Ontario

Southern Ontario Land Resource Information System (SOLRIS) Version 3.0: Data Specifications

Ministry of Natural
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Science and Research
Branch

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1.0 Data specifications sheet

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Section 1: Data standard information

This section identifies the name, abbreviation, and extent of the Southern Ontario Land Resource Information System, and provides contact information for the producer and custodian of this data layer.

Layer properties	Data standard information
Layer name:	Southern Ontario Land Resource Information System Version 3.0
Layer abbreviation:	SOLRIS 3.0
Layer description:	Regional, ecologically based, land cover /land use inventory. Represents the landscape from 2000 to 2015.
References:	SOLRIS Methodology Pilot Study, SOLRIS Version 1.0
Production:	Science and Research Branch, Ministry of Natural Resources and Forestry (MNRF)
Product contact:	Derek Landry, Coordinator – Forest Resources Inventory Program, Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, derek.landry@ontario.ca
Extent:	Ecoregions 7E, 6E, and 5E (Growth Plan for the Greater Golden Horseshoe Study Area and Eastern Ontario extension to Forest Resources Inventory boundary).
Custodian:	Science and Research Branch, MNRF

Section 2: GIS Data layer specifications

This section identifies the geospatial criteria for this data layer.

File type:	ESRI File geodatabase (feature classes and raster datasets), TIF.
Geometry type:	Polygon, grid, raster
Projection	MNR Lambert Conformal Conic
Datum	North American 1983 CSRS

2.0 SOLRIS data specifications

2.1 Data dictionary

SOLRIS Version 3.0 is available in an ESRI ArcGIS file geodatabase. The land cover is provided as a raster data set layer. The land cover changes are represented as polygonal feature class layers.

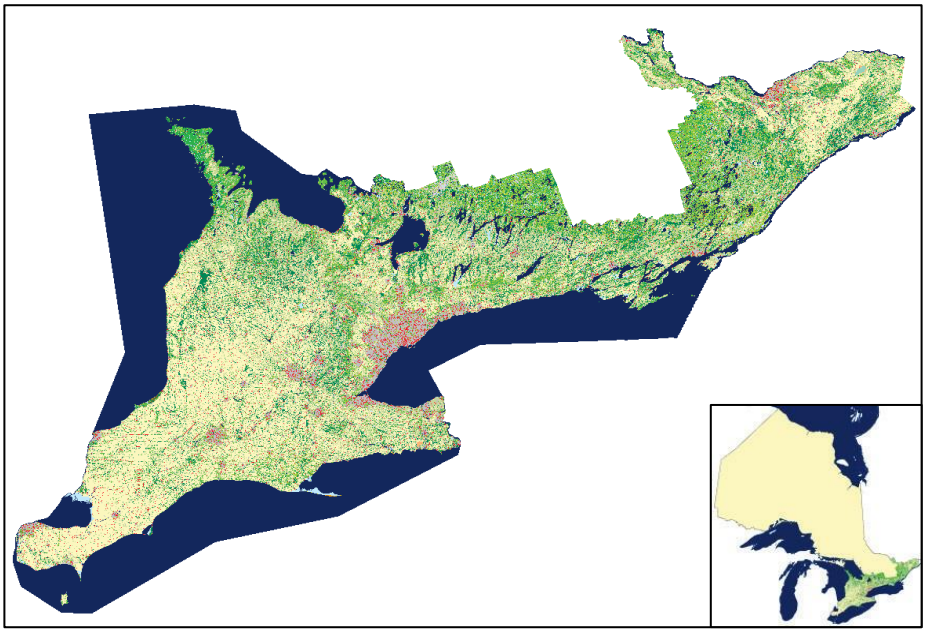

Figure 1. Map showing SOLRIS extent.

2.1.1 Feature classes and raster datasets

Spatial data layer name	Entity	Description	Feature type
Project_Area_ Lambert	Feature class	The project area determined by unique Landsat track and frame index used to complete the land cover modelling.	Polygon

SOLRIS_Version_3_0_Changes_2000to2015_Lambert	Feature class	Land cover changes from 2000 to 2015.	Polygon
SOLRIS_Version_3_0_Class_Corrections_2000to2015_Lambert	Feature class	Land cover class corrections from 2000 to 2015.	Polygon
SOLRIS_Version_3_0_Lambert	Raster dataset	Land cover. SOLRIS_Version_3_0.lyr provides the class legend and cartographic colour ramp file for ESRI ArcGIS applications.	Grid

2.1.2 Feature class attributes

Project_Area_Lambert

Image footprints and dates for SOLRIS modelling

Field	Description
Landsat_TrackFrame	Landsat track and frame index.
Scene_Date_00	Representative Landsat image date for time 00.
Scene_Date_00_CloudReplace	Replacement Landsat image date used where clouds and cloud shadow are present in the designated Landsat image for time 00.

Scene_Date_01	Representative Landsat image date for time 01.
Scene_Date_01_CloudReplace	Replacement Landsat image date used where clouds and cloud shadow are present in the designated Landsat image for time 01.
Scene_Date_02	Representative Landsat image date for time 02.
Scene_Date_02_CloudReplace	Replacement Landsat image date used where clouds and cloud shadow are present in the designated Landsat image for time 02.
Scene_Date_03	Representative Landsat image date for time 03.
Scene_Date_03_CloudReplace	Replacement Landsat image date used where clouds and cloud shadow are present in the designated Landsat image for time 03.

SOLRIS_Version_3_0_Changes_2000to2015_Lambert

Land cover changes from 2000 to 2015.

Field	Description	Value
Change_Direction	Land cover class transformation.	• **{SOLRIS class/class group}.** Some SOLRIS classes were grouped for the sake of simplicity. SOLRIS class groups. • **Wetland:** swamp (change period 00, 01 or 02.), treed/thicket swamp (change period 03), bog,

		fen and marsh. • **Woodland:** forest, coniferous/mixed/ deciduous forest. • **Undifferentiated:** undifferentiated includes tilled for change periods 00, 01 and 02.
Change_Type	Type of change.	• **Non-Vegetation Transition**. A land cover change where a non-wetland or non-woodland class transitioned into a non-wetland or non-woodland class. • **Vegetation Gain.** Very rare event. A land cover change where a non-wetland or non-woodland class transitioned into a wetland or woodland class. • **Vegetation Transition.** A land cover change where a wetland or woodland class transitioned into a different wetland or woodland class. No vegetative losses or gains. • **Wetland Loss.** A land cover change where a wetland class transitioned into a non-wetland or non-woodland class. • **Woodland Loss**. A land cover change where a woodland class transitioned into a non-woodland or non-wetland class.
Change_Period	Time period of change.	• **00.** Prior to time 00 (1999

		to 2002). • **01.** Time 00 (1999 to 2002) to 01 (2005 to 2007). • **02.** Time 01 (2005 to 2007) to 02 (2009 to 2011). • **03.** Time 02 (2009 to 2011) to 03 (2014 to 2017). •
Change_Dates	The imagery with dates that best represent time 00, 01, 02 and 03. The actual dates can be determined by displaying the project area image footprint over the change polygons. The dates are listed in the Scene_Date_00/01/02/03 attribute fields.	• **Time 00{date}/01{date}/02{date} to Time 01{date}/02{date}/03{date}** respectively.
Change_Cause	The cause of land cover class change.	• **Cut.** Commercial forestry harvesting. • **Other – Anthropogenic.** Infrastructure development or actively managed lands. • **Other – Natural.** Other natural events such as insect/pest damage, burns, etc. • **Weather.** Weather events. (i.e. blowdown, hail, ice). There is no differentiation between types of weather events.
Confidence_ Existence	The confidence level associated with the occurrence of a land	• **Confirmed.** The land cover change was confirmed by a recognized,

	cover change.	third party ancillary data source. • **High.** The land cover change has a strong spectral response in the automated change detection analysis. The response is confirmed with high resolution orthophotos. • **Medium.** The land cover change has a moderate spectral response in the automated change detection analysis. The response is confirmed with high resolution orthophotos. • **Low.** The land cover change has a low spectral response in the automated change detection analysis. The response is confirmed with high resolution orthophotos.
Confidence_Cause	The confidence level associated with the type of land cover transition.	• **Confirmed.** The type of land cover change transition was confirmed by a recognized, third part ancillary data source. • **High.** The type of land cover change transition was confirmed with high resolution orhtophotos. Orthophoto dates closely approximate the date of the satellite image used in the change detection analysis. • **Medium.** The type of land cover change transition was confirmed with high resolution orthophotos.

		Orthophoto dates are within 1-2 years of the date of the satellite image used in the change detection analysis. • **Low.** The type of land cover change transition could not be accurately confirmed with high resolution orthophotos. Orthophotos are not available within 1-2 years of the satellite image used in the change detection analysis.
Verification	Land cover change verification or SOLRIS class mapping correction.	• **True Change.** A verified land cover change.

SOLRIS_Version_3_0_Class_Corrections_2000to2015_Lambert

Land cover class corrections from 2000 to 2015.

Field	Description	Value
Change_Direction	Land cover class transformation.	• **{SOLRIS class/class group}.** Some SOLRIS classes were grouped for the sake of simplicity. SOLRIS class groups. • **Wetland:** swamp (change period 00,01 or 02), treed/thicket swamp (change period 03), bog, fen and marsh. • **Woodland:** forest, coniferous/mixed/

		deciduous forest. • **Undifferentiated:** undifferentiated includes tilled for change periods 00, 01 and 02.
Verification	Land cover change verification or SOLRIS class mapping correction.	• **SOLRIS class mapping correction.** The land cover value associated with change period 00, 01, 02 or 03 is due to the presence of a modelling error. SOLRIS Version 3.0 was updated with this correction. This is not a true land cover change.
Class_Update	Time period of class correction.	• **00.** Prior to time 00 (1999 to 2002). • **01.** Time 00 (1999 to 2002) to 01 (2005 to 2007). • **02.** Time 01 (2005 to 2007) to 02 (2009 to 2011). • **03.** Time 02 (2009 to 2011) to 03 (2014 to 2017). •

2.1.3 Raster dataset values

SOLRIS_Version_3_0_Lambert

Land cover.
SOLRIS_Version_3_0.lyr provides the class legend and cartographic colour ramp file for ESRI ArcGIS applications.

SOLRIS class name	ELC code	Value	Description	MMU (ha)	Input source	Possible confusion
Open Beach/Bar	BBO	11	Unconsolidated mineral substrates. Subject to active shoreline processes: ice scour, wave energy, erosion, and deposition. Tree cover < 25%; shrub cover <25%.	0.5	Field verified NHIC rare community database.	Assumed correct.
Open Sand Dune	SDO	21	Exposed sands formed by extant or historical shoreline or Aeolian processes. Subject to active processes/ <25% vegetative cover.	0.5	Field verified NHIC rare community database.	Assumed correct.
Treed Sand Dune	SDT	23	Exposed sands formed by extant	0.5	Field verified NHIC rare	Assumed correct.

			or historical shoreline or Aeolian processes. Subject to active processes/ 25% < tree cover < 60%.		community database.	
Open Cliff and Talus	CTO	41	Vertical or near-vertical exposed bedrock > 3 m in height/ slopes of rock rubble at the base of cliffs. Subject to active processes/ < 25% vegetative cover.	0.5	Field verified NHIC rare community database.	Assumed correct.
Treed Cliff and Talus	CTT	43	Vertical or near-vertical exposed bedrock > 3 m in height/ slopes of rock rubble at the base of cliffs. Subject to active processes/ 25% < vegetative cover < 60%.	0.5	Field verified NHIC rare community database.	Assumed correct.
Open Alvar	ALO	51	Level, unfractured limestone (carbonate)	0.5	Field verified NHIC rare community	Assumed correct.

			bedrock/ patchy mosaic of bare rock pavement and shallow substrates (< 15 cm) over bedrock/ vegetative cover < 25%.		database.	
Shrub Alvar	ALS	52	Level, unfractured limestone (carbonate) bedrock/ patchy mosaic of bare rock pavement and shallow substrates (< 15 cm) over bedrock/ tree cover < 25%; shrub cover => 25%.	0.5	Field verified NHIC rare community database.	Assumed correct.
Treed Alvar	ALO	53	Level, unfractured limestone (carbonate) bedrock/ patchy mosaic of bare rock pavement and shallow substrates (< 15 cm) over bedrock/ 25% < tree cover < 60%.	0.5	Field verified NHIC rare community database.	Assumed correct.
Open Bedrock		64	Primarily non-calcareous bedrock features,	0.5	Derived from eFRI and spectrally	Automated classification procedure is

			confined to the Canadian Shield in ecoregion 5E. Tree cover < 10%.		refined from Landsat automated analysis.	constrained to eFRI polygons. May be confused with undifferentiated and sparse treed classes.
Sparse Treed		65	60% < tree cover < 10%. Confined to the Canadian Shield in ecoregion 5E. Tree communities often situated on non-calcareous bedrock features, rapidly draining soils, or raised mineral soils.	0.5	Derived from eFRI and spectrally refined from Landsat automated analysis.	Automated classification procedure is constrained to eFRI polygons. May be confused with undifferentiated, open bedrock and coniferous /mixed/ deciduous forest classes.
Open Tallgrass Prairie	TPO	81	Ground layer dominated by prairie graminoids; variable cover of open-grown trees/ Tree cover <= 25%; shrub cover <= 25%.	0.5	Field verified NHIC rare community database.	Assumed correct.
Tallgrass Savannah	TPS	82	Ground layer dominated by prairie graminoids;	0.5	Field verified NHIC rare community database.	Assumed correct.

			variable cover of open-grown trees/ 25% < tree cover < 35%.			
Tallgrass Woodland	TPW	83	Ground layer dominated by prairie graminoids; variable cover of open-grown trees/ 35% < tree cover < 60%.	0.5	Field verified NHIC rare community database.	Assumed correct.
Forest	FO	90	Tree cover > 60%. Upland tree species > 75% canopy cover > 2m in height.	0.25	Perimeters visually extracted from high resolution ortho or satellite imagery. Attribute for forest type could not be derived spectrally from Landsat automated analysis due to size of feature.	Automated classification procedure is constrained to forest area polygons. Proportions of forest type cannot be determined due to size of feature. Forest may be confused with swamp and undifferentiated.
Coniferous Forest	FOC	91	Tree cover >	0.5	Perimeters	Automated

			60%. Upland coniferous tree species > 75% canopy cover > 2m in height.		visually extracted from high resolution ortho or satellite imagery. Attribute derived spectrally from Landsat automated analysis.	classification procedure is constrained to forest area polygons. Proportions of forest type may not be exact. Forest may be confused with swamp and undifferentiated.
Mixed Forest	FOM	92	Tree cover > 60%. Upland coniferous tree species > 25% and deciduous tree species > 25% of canopy cover > 2m in height.	0.5	Perimeters visually extracted from high resolution ortho or satellite imagery. Attribute derived spectrally from Landsat automated analysis.	Automated classification procedure is constrained to forest area polygons. Proportions of forest type may not be exact. Forest may be confused with swamp and undifferentiated.
Deciduous Forest	FOD	93	Tree cover > 60%. Upland deciduous tree species > 75% canopy cover > 2m in height.	0.5	Perimeters visually extracted from high resolution ortho or satellite	Automated classification procedure is constrained to forest area polygons. Proportions of

					imagery. Attribute derived spectrally from Landsat automated analysis.	forest type may not be exact. Forest may be confused with swamp and undifferentiated.
Treed Swamp	SWC/ SWM/ SWD	131	Treed communities. Water table seasonally or permanently at, near, or above substrate surface/ Tree cover > 25%. Dominated by hydrophytic tree and shrub species.	0.5	Combined from NRVIS evaluated wetlands database, modelled / interpreted OBM wetlands from DEM, soils, orthos, and satellite imagery.	Possible confusion with upland forest and undifferentiated. Results visually assessed from ortho imagery and adjusted where required.
Thicket Swamp	SWT	135	Open and shrub communities. Water table seasonally or permanently at, near, or above substrate surface/ Tree cover <= 25%; hydrophytic shrubs > 25%. Dominated by hydrophytic tree and shrub species.	0.5	Combined from NRVIS evaluated wetlands database, modelled / interpreted OBM wetlands from DEM, soils, orthos, and satellite imagery.	Possible confusion with upland forest and undifferentiated. Results visually assessed from ortho imagery and adjusted where required.

Fen	FE	140	Mineotrophic peatland. Open, shrub and treed communities. Water table seasonally or permanently at, near, or above substrate surface/ Tree cover (trees > 2m height) <= 25%. sedges, grasses, and low (< 2m) shrubs dominate, sedge and brown moss substrate.	0.5	Derived from NRVIS evaluated wetlands database.	Rare event, previously mapped in the field.
Bog	BO	150	Ombrotrophic peatland. Open, shrub and treed communities. Water table seasonally or permanently at, near, or above substrate surface/ Tree cover (trees > 2m height) <= 25%	0.5	Derived from NRVIS evaluated wetlands database.	Rare event, previously mapped in the field.

			sphagnum peat substrate.			
Marsh	MA	160	Open and shrub communities. Water table seasonally or permanently at, near, or above substrate surface – tree and shrub cover <=25%. Dominated by emergent hydrophytic macrophytes.	0.5	Combined from NRVIS evaluated wetlands database, modelled / interpreted OBM wetlands from DEM, soils, orthos, and satellite imagery.	Possible confusion with undifferentiated. Results visually assessed from ortho imagery and adjusted where required.
Open Water	OA	170	Water depth > 2 meters. Lake trophic status. No macrophyte vegetation, trees or shrub cover.	0.5	Derived from NRVIS hydrology database.	Results visually assessed from ortho imagery and adjusted where required.
Plantations – Tree Cultivated	CUP	191	Tree cover > 60%, (trees > 2m height), linear organization, uniform tree type.	0.25	Perimeters visually extracted from high resolution ortho or satellite imagery.	Forest type not differentiated. Mostly coniferous species. May be confused with upland forest. May include nurseries or Christmas

						tree plantations.
Hedge Rows	CUH	192	Tree cover > 60%, (trees > 2m height), linear arrangement, minimum 10 meters width, maximum 30 meters width.	0.25	Perimeters visually extracted from high resolution ortho or satellite imagery.	Confusion may exist with trees under 2 meters in height.
Tilled		193	Agricultural fields managed as continuous annual row crops inferred from 3 observed sequential time periods over a 10 year time period. There can be as many as 2 time periods where fields are rotated with perennial crops. (e.g., hay, improved pasture)	0.5	Derived from Landsat change detection analysis.	Automated classification procedure is constrained to rural areas. May include specialty crops and nurseries. Results visually assessed from ortho imagery and adjusted where required.
Transportation	COT	201	Highways, roads.	0.5	Derived from the National Road Network – buffered to standard road allowance of 22	National Road Network data deemed correct.

					m.	
Built-Up Area – Pervious	COP	202	Urban recreation areas. (i.e., golf courses, playing fields)	0.25	Perimeters visually extracted from high resolution ortho or satellite imagery.	Results visually assessed from ortho imagery and adjusted where required.
Built-Up Area – Impervious	COI	203	Residential, industrial, commercial, and civic areas.	0.25	Perimeters visually extracted from high resolution ortho or satellite imagery.	Results visually assessed from ortho imagery and adjusted where required.
Extraction – Aggregate	COE	204	Pits, quarries.	0.5	Derived from NRVIS licensed pit/ quarry data base. Active area derived spectrally from Landsat TM.	Automated classification procedure is constrained to licensed area. Results visually assessed from ortho imagery and adjusted where required.
Extraction – Peat/Topsoil		205	Peat and topsoil extraction.	0.5	Active area derived spectrally from Landsat TM.	Automated classification procedure is constrained to areas of wetland

						loss from 2000 to 2011. Results visually assessed from ortho imagery and adjusted where necessary.
Undifferentiated	UN	250	Includes some agricultural features not included in tilled (i.e. orchards, vineyards, perennial crops and idle land > 10 years – out of agricultural production) as well as urban brown fields, hydro and transportation right-of- ways, upland thicket and openings within forests.	0.5	Areas not mapped by the previous classes.	May include tilled and wetlands.

2.2 Classification scheme

2.2.1 Mapping scale

The minimum mappable unit (MMU) of SOLRIS Version 2.0 is 0.5 ha. This was determined by using Landsat-7 ETM+, 15 m pixel resolution for the initial Version 1.0 mapping. Although Version 2.0 updates applied Landsat-5 TM, 30 m pixel resolution imagery, the outer Version 1.0 class perimeters were preserved. As a result, the MMU remains the same.

The mapping scale is appropriate for regional or landscape mapping analysis at 1:10,000 to 1: 50,000 scale. Features less than the MMU of 0.5 ha or less than 90 meters wide cannot be reliably detected and are therefore more likely to be error. The exception is streams, roads, hedge rows and NHIC rare communities. This minimum mapping standard should be considered when analyzing and reporting results.

2.2.2 Methodology and data sources – Version 1.0

Initially, SOLRIS (Version 1.0) was developed in 3 phases.

Phase 1: Provincial base data compilation/updating

All relevant base data layers (hydrology, wetlands — Ontario Base Mapping [OBM]) and evaluated, woodlands, built up areas, and Ontario Road Network), were acquired at 1:10,000 scale. Some layers were updated by using soft- copy photo-interpretive techniques and interactive on-screen editing/digitizing. Updates were completed with high resolution orthophotos, satellite imagery and digital elevation models. The effort was coordinated through MNR district offices using rigorous standards and protocols to ensure consistency.

Phase 2: Modelling analysis

Land cover classification was based on community class/series units derived from the Ecological Land Classification for Southern Ontario — First Approximation and Its Application (Lee et al. 1998) at 1:50,000 scale. The methodology used eCognition image object technology. Data inputs included updated Phase 1 provincial base data, remote sensing data (Landsat-5 TM, Landsat-7 ETM+, and Radarsat-1 Standard Beam Mode), digital elevation model derivatives (topographic wetness index, slope), and the NHIC rare communities data base.

Phase 3: Accuracy assessment

An accuracy assessment was completed to provide the user with quantitative measures of error such as type, magnitude, and frequency. These metrics are displayed in an error matrix table. This allows the user to determine the suitability of applying SOLRIS for their work applications.

2.2.3 Methodology and data sources – Version 2.0 updates

SOLRIS Version 1.0 was updated using a remote sensing process called change detection. Change detection analyzes the increases and decreases in vegetation greenness using full-leaf summer Landsat-5 TM imagery for three time periods from 2000 to 2011. If the change is strong enough to describe vegetation loss, then it is called a change event. Change detection is efficient as it focuses on areas where a landscape change has occurred, resulting in a greatly reduced effort of keeping the source data current. The change detection reports land cover changes over two time periods:

- 1999–2002 to 2005–2007
- 2005–2007 to 2009–2011

Each change event was verified with high resolution orthophotos, when available. The change events were tagged with contextual information. These attributes are summarized in Section 2.1.2.

SOLRIS change events were used to update the land cover to 2009–2011. Additional land cover classes were also created using satellite imagery and/or updated provincial base data layers. The complete list of land cover classes and descriptions are provided in Section 2.1.3. New classes include:

- Tilled. Defined as agricultural fields managed as continuous row crops or rotational systems where field crops are rotated with perennial crops, such as hay or improved pasture. Tilled was mapped using change detection. Data inputs were pre-leaf spring Landsat-5 TM imagery for three time periods from 2000 to 2011 within the perimeters of the undifferentiated class in SOLRIS Version 1.0. If row crops were observed in any of these 3 time periods, then it was assigned tilled. The undifferentiated class in Version 2.0 remains the same with tilled lands excluded.

- Treed and Thicket Swamp. The Version 1.0 swamp class was separated into Version 2.0 treed and thicket swamp classes by the intersection of the original Phase 1 woodland polygons. The Version 1.0 perimeters remain the same after

the “wetland losses” were incorporated. Treed swamp was assigned where there is spatial overlap between the two data sources. Thicket swamp was assigned where Version 1.0 swamp did not overlap with woodlands.

- Extraction – Peat/Topsoil. Defined as peat and/or topsoil removal. This class was initiated to describe wetland loss events from 1999–2002 to 2009–2011.

- Additional rare community classes provided by the Natural Heritage Information Centre (NHIC).

2.2.4 Methodology and data sources – Version 2.1 updates

SOLRIS Version 2.1 includes new areas not previously mapped: Growth Plan for the Greater Golden Horseshoe Study Area (complete coverage for the City of Kawartha Lakes and Peterborough County) and an Eastern Ontario extension (areas not mapped by the existing forest resources inventory).

Two new land cover classes have been created to better represent the Canadian Shield landscape located in these two extension areas. New classes include:

- Sparse Treed. Represents treed communities with 10% to 60% canopy cover.
- Open Bedrock. Non-calcareous bedrock with < 10% canopy cover.

Corrections were applied to the mapping of SOLRIS classes. These changes are due to the availability of improved reference data. These corrections are not indicative of landscape changes.

2.2.5 Methodology and data sources – Version 3.0 updates

SOLRIS Version 3.0 was updated with the same change detection procedure used to update version 1.0. Landsat-8 OLI imagery acquired from 2014 to 2017 represents the 2015 baseline.

SOLRIS version 3.0 reports land cover change over three time periods:

- 1999–2002 to 2005–2007
- 2005–2007 to 2009–2011
- 2009–2011 to 2014–2017

2.2.6 Limitations

Summer imagery with full leaf-out conditions is ideal for mapping most vegetative features. Acquiring optimal cloud- free imagery representing these conditions is a challenge. Consequently, concessions have to be made, which include allowing for a range of years and leaf-out conditions. For example, a hardwood stand on an optimal image may look 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.

Land cover classification accuracy and precision are affected by many factors. The product was created using imagery acquired on many different dates that exhibited differing physiographic and vegetative conditions. Image pixel generalization occurs when a single pixel represents a mixture of many physiographic and vegetative surface conditions. This can cause a number of discrepancies between mapping products and field based classification systems such as ELC. Furthermore, numerous remote sensing analysts contributed to the creation of this product, resulting in differing interpretations. This kind of approach can introduce error and inconsistency into classification results.

Vegetation loss change events derived from the change detection model yielded good results when associated with strong changes in vegetation chlorophyll from 1999–2002 to 2009–2011. (e.g., treed woodland converted to concrete/ ploughed field). Some of the woodland/wetland losses could not be modelled when they are associated with weak to no changes in vegetation chlorophyll. (e.g., treed woodland/wetland converted to cropped field/dense grassy meadow, marsh with mats of dense senesced grasses converted to ploughed/bare field). These types of change events were mapped through an extensive manual editing initiative using high resolution orthophotos. Although attempts were made to capture all major events, some remain undetected. The quantity is difficult to assess in the absence of manually scanning orthophotos at a very high map scale for all of Ecoregions 6E and 7E. Such an effort was not deemed feasible.

2.3 Class descriptions

This section provides a more detailed description of derived class units.

2.3.1 Coniferous/Mixed/Deciduous Forest

Description: A terrestrial vegetation community with at least 60% tree cover (definition of “forest” by Lee et al 1998) of which more than 75% is either coniferous or deciduous canopy cover to be considered coniferous or deciduous forest, respectively. A mixed forest class has at least 60% tree cover, with more than 25% conifer canopy cover, and more than 25% deciduous canopy cover. A tree is defined as a woody plant usually with a single main stem and capable under the right condition, of reaching heights of several metres or more (Lee et al. 1998). Cover is described as the area of ground covered or the relative proportion of

coverage by a particular plant species, vegetation layer or plant form (Lee et al. 1998).

Interpretation: Several considerations are made in interpreting forested areas (e.g., texture, shape, tone, and location / context). Discerning whether trees vs. tall shrubs are present is aided in part by the size of crowns, and the resulting shadow lengths. The proportion of coniferous vs. deciduous is best examined from spring orthophotography. The percent cover charts in Lee et al. (1998) provide a guide for estimating percent cover. The Woodland editing strategies (SOLRIS 2005c) also describes a method of how a 0.25 hectare square graphic can be used to help estimate percent cover.

Other distinguishing features include irregular stand boundaries (in contrast to well defined and linear plantations), and relatively coarse texture from canopies of uneven age and composition. Deciduous species are grey - beige in appearance (true colour, leaf-off spring imagery), and light red or yellow - pale orange in false-colour and Landsat 4-5-3 band combinations, respectively. In contrast, coniferous species are dark green in appearance (true colour spring imagery), and dark red or orange in false colour and Landsat 4-5-3 band combinations, respectively. Deciduous species typically have billowy closed-canopy conditions vs. coarse and irregular canopies of conifers. Site conditions and substrate type are variable, but poorly drained, lower elevation organic areas are likely swamp or idle land.

Possible confusion: Identifying tree vs. tall shrub cover may be difficult since a tall shrub is defined as “a shrub species that has the potential to grow > 2 m tall, or that forms part of a community in which at least some of the individuals are > 2 m tall” (Lee et al., 1998). Similarly, confusion may arise with thicket communities which are characterized by <10% tree cover and >25% tall shrub cover (Lee et al., 1998). Class confusion may also be present with swamps (coniferous, mixed or deciduous) where hydrological conditions, such as gently flowing water that occurs seasonally or persists for long periods, may not be apparent. Other areas of confusion include plantations and hedgerows, as well as specialty crops such as Christmas trees, orchards, and nurseries. Refer to definitions of these classes for clarification.

MMU: Approximately 0.5 hectares.

2.3.2 Treed/Thicket Swamp:

Description: A mineral-rich wetland characterized by a cover of deciduous or coniferous trees (Lee et al.,1998). A treed swamp is a wooded wetland with ≥ 25% tree cover. Tree height is > 5 meters. A thicket swamp is dominated by hydrophytic shrubs with ≥ 25% cover and < 25% tree cover. Occasionally swamp communities have a strong component of low shrubs. In this case, the tall shrub component must be dominant for the community to be considered a swamp. In swamps, standing or gently flowing waters occurs seasonally or persist for long periods on the surface. Frequently there is an abundance of pools and

channels indicating subsurface water flow. The substrate is usually continuously waterlogged. Waters are circumneutral to moderately acid in reaction, and show little deficiency in oxygen or in mineral nutrients. The vegetation cover may consist of coniferous trees, tall shrubs, herbs, and mosses.

Many swamps are characteristically flooded in spring, with dry relict pools apparent later in the season (OMNR 1993 ab). There is usually no deep accumulation of peat (OMNR 1993a). Swamps include both forest swamps (with mature trees) and thicket swamps (shrub carrs). Thicket swamps are characterized by thick growths of tall shrubs such as willow, dogwood, and alder. Both forest and thicket swamps have similar water levels and chemistry. Both are assessed as “swamp” wetland type, but can be distinguished by the predominance of either “tree” or “shrub” form. Silver maple, elm, black ash, and yellow birch are among the best indicators of a hardwood forest swamp, while white cedar, tamarack, and black spruce indicate conifer swamps. White cedar, however, also grows well in upland sites (OMNR 1993a,b).

Possible confusion: The seasonal (ephemeral) nature of some swamps may result in confusion with upland forest classes (mixed, deciduous, and coniferous) and idle land. Discerning the extent of a wetland — especially in low relief areas — may also be problematic. As well, the degree and type of cover may be difficult to quantify, resulting in possible confusion with marshes and undifferentiated features.

MMU: Approximately 0.5 hectares.

2.3.3 Marsh:

Description: Marshes are wet areas periodically inundated with standing or slowly moving water, and/or permanently inundated areas characterized by robust emergents and, to a lesser extent, anchored floating plants and submergents. Surface water levels may fluctuate seasonally, with declining levels exposing drawdown zones of matted vegetation or mud flats. Water remains within the rooting zone of plants during at least part of the growing season. The substratum usually consists of mineral soils or organic soils with a high mineral content, but in some marshes there may be as much as 2 m of peat accumulation. Waters are usually circumneutral to slightly alkaline, and there is relatively high oxygen saturation. Marshes characteristically show zones or mosaics of vegetation, frequently interspersed with channels or pools of deep or shallow open water. They include open expanses of standing or flowing water which are variously called ponds, shallow lakes, oxbows, reaches, or impoundments. Marshes may be bordered by peripheral bands of trees and shrubs, but the predominant vegetation consists of a variety of emergent woody plants such as rushes, reeds, reed grasses, and sedges. Low shrubs such as sweetgale, red osier, and winterberry may also occur. Where open water areas occur, a variety of submerged or floating plants flourish (MNR 1993a, b).

Possible confusion: Discerning the extent of a wetland —especially in low relief areas — may be problematic. Determining the degree and type of cover may also lead to possible confusion with thicket swamp and undifferentiated classes. Shallow water marshes may result in confusion with shallow water and possibly open water classes. Finally, riparian meadow marsh may be confused with pasture and upland grass communities.

MMU: Approximately 0.5 hectares.

2.3.4 Open Water:

Description: Aquatic communities in which the permanent water is generally >2 m deep and the total vegetation cover is <25%. Lake water that is free of emergent vegetation or artificial obstruction (Arnup et al., 1999, OMNR 1993a, b). No macrophyte vegetation, trees or shrub cover.

Interpretation: Typically appears as very dark black objects in true-colour or false- colour imagery. These features become lighter in colour with increasing turbidity.
Reflected sunlight or waves may also brighten the appearance of open water.
Distinguishing shallow (< 2m) vs. deep water may be problematic in some cases where high turbidity appears similar to shallow water conditions where backscattering from substrates such as sand are present. As well, ensuring the absence of any deeply submerged or sparse floating macrophytes can be difficult.

Possible confusion: May include shallow water, which is characterized by submerged or floating leaf macrophytes. Portions may also include structural features (e.g., docks) and open shoreline or shallow water artefacts. Septic lagoons, golf course water features, and shallow (< 2 m) streams are not intentionally included in this class.

MMU: Approximately 0.5 hectares.

2.3.5 Plantation:

Description: A treed community with at least 60% tree cover in which the majority of trees have been planted (Lee et al., 1998). A tree is defined as a woody plant usually with a single main stem and capable, under the right condition, of reaching heights of several metres or more (Lee et al., 1998). Cover is described as the area of ground covered or the relative proportion of coverage by a particular plant species, vegetation layer, or plant form (Lee et al., 1998).

Interpretation: Well defined stand boundaries and evidence of linear tree planting are key identifiers. Discerning whether trees vs. tall shrubs are present is aided in part by the size of crowns and the resulting shadow lengths. The charts presented by Lee et al. (1998) provide a guide for estimating percent cover. A method of how a ¼ hectare square graphic can be

used to aid in estimating percent cover is also described in Woodland Editing Strategies (SOLRIS 2005c). Image tones and texture typically appear relatively darker and smoother than forest communities since most plantations are even-aged coniferous plantings.

Possible confusion: Class confusion may be present with natural forest communities (coniferous, mixed, or deciduous), and specialty crops such as Christmas trees, orchards, and nurseries. Identifying tree vs. tall shrub cover may also be difficult since a tall shrub is defined as "a shrub species that has the potential to grow > 2 m tall, or that forms part of a community in which at least some of the individuals are > 2 m tall" (Lee et al., 1998). Similarly, confusion may arise with thicket communities which are characterized by <10% tree cover and >25% tall shrub cover (Lee et al., 1998). In some instances, confusion may arise with swamps where hydrological conditions such as gently flowing water that occurs seasonally or persist for long periods may not be apparent.

MMU: Approximately 0.25 hectares.

2.3.6 Hedgerow:

Description: A terrestrial vegetation community of at least 60% tree cover (definition of "forest" by Lee et al. 1998) that is naturally occurring or planted as a linear feature, with a minimum width of 10 m and a maximum width of 30 m. Hedgerows not connected to existing forested areas were to be excluded. A tree is defined as a woody plant usually with a single main stem and capable, under the right condition, of reaching heights of several metres or more (Lee et al. 1998). Cover is described as the area of ground covered or the relative proportion of coverage that a particular plant species, vegetation layer or plant form represents (Lee et al. 1998).

Interpretation: Several considerations are made in interpreting forested features such as hedgerows. The principle identifiers for hedgerow are the geometry (i.e., linear shape) and overall size (10m to 30m wide, with an MMU of 0.25 ha). Only hedgerows adjoining woodlots were to be captured, which forms an additional identifier for interpreting this class. Discerning whether trees vs. tall shrubs are present is aided in part by the size of crowns, and the resulting shadow lengths. The charts presented by Lee et al. (1998) provide a guide for estimating percent cover. A method of how a ¼ hectare square graphic can be used to aid in estimating percent cover is also described in Woodland Editing Strategies (SOLRIS 2005c).

Possible confusion: Identifying tree vs. tall shrub cover may be difficult since a tall shrub is defined as "a shrub species that has the potential to grow > 2 m tall, or that forms part of a community in which at least some of the individuals are > 2 m tall" (Lee et al. 1998). Similarly, confusion may arise with thicket communities which are characterized by <10%

tree cover and >25% tall shrub cover (Lee et al. 1998). Class confusion may also be present with swamps (coniferous, mixed, or deciduous) where hydrological conditions such as gently flowing water that occurs seasonally or persist for long periods may not be apparent. Other areas of confusion include plantations or tree farms where harvesting operations may result in similar geometries to hedgerow features. Refer to definitions of these classes for clarification.

MMU: Approximately 0.25 hectares.

2.3.7 Tilled:

Description: The agricultural land-use class for continuous annual row crops and mixed crops where annual crops are rotated with perennial crops. These classes were derived from a change analysis of spring Landsat imagery within the perimeters of the SOLRIS Version 1.0 undifferentiated class. The spatial variation of land-use within a field was estimated by classifying the presence or absence of mid- to late spring vegetation over three images sequentially sampled within a 10-year time series. While crop type cannot be identified, the absence of vegetation (ploughed fields) in 3 mid-to late spring images (out of a possible 3 date time series) implies annual tilling. This is a seeded crop type such as corn, beans or spring grain. It may however include other specialty cropping operations such as ginseng, tobacco and sod. This class does not include hay-pasture, orchards, vineyards, or plantations. However, this class does include rotational systems such as mixed agricultural crops. These are detected by the presence of vegetation across 1 or 2 dates in the imagery time series.

Interpretation: The applied methodology does not explicitly identify crop type, but it does allow for a classification of managed tilled lands. Distinguishing features of managed classes include the evidence of furrows, defined fields often with no fence boundaries, and generally large operations (150 ha to 250 ha in size). As described by Huffman and Dumanski (1986), mixed crop systems are generally of moderate size (100 ha) and often associated with dairy or beef production. It would therefore be expected that mixed crops would be associated with pasture land surrounded by fences and larger farm structures (e.g., silos).

Possible confusion: Ideally, the classification of imagery over a series of consecutive dates would be preferred over sequentially sampled images, however that would require consecutive sequences of cloud-free satellite imagery for the entire project area during the spring months. Nevertheless, statistically the probability of correctly predicting annual crop (given equal weight to the occurrence of vegetated vs non-vegetated within three observation periods over 10 years) is at minimum 64%. Mixed crops, by definition may be either vegetated or non-vegetated; therefore the predictive probability of this occurrence is

100%. It should be noted that the probability of each occurrence type has been improved significantly through visual checking with ortho-imagery. Inferences of land-use were based on the presence or absence of spring vegetation. Without crop records or identifying crop type, it is possible that the potential for error exists if the underlying assumption does not hold true. The assumption is that appropriately obtained spring imagery should only have annual crops that are in a bare field state, and that other land uses have varying degrees of vegetation greenness. Where this assumption may not hold true is when crops such as winter wheat that are planted in the fall, appear vegetated in the spring (unlike most other row crops). Confusion may
also arise in areas of disturbance or vernal pooling were re-vegetation occurs later in the spring and thus considered fallow leading to the site being deemed more intensive.

MMU: Approximately 0.5 hectares.

2.3.8 Built-up area pervious:

Description: Built-up areas range from small hamlets at rural cross roads to large cities. An area is considered built-up when linear frequencies of structures are more than 10 per 500 metres or 4 per 1 hectare box (SOLRIS 2005b). Features within built- up areas are further defined as pervious if green spaces and other permeable surfaces (e.g., grass, shrubs, and residential ornamentals) represent more than 80% per 0.5 hectare. Built-up pervious areas may include land cover features such as water, woodlands, and impervious features (e.g., parking lots) below the MMU of 0.5 hectare. This class does not represent the intended land-use extent as typically outlined in operational plans or zoning permits; instead, it delineates pervious features according to the aforementioned building density criteria. New developments adjacent to or enclosed as urban are considered built-up pervious. These new developments typically have early residential road patterns or partially built homes present. Interpretable recreation outside of an urban area such as golf courses, baseball diamonds, soccer fields, and football fields are mapped as built-up pervious. Similarly, cemeteries are classified as built-up pervious. This class does not included permeable features within or adjacent to a farmstead.

Interpretation: Examples of built-up pervious are provided in SOLRIS (2005b), with green spaces, golf courses, and ball diamonds clearly evident in orthophotography. Primary identifiers are the shape and associated characteristics such as linear fairways, sand traps, and the diamond pattern of ball fields. These permeable features are typically smooth, and evenly toned given the predominance of grass. False or true colour infrared imagery displays grass and low lying vegetation as pink – red in appearance. In contrast, built-up pervious features within a new urban development appear cyan to white in false or true colour infrared imagery. These new developments are generally along the urban fringe and have residential road patterns.

Possible confusion: Extraction sites and exposed rock can be confused with pervious surfaces that are characterized as bright white – cyan in appearance. Estimating vegetation cover above the 80%-per-0.5-hectare rule may also be challenging when differentiating pervious vs. impervious. This occurs in fragmented areas such as subdivisions. In the absence of orthophotography, recreational fields and cemeteries may appear as undifferentiated features.

MMU: Approximately 0.25 hectares.

2.3.9 Built up area-impervious:

Description: Areas with buildings, pavement and most other anthropogenic features are generally impermeable and thus classified as built-up impervious. These features along with residential, industrial, civic, and commercial buildings are all found in urban areas and were spatially mapped when linear frequencies of structures were more than 10 per 500 metres or 4 per 1 hectare box (SOLRIS 2005b). A road or railway line on its own is not a built-up feature, but within an urban area it is considered as built-up impervious. Green spaces and other pervious features may be included within built-up impervious if the portion of pervious surfaces (e.g., grass, vegetation and bare ground) is less than 80% per 0.5 hectare. Built-up areas range from small hamlets at rural cross roads to large cities. This class does not represent the intended land-use extent as typically outlined in operational plans or zoning permits, but delineates constructed features according to the aforementioned building density criteria. This class does not included constructed features such as farmsteads (silos, barns, and houses) or extraction sites. It does, however, include greenhouse complexes.

Interpretation: Examples of built-up impervious are provided in SOLRIS (2005b), with buildings, residential areas and infrastructure clearly evident in orthophotography as light to cyan tones of constructed materials mixed with darker tones from roof tops and shadows. Vegetated areas comprising less than 80% per hectare, which are typically present within residential subdivisions, are also characteristic of built-up impervious features. Satellite imagery such as Landsat and IRS display similar characteristics (albeit with coarser spatial resolution) to built-up impervious features, which are typically displayed as a cyan to almost white colour in false colour composites.

Possible confusion: Extraction sites and exposed rock can be confused with impervious surfaces that are characterized by bright white to cyan in appearance. Estimating vegetation cover above the 80% per 0.5 hectare rule may also be challenging when differentiating pervious vs. impervious. This occurs in fragmented areas such as subdivisions.

MMU: Approximately 0.25 hectares.

2.3.10 Extraction-aggregate:

Description: An open-pit aggregate extraction site. Associated infrastructure such as roads, buildings, weigh scales and ponds below the MMU of 0.5 hectare are included in this class. This class does not represent the intended land-use extent as typically outlined in operational plans or zoning permits, but instead delineates areas of exposed aggregate from current or past operations.

Interpretation: Examples of extraction are presented in SOLRIS (2005), with interpretative characteristics of exposed and disturbed areas over gravel deposits.
Aggregate mounds and processing equipment are typically present along with a small building and road infrastructure. The feature is generally not within a residential or urban area, and the operation generally has a fenced boundary that is typically treed. Image tones and texture typically appear bright with darker tones from shadows and ponds.
Exposed soil and aggregates appear cyan to white in false or true colour infrared imagery.

Possible confusion: New residential development (urban pervious) and exposed rock can be confused with this class since they are characterized as bright white to cyan in false or true colour infrared imagery. Abandoned operations may also appear as idle land.

MMU: Approximately 0.5 hectares.

2.3.11 Extraction – peat/topsoil:

Description: The term peat is often used to describe the soil product extracted from wetlands for consumptive and non- consumptive uses. The Canadian Sphagnum Peat Moss Association (CSPMA) defines peat as “referring to largely organic residues of plants that are incompletely decomposed through lack of oxygen.” Additional definitions of peat often include modifiers to describe the organic material contained by the peat and its level of decomposition. For example, the CSPMA describes peat moss (also commonly referred to as sphagnum peat moss) as partially decayed mosses including sphagnum and hypnum moss species. This group also defines peat humus as peat that is fully decomposed so that none of the original plants can be identified. Topsoil is also a term associated with soil use for horticultural purposes. In the Municipal Act, 2001, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) clearly defines topsoil as “those horizons in a soil profile, commonly known as the “O” and the “A” horizons, containing organic material and includes deposits of partially decomposed organic matter such as peat. Peat removal for consumptive uses includes harvesting commercial materials such as trees, peat, and wildlife, while non- consumptive uses include water conservation, erosion protection, wildlife habitat, education, and research (Grand River Conservation Authority. 1997).

Interpretation: Tilled appearance with very dark, wet tones arranged in rectangular

patterns. They are converted from natural wetlands with a large peat source, often found in the middle of or adjacent to large wetlands such as Wainfleet Bog, Alfred Bog and the Zephyr Wetland Complex. On satellite imagery, they appear very similar to bare fields with exposed topsoil. Image tones are black in true or false colour infrared imagery.

Possible Confusion: Confused with tilled and undifferentiated classes. MMU:

Approximately 0.5 hectares.

2.3.12 Undifferentiated:

Description: Represents all remaining areas that are exclusive to the other data classes. Includes all agricultural lands not included in tilled (e.g., hay/pasture, orchards, vineyards, nurseries, and rural properties and farmland not currently in production), as well as urban brown fields, hydro right-of- ways, the edges of transportation corridors, upland thickets, and clearings within forests.

Interpretation: Represents all remaining areas that are exclusive to the other data classes; consequently a summary of interpretive characteristics cannot be provided.

Possible confusion: Wetlands may be included in the undifferentiated class. MMU:

Approximately 0.5 hectares.

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