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INTRODUCTION TO THE ONTARIO LAND COVER DATA BASE, SECOND EDITION (2000): OUTLINE OF PRODUCTION METHODOLOGY AND DESCRIPTION OF 27 LAND COVER CLASSES

Prepared by SPECTRANALYSIS Inc.

For the Inventory, Monitoring and Assessment Section
Science and Information Branch
Ontario Ministry of Natural Resources

November 23, 2004

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INTRODUCTION TO THE ONTARIO LAND COVER DATA BASE, SECOND EDITION (2000)

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1.0 NATURE OF THE DATA BASE

The Ontario Land Cover Data Base provides a classification of 27 broad land cover types across the province of Ontario. The Second Edition (2000) of the data base covers the territory of the province north of the southern boundary of the Canadian Shield. The land cover classes consist of vegetation types (such as forest, wetlands, and agricultural crops or pasture) and categories of non-vegetated surface (such as waterbodies, bedrock outcrops, or settlements). These classes reflect the nature of the land surface rather than actual or potential land use.

The land cover classification was produced by the digital analysis of spectral reflectance data recorded in Landsat-7 satellite images. The classification was conducted using the original resolution of the source data; however, in the final product, the smallest area mapped as a discrete feature is 0.5 hectare.

The land cover classes have been defined at a level of generality that could be sustained across the province; however, some level of regional variation persists. Furthermore, the differences in vegetation cover among certain land cover classes are not sharply distinct but constitute stages in a continuum. Users of the data are strongly advised to reflect on the descriptive notes on individual classes provided in Section 7.0 of this document and to consider how the land cover classes can be most usefully interpreted for the purposes of their studies.

2.0 ORIGIN OF THE DATA BASE

The 2000 Edition of the Ontario Land Cover Data Base is the Second Edition of this provincial land cover classification. The coverage is derived wholly from Landsat-7 Thematic Mapper (TM) satellite data frames recorded between 1999 and 2002, most from 2000 onward. The classified data set was produced by Dr. Simsek Pala of SPECTRANALYSIS Inc. (Oakville, Ontario), under contract to the Inventory, Monitoring and Assessment Section, Science and Information Branch, Ontario Ministry of Natural Resources (OMNR). As noted above, the 2000 Edition covers all areas of the province north of the southern edge of the Canadian Shield, including the Hudson Bay-James Bay Lowlands.

The First Edition of the Ontario Land Cover Data Base was produced from data recorded by an earlier TM sensor system aboard previous satellites in the Landsat series. This original data base, in turn, built upon an extensive earlier program of land cover classification commissioned by the Forest Landscape Ecology Program, Ontario Forest Research Institute. The first provincial classification coverage was likewise produced by SPECTRANALYSIS Inc. under contract to the Inventory, Monitoring and Assessment Section of OMNR. The First Edition included coverage for Southern Ontario but did not include coverage for the Hudson Bay-James Bay Lowlands region of the province. Land cover classification data for the Lowlands was produced by Andrew Jano and Tracey Ellis, scientists on the staff of OMNR.

As an interim measure, the forest cutovers and burns in the First Edition of the data base were updated using satellite image frames recorded mainly in 1996. Production of the Second Edition of the data base was undertaken in 2001 and completed in 2004.

Under contract to Natural Resources Canada, SPECTRANALYSIS Inc. also produced a generalized, national-scale version of the Ontario landcover classification, derived from the updated First Edition of the land cover data base. That information product, containing 15 land cover classes mapped with a minimum feature area of 50 hectares and a pixel size of

100 metres, is available by 1:250,000-scale NTS map sheet areas from the GeoGratis program of Natural Resources Canada

3.0 METHOD OF PRODUCTION

3.1 Recognition of Land Cover Types

Satellite land cover classification identifies cover types by their spectral character, as determined by the electromagnetic energy reflected from the vegetation and other surfaces that make up that cover type. Forest types are identified by the mixture of coniferous and deciduous species, the degree of canopy closure, and the ground cover visible through canopy gaps. Wetland types are identified by the nature of the vegetation cover (trees, grasses, or mosses) and the proportion of open water. Agricultural land cover is distinguished by the spectral character of growing row crops, pasture, or open soil. Forest cutovers are recognized by a combination of spectral reflectance, internal pattern, and context. Settlements and infrastructure features are identified from the lack of vegetation cover and from contextual clues.

3.2 Classification Approach

The primary method employed was supervised classification, by which representative image samples (termed “training sites”) of each land cover type were identified and integrated into a spectral signature for the type.

A few images contained areas where the contrast among land cover types was diminished by the presence of atmospheric haze and smoke from forest fires. Where this problem was significant, and where the vegetation mosaic was very greatly interrupted by a complex pattern of cutovers, burns and bedrock outcrops, a secondary, unsupervised classification was used. By this method, the spectral variations in the problem areas were first identified then grouped into ranges indicative of the various land cover types.

3.3 Classification Control and Editing

Digital image analysis depends on the use of software functions to discriminate among quantitative data on spectral reflectance in various wavelengths; nevertheless, the process is interactive and interpretive. The classification process of the Second-Edition Ontario Land Cover Data Base was informed, at all stages, by the interpreter's extensive field experience of land cover conditions throughout Ontario and their representation on satellite imagery.

Ideally, satellite data used for vegetation classification should be recorded in summer, during the period of stable phenological conditions, so that vegetation types are uniformly presented across their area of distribution. In practice, usable images may not be recorded during the ideal period, and developmental differences due to latitude may cause variations in the appearance of vegetation types. Moreover, even in mid-summer, extensive, light haze from humidity and smoke from forest fires create inconsistencies in the presentation of vegetation types across their range. (This effect is reduced to some degree by excluding the blue-light band [TM 1] and including the farther-infrared band, TM 7.) The image analyst is required to accommodate all of these sources of variation in the classification and editing processes. To produce a consistent land cover classification under these conditions requires judgment derived from experience.

Interactive editing was used extensively to map certain classes that could not be positively identified without taking pattern and/or context into account in addition to spectral values. Through visual interpretation regenerating old cutovers, for example, were differentiated from deciduous forest, wetlands occurring within cutovers were differentiated from their surroundings, and densely treed wetlands were differentiated from coniferous forest. Likewise, areas that appeared to be sparse forest were identified by context as settlements. The knowledgeable use of editing techniques improved the overall accuracy of the land cover data significantly.

3.4 Spatial Geometry

The source images for most of the land cover classification were orthocorrected frames supplied by Natural Resources Canada; however, parts of the coverage area were classified

before orthocorrected images became available. All source images had an original spatial resolution of 30 metres. After classification, the orthocorrected frames were resampled to a 25-metre pixel through use of a nearest-neighbour algorithm. In areas classified from non-orthocorrected frames, the spatial geometry was subsequently corrected to waterbody boundaries derived from the orthocorrected frames. The entire Second-Edition Ontario Land Cover Data Base is thus consistent in spatial geometry with the orthocorrected frames.

A land cover classification produced from 25-metre-resolution satellite data is not well suited to printing, display or analysis at scales larger than 1:50,000. To use selected areas of the land cover data at larger scales, users are advised to carry out an additional geometric correction to their larger-scale reference source.

3.5 Continuity of the Classification Fabric

Interactive editing and comparative classification were used to provide a seamless transition in the classification data across the boundaries between images.

The land cover data base extends over UTM Zones 15, 16, 17 and 18. The classification output was generated for each UTM zone separately, and the classification data for each zone is spatially matched to the projection of that zone.

An area of overlap in the classification was produced along UTM zone boundaries in order to provide a continuous classification fabric. The width of the overlap area ranges from 10 km in the south to 40 km in the north, a variation which reflects meridian convergence.

3.6 Minimum Feature Size

As noted above, the original spatial resolution of the satellite data, a little less than 30 metres, was resampled to 25 metres and was maintained at that resolution level throughout the classification process. The final classification results were filtered to an eight-pixel minimum area. The spatial resolution of the classification data is thus 0.5 hectare. In theory, therefore, individual features as small as 0.5 hectare can be represented as discrete units. In reality, the

presence of spectral contrast with adjacent features determines whether a feature of that size can be distinguished.

3.7 Project Review Process

Throughout the production process, both at predetermined milestones and in response to specific classification issues, the OMNR remote sensing specialists in charge of the project (David White and Andrew Jano of the Inventory, Monitoring and Assessment Section) inspected work in progress at the premises of the consultant, SPECTRANALYSIS Inc. These specialists also conducted a detailed review of segments of the final classification results, as they were delivered, and advised the consultant of any adjustments required.

4.0 PERSPECTIVE ON ACCURACY

Satellite image analysis has been used to produce the contents of the Ontario Provincial Land Cover Data Base because the vast area to be mapped (1 million km^2) made the use of more detailed mapping methods impractical. The resulting data base has not been subjected to standard techniques of accuracy assessment, for two reasons. First, the land cover classes are broad and thus subject to broad interpretation. Secondly, gathering sufficient ground truth data to provide a meaningful assessment of accuracy over so vast an area has not been financially feasible.

Experience suggests the following accuracy considerations by land cover class:

- Waterbodies are classified with a higher confidence than any other class.
- Forest types are classified with a high level of confidence. Some degree of unavoidable confusion exists, however, between treed wetlands and sparse forest classes. Regional variations in canopy closure and ground vegetation suggest that forest classification derived from spectral evidence is most effectively interpreted from an in-depth knowledge of local forest conditions.

- Forest clearcuts and forest burns (both recent and old) are classified with a high level of confidence; however, bedrock outcrops may be confused with recent clearcuts if the two classes occur in close proximity.

- Unvegetated classes (bare sand and gravel on beach ridges, mines and mine tailings, bedrock outcrops and Hudson-James Bay coastal mudflats) are classified with a relatively high level of confidence.

- Agricultural land cover types (pasture and cropland) are distinguished with a lower level of confidence, as there is widespread, unavoidable confusion between cropland and pasture and between agricultural land and clearings for settlement and other economic activity.

- Major settlements and roads are spectrally distinguished with a lower level of confidence than any other class.

5.0 SOURCE DATA

The source data for the 2000 Ontario Land Cover Data Base consisted of 55 Landsat-7 TM images. Only frames containing little or no cloud cover were selected. Table 1 presents the number of images recorded in each of the coverage years (1999 to 2002) by UTM zone. The 1999 images were used for lack of more recent data of acceptable quality; moreover, only minor segments of these frames were used, as areas of overlap from adjacent, more recent frames filled in the remainder of the area.

Figure 1 provides a frame area diagram for the UTM Zone 15 portion of the data base and lists the dates and path/frame numbers of the images used in the classification of that zone. Figures 2, 3 and 4 provide the same information for UTM Zones 16, 17 and 18, respectively.

Table 1.

Recording Year and Month of Landsat-7 Satellite Images

Used to Produce the Second-Edition Ontario Land Cover Data Base

UTM Zone	Recording Month										
	1999	2000	2001	2002	June 1-15	June 16-30	July 1-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	Sept. 16-30
15	3	8	1	1			5		6	1	1
16	4	8	6	3	2	1	12	1	3	1	1
17	1	7	4	6	2	1	7	6	2		
18		1	1	1			1	1	1		
Total	8	24	12	11	4	2	25	14	6	2	2

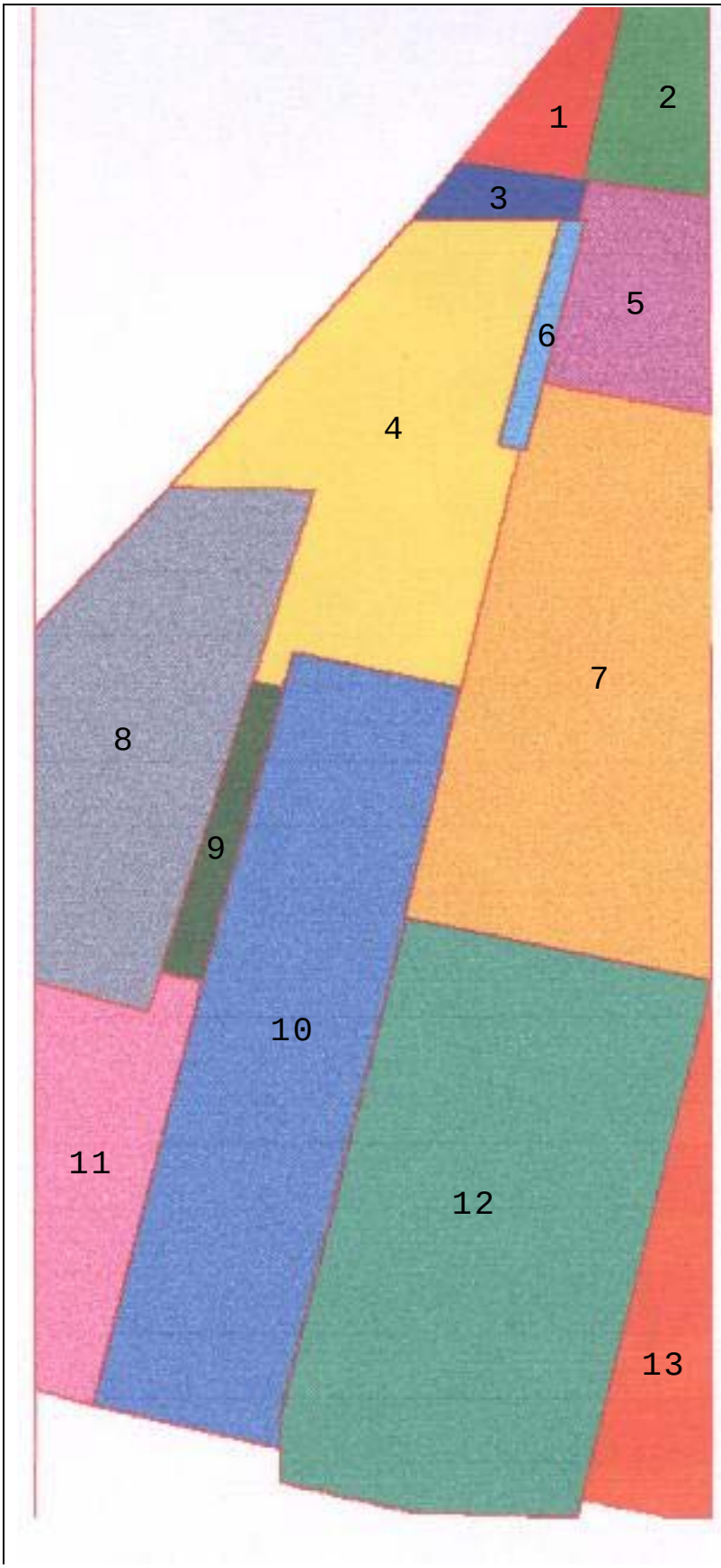


Figure 1.

Second-Edition Ontario Land Cover Data Base: UTM Zone 15 Frame Outline Diagram with Image Recording Dates and Path-Frame Numbers

1.	August 26, 2000	28/21
2.	August 19, 2000	27/21
3.	August 24, 1999	28/24
4.	July 3, 2001	29/22-23
5.	August 17, 1999	27/22
6.	July 25, 2000	28/23
7.	September 4, 2000	27/23-24
8.	August 24, 2000	30/23-24
9.	September 16, 1999	29/24
10.	August 26, 2000	28/24-25-26
11.	July 16, 2000	29/25-26
12.	July 18, 2000	27/25-26
13.	July 1, 2002	26/25-26

Figure 2.

Second-Edition Ontario Land Cover Data Base: UTM Zone 16 Frame Outline Diagram with Image Recording Dates and Path-Frame Numbers

1.	August 10, 2000	28/20
2.	August 19, 2000	27/21
3.	August 17, 1999	27/22
4.	July 11, 2000	26/21-22-23
5.	September 4, 2000	27/23-24
6.	July 1, 2002	26/25
7.	July 10, 2002	25/21
8.	June 5, 2001	25/22-23-24-25
9.	July 4, 2000	25/26-27
10.	July 22, 1999	23/22
11.	July 29, 2000	24/23
12.	September 18, 2001	24/24
13.	June 7, 2001	23/23-24-25
14.	July 11, 1999	24/25-26
15.	July 6, 2000	23/26
16.	July 15, 2000	22/24-26
17.	July 5, 2002	22/25
18.	June 16, 2001	22/27
19.	August 31, 2001	21/26
20.	July 27, 2001	21/27
21.	July 22, 1999	21/28

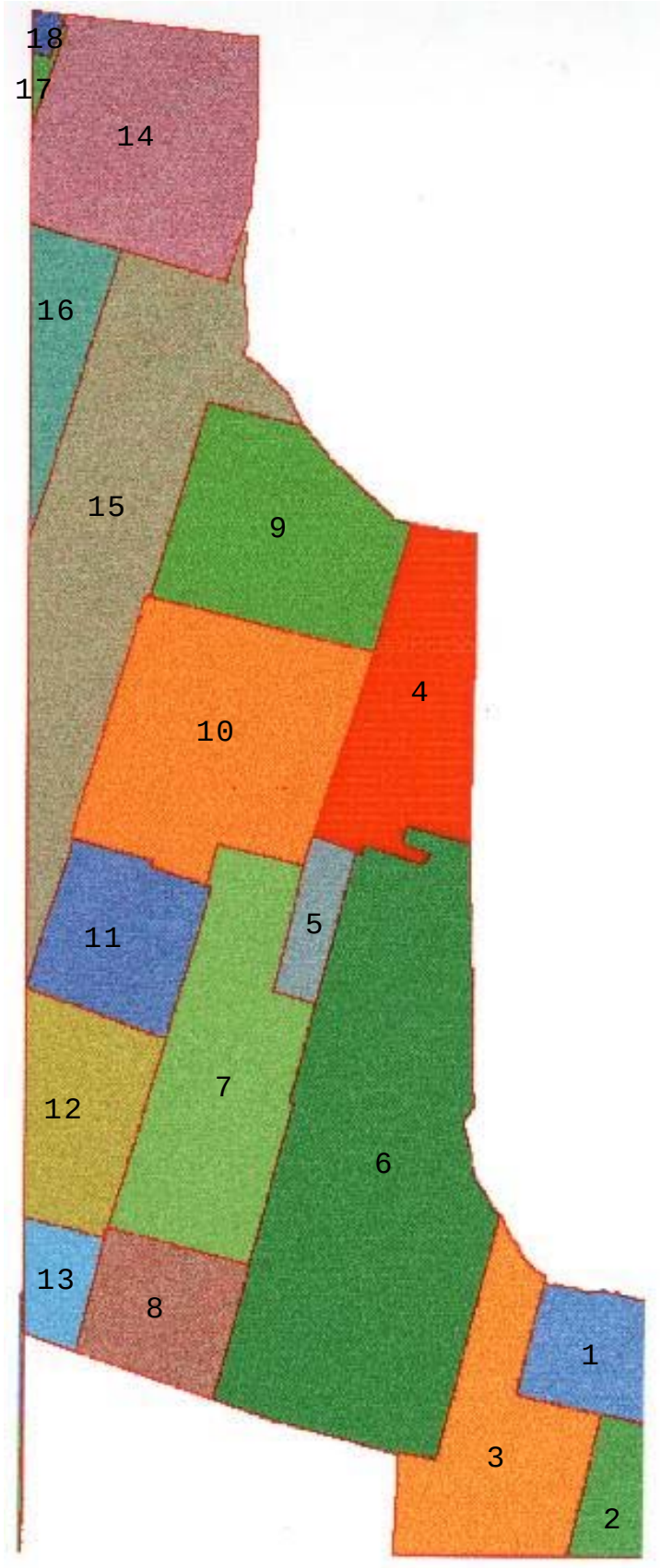


Figure 3.

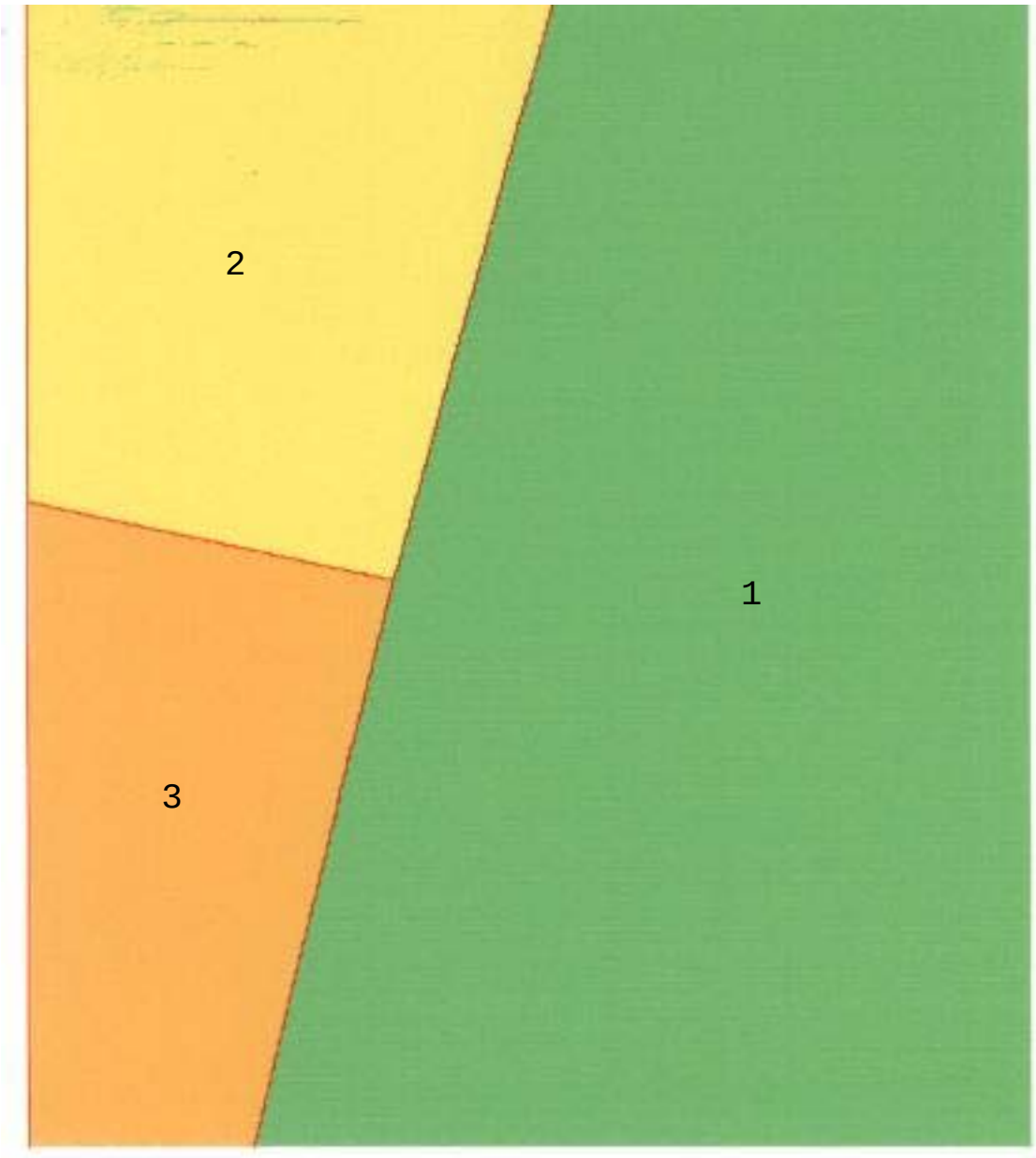
Second-Edition Ontario Land Cover Data Base: UTM Zone 17 Frame Outline Diagram with Image Recording Dates and Path-Frame Numbers

1.	July 12, 2000	17/28
2.	August 3, 2002	17/29
3.	August 10, 2002	18/28-29
4.	August 9, 2000	21/23-24
5.	August 8, 2002	20/25
6.	August 27, 2000	19/25-26-27
7.	July 15, 2000	20/24-25
8.	August 5, 2001	20/26
9.	August 9, 2000	21/23-24
10.	June 28, 2002	21/25
11.	August 31, 2002	21/26
12.	July 27, 2001	21/27
13.	July 23, 1999	21/28
14.	July 22, 2000	23/22
15.	July 15, 2000	22/22-23-24-25
16.	June 7, 2001	23/23-24
17.	June 5, 2001	25/22
18.	July 10, 2002	25/21

Figure 4.

Second-Edition Ontario Land Cover Data Base:
UTM Zone 18 Frame Outline Diagram
with Image Recording Dates
and Path-Frame Numbers

1. August 25, 2001 16/28
2. July 12, 2000 17/28
3. August 3, 2002 17/29



6.0 DIFFERENCES IN CLASSIFICATION SCHEME BETWEEN THE FIRST AND SECOND EDITIONS OF THE ONTARIO LAND COVER DATA BASE

The land cover classification scheme used to generate the Second Edition of the Ontario Land Cover Data Base parallels the classification scheme used in the First Edition but differs from it in several respects.

Mixed Forest: The Second Edition does not make the distinction between predominately conifer and predominately deciduous mixed forest that was made in the First Edition. A single *Mixed Forest* class is mapped.

Coniferous Forest: The Second Edition does not retain the distinction between predominately jack pine forest and predominately black spruce forest but combines these subclasses into a single *Coniferous Forest* class.

Sparse Forest: The Second Edition does not make the distinction between predominately conifer and predominately deciduous sparse forest, as was done in the First Edition. A single *Sparse Forest* class is mapped.

Cutovers: While the First Edition contained a separate class for cutovers over approximately 10 years of age, the Second Edition does not map young regeneration in a separate cutover class. Instead, regenerating growth on cutovers is identified as either sparse forest or dense mixed forest, depending on the spectral evidence of foliage density presented by the target area. Both the First and Second Editions map new cutovers, those less than about 10 years of age, as a distinct *Cutovers* class.

Wetlands: The wetland classes in the Second Edition are defined within the same overall framework as the wetland classes in the First Edition but are more broadly defined. The First Edition wetland classes reflect a separate classification scheme developed specifically for the Hudson-James Bay Lowlands, as the Lowlands region was classified separately and subsequently integrated into the First Edition.

Classes Specific to Southern Ontario: The coverage contained in the Second Edition does not extend to Southern Ontario but terminates at the southern margin of the Precambrian Shield. The classes of *Inland Marsh* (Class 16), *Deciduous Swamp* (Class 17) and *Coniferous Swamp* (Class 18), which were defined specifically for use in Southern Ontario, are retained in the classification scheme of the Second Edition only to provide for continuity with the Southern Ontario area of the First Edition Data Base. No occurrences of these classes are mapped within the Second Edition coverage area.

Merging of Alvar with Pasture: A separate subclass was created in the Second Edition for the *Alvar* class, in order to provide for continuity with the First-Edition classification persisting in Southern Ontario. For purposes of the Northern Ontario classification, this subclass has been merged into the *Pasture* class.

1996 Cutovers and Burns Update Class: The First-Edition Data Base was updated to include forest cutovers and burns mapped from Landsat TM data recorded in 1996. The updated depletion areas were retained as a separate class, which is not included in the classification scheme of the Second Edition.

Other: New to the Second Edition, the *Other* class identifies vegetation conditions that cannot be identified as any other land cover class. It includes bedrock outcrops that support sparse vegetation, undefined clearings in areas of disturbance, small unburned patches of forest within areas recently burned, and undefined areas of transition from one land cover type to another.

7.0 CLASSIFICATION SCHEME OF THE SECOND EDITION ONTARIO LAND COVER DATA BASE

Table 2 sets out the hierarchy of land cover types from which the Second-Edition land cover classification is derived. Table 3 lists the 27 Second-Edition land cover classes.

Table 2.

**Hierarchy of Land Cover Types
from which the Land Cover Classification Scheme
of the Second Edition Ontario Land Cover Data Base is Derived**

Category Level 1	Category Level 2	Category Level 3	Class Name	Class Number *
Non-Vegetated	Water	Deep or Clear	Water - Deep or Clear	**1**
		Shallow or Sedimented	Water - Shallow or Sedimented	**2**
	Land	Settlement/ Infrastructure	Settlement/Infrastructure	**3**
		Sand/Gravel	Sand/Gravel/Mine Tailings	**4**
		Bedrock	Bedrock	**5**
		Mudflats	Mudflats	**6**
	Depletion	Cuts	Cuts	**7**
		Burns	Burns	**8**
Vegetated	Forest	Regenerating Depletion	Regenerating Depletion	**9**
		Sparse	Sparse Forest	**10**
		Dense	Deciduous Forest	**11**
			Mixed Forest	**12**
			Coniferous Forest	**13**
	Wetland	Marsh	Intertidal Marsh	**15**
			Supertidal Marsh	**16**
			Inland Marsh	**17**
		Swamp	Deciduous Swamp	**18**
			Coniferous Swamp	**19**
		Fen	Open Fen	**20**
			Treed Fen	**21**
		Bog	Open Bog	**22**
			Treed Bog	**23**
	Tundra	Tundra	Tundra Heath	**24**
	Agriculture	Pasture	Pasture	**25**
		Cropland	Cropland	**27**
Other	Other	Other	Other (Undefined)	**28**
			Cloud and Shadow	**29**

***** There are 27 land cover classes but 29 class positions. Positions 14 and 26 are kept for the storage of subclass data not represented in the final Second-Edition data base.

Table 3. A Summary List of the Land Cover Classes of the Second-Edition Ontario Land Cover Data Base

Class Number	Class Name	Class Description
1	Water - Deep or Clear	Deep or clear waterbodies.
2	Water - Shallow or Sedimented	Shallow waterbodies and waterbodies with a high concentration of suspended sediment.
3	Settlement/Infrastructure	Clearings for human settlement and economic activity; major transportation routes.
4	Sand/Gravel/Mine Tailings	Beach deposits, aggregate quarries and sand dunes; mines and mine tailings.
5	Bedrock	Exposed bedrock, lacking vegetation cover.
6	Mudflats	Unvegetated coastal areas of the Hudson Bay-James Bay Lowlands, partly submerged at high tide.
7	Cutovers	Forest clearcuts estimated to be less than 10 years of age.
8	Burns	Forest burns estimated to be less than 10 years of age.
9	Regenerating Depletion	Old burns supporting very sparse vegetation.
10	Sparse Forest	A patchy or sparse forest canopy composed of coniferous or deciduous species or a combination of the two.

11	Deciduous Forest	Largely continuous forest canopy composed primarily of deciduous species.
12	Mixed Forest	Largely continuous forest canopy composed of both deciduous and coniferous species. In more northerly areas, a greater component of coniferous species can be expected; in more southerly areas, a greater component of deciduous species can be expected.
13	Coniferous Forest	Largely continuous forest canopy composed primarily of coniferous species
15	Intertidal Marsh	Coastal marshes of the Hudson Bay-James Bay Lowlands lying between the coastal mudflats and the supertidal zone.
16	Supertidal Marsh	Coastal marshes of the Hudson Bay-James Bay Lowlands lying inland of both the coastal mudflats and intertidal marshes, and subject to only exceptionally high tides.
17	Inland Marsh	Lakeshore and inland marshes of Southern Ontario.
18	Deciduous Swamp	Hardwood swamps of Southern Ontario occurring along rivers and in old lakebeds and other low-lying areas.
19	Coniferous Swamp	Swamps with dense conifer tree or shrub cover occurring in Southern Ontario.
20	Open Fen	Fens generally lacking tree cover that may support some shrub cover and tamarack. Open fens include fens with an open water surface, graminoid fens, pattern fens, and shrub-rich fens.
21	Treed Fen	Fens supporting a sparse to dense cover of trees or shrubs.

22	Open Bog	Bogs generally lacking tree cover.
23	Treed Bog	Bogs supporting a sparse to dense cover of trees.
24	Tundra Heath	Low tundra vegetation growing on slightly raised beach deposits and strand lines along the Hudson Bay coast.
25	Pasture	Open grassland with sparse shrubs in rural land.
27	Cropland	Areas of row crops and fallow fields.
28	Other	Landcover conditions not accurately defined by any other landcover class. This class includes the following: undefined clearings in disturbed areas; small, unburned areas within recent burns; and undefined transitional areas between classes, such as some wetland boundaries.
29	Cloud and Shadow	Areas of cloud or shadow on the satellite images.

7.0 CLASSIFICATION SCHEME OF THE SECOND-EDITION ONTARIO LAND COVER DATA BASE (CONTINUED)

The following are descriptive notes provided to assist the user in interpreting occurrences of the classes.

Class 1 (Water - Deep or Clear) and Class 2 (Water - Shallow or Sedimented)

In general, waterbodies are one of the most accurately mapped features, in the sense that the spectral reflectance from waterbodies is almost never confused with that of any other feature. The distinction between the two water classes lies in the degree of sediment loading, which may or may not represent depth. Major sediment-loaded lakes and rivers were clearly identifiable; however, shallow lakes that were relatively free of sediment load at the time of image recording have been mapped in the clear-water class. For most purposes, it may be appropriate to combine the two water classes.

Whether waterbodies are large or small, their shoreline zone inevitably contains numerous pixels with a spectral reflectance that might be termed “blended”, being representative of neither water nor of any specific vegetation cover type found at the edge of the water. These pixels have been included in the water class, thus enlarging the waterbodies. An additional reason for this effect is the final filtering of the classification results to a minimum area of eight pixels, or 0.5 hectare. In this process, features extending over an area smaller than eight pixels that had contact with water pixels may have also been included in the water class.

If a user superimposes vector files created either directly from satellite data or from other sources on waterbody boundaries taken from the Second Edition land cover classification, discrepancies will be evident, even if the geometric match between the two data sources is perfect. To use the classification data in conjunction with another data source, therefore, it is necessary to take the waterbody boundaries from the classification data and superimpose them on the other data source.

Rivers that could be identified as continuous features by their width and contrast to their surroundings were mapped as waterbodies. In some cases, the edge-pixel effect described in

the preceding paragraph must make the width of rivers appear greater on the classification data than it would appear in visual interpretation of the original satellite imagery.

Settlement/Infrastructure (Class 3)

By the spectral classification method, even as supplemented with significant use of interactive editing, this class is mapped with a lower level of confidence than any other class. More precise information could have been obtained if the linear features had been traced on the basis of visual interpretation and a vector file created for each, but that approach was beyond the scope of the land cover classification project.

Major settlements, major roads, railroads, pipelines and power transmission corridors have been identified on the basis of minimal vegetation cover and linear pattern; however, it is extremely difficult to distinguish small settlements located along highways or within agricultural land from their surroundings. Along Highway 11 from Orillia to Sault Ste. Marie, most of the areas with minimal vegetation are rock outcrops, so relatively small clearings created by human activity are included in the *Bedrock* class. The same confusion occurs along the shores of Lake Superior and Georgian Bay and along the southern edge of the Precambrian Shield.

Away from major highways, small settlements and other clearings for human activity are readily confused with cutovers and even adjacent sparse forest. Logging roads visible near areas of cutting operations have been deliberately included in the *Cutovers* class.

As defined by the land cover classification approach used in the Ontario Land Cover Data Base, the *Settlement/Infrastructure* class serves to separate major areas of human activity from other land cover types. Users of the data base who require a more accurate definition of infrastructure features are recommended to derive these features from other sources, create a buffer around the features, and use the resulting definition in conjunction with the land cover classification.

Sand/Gravel/Mine Tailings (Class 4)

In addition to open sand and gravel deposits and larger aggregate quarries, this class includes mines and mine tailings, which are readily recognized in most of the areas where they occur. In the Timmins and Sudbury areas, however, where mine and mine-tailing features occur in a complex mosaic with settlement/infrastructure and agriculture, some degree of confusion exists between the *Sand/Gravel/ Mine Tailings* class and surrounding features. In areas of bedrock outcropping, small mines and mine tailings may be missed. Users requiring more complete information on mines and mine tailings are advised to conduct a narrower, customized classification of the source satellite data for this purpose.

Extensive sand and gravel deposits have been mapped in the Hudson Bay-James Bay Lowlands, in the form of beach deposits that occur in roughly parallel ridges in both the coastal zone and inland areas. The broader and more continuous beach deposits are mapped as individual *Sand/Gravel* features. The smaller, less continuous ones are mapped according to spectral evidence of vegetation cover as either tundra vegetation (closer to the shorelines) or sparse forest (inland). The sparse forest growing over these ridges appears brighter than sparse forest elsewhere because of the brightness of lichen ground cover showing through the canopy. In fact, the forest cover on some beach deposits may be quite dense, but the contribution of the lichen ground cover gives it a sparse appearance. Where the sparse forest cover has been burned, the ridge may appear even brighter.

The beach deposits are represented as unique sand/gravel features only partly for the difficulty of identifying their vegetation cover but primarily for their significance as the only surface areas of mineral soil in the Lowlands.

Bedrock (Class 5)

Extensive bedrock outcrops are found in Northwestern Ontario (between Sandy Lake and Lake of the Woods), along the Lake Superior and northern Georgian Bay shorelines, and at the southern edge of the Precambrian Shield. Some of the outcrops may support very sparse vegetation growth, mostly of jack pine because of the dry condition of the ground, but the vegetation is too sparse to warrant the *Sparse Forest* class.

In areas of forest cutting activity, such as Northwestern Ontario, some cutovers that occur in areas of extensive bedrock outcropping may have been included in the bedrock class. Similarly, some settlements or portions of road may have been mapped as bedrock, where these conditions occur together, along the shorelines of Lake Superior, the North Channel and Georgian Bay and in the southern part of the Canadian Shield.

Mudflats (Class 6)

Mudflats are found only along the Hudson Bay and James Bay shorelines, as a function of very extensive tidal action. The breadth of the mudflats in the classification data depends on the point in the tidal cycle when the source satellite image was recorded.

Cutovers (Class 7)

There is only one class for cutovers, that of cutovers less than approximately 10 years of age. In general, recent cutovers are readily recognized by high reflectance values from the ground cover. However, areas of cutting operations often consist of a mosaic of cutovers from different years. With the passage of time, the cutovers may show increasing evidence of regeneration. The new growth can only be mapped as sparse forest, even though it may be far from mature. The regeneration may also have a distribution of stems closer to a dense forest condition, but at this stage reflectance from the ground through the open canopy makes the growth appear sparse.

As noted under Class 3 above, access roads visible within areas of cutovers have been included in the *Cutovers* class instead of the *Settlement/Infrastructure* class, as they are an integral part of the cutting operations.

As a result of similar reflectance characteristics, some cutovers occurring where bedrock outcrops are prevalent may have been mapped as bedrock, and some bedrock outcrops mapped as cutovers. This confusion is most likely to occur in Northwestern Ontario, along the shores of Lake Superior, the North Channel and Georgian Bay, and in the southern zone of the Precambrian Shield.

Burns (Class 8)

Quite recent forest burns, readily identified by the dark appearance of the burned ground, are mapped in the *Burns* class, Class 8. In the northernmost areas of the province, where burns are both numerous and very extensive, complex burn patterns have developed that would not rightly be combined with more recent burns. The *Regenerating Depletion* class, Class 9, was created to represent these older, very sparsely regenerated northern burns which may contain patches of unburned forest and patches of repeatedly burned forest, and which may show some evidence of regeneration but not enough to invoke any of the forest classes. Both burn classes occur extensively in UTM Zone 15, in the northern part of UTM Zone 16, and are also found in the Hudson Bay-James Bay Lowlands.

Regenerating Depletion (Class 9)

As noted above, the *Burns* class (Class 8) identifies recent forest burns. The *Regenerating Depletion* class (Class 9) represents older, very sparsely regenerated northern burns which may contain patches of unburned forest and patches of repeatedly burned forest, and which may show some evidence of regeneration but not enough to invoke any of the forest classes. In general, vegetation cover that could be described as “barren and scattered” is included in the *Regenerating Depletion* class, even if specific evidence of fire is not available. This class may thus offer information of interest for northern wildlife studies. Both the *Burns* and *Regenerating Depletion* classes occur extensively in UTM Zone 15 and in the northern part of UTM Zone 16. They are also found in the Hudson Bay-James Bay Lowlands.

Sparse Forest (Class 10)

Forest vegetation appears sparse when ground cover visible through the canopy influences the overall pattern of spectral reflectance. In the Second Edition of the Ontario Land Cover Data Base, no distinction is made between sparse forest areas containing mainly coniferous species and those containing mainly deciduous species. Some obvious influences, however, can be considered. In the Great Lakes-St. Lawrence Forest Region, deciduous species are more likely to dominate; in the Boreal Forest Region, coniferous species are more likely to

dominate. In areas where cutovers are prevalent, deciduous species may represent a larger proportion of the regenerated sparse forest than coniferous species.

In areas of human activity along highways and utility routes or in settlements, areas of sparse vegetation that cannot be definitively identified as either settlements or agriculture have been mapped as sparse forest.

In the northernmost parts of the province, the densest forest growth is apt to have a somewhat more open canopy than found in dense forest further south. As a result, a ground cover of lichens or an undergrowth of shrubs may be visible through the canopy. Forests mapped as sparse under these conditions may be denser than they appear, as the bright appearance of lichens and shrubs dominates the darker evidence of dense forest.

Sparse forest in the Hudson Bay-James Bay Lowland should be more broadly interpreted than elsewhere in the province. Here, bogs with a dense tree cover have a spectral reflectance very similar to that of sparse forest growing on areas of mineral soil; therefore, the fact that an area is mapped as sparse forest does not rule out the possibility that it is a wetland. In addition, areas of sparse forest occurring on beach deposits may be denser than they appear because of interference from the bright reflectance of underlying lichen cover or open sand.

In areas of extensive bedrock exposure, the canopy of sparse forest may be considerably sparser than in areas without bedrock outcrops. As noted above, bedrock outcropping is especially prevalent along the shores of Lake Superior, the North Channel and Georgian Bay, as well as along the southern edge of the Precambrian Shield.

Deciduous Forest (Class 11)

Dense deciduous forest is readily recognized by high infrared reflectance values from broadleaf chlorophyll. Most of the vegetation mapped in this cover type is true forest; however, the data user should be aware of possible exceptions. First, the dense deciduous regeneration in cutovers may be less than mature forest. Secondly, in the most northerly areas of the province, and especially within the Hudson and James Bay coastal zone, the only representation of the deciduous forest type may consist of dense willow and alder thickets,

sometimes mixed with poplar or birch trees, growing on sand deposits and at the mouths of rivers. Riverbanks and levees in the Lowlands may support true deciduous forest, but trees may give way to shrubs in lower areas near the river edges.

Mixed Forest (Class 12)

This is one of the most extensive and widely distributed forest cover types. It is found on regenerated old cutovers and burns. No distinction has been made in the Second Edition between mixed forest where coniferous species are dominant and mixed forest where deciduous species are dominant. In general, however, mixed forest in the northern Boreal Forest is likely to contain a greater proportion of coniferous species, while mixed forest further south is likely to contain a greater proportion of deciduous species.

In the Hudson-James Bay Lowlands, confusion occurs between mixed forest and treed fens, as both features may support a dense growth of alder shrub, with tamarack and some black spruce. Treed fen occurs extensively along the coastline of James Bay. Along the coastline of Hudson Bay, rivers deposited sand as the land rose, and true mixed forest grows on the sand deposits. Just adjacent to those deposits, however, extensive treed fen wetlands have developed. Treed fen is readily mapped when the tree cover is sparse, but when the tree cover is dense, the distinction can only be made by pattern and context. Where the pattern was clearly apparent, the treed fen was separated out through the use of interactive editing, but in other areas the confusion must persist.

Coniferous Forest (Class 13)

Dense coniferous forest is readily differentiated from most other vegetation types. No distinction has been retained in the Second Edition between coniferous forest where jack pine is dominant and coniferous forest where black spruce is dominant. In northern latitudes, some occurrences of coniferous forest may be mapped as sparse forest because of the brightening effect of lichens and shrub undergrowth visible through the canopy.

In the Hudson-James Bay Lowlands, some densely treed bogs have been mapped as coniferous forest. This confusion occurs because the vegetation cover is much the same on both features, although the bog vegetation grows on peat instead of mineral soil.

Some conifer swamps in the Lowlands are also mapped as coniferous forest. Covered with a dense coniferous growth, these swamps occur mainly in the basins of the Moose River and Upper Albany River.

Intertidal Marsh (Class 15)

Intertidal marshes are found mainly along the Hudson Bay coastline and there are some along the James Bay coastline as well. These marshes are flooded at high tide and slowly drain as the tide falls. They contribute to the coastal mosaic of mudflats, marshes and tundra vegetation.

Supertidal Marsh (Class 16)

Supertidal marshes are located in the coastal zone of Hudson Bay, further inland than the normal high tide mark, between the beach ridges and strand lines. (Beach ridges are higher and generally more continuous features, while strand lines have only a slight elevation.) Supertidal marshes are easily confused with open fen in this part of the Lowlands, because these open fens have an open water surface. In fact, both features have an equally wet surface and would be difficult to distinguish without detailed, botanical evidence.

Inland Marsh (Class 17)

This wetland class occurs only in Southern Ontario and is retained in the Second-Edition classification scheme for the sake of continuity with the First-Edition Southern Ontario land cover fabric. Some of these marshes are found along lakeshores. The class also denotes seasonal marshes (flooded in spring but often dry by fall), cattail marshes and grassy meadow marshes.

Deciduous Swamp (Class 18)

This class denotes swamps with deciduous vegetation cover occurring only in Southern Ontario, along rivers, in old lakebeds, and in other low-lying areas. The class is retained in the Second-Edition classification scheme for the sake of continuity with the First-Edition Southern Ontario land cover fabric.

Coniferous Swamp (Class 19)

This class denotes swamps with dense conifer tree or shrub cover occurring in Southern Ontario. The class is retained in the Second-Edition classification scheme for the sake of continuity with the First-Edition Southern Ontario land cover fabric.

Open Fen (Class 20)

Ontario contains a wide variety of wetland types, especially in the Hudson-James Bay Lowlands. For wetland mapping at a provincial scale, only four classes are distinguished: open and treed fens; and open and treed bogs. This level of generality required the merging of many wetland conditions that might be of interest for special purposes.

Wetlands in the *Open Fen* class are generally characterized by a lack of tree cover, although they may support some shrub cover and tamarack. Open fens include the following variations: open graminoid fens, fens with a sheet of water on the surface, pattern fens (i.e., fens marked by a lace-like combination of surface vegetation and open pools), and shrub-rich open fens. Fens with an open water surface occur extensively from the Moose River basin to the Hudson Bay Lowlands and all along the Hudson Bay coast, interwoven with open graminoid fens. Most pattern fens occur further inland.

Treed Fen (Class 21)

Treed fens support sparse to dense tree cover or shrub cover. Some of the more densely treed fens have an appearance similar to that of dense mixed forest, so they may be mapped as

such. The alder shrubs that grow along rivers flowing into Hudson Bay are mapped as either treed fen or mixed forest, depending on the brightness of their chlorophyll reflectance. Treed fens occur extensively in the Hudson-James Bay Lowlands, both in the coastal zone and inland. Some shrub-rich open fen may be identified as treed fen.

Open Bog (Class 22)

Bogs contain standing water and a thick foundation of peat. Fens develop without a thick peat layer in areas of flowing water. The degree of open water at the surface and the presence of a dry peat layer are the main factors distinguishing the appearance of bogs and fens on satellite imagery.

Open bogs have little or no tree cover. This class includes several distinct variations of the type, among them lichen-rich bog, low-shrub-rich bog and string bog (so called from its pattern of parallel strips of vegetation separating open pools). Most of the open bogs found in Northwestern Ontario are lichen-rich open bogs and peat plateaus. Some confusion occurs between graminoid-rich open bog and graminoid fen, as both features are mapped on the basis of their cover of grasses.

Treed Bog (Class 23)

Treed bogs are the most extensive wetland class in the area of the Second Edition of the Ontario Land Cover, both in the Hudson-James Bay Lowlands and elsewhere. This classification scheme makes no distinction among degrees of tree cover density. For the most part, treed bogs can be distinguished with confidence from open bogs; however, the two may be confused where they occur together in small patches and where the tree cover on the treed bog is sparse. Treed bog may be confused with sparse forest, both in the Lowlands and in upland areas.

Tundra Heath (Class 24)

Low, tundra heath vegetation occurs on areas of mineral soil in the beach deposits and strand lines of the Hudson Bay coastal zone. Narrow, flat areas between beach ridges and strand

lines that have been drained by the slight increase in elevation also support this vegetation type. Many of the beach ridges mapped further inland may also support tundra vegetation but the choice has been made to map them as beach ridges instead (in the *Sand/Gravel* class), to reflect the importance of their mineral soils.

Tundra heath occurs in a narrow zone parallel to the Hudson Bay coast, except in two locations where it forms a large homogeneous expanse. The major tundra heath features are found in Cape Henrietta Maria and south of Pen Island, in the extreme northwest of the province near the Manitoba border.

In general, the Hudson Bay coastline contains an intricate pattern of tundra heath, beach ridges and strand lines, intertidal and supertidal marshes, open fens and narrow pools. The land cover classification provided in the Second Edition of the Ontario Land Cover Data Base attempts to represent these features at a provincial scale. For wildlife habitat mapping or any other detailed study in this zone, a customized classification may need to be conducted, based on a greater number of more narrowly defined themes applied in specific target areas.

Pasture (Class 25)

Pasture (Class 25) is defined as land cleared for agriculture that does not show evidence of a plowed surface or row crops. In Northern Ontario, agricultural land use consists mainly of pasture for dairy farming and hay crops, except for the agricultural area in the Little Clay Belt around New Liskeard, where a greater component of cropland occurs in combination with pasture land.

Relatively small occurrences of cropland amid open fields may be mapped as pasture. Open clearings around settlements have been mapped as pasture, although they may be put to other uses. Some older clearcuts close to settlements may have been mapped as pasture. Many clearings along the shores of Lakes Superior and Huron are mapped as pasture but may be planted with crops or used for other economic activity. Clearings along Highway 11 from Sudbury to Orillia that have been mapped in the *Settlement/Infrastructure* class may actually be pasture land; in fact, the vegetation cover may be much the same in both cases. Greater

accuracy might be obtained by considering the *Pasture* class as undifferentiated rural land use.

Cropland (Class 27)

Cropland (Class 27) is defined as agricultural land showing evidence of a plowed surface or row crops. As noted under *Pasture* (Class 25) above, agricultural land use in Northern Ontario consists mainly of pasture for dairy farming and hay crops, but a greater component of cropland occurs, in combination with pasture land, in the Little Clay Belt agricultural area around New Liskeard. Relatively small patches of cropland that occur amid open fields may be included in the *Pasture* class. Patches of cropland along the shores of Lake Superior and Huron which could not be distinguished from pasture or clearings for other economic activity are also included in the *Pasture* class.

Other (Class 28)

This class represents conditions that cannot be identified with confidence as any particular land cover type, in areas where several similar vegetation cover types may be present but no single one is dominant. The *Other* class occurs primarily in UTM Zone 15, within the complex mosaic of old burns, cutovers and bedrock outcrops.

The following conditions are mapped as *Other*:

(a) Areas of bedrock outcrop supporting very sparse vegetation. These outcrops are not so devoid of vegetation as to fall into the *Bedrock* class but the vegetation cover is not sufficient to evoke even the sparse forest class. This condition has been described in other sources as “poorly vegetated” or “barren and scattered”. This condition was represented in the First Edition by a *Poorly Vegetated* class but is now subsumed in the *Other* class.

(b) Undefined clearings in disturbed areas: Some areas containing cutovers or roads also contain other unvegetated areas that cannot be identified as either of those features.

(c) Small, unburned patches within recent burns: These small areas of residual vegetation or wetland are neither part of the burned forest and may not be identifiable as any other specific feature.

(d) Undefined areas of transition from one landcover class to another: The *Other* class has been assigned to distinct transitional areas whose landcover is substantially in doubt. For example, some areas of transition from waterbodies to adjacent vegetated areas cannot be specifically identified as rocky shoreline, stunted vegetation, or marsh. Similarly, the margins of some wetlands, such as treed bogs, may have a distinct zone of vegetation that is not typical of that wetland class but does not satisfy the criteria of any other class.

Cloud and Shadow (Class 29)

The most cloud-free satellite images available were used in the land cover classification, but there were still a few patches of cumulous cloud obscuring the land surface. Where possible, land cover classification data from an overlapping image was patched into the gaps, but a very few cloud-covered areas remain in the classification data, especially in UTM Zone 18.