agriculture and other green spaces.

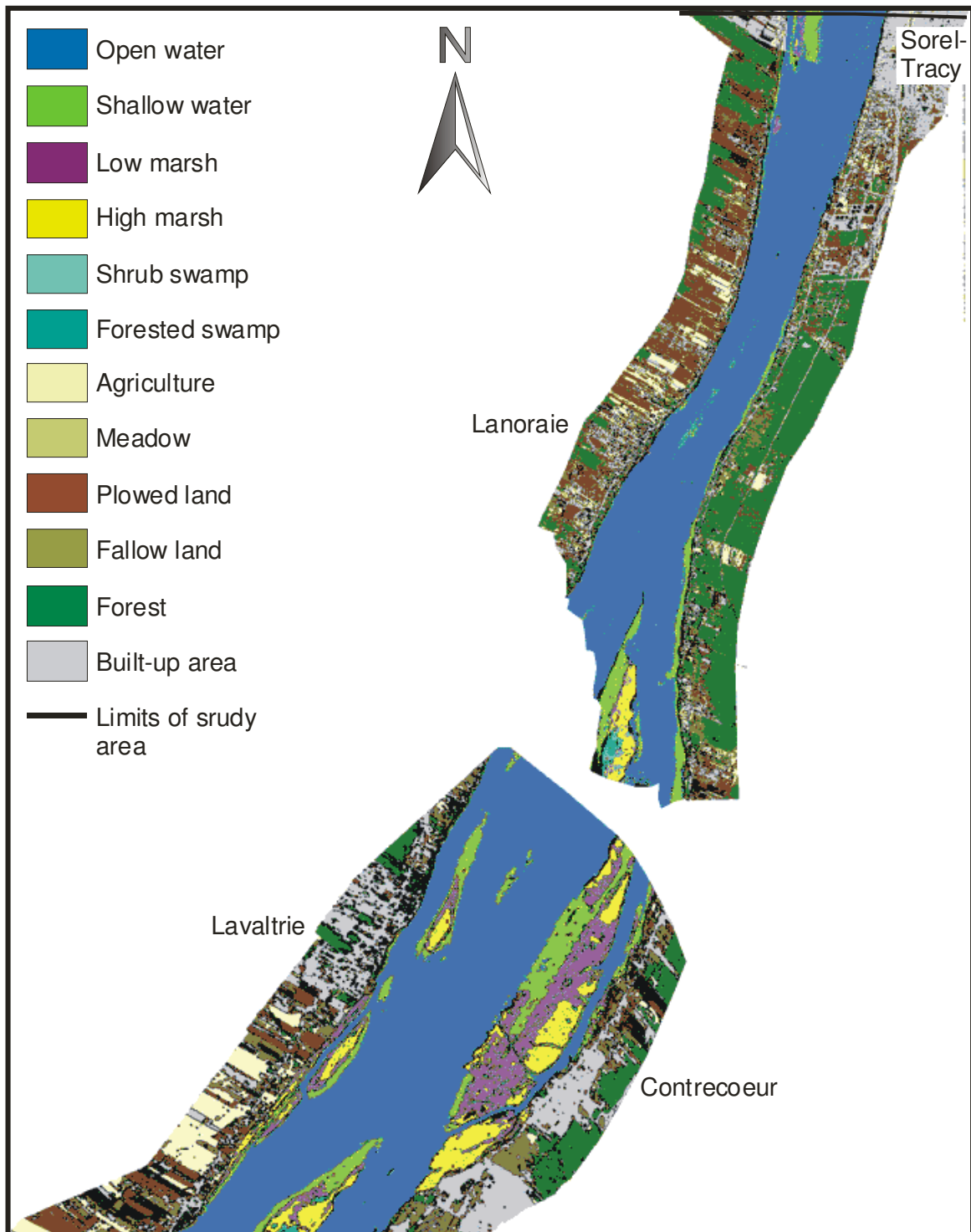
Two overflights were made over the study sector, on July 26 and August 21, 1990, and it was surveyed at the same time as the Valleyfield–Beauharnois and Lake Saint-Pierre sectors. The images obtained on August 21 (from Pointe-aux-Trembles to Contrecoeur) were processed during the pilot project and were not corrected or refined during the classification of the Cornwall–Trois-Rivières section. Images acquired on July 26 (Saint-Ours Island to Lanoraie) were classified along with the entire Cornwall–Trois-Rivières section, although the presence of clouds during the overflight eliminated a portion of Saint-Ours Island.

Areas of vegetation in built-up areas in the Tracy region were confused with the “plowed land” and “agriculture” classes due to local atmospheric haze. The same occurred with Saint-Ours Island, where the cloud shadows modified the spectral characteristics.





**Figure 9** Mapping (July 26 and August 21, 1990) of wetlands in the Varennes-Contrecoeur study sector (southern portion)



**Figure 10 Mapping (July 26 and August 21, 1990) of wetlands in the Varennes-Contrecoeur study sector (northern portion)**

The “high marsh dominated by tall grasses” class was present and indeed dominant on the shoreline of all the islands mapped by Aménatech (1992b). Based on information in Pilon et al. (1980), the St. Lawrence Centre made some corrections to this class, which involved adding the “dry meadow” class, obtained by masking the portions of high marsh located outside the floodplain. (Classification per se was not carried out to obtain this class; instead, a mask representing areas of dry meadow was applied). The areas most affected by the corrections were the islands downstream of Sainte-Thérèse Island and the Île de Verchères.

**Table 8**  
**Wetlands in the Varennes–Contrecoeur study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	811.58
Shallow water dominated by floating vegetation	11	51.26
Low marsh dominated by <i>Sagittaria</i> sp.	25	73.63
Low marsh dominated by <i>Bolboschoenus fluviatilis</i>	27	150.02
Low marsh dominated by <i>Typha</i> sp.	38	203.30
Low marsh dominated by narrow-leaved vegetation	44	1.88
Low marsh dominated by emergent and floating vegetation	47	2.19
Low marsh dominated by robust vegetation	54	1.61
Low marsh dominated by robust vegetation and other herbaceous plants	55	10.99
High marsh	80	45.50
High marsh dominated by tall grasses	81	380.90
High marsh dominated by short grasses	82	135.48
High marsh dominated by <i>Taraxacum officinale</i>	93	21.59
High marsh dominated by broad-leaved vegetation	94	0.33
Shrub swamp	110	12.21
Forested swamp	130	54.30
Total		1956.77

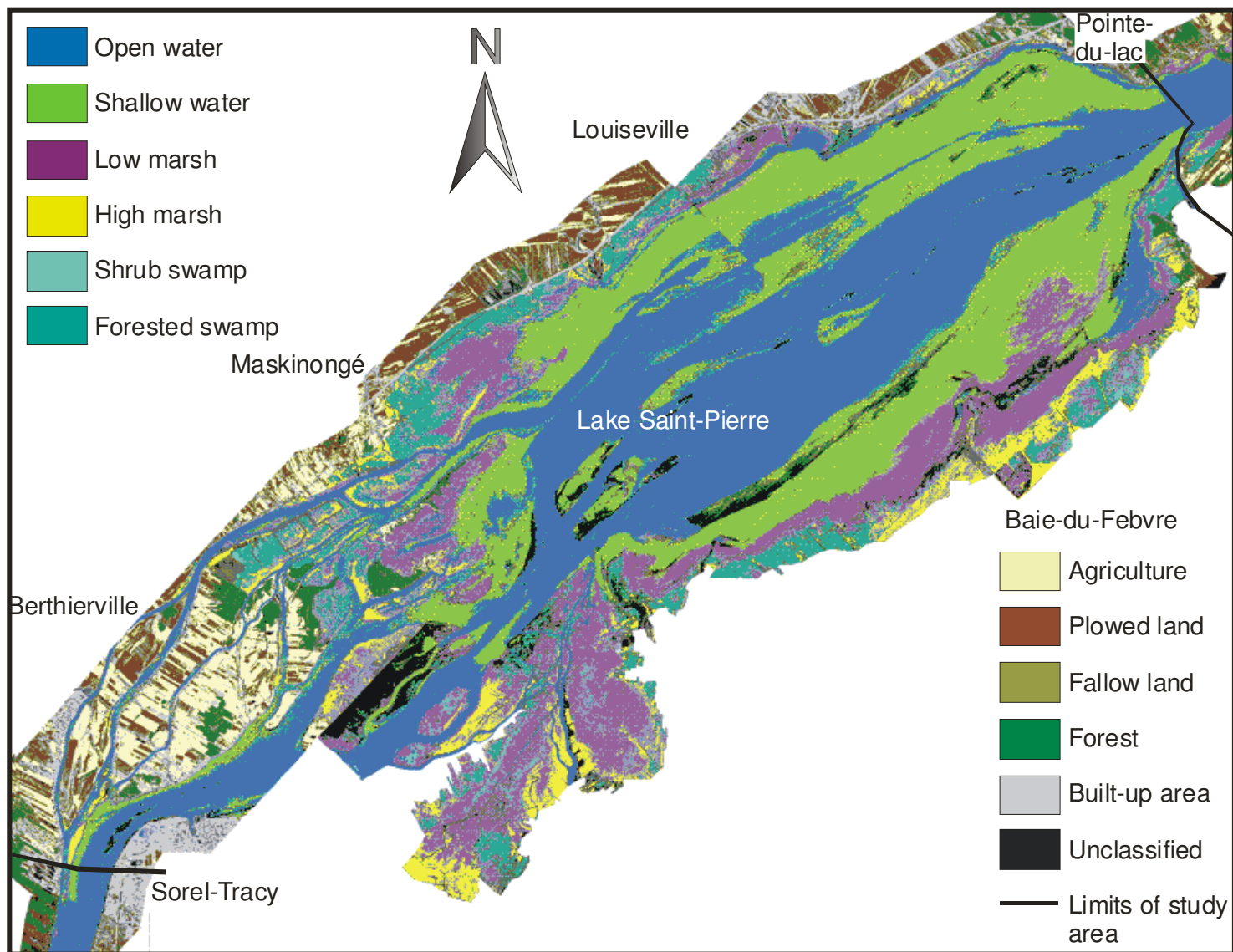
Unclassified pixels in the stretch between Saint-Ours Island and Lanoraie are mainly mixed pixels at the water’s edge or farm fields (bare soil) with variations in moisture or density.

## 5.7 CLASSIFICATION OF THE LAKE SAINT-PIERRE STUDY SECTOR

The Lake Saint-Pierre sector is very rich in wetlands. As Figure 11 shows, the south shore of the lake consists almost entirely of wetlands. Over 12 classes of low marsh were identified (Table 9), including over 13 000 ha of submerged aquatic vegetation, close to 8580 ha of low marshes, over 3380 ha of high marshes and roughly 4000 ha of swamps. Agriculture is also very prevalent, representing over 6250 ha. Forests on the islands and along the north shore cover a total area of over 1270 ha. Urban habitats include, in some areas, zones of bare soil, occupying close to 2600 ha. The Sorel-Tracy region and the north shore near Pointe-du-Lac are also highly urbanized.

**Table 9**  
**Wetlands in the Lake Saint-Pierre study sector**

Classes	Code	Hectares
Low marsh dominated by submerged vegetation	10	12 898.37
Low marsh dominated by floating vegetation	11	105.68
Low marsh dominated by <i>Schoenoplectus pungens</i>	20	64.10
Low marsh dominated by <i>Sagittaria</i> sp.	25	900.12
Low marsh dominated by <i>Bolboschoenus fluviatilis</i>	27	2 071.80
Low marsh dominated by <i>Typha</i> sp.	38	704.47
Low marsh dominated by <i>Schoenoplectus pungens</i> and other emergent vegetation	43	6.29
Low marsh dominated by narrow-leaved vegetation	44	2 895.13
Low marsh dominated by emergent and floating vegetation	47	387.00
Low marsh dominated by <i>Schoenoplectus pungens</i> and <i>Scirpus lacustris</i>	48	3.49
Low marsh dominated by robust vegetation and other herbaceous plants	55	1 101.76
Low marsh dominated by <i>Typha</i> sp. and <i>Zizania</i> sp.	56	164.87
Low marsh dominated by dead vegetation	58	240.80
Low marsh	61	40.06
High marsh dominated by tall grasses	81	3 384.34
Shrub swamp	110	903.55
Forested swamp	130	3 096.18
Total		28 968.01



**Figure 11 Mapping (July 26 and August 21, 1990) of wetlands in the Lake Saint-Pierre study sector**

Two overflights were required to cover Lake Saint-Pierre. Unfortunately, when the images were acquired on July 26, cloud cover was present over the Îles de Berthier, so that another overflight on August 21 was required to cover this area. Despite this, a portion of the islands and the south shore were still not covered.

According to Aménatech (1992b), in the Baie de Lavallière sector, the “low marsh dominated by dead vegetation” class consists of bare soil with sparse vegetation. Human activities carried out before the reference documents (Jacques 1986) were written could be the cause of this phenomenon.

The Aménatech report (1992b) added that the “built-up area” class can easily be confused with the bare soil subclass of the “plowed land” class. In the area overflown on August 21, 1990, the “low marsh dominated by *Sagittaria* sp.” class was overestimated in the Commune de l’île Dupas, southeast of the area managed by Ducks Unlimited Canada; the class was confused with the “shrub swamp” and “forested swamp” classes.

In this sector, unclassified pixels corresponded to mixed pixels and to areas in the image with interference from clouds and shadows.

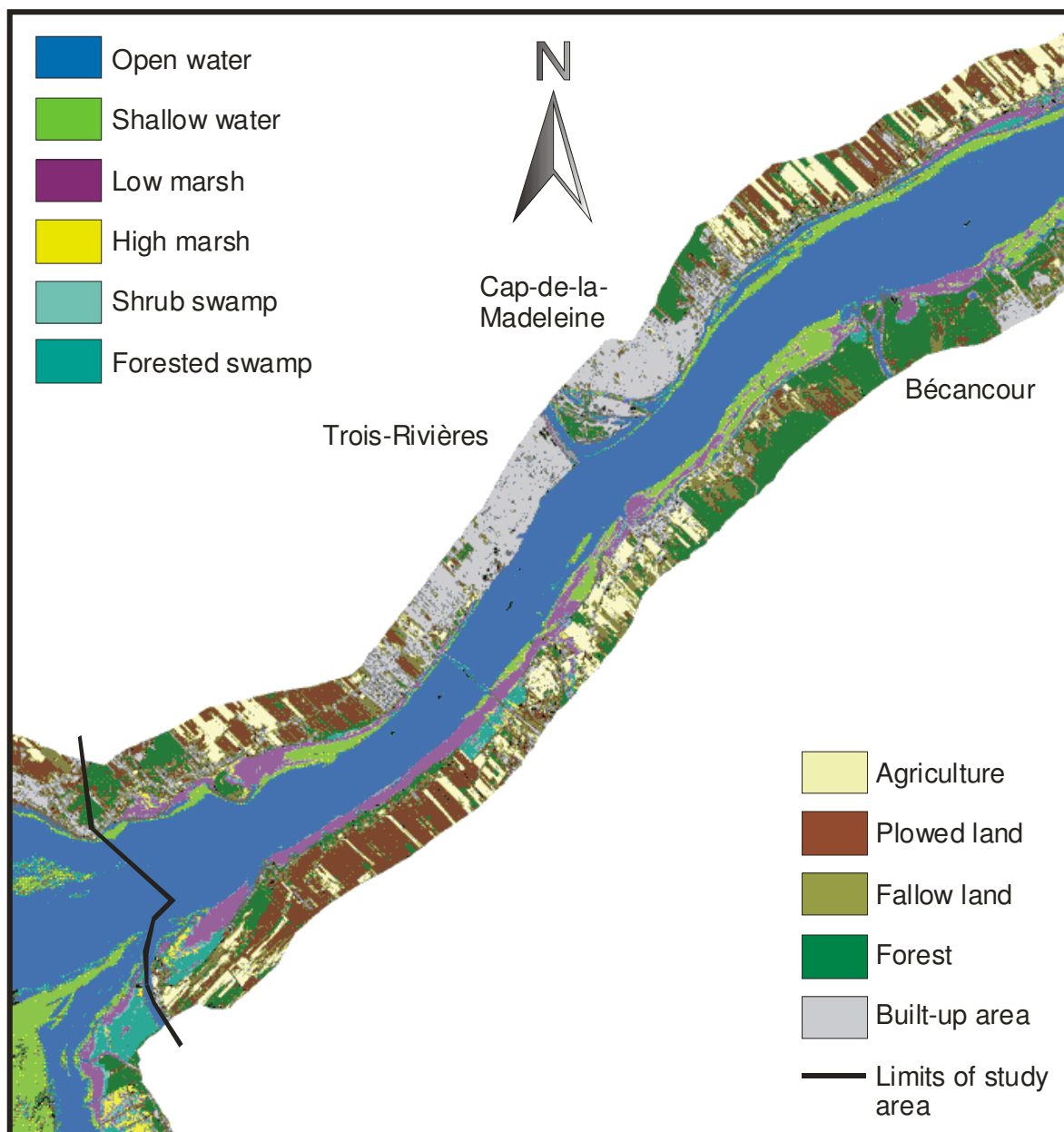
## **5.8 CLASSIFICATION OF THE TROIS-RIVIÈRES–BÉCANCOUR STUDY SECTOR**

The Trois-Rivières–Bécancour study sector actually covers the section from Trois-Rivières to Saint-Nicolas. Figures 12 to 17 show the study sector, which has more than 2725 ha of submerged aquatic vegetation, over 3060 ha of low marshes, over 170 ha of high marshes and over 740 ha of swamps within the first kilometre of the shoreline and in the river itself, which is relatively narrow here (Table 10).

In the Saint-Maurice River sector, the “shallow water with submerged vegetation” and “open water” classes were confused, due mainly to the type of water in the river. In this area, the “logs” class was created to represent the floating log booms at the western outlet of the Saint-Maurice River. In the area off the Gentilly II power station and Grondines, submerged aquatic vegetation were slightly overestimated due to radiometric differences between the two flight lines.

The classification of marshes was difficult in general in this sector, mainly because of the large number of variations within each class. Variations in the density of vegetation resulted

in a greater contribution of the river bottom in the remote sensing images, requiring the splitting up of some classes.



**Figure 12** Mapping (September 3, 1991) of wetlands in the Trois-Rivières–Bécancour study sector (part A)

In addition, different signals can be emitted when other species associated with the class are present. However, marsh classes become more spectrally uniform downstream of Trois-Rivières, facilitating sampling. These marshes, most of which are dominated by *Schoenoplectus pungens*, have different degrees of heterogeneity and density, related to the presence of tides.

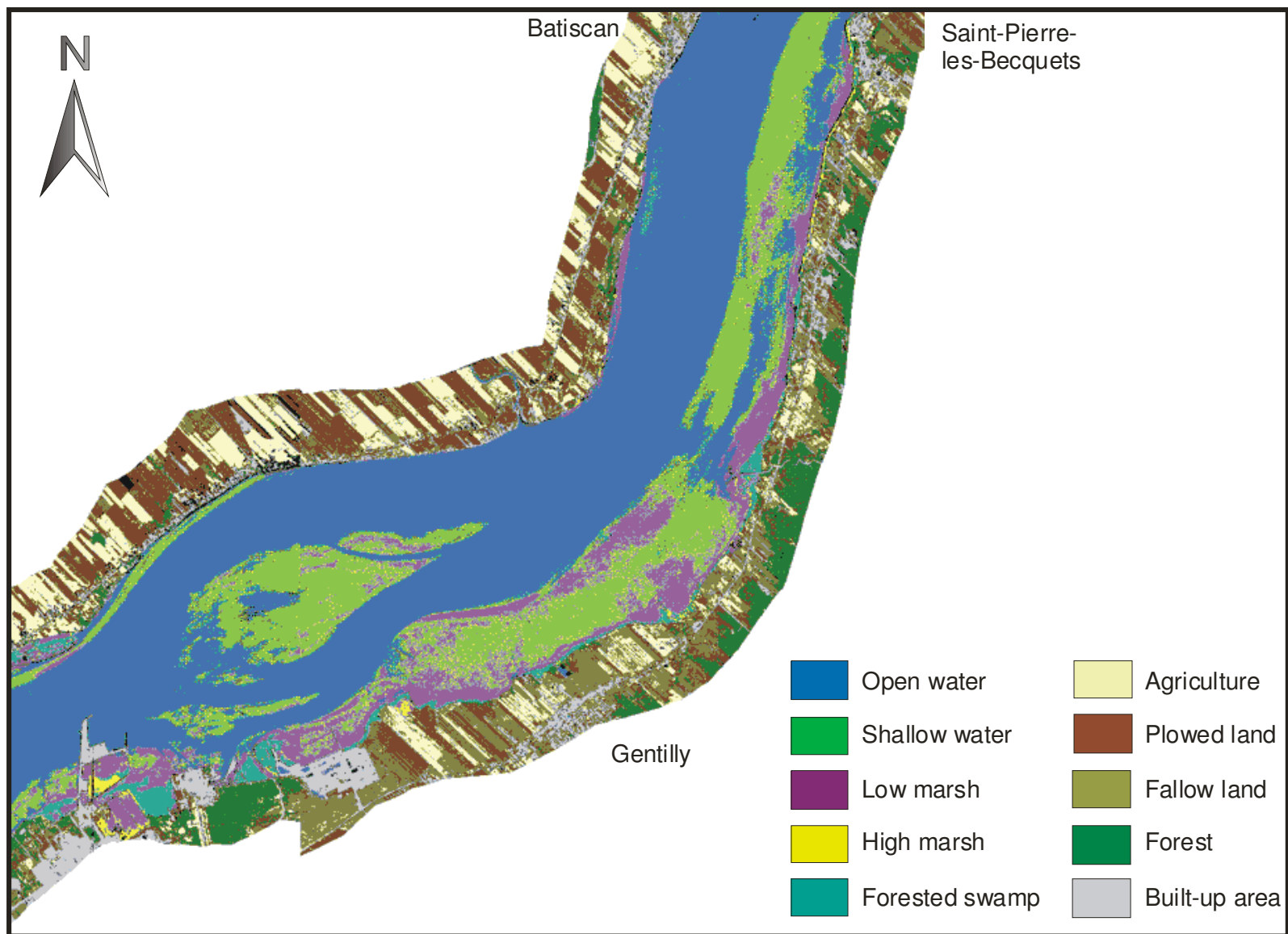
High marshes are very scarce in this sector and are concentrated in the area upstream of Trois-Rivières and the area near the Gentilly power station. Almost no high marshes were detected downstream of Portneuf, where the nature of the shoreline, which is precipitous in spots, does not allow for the inflow of water during spring flooding, resulting in a general scarcity of wetlands.

Very high concentrations of swamps were located at the mouth of the La Pérade River and at Grondines.

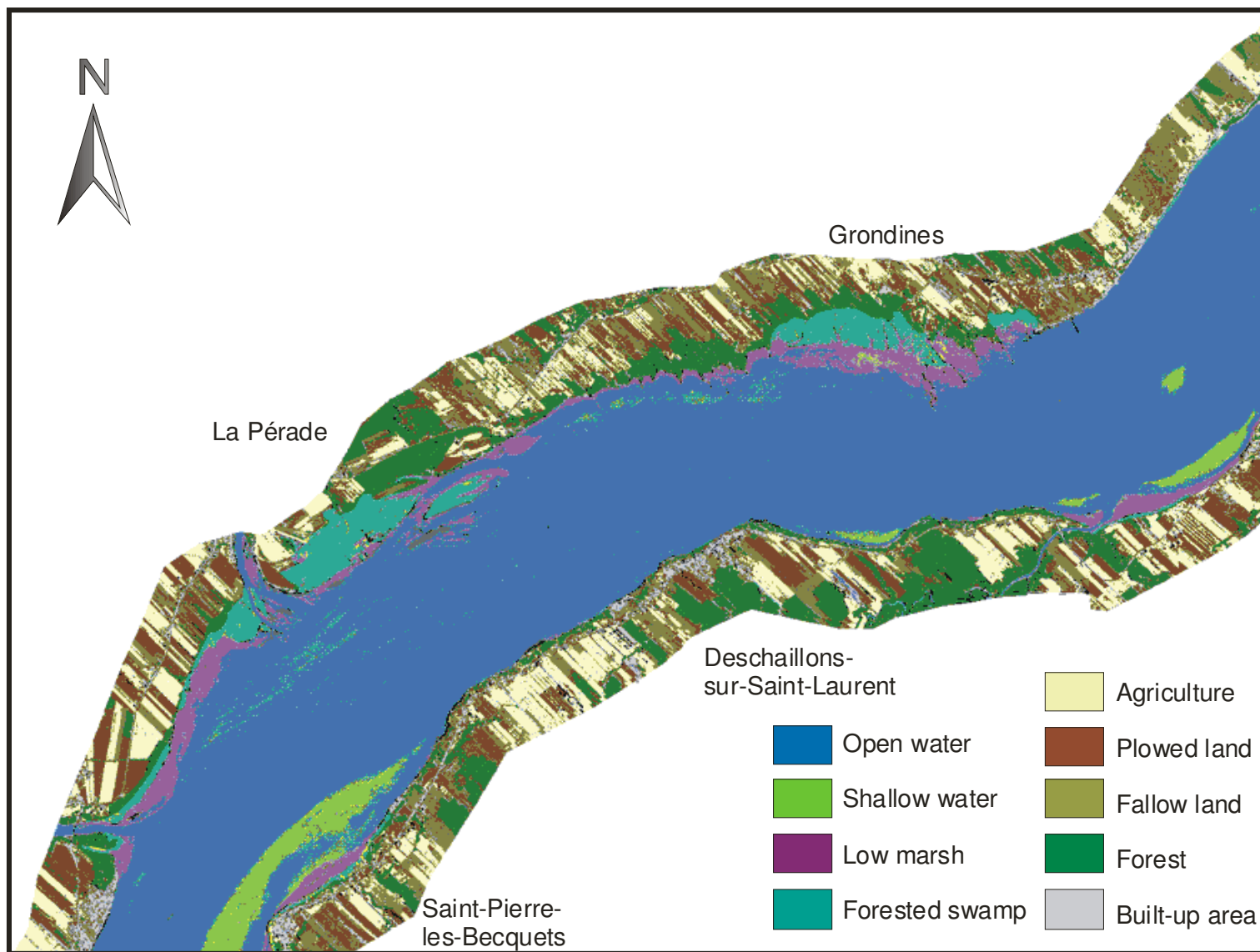
**Table 10**  
**Wetlands in the Trois-Rivières–Bécancour study sector**

Classes	Code	Hectares
Shallow water dominated by submerged vegetation	10	2726.62
Low marsh dominated by <i>Schoenoplectus pungens</i>	20	368.59
Low marsh dominated by <i>Sagittaria</i> sp.	25	27.31
Low marsh dominated by <i>Schoenoplectus pungens</i> and other emergent vegetation	43	1477.27
Low marsh dominated by <i>Schoenoplectus pungens</i> and <i>Scirpus lacustris</i>	48	331.67
Submerged low marsh dominated by <i>Schoenoplectus pungens</i>	50	496.94
Low marsh dominated by sparse <i>Schoenoplectus pungens</i> and/or other emergent plants	51	6.57
Low marsh	61	353.06
High marsh dominated by tall grasses	81	171.84
Shrub swamp	110	43.41
Forested swamp	130	703.06
Total		6706.34

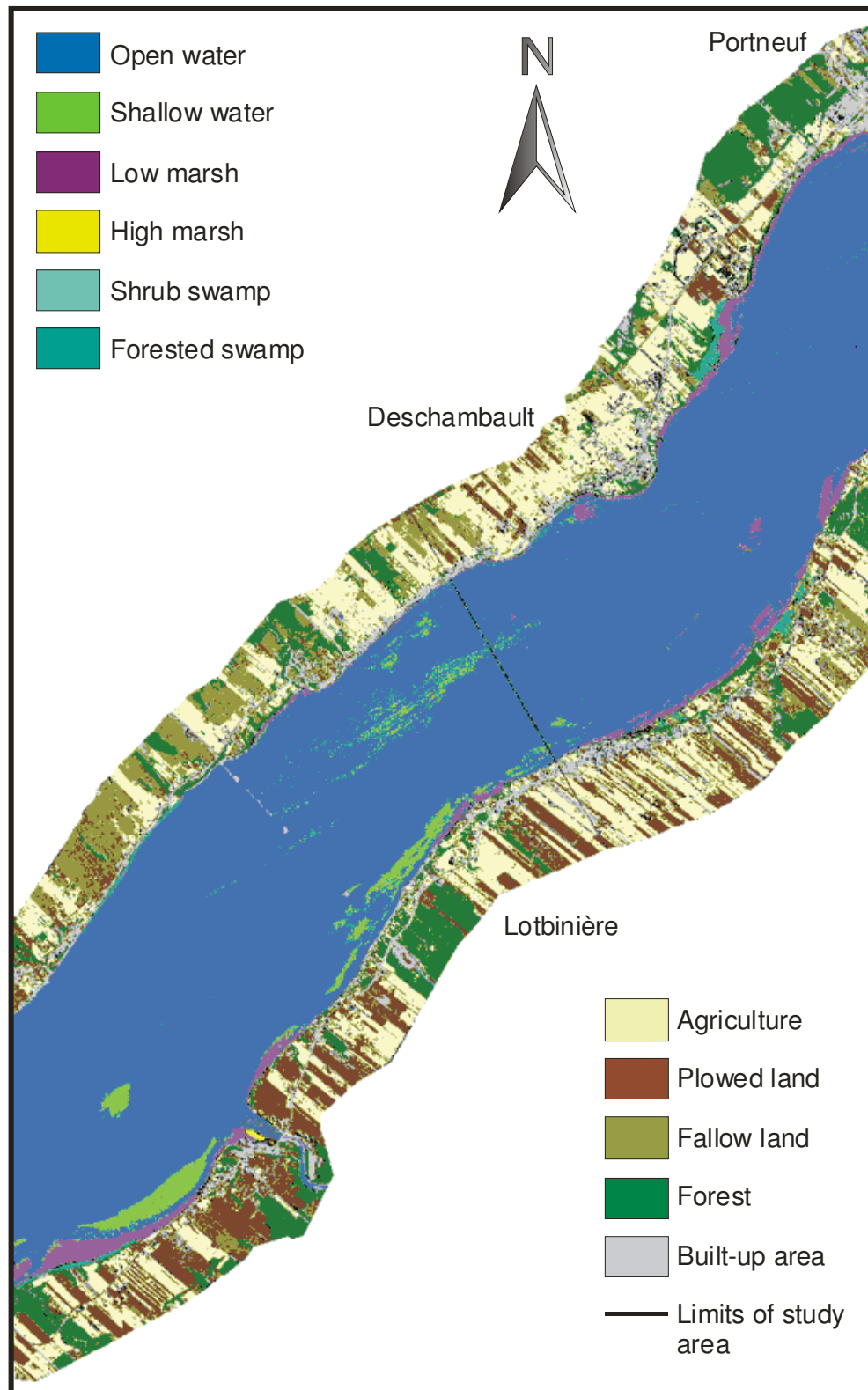




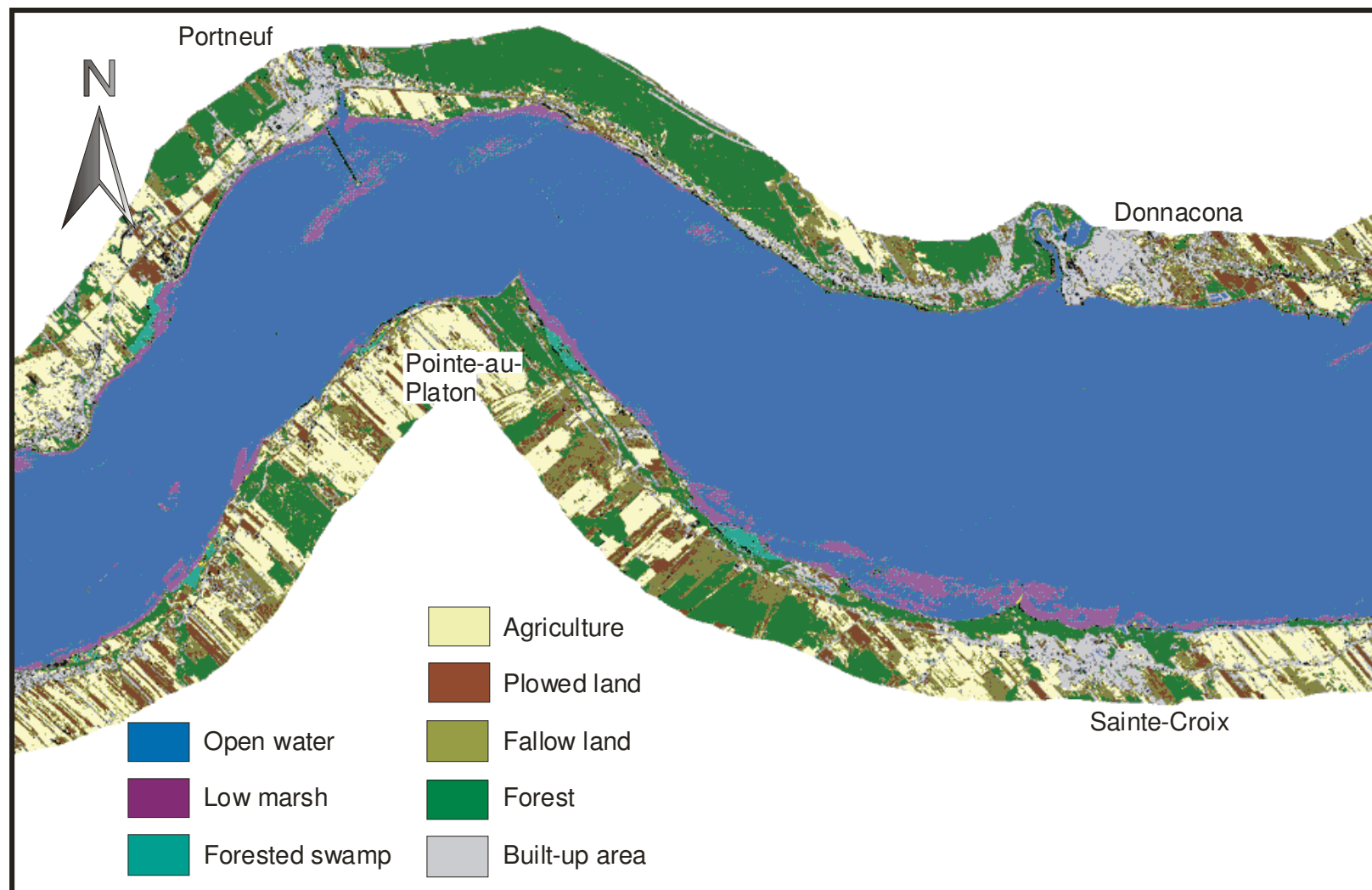
**Figure 13 Mapping (September 3, 1991) of wetlands in the Trois-Rivières-Bécancour study sector (part B)**



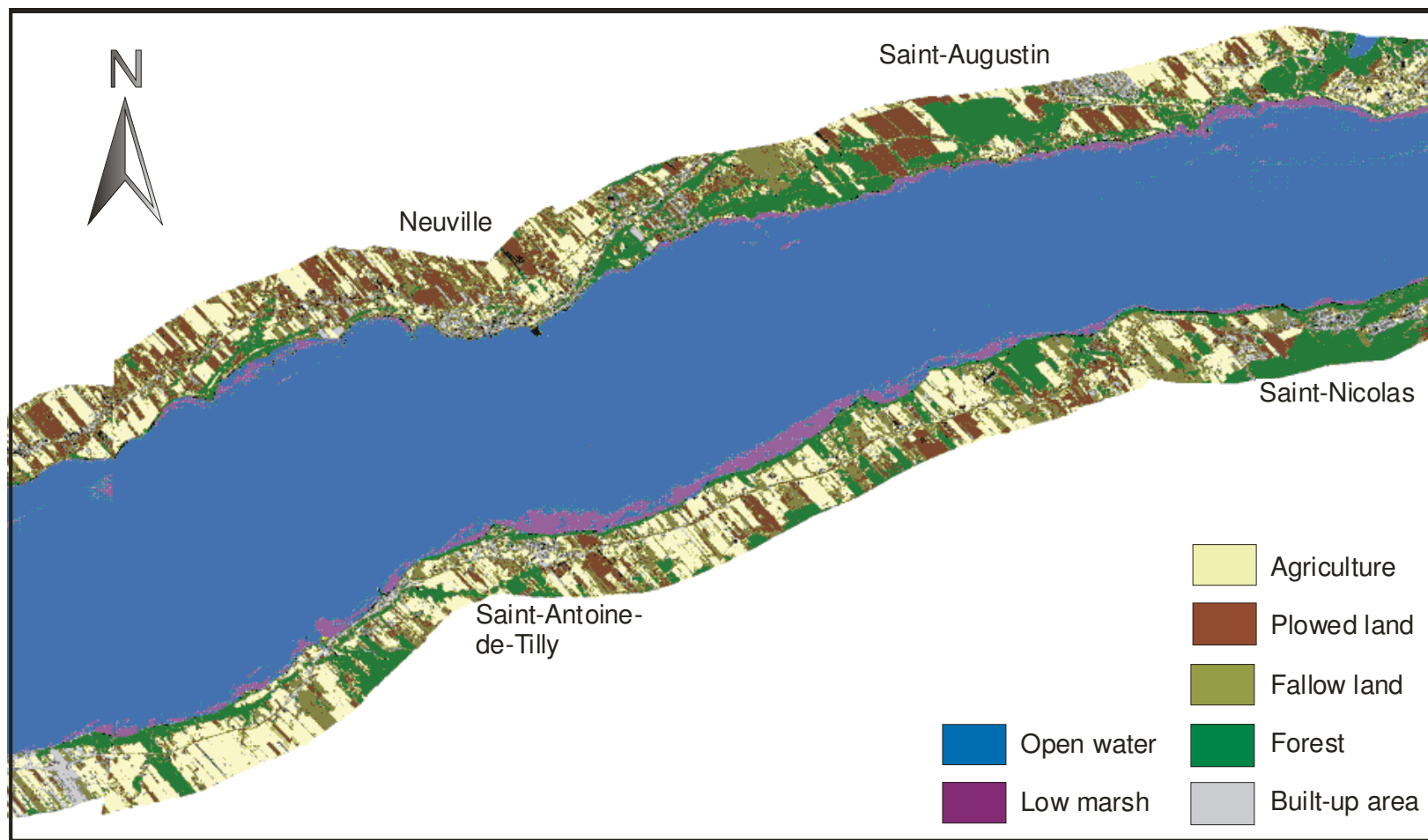
**Figure 14 Mapping (September 3, 1991) of wetlands in the Trois-Rivières-Bécancour study sector (part C)**



**Figure 15 Mapping (September 3, 1991) of wetlands in the Trois-Rivières-Bécancour study sector (part D)**



**Figure 16 Mapping (September 3, 1991) of wetlands in the Trois-Rivières-Bécancour study sector (part E)**



**Figure 17 Mapping (September 3, 1991) of wetlands in the Trois-Rivières-Bécancour study sector (part F)**



Some confusion between the “plowed land” and “fallow land” classes was caused by the resemblance between the spectral characteristics of corn and fallow land. The “built-up area” class was slightly overestimated due to the bare soil that appeared in very light tones on the remote sensing images. Roads in the southern portion of the study sector were classified as “plowed land” while they should appear in the “built-up area” class. The confusion is due to the pixels representing roads in the area, which are dominated by adjacent pixels corresponding to the “plowed land” class.

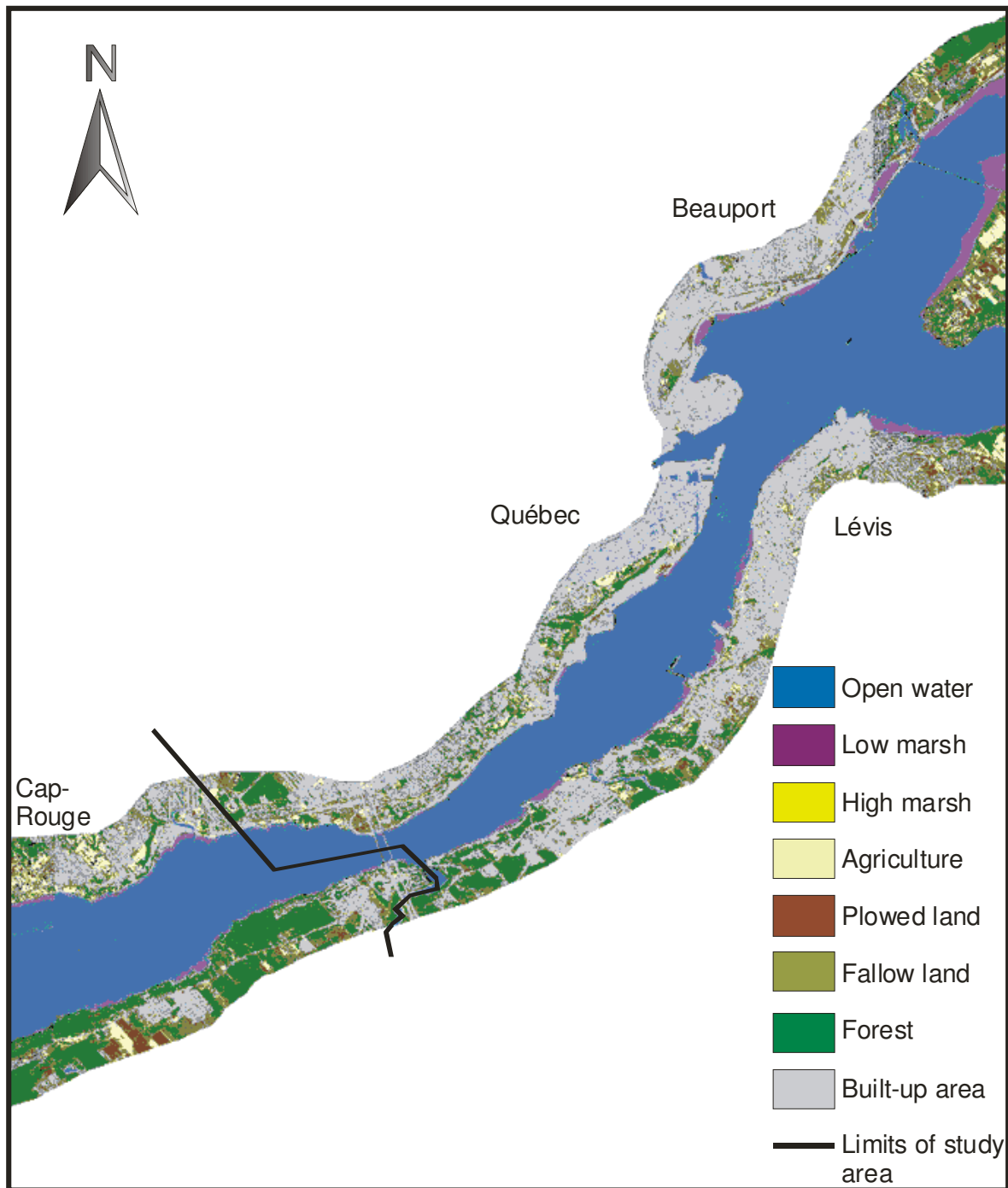
Some of the unclassified pixels along the shoreline basically correspond to areas of shadow in the “forested swamp” class, caused by the steep cliffs found in the sector. Others mainly involve upland areas (wharves, piers, jetties, etc.) that were not sampled.

## **5.9 CLASSIFICATION OF THE QUEBEC CITY–LÉVIS STUDY SECTOR**

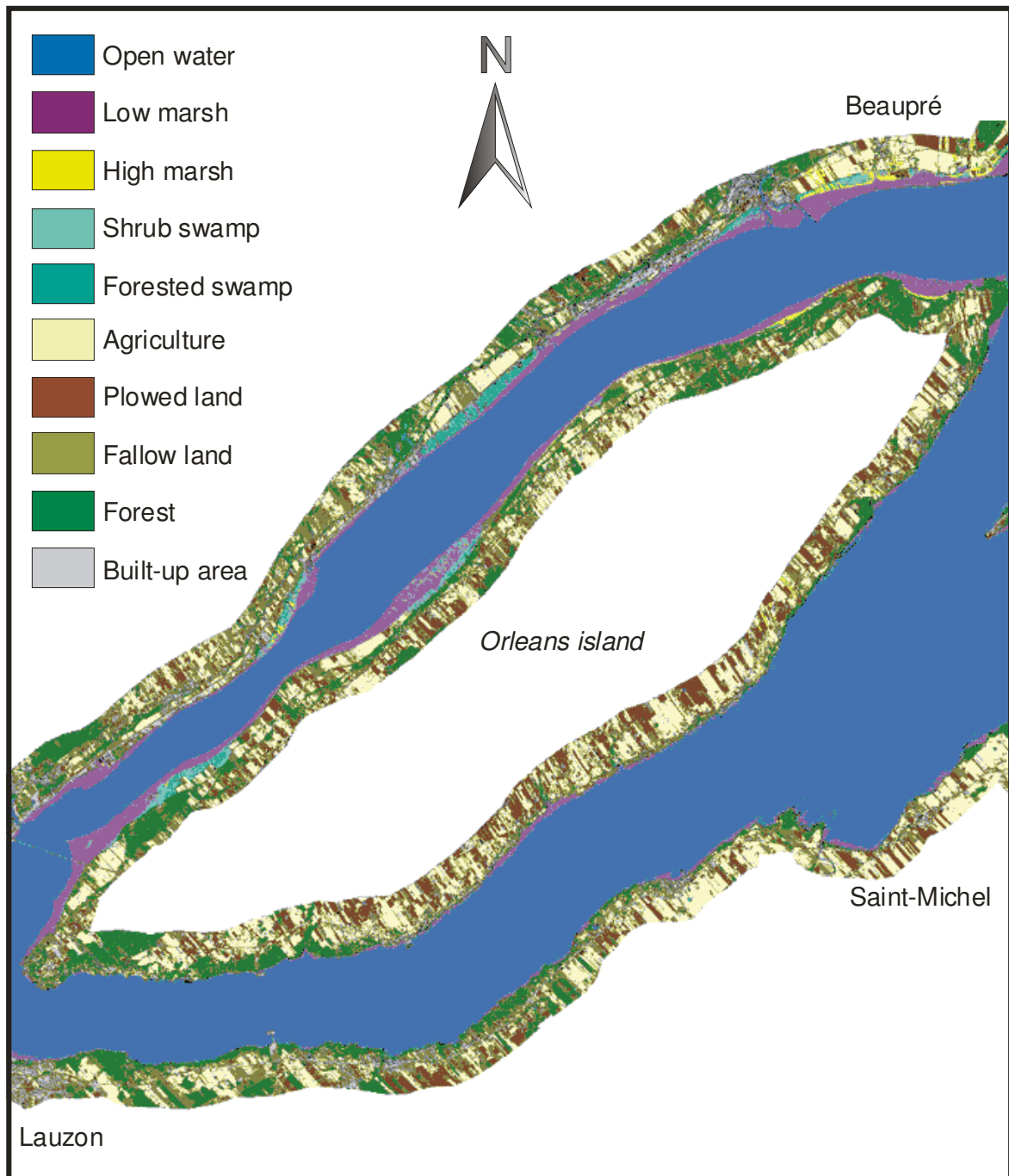
The Quebec City–Lévis study sector, as shown in figures 18 to 20, covers the area from Quebec City to Cap Tourmente on the north shore and from Saint-Rédempteur to Berthier-sur-Mer on the south shore. In this stretch of the St. Lawrence, no class of shallow water is present due to the river’s hydrodynamics and great depth. The low marshes found are dominated by *Schoenoplectus pungens* and cover 1635 ha (Table 11), mainly along the Côte de Beaupré and the north shore of the Île d’Orléans. High marshes, which are scarce, occupy nearly 151 ha. Swamps, which are more common in the north channel of the St. Lawrence between the Île d’Orléans and the north shore (Île d’Orléans Channel), represent slightly over 315 ha. This region is characterized by a highly urbanized shoreline in the Quebec City–Lauzon portion. Extensive agriculture is found on the Île d’Orléans and along both shores east of Quebec City and Lauzon.

In the sector between Île d’Orléans and Montmagny, particularly in the Cap Tourmente region, the “shallow open water” class was slightly overestimated in relation to the “open water” class. This can be explained by the high concentrations of suspended matter in the water in this area.

Areas of open water in the Montmorency River near Quebec City were overestimated due to the steep riverbanks, which cause shadowy areas that spectrally resemble the “open water” class.



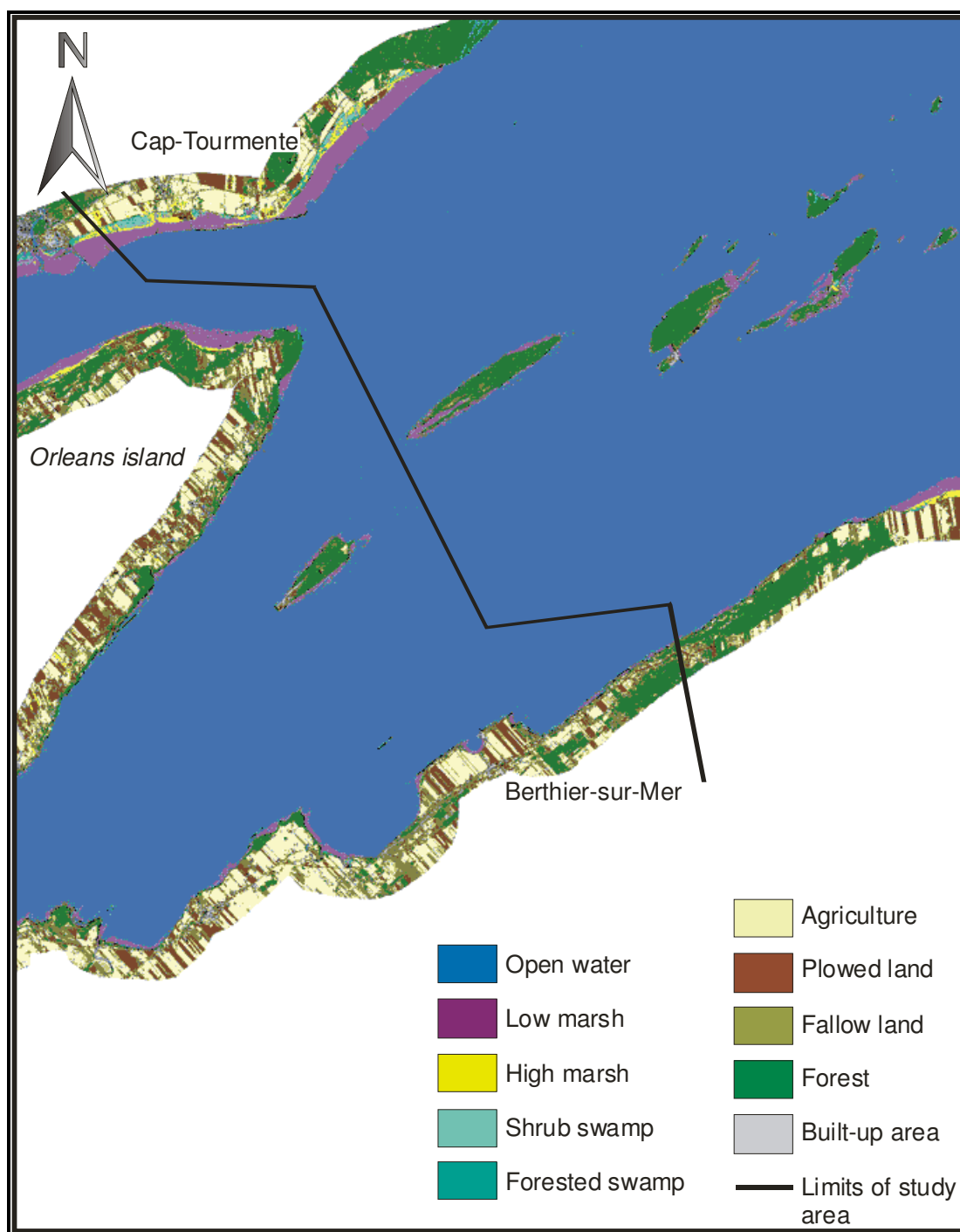
**Figure 18 Mapping (September 3, 1991) of wetlands in the Quebec City-Lévis study sector (part A)**



**Figure 19 Mapping (September 3, 1991) of wetlands in the Quebec City-Lévis study sector (part B)**



Most of the rock outcrops found around the islands and in some locations along the river were included in the “shallow water” class because they are difficult to distinguish spectrally from sandy beaches.



**Figure 20 Mapping (September 3, 1991) of wetlands in the Quebec City-Lévis study sector (part C)**

There was some confusion between the “deciduous forest” and “fallow land” classes due to their spectral resemblance, particularly in areas where the fallow land had a large percentage of shrubs. Roads in lightly urbanized areas appeared as “plowed land” instead of “built-up area.” The percentage of pixels representing roads in these areas was low and these pixels took on values corresponding to bare soil in the “plowed land” class.

**Table 11**  
**Wetlands in Quebec City–Lévis study sector**

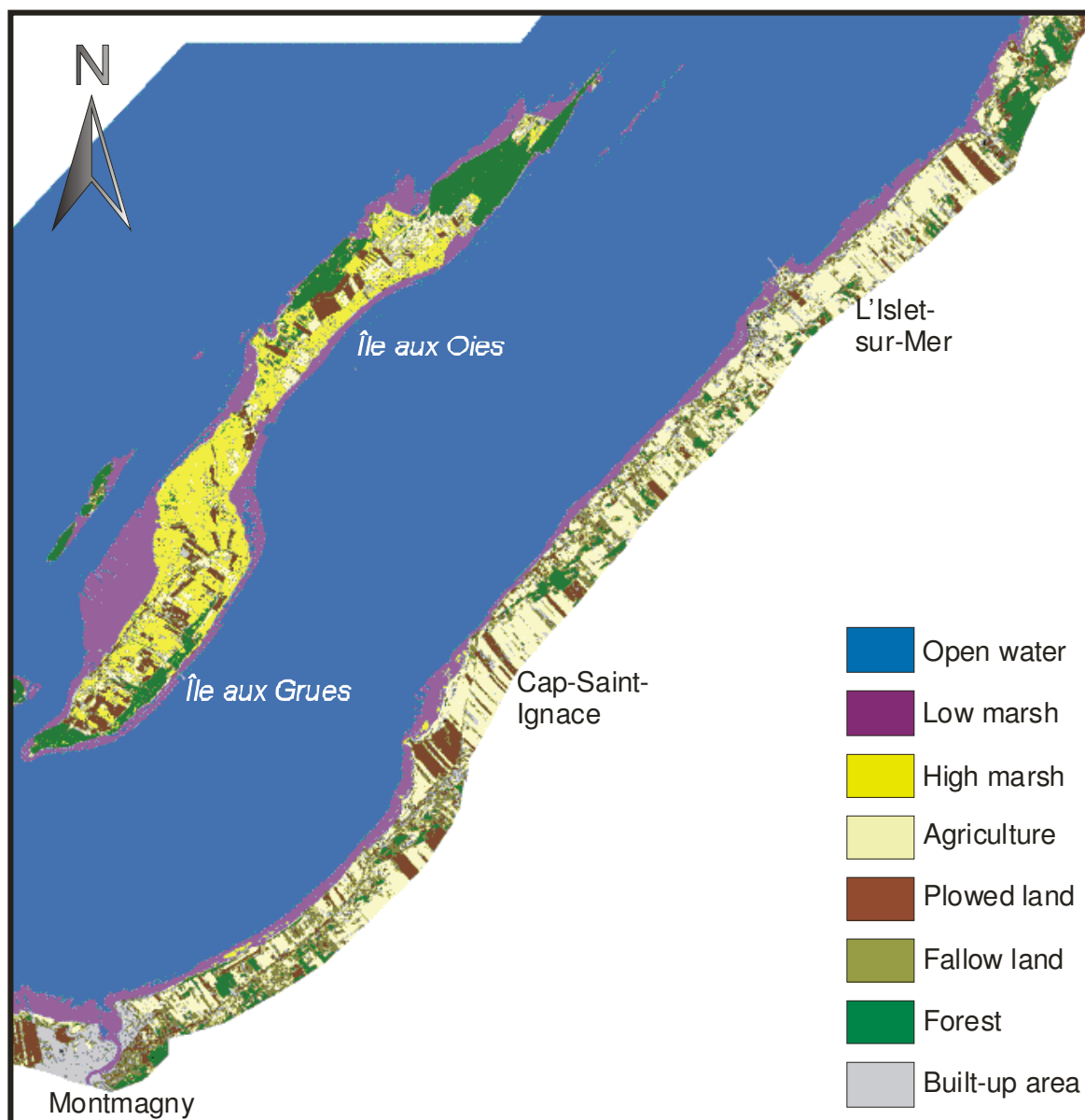
Classes	Code	Hectares
Low marsh dominated by <i>Schoenoplectus pungens</i>	20	194.74
Low marsh dominated by <i>Schoenoplectus pungens</i> and other emergent plants	43	722.61
Submerged low marsh dominated by <i>Schoenoplectus pungens</i>	50	71.14
Low marsh dominated by sparse <i>Schoenoplectus pungens</i> and other emergent plants	51	646.33
High marsh	80	40.65
High marsh dominated by tall grasses	81	110.29
Shrub swamp	110	174.47
Forested swamp	130	141.67
Total		2101.90

## 5.10 CLASSIFICATION OF THE UPPER ESTUARY STUDY SECTOR

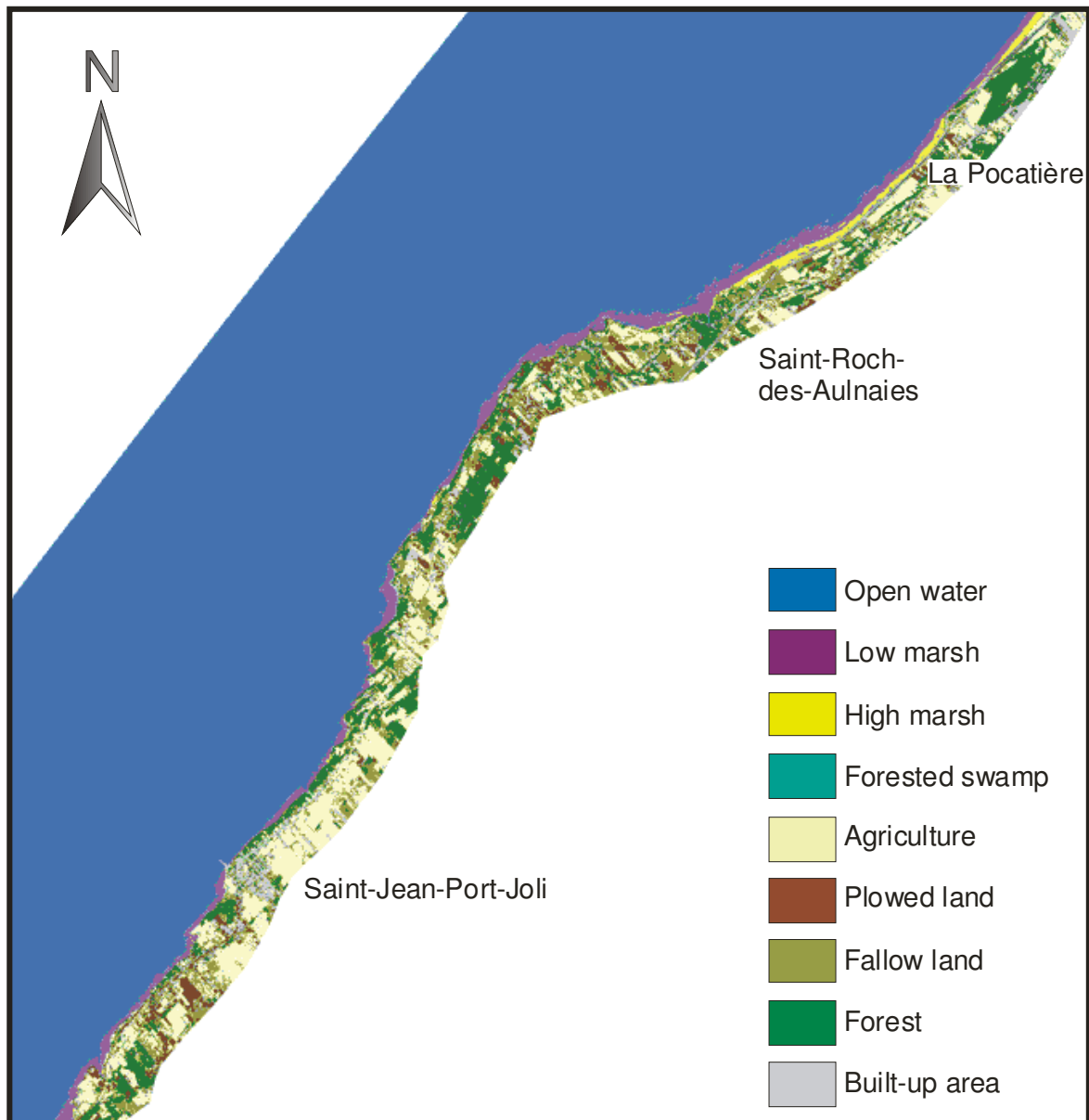
The Upper Estuary study sector, as shown in figures 20 to 26, covers a huge territory between Cap Tourmente on the north shore and Cacouna, just downstream from Rivière-du-Loup, on the south shore. The sector contains two sites with excellent habitat for migrating birds: Cap Tourmente and Île aux Grues. Low marshes total roughly 3430 ha, high marshes, 2000 ha, and swamps, only 85 ha.

Low marsh dominated by *Schoenoplectus pungens* (2372 ha) is widespread as far downstream as Saint-Roch-des-Aulnaies, where the degree of salinity becomes too great for the species to tolerate. The furthest downstream this community was found was at the mouth of the Ouelle River, where the species appears to be able to grow, presumably due to the input of freshwater. There are several types of low marshes on Île aux Grues, but due to the lack of ground data for identifying them, we were forced to include them in the single dominant class in the sector — “low marsh dominated by *Schoenoplectus pungens*.” However, several different

colour patterns can be distinguished in the MEIS-II images in the low marshes around Île aux Grues, which may correspond to density classes or submerged or emergent vegetation classes, and could be used to distinguish the different types of marshes observed. This type of information will be useful for future overflights.



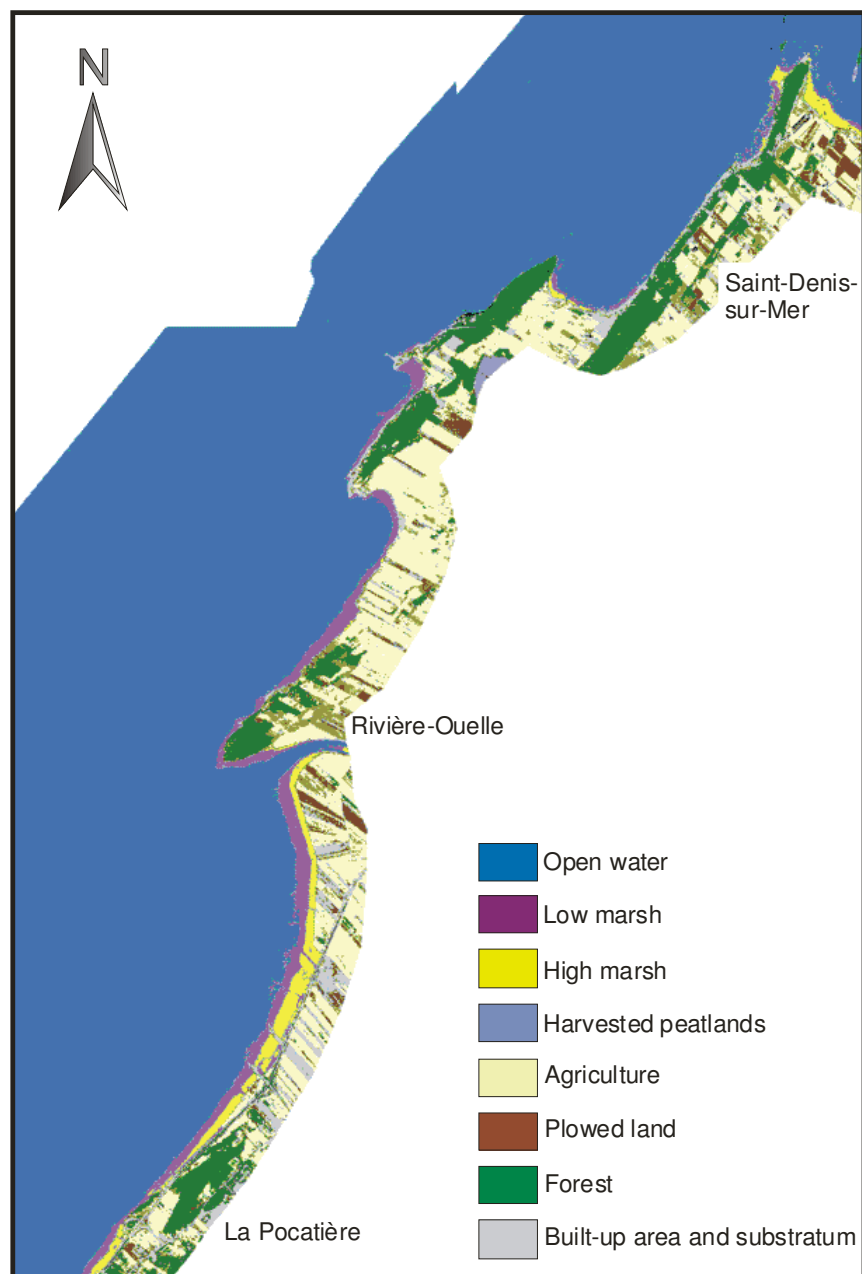
**Figure 21 Mapping (September 3, 1991) of wetlands in the Upper Estuary study sector (part A)**



**Figure 22 Mapping (September 3, 1991) of wetlands in the Upper Estuary study sector (part B)**

The first *Spartina alterniflora* communities (Table 12) appear at Saint-Roch-des-Aulnaies, where they replace low marshes dominated by *Schoenoplectus pungens*. These communities become denser closer to Cacouna (1055 ha) and *Spartina alterniflora* is the dominant plant species throughout the rest of the sector. The distribution of *Spartina alterniflora* in the St. Lawrence stands out more clearly on the remote sensing maps than in those created by

Garneau (1984). At the mouth of the Rivière du Loup, an area was classified as “shallow open water” when it should have been associated with the “low marsh dominated by *Spartina alterniflora*” class. The confusion between the classes can be explained by the greenish hue of the water, probably due to the presence of suspended matter transported by the strong river currents.

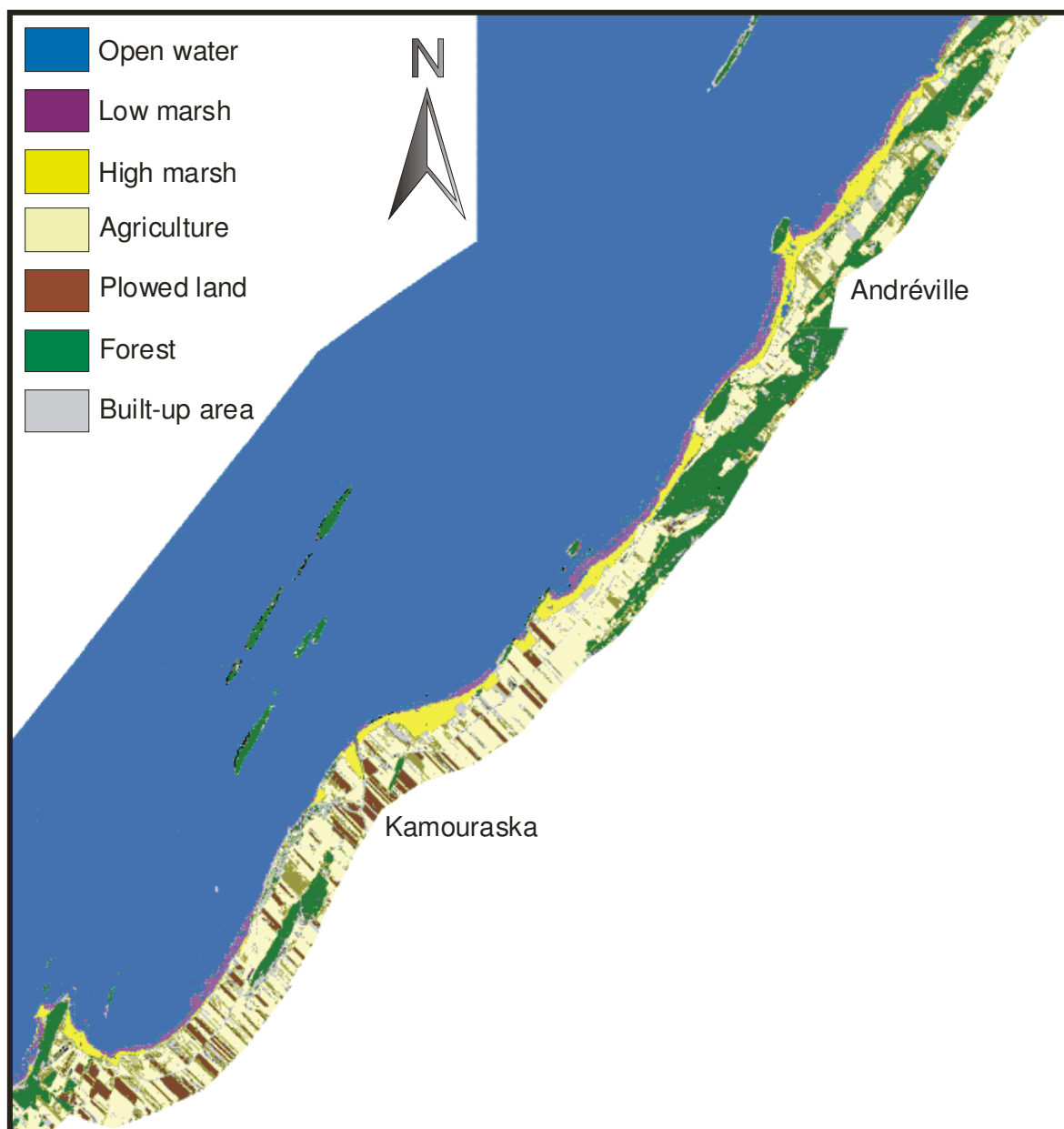


**Figure 23 Mapping (September 3, 1991) of wetlands in the Upper Estuary study sector (part C)**

**Table 12**  
**Wetlands in the Upper Estuary study sector**

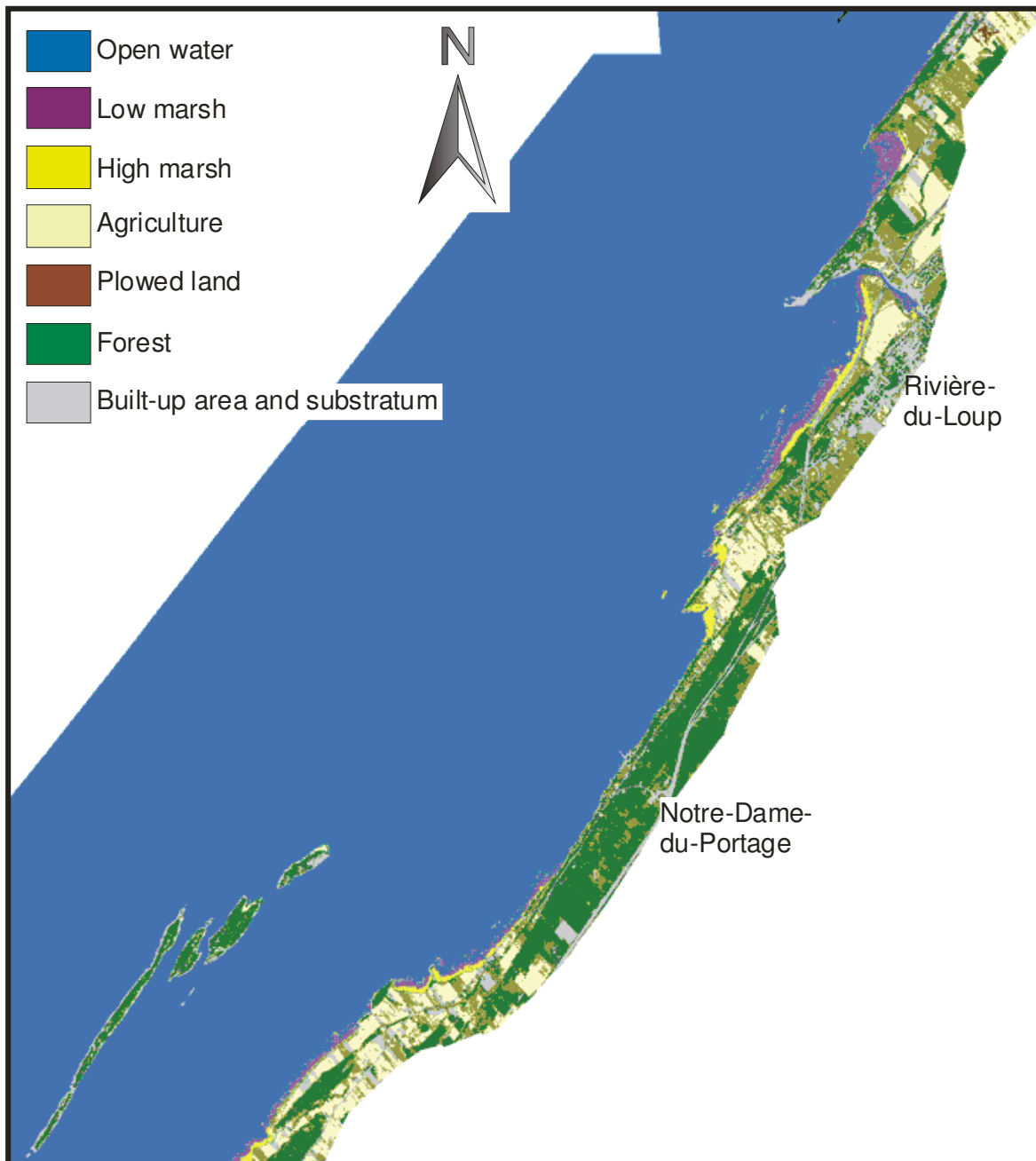
Classes	Code	Hectares
Low marsh dominated by <i>Schoenoplectus pungens</i>	20	2040.64
Low marsh dominated by <i>Spartina alterniflora</i>	28	1051.49
Low marsh dominated by <i>Schoenoplectus pungens</i> and other emergent vegetation	43	266.49
Low marsh dominated by <i>Spartina alterniflora</i> and <i>Salicornia europaea</i> L. (S.L.)	49	5.84
Low marsh dominated by sparse <i>Schoenoplectus pungens</i> and/or other emergent plants	51	65.38
High marsh	80	57.89
High marsh dominated by tall grasses	81	99.70
High marsh dominated by <i>Carex</i> sp.	83	38.35
High marsh dominated by <i>Spartina pectinata</i>	85	9.72
High marsh used for agriculture	95	894.31
High salt marsh	96	721.73
High marsh dominated by <i>Spartina patens</i>	97	108.91
High marsh dominated by <i>Salicornia europaea</i> L. (S.L.) and <i>Spergularia canadensis</i>	98	15.59
High marsh dominated by <i>Spartina patens</i> and <i>Bolboschoenus maritimus</i> var. <i>paludosus</i>	99	21.39
High marsh dominated by <i>Spartina patens</i> and <i>Hierochloe odorata</i>	100	2.37
High marsh dominated by <i>Spartina patens</i> and <i>Plantago maritima</i>	101	28.72
Shrub swamp	110	56.14
Forested swamp	130	29.21
Harvested peatlands	159	23.03
Total		5536.90

High marshes, prevalent on Île aux Grues, reappear at Cacouna. In between, the generic class “high salt marsh” was used to describe heterogeneous plant communities in this type of environment. East of Île aux Grues, north of Montmagny, a new class entitled “upland high marsh” was created by Aménatech (1992) to reflect the special conditions of land use in this area and the high-marsh-like appearance of the area in the colour composite images. When the sector was covered again, in the mapping of the Montmagny–Trois-Pistoles section, the class was renamed “high marsh used for agriculture.” Michel Robert of the Canadian Wildlife Service assisted us in validating information on land use on Île aux Grues.



**Figure 24 Mapping (September 3, 1991) of wetlands in the Upper Estuary study sector (part D)**

As Figure 21 shows, around Montmagny, a misalignment of the image between the high and low marsh resulted from the merging of the files processed by Aménatech (1992) and the St. Lawrence Centre. The information contained in the map by Dryade (*Scirpus* marsh with a few shrubs) and the visual appearance of the sector in the images did not allow us to distinguish among the different types of land use.



**Figure 25 Mapping (September 3, 1991) of wetlands in the Upper Estuary study sector (part E)**

Certain other species (*Spartina patens*, *Plantago maritima*, *Bolboschoenus maritimus* var. *paludosus*, *Salicornia* sp. and *Spergularia* sp.) also add to the plant diversity of the high marshes in the Baie de Cacouna. These classes were defined as low marshes under the old



nomenclature, but since the definition of high marsh was broader than that of wet meadow, a change of category was required. The “high salt marsh” class was more prevalent than the *Spartina patens* class on Dryade’s maps.

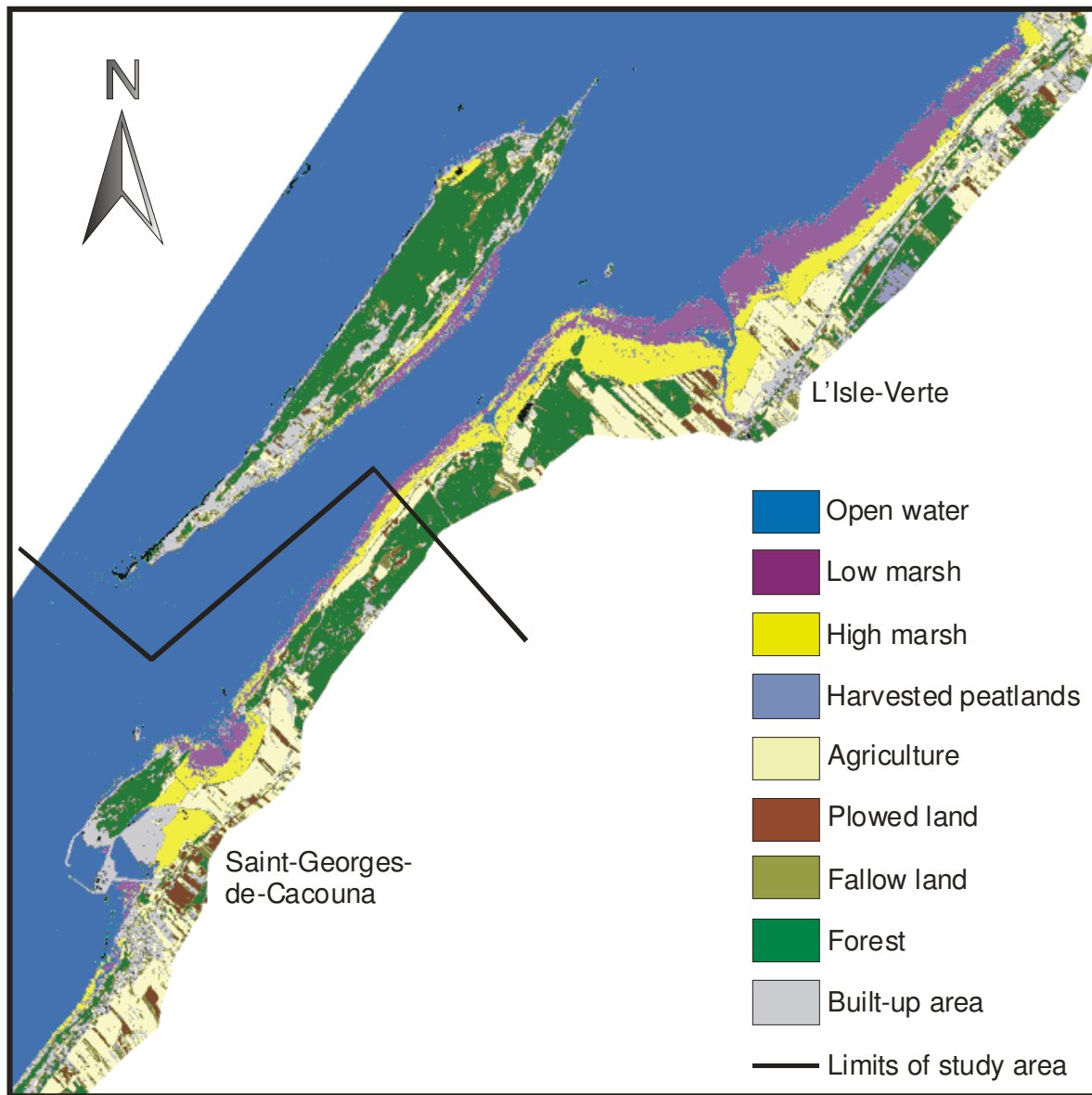
Downstream of Montmagny, swamps can no longer be distinguished from forests in the remote sensing images. However, since the Cap Tourmente National Wildlife Area is part of the Upper Estuary sector, over 80 ha of swamps in the wildlife area were tallied for the sector.

Most of the upland areas in the sector were classified using Quebec’s Ministère des Forêts ecoforest maps. Consequently, in the Montmagny–Trois-Pistoles section, we decided not to classify swamps and to identify forest communities based on these maps instead.

## **5.11 CLASSIFICATION OF THE LOWER ESTUARY STUDY SECTOR**

Airborne images only covered a very small part of the Lower Estuary study sector, which normally would include the entire Lower Estuary (Figure 2). As figures 26 and 27 show, the sector covered extends from just downstream of Cacouna to downstream of Trois-Pistoles. This sector is distinguished from the previous one by the presence of Anse de L’Isle-Verte, which has a high diversity of plant species. It contains two classes of low marsh covering over 838 ha and nine classes of high marshes covering over 740 ha.

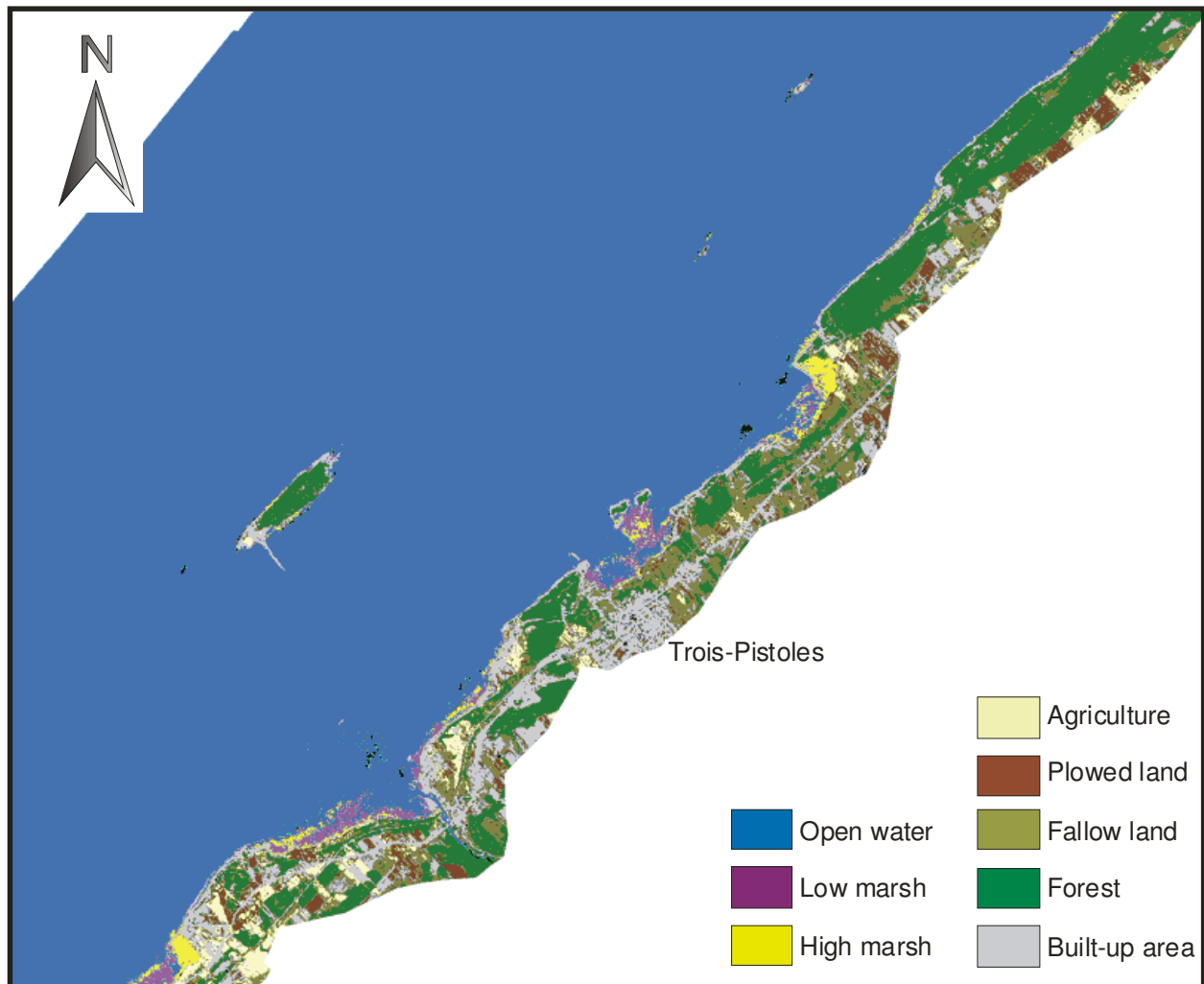
Classification of the L’Isle-Verte–Trois-Pistoles section was greatly facilitated by the field and mapping work done by Garneau (1984). Garneau’s maps include a large number of classes categorized by dominant species. The mapping corresponds, in the case of many classes, to the various patterns identified on the MEIS-II images. The good radiometric quality of the images, total absence of clouds and relatively clear water mass allowed the various classes to be clearly distinguished.



**Figure 26 Mapping (September 3, 1991) of wetlands in the Lower Estuary study sector (part a)**

Part of the developed area in the Port of Cacouna does not appear to correspond to either a wetland or upland area. Although in all likelihood this area is a high marsh, it was not classified in the two other classes of high marshes (*Carex* sp. and *Spartina pectinata*).

Jean Bachand, from the Société de conservation de la baie de L'Isle-Verte, participated in validating the mapping, thus allowing us to make some corrections to more problematic areas. Some areas and plant communities retained their original classifications, however.



**Figure 27 Mapping (September 3, 1991) of wetlands in the Lower Estuary study sector (part B)**

Table 14 shows the correspondence between the fieldwork and the mapping for selected transects. The dominant species found in the images correspond fairly well to what was found in the field during the field checks. However, some species identified in the field are difficult to distinguish on the images. For reasons of scale and perception, we preferred to retain certain original classes, which are more general, than to identify highly diverse classes that do not apply to the entire mapped area. The greatest difference occurs in areas with *Spartina pectinata*, *Calamagrostis canadensis* and *Epilobium* sp. These species sometimes occur in higher areas that are flooded during spring tides. They are difficult to distinguish from adjoining pastureland and

forage fields. In the Ronde Island area, it is impossible to distinguish between *Spartina pectinata* and *Spartina patens* in the images.

**Table 13**  
**Wetlands in the Lower Estuary study sector (partial table)**

Classes	Code	Hectares
Low marsh dominated by <i>Spartina alterniflora</i>	28	637.43
Low marsh dominated by <i>Spartina alterniflora</i> and <i>Salicornia europaea</i> L. (S.L.)	49	200.72
High marsh dominated by <i>Carex</i> sp.	83	21.47
High marsh dominated by <i>Spartina pectinata</i>	85	55.41
High marsh used for agriculture	95	2.26
High salt marsh	96	60.11
High marsh dominated by <i>Spartina patens</i>	97	349.63
High marsh dominated by <i>Salicornia europaea</i> L. (S.L.) and <i>Spergularia canadensis</i>	98	59.63
High marsh dominated by <i>Spartina patens</i> and <i>Bolboschoenus maritimus</i> var. <i>paludosus</i>	99	104.01
High marsh dominated by <i>Spartina patens</i> and <i>Hierochloe odorata</i>	100	53.07
High marsh dominated by <i>Spartina patens</i> and <i>Plantago maritima</i>	101	36.63
Harvested peatlands	159	36.96
Total		1617.33

**Table 14**  
**Results of field checks by the Société de conservation de la baie de L'Isle-Verte**

Comments of Jean Bachand	Remote sensing results
<i>Spartina patens</i> + <i>Hierochloe odorata</i> + <i>Scirpus</i> sp.	<i>Spartina patens</i> + <i>Bolboschoenus maritimus</i> var. <i>paludosus</i>
<i>Spartina patens</i> + <i>Ordeum jubatum</i>	<i>Salicornia europaea</i> L. (S.L.) and <i>Spergularia canadensis</i> + <i>Spartina patens</i> and <i>Bolboschoenus maritimus</i> var. <i>paludosus</i> + <i>Spartina patens</i>
<i>Spartina alterniflora</i> + <i>Plantago maritima</i> + <i>Spergularia canadensis</i> + <i>Salicornia europaea</i> L. (S.L.) + <i>Puccinellia paupercula</i>	<i>Spartina patens</i> and <i>Plantago maritima</i> + <i>Spartina alterniflora</i> and and <i>Salicornia europaea</i> L. (S.L.)
<i>Spartina patens</i>	<i>Spartina patens</i>
<i>Spartina patens</i> + <i>Ordeum jubatum</i>	<i>Spartina patens</i> + <i>Spartina patens</i> and <i>Plantago maritima</i>
<i>Spartina pectinata</i>	<i>Spartina patens</i>
<i>Calamagrostis canadensis</i> + <i>Epilobium</i> sp.	Agriculture
<i>Spartina pectinata</i>	Agriculture

In upland areas, shrub classes were identified based on Quebec's Ministère des Forêts ecoforest maps. The only class that could possibly be considered wetland is the "harvested peatlands" class. However, peatlands only occupy a very small portion of the one-kilometre-wide inland strip (34 ha).

## 6 Discussion

The discussion that follows deals basically with the classification of the vegetation, water quality and the level of resolution or classification attained for wetlands. In general, the topics of discussion were taken from reports by Aménatech (1992a, 1992b, 1991). For the sake of conciseness, text taken word for word from these reports is not cited in parentheses. The portions added mainly involve the Montmagny–Trois-Pistoles sector, which was mapped by the St. Lawrence Centre. To ensure the consistency of this text, the nomenclature used by Quebec for the classification of wetlands (Buteau et al. 1994) will continue to be employed throughout, regardless of the source, replacing the nomenclature used by Jacques and Hamel (1982).

### 6.1 VEGETATION CLASSIFICATION

Various methods exist for classifying vegetation; the cartographic references used refer to three:

- a) For the Lac Saint-François National Wildlife Area, Melançon and de Repentigny (1981) classified the vegetation using a phytosociological inventory. After the fieldwork was completed, those vegetation units surveyed with the greatest affinities in terms of habitat characteristics and the physiognomy<sup>5</sup> and composition of the plant cover were combined. These communities were assigned a name referring to the dominant and co-dominant species. Sometimes a less abundant but relatively frequent species was used to designate a community, in order to reflect a difference corresponding in general to a specific characteristic of the habitat.
- b) on the Îles de Boucherville, Îles de Varennes and Sainte-Thérèse Island, Pilon et al. (1980) highlighted the physiognomy of the vegetation on the maps using a pattern, with each mapping unit designated by one or more characteristic species.

Wetlands in the same sector were mapped again in 1983 by Jacques (1983), and as in the case of Lake Saint-Louis, the La Prairie Basins and Lake Saint-Pierre, the wetland classification system developed by Jacques and Hamel (1982) was used for vegetation mapping. The purpose of this system, developed for Quebec's Ministère du Loisir, de la Chasse et de la Pêche, is to simplify and facilitate the description of vegetation to assess the potential of wetlands for wildlife. The method uses classes established based on the physiognomy of the vegetation and the two main species dominating the cover (dominance type and site type).

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<sup>5</sup> In plant ecology, the term “physiognomy” refers to the type of cover, vegetative structure, developmental stage, type of disturbance (where applicable) and characteristics of the lower strata (Jurdant et al. 1977).

Independently of the classification system used, percent cover was prioritized in the choice of species used to describe the mapping unit. A unit with 25% tree or shrub cover but dominated by herbaceous vegetation was classified as a forested or shrub swamp as appropriate. Similarly, in units with a denuded substrate, where herbaceous plants represented 25% of the cover, the unit would be designated by the dominant species of herbaceous vegetation. However, this interpretation resulted in a few problems in transposing the information onto the remote sensing images. The somewhat arbitrary vegetation hierarchy was not reproduced exactly in the image classification.

In addition, the percent cover occupied by a dominant or co-dominant species in a unit may vary significantly and influence spectral characteristics during classification. Furthermore, some units composed of a mosaic of small plant communities that ordinarily would remain grouped together in conventional mapping may be split.

- c) In the case of the Îles de Contrecoeur, classified by Aménatech (1991), it was relatively easy to get around these problems since we had recent aerial photographs (August 1990), as well as over 100 ground surveys describing the vegetation, which allowed slight differences appearing after image classification to be identified. In the remainder of the study area, the lack of reference data was a major constraint.

## **6.2 WATER QUALITY**

In this mandate, water quality emerged as a new constraint that was not identified during the previous mapping involving three test sites (Aménatech 1991). This problem was particularly evident in Lake Saint-Louis and the La Prairie Basins, where the presence of sediment-laden brown water from the Ottawa River and the clear, green water of the Great Lakes resulted in some confusion in classifying shallow water of varying densities.

Moreover, high concentrations of suspended matter, caused by shoreline erosion or input from tributaries, masked the river bottom to varying degrees.

In addition, throughout the study area, the radiometric corrections of the juxtaposed flight lines for each study sector had particularly significant effects on aquatic habitats. These effects were so marked that sparsely vegetated shallow water in the Valleyfield–Beauharnois sector could not be mapped.

## **6.3 RESOLUTION OR CLASSIFICATION LEVEL ACHIEVED FOR WETLANDS**

The classification of wetlands by the processing of airborne images allows a fairly accurate distinction to be made between broad vegetation categories, which can easily be made to

correspond to physiognomic classes. Examples of these classes include shallow water dominated by submerged vegetation; shallow water dominated by floating-leaved plants or filamentous algae; low marshes dominated by emergent narrow-leaved plants (*Typha* spp., *Scirpus* spp., *Eleocharis smallii*, *Sparganium eurycarpum* and *Butomus umbellatus*) and by broad-leaved plants (*Sagittaria* spp.); tall-grass and short-grass wet meadows (high marshes); and shrub and forested swamps.

For a given region, some of these classes can be correlated with groups of specific species. For example, in many cases, shallow water dominated by submerged vegetation in the study area were found to have distinctly regional features. In Lake Saint-Louis, the La Prairie Basins and the Îles de Boucherville, shallow water dominated by *Myriophyllum spicatum*, which reach the surface of the water by summer's end, were found. Shallow water dominated by floating-leaved vegetation occurred most frequently in Lake Saint-Pierre (Saint-François Bay), and could be easily distinguished by the way they reflect light due to the horizontal position of the foliage. In the Trois-Rivières–Quebec City section, although broad changes can be observed due to the gradual transition from a tideless regime to the tidal freshwater regime characteristic of the Fluvial Estuary, the regional features of shallow water dominated by submerged vegetation cannot be distinguished. (Such communities are fairly abundant in the Pointe-du-Lac–Portneuf stretch, particularly around the Gentilly flats.) Downstream of Portneuf, submerged vegetation is no longer referred to as shallow water but rather as a low marsh dominated by submerged *Schoenoplectus pungens*. According to the references consulted (maps and photographs), these formations appear to be portions of *Schoenoplectus pungens* communities submerged by the tide.

Turning to low marshes in deep water, in the Lake Saint-Pierre region, these marshes are generally associated with *Schoenoplectus pungens* and *Scirpus lacustris*. In the Valleyfield–Longueuil portion of the fluvial section and Lake Saint-François, these low marshes are usually dominated by *Typha angustifolia*. In the Dundee sector (Lake Saint-François), this robust emergent species is easily recognizable due to the presence of dead portions, which remain standing over the winter and subsequent summer, and although mixed with living specimens, stand out clearly in the red spectral band (channel 2) due to the absence of photosynthetic activity. In the Trois-Rivières–Quebec City sector, low marshes are less diverse than they are upstream. As in the Lake Saint-Pierre region, low marshes in deep water between Trois-Rivières



and Portneuf are generally associated with *Schoenoplectus pungens* or *Schoenoplectus pungens* and *Scirpus lacustris* communities. *Eleocharis palustris* can also be mixed in with these classes. In the Portneuf–Saint-Nicolas section, the deepwater low marshes are also dominated mainly by *Schoenoplectus pungens* but, due to the lack of more precise references, companion species are described here simply as other emergent plants. Beginning in the Quebec City–Lévis section, where increasingly well-developed communities of *Schoenoplectus pungens* occur, the classes retained better represent the density and/or composition of the community (*Schoenoplectus pungens*, sparse or dense *Schoenoplectus pungens* and/or other emergent plants). The emergent plants in question no doubt consist of the species described by Doran (1981), such as *Zizania aquatica* var. *brevis*, *Sagittaria latifolia*, *Sagittaria cuneata* and *Eleocharis calva*. Without field checks, however, it is impossible to verify the value of defining these classes and to correlate them with the communities described by Doran (1981).

Low marshes are more diverse where the water is shallowest and a number of types can be identified: those dominated by tall emergent plants (*Typha angustifolia* and *Typha latifolia*) and with narrow leaves (*Sparganium eurycarpum*, *Butomus umbellatus*, *Eleocharis palustris*); those dominated by *Bolboschoenus fluviatilis*, whose spectral signature is affected by the long involucre (involucral bract) at the tip; and those dominated by broad-leaved emergent plants (*Sagittaria latifolia*, *Sagittaria rigida* and, more rarely and only in Lake Saint-Pierre, *Pontederia cordata*). In the shallow portion of the low marshes in the Trois-Rivières–Bécancour study sector, two further types can be distinguished: those dominated by narrow-leaved emergent plants (*Typha angustifolia*, *Typha latifolia*, *Sparganium eurycarpum*, *Butomus umbellatus*, *Eleocharis palustris*, *Scirpus americanus*, *Scirpus lacustris*) and those dominated by broad-leaved emergent plants (*Sagittaria latifolia*, *Sagittaria rigida*).

The shoreline becomes increasingly steep between Trois-Rivières and Quebec City. Here, the presence of riparian vegetation is closely associated with floodplains at the mouths of tributaries. Downstream of Quebec City, well developed riparian areas are found locally (Cap Tourmente, Île aux Grues, etc.).

Some high marshes are composed almost exclusively of grasses, hence the use of the synonym “wet meadow.” These formations are generally restricted to a narrow band along the shoreline where they colonize abandoned land in the floodplain. In Lake Saint-Louis, Lake Saint-

Pierre and the accompanying freshwater reaches, plant species dominating the cover of high marshes such as *Phalaris arundinacea*, *Calamagrostis canadensis* and *Spartina pectinata* cannot be distinguished from one another. In Lake Saint-François, *Carex aquatilis* and *Carex lacustris* occupy this physiognomic niche. In Lake Saint-Pierre, the broad-leaved species *Lythrum salicaria* is sometimes abundant in tall-grass wet meadows, but cannot be distinguished in the images. According to the literature, *Phalaris arundinacea* is the dominant species in high marshes between Trois-Rivières and Portneuf, but is often replaced by *Calamagrostis canadensis* and *Spartina pectinata* downstream of Portneuf. In the Quebec City–Lévis study sector and particularly in the well-studied Cap Tourmente region, *Carex aquatilis* and *Carex paleacea* often occupy this physiognomic niche. *Lythrum salicaria* is sometimes very abundant here, but cannot be distinguished in the images. Downstream of Montmagny, the only other high marshes were found near Cacouna and L'Isle-Verte. Michelle Garneau (1984) identified three types of high marshes:

- a) *Carex paleacea* and *Festuca rubra* community;
- b) *Spartina pectinata* and *Hierochloe odorata* community;
- c) *Calamagrostis canadensis* and *Sanguisorba canadensis* community.

Three types of high marshes were retained in the mapping:

- a) High marsh dominated by *Carex* sp.;
- b) High marsh dominated by *Spartina pectinata*;
- c) High marsh used for agriculture.

The lower sections of the high marshes, though dominated by grasses (*Agrostis stolonifera*, *Agropyron repens*, *Poa pretensis*, etc.), have a greater diversity of species in general than the upper section of the high marshes. They are rare in the study area as a whole.

High salt marshes only really begin appearing around Saint-Roch-des-Aulnaies, upstream of La Pocatière. This class is found in the upper part of the floodplain. It replaces other high marsh classes as far as Cacouna, where high salt marshes and high marshes again coexist. The lack of information on the area between La Pocatière and Cacouna prevents us from identifying high marshes there in greater detail. High salt marshes may in fact partly consist of high (freshwater) marshes.

Shrub swamps are generally dominated by various undifferentiated willow species. In Lake Saint-Louis, however, areas of *Cephalanthus occidentalis* appear to predominate while, in Lake Saint-François, *Alnus rugosa* is the dominant species in this type of habitat. Shrub swamps can usually be distinguished clearly from forested swamps unless they contain the same species (such as *Salix nigra* around Lake Saint-Pierre). In the Trois-Rivières–Quebec City section, shrub swamps tend to be infrequent and to be dominated by willows (*Salix* spp.) and *Alnus rugosa*. They generally grow right along the shoreline. More extensive shrub swamps are most often the result of disturbances to forested swamps and are often inseparable from the latter.

Lastly, forested swamps cannot be identified to the species level in the remote sensing images. However, *Acer saccharinum* and *Salix* spp. stands are associated more with Lake Saint-Pierre and nearby freshwater reaches, while *Acer rubrum* are associated with Lake Saint-François. Softwoods (*Larix laricina*) are also found in the floodplain of the latter region.

Although forested swamps cannot be identified to the species level, *Acer saccharinum* dominates a small number of areas with well-developed forested swamps like Bécancour and Gentilly. Further east, the nature of the shoreline creates conditions generally favourable to other species such as *Fraxinus americana*, *Fraxinus pennsylvanica*, *Populus deltoides* and *Ulmus americana*. *Salix nigra* and *Salix fragilis* sometimes form a discontinuous strip along the water's edge. Beginning in Montmagny and downstream to Trois-Pistoles, the “swamp” class (forested or shrub) is no longer found. Most of the forest cover was identified as deciduous, coniferous or mixed. Some harvested peatlands were identified just downstream of the Ouelle River and in the L'Isle-Verte area.

## 7 Conclusion

The classification of wetland and upland habitats must be carried out separately; this is particularly true of agricultural areas, where there is a significant risk of confusing wetland classes with agricultural classes.

By themselves, airborne remote sensing images do not allow dominant and co-dominant species to be determined, but they do allow physiognomic classes to be identified, which can then be associated with groups of specific species through fieldwork and the consultation of reference documents.

The accuracy of mapping depends greatly on the amount of existing information on the area being studied. Some sectors like the Lac Saint-François National Wildlife Area, Îles de la Paix, Îles de Contrecoeur, Lake Saint-Pierre and L'Isle-Verte have been recently documented, allowing for the accurate identification of the various physiognomic classes appearing on the images. Other sectors, however, were classified with less accuracy and validation.

In addition, image quality is a key factor in mapping accuracy. The presence of clouds over Cornwall and the Berthier–Sorel islands, along with atmospheric haze, reduced image quality, and therefore did not provide the level of accuracy required to differentiate certain physiognomic classes.

This document provides a snapshot of the state of wetlands along the St. Lawrence in the early 1990s and can serve as a starting point for a program to monitor changes in these important St. Lawrence ecosystems.

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## Appendix



## Scientific, English and French Nomenclature of Plant Species

Scientific name	English name	French name
<i>Acer rubrum</i>	Red Maple	Érable rouge
<i>Acer saccharinum</i>	Silver Maple	Érable argenté
<i>Agropyron repens</i>	Quackgrass	Chiendent
<i>Agrostis stolonifera</i>	Creeping Redgrass	Agrostide blanche
<i>Ascophyllum nodosum</i>	Knotted Wrack	Ascophylle noueuse
<i>Atriplex prostrata</i>	Hastate Atriplex	Arroche hastée
<i>Bolboschoenus fluviatilis</i>	River Bulrush	Scirpe fluviatile
<i>Bolboschoenus maritimus</i> var. <i>paludosus</i>	Cosmopolitan Bulrush	Scirpe maritime
<i>Brasenia</i> Schreb.	Brasenia	Brasénie
<i>Butomus umbellatus</i>	Flowering Rush	Butome à ombelle
<i>Calamagrostis canadensis</i>	Bluejoint	Calamagrostis du Canada
<i>Carex</i> sp.	Sedges	Carex
<i>Carex aquatilis</i>	Aquatic Sedge	Carex aquatique
<i>Carex lacustris</i>	Lake Sedge	Carex lacustre
<i>Carex paleacea</i>	Chaffy Sedge	Carex paléacé
<i>Cephalanthus occidentalis</i>	Common Button-bush	Céphalanthe occidental
<i>Chara</i> sp.	Chara	Charas
<i>Eleocharis erythropoda</i>	Bald Spikerush	Éléocharide à tiges rouges
<i>Eleocharis palustris</i>	Common Spikerush	Éléocharide des marais
<i>Elodea</i> sp.	Waterweed	Élodées
<i>Epilobium</i> sp.	Willowherb	Épilobes
<i>Festuca rubra</i>	Red Fescue	Fétuque rouge
<i>Fraxinus americana</i>	White Ash	Frêne d'Amérique
<i>Fraxinus pennsylvanica</i>	Red Ash <sup>1</sup>	Frêne rouge <sup>1</sup>
<i>Fucus</i> sp.	Wrack	Fucus
<i>Fucus edentatus</i>	Rockweed	Fucus bifide
<i>Fucus vesiculosus</i>	Bladder Wrack	Fucus vésiculeux
<i>Glaux maritima</i>	Sea Milkwort	Glaux maritime
<i>Hierochloa odorata</i>	Vanilla Grass	Hiéochloé odorante
<i>Hordeum jubatum</i>	Foxtail Barley	Orge agréable
<i>Juncus arcticus</i> var. <i>balticus</i>	Baltic Rush	Jonc de la Baltique
<i>Laminaria</i> sp.	Kelp	Laminaires
<i>Larix laricina</i>	Tamarack	Mélèze laricin
<i>Lythrum salicaria</i>	Purple Loosestrife	Salicaire commune <sup>2</sup>
<i>Myriophyllum</i> sp.	Watermilfoil	Myriophylles
<i>Myriophyllum spicatum</i>	Eurasian Watermilfoil	Myriophylle à épi
<i>Nuphar</i> sp.	Pond-lily	Nénuphars
<i>Nymphaea</i> sp.	Waterlily	Nymphéas
<i>Phalaris arundinacea</i>	Reed Canarygrass	Phalaris roseau
<i>Phragmites australis</i>	Common Reed	Phragmite commun <sup>3</sup>
<i>Plantago maritima</i>	Goose Tongue	Plantain maritime
<i>Poa pratensis</i>	Kentucky Bluegrass	Pâturin des prés
<i>Polygonum</i> sp.	Knotweed	Renouées
<i>Pontederia cordata</i>	Pickernelweed	Pontéderie cordée
<i>Populus deltoides</i>	Eastern Cottonwood	Peuplier à feuilles deltoïdes

Scientific name	English name	French name
<i>Potamogeton</i> sp.	Pondweed	Potamots
<i>Puccinellia paupercula</i>	Poor Puccinellia	Puccinellie maigre
<i>Ruppia maritima</i>	Widgeongrass	Ruppie maritime
<i>Sagittaria</i> sp.	Arrowheads	Sagittaires
<i>Sagittaria cuneata</i>	Arumleaf Arrowhead	Sagittaire cunéaire
<i>Sagittaria latifolia</i>	Broadleaf Arrowhead	Sagittaire latifolié
<i>Sagittaria rigida</i>	Sessilefruit Arrowhead	Sagittaire dressée
<i>Salicornia europaea</i> L. (S.L.)	Common Glasswort <sup>4</sup>	Salicorne d'Europe
<i>Salix fragilis</i>	Crack Willow	Saule fragile
<i>Salix nigra</i>	Black Willow	Saule noir
<i>Sanguisorba canadensis</i>	Canadian Burnet	Sanguisorbe du Canada
<i>Schoenoplectus pungens</i>	Common Threesquare	Scirpe d'Amérique
<i>Scirpus</i> sp.	Bulrush	Scirpes
<i>Scirpus lacustris</i> <sup>1</sup>	Great Bulrush	Scirpe des étangs <sup>5</sup>
<i>Sparganium</i> sp.	Bur-reed	Rubaniers
<i>Sparganium eurycarpum</i>	Broadfruit Bur-reed	Rubaniar à gros fruits
<i>Spartina alterniflora</i>	Smooth Cordgrass	Spartine alterniflore
<i>Spartina patens</i>	Saltmeadow Cordgrass	Spartine étalée
<i>Spartina pectinata</i>	Prairie Cordgrass	Spartine pectinée
<i>Spergularia canadensis</i>	Canada Sandspurry	Spergulaire du Canada
<i>Taraxacum officinale</i>	Common Dandelion	Pissenlit officinal
<i>Typha</i> sp.	Cattails	Typhas
<i>Typha angustifolia</i>	Narrowleaf Cattail	Typha à feuilles étroites
<i>Typha latifolia</i>	Broadleaf Cattail	Typha à feuilles larges
<i>Ulmus americana</i>	American Elm	Orme d'Amérique
<i>Vallisneria</i> sp.	Eelgrass	Vallisnérias
<i>Zizania</i> sp.	Wildrice	Zizanies
<i>Zizania aquatica</i> var. <i>brevis</i>	Annual Wildrice	Zizanie aquatique courte
<i>Zostera marina</i>	Seawrack	Zostère marine

Source: Unless otherwise indicated, English plant names are taken from The PLANTS Database (USDA 2006); Latin and French names are taken from Marie-Victorin (1997).

<sup>1</sup> Farrar 1996.

<sup>2</sup> Darbyshire et al. 2000.

<sup>3</sup> Fleurbec 1983.

<sup>4</sup> The name Common Glasswort is taken from the Web site *Den virtuela floran*:  
<http://linnaeus.nrm.se/flora/di/chenopodia/salic/salieur.html>

<sup>5</sup> Fleurbec 1987.