Sustainable Landscapes Sustainable Futures

Natural Area Mapping for the Sturgeon River Watershed

Prepared For

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1 Executive Summary

The Sturgeon River Watershed contains a diverse landscape, with networks of forests, lakes, wetlands, and riparian areas. These natural areas are important components of a properly functioning ecosystem and are important for the overall health of the watershed. As such, it is important to map their locations within the watershed and effectively conserve them. By identifying the location and relative value of natural areas in a watershed, efforts towards prioritizing for conservation of environmental management can be made.

The NSWA has retained ALCES Landscape and Land-Use Ltd. (ALCES) to provide natural areas mapping for the Sturgeon River Watershed. This report outlines the data sources and methods used to delineate and value natural areas throughout the entire Sturgeon River Watershed. The general workflow consisted of 1) developing natural area themes, 2) building indicators to meet specific themes, 3) combining indicator layers using equal weights, 4) delineating natural areas from final output, and 4) comparing results with previous studies.

Results identified distinct areas within the Sturgeon River Watershed as natural areas hotspots, which scored relatively high after combining all assessed indicators. These areas include the headwaters of the watershed, and the areas surrounding the Sturgeon River and Big Lake. As you move further east in the watershed agricultural activity begins to dominate and human footprint becomes ubiquitous.

This study was based on similar approaches taken in other studies and the results of this project align quite well with these previous works. Specifically, the inventories in the Parkland County ECMP, and the provincial ESA mapping exercise by Fiera both delineate similar areas as what was mapped through this project. Furthermore, this project has identified, and confirmed through aerial imagery inspection, other areas in the Sturgeon River Watershed that were not identified in past inventories.

It is recommended to identify areas of priority for restoration and conservation efforts within the Sturgeon River Watershed. This could be done by identifying high value natural areas for conservation, or identifying low value natural areas with a high concentration of anthropogenic footprint for restoration efforts. It is the hope of the NSWA that the findings of this project be considered in future land use planning within the Sturgeon River Watershed, and that such a consistent and standardized methodology for natural areas mapping be applied to other watersheds in the North Saskatchewan Basin.

2 Introduction

ALCES Landscape and Land-Use Ltd. (ALCES) was retained by the North Saskatchewan Watershed Alliance (NSWA) to provide natural areas mapping in the Sturgeon River Watershed.

ALCES expanded upon previous work that had been done in discreet areas of the watershed to provide a comprehensive assessment of natural areas throughout the entire watershed.

Natural areas are defined as areas of naturally occurring surface water and/or land that is dominated by native plant species and subject to natural processes that result in naturally occurring vegetation patterns (St. Albert Natural Areas Assessment, 2015). Natural areas can include intact riparian areas, wetlands, lentic and lotic waters, forests, grasslands, shrublands, wildlife corridors, and protected areas.

The objectives of this project were to expand the work done as part of the St. Albert Natural Areas Assessment (Spencer 2015) to the entire Sturgeon River Watershed using innovative techniques and web-based software. Other previous works that also informed this project include the Sturgeon River Watershed Riparian Area Assessment (Fiera Biological Consulting 2018), and the Parkland County Environmental Conservation Master Plan (O2 Planning + Design 2014). Significant natural areas for the entire Sturgeon River Watershed were identified by:

- Reviewing previous natural area inventory reports,
- Incorporating existing datasets such as riparian areas and other mapping products available from NSWA as well as municipalities,
- Delineating terrestrial habitat, including vegetation communities,
- Delineating lotic (rivers, streams) and lentic (lakes, wetlands) areas, and
- Delineating wildlife corridors.

Previous recent studies that encompassed all or portions of the Sturgeon River Watershed include the St. Albert Natural Areas Assessment (Spencer Environmental 2015), the Parkland County Environmental Conservation Master Plan (O2 Planning + Design 2014), and the Sturgeon Watershed Riparian Area Assessment (Fiera Biological Consulting 2018).

In 2015, Spencer Environmental worked with the City of St. Albert to update an existing inventory of natural areas in the lower reaches of the Sturgeon River. All identified natural areas within the study area were further subject to an ecological connectivity analysis that assessed the effectiveness of the ecological network on the landscape (Spencer Environmental 2015). The inventory of natural areas identified during the St. Albert study was expanded upon for the entire Sturgeon River Watershed, by including natural areas identified using ALCES Online, a computer simulation technology specifically designed for assessing the cumulative effects of multiple land uses and natural disturbances (Carlson et al. 2014). . The methodology used for identifying natural areas was modified from the aerial photography interpretation used in the St. Albert inventory (Spencer 2015) to utilize existing datasets available in ALCES Online and integrating newly developed datasets for analysis.

The results of the analyses were assembled into a Natural Areas indicator; digital output made available on the ALCES Online platform. ALCES Online was made available for this project through funding from the Watershed Resiliency and Restoration Program grant obtained by the NSWA. In addition to developing the ALCES Online Natural Areas indicator, stand-alone spatial maps of the Natural Areas identified within the Watershed were created and made available in PDF format.

2.1 The Sturgeon River Watershed

The Sturgeon River Watershed is located in the White Zone of Alberta; the settled portion of the province containing populated centres and agricultural areas (GOA 2008). Major settled areas within the Watershed include a portion of the City of Edmonton, cities of St. Albert, Spruce Grove and Stony Plain. The Watershed encompasses the Alexander and Alexis Indian Reserves and is located in portions of Barrhead, Lac St. Anne, Parkland, Sturgeon, and Westlock Counties (City of St. Albert 2012).

Covering approximately 3,500 km^2, the Sturgeon River Watershed ranges in elevation from 606 m to 871 m above sea level. The Sturgeon River meanders east from its headwaters near Hoople Lake for approximately 260 km before entering the North Saskatchewan River, northeast of the City of Edmonton (Figure 1).

The Manawan Drainage District (Figure 1) was formed in 1948 with the purpose of lowering and stabilizing Lake Manawan to prevent flooding and to drain surrounding lowlands in the district. Formal approval was given in 1950, and drainage district boundaries expanded with additional inclusions in 1953 and 1954 (Alberta Environment, 1983). The drainage worked for a number of years, but due to eventual flooding in 1974 it was suggested that the government purchase lands below a certain elevation and that channel improvement works be initiated (Alberta Environment, 1983). A newer weir was put in place on Manawan Lake in 2003 to further stabilize lake levels.

In 2012, the City of St. Albert conducted a study on the State of the Sturgeon Watershed. Four categories of ecological health indicators were selected and assessed as part of the process. Indicators belonged to land use, water quantity, water quality and biological health categories. As a result of the assessment, an overall grade of "Fair" was assigned to the watershed.

Vegetation and ecosystems within the Sturgeon River Watershed have been extensively modified by agriculture and other development so that approximately 20 percent of the landscape is classified as natural land cover types, in 2012 according to the State of the Watershed report. Urban land use accounts for approximately 4 percent and agricultural land use approximately 70 percent, with the remaining area occupied by roads and other industrial developments (City of St. Albert, 2012).

Three Natural Subregions are found within the Sturgeon River Watershed: Central Parkland, Dry Mixedwood and Central Mixedwood. The heavily populated Central Parkland Natural Subregion is found in the eastern portion of the Watershed and is mostly cultivated with a mosaic of aspen and prairie vegetation. It is estimated that native vegetation accounts for only about 5 percent of the Central Parkland Natural Subregion. Many small waterbodies and wetlands are distributed throughout the Subregion (Natural Regions Committee 2006).

The western portion of the Sturgeon River Watershed is dominated by the Dry Mixedwood Natural Subregion, the warmest boreal Natural Subregion. This subregion is characterized by undulating plains, aspen-dominated forests and fens occurring in low-lying areas (Natural Regions Committee 2006).

The Central Mixedwood Natural Subregion is found in a small area in the upper Watershed and is typically associated with terrain that is low relief and exhibits a level to undulating surface. The vegetation is similar to that of the Dry Mixedwood Natural Subregion, described as a mosaic of aspen, mixedwood and white spruce forests with jack pine forests found on coarse materials. The differences between the Subregions are exhibited in the proportions of various vegetation types and landscape features. Wetlands are extensive and are dominated by black spruce fens and bogs (Natural Regions Committee 2006).

2.2 Review of previous studies

A detailed review of the methodologies and results of the following natural area studies that encompassed all or portions of the Sturgeon River Watershed was conducted:

1) St. Albert Natural Areas Assessment (Spencer Environmental 2015),
2) Sturgeon Watershed Riparian Area Assessment (Fiera Biological Consulting 2018),
3) Parkland County Environmental Conservation Master Plan (O2 Planning + Design 2014), and
4) City of Edmonton State of Natural Areas Project (Spencer Environmental 2006).

St. Albert Natural Areas Assessment (Spencer Environmental 2015)

In 2015, Spencer Environmental worked with the City of St. Albert to update an existing inventory of natural areas – the overall study area included the lower reaches of the Sturgeon River within City limits and a three km buffer around the City (Figure 2). All identified natural areas within the study area were further subject to an ecological connectivity analysis that assessed the effectiveness of the ecological network on the landscape (Spencer Environmental 2015).

The natural area inventory was conducted by overlaying existing natural area polygons from previous studies (Stantec 2014; Golder 2010; Spencer 1999; Spencer 2006) with 2014 aerial photography. Discrepancies between the data sets were analyzed and polygon boundaries were adjusted to reflect the changes in natural areas observed during the aerial photography interpretation. Natural areas identified during recent inventories that overlapped the study area were incorporated into the inventory. Road-side reconnaissance surveys of undeveloped lands identified during the aerial photography review were conducted for methodology verification.

Identification of natural areas for the inventory update was conducted by:

1) Overlaying known natural area polygons on 2014 aerial photos (1:2000 to 1:4000 scales), analyzing discrepancies and adjusting natural area boundaries. Natural areas in the

overall study area, the 3 km buffer outside the City boundaries, were not characterized, only mapped (no field observations) using aerial photo interpretation, and

2) Performing roadside reconnaissance surveys of detailed study areas within City limits to verify aerial photo interpretation.

Data reported for the natural area inventory included a count of natural areas, the surface area of each, and the jurisdiction in which it belonged.

After the natural area inventory was updated, natural areas were subject to an ecological connectivity analysis to determine if the landscape supported necessary components essential to an effective ecological network. Effective ecological networks allow native species to persist by facilitating ecological processes and movement among the habitat patches on the landscape. Ecological connectivity analysis was achieved by:

1) Performing a qualitative evaluation of the natural area size, shape and position in the landscape,
2) Assigning a descriptor to the natural area based on its function as a core area, corridor or stepping stone as per Forman's (1995) definitions, and
3) Performing GIS analysis on natural area patches to identify important stepping stone clusters (minimum 2 ha patches buffered by 100 m identified the most relevant stepping stone clusters, from the perspective of constituent patches and location on the landscape).

The analysis of natural areas within the overall study area resulted in a total inventory of 350 natural areas with a combined total area of 1810 ha. The results of the ecological connectivity analysis showed that the network formed by the natural areas in the study included the necessary components (core habitat areas, corridors, and stepping stones) to function as an effective ecological network.

Sturgeon Watershed Riparian Assessment (Fiera Biological Consulting 2018)

Fiera Biological Consulting (Fiera) used the geospatial riparian habitat assessment method that was previously developed and validated in the Modeste Watershed (Fiera Biological 2018) to inventory and assess riparian areas along shorelines in the Sturgeon River Watershed (Figure 2). In total, 1770 km of shoreline along 18 lakes, 8 named creeks and rivers, and 53 unnamed creeks was assessed as part of the study.

The objectives of the study were to assess the condition of riparian areas in a Geographic Information System (GIS) using metrics comparable to and validated against existing aerial videography methods and to quantify natural and anthropogenic pressures that exist upslope (local catchments) of riparian areas.

The GIS metrics that were used to assess the condition of the riparian areas were:

1) Proportion of cover by land cover classes containing natural vegetation,

2) Proportion of cover by land cover classes containing woody vegetation (forest, swamp, bog), and
3) Proportion of cover by land cover classes containing human footprint.

Each metric was quantified using a high resolution (6 m) land cover data derived from SPOT satellite imagery, and the scores for each metric were aggregated into a single value that was assigned to a condition class. Riparian Intactness classes were created, which is analogous to riparian condition.

The pressure on the riparian system function resulting from natural and anthropogenic stressors within each local catchment area was assessed by adopting the Watershed Integrity scoring methodology developed by Flotemersch et al. (2016).

Overall, 41 percent of the shoreline that was assessed for riparian condition was classified as High Intactness and 13 percent was classified as Moderate Intactness. The remaining riparian areas were classified as either Low (20 percent) or Very Low (25 percent) Intactness. The study did not find distinct spatial patterns relative to Riparian Intactness, with a majority of waterbodies showing variation along banks and between right and left banks.

Of the 600 local catchments covering an area of approximately 3300 km^2 in the Sturgeon River Watershed, approximately 25 percent was classified as High Pressure. A majority of the catchments (58 percent) were classified as Moderate Pressure. Areas of high pressure were concentrated in the central and southern portions of the Sturgeon River Watershed. Pressure scores for catchments that intersect creeks and streams were found to be higher than those adjacent to lakes.

Parkland County Environmental Conservation Master Plan (O2 Planning + Design 2014)

Parkland County is situated in the southern portion of the Sturgeon River Watershed (Figure 2). The Parkland County Environmental Conservation Master Plan (ECMP) contains a comprehensive index of Environmentally Significant Areas (ESAs) identified within the county. ESAs were defined as "places that are vital to the long-term maintenance of biological diversity, soil, water, or other natural processes at multiple scales, that can be used as a strategic conservation tool for land use planning and policy (Fiera Biological Consulting 2009)."

The criteria used for identifying ESAs was based on landscape ecology principles demonstrated by Forman (1995). For an ecologically viable landscape, the following Indispensable Landscape Patterns are recognized: 1) Large patches of natural vegetation, 2) Connectivity between large patches, 3) Vegetated corridors along streams and rivers, and 4) Stepping stones of small natural vegetation patches (Forman 1995). Table 1, below lists the ESA criteria that was selected for the Parkland County ECMP.

ESA criteria were weighted according to relative importance and overlain in a multi-criteria model. GIS-based analysis using a polygon overlay approach based on existing available datasets was used to identify ESAs.

Table 1. ESA criteria and associated landscape values, from Parkland County ECMP (O2 Planning + Design 2014)

ESA Criteria Theme	GIS Layers	Landscape Values			
		Biodiversity	Connectivity	Water Quality	Water Quantity
Species and habitats of conservation concern	Rare plant species	x			
	Important fish habitat	x		x	x
	Important wildlife habitat	x	x		
	Important bird habitat	x	x		
	Riparian habitat	x	x	x	
Landscape Ecology Measures	Patch size	x	x	x	x
	Patch complexes	x	x	x	x
	Circuit connectivity	x	x	x	
	Major rivers valleys systems	x		x	x
Landforms and Steep Slopes	Rare or unique landforms	x			
	Steep slopes			x	x
Wetlands	Wetland ecosystems	x	x	x	x
	Peatland ecosystems	x	x	x	x
Surface water resources	Amount of water flowing into rivers (water yield)			x	x
	Surface water licenses volume per unit area			x	x
	Lake and river water quality			x	x
	Water erosion potential			x	x
	Rivers, lakes, and streams			x	x
	Lakeshore environments			x	x
Groundwater resources	Water wells per unit area			x	x
	Licensed groundwater volume per unit area			x	x
	Groundwater recharge areas			x	x
	Natural springs			x	x
	Buried valley aquifers			x	x
	Surficial sand and gravel aquifers			x	x
	Risk of groundwater contamination			x	x
Protected Areas and Research Areas	Provincial protected areas	x	x	x	x
	Municipal conservation areas	x	x	x	
	NGO owned and managed areas	x	x	x	x
	Areas of significant on-going ecological research	x		x	x

Results from the analysis were examined and field reconnaissance surveys were conducted to validate the results of the model. Each potential ESA identified in the model was checked using a combination of recent aerial photographs, driving public access roads, helicopter aerial surveys, and other available information.

City of Edmonton State of Natural Areas Project (Spencer Environmental 2006)

In 2005, Spencer Environmental worked with the City of Edmonton to conduct a State of Natural Areas project, in which the objectives of conservation mapping (using existing datasets), landscape connectivity analysis, and natural areas systems analysis would be fulfilled. This was done by updating an existing inventory of natural areas, as well as mapping other natural areas through a subtractive mapping exercise. The regional study area for this initiative included the Sturgeon, Beaverhill, and Strawberry watersheds, as well as the boundaries of the City of Edmonton (Figure 2). A landscape connectivity analysis was then conducted within a 2 mile buffer of the City of Edmonton, through which a functional ecological network was identified and mapped (Spencer Environmental 2006).

Natural areas within the regional study area were mapped through the following processes:

1) Within the boundaries of the City of Edmonton, a pre-existing natural areas inventory from 1993 was updated based on hi-resolution aerial photography from 2005 (Spencer Environmental 2006). Polygon boundaries were adjusted to reflect the changes in natural areas observed from imagery. Changes were either reductions in polygon size due to clearings and fillings, or increases in polygon size due to vegetation expansion.
2) For areas within the city of Edmonton, in which no pre-existing datasets were available a subtractive mapping process was applied. Essentially all lands were assumed to be natural, then known non-natural lands were extracted from this. Non-natural lands were defined as built-up areas, manicured areas, agricultural lands, gravel extraction areas, and exposed soils. Finally, areas smaller than 1 ha were also eliminated and remaining polygons were defined as natural areas and validated with 2005 aerial photography (Spencer Environmental 2006).
3) Finally, for areas outside the City of Edmonton, municipal ESA inventories were queried. Where digital inventories were unavailable, original maps were digitized and used. For municipalities with no existing inventories at all, provincially designated protected areas (including parks, natural areas, and wildlife areas) were used. It is important to note that data used for the Sturgeon River Watershed in this assessment was dated back to 1989 and not updated (Spencer Environmental 2006).

Natural areas identified within the 2 mile buffer of the City of Edmonton were subject to a landscape connectivity analysis. Connectivity was mapped by defining the landscape in terms of the following features, and assessing them according to the level of resistance they provide to movement:

1) Habitat patches, which are defined as contiguous units of native habitat (synonymous with natural areas) and provide no resistance to movement (Spencer Environmental 2006).
2) Linkages, which are contiguous units of manicured vegetation (i.e. parks, golf courses, vegetated rights of way), and which provide a moderate resistance to movement (Spencer Environmental 2006)
3) Barriers, which are features that wildlife would avoid (i.e. roads), and which provide a high resistance to movement (Spencer Environmental 2006)
4) and the landscape matrix in which travel occurs from one of these features to another, (i.e the surrounding land use layer; Spencer Environmental 2006).

Resistance to movement values were mapped and only positive scores were kept. Specific types of habitat patches and linkages were then categorized (based on patch metrics) and the resulting map demonstrated Edmonton's Ecological Network (Spencer Environmental 2006).

As a final step to the State of Natural Areas project, a Natural Areas System Analysis was conducted, in which the current scientific approaches to natural areas conservation, existing policies and strategies aimed towards conservation, and trends associated with Edmonton's natural areas were discussed. Important findings of this analysis include the concepts of engaging the public, forming cooperative partnerships, and focussing on habitat protection (Spencer Environmental 2006). Trends in Edmonton's natural areas have shown 308 ha of loss since 1993, with majority of this loss due to suburban expansion. Of note, the Sturgeon River Watershed contains approximately 494 ha of the natural areas, while 0 ha of this total is designated with protected status (Spencer Environmental 2006).

2.3 Natural area mapping for the Sturgeon River Watershed

Expanding on the natural areas inventory and mapping conducted by the City of St. Albert (2015), natural areas within the entire Sturgeon River Watershed were identified using an approach similar to that outlined in Parkland County's ECMP (2014), utilizing existing datasets where available, and developing new spatial layers using ALCES Online.

Table 2 below, outlines the newly developed and existing datasets that were used in the identification of natural areas in this report.

Table 2. Datasets obtained or derived for use in the assessment of natural areas

Data Layer	Source and Year	Usage
Water Undifferentiated	ABMI 2010, AAFC 2014, EOSD 2000	Natural Land Cover Layer
Exposed Land	ABMI 2010, AAFC 2014, EOSD 2000	Natural Land Cover Layer
Shrubland	ABMI 2010, AAFC 2014, EOSD 2000	Natural Land Cover Layer
Wetlands Undifferentiated	AAFC 2014	Natural Land Cover Layer
Forest Wetland	AAFC 2014	Natural Land Cover Layer
Treed Wetland	AAFC 2014	Natural Land Cover Layer
Shrub Wetland	AAFC 2014	Natural Land Cover Layer
Herb Wetland	AAFC 2014	Natural Land Cover Layer
Grassland	GVI 2006, AAFC 2014, EOSD 2000	Natural Land Cover Layer
Forest Coniferous	GVI 2006, AAFC 2014, EOSD 2000, ABMI 2010	Natural Land Cover Layer

Data Layer	Source and Year	Usage
Forest Deciduous	GVI 2006, AAFC 2014, EOSD 2000, ABMI 2010	Natural Land Cover Layer
Forest Mixedwood	GVI 2006, AAFC 2014, EOSD 2000, ABMI 2010	Natural Land Cover Layer
Human Footprint	See Appendix	Cost Surface layer
Riparian polygons	Fiera Biological Consulting 2018	Riparian Indicator
Environmental Reserves	Schedule 6 of Growth Plan Update Task Force 2016	Areas of Specific Interest Indicator
Conservation Easements	Geogratis	Areas of Specific Interest Indicator
Wilderness Areas	AltaLIS 2012	Areas of Specific Interest Indicator
Provincial Parks	AltaLIS 2012	Protected Areas Indicator
Crown Grazing	Government of Alberta 2014	Areas of Specific Interest Indicator

3 Methods

The following steps were taken to identify natural areas in the landscape:

1) Develop natural area themes
2) Build indicators to meet specific themes in ALCES Online
3) Combine indicator layers using equal weights, and delineate natural areas from final output
4) Compare results with previous studies (St. Albert Natural Areas Assessment, Parkland County's Environmental Conservation Master Plan, City of Edmonton's State of Natural Areas Project, and provincially mapped Environmentally Significant Areas).

3.1 Develop Themes

Basic themes defining a natural area were identified and indicator(s) for each theme were selected. Indicators used in this assessment were based off previous works and are listed in Table 3 below. Indicators were then developed using ALCES Online (AO), a computer simulation technology designed for comprehensive assessment of the cumulative effects of multiple land uses and natural disturbances to ecosystems (Carlson et al. 2014). In most cases, indicators were scaled from zero to one; however, in some cases indicators were assigned values based on the indicator class, as in Table 3 below. These values were derived from previous ESA studies in the watershed.

Table 3. Indicators and scoring criteria used in current assessment.

Theme	Indicator	Class	Score
Landscape Ecology	Patch Size	Patches > 500 ha	1
		500 ha > Patches > 200 ha	0.75
		200 ha > Patches > 50 ha	0.5
		50 ha > Patches > 5 ha	0.25
		Patches < 5 ha	0.1
	Patch Complex Size	Complex > 10,000 ha	1
		10,000 ha > Complex > 1,000 ha	0.75
		1,000 ha > Complex > 500 ha	0.5
		500 ha > Complex > 200 ha	0.2
		200 ha > Complex > 50 ha	0.1
	Connectivity	Scaled from 0-1 based on percentage of cell allocated to Connectivity Corridor indicator	0 - 1
Surface Water Resources	Riparian Areas	Scaled from 0 to 1 based on the proportion of natural land cover in each riparian area	0 – 1
	Wetland Areas	Scored either 0 or 1, depending on absence or presence	0 or 1
	Lentic and Lotic Waters		
Vegetative Ecosystems	Forest Patches	Scaled from 0-1, zero representing the smallest patch, and one representing the largest.	0 – 1
	Grassland Patches		
	Shrubland Patches		
Other	Protected Areas	Provincial Parks	0.75
	Areas of Specific Interest	Environmental Reserves	1
		Conservation Easements	1
		Wagner Natural Area	1
		Provincial Grazing Reserves	0.5
		Clifford E. Lee Natural Area	0.5

3.2 Derive Indicator Layers

3.2.1 Landscape Ecology Theme

The principals of landscape ecology highlight certain areas and patterns in the landscape that help preserve ecological functions. These areas and patterns, being of the utmost ecological importance should be identified and conserved. Such patterns include:

1) Large patches of natural vegetation
2) Connectivity between large patches in the form of wide corridors
3) Clusters of small vegetation patches which act as stepping stones and enable movement from one large patch to another. Small micro-site natural areas (i.e. wetlands, forest patches) play this role.

These landscape types are vital to a properly functioning ecosystem (Forman 1995).

Ecological networks allow native species to persist on a landscape by facilitating critical ecological processes such as nutrient dispersal, genetic exchange, and daily and seasonal movement among the habitat patches within the landscape (Forman 1995). Connectivity refers to the spatial arrangements and characteristics of habitat patches in the network. A successful ecological network achieves connectivity within a landscape through a linked system of habitat patches (Forman 1995).

3.2.1.1 Patch Size

Large patches of natural vegetation provide habitat diversity and core function for species with large home ranges and enable higher population sizes. Patch size is also correlated to the capacity of a landscape's biodiversity (O2 Planning + Design 2014).

In this assessment, Total Natural Land Cover was represented as the sum of all natural land cover types including exposed land, coniferous forests, deciduous forests, mixedwood forests, grasslands, shrublands, and wetlands. Natural Land Cover Patch area was then calculated and patches were binned and subsequently assigned values based on pre-defined classes, as used in Parkland County's Environmental Conservation Master Plan and as listed in Table 3.

3.2.1.2 Patch Complexes

While larger patches of natural landcover are important for ecological health, smaller disconnected patches that are within close proximity to each other may function as a single large patch and therefore are also important for proper ecological function and health. Patch complexes, as they are called, were incorporated into this assessment by first calculating a cost surface which represents the restrictions of travel through the landscape. Natural cover types were given a value of 1, indicating that travel through these cover types is unrestricted. Disturbed landcover types were given a value of 3, and developed cover types a value of 10, indicating impeded travel and greatly restricted travel, respectively. This cost surface was then used to buffer each natural landcover patch by a value of 50 cost units, which connected patches that were easily accessible from each other, and therefore identified complexes of patches that could function as a single large patch. Any overlapping buffers delineated a single complex and the total area of all patches that fell within a single complex was then assigned to each patch within that complex. Area values were then binned and assigned scores based on pre-defined classes, as used in Parkland County's Environmental Conservation Master Plan and as listed in Table 3.

3.2.1.3 Patch Connectivity

Connectivity of patches, enabling travel from one patch to another or from one complex to another, is important to consider in the overall ecological health of a landscape. Maintaining an unobstructed landscape on which ecological processes, such as geneflow and species dispersal can act is important for biodiversity and the longevity of species. Connectivity was modelled in this study by calculating the least-cost path, based on the pre-defined cost surface, between each patch that fell within the large patch size class, regardless of distance between patches. The cumulative overlap of all least cost paths represented the relative value of each cell towards maintaining connectivity between existing large patches. These values were then scaled from 0 to 1, zero representing no ability to maintain connectivity between patches and one representing a higher ability to maintain connectivity. As a last step the large patches themselves were added to this indicator layer and represented a value of 1.

3.2.2 Surface Water Resource Theme

Surface water resources are important to include in any natural areas inventory as they comprise important ecosystems such as riparian areas, wetlands, and lotic and lentic habitats. These ecosystems perform many functions in maintaining the integrity and function of a natural area. These ecosystems are also of great importance to the communities in the watershed as they provide many human functions, such as recreational opportunities, irrigation for agriculture, and drinking water.

3.2.2.1 Riparian Areas

Riparian areas are critical to ecological health as they provide important functions such as bank stabilization and erosion control, water quality control, flood mitigation, as well as fish and wildlife habitat. They also often act as corridors connecting larger patches of habitat and enabling dispersal and gene flow. Riparian areas are characterized by vegetation that grows in response to the site conditions found in the transition zone between uplands and surface waterbodies.

In this assessment, natural land cover was calculated within pre-defined riparian areas that demonstrated high intactness. Riparian polygons were acquired from the Sturgeon Watershed Riparian Area Assessment (from Fiera Biological Consulting) and were delineated by a fixed 50 m buffer width and variable length dependant on breaks in percent cover of natural vegetation. Intactness categories were defined by intactness scores which were dependant on the equal weighted average of three different riparian health metrics. Metrics were percent cover of natural vegetation, percent cover of woody species, and percent cover of human footprint. Natural landcover proportion was then calculated within the high intactness riparian polygons.

3.2.2.2 Wetland Areas

The upper headwaters of the Sturgeon River drain a large area southwest and west of Isle Lake. Headwaters are composed of a network of wetland and riparian areas that may be important for maintaining flows within the Sturgeon River (O2 Planning + Design Inc. 2014).

Wetlands, transitional environments intermediate between aquatic and terrestrial ecosystems, perform many ecological functions such as erosion control, flood mitigation, and water quality control. They also provide unique and diverse habitat for an abundance of plants and wildlife species. Wetlands are characterized by specific soil types and dominant hydrophytic vegetation (Steward & Kantrud, 1971).

The wetland indicator was incorporated into the assessment by using total wetland data from Alces Online. Total wetlands were represented in a binary fashion, with 0 value representing absence of wetland area and one representing the presence of a wetland area.

3.2.2.3 Lentic and Lotic Habitat

Lentic and lotic water resources are important ecosystems for fish and other aquatic organisms. They also often provide connectivity across the landscape. These water systems are not included in the overall Total Natural Land Cover calculation, yet they are still important natural areas that should be considered and included in any natural area inventory. Therefore, lentic and lotic waters were included in this assessment by filtering the AAFC land cover datasets for lentic and lotic coverage types. These data were then assigned binary values of 0 or 1, with zero representing absence of lentic or lotic features on the landscape and one representing the presence of these features.

3.2.3 Vegetative Ecosystems Theme

Vegetated land cover such as forest, grassland, or shrubland, is a key component that can regulate the water, carbon, and nitrogen cycles in an ecosystem (CNVC, 2013). Moreover, vegetation, as biomass, forms the basis of all food chains and therefore provides direct goods to all species. Vegetation also releases oxygen, sequesters carbon, facilitates productive soils, and provides habitat (Science Daily, 2018). As such, vegetative ecosystems are considered vital for overall ecosystem health, and form an important part of a natural areas inventory.

3.2.3.1 Forest Patches

Forests are important within the Sturgeon River Watershed because of the cover they provide many species, as well as the other ecological functions they perform. Forests can store carbon, preserve soils, and help purify air and water (Natural Resources Canada, 2017). Larger patches of forest are even more important as they can support larger populations, larger species, and provide more diverse habitat. Increasing forest patch size has been shown to be positively correlated with plant species density (Guldemond & van Aarde, 2010), avian species diversity (McIntyre, 1995), and negatively correlated with physiological stress in certain bird species (Suorsa et al., 2004). Forest patch size has even been shown to alter mammal behaviour in Amazonian forest fragments (Norris et al., 2010).

In this assessment, forests were represented on the landscape as any forest type, including deciduous, coniferous, or mixed. Patch size was then calculated and scaled from 0 to 1, representing smallest to largest patch sizes.

3.2.3.2 Grassland Patches

Like forests, grasslands can provide important ecosystem services such as soil stability and forage quality (Lamarque et al., 2011). According to the U.S. Forest Service, grasslands facilitate long distance seed dispersal, mitigate drought and floods, and even detoxify and decompose waste (US Forest Service, n.d.) Grassland patch size can also be an important indicator of natural areas, as it has been positively correlated with abundance and occurrence of certain mixed-grass prairie passerine birds (Davis, 2004). As an important habitat type in the Sturgeon River Watershed, grasslands were incorporated into this assessment through a patch calculation. Cells categorized as grassland were included in the patch calculation, and patches were scaled from 0 to 1, representing smallest to largest patches.

3.2.3.3 Shrubland Patches

Similarly, shrublands are important natural ecosystems as they provide an array of goods and services including, provisioning of food and fiber, regulating water and air quality, and supporting primary production and nutrient cycling (Havstad et al., 2007). Shrubland patch size is also important to consider as it has been positively correlated to shrubland bird diversity (Shake et al., 2012). Shrublands were incorporated into the current natural areas assessment through a patch calculation as well. Cells categorized as shrubland were included in the patch calculation, and patches were scaled from 0 to 1, representing smallest to largest patches. Shrublands are considered plant communities that are dominated by shrubs, brush, and bush.

3.2.4 Other Themes

3.2.4.1 Protected Areas

This indicator included all provincially designated parks and assigned them a value of 0.75 (Table 3). Although provincial parks often have a high human presence, they are still considered natural areas in this assessment, as they are assumed to have minimal development and anthropogenic footprint.

3.2.4.2 Areas of Specific Interest

Areas considered in this assessment include the Wagner Natural Area, the Clifford E. Lee Natural Area, environmental reserves, conservation easements, and any Provincial Grazing reserves. Different values were applied to different areas, as replicated from Parkland County's

Environmental Conservation Master Plan (O2 Planning + Design Inc. 2014) and outlined in Table 3.

3.3 Combine Indicator Layers and Delineate Natural Areas

Indicator layers were then aggregated into a single Natural Areas roll-up layer, using an equal weighted average approach. A minimum size of 0.5 ha was applied; areas below this size limit are unlikely to perform ecological functions in a manner that contributes in a meaningful way to the greater ecosystem. Sites under 0.5 ha are vulnerable to a number of pressures, including rapidly changing hydrology, sedimentation, contamination, and invasive species. Our data was assessed at 100m resolution, therefore the smallest patch size possible is 0.01 km^2, which is greater than 0.5 ha. From this, the process of filtering out patches less than 0.5ha, although important to note, was unnecessary.

Results for this Natural Areas roll-up layer are presented in the following section.

4 Results

4.1 Percentage of land cover types in the Sturgeon River Watershed

Total natural land cover only makes up approximately 31% of the Sturgeon River Watershed, with the dominant cover type represented by deciduous forest at 17.3%, followed by lakes, represented by lentic water at 5.5% (Table 4).

Table 4. Land cover types by percentage in the Sturgeon River Watershed.

Land Cover Types	Percentage of Watershed
Coniferous Forest	2.1%
Deciduous Forest	17.3%
Mixed Forest	0.5%
Grassland	0.7%
Shrubland	0.7%
Exposed Land	0.3%
Lentic Water	5.5%
Lotic Water	0.5%
Wetland	3.9%
Total Natural Land Cover	**31.5%**

4.2 Indicator Results

4.2.1 Patch Size

Natural land cover patch size ranged from 0.5 ha to 14,000 ha within the Sturgeon River Watershed. The largest patches were primarily concentrated in the headwaters near Isle Lake, Birch Lake, and Lac Ste. Anne, as well as near the alexander First nation Reserve and Sandy Lake (Figure 3). Smaller patches were scattered in the mid to eastern portion of the watershed (Figure 3). Elongated patches, which can act as travel corridors, surrounded the Sturgeon River near its mouth. Average patch size in the watershed was 38 ha, which corresponds to a score of 0.25, indicating an abundance of smaller patches on the landscape in the Sturgeon River Watershed.

4.2.2 Patch Complexes

Patch complexes within the watershed ranged from 52 ha to 54,080 ha, with an average size of 2,827 ha. This corresponds to an average score of 0.75 for the basin and indicates that even though the watershed has predominantly small patches, they can still act together as a functionally large patch. Patch complexes smaller than 50 ha in size were designated a score of 0 and were therefore effectively filtered out of the indicator. As a result, there are no functional patch complexes in the Morinville area (Figure 4).

4.2.3 Patch Connectivity

Connectivity between the large patches on the landscape shows a concentration of connective corridors, between the City of St. Albert, the Town of Onoway, the Sandy Lake area near the Alexander First Nation Reserve, and the areas surrounding Lac St. Anne and Isle lake (Figure 5). Considering that the large patches only occur in the western portion of the watershed, connective corridors were only delineated in that portion as well.

4.2.4 Riparian Areas

The riparian areas, as defined polygons from Fiera Environmental, delineate distinct areas of intact land cover along the major rivers, creeks, lakes, and wetlands in the watershed (Figure 6). The highest concentration of natural land cover within the intact riparian areas occurs along the Sturgeon River near the mouth, along Sandy Lake, and near the Alexis Nakota Sioux First Nation reserve.

4.2.5 Wetland Areas

Wetlands are scattered throughout the Sturgeon River Watershed, with high concentrations occurring near Big Lake, Lois Hole Centennial Provincial Park, Johnny's Lake, Alexander First Nation Reserve, and near the Town of Gibbons (Figure 7). A notable lack of wetland occurs near the Town of Morinville and the City of Spruce Grove. Together wetlands cover 3.9% of the watershed and are comprised of fens, bogs, swamps, shallow open water, and marshes.

4.2.6 Lentic and Lotic Habitat

All natural lotic and lentic habitats make up approximately 6% of the Sturgeon River Watershed (Figure 8). The major lentic waterbodies include Isle Lake, Lac St. Anne, Birch Lake, Sandy lake, Big Lake, and Manawan Lake. The major lotic waterways include the Sturgeon River, Kilini Creek, Riviere Qui Barre, Atim Creek, and Toad Creek.

An important component of the surface water network, which is composed of lentic and lotic waters, is the interaction and interplay it can have with the groundwater system. The Carvel Pitted Delta area, the wet hummocky depressions near Spring Lake, and the pitted delta sediments south of Big Lake, are of specific interest as they have been identified as groundwater recharge zones, or areas where groundwaters can be replenished by surface waters (Oiffer, n.d; Figure 8). Conversely, the fen complexes around the Wagner wetlands area are dependant on groundwater inputs in order to maintain their water levels, nutrient levels, and temperature regimes (Oiffer, n.d; Figure 8). These areas are examples of natural areas that are dependant on surface water – groundwater interactions, and are delineated as natural areas in Figure 13 of this report.

4.2.7 Forest Patches

Forest patch size ranged from 0.75 ha to 4,630 ha, with average patch size over the entire Sturgeon River Watershed at 26 ha. Total forest coverage comprised approximately 19.9 % of the watershed and was primarily made up of deciduous forest types (17.3%), with some coniferous (2.1%), and a small amount of mixed (0.5%). The larger forest patches were primarily found in the headwaters surrounding Isle lake and Lac St Anne, as well between the town of Onoway and Villeneuve, and near Sandy Lake, while there was a notable lack of forest coverage in the eastern portion of the watershed (Figure 9).

4.2.8 Grassland Patches

Although minimal by area in the Sturgeon River Water and only covering approximately 0.7% of the basin, grasslands are an important ecosystem for the Sturgeon River Watershed. With patch sizes ranging from 0.5 ha to 31.5 ha, and an average patch of 2.1 ha, grassland hotspots are found mostly east of Sandy Lake, near Alexander First Nation Reserve (Figure 10).

4.2.9 Shrubland Patches

Shrublands are also very rare in the Sturgeon River Watershed, covering only 0.7% of the basin by area. Shrubland patch size range from 0.5 ha to 2.8 ha, with the largest patch found near the Alexis Nakota Sioux First Nation reserve (Figure 11).

4.2.10 Protected Areas

The only provincial park that is designated within the Sturgeon River Watershed is the Lois Hole Centennial provincial park (Figure 12).

4.2.11 Areas of Specific Interest

Other areas of specific interest that were considered in the assessment include environmental reserves, conservation easements, the Wagner and Clifford E. Lee Natural Areas, and provincial grazing reserves (Figure 12). At 2.1% by area, these regions make up a fairly small proportion of the watershed.

4.3 Natural Areas in the Sturgeon River Watershed

Figure 13 delineates the natural areas in the Sturgeon River Watershed, with darker colours representing areas that score higher, and lighter colour the areas that score lower. The headwaters of the watershed, and the areas surrounding the Sturgeon River and Big Lake, as well as the areas near Sandy Lake within the Alexander First Nation Reserve, are clearly delineated as natural area hotspots, relative to the eastern portion of the watershed that is dominated with agricultural activity. This pattern is recognized in reverse when looking at total human footprint on the landscape (Figure 14). Encompassing approximately 69% of the watershed, total footprint types are concentrated in the mid to eastern portion of the watershed, especially near the town of Morinville. This finding may highlight a need for more natural areas conservation or restoration initiatives in this region.

Using a roll up cut-off value of 0.2 and only displaying natural areas above that value, results coincide well with the previous studies reviewed in Section 1. The natural areas delineated by the City of St. Albert overlay fairly well, with only a few small patches of outliers (Figure 15). Furthermore, these results identify additional natural areas that are not delineated in past studies.

The Parkland County ECMP identified Environmentally Significant Areas (ESAs) within the county, some of which overlap with the Sturgeon River Watershed. When assessing these ESAs alongside the current assessment results for high scoring natural areas (using a cut-off value of 0.2), the spatial overlap aligns quite well (Figure 16). Other natural areas are identified in additions to those coinciding with the ESAs and underlying imagery confirms their natural appearance.

Most of the natural areas identified by the City of Edmonton in 2006 are also identified through this mapping approach, expect for the natural area around the Lois Hole Centennial Provincial Park region (Figure 17). It is important to note, that the current assessment also identifies numerous other areas within the Sturgeon River Watershed as high value natural areas that are not delineated in the City of Edmonton State of Natural Areas Project. This could be because the natural areas for the Sturgeon Watershed were digitized from a 1989 report, and have not been updated since. Therefore, they are indeed out dated and may not reflect the most up-to-date technologies for mapping and delineating natural areas.

Finally, provincially delineated ESAs also show a similar pattern, in which there are few ESAs in the eastern portion of the watershed near Morinville, and concentrated ESAs in the headwaters (Figure 18).

5 Conclusion & Recommendations

The primary objective of this project was to expand the work done as part of the St. Albert Natural Areas Assessment (Spencer 2015) to the entire Sturgeon River Watershed. To achieve this, we used Alces Online, a web-based software, and employed a multicriteria approach to delineate and value natural areas within the Sturgeon River Watershed. The outcome of this project, a continuous natural areas value surface for the entire Sturgeon River Watershed, allows for a more comprehensive understanding of the Sturgeon River landscape, based on the criteria and indicators assessed. The criteria selected to identify natural areas represented a broad range of important environmental indicators. In total, four themes and 11 indicators were selected to help define, measure, and map natural areas in the Sturgeon River Watershed. The application of criteria to objectively delineate and value natural areas has resulted in a transparent and repeatable process that can be replicated in other watersheds or updated with new data or indicators. It is hoped that the outcomes of this project may be used in future land-use planning efforts within the Sturgeon River Watershed to help conserve existing natural areas.

The findings of this project have identified the headwaters of the watershed, as well as the areas surrounding Sturgeon River, Big Lake, and the Alexander First Nation Reserve as natural area hotspots. Other natural areas existing as well within the watershed and are mostly located in the western portion of the drainage area. Further to the east the landcover begins to become dominated by human footprint, primarily agricultural activity. In fact, approximately 69% of the watershed encompasses some form of anthropogenic footprint. The area surrounding the town of Morinville has an especially high concentration of human footprint and is therefore a priority area for natural areas restoration initiatives.

Although this project establishes a robust methodology for delineating and valuing natural areas in a watershed, the proposed methodology also has a few limitations. These limitations surround the concept of data availability and resolution. Updated landcover and footprint data could be used for more accurate results and higher resolution data could be used to increased precision. Furthermore, ground-truthing of results was not conducted and is a recommended next step.

It is recommended to focus conservation efforts on the headwaters of the Sturgeon River Watershed where the identified natural areas are of highest value and density, while focussing restoration efforts in the lower eastern portion of the watershed where human impacts are more widespread. Specific areas for restoration could include the areas surrounding Spruce Grove, Manawan Lake, and the town of Morinville. Reclaiming riparian areas and wetlands should be prioritized as these types of natural areas provide many important ecological functions and habitats. Other general recommended practices for conserving and restoring natural areas include, education and outreach to individuals and industry to encourage responsible land management, consideration of cumulative effects in all future project developments, and encouraging compliance with environmental best management practices through incentives and penalty enforcement.

Specific next steps involve ground-truthing results to validate the model, identifying each natural area as a core habitat, stepping stone, or corridor, prioritizing areas for conservation and/or restoration, and developing and implementing area-specific conservation management plans and/or detailed restoration plans.

6 Figures

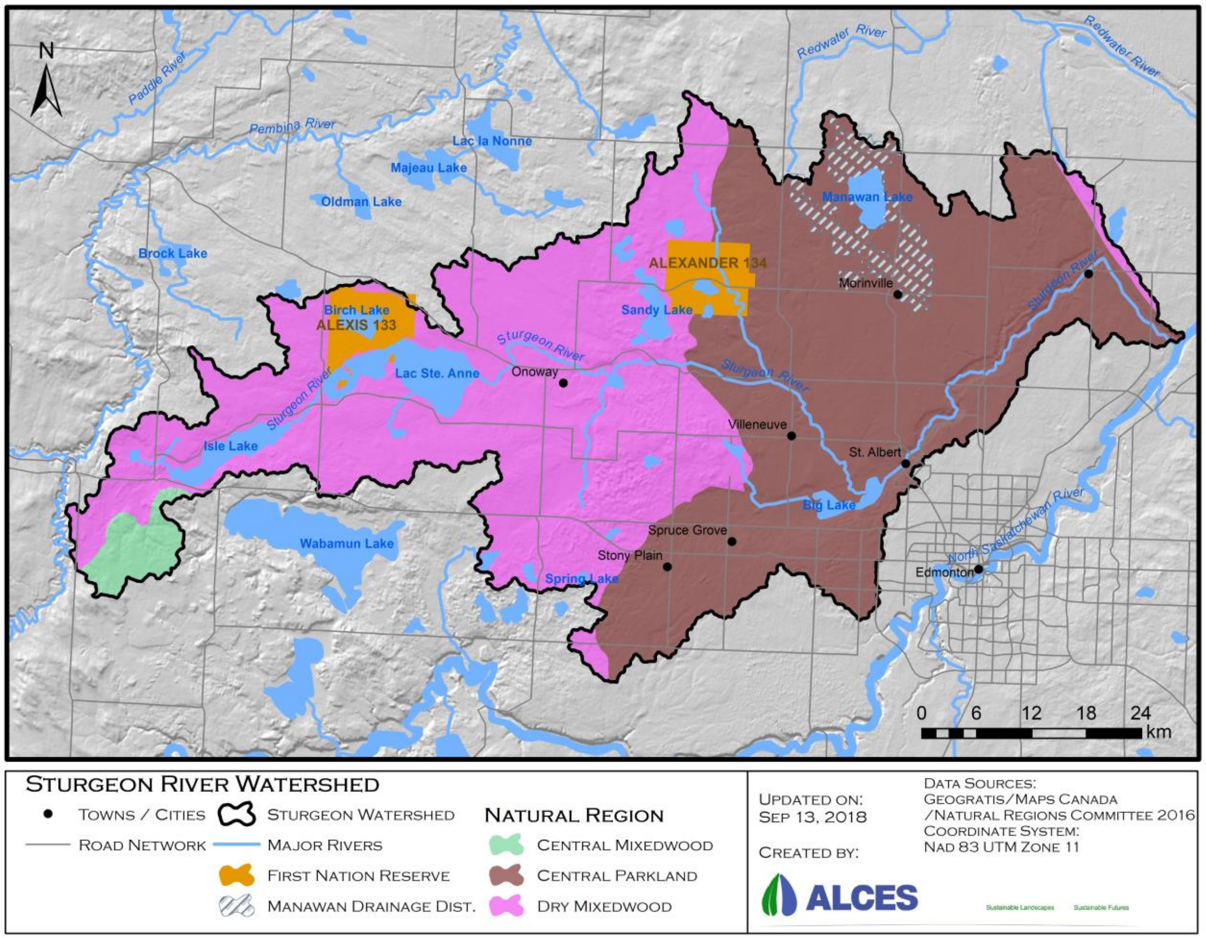


Figure 1. Map of the Sturgeon River Watershed

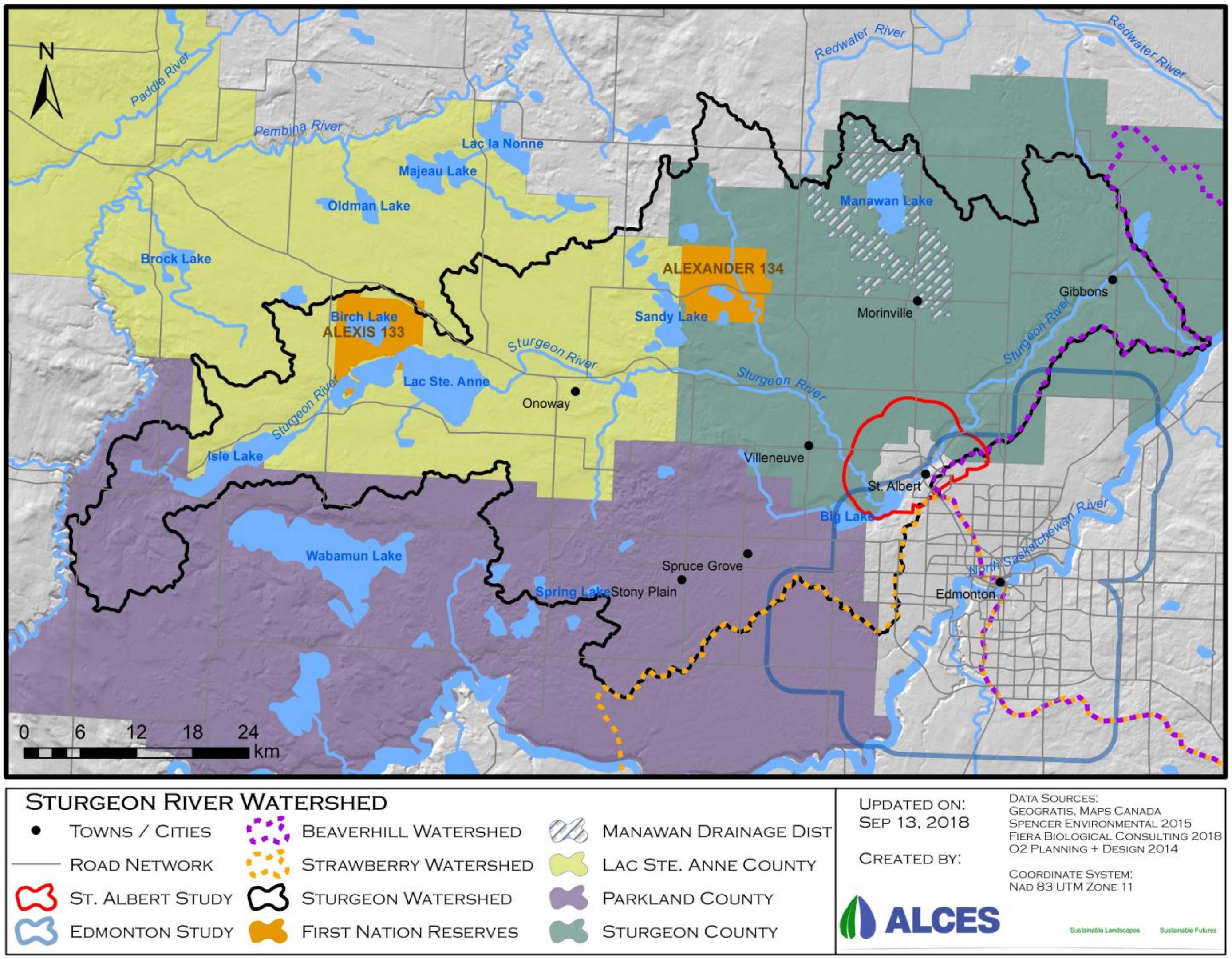


Figure 2. Sturgeon River Watershed depicting assessment areas for previous studies.

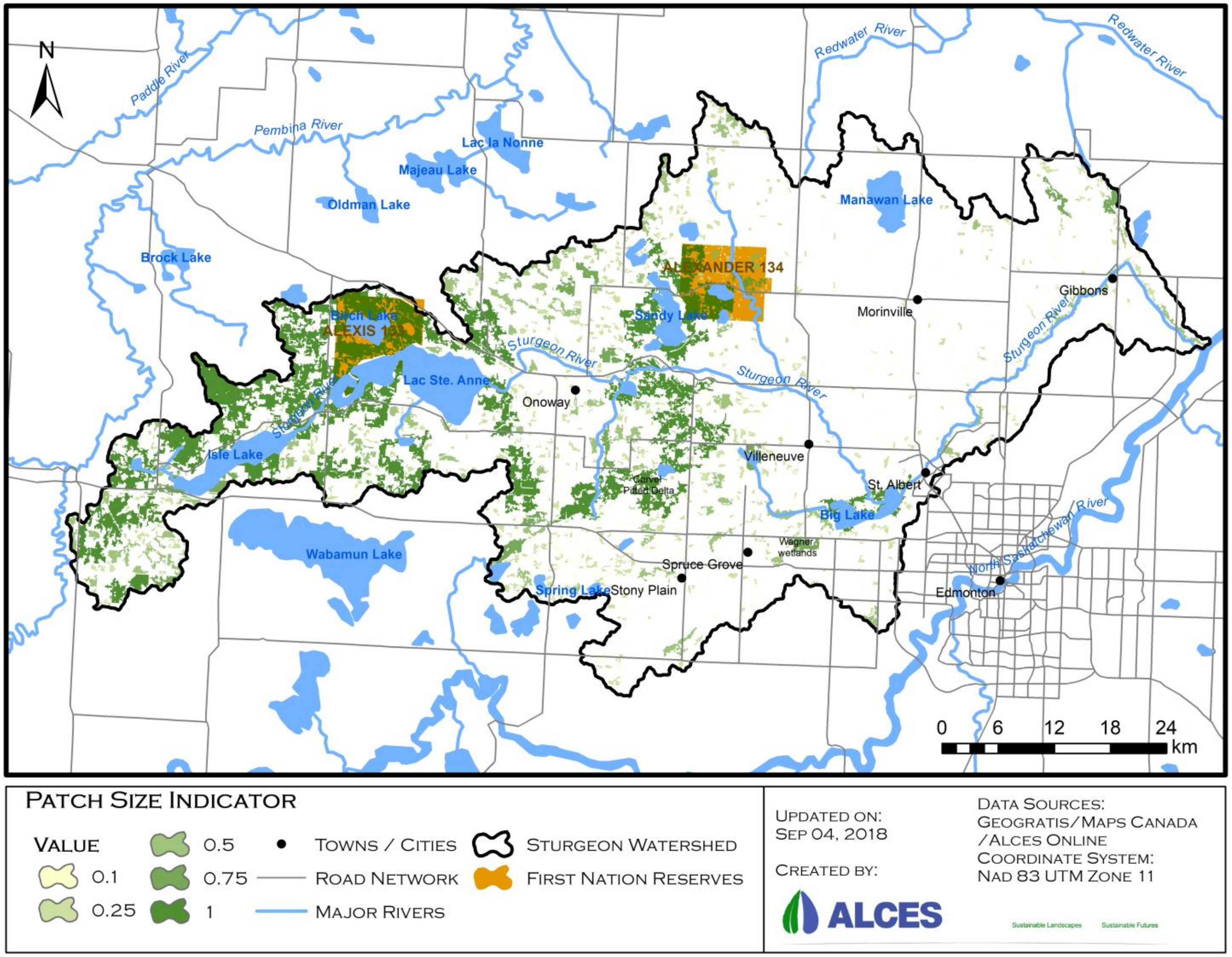


Figure 3. Map of the natural landcover patch size indicator, where 0 = low and 1 = high value.

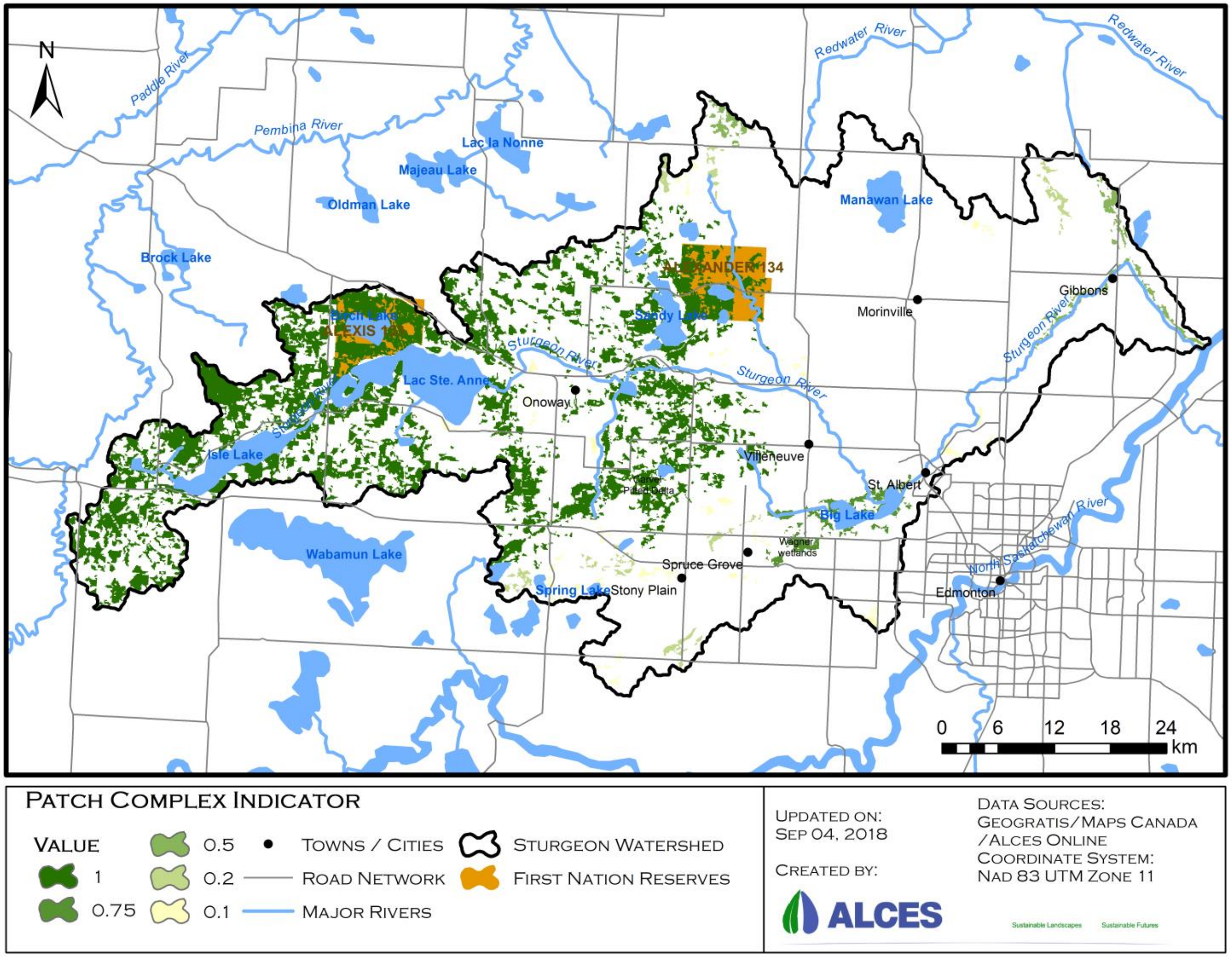


Figure 4. Map of patch complexes within Sturgeon River Watershed, where 0 = low and 1 = high value.

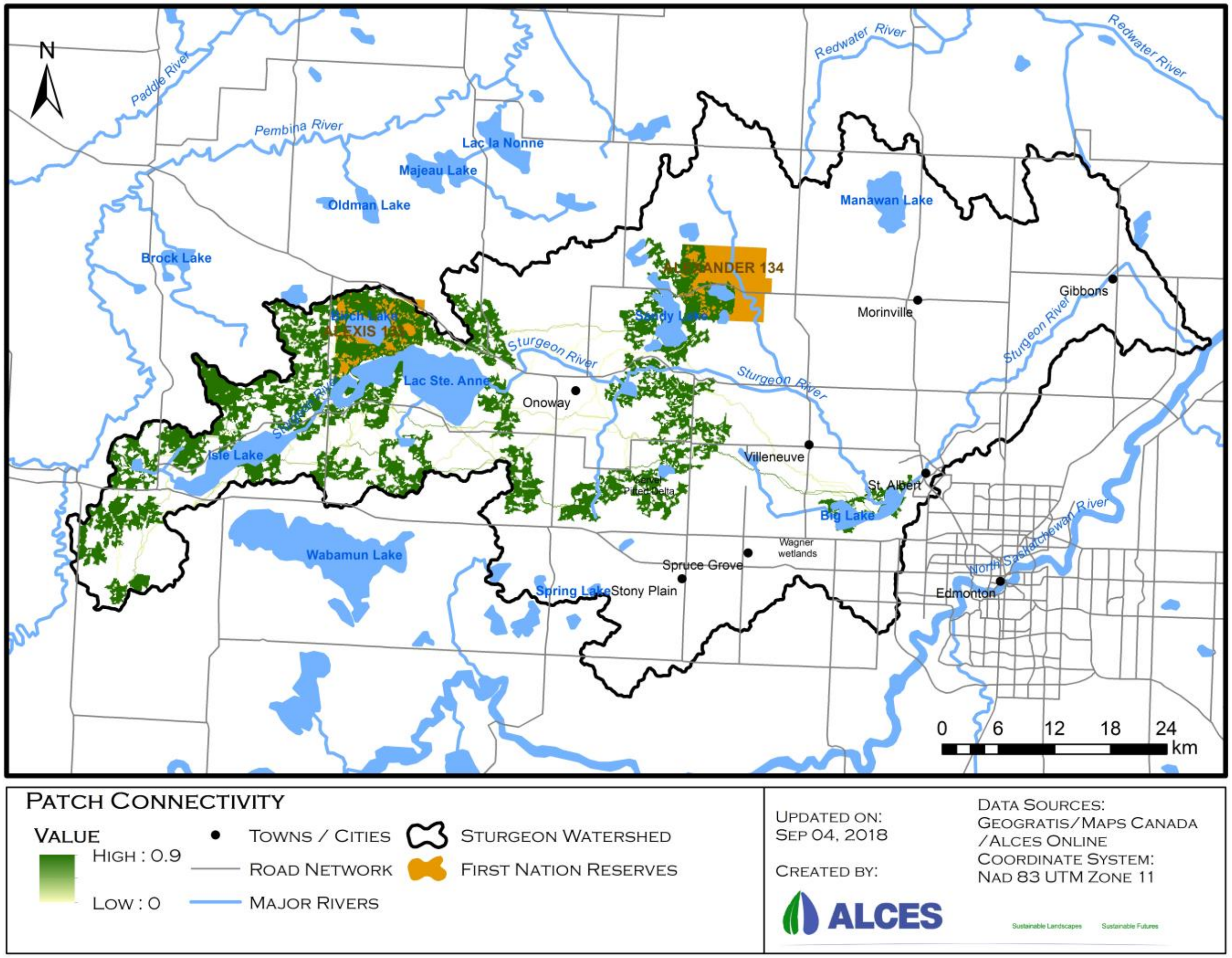


Figure 5. Map of connectivity indicator representing least cost paths between all large patches, where 0 = low and 1 = high value.

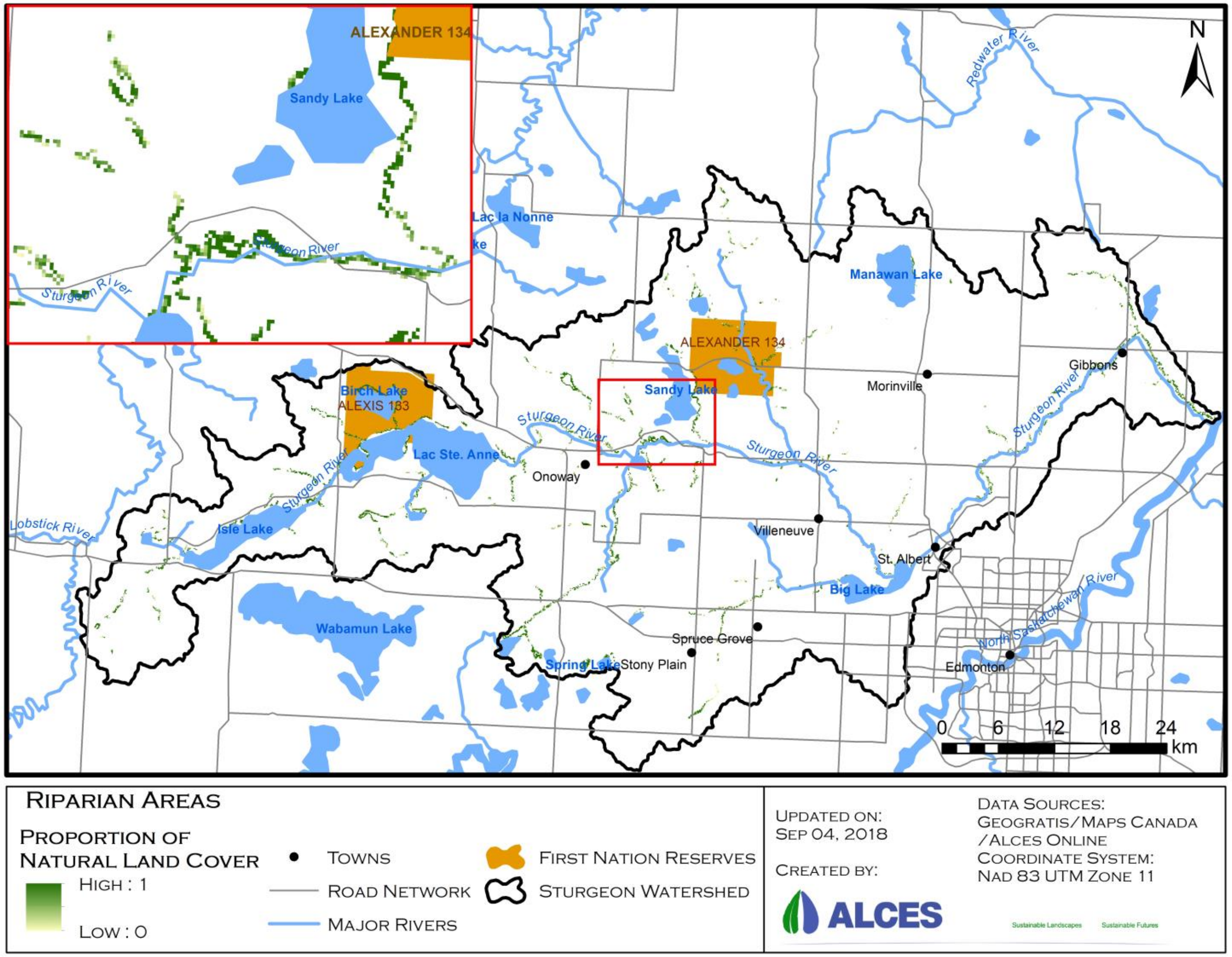


Figure 6. Map of the riparian areas indicator (representing highly intact riparian areas), scaled from zero to one.

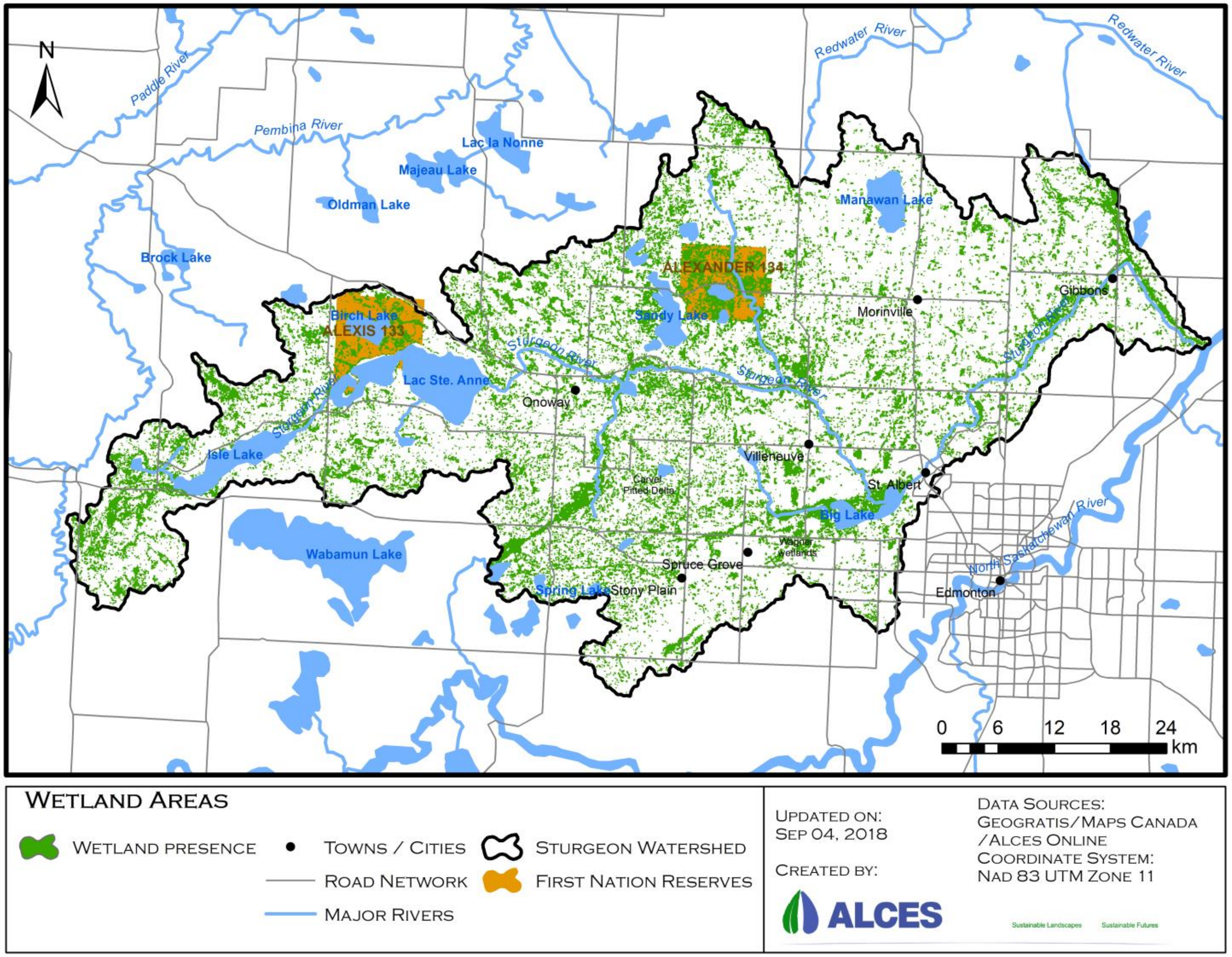


Figure 7. Map of the wetland areas indicator.

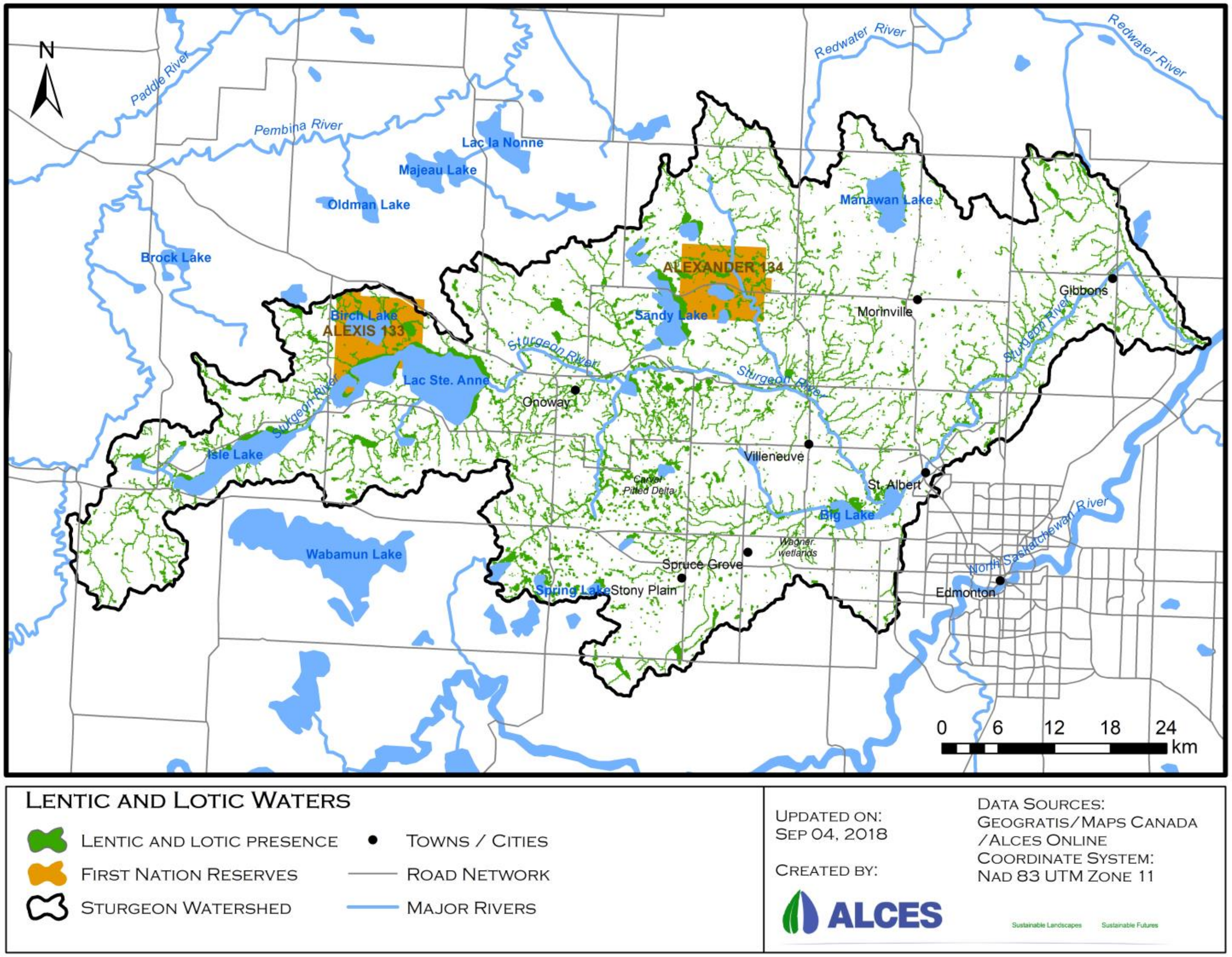


Figure 8. Map of the lentic and lotic water resources.

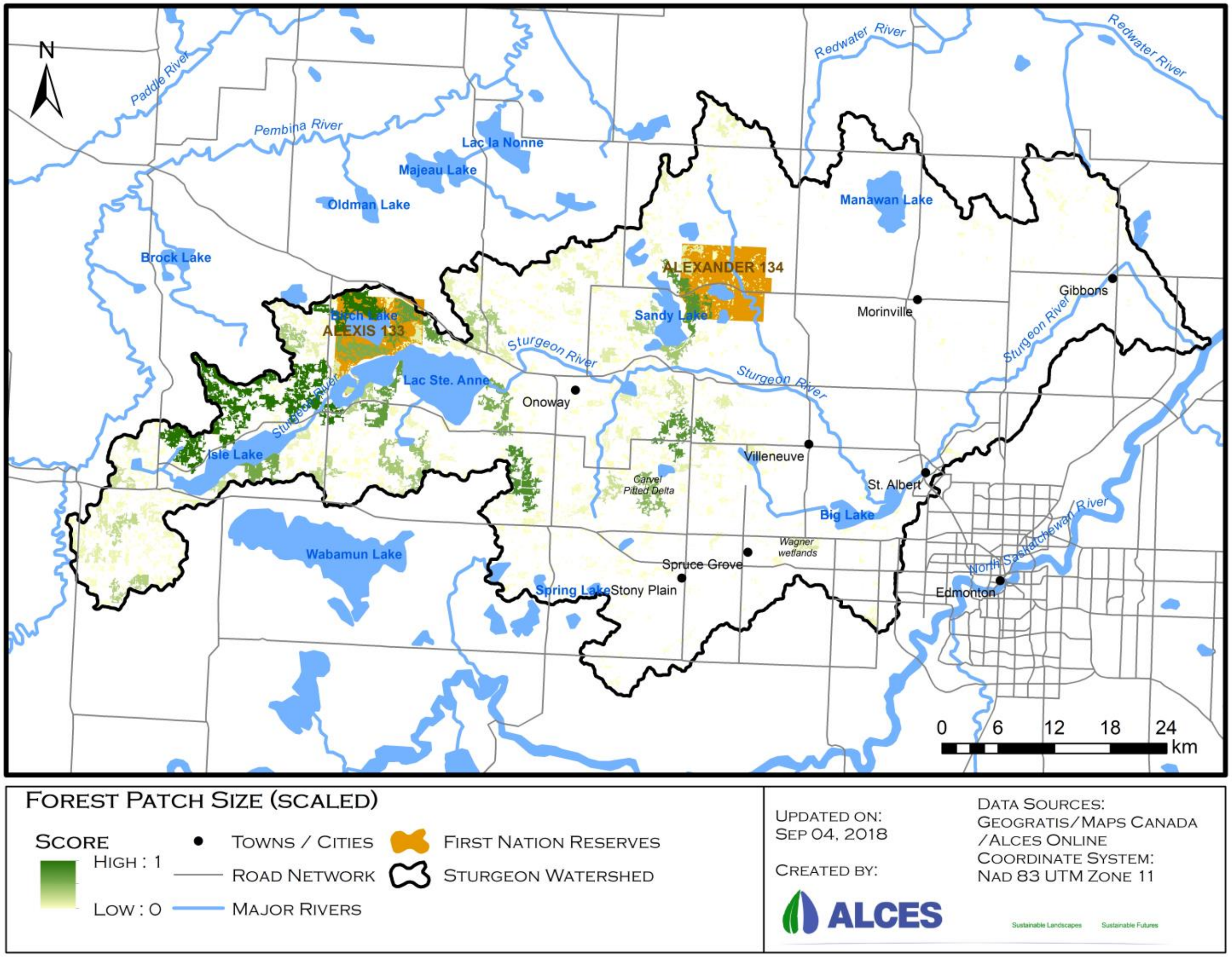


Figure 9. Map of forest patches, scaled by size from zero to one.

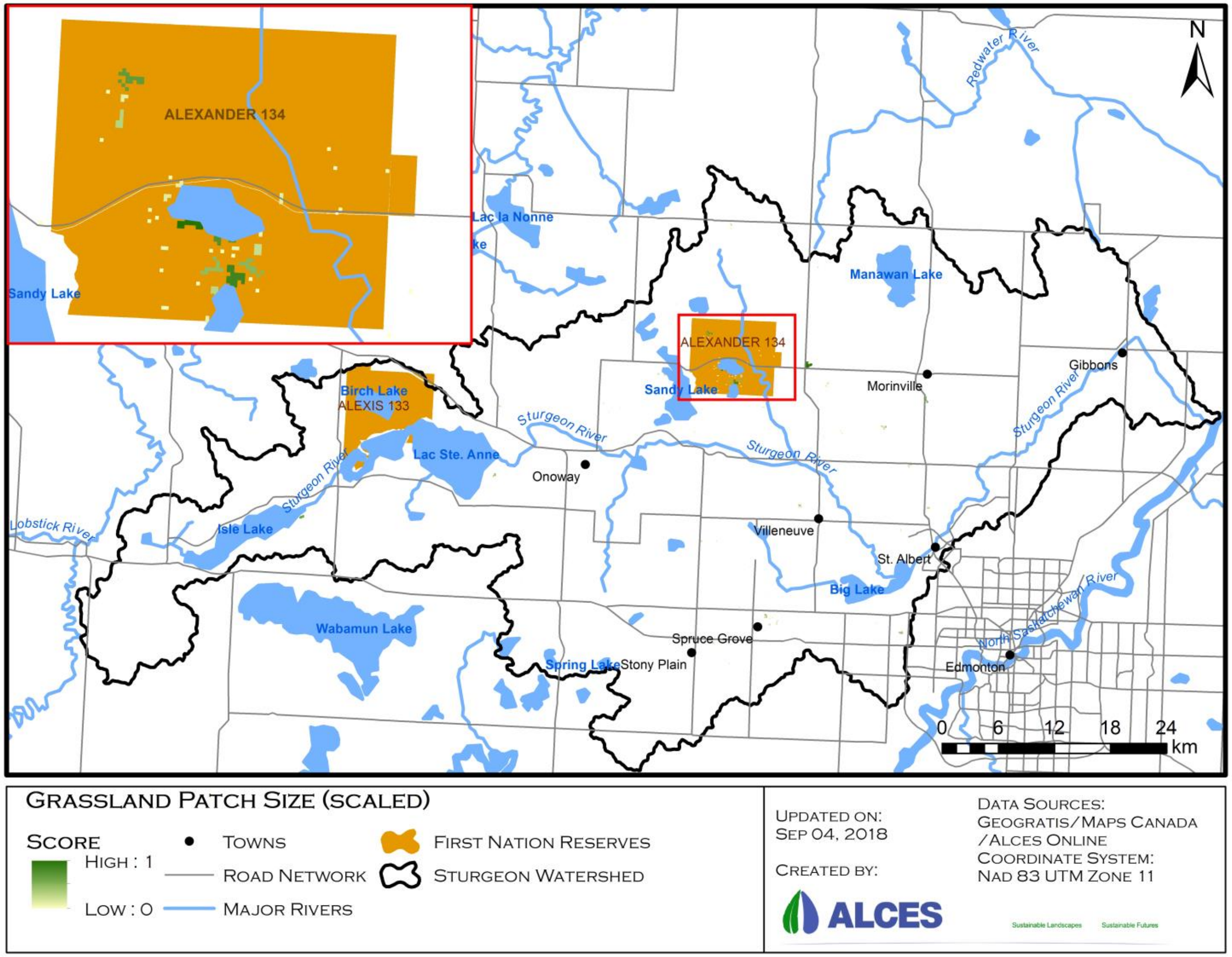


Figure 10. Map of grassland patches in the Sturgeon River Watershed, scaled by size from 0 to 1.

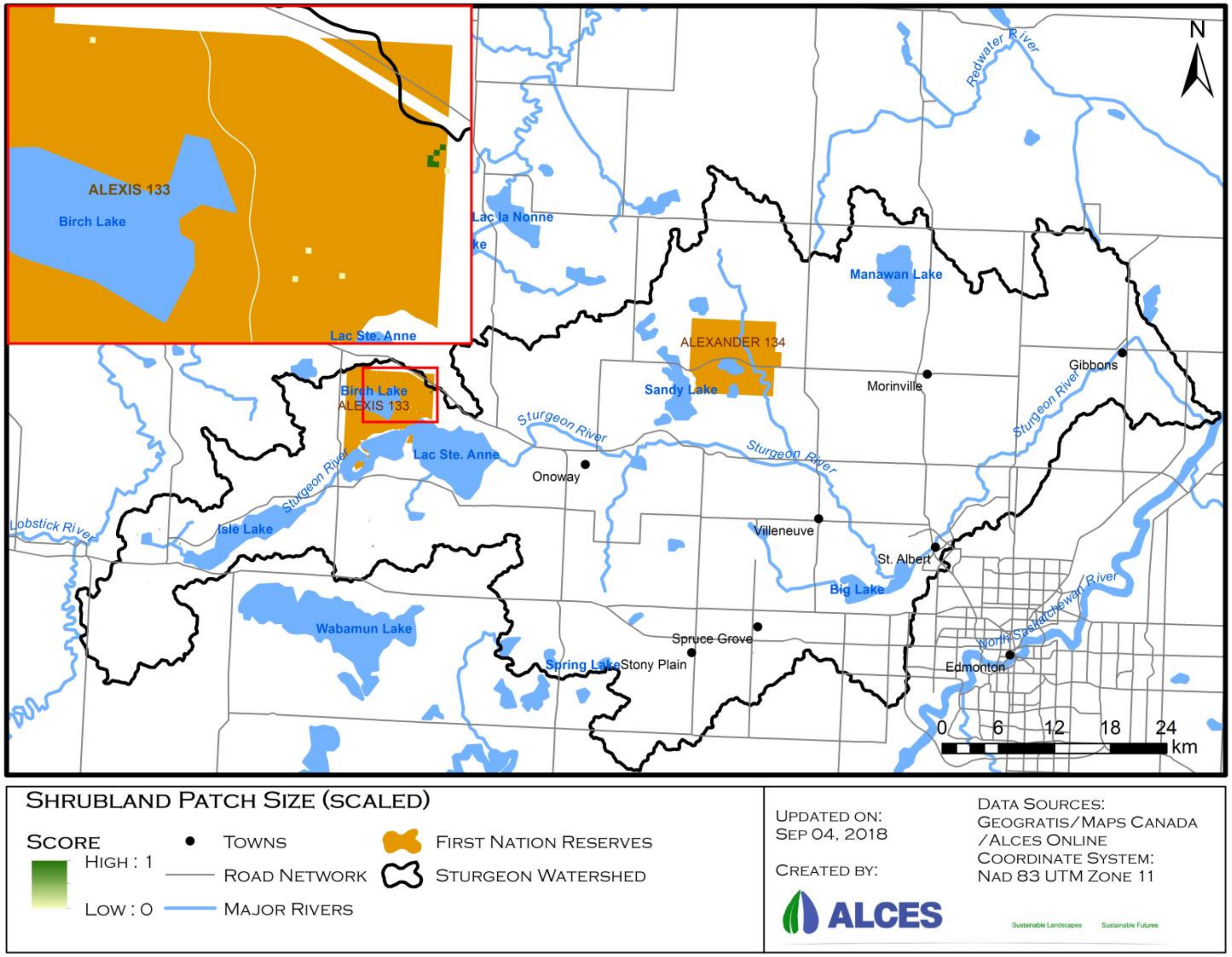


Figure 11. Map of shrubland patches in the Sturgeon River Watershed, scaled by size from 0 to 1.

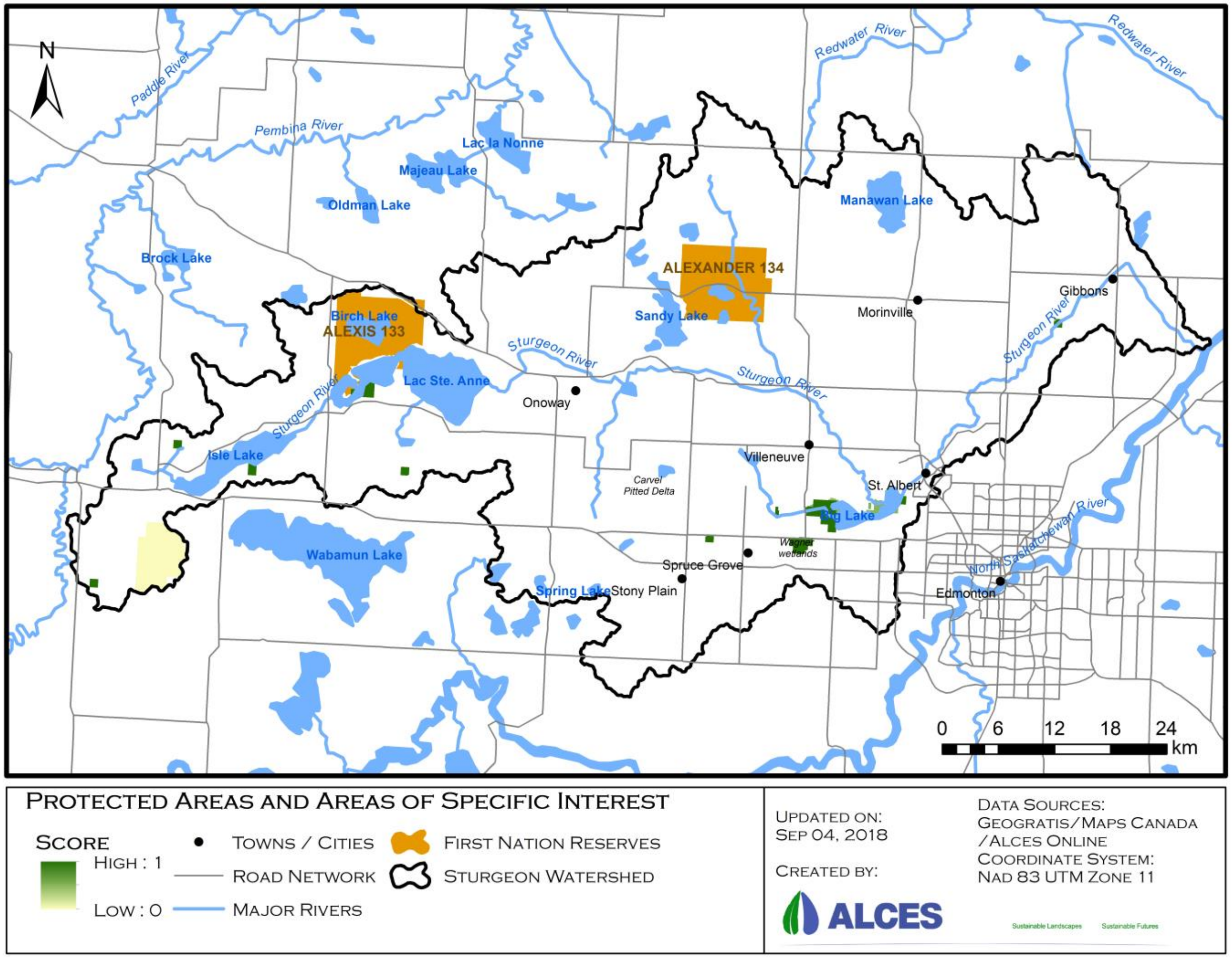


Figure 12. Map of the protected areas and areas of specific interest within the Sturgeon River Watershed. Regions are assigned values based on Table 3.

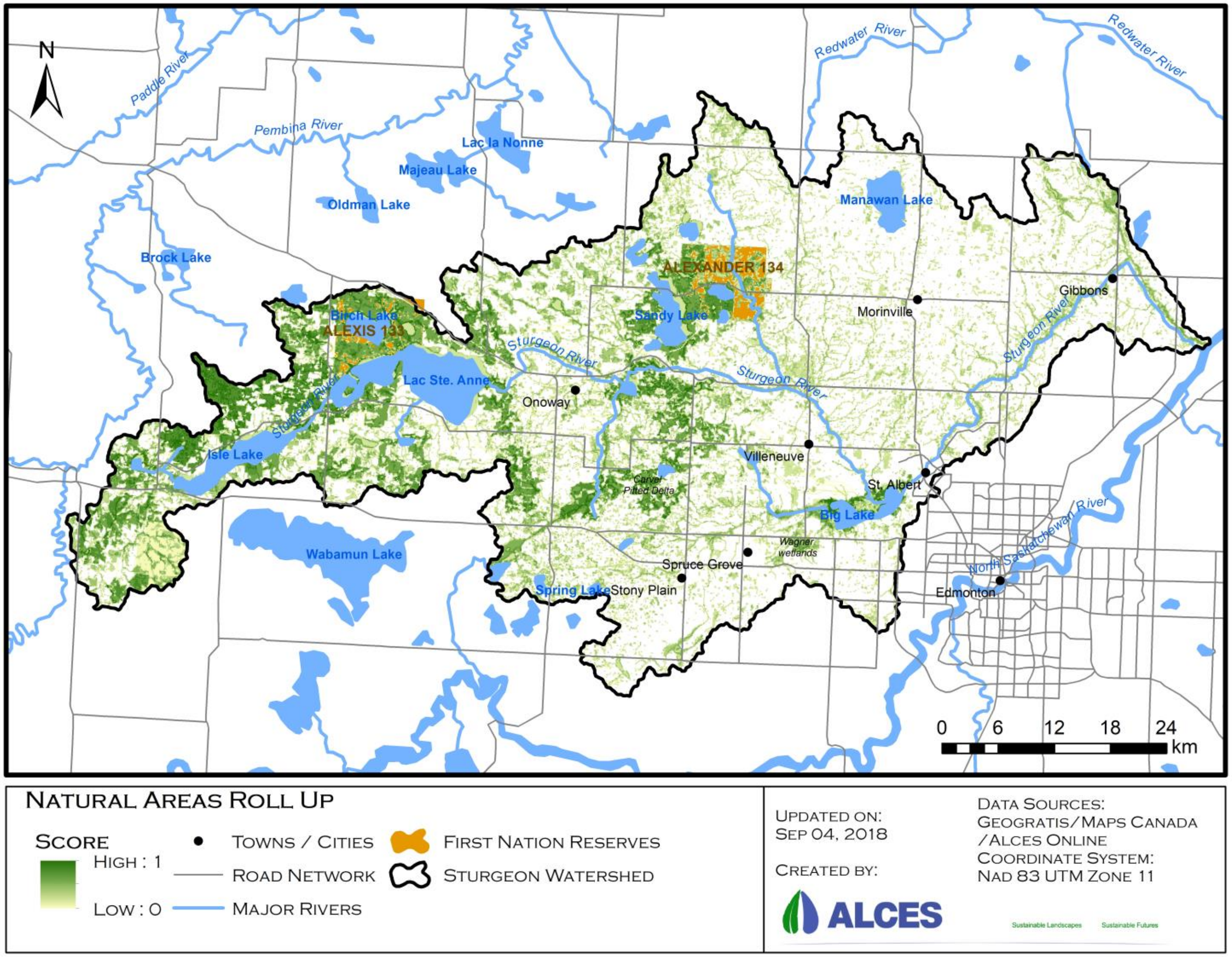


Figure 13. Map of the Natural Areas Roll-Up Layer, which combines all indicator layers.

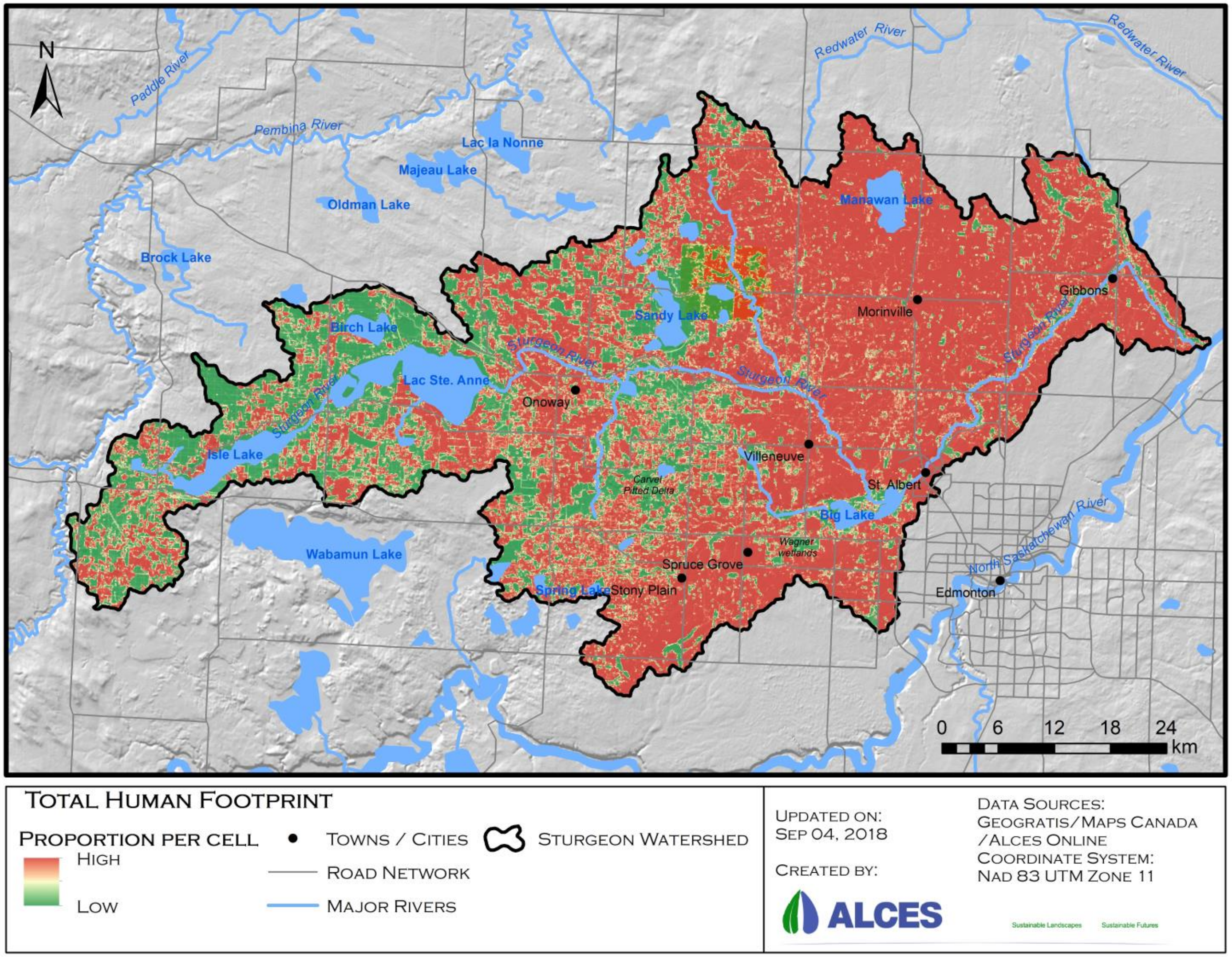


Figure 14. Total Human Footprint in the Sturgeon River Watershed.

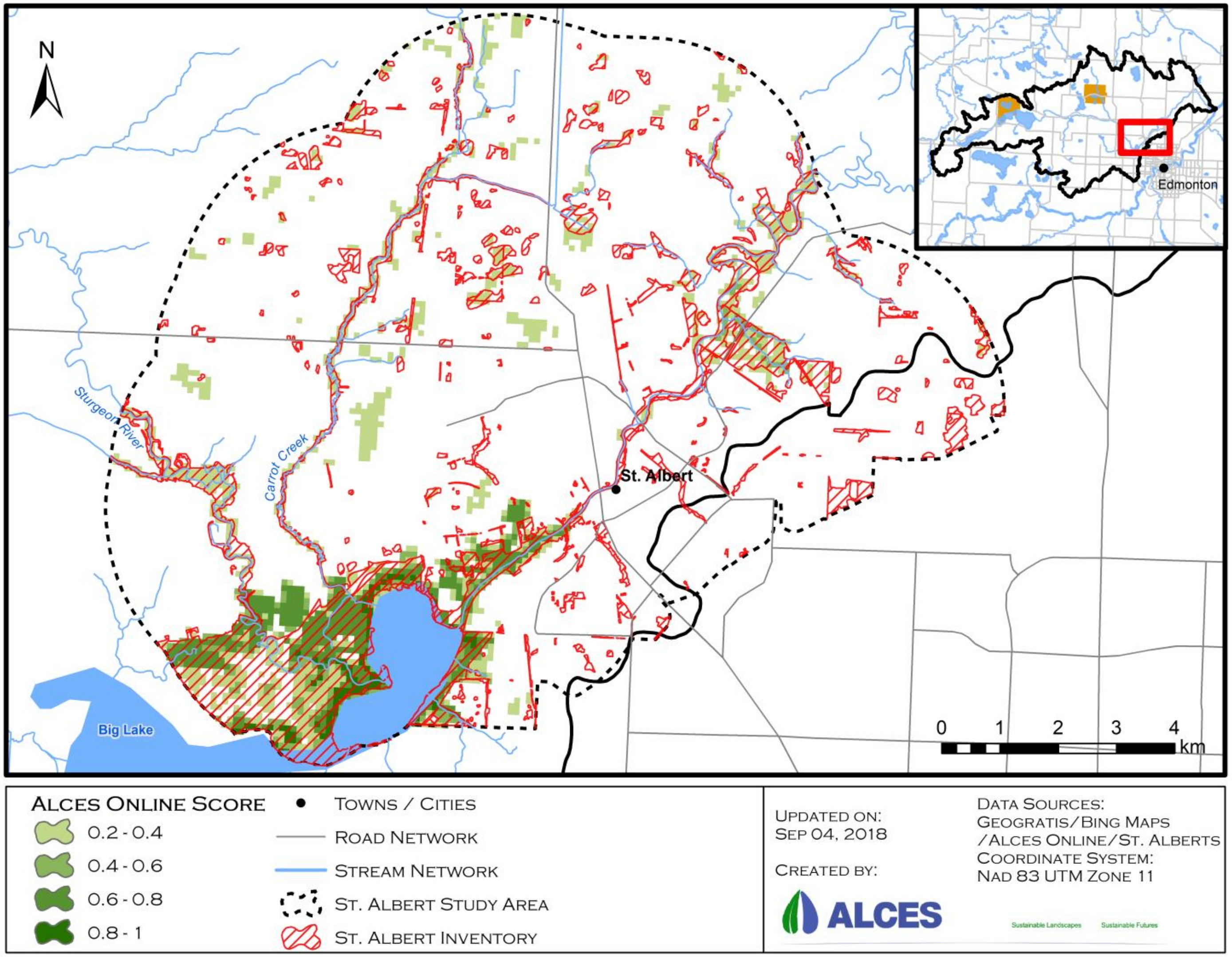


Figure 15. Comparison of City of St. Albert Natural Area Inventory results, with current assessment results.

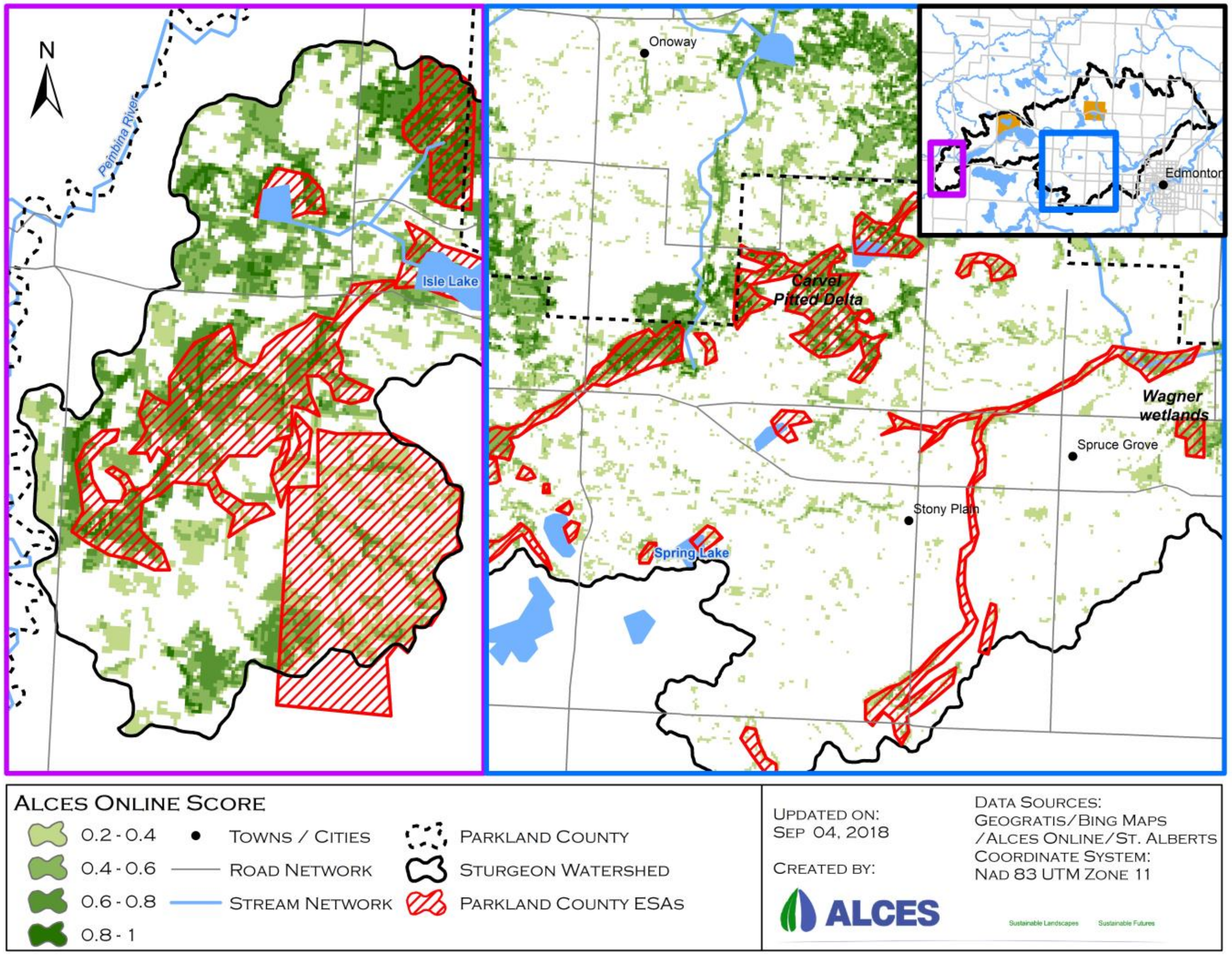


Figure 16. Comparison of Parkland County ECMP ESA results, with current assessment results. NB: This map shows a closeup of the headwaters of the basin on the left and a closeup of the southern portion of the basin on the right.

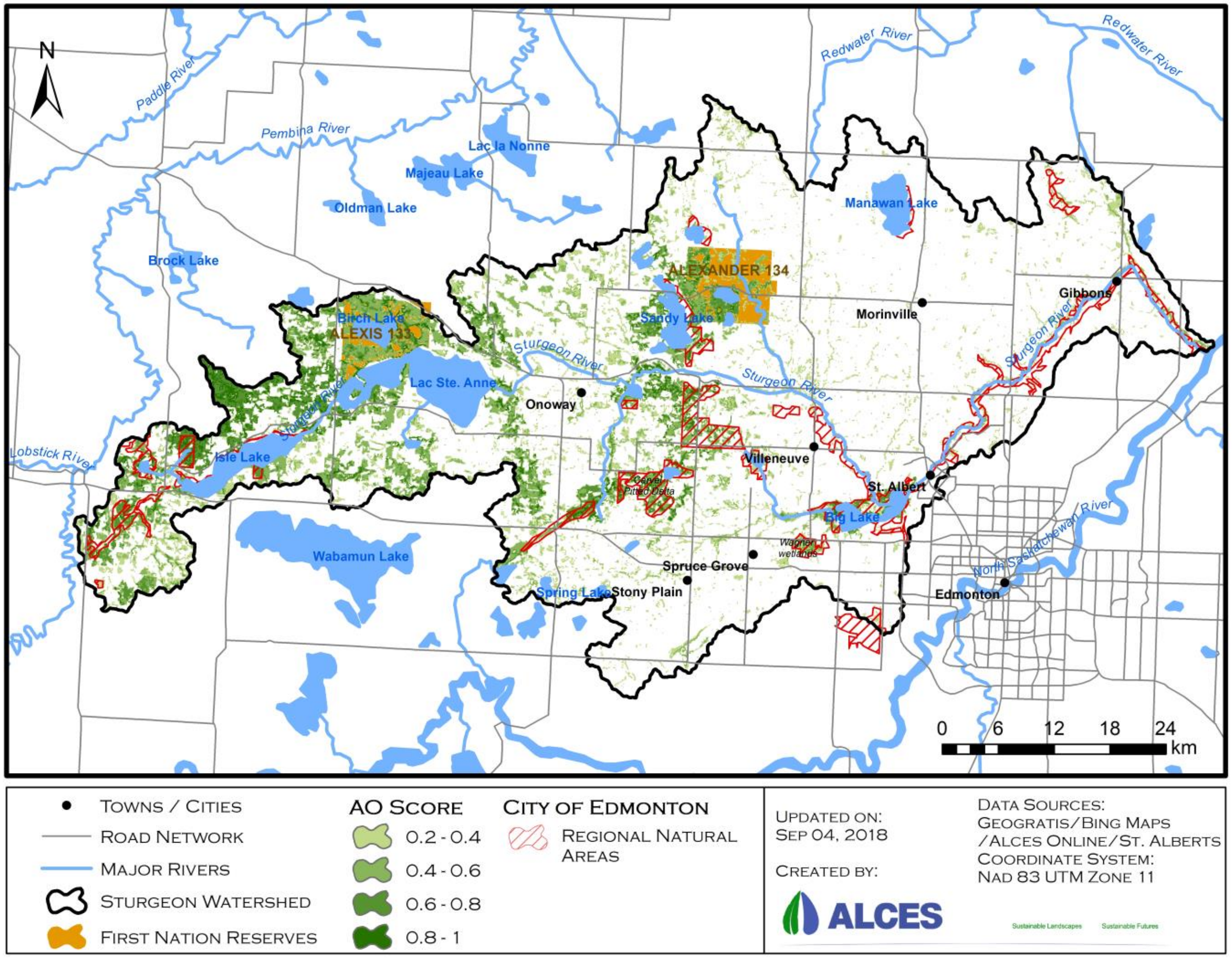


Figure 17. Comparison of City of Edmonton regional natural areas (Spencer Environmental 2006), with current assessment results.

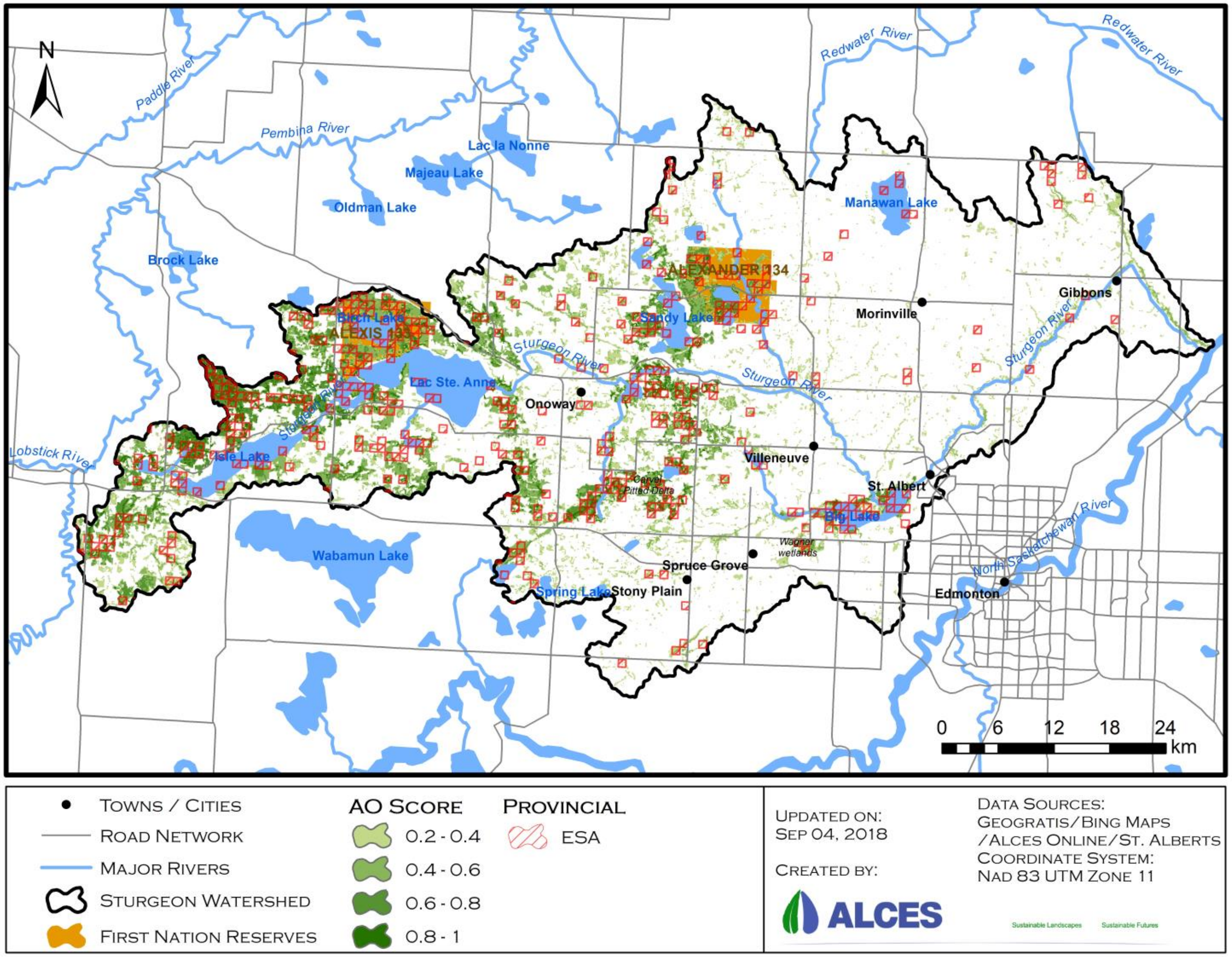
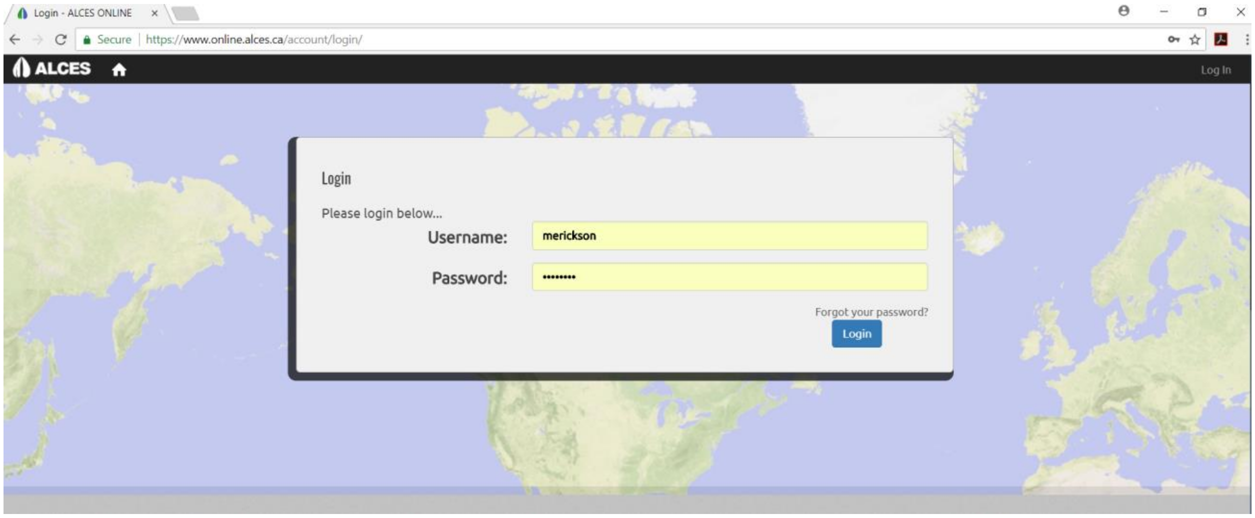


Figure 18. Comparison of provincial ESAs (Fiera, 2014), with current assessment results.

7 Notes

For access to live maps please log in to ALCES Online at:

https://www.online.alces.ca/account/login/.



Once logged in, click the Maps icon at the top left of the browser. This will redirect you to the Maps page, where you can then select the Saved Simulations icon at the top right of the browser. From the Saved Simulations pop-up window you can select and load live maps. See appendix C for Alces Online User Guide.

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9 Appendices

9.1 Appendix A: Acronym List

AAFC: Agriculture and Agri-Food Canada

ABMI: Alberta Biodiversity Monitoring Institute

AEP: Alberta Environment and Parks

AER: Alberta Energy Regulator

EOSD: Earth Observation for Sustainable Development of Forests

ESRI: Environmental Systems Research Institute

GVI: Grassland Vegetation Inventory

NRCB: Natural Resources Conservation Board

9.2 Appendix B: Data Sources for Human Footprint Layer

Indicator	Data Source
Agriculture Crop Undifferentiated	GVI
Agriculture Pasture	GVI
Commercial Business Services	City of Edmonton Landuse Map
Commercial Finance Insurance Real Estate	City of Edmonton Landuse Map
Commercial Food	City of Edmonton Landuse Map
Commercial General	City of Edmonton Landuse Map
Commercial Home Improvement	City of Edmonton Landuse Map
Commercial Professional Services	City of Edmonton Landuse Map
Commercial Retail	City of Edmonton Landuse Map
Commercial Services	City of Edmonton Landuse Map
Commercial Vehicles	City of Edmonton Landuse Map
Commercial Entertainment	City of Edmonton Landuse Map
Commercial Hospitality	City of Edmonton Landuse Map
Commercial Office	City of Edmonton Landuse Map

Commercial Other	City of Edmonton Landuse Map
Commercial Service	City of Edmonton Landuse Map
Commercial Shopping Centre	City of Edmonton Landuse Map
Community Facility	City of Edmonton Landuse Map
Education	City of Edmonton Landuse Map
Entertainment	City of Edmonton Landuse Map
Industry Extractive	City of Edmonton Landuse Map
Industry NonDurable Goods	City of Edmonton Landuse Map
Industry Other	City of Edmonton Landuse Map
Industry Storage	City of Edmonton Landuse Map
Infrastructure Parking	City of Edmonton Landuse Map
Infrastructure Road Other	City of Edmonton Landuse Map
Institutional	City of Edmonton Landuse Map
Medical	City of Edmonton Landuse Map
Membership Organizations	City of Edmonton Landuse Map
Military	City of Edmonton Landuse Map
Prison	City of Edmonton Landuse Map
Residential Collective Dwelling	City of Edmonton Landuse Map
Residential Mobile Home	City of Edmonton Landuse Map
Residential Multi-Unit	City of Edmonton Landuse Map
Residential One-Unit	City of Edmonton Landuse Map
Residential Other	City of Edmonton Landuse Map
Residential Two-Unit	City of Edmonton Landuse Map
Right-of-Way	City of Edmonton Landuse Map
Telecom Other	City of Edmonton Landuse Map
Transportation	City of Edmonton Landuse Map
Utility Power	City of Edmonton Landuse Map
Utility Sewage	City of Edmonton Landuse Map
Utility Waste	City of Edmonton Landuse Map

Utility Water	City of Edmonton Landuse Map
Seismic Line	AltaLIS BF_Cutline_Trail
Towers	Canvec Land
Rural Acreage Undifferentiated	ABMI, GVI
Rural Farm Undifferentiated	ABMI, GVI
Rural Residence Undifferentiated	ABMI, GVI
Urban Undifferentiated	EOSD, AAFC, ABMI, AltaLIS
Parks Hard Surface	City of Calgary
Trail ATV	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS BF_Cutline_Trails, AB Parks
Trail Bike	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS, AB Parks
Trail Footpath	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS, AB Parks
Trail Horse	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS, AB Parks
Trail Ski	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS, AB Parks
Trail Undifferentiated	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS, AB Parks
Pipeline	Alberta Energy Regulator; AltaLIS
Industrial Agriculture Processing	AltaLIS, CanVec, GVI
Industrial High Density	AltaLIS, CanVec, GVI
Industrial Low Density	AltaLIS, CanVec, GVI
Industrial Processing	AltaLIS, CanVec, GVI
Industrial Undifferentiated	AltaLIS, CanVec, GVI
Recreation SportRink Undifferentiated	Open Street Map, City of Edmonton

Recreation SportField Undifferentiated	Open Street Map, City of Edmonton
Recreation SportCentre Undifferentiated	Open Street Map, City of Edmonton
Recreation SportStadium Undifferentiated	Open Street Map, City of Edmonton
Recreation SportTrack Undifferentiated	Open Street Map, City of Edmonton
Recreation Campground	Open Street Map, City of Edmonton
Recreation Picnic	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation SkiHill	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation Zoo	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation Golf Course	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation Golf Mini	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation Golf DrivingRange	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation Playground	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation IndoorOther	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Recreation OutdoorOther	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Rec Park	Open Street Map, City of Edmonton, ESRI Basemap, CanVec, AltaLIS
Powerline	AltaLIS, CanVec
Feedlot Beef	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Bison	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Cervid	NRCB, ABMI, GVI, County Grande Prairie

Feedlot Dairy	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Horse	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Multi	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Poultry	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Sheep	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Swine	NRCB, ABMI, GVI, County Grande Prairie
Feedlot Undifferentiated	GVI
PetroWell Undifferentiated Abandoned	ABMI, AER
PetroWell GasCapped	ABMI, AER
PetroWell CBMAbandoned	ABMI, AER
PetroWell GasAbandoned	ABMI, AER
PetroWell OilAbandoned	ABMI, AER
PetroWell Undifferentiated	ABMI, AER
PetroWell CBM	ABMI, AER
PetroWell Gas	ABMI, AER
PetroWell Oil	ABMI, AER
PetroWell WaterAbandoned	ABMI, AER
PetroWell Water	ABMI, AER
Sump	ABMI
Oil and Gas Facility	AltaLIS, CanVec, AER
Wind Turbine	ABMI, CanVec
Power Plant Coal	AltaLIS
Power Plant Gas	AltaLIS
Power Plant Undifferentiated	AltaLIS
PowerTransformer Station	CanVec
LumberMill	CanVec
Landfill	ABMI

Mine OilSands Disturbed NoVegetation	AEP, ABMI, AltaLIS, CanVec, GVI
Mine OilSands Pit Lake	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Tailing Pile	AEP, ABMI, AltaLIS, CanVec, GVI
Mine OilSands Disturbed Vegetation	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Coal	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Peat	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Gravel	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Quarry	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Sand	AEP, ABMI, AltaLIS, CanVec, GVI
Mine Clay	AEP, ABMI, AltaLIS, CanVec, GVI
BorrowPit	AEP, ABMI, AltaLIS, CanVec, GVI
Dugout	AEP, ABMI, AltaLIS, CanVec, GVI
Lagoon Mine	AEP, ABMI, AltaLIS, CanVec, GVI
Lagoon Waste Water	AEP, ABMI, AltaLIS, CanVec, GVI
Lagoon Undifferentiated	AEP, ABMI, AltaLIS, CanVec, GVI
Rail Operational Main	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie
Rail Passenger Train	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie
Rail Operational Yard	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie
Rail Operational Siding Spur	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie

Rail NonOperational	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie
Rail ROW	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie
Rail Other	Open Street Map, National Railway Network, AltaLIS, City of Calgary, City of Grande Prairie
Cemetary	CanVec
Road Truck Trail	Open Street Map, AltaLIS
Road Winter Road	Open Street Map, AltaLIS
Road Access Road	Open Street Map, AltaLIS
Road Service Road	Open Street Map, AltaLIS
Road Residential Road	Open Street Map, AltaLIS
Road Quaternary Highway	Open Street Map, AltaLIS
Road Tertiary Highway	Open Street Map, AltaLIS
Road Secondary Highway	Open Street Map, AltaLIS
Road Primary Highway	Open Street Map, AltaLIS
Road Core Highway	Open Street Map, AltaLIS
Airport Terminal	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
Airport Hangar	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
Airport Building	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
Airport Apron	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
Airport Helipad	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
Airport Runway	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
Airport Greenspace	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton

Airport Other	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton

9.3 Appendix C: Alces Online User Guide

Why?

Societies, and the landscapes on which they depend and affect, are dynamic. As populations grow, land uses expand, and landscapes become increasingly busy, planners are challenged to devise management strategies that maximize benefits, minimize liabilities, and achieve a holistic balance. To complicate their mandate further, the natural dynamics of climate change, insect outbreaks, plant succession, and wildlife populations are also major architects of human-shaped landscapes. Clearly, striking an acceptable balance between competing economic, social and environmental objectives is the most challenging of planning goals. That is why we created ALCES Online.

What?
ALCES Online is a powerful, fully integrated, web-delivered GIS and land use simulator. It provides unprecedented capability for today's planners. By adopting the most advanced spatial programming technologies, ALCES provides stakeholders with the ability to visualize current landscapes, to understand the historical back-casts that built our contemporary settings, and can rapidly assess alternative future land use trajectories.

Where?
The ALCES Simulator can be rapidly deployed on a diversity of spatial scales, ranging from small towns, large cities, suburbs, municipalities, regions, or entire countries. Its highly customizable interface allows planners to understand spatial patterns, view and manipulate an exceptional diversity of pre-loaded mapping strata, or to quickly build their own indicators.

Who?
The ALCES Group has worked hard to understand the evolving priorities of planners, whether their professions are based in urban design, industrial sectors, hydrology, carbon pool dynamics, or wildlife biology. The ALCES Group provides customized training sessions to all users of ALCES Online.

A) Basic Navigation

The black stripe at the top contains the highest-level navigation tools. Starting from the left:

The **Home** button will take the user back to the default web page for the current project, displaying the default map.

The **Map** button takes the user to the main mapping window. This is the primary workspace where most simulations will be built and viewed.

The **Charts** button takes the user to the Charts and Dashboards tool.

The **Scatterplot** button takes the user to the Scatterplots and Magnitude Map tools.

The **Information** button takes the user to the help section (incomplete).

The **Data Library** button takes the user to the Data Library tool that is used to upload new data layers.

The **Mapper** button takes the user to the Mapper tool that is used to build and simulate landscape scenarios.

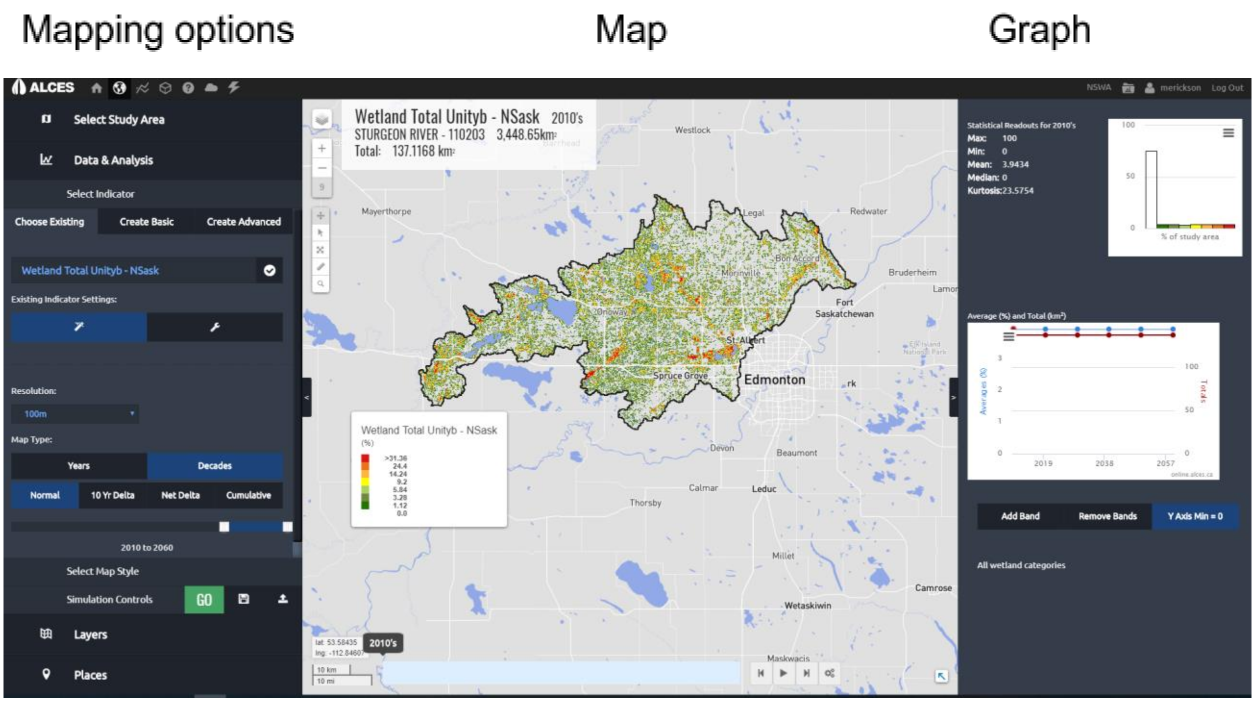
The **Account name** NSWA will bring up a list of all projects to which a user has permissions. Users will select one and AO will go the home page of that project, displaying the default map screen.

The **Head and Shoulders** symbol with a user name beside it will take the user into a screen where their contact info and passwords can be changed.

The **Log Out** button will allow users to safely and cleanly exit the web session.

B) Maps Tool

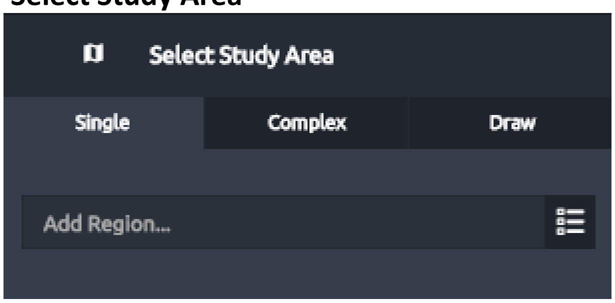
ALCES Online contains a large volume of time sequenced area based cell data, regions, lines, and point data. The Maps Tool allows the user to create customized maps of these data and combine data to create new data layers. The Maps Tool has three panels: the Mapping Options panel on the left, the Map Panel in the middle, and the Graph panel on the right. These panels are now described, with emphasis on the Mapping Options panel that is used to define a map and create new indicators.



i. Mapping Options

The Panel on the left side of the Maps screen provides the user with several tools to view and create spatial data. The following sections briefly describe some of these options.

Select Study Area

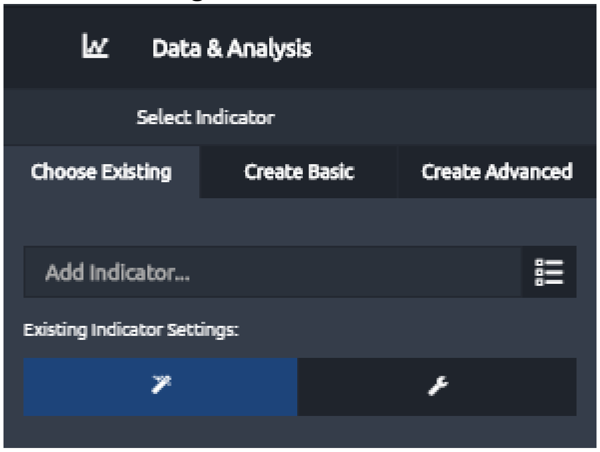


Three options are available to select a study area:

1. Single - select a region from the list
2. Complex - combine multiple regions using Add, Subtract, Intersect, or Exclude options
3. Draw a new region to use as a study area

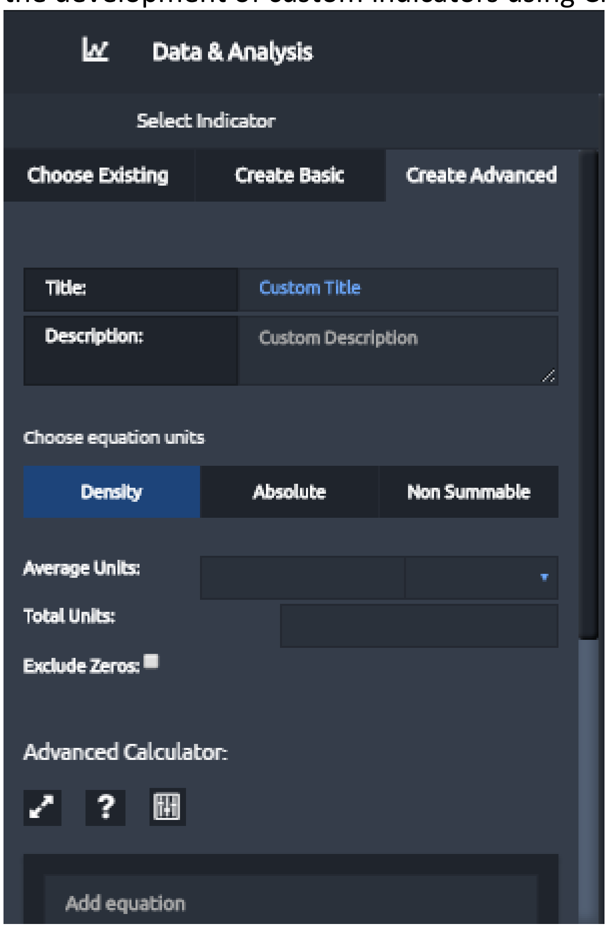
Data & Analysis > Select Indicator > Choose Existing

The Choose Existing option allows the user to select an indicator from the existing list. These are organized into user defined groupings. The text entry boxes also employ smart searching for ease of finding the desired indicator. Each existing indicator has a default scenario (if temporal data exist). The scenario can be changed by clicking the wrench symbol located under the Choose Existing box.



Data & Analysis > Select Indicator > Create Advanced

The capacity of ALCES Online to explore the consequences of land use can be expanded through the development of custom indicators using Create Advanced.



With Create Advanced, a new indicator is defined using an equation to combine existing indicators. A wide range of modifiers as well as mathematical and logical functions are available when creating the equation, providing a flexible tool that allows for the development of complex indicators.

When Create Advanced is selected, the user first enters the Title of the indicator and has the option of entering a Description.

The user selects the equation units. It is very important that proper unit is selected or else outputs will be incorrect. The user must select the type of unit (Density, Absolute, or Non Summable) and enter the unit.

- Density is appropriate if the equation calculates percent coverage of a cell (which is the default format in ALCES Online for landscape composition indicators) or number per unit area (km2, ha, or m2). If density is selected, the Average Units must be entered as a density.
- Absolute is appropriate if the equation calculates the total amount per cell (e.g., km2, people) in a unit that can be summed across cells. If Absolute is selected, the Total Units must be entered.
- Non Summable is appropriate if the equation calculates a value that is not a density and is not summable. Examples include age (e.g., years) and indices such as a habitat suitability index. If Non Summable is selected, the Average Units must be entered (but not as a density).

The user has the option to Exclude Zeros. If Exclude Zeros is selected, cells with zero values will be excluded when the average value for a study area or region is calculated. This is useful if a the average value should not be influenced by zeros. For example, an approach for calculating average forest age involves applying a value of 0 to cells without forest. Average forest age should not be affected by the zero's, so Exclude Zeros should be selected.

To enter an equation, the user selects existing indicators, previously saved simulations, numbers, and functions to generate a customized output.

- You can type numbers or type ***coefficient*** to trigger a prompt.
- You can type an existing indicator name or type ***variable*** to trigger a prompt.
- Add, subtract, divide, and multiply functions can be typed
- More advanced functions can be typed. A summary of some of the functions is provided below. For a more complete list, click the **?** above the equation box in Create Advanced and then click See Full List.
- Indicators that were previously created with Create Advanced can be included in another indicator's equation. To do so, click ***saved simulation*** to trigger a dialogue for selecting the indicator. The dialogue box asks the user to select the saved simulation and to specify whether the saved simulation should be Linked or Copied. Link means that future changes to the previously created indicator (i.e., saved simulation) will affect

the equation that you are building. Copy means that future changes to the previously created indicator will not affect the equation that you are building.

Function	Description
If	Logical statement of the form: If … then… else. Comparisons (<, >, >=, <=, !=, ==) and adjoining functions (and, or) are used to define the condition to be assessed by the If statement.
Status	A dialogue box appears when the Status function is selected that requests the user to enter the Status Indicator (e.g., Forest Origin), the Scenario, the Operator (!= or ==), and the Status (fire vs pest vs harvest origin). A 1 is returned if the condition is met by the origin indicator, 0 otherwise.
Buffer	A dialogue box appears when the Buffer function is selected that requests the user to enter an expression and a Distance. If the Include type is selected, the buffer function returns a 1 if a cell is within the buffer distance of cells with a non-zero result for the expression, and 0 otherwise. If the Exclude type is selected, the buffer function returns a 0 if a cell is within the buffer distance of cells with a non-zero result for the expression, and 1 otherwise.
Patches	A dialogue box appears when the Patches function is selected that requests the user to enter the summary method and an expression. The function identifies patches of contiguous cells with a non-zero result for the expression, and returns the patch area (Patch Areas (m2)) or the sum of the expression's value across cells within a patch (Patch Sums).
max	Returns the maximum value for a series
min	Returns the minimum value for a series
pow	Applies an exponent to an expression
exp	Returns the exponential of an expression

Once an existing indicator or saved simulation is included in the equation, the existing indicator or saved simulation can be right-clicked for options. The options include Edit, Copy, Comment (to add explanatory text), and Delete.

Clicking Edit to an existing indicator results in a dialogue box with the following options:

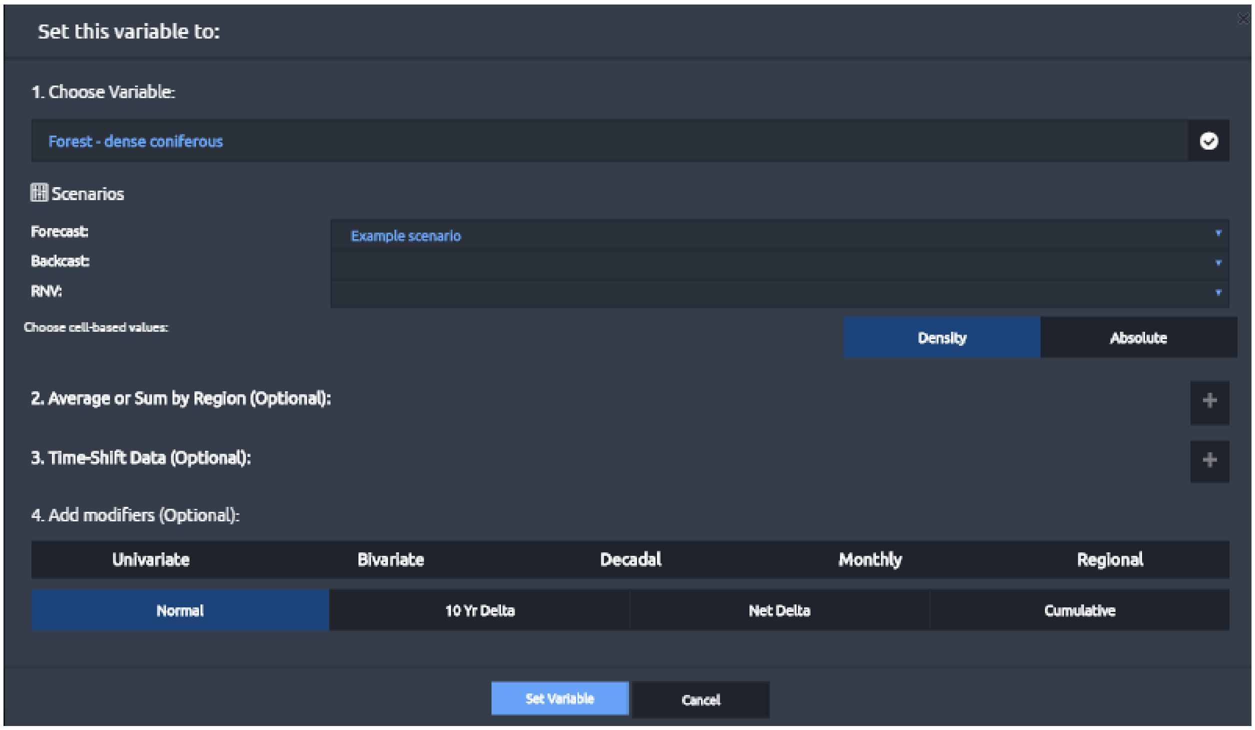
1. Choose Variable. The user can select which indicator and which scenario to use, and whether the variable should be expressed as a Density or Absolute when calculating the

equation. For example, for a landscape composition variable, choose Density if the variable should be included as % or choose Absolute if the variable should be included as km2.

2. Average or Sum by Region. Clicking the + symbol allows the user to summarize a variable by a region for the purpose of the equation. For example, if a wildlife indicator is to be calculated at the scale of a watershed, then explanatory variables such as footprint or forest age should be averaged or summed by watershed for the purpose of calculating the wildlife indicator. Region Category should be selected if the intent is to summarize a variable for each of a type of region (for example, by watershed). Total should be selected if the variable is to be summed across cells within each region, and average selected if the variable is to be averaged across cells within each region.
3. Time-Shift Data. Clicking the + symbol allows the user to apply results from another timestep than the reporting timestep. This can be achieved using Shift, if the intent is to implement a lag, or Static, if the intent is to always apply a variable's value from the same timestep (e.g., current or pre-disturbance).
4. Add Modifiers. Five types of modifiers can be applied to variables.
   i) Univariate: The user defines a curve that converts the variable's value (x-axis) to other values (y-axis). Univariate modifiers are useful for dose-response relationships such as a habitat quality metric that is determined by road density.
   ii) Bivariate: The user selects a second variable to be used to define a coefficient that is then multiplied against the original variable. The user defines a curve that converts the secondary variable (x-axis) to the coefficient (y-axis). Bivariate modifiers are useful when the influence of a variable (e.g., coniferous forest as wildlife habitat) is affected by a secondary attribute (e.g., forest age).
   iii) Decadal: Allows the user to apply a coefficient that varies by decade (i.e., over time). The coefficient can be Compound, in which case the coefficient is multiplied by the variable, or Override, in which the coefficient replaces the variable. Decadal modifiers can differ across regions by using Add a Regional Decadal Modifier. Decadal modifiers are useful when the influence of a variable changes over time (e.g., mine footprint releasing less effluent after a future improvement in mining practices).
   iv) Monthly: Allows the user to distribute a variable's value across months. This is useful when it is important to understand monthly status of an indicator, for example by distributing annual stream flow across months.
   v) Regional: A regional modifier allows the user to apply a coefficient that differs by region (e.g., forest management unit, watershed, etc.). Typically, the Full Value option is used to apply the modifier to every cell in a region. Alternatively, the modifier can be Distributed across the cells occurring in a region. When applied to a variable, the regional modifier is multiplied against the variable. When applied to a constant (e.g., 10), the regional modifier replaces the constant. A regional modifier is useful when the influence of a variable differs by region; for example, a reduced effect of roads on wildlife habitat within management units where access

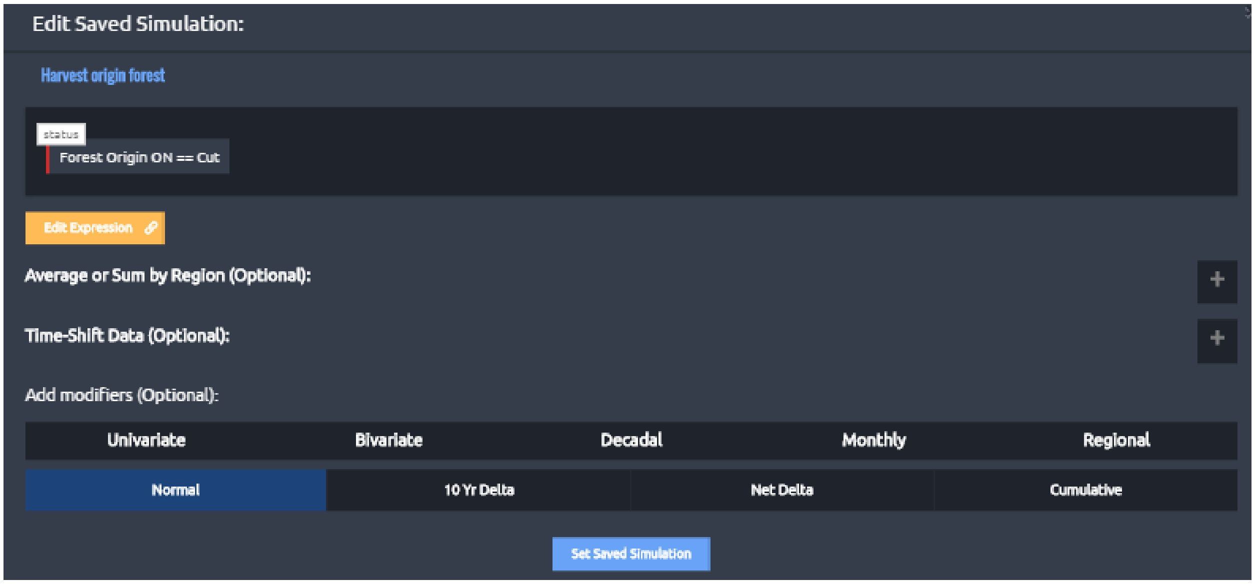
management is being applied. Regional modifiers are also useful in Mapper for defining filters that include or exclude a portion of the landscape from receiving a simulation action (e.g., excluding protected areas from development).

5) The format of a variable can be changed from Normal (i.e., the value of a variable in a given year) to 10 Yr Delta (change in value by decade), Net Delta (change in value between two reporting intervals defined by the user), or Cumulative (sum of a variable's value across reporting intervals). Typically, however, the Normal format should be used.



Clicking Edit to a saved simulation results in a dialogue box with the following options:

1. Edit expression will modify the previously created indicator's (i.e., saved simulation) equation. If the saved simulation was Linked, then edited the expression will also modify the original saved simulation.
2. Average or Sum by Region. See above description.
3. Time-Shift Date. See above description.
4. Add modifiers. See above description.



If the user wants to change the scenario that is selected for all of the variables in a Create Advanced equation, they can do so by clicking the Update Scenarios button  located above the equation box.

Resolution

The Resolution used when mapping and/or analyzing data can be specified. The default resolution is very coarse and most users will want to increase the resolution. Higher resolution data require more time to render and calculate, but result with more detailed mapping.

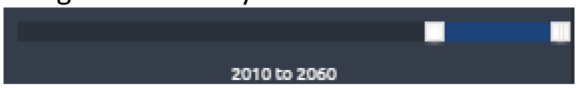
Map Type

The user may select from 4 broad types of maps. They all display the same data in a different way:

- Normal – the value of the indicator at a point in time

- 10 Year Delta – The amount that the indicator has changed in the past 10 years for different points in time
- Net Delta – the amount that the indicator has changed during a user defined time interval
- Cumulative – The cumulative change that the indicator has experienced between two user defined time points

The reporting intervals (typically decades) to include when preparing a map series is specified using the year slider located below the Map Type options.

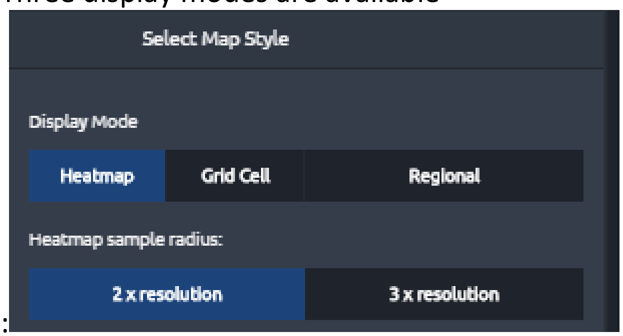


Select Map Style

This panel allows the user to customize mapping settings such as the display mode and break points.

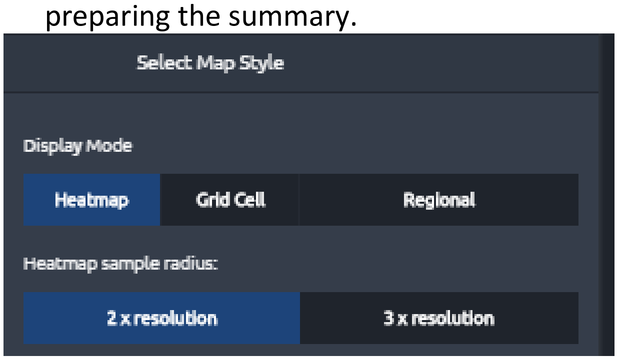
9.3.1.1.1.1 Display Mode

Three display modes are available



:

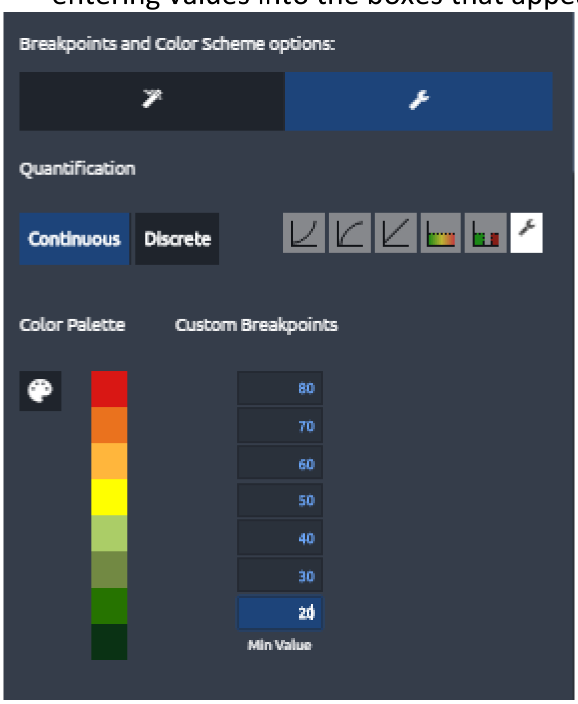
1. Heatmap (default). With a heat map, the mapped value for a cell is influenced not only by the cell's value but the value of its surrounding cells. The user may select 2X resolution or 3X resolution sample radius depending on how 'fuzzy' one wants the generalized colors to appear. This a generalized map style that shows trends across large areas.
2. Grid Cell. Displays individual cell values.
3. Regional. The user may summarize an indicator at a regional scale (e.g., by watershed). AO will retrieve the selected indicator values for each cell and then compile it up to the region level selected. The returned map provides one value for each polygon in the selected region. If this option is selected, the user can specify whether the indicator should be summarized by calculating the average value across cells within each region or by summing the value across cells within each region. The Flow Regional Mode is not currently operational. The user must also specify the region category to use when preparing the summary.



9.3.1.1.1.2 3.1.2.2.2 Breakpoints and Color Scheme options

By clicking the wrench symbol, the user can select the method used to define breakpoints and the colour scheme.

- Maps can either be Continuous or Discrete. With Continuous, mapping occurs across a spectrum of colours and each breakpoint defines values associated with colours located along that spectrum. With Discrete, one colour is associated with each breakpoint category.
- The default option for defining breakpoints is Equal Quantiles whereby breakpoints are automatically set by ALCES Online so that an equal proportion of the study area is within each category in year 2010 (i.e., current). Other options for automatically generated breakpoints are Exponential Increase, Exponential Decrease, Linear, and Binary. Alternatively, Custom breakpoints can be created by clicking the wrench symbol and entering values into the boxes that appear.



- The user can select from a variety of colour palettes.

Simulation Controls

The GO button will render the map or map series defined by the Study Area, Indicator, and Map Style settings.

The disk symbol provides the user with options for saving an indicator created using the Basic or Advanced calculators.

The arrow symbol provides the user with options for downloading the rendered maps. Options (formats) are CSV, JPG, and TIFF.

Layers

The layers panel allows the user to select Features and Regions to include in a map as overlays.

Places

Point locations can be stored and named as sets. The user can then define how they want to virtually tour those locations. Responding to a set of user defined parameters, AO changes the scene on the map window in a sequence determined by the user defined inputs. The scene changes will zoom in to desired levels and pause and then zoom out and move the next sequential point location. Used in conjunction with the detailed base maps, it provides users the opportunity to get a quick view of actual landscape conditions at pertinent features' locations. Places can be manually digitized using the Create tool or entered as X,Y coordinates. The order in which points are toured may be set with a variety of options using the View tool. Collections of points can be saved as named Tours for collaboration and later re-use.