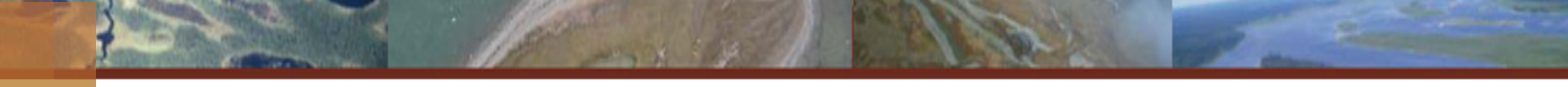
Far North Land Cover Data Specifications Version 1.4

November 2014



Contact :

Provincial Remote Sensing Specialist, Science and Information Branch, Ontario Ministry of Natural Resources anf Forestry. (705) 946-7450

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1.0 Data specifications sheet

Date: November 2014

Section 1: Data standard information This section identifies the name, abbreviation, and extent of the Far North Land Cover, and provides contact information for the producer and custodian of this data layer.	
Layer name:	Far North Land Cover
Layer abbreviation:	
Layer description:	Regional, ecologically based, land cover and change inventory. Represents the landscape current to between 2005-2011.
References:	Far North Land Cover Methodology
Production:	Science and Research Branch, Ministry of Natural Resources and Forestry (MNRF)
Product contact:	Provincial Remote Sensing Specialist, Ontario Ministry of Natural Resources and Forestry, Science & Research Branch. (705) 946-7450
Extent:	Ontario north of approximately the 48th parallel. Includes most of ecoregion 3W and 3S and portions of 4S and 3E.
Custodian:	Science and Research Branch, MNRF

Section 2: GIS Data layer specifications This section identifies the geospatial criteria for this data layer.										
1. File information										
File type:					GRID					
Projection file name:					UTM Zones 15, 16 and 17					
Geometry type	X	Grid	Point		Line			Polygon		Raster
2. Coordinate system										
	Geographic			X	UTM					
Horizontal coordinate system: NAD83/UTM Zones 15, 16 and 17										

2.0 Far North Land Cover classification

2.1 Overview

The aim of creating a revised land cover for the Far North is to produce a consistent map to meet regional - to landscape level analysis (1:50,000 – 1:100,000). Remote sensing analysts apply image analysis, and combine other data such as geology and elevation, to create the land cover database. This is an advantage to previous land cover databases that relied on spectral data alone. The revised land cover will have a vintage across the entire Far North of 2006-11.

A secondary objective is to develop ways of identifying changes over time to ensure land cover data can be updated, and be used in long-term resource monitoring. Changes over time from natural disturbances (e.g., fire and wind damage) and from forest harvesting are being mapped. Disturbances are being classified as either anthropogenic (cuts, infrastructure) or natural. The vintage of these events (pre 1990, 1990-2000, and post 2000) are also captured. More specific time periods and event types (burns, weather related, and insect/disease) are identified wherever suitable data is available. These changes have been incorporated into the land cover as two different types of disturbance features while greater detail on the nature and time period of disturbance is offered in the Provincial Satellite Derived Disturbance Mapping.

2.2 Data dictionary

Far North Land Cover classification products are available in an ESRI ArcGIS File Geodatabase. Contained within the geodatabase are a series of raster datasets and tables.

The following sections are provided as a data dictionary.

2.2.1 Dataset attributes

FarNorth_LandCover				
Field Name	Alias	Description	Tabular Join	Data Type
CODE	Land cover code	The unique numerical code assigned to each Far North Land Cover class name.	To retrieve land cover class names, this field can be joined to Geodatabase Table – FarNorth_LandCover Class_Names – CODE field.	Type: short integer

FarNorth_LandCover				
Field Name	Alias	Description	Tabular Join	Data Type
CODE	Land cover code	The unique numerical code assigned to each Far North Land Cover group name.	To retrieve land cover group names, this field can be joined to Geodatabase Table – FarNorth_LandCover Group_Names – CODE field.	Type: short integer

FarNorth_LandCover				
Field Name	**Alias**	**Description**	**Tabular Join**	**Data Type**
CODE	Land cover code	The unique numerical code assigned to each Far North Land Cover section name.	To retrieve land cover section names, this field can be joined to Geodatabase Table – FarNorth_LandCover Section_Names – CODE field.	Type: short integer

FarNorth_LandCover				
Field Name	**Alias**	**Description**	**Tabular Join**	**Data Type**
SCENE	Landsat track and frame	The Landsat track and frame number		Type: text Length:10
Scene_Date	Image date	The image acquisition date.		Type: date
UTM_Zone	UTM zone	The UTM zone assigned to the image footprint.		Type: short integer

2.2.2 Raster datasets

Name	Entity	Description	Feature type
FarNorth_LandCover_Class_Grid_{UTM Zone}	Raster dataset	Far North Land Cover classification – class level shown in Chart 1: Land Cover Class Aggregation.	Grid
FarNorth_LandCover_Group_Grid_{UTM Zone}	Raster dataset	Far North Land Cover classification – group level shown in Chart 1: Land Cover Class Aggregation.	Grid
FarNorth_LandCover_Section_Grid_{UTM Zone}	Raster dataset	Far North Land Cover classification – section level shown in Chart 1: Land Cover Class Aggregation.	Grid

2.2.3 Geodatabase tables

FarNorth_LandCover_Class_Names The land cover class name as shown in Chart 1: Land Cover Class Aggregation				
Field Name	**Alias**	**Description**	**Spatial Attribute Table Join**	**Data type**
CODE	Land cover code	The unique numerical code assigned to each Far North Land Cover class name.	This field can be joined with feature class FarNorth_ LandCover Class_Poly_{UTM Zone} – CODE attribute or FarNorth_LandCover Class_Grid_{UTM Zone} VALUE	Type: short integer
CLASS_ NAMES	Land cover class name	The land cover class name.		Type: text Length:50

FarNorth_LandCover_Group_Names The land cover group name as shown in Chart 1: Land Cover Class Aggregation				
Field Name	**Alias**	**Description**	**Spatial Attribute Table Join**	**Data type**
CODE	Land cover code	The unique numerical code assigned to each Far North Land Cover group name.	This field can be joined with feature class FarNorth_ LandCover Group_Poly_{UTM Zone} – CODE attribute or FarNorth_LandCover Group_Grid_{UTM Zone} VALUE	Type: short integer
GROUP_ NAMES	Land cover group name	The land cover group name.		Type: text Length:50

FarNorth_LandCover_Section_Names The land cover section name as shown in Chart 1: Land Cover Class Aggregation				
Field Name	Alias	Description	Spatial Attribute Table Join	Data type
CODE	Land cover code	The unique numerical code assigned to each Far North Land Cover section name.	This field can be joined with feature class FarNorth_ LandCover Section_Poly_{UTM Zone} – CODE attribute or FarNorth_LandCover Section_Grid_{UTM Zone} VALUE	Type: short integer
SECTION_ NAMES	Land cover section name	The land cover section name.		Type: text Length:50

2.2.4 Cartographic legend files for Far North Land Cover geodatabase data layers

ESRI ArcGIS legend (.lyr) files are available for all land cover classification products in raster format.

Legend (.lyr) name	Description
Legend_FarNorth_LandCover_Class_GRID	The legend file for raster dataset –FarNorth_LandCover Class_Grid_{UTM Zone}.
Legend_FarNorth_LandCover_Group_GRID	The legend file for raster dataset –FarNorth_LandCover Group_Grid_{UTM Zone}.
Legend_FarNorth_LandCover_Section_GRID	The legend file for raster dataset –FarNorth_LandCover Seciton_Grid_{UTM Zone}.

2.3 Classification scheme

In an effort to maintain consistency with previous land cover products the majority of classes have been adopted from previous provincial land cover class schemes as outlined in "User Manual on the Provincial Land Cover Database with Recommendations for Database Management" (Spectranalysis, Inc.. 1997), and "Introduction to the Ontario Land Cover Data Base, Second Edition (2000): Outline of Production Methodology and Description of 27 Land Cover Classes" (Spectranalysis, Inc.. 2004).

Classes and descriptions have been slightly modified to account for recent advances in ecological classification science using ***The Ecosystems of Ontario, Part 1: Ecozones and Ecoregions*** (Crins ***et al***.. 2009) "Provincial Ecosites of Ontario" (Ecological Land Classification Work Group, 2009) and ***Wetlands of the Ontario Hudson Bay Lowland: A Regional Overview*** (Riley, 2011). Additionally, significant effort has been expended attempting to match land cover classes with Ontario ecosite decision structure and conditions. However, limitations associated with source data resolution prevents a one to one relationship. The following sections discuss these limitations and offer a description of the basic ecology of each land cover class mapped, much of which has been borrowed from the references cited.

2.4 Considerations

- The Far North encompasses approximately 441,000 km^2 (roughly 43% of Ontario). Medium resolution Landsat satellite imagery was used because of its synoptic and temporal coverage. The Far North Land Cover includes a southern extension into the Area of Undertaking (AOU) for an additional area of 175,000 km^2. In total this represents 60% of Ontario for a total of 616,000 km^2 mapped. An additional 85,000 km^2 was mapped on the Manitoba/Ontario border to support ecological land cover and wildlife research activities.

- The Landsat sensor records data on a grid of approximately 30 m x 30 m cells or 'pixels'. This pixel size is ideal for regional or landscape level mapping since it is capable of mapping features as small as 0.5 hectare. The overall minimum mapping unit is approximately 1 hectare. Data users should be aware of this minimum mapping standard in reporting and analysing results.

- Single year full leaf conditions are ideal for mapping most vegetative features. However, acquiring optimal cloud free imagery representing these conditions for an area the size of the Far North is challening. Consequently, concessions have to be made which include allowing for a range of years and leaf out conditions. By doing so, mapping consistency can be impacted. For example, a hardwood stand on an optimal image may look more like a mixed wood stand on a non-optimal image. A spatial index of the image extents and dates has been provided to enable users to account for these differences.

- This product was created using imagery acquired on many different dates that exhibited differing physiographic and vegetative conditions. Furthermore, numerous remote sensing analysts contributed to the creation of this product. While extensive efforts were made to rationalize discrepancies, not all artificial boundaries between individual mapping tiles could be resolved.

- Landsat imagery used for classifying has known limitations. Most obvious is image pixel generalization: a pixel represents mixtures of many physiographic and vegetative surface conditions. This can cause a number of discrepancies between it and field based classification systems such as Ecosites of Ontario (Ecological Land Classification Work Group, 2009). Typical discrepancies related to this limitation include:

- Classes associated with tree cover terminology commonly used to classify provincial ecosites. Reliably discriminating classes on the basis of percent canopy cover is problematic, particularly at lower covers between approximately 10% and 40%.
- This imagery is not a precise separator of sparsely treed and completely open vegetation communities. This is particularly true for sparsely treed fen and bog where tree growth is often also stunted. For example, bogs are typically dry and vegetatively homogeneous. In such situations the dry homogeneous areas significantly reduce the satellite sensors ability to detect the sparse, poorly growing black spruce scattered within, causing an averaged pixel tone that is more representative of completely open conditions.
- The separation of some ecological features, such as fen and bog, can rely on the presence of as little as one indicator graminoid, herbaceous plant, moss or lichen. A few simple assumptions and concessions have therefore been made when mapping wetlands. The presence of pure image tones reflecting primarily sparse tamarack/graminoid or sphagnum moss communities are used to map fen and bog respectively. Efforts were made to account for non-spectral characteristics such as feature shape, size and relationship to other mapped classes. However, the inclusion of such information was challenging and therefore largely based on an individual image analyst's ability to recognize these characteristics as class determining factors.
- Wetland features are smaller and more physiographically heterogeneous in the southern portion of the Boreal Shield. Consequently treed fen, treed bog and coniferous swamp are particularly challenging to separate on satellite imagery.
- A review of the land cover mapping in the Boreal Shield, including feedback from 2011 field observations, indicates that there may be an underestimation of coniferous swamp and deciduous swamp. While the best available topographic data was used to aid the mapping of these features this elevation source does not penetrate dense tree canopies. Such situations can create artificial topographic mounds that appear to represent false upland ecology.
- A comprehensive ecological description of wetlands in the Hudson Bay Lowlands was completed in 2011 (Riley, 2011), including a reference to a "peat plateau" wetland class. On the surface these features contain both bog- and fen-like communities, though the latter is not well documented. Below the surface they differ in that they are an expression of various permafrost mechanisms and therefore their formation is the result of differing physiographic processes. While land cover analysts were aware of these features, no effort was made to distinguish them from bog or fen features. However, given their significance for both wildlife (i.e. caribou) and climate change monitoring it is hoped that future mapping will distinguish these features with the aid of Riley's ecological description and existing permafrost, geology and vegetative mapping.
- The Forest Resources Inventory (FRI) was used as auxillary information for the portion of the study area extending into the Area of Undertaking (AOU)(OMNR, 2010). FRI data were derived by interpretation of aerial photos which have significantly finer resolution than Landsat imagery. Although an intentional attempt was made to preserve the consistency across the entire product, it can be expected that the land cover accuracy in the southern extension exceeds the previously mapped territories to some extent. For instance, Deciduous Swamps are separately mapped in the southern extension of FNLC Release 1.3. The class is mapped mostly through FRI data interpretation. North of the extension area this class has been lumped into Thicket Swamps because it occurs with little frequency and exhibits poor spectral severability based on Landsat data alone.

2.5 Table 1: Description of Far North Land Cover classes

Unit name	CODE #	Description	Possible confusion	Input source
Clear Open Water	1	This class is characterized by water with minimal or no evidence of turbidity or sediment. There is also an absence of macrophyte vegetation, tree or shrub cover.	**Cloud shadow, tree shadow** —the dark image tones of cloud and tree shadows can be confused as water. Additionally, water features greater than l ha perched on fen and bog wetlands will also be included.	Satellite imagery and OHN water layer
Turbid Water	2	This class is characterized by water with varying degrees of turbidity, sediment and marl. Sparse floating and submerged vegetation is also included in this class as tones are similar to water with turbidity and sediment. Little to no tree or shrub cover is present. The mixture of sparse emergent and floating vegetation, suspended sediment, turbid water and clear water create a unique and identifiable image tone.	Polygonal and linear (stream) Ontario Hydro Network (OHN) water features were included as raster water features regardless of satellite image tone. Forcing hydrology in this way allowed for the mapping of small and narrow water features, while also including portions of both vegetation and exposed substrates. Additionally, regardless of vegetation content the provincial ELC considers all water with less than 2 metres, as open or salt water marsh. These features will often be mapped as turbid water.	Satellite imagery and OHN water layer
Intertidal Mudflat	3	Completely unvegetated coastal areas of Hudson and James Bays. These features are covered by varying depths of water depending on distance from the coast, as well as the point in the tidal cycle when the imagery was acquired. These features have a unique and identifiable image tone due to the combination of wet and exposed soil. Proximity to James and Hudson Bays also aids detection.	**Intertidal marsh, turbid water, clear open water** —mudflat covered with water can be confused with intertidal marsh and mixed water features, while completely exposed mudflats can be confused with sand, gravel and mine tailings.	Satellite imagery

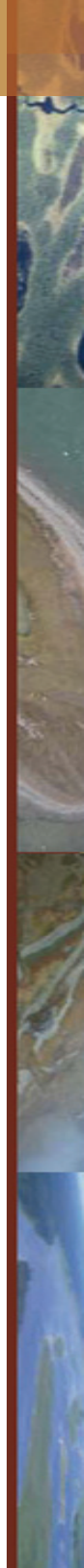
Unit name	CODE #	Description	Possible confusion	Input source
Intertidal Marsh	4	Primarily open communities containing living and senesced grasses, sedges and emergents. These marshes are directly adjacent to the Hudson and James Bay coasts between mudflats and the supertidal zone, and are constantly influenced by brackish and freshwater. They are flooded at high tide and slowly drain as the tide falls; a process that leaves a mosaic of pools of standing water. Estuarine intertidal marshes are found at the outflows of freshwater rivers and are also included in this class. Last year's dead vegetation is sometimes present while fluctuating water levels and other natural disturbance (e.g. overgrazing by abnormally high geese populations) can also stress vegetation in this zone causing it to senesce early. A combination of higher amounts of dead and senesced grasses and heterogeneous conditions provide a unique mosaic of image tones that allows for mapping. Proximity to James and Hudson Bays also aids detection.	**Dry upland meadows** — open dry meadows with green and senesced vegetation that are adjacent to Hudson and James Bays can be confused with intertidal marsh.	Satellite imagery
Supertidal Marsh	5	Primarily open communities containing some shrubs and trees. Tree and shrub cover ≤ 25% and dominated by emergent hydrophytic macrophytes. Water table is seasonally or permanently at, near, or above substrate surface. This class includes coastal marshes beyond the intertidal zone and as such, subjected to salt water via exceptional tides and storm surges. Lower amounts of visible sensed vegetation and water along with proximity to James and Hudson Bays allows for image detection.	**Thicket swamp, upland thicket, open fen, freshwater marsh**— the supertidal zone often consists of both emergent and herbaceous marsh communities, subjected to more frequent tidal flooding, and thicket swamp communities further inland and therefore less frequently impacted by tides. The transition between communities can be gradual and therefore difficult to map. Additionally, supertidal marsh vegetation can have similar image tones to thicket swamp and upland shrub thicket on beach ridges. These two shrub communities are therefore easily confused with supertidal marsh.	Satellite imagery

Unit name	CODE #	Description	Possible confusion	Input source
Freshwater Marsh	6	Fresh water marshes occur in close proximity to Hudson and James Bays. They are often adjacent to supertidal marshes but not subjected to any salt water influences. Otherwise, freshwater marsh features are relatively rare in the Far North but do occur. When they occur these features are located on inland lakes and rivers in the southern portion of the Ontario Shield and in river oxbows in the Hudson Bay lowlands. These are generally open communities where the water table is seasonally or permanently at, near, or above substrate surface. Vegetation is composed primarily of grasses, sedges and emergents while tree and shrub cover ≤ 25%.	**Open fen, bedrock, and upland meadow** - Dense grass, sedge and emergent communities occurring in both fresh water marsh and open fen appear similar on satellite imagery leading to confusion between these classes. Open bedrock and upland meadow are also similar in image tone, especially in areas of disturbance.	Satellite imagery
Heath	7	Heath commonly occurs on the raised mineral soils deposited as beach ridges and strandlines. The slightly higher elevations and close proximity to the coast ensures these features are constantly exposed to all intensities of prevailing and coastal winds. The relative high elevation and coarse soil ensures these areas are well drained therefore water table is typically well below the substrate surface creating upland conditions. Although vegetation cover is greater than 25%, extreme conditions limit vegetation primarily to lichen, artic herb and various ericaceous shrub species. The combination of lichen and ericaceous shrub image tones, proximity to the coast and spatial coincidence with beach ridges allow for identification and mapping.	**Open bog, sparse treed, sand/gravel/mine tailings** — vegetation and surface moisture conditions can be similar to lichen rich open bogs. Sparse forest communities can also occur at densities close to 20%. However, extremely dry conditions and high lichen densities can prevent accurate representation in image tones.	Satellite imagery, Ontario Radar Digital Surface Model (ORDSM) and quaternary geology
Thicket Swamp	8	Greater than 25% hydrophytic shrub species capable of growing taller than 2 metres and tree cover less than 10%. These are typically found within or on the edges of small to large flowing water bodies and in supertidal portions of the Hudson Bay Lowlands. Their mineral or organic soil is subject to seasonal flooding or characterized by a high water table. In many cases a circulation of water rich in dissolved minerals allows for dense vegetation growth. Their association to water and unique image tones due to high deciduous leaf densities enables mapping.	**Upland thicket, deciduous treed** — dense upland thicket, often found in disturbance areas and deciduous forest, have similar image tones to dense thicket swamp. In the event ORDSM data are not precise enough to infer saturated conditions confusion may occur. Tamarack fen containing ample tall shrub can also exhibit similar image tones to thicket swamp. In some cases image pixel generalization causes confusion with the treed fen class.	Satellite imagery, ORDSM, quaternary geology, and OHN streams

Unit name	CODE #	Description	Possible confusion	Input source
Coniferous Swamp	9	Greater than 25% hydrophytic shrub and/or coniferous tree species. Their mineral or organic soil is subject to seasonal flooding or characterized by a high water table and a circulation of water rich in dissolved minerals. Hydrologically these features exist in isolated depressions or adjacent to streams, lakes, fens or bogs.	**Coniferous treed** — flat forested landscapes with 25% canopy closure or greater present significant challenges for remote mapping of swamps. Canopy densities often prevent detection of water and the transition from swamp to forest often occurs gradually over long distances.	Satellite imagery and ORDSM
Deciduous Swamp	10	Greater than 25% hydrophytic shrub and deciduous tree species. The tree cover mostly deciduous is greater than 10%. Their mineral or peaty phase substrate is subject to seasonal flooding or characterized by a high water table and a circulation of water rich in dissolved minerals. Hydrologically these features exist in depressions or level slope, adjacent to lakes, streams and rivers, or open peatlands.	**Deciduous treed or thicket swamps** — dense thicket or deciduous swamps and deciduous forest have similar image tones since deciduous vegetation has strong reflection. In addition, high canopy closure prevents detection of water. Also the transition from swamp to forest often occurs gradually over long distances.	FRI data, satellite imagery, and ORDSM
Open Fen	11	Fens develop in areas of generally slow flowing water and often have saturated or flooded surfaces. These features are fed by water from precipitation, ground and/or surface water, with the latter two sources enriched by contact with surrounding mineral soils. These conditions enable slightly more vegetative diversity and density than bogs. Mosses (generally not sphagnum), graminoids and low ericaceous shrubs are all common. Tall shrubs may also be present but at densities of less than 25%. Conditions such as open water surfaces and saturation, dense graminoids, string patterns and textured ericaceous shrub-rich communities all aid their remote detection. Additionally, low tree cover, approximately zero to 10%, also aids identification.	**Treed Fen, Freshwater Marsh, Bedrock, Upland Meadow** - Distinguishing percent of treed vegetation is difficult using satellite imagery, particularly when percentages are low. Treed and open fen communities can therefore be confused. Dense grass, sedge and emergent communities occurring in both fresh water marsh and open fen classes appear similar on satellite imagery. Confusion may also arise following a disturbance where open bedrock and upland meadow have similar image tones to the open fen class.	Satellite imagery and OHN streams

Unit name	CODE #	Description	Possible confusion	Input source
Treed Fen	12	As described above fens receive ground and surface water. These conditions allow for slightly higher vegetation density than bogs. Tamarack is usually associated with fens due to its adaptation to the telluric conditions common in this wetland type. At densities predominatly over 10%, trees display a unique image tone that, when combined with the other observable conditions noted for open fen, allow for their detection on imagery. Black spruce is also present in these features, but not typically used as an image identifier as these trees are also evident in several other land cover classes.	**Open fen, treed bog** — determining vegetation density is difficult using satellite imagery, particularly when percentages are low. This known limitation may result in confusion between treed and open fen communities. Additionally, mineral poor treed fens can contain communities of sphagnum moss, black spruce and ericaceous shrub that are dense enough to influence image tone. When this occurs the presence of "fen indicator" graminoids and/or herbaceous vegetation is often the only way to separate fen from bog and/or mineral poor swamp. Since these indicators are often sparse, even occurring as one plant, remote detection is not possible.	Satellite imagery and OHN streams
Open Bog	13	Bogs have a thick accumulation of peat often forming dome, plateau and hummock-like landforms that are level or slightly higher than surrounding surfaces. These thick layers of organic peat material are virtually unaffected by surface runoff or groundwater from surrounding mineral soils; the primary water source is precipitation. Open bogs have water tables seasonally or permanently at, near, or above substrate surface. Substrates are sphagnum peat. Hydrologic and substrate properties significantly limit vegetation growth and diversity. In open bogs tree cover is sparse at less than 10% while tall shrubs can occur at densities less than 25%. Dense and pure sphagnum and lichen ground cover are the primary contributors to image identification. Various densities of ericaceous shrubs can also occur; higher densities also produce a unique image tone that can be used for mapping.	**Heath, treed bog** — distinguishing percentage of treed vegetation is difficult using satellite imagery. Similarities in vegetation and surface moisture conditions can result in confusion with lichen rich tundra heath.	Satellite imagery and OHN streams

Unit name	CODE #	Description	Possible confusion	Input source
Treed Bog	14	The ecological characteristics of treed bog are similar to those described for open bog. Treed bogs have either tree cover greater than 10% and tall shrub cover less than 25%. A combination of low ericaceous shrub, lichen, sphagnum moss and black spruce all aid detection.	**Open bog, treed fen** — determining vegetation density is difficult using satellite imagery, particularly when percentages are low. Additionally, mineral poor treed fens can contain communities of sphagnum moss, black spruce and ericaceous shrubs that are dense enough to influence image tone. The presence of "fen indicator" graminoids and/or herbaceous vegetation is often the only means of separating fen from bog and/or mineral poor swamp. These fen indicators are often sparse, even occurring as one plant that cannot be resolved using remote sensing data.	Satellite imagery and OHN streams
Sparse Treed	15	Treed (> two metres in height) area containing coniferous or deciduous species or a combination of the two. Treed sites with tall and/or low treed canopy closure between 10 and 25%. These communities are often situated on bedrock knobs, rapidly draining soils, or on raised mineral soils, deposited as beach ridges and strandlines in close proximity to Hudson/James Bay. They often exhibit a dry and very shallow substrate. Dense communities of ground lichens, graminoids and/or mosses are also common. The combination of ground cover, dry conditions and sparse canopy offer unique image tones aiding identification. Elevation information extracted from an elevation model and quaternary geology parent material also aids mapping.	**Treed Bog, Heath -** Treed bog with dense lichen communities can have similar image tones. Digital elevation slope and landscape position (i.e. top of a ridge or hill feature greater than approximately 10 metres in height) are used to aid separation, but data and classification limitations can limit proper topographic definition causing confusion. Tundra heath also exhibits similar topographic traits and image tones to sparse forest and can thus easily be confused.	Satellite imagery, ORDSM and geology layer
Deciduous Treed	16	Predominately deciduous tree cover situated on varying soil depths having dry, fresh and sometimes moist conditions. Vegetation cover is typically closed and tall (greater than 10 metres in height and 60% closure). May also include open tall (greater than 10 metres in height and between 25 and 60% closure) and low (less than 10 metres in height and greater than 25% closure) communities. Upland deciduous tree species make up greater than 75% of canopy closure. Species are primarily poplar and birch.	**Thicket Swamp, Treed Fen, Mixed Treed** Thicket swamp often contains dense thickets of alder and willow that appear similar to deciduous forest on satellite imagery. Limitations in the ORDSM and stream data used to help separate these features can cause confusion. Similarly, fens with higher densities of tamarack can also appear similar to deciduous forest and cause confusion.	Satellite imagery, ORDSM and geology layer



Unit name	CODE #	Description	Possible confusion	Input source
Mixed Treed	17	A mixture of deciduous and coniferous tree cover situated on varying soil depths that can have dry, fresh and sometimes moist conditions. Vegetation cover is typically closed and tall (greater than 10 metres in height and 60% closure). May also include open tall (greater than 10 metres in height and between 25 and 60% closure) and low (less than 10 metres in height and greater than 25% closure) communities. Upland deciduous and coniferous tree species are present and make up less than 75% of canopy closure. Species are primarily jack pine, black spruce, white spruce, poplar and birch.	**Thicket swamp, deciduous treed, coniferous treed —** thicket swamp often contains dense thickets of alder and willow that appear similar to deciduous forest. When mixed with water and low coniferous trees these features can appear similar on satellite imagery. Additionally, percentages of deciduous and coniferous forest estimated using satellite imagery may not align with field based estimates resulting in a source of field - remote mapping discrepancy.	Satellite imagery, ORDSM and geology layer
Coniferous Treed	18	Predominately coniferous tree cover situated on varying soil depths that can have dry, fresh and sometimes moist conditions. Vegetation cover is typically closed and tall (greater than 10 metres in height and 60% closure). May also include open tall (greater than 10 metres in height and between 25 and 60% closure) and low (less than 10 metres in height and greater than 25% closure) communities. Upland coniferous tree species make up greater than 75% of canopy closure. Species are primarily jack pine, black spruce, white spruce.	**Coniferous swamp, mixed treed** — coniferous swamp often contains dense black spruce communities that appear similar to coniferous forest on satellite imagery. Limitations in the ORDSM that is used to help separate these features can cause confusion. Additionally, percentages of deciduous and coniferous forest estimated using satellite imagery may not align with field-based estimates resulting in a source of field – remote mapping discrepancy.	Satellite imagery, ORDSM and geology layer
Disturbance – Non and Sparse Woody	19	The result of natural and/or anthropogenic disturbance occurring some time over the last 20 years. Vegetation cover includes herbaceous (forbs and graminoids greater than 25%), sparse herbaceous (between two and 25%) and non vascular (lichen and or moss greater than 10%). Sparse tall and low trees along with tall and low shrub may also be present at canopy closures of less than 25%. Dead trees can exist at greater than 25% cover and can be either up rooted and horizontal on the ground or standing. Sites are most often drier upland sites with varying soil depths. This class is mapped by taking advantage of the spatial context provided by disturbance mapping and the unique image tones associated with largely dead and/or senesced vegetation.	**Open fen, sparse treed —** these features can have a dense mat of graminoid vegetation appearing senesced and dry in satellite imagery.	Multi-date satellite imagery and single-date image classification Ancillary data (e.g., insect, disease and fire data) where available is used to support classification

Unit name	CODE #	Description	Possible confusion	Input source
Disturbance – Treed and / or Shrub	20	The result of natural and/or anthropogenic disturbance occurring sometime over the last 20 years. Vegetation cover is predominately low treed (less than 10 metres in height and greater than 60% cover) and tall shrub (greater than 2 metres in height and 60% closure). Patches of closed tall tree cover (greater than 10 metres height and 60% cover) may also be present. Dead or dying trees can exist at less than 20% cover and can be either up rooted and horizontal on the ground or standing. Sites are most often drier upland sites with varying soil depths. This class is mapped by taking advantage of the spatial context provided by disturbance mapping and the unique image tones associated with living, dead and/or senesced vegetation.	Sparse, Deciduous, Mixed and Coniferous Forest - Percentages of deciduous and coniferous forest estimated using satellite imagery may not align with field based estimates resulting in a source of field - remote mapping discrepancy.	Multi-date satellite imagery and single date image classification. Ancillary data (e.g., insect, disease and fire data) where available is used to support classification.
Sand / Gravel / Mine Tailings	21	These areas are dominated by exposed soil having less than 25% vegetation cover. Beach deposits, sand dunes, aggregate quarries, mines and mine tailings are all included. Also included are sand islands in larger rivers, un-vegetated beach ridges, drier coastal mudflats and very shallow or dry marl lakes.	Bedrock – Image tones for exposed soil and bedrock a similar. Though parent material and land form features mapped in a geology layer are used to help map this class the smaller scale geology layer omits some features identifiable on imagery. When depending solely on imagery these features can be confused.	Satellite imagery and geology layer
Bedrock	22	Exposed bedrock with less than 25% vegetation cover.	Sand/Gravel/Mine Tailings – Image tones for exposed soil and bedrock a similar. Though parent material and land form features mapped in a geology layer are used to help map this class the smaller scale geology layer omits some features identifiable on imagery. When depending solely on imagery these features can be confused.	Satellite imagery and geology layer
Communi ty/ Infrastructure	23	Clearings for human settlement and economic activity; major transportation routes	Relatively few settlement features exist in the far north. A manual interpretive approach has been used which limits classification error.	Satellite imagery and far north communities layer

Unit name	CODE #	Description	Possible confusion	Input source
Agriculture	24	Land cleared for agricultural use that may or may not be currently active.	Agricultural features have been classified using a combination of contextual Forest Resource Inventory data and Landsat change detection imagery.	Satellite imagery, FRI data
Cloud / Shadow	-9	Areas of cloud or shadow on the satellite image.	Clear Open Water, Tree Shadow - The dark image tones of cloud and tree shadows as well as water can be confused.	Satellite imagery
Other	-99	Land cover features that were not classified for a variety of reasons	All Classes	Satellite imagery

2.6 Chart 1: Class aggregation hierarchy

The classes designated in the Provincial Land Cover represent the finest precision possible using the medium resolution data and methods discussed. In the event that summaries based on less detailed classes are desired, aggregation is required. The following flow chart illustrates a recommended aggregation offering two less detailed tiers of class groupings. All suggested aggregations are mutually exclusive with the exception of those involving the sand/gravel/mine tailings class. Since the majority of these features will be natural, non-treed areas, aggregation to non-treed is suggested. In the event users desire separation and aggregation into non-treed and anthropogenic land cover sections, a simple GIS overlay should be employed through using land cover data in combination with spatial extraction and/or mining data.

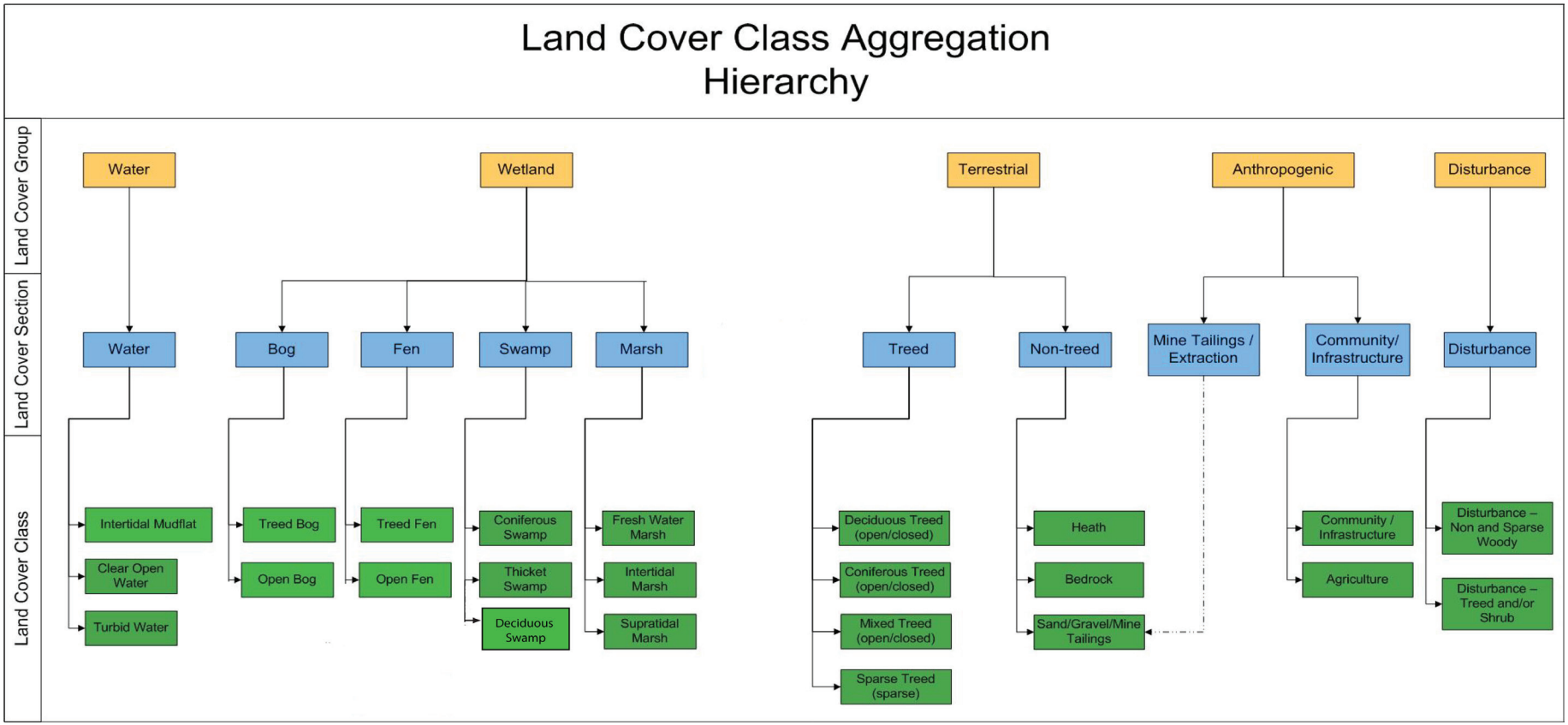


Chart 1: Land cover class aggregation

3.0 Far North Land Cover to PLC 2000 correspondence

The remote sensing analysts and specialists that produced the Far North Land Cover mapping do not advocate performing a post hoc comparison between the group, section or class versions of Far North Land Cover and previous products such as the PLC 2000. Reasons for not performing a comparison include: dramatically differing mapping methods, low accuracies reported for the PLC 2000, subjectivity associated with the land cover mapping process and class definition differences between a few classes.

Over the last 20 years there has been a remarkable increase in available spatial digital data in Ontario. This combined with our enhanced understanding of how to use these data to aid land cover mapping has led to major changes in how the land cover is produced. For example, in their summary of medium spatial resolution satellite data classification, Franklin and Wulder (2002) noted compelling supporting evidence in the literature for the incorporation of critical data resources such as spatial context, texture and elevation data to increase classification accuracy. These types of data have been incorporated into the Far North Land Cover mapping method.

The Far North Provincial Satellite Derived Disturbance Mapping, as described by OMNR (2013), has also been incorporated into the Far North Land Cover. While all previous Ontario land cover products depended on single date identification of areas impacted by disturbance, the method used for the Far North project employed multi-date change detection, which is well known to produce more accurate results. This new product maps disturbances occurring prior to 1990, up to and including 2011. Additionally, the Far North Land Cover has further separated disturbance features into open and treed. Therefore, although a comparison of disturbance mapping between products is possible it is not necessary or desirable, given Far North mapping identifies disturbance features captured by all land cover products with higher accuracy and class precision.

At the onset of the Far North Planning Initiative an accuracy assessment was performed on the PLC 2000. This was done to better understand this product and help gauge the need for producing a new land cover product. A report was produced by the Inventory, Monitoring and Assessment Section (2009) summarizing this effort which revealed an overall mapping accuracy of 51%. Although an accuracy assessment has yet to be completed for the new Far North Land Cover mapping, the incorporation of new methods and data are expected to dramatically improve mapping accuracies.

The mapping processes employed to create the Far North Land Cover product are primarily automated. That said, considerable analyst input is still required, some of which involves subjective interpretation and matching of image tone to perceived land cover feature. It is this subjectivity that makes comparison between different land cover products undesirable. This is especially true in this case as older PLC products were created by a different group of analysts with differing perceptions of the image tone to class relationship.

Many of the classes in the Far North Land Cover product are conceptually a direct match to classes created through older land cover products like the PLC 2000. However, a few differences make inter land cover comparison difficult. For example, percentages used to define all upland treed classes are quite different. While PLC 2000 defines sparse forest as having 30 to 60% canopy closure, the Far North Land Cover defines sparse treed (in this case treed is analogous to forest) as having 10 to 25% closure. Additionally, dense forest classes in the PLC 2000 include areas with 60 to 100% closure while the Far North Land Cover considers any upland canopy closure greater than 25% as deciduous, coniferous or mixed treed. These changes were made primarily to conform to percentages outlined in the *Ecosites of Ontario* (Ecological Land Classification Work Group, 2009) and the national land cover product created for Earth Observation for Sustainable Development of Forests (EOSD) (Wulder & Nelson, 2003).

As outlined above there are numerous reasons why post hoc comparison between the Far North Land Cover and previous products such as the PLC 2000 is undesirable. Such a comparison would yield results containing differences due to actual change, change in methodology, poor accuracy of previous products, subjectivity and class definition discrepancy. Therefore determining the amount of discrepancy each product accounted for would be inherently challenging. However, there are methods of determining change in land cover; most major changes have been identified and mapped through the Far North Provincial Satellite Derived Disturbance Mapping (OMNR, 2013). This mapping could be overlain with past land cover products to produce a rough estimate. In the event the inaccuracies of the PLC 2000 are not acceptable, a more complex change back casting method could be employed.

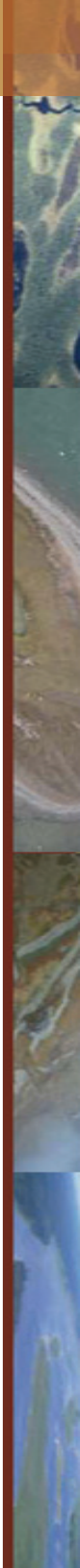
4.0 Table 2: Land cover class to provincial ecosite correspondence

Land cover class	Land cover code	Ecosite name(s), correspondence and rationale	Corresponding ecosite code(s) Including both Boreal (B) and Sub Arctic (A) zones
Clear Open Water	1	The majority of this class has water depths greater than two metres for which there is currently no ELC equivalent. When occurring in coastal or fresh water lake shore environments with less than two metres of water these are open salt or open water marshes respectively. Open water marsh could have either mineral or organic substrates.	221N, 151N, 152N
Turbid Water	2	Much of this class will include open salt marsh and open water marsh. Fresh water marsh could have either mineral or organic substrates. Will also include water depths greater than two metres for which no current ELC equivalent exists.	221N, 151N, 152N
Intertidal Mudflat	3	Most of this class will include active costal mineral shoreline.	213X
Intertidal Marsh	4	Includes primarily salt marsh and open salt marsh. Distinction between these two ecosites is dependant upon the % emergent vegetation which can not be estimated consistently using medium resolution satellite imagery. In these cases other information is used (e.g. amount of visible water, distance from coast).	220N, 221N
Supertidal Marsh	5	Includes primarily salt meadow marsh which is dependant upon % herbaceous cover. Estimating % of herbaceous vegetation cannot be done using medium resolution satellite imagery so other information is used (e.g. amount of visible water, distance from coast). Therefore, this class may also include salt marsh.	219N, 220N
Freshwater Marsh	6	Includes organic and mineral shallow marshes with permanently flooded conditions and greater than 25 % emergent vegetation. Will also include organic, mineral and rock meadow marsh with water typically below the substrate, tree cover less than 10%, tall shrub less than 25% and herbaceous cover greater than 50%.	148N, 149N, 142N, 143N, 144N
Heath	7	Greater than 25% vegetation cover and tree cover of less than 10%. A range of ecosites are included in this class including: dry sandy meadow, sparse shrub and shrub communities and dry to fresh coarse meadow, sparse shrub and shrub communities.	030N, 031S, 032S, 045N, 046S, 047S
Thicket Swamp	8	Tall shrub communities making up greater than 25% of the cover and typically higher than two metres. Both mineral and organic thicket swamps can occur.	134S, 135S

Coniferous Swamp	9	Many swamps in the Far North are composed primarily of tall or low treed black spruce, and tamarack with alder. To a lesser extent balsam fir and balsam poplar can also be present. Eastern white cedar can grow as far north as the southern tip of James Bay but is not common in the Far North area. Since this is a key indicator of rich coniferous swamp it is assumed these ecosites are not common. Both organic and mineral poor and intermediate conifer swamps make up the majority of this class.	127Tl/Tt, 128Tl/Tt, 222Tl/Tt, 223Tl/Tt
Deciduous Swamp	10	Intolerant hardwood swamps and hardwood swamps make the majority of this class. Both classes are widespread across the boreal range. Greater than 50% cover of the hardwood spices. Canopy closure is greater than 25%. Intolerant Hardwood Swamps are composed mainly of poplar and/or ash often mixed with balsam fir, white birch, black spruce, and white spruce. Hardwood swamps canopy consist of white birch and/or mixture of other hardwood species. Substrate is mineral or peaty phase.	130Tl/Tt, 133Tl/Tt,
Open Fen	11	Primarily fens with less than 10% and 25% tree and tall shrub cover respectively. Low shrub cover can be between zero and 100%. Herbaceous cover is less than 50%. Vegetative and water patterning (i.e. strings and flarks) can exist. Ecosites included are: poor fen, open moderately rich fen, open extremely rich fen and open shore fen.	139N, 139S, 140N, 140S, 141N, 141S, 146N, 146S
Treed Fen	12	Greater than 10% tree cover with tamarack, less than 25% tall shrub cover and zero to 100% low shrub cover.	136Tl/Tt
Open bog	13	Hydrologically isolated and have less than 10% and 25% tree and tall shrub cover respectively. Low shrub cover can be between zero and 100%. Herbaceous cover is less than 50% and there are no fen indicators.	138N, 138S
Treed bog	14	Hydrologically isolated, greater than 10% tree cover (primarily black spruce with no tamarack), less than 25% tall shrub cover and zero to 100% low shrub cover.	126Tl/Tt, 137Tl/Tt
Sparse Treed	15	A collection of mainly very shallow and dry sandy ecosites. Tree cover is composed of primarily black spruce between ten and 25%. Possible ecosites include: very shallow, dry to fresh pine – black spruce conifer, dry sandy jack pine - black spruce dominated, dry sandy pine - black spruce conifer and dry sandy spruce – fir conifer. These ecosites have the "sparse" (s) vegetation cover designation.	012sTl/sTt, 034sTl/sTt, 035sTl/sTt, 038sTl/sTt
Deciduous Treed	16	Composed primarily of poplar and birch species but may have as much as 25% coniferous species. Trees are both tall and low between 25 and 100% cover, with both closed (c) and open (o) designations. Occurring on most upland soil substrate depths and types a variety of ecosites are possible including: very shallow humid mixed wood and aspen-birch hardwood occurring on most deep substrates (dry to fresh, dry sandy, dry to fresh coarse, moist coarse, fresh clayey, fresh silty to fine loamy and moist fine).	016cTl/cTt/oTl/oTt, 028cTl/cTt/oTl/oTt, 040cTl/cTt/oTl/oTt, 055cTl/cTt/oTl/oTt, 070cTl/cTt/oTl/oTt, 088cTl/cTt/oTl/oTt, 104cTl/cTt/oTl/oTt, 119cTl/cTt/oTl/oTt

Mixed Treed	17	No true mixed forest condition defined by per cent cover is recognized as an ecosite. By default, if an ecosite is not mostly one of the tree species designated at decision points on the keys it is considered mixed wood. Mixed wood ecosites representative of this class cover all upland substrate types and depths with both closed (c) and open (o) designations.	019cTl/cTt/oTl/oTt, 028cTl/cTt/oTl/oTt, 043cTl/cTt/oTl/oTt, 076cTl/cTt/oTl/oTt, 092cTl/cTt/oTl/oTt, 0108cTl/cTt/oTl/oTt, 0125cTl/cTt/oTl/oTt,
Coniferous Treed	18	Composed primarily of jack pine, black spruce and white spruce. White and red pine may also be present in southern portions of the Ontario shield. While coniferous species are dominant, deciduous may be present at covers as high as 25%. Trees are both tall and low between 25 and 100% cover, with both closed (c) and open (o) designations. Occurring on most upland soil substrate depths and types, a variety of ecosites are possible including: very shallow white pine - red pine conifer and pine - black spruce conifer; and very shallow, dry fresh coarse, fresh clayey and fresh silty fine loamy pine - black spruce conifer and jack pine – black spruce conifer. Additionally, moist coarse and moist fine pine-black spruce conifer can occur.	011cTl/cTt/oTl/oTt, 012cTl/cTt/oTl/oTt, 024cTl/cTt/oTl/oTt, 034cTl/cTt/oTl/oTt, 049cTl/cTt/oTl/oTt, 050cTl/cTt/oTl/oTt, 065cTl/cTt/oTl/oTt, 082cTl/cTt/oTl/oTt, 083cTl/cTt/oTl/oTt, 098cTl/cTt/oTl/oTt, 99cTl/cTt/oTl/oTt 114cTl/cTt/oTl/oTt
Disturbance – Non and Sparse Woody	19	Includes non vegetated areas along with herbaceous, non-vascular and sparse shrub and treed communities. Possible ecosites include all non-calcareous rock barren, meadow and sparse shrub primarily on non-hydric substrates. All treed ecosites noted in the treed classes may also be present with the sparse vegetation cover class modifier (e.g., 011sTt/sTl).	163X, 164S/Tl/Tt, 164S/Tl/Tt, 008H/sH/Nv, 009sSt/sSl, 020H/sH/Nv, 021sSt/sSl, 045H/sH/Nv, 046sSt/sSl, 061H/sH/Nv, 062sSt/sSl, 078H/sH/Nv, 079sSt/sSl, 094H/sH/Nv, 095sSt/sSl
Disturbance – Treed and / or Shrub	20	Includes low and tall shrub and, due to the temporal range of disturbance (i.e., 20 years), primarily low treed communities occurring on all substrate depths and types. All treed ecosites noted in the treed classes may be present with the low treed cover class modifier (e.g., 011cTl/oTl).	010sSt/sSl, 022sSt/sSl, 047sSt/sSl, 063sSt/sSl, 080sSt/sSl, 096sSt/sSl
Sand / Gravel / Mine Tailings	21	Includes primarily un-vegetated features such as active sand dune, mineral shoreline and mineral barren. Active and open coastal coarse shoreline and bluffs are also included. Features associated with extraction are considered excavated bluff.	006X, 005X, 007X, 207X, 208X, 209X, 002X, 003X, 001X
Bedrock	22	Primarily non-calcareous bedrock features with less than 25% vegetation. Ecosites included are: open and active bedrock shoreline, rock barren and coastal bedrock shoreline.	160X, 161X, 162X, 163X, 164X, 165X, 204X, 205X, 206X
Community / Infra-structure	23	Settlement and infrastructure ecosites including: active waste disposal/ landfill, pavement/concrete, compacted gravel surface and compacted mineral surface.	191X, 197X, 198X, 199X, 200X

Agriculture	24	Not applicable.	Not applicable.
Cloud / Shadow	-9	Not applicable.	Not applicable.
Other	-99	Not applicable.	Not applicable.



5.0 Listing of terms adopted from *Ecosites of Ontario*

A number of ecological terms are used throughout this document that are descried in detail in the ***Ecosites of Ontario*** (Ecological Land Classification Work Group, 2009). Below is a list of these terms for reference purposes.

active
bedrock
bog
bryophyte
calcareous
canopy closure
closed tall treed
conifer
cover
deep (soils)
depth
diversity
dry
ecosite
emergent
fen
floating-leaved
floating mat
fresh
graminoid
ground cover
hardwood
herbaceous
humid
hydric
hydrologically isolated
indicator species
lichens
low shrub
low treed
marsh
mixed wood
moderate
moderately deep
moist
moisture regime
non-vascular
not vegetated
not woody
open tall treed
organic material
patterning
peat
permanently flooded
rock
saline
salt water shoreline
saturated
shallow
shoreline
shoreline process
shrub
sparse herbaceous
sparse low shrub
sparse low treed
sparse tall shrub
sparse tall treed
stunted
substrate
substrate type
swamp
tall shrub
tall treed
texture
tree
vascular plants
very moist
vegetation cover class
vegetation cover
vegetation type
very shallow
wet

6.0 Acknowledgments

The land cover analysts would like to extend their gratitude to the Far North Branch for their continued support. Analysts would also like to extend thanks to Monique Wester and Peter Uhlig for their continued guidance and support. Their understanding of remote classification and input regarding the ecosites of Ontario significantly aided the development of this document and the land cover mapping product.

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1 To obtain the data: Land Information Ontario Warehouse Data Set: Forest Resources Inventories - Planning Composite Inventory or Base Model Inventory. Ontario Ministry of Natural Resources and Forestry. http://www.mnr.gov.on.ca/en/Business/LIO/index.html

2 To obtain the data: Land Information Ontario Warehouse Data Class: Provincial Satellite Derived Disturbance Mapping. Ontario Ministry of Natural Resources and Forestry. http://www.mnr.gov.on.ca/en/Business/LIO/index.html