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CHRISTINA LAKE REGIONAL PROJECT

BIODIVERSITY ENVIRONMENTAL SETTING REPORT

Prepared For:
MEG Energy Corp.

Prepared By:
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July 2005 **04-1334-001**

MEG Energy Corp. (MEG) is a Calgary-based, private energy company focused on the development and recovery of bitumen, shallow gas reserves and the generation of power in northeast Alberta. MEG is proposing to develop the Christina Lake Regional Project (the Project) on part of the 52 sections of oil sands leases that it holds in the area of Christina Lake, Alberta. The Project would be located within the Regional Municipality of Wood Buffalo in northeastern Alberta, approximately 15 km southeast of local Secondary Highway 881 and 20 km northeast of Conklin.

MEG is proposing to develop their oil sands lease area by building and operating the Project utilizing a steam assisted gravity drainage (SAGD) oil recovery technology. The Project would consist of a central processing facility, SAGD wells, co-generation facilities and additional infrastructure.

The Biodiversity Environmental Setting Report provides information required to complete the Environmental Impact Assessment (EIA) for the Project. Biodiversity was addressed at the species, community and landscape levels.

The location and extent of vegetation types and corresponding species biodiversity were measured for the Project using indicators identified by the regional stakeholder groups. Separate spatial representations of the landscape were analyzed for the Regional Study Area (RSA) and Local Study Area (LSA) using the selected biodiversity indicators. Regional Land Cover Classes in the RSA were analyzed using the reflectance value classes of satellite imagery. The ecosite phases/wetlands types in the LSA were analyzed using Alberta Vegetation Inventory (AVI), Alberta Wetlands Inventory (AWI) and vegetation composition field data.

Wetlands were found to have higher biodiversity potential than terrestrial vegetation types based on a set of ranked criteria in the Oil Sands Region. Wetlands in the Oil Sands Region support more rare plant species and more “At Risk” wildlife species, as part of a higher overall number of species, than terrestrial vegetation types. Plant species in wetlands are less likely to occur in other vegetation types, some being specific to certain types of fens. Other key findings indicate that there is a high degree of variability in size among the five wetlands types with high biodiversity potential; wooded fens comprise the greatest area of relatively large patches. The wooded fen with no internal lawns (FTNN) is a highly connected, yet well-interspersed vegetation type with short distances separating the patches. The uncommon types of wooded fens in the LSA, including non-patterned wooded fens with internal lawns (FTNI) and wooded patterned fens with no internal lawns (FTPN), have the highest biodiversity ranking. A large factor in the high biodiversity potential rank is the low abundance on the landscape and the high scores for the other criteria such as species richness and rare plant potential. Of the regional land cover classes with high biodiversity potential, the wooded fen and shrubby fens are the most abundant.

Terrestrial vegetation types in the RSA are dominated by aspen and deciduous aspen/aspen balsam poplar. In the LSA, the Labrador Tea-mesic jack pine-black spruce (c1) ecosite phase dominates. These vegetation types occur as variably sized, well-connected patches with a large mean patch size. The biodiversity potential is low due to the abundance of these vegetation types in the landscape, low rare wildlife species potential and high number of generalist species. The high biodiversity land cover classes in the RSA occupy 39%, moderate ranked classes 13%, low ranked classes 32% and unranked classes 16%.

This report was prepared for MEG Energy Corp. (MEG) by Golder Associates Ltd. (Golder) as part of the Christina Lake Regional Project EIA under the direction of Al Siemens. Tod Collard was the Project Manager, John Gulley was the Project Director and Mark Sherrington was the Biodiversity Component Leader. Ian Gilchrist was the coordinator for the terrestrial components.

Coordination of this report was conducted by Mark Sherrington and Yvonne Patterson with technical advice provided by Carol Stefan. This report was prepared by Mark Sherrington and reviewed by Ian Gilchrist and Tod Collard. The drafting and geographic information systems (GIS) mapping was prepared by Guy Eiserman and Arturo Spuler. Report figures were prepared by Susanne Klassen and Vanessa Somborovic. The report was formatted by Kelsi LeRossignol.

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1 INTRODUCTION

MEG Energy Corp. (MEG) is a Calgary-based, private energy company focused on the development and recovery of bitumen, shallow gas reserves and the generation of power in northeast Alberta. MEG is proposing to develop the Christina Lake Regional Project (the Project) on part of the 52 sections of oil sands leases that it holds in the area of Christina Lake, Alberta. The Project would be located within the Regional Municipality of Wood Buffalo in northeastern Alberta, approximately 15 km southeast of local Secondary Highway 881 and 20 km northeast of Conklin.

MEG is proposing to develop their oil sands lease area by building and operating the Project utilizing a steam assisted gravity drainage (SAGD) oil recovery technology. The Project would consist of a central processing facility, SAGD wells, co-generation facilities and additional infrastructure. The proposed central processing facility and the co-generation unit would be located adjacent to MEG's Pilot facilities located in NE¼ 9 and SE¼ 16, Township 77, Range 5, W4M. The Project would be designed and built to produce 22,000 barrels per day of bitumen (approximately 3,500 cubic metres per day). This production, which would be in addition to the 3,000 barrels of bitumen per day from the pilot operation, would result in a total production of 25,000 barrels of bitumen per day (approximately 4,000 cubic metres per day).

Biodiversity encompasses the variety of life at all levels of organization, from genes to landscapes and all the ecological and biological processes through which these levels, are connected. The Canadian Biodiversity Strategy (Environment Canada 1995) stresses the need for ecological management and an increased understanding of ecosystems for the conservation of biodiversity. This includes using biological resources in a sustainable manner. Following those recommendations, a strategy was developed by Golder to focus on the landscape- and ecosystem-level assessments of biodiversity to evaluate baseline conditions.

This Environmental Setting Report (ESR) provides a summary of the biological diversity (biodiversity) resources, using a hierarchical framework, within the Terrestrial Resources Regional Study Area (RSA) and Local Sudy Area (LSA) of the Project. The composition of ecosystems was evaluated using a ranking approach combining ecosystem and landscape parameters. Ecosystem composition is determined by the dynamic interaction of plants, animals and micro-organisms within a range of moisture and nutrient regimes of the non-living environment. Vegetation units, mappable from aerial photography and satellite imagery were the basis for measuring the biodiversity potential using the ranking system.

Landscape level heterogeneity results for the distribution of forested and non-forested areas, riparian zones and old growth forest in the RSA and LSA are presented in the Terrestrial Vegetation, Wetlands and Forest Resources ESR (Golder 2005a). Landscape-level fragmentation results including the configuration of undisturbed habitat, comparison of natural process and human caused disturbance in the RSA and LSA are presented in the Wildlife ESR (Golder 2005b).

1.1 STUDY OBJECTIVES

The specific objectives of this report are to:

- describe ecosystem-level, species-level and key ecosystem function biodiversity indices in the context of landscape-level analysis;
- show the interrelationship between biodiversity and the arrangement and composition of landscape components (i.e., vegetation types); and
- identify areas of high, moderate, low biodiversity potential in the LSA and RSA and provide information on the distribution of these types.

1.2 STUDY AREAS

The ecosystem-level analyses describe the biodiversity conditions within the RSA and LSA. The RSA and LSA were chosen by considering all terrestrial components (soil and terrain, terrestrial vegetation, wetlands and forest resources, wildlife and wildlife habitat and biodiversity) so are the same for all of these components.

1.2.1 Regional Study Area

The RSA is 1,538,591 ha (Figure 1-1). The RSA boundary was defined with consideration of the following terrestrial resources:

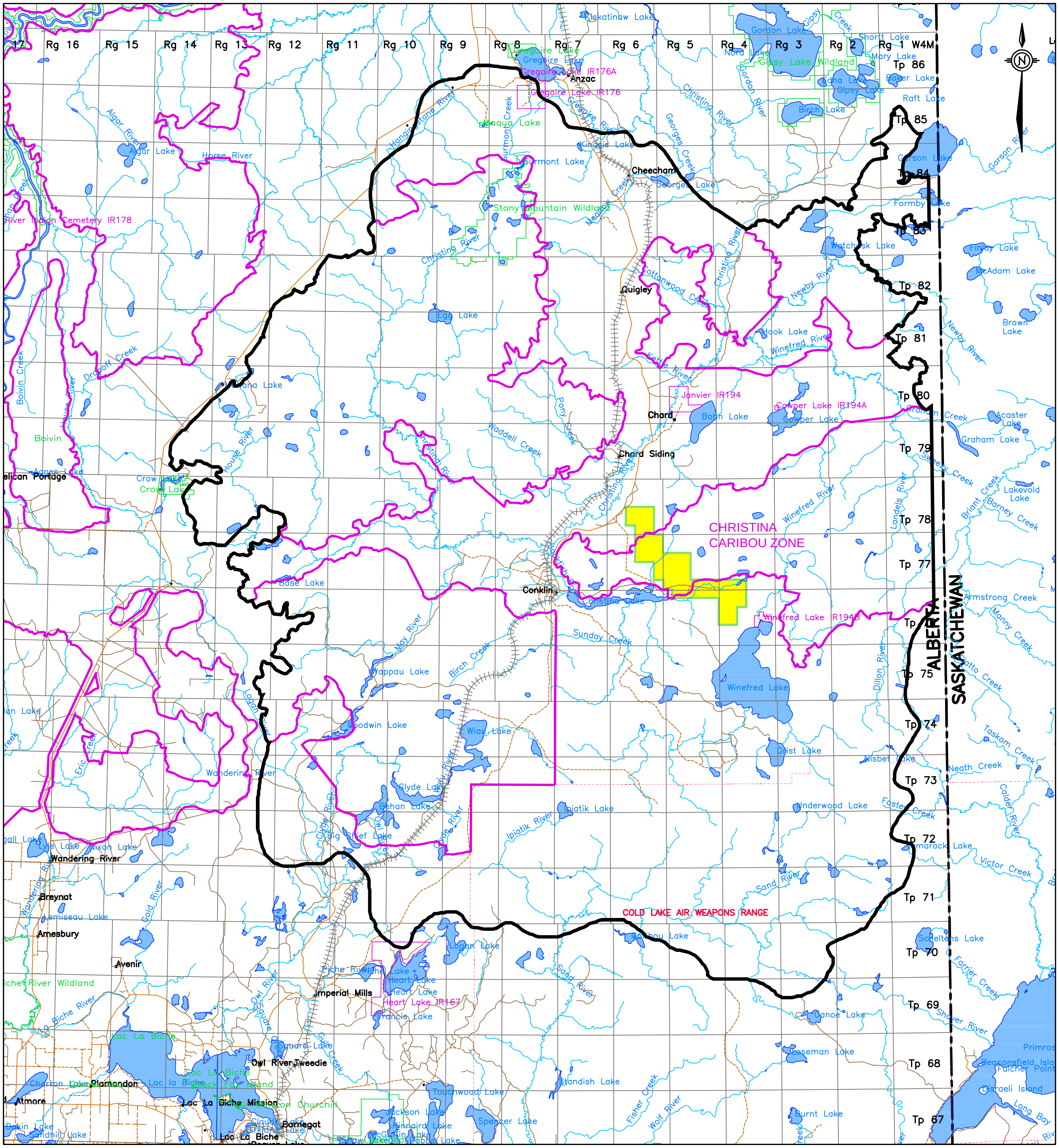
- ecodistrict and/or vegetation classification boundaries;
- geographic areas such as the northern shoulder of the Stony Mountain;
- defined woodland caribou habitat areas (e.g., Christina Caribou areas);
- one female caribou home range; and
- average width of two moose home ranges.

The RSA is situated primarily within the Central Mixedwood and Boreal Highlands subregions (AENV 1999) of the Boreal Mixedwood and Boreal

Highlands ecological areas (Beckingham and Archibald 1996). Within this area, dry and sandy sites are poorly represented and tend to be dominated by jack pine. Black spruce and tamarack dominate the forested wetlands areas and numerous lakes and streams support wetlands vegetation species. Fire has been a prevalent form of natural disturbance throughout the area with many parts of the area now supporting young.

1.2.2 Local Study Area

The LSA was established to assess the effects of the Project at the local scale. The LSA encompasses an area of 3,549 ha within Townships 76 and 77, Ranges 4, 5 and 6 west of the 4^{th} Meridian (Figure 1-2). The LSA falls completely within the Central Mixedwood Natural Region of the Boreal Mixedwood ecological area (Natural Subregion) (AENV 1999).



LEGEND

- ROADWAY
- RAILWAY
- MEG OIL SANDS LEASE
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- CARIBOU ZONE

20 0 20

SCALE 1:1,000,000 KILOMETRES

REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001. DATUM: NAD 83 PROJECTION: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT

TITLE

TERRESTRIAL RESOURCES REGIONAL STUDY AREA

MEG ENERGY CORP.

PROJECT 04-1334-001.7740			FILE No. Terrestrial Res. RSA	
DESIGN	PB	12/01/05	SCALE AS SHOWN	REV. 0
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CHECK	PB	21/01/05		
REVIEW	TC	27/01/05		

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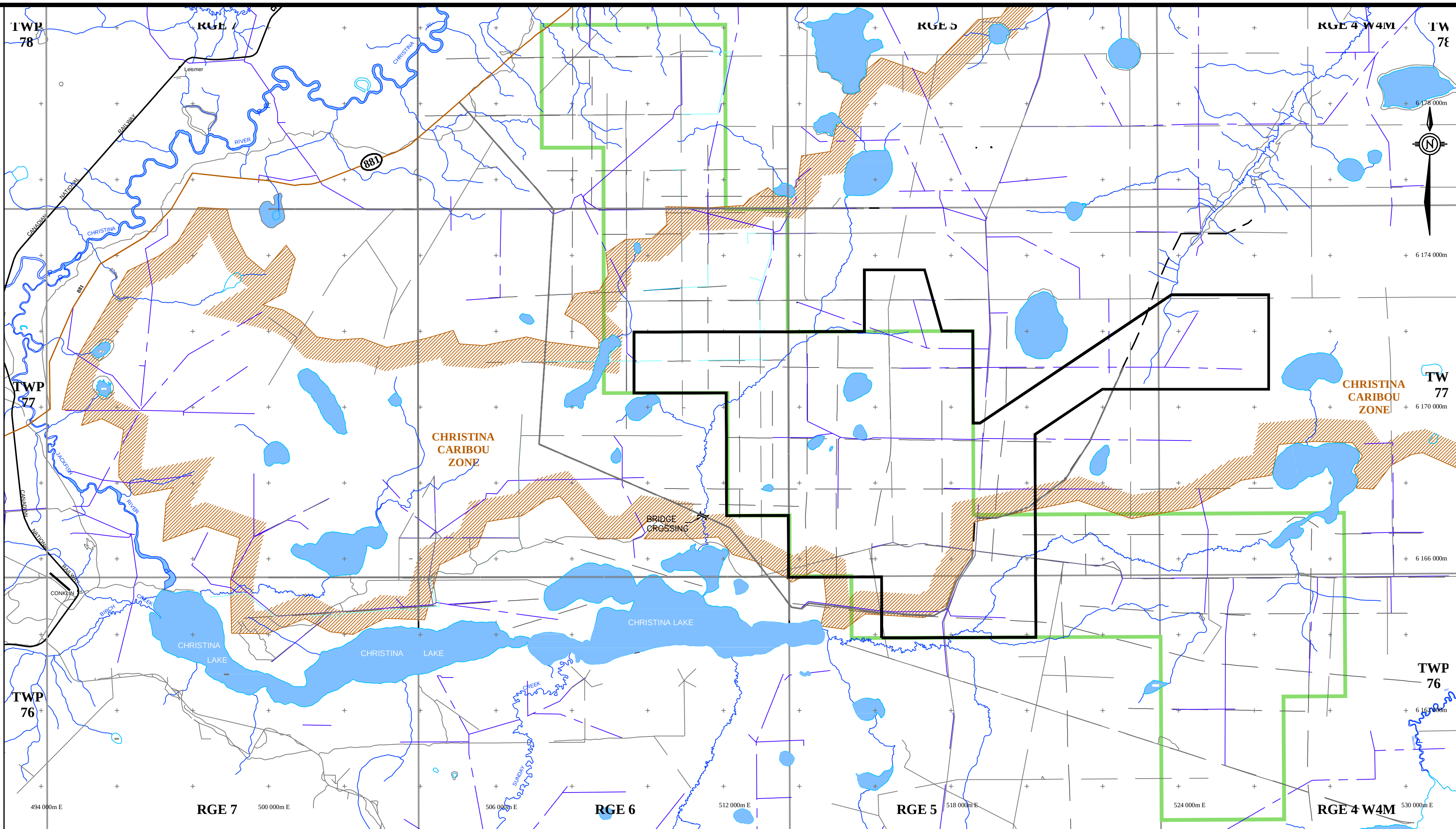

LEGEND

- MEG OIL SANDS LEASE
- EXISTING ACCESS ROAD
- CHRISTINA CARIBOU ZONE
- TERRESTRIAL RESOURCES LOCAL STUDY AREA

3 0 3
SCALE KILOMETRES

PROJECT

CHRISTINA LAKE REGIONAL PROJECT

TITLE

TERRESTRIAL RESOURCES LOCAL STUDY AREA

MEG ENERGY CORP.

PROJECT 04-1334-001.7740			FILE No. Terrestrial Res. LSA	
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CADD	SWD	05/07/05	**FIGURE: 1-2**	
CHECK	AA	11/07/05		
REVIEW	TC	12/07/05		

2 METHODS

2.1 BIODIVERSITY INDICATORS

The biodiversity assessment is applied to vegetation types, ranked using ecosystem-level and landscape-level indicators. Both ecosystem and landscape-level indicators are used in the assessment of biodiversity, as the variety and number of vegetation types and how they are arranged on the landscape can affect species and the processes that influence them (McGarigal and Marks 1995).

A combination of landscape and ecosystem-level indicators were used to describe the baseline biodiversity in the LSA and RSA. Landscape-level indicators show that the distribution of high, moderate and low biodiversity is an important determinant of biodiversity. The location of patches of biodiversity relative to each other influence the movement of species affecting species richness, habitat specificity and the occurrence of rare species (parameters measured in the ranking system, Appendix II).

One landscape-level index, the rarity of vegetation types in the Oil Sands Region is used in the biodiversity ranking. The other four indices of the biodiversity ranking are considered ecosystem-level (where species populations interact within an ecosystem). The number, habitat overlap and rarity of the species comprising ecosystems as well as the complexity of forest stands in the Oil Sands Region, are ecosystem-level indices. The ranking indices are presented in Table 2-1. The full biodiversity ranking methodology is presented in Appendix II.

The biodiversity evaluation focuses on the ecosystem scale within the RSA and LSA with information presented on the arrangement and distribution of vegetation types to link landscape processes (i.e., fire-regenerated vegetation types) to ecosystem-level indicators (i.e., species overlap). The indicators were recommended by stakeholder groups in the Oil Sands Region (Table 2-1).

At the ecosystem level, four indices were chosen, corresponding in part to local-scale biodiversity indicators used in gap analysis research on biodiversity potential (USGS 2004:website; Noss 1983).

At the ecosystem level, vegetation types were ranked for their relative contribution to overall biodiversity. The biodiversity ranking combined scores for different indices that measure the composition, structure and function of ecosystems. The indices were also chosen because they could be quantified from available vegetation and wildlife information for the Oil Sands Region.

Table 2-1 Landscape and Ecosystem-Level Indices Assessed

Biodiversity Ranking Indices[a]	Indicators Assessed	Level of Analysis
rarity of vegetation type	uniqueness of vegetation types based on relative abundance in the Oil Sands Region	Landscape
total species richness	number and distribution of native and non-native vascular plant species; estimates of species diversity and distribution for bryophytes, fungi and lichens	Ecosystem
rare species potential – wildlife and plants	number of special status animal and plant species (e.g., COSEWIC 2004, rare plants)	Ecosystem
species overlap (habitat specificity)	measurement of evenness within species groups	Ecosystem
structural complexity	number of forest layers	Ecosystem

[a] Detailed descriptions of each component can be found in the environmental setting reports listed in Table II-1.

2.1.1 Mapping

In the RSA, ecodistricts and regional land cover classes are the spatial units used at the landscape and ecosystem scales. Ecodistrict classes were developed using the ecodistrict descriptions obtained from the National Ecological Framework (Marshall and Schut 1999:website). Ecodistricts, originally delineated by Strong (1992), were modified based on the regional land cover classes derived from satellite imagery, as well as surficial geology maps (Bayrock 1969, 1973; Bayrock and Reimchen 1974), 1:250,000 NTS topographical maps and soils inventory/Ecological Land Classification (ELC) mapping (Turchenek and Lindsay 1982).

The regional land cover classes were derived from satellite imagery. Vegetation was mapped using LANDSAT satellite imagery and a geographic information system (GIS) was used to compare the relative abundance of plant communities within the RSA. Image classification is a method used to automatically categorize all pixels in an image. The image classification for the RSA satellite imagery is at a coarser scale than completed for the LSA (which uses finer scale Alberta Vegetation Inventory [AVI] data), resulting in slight differences in area calculations for environmental setting and impact values.

Ecosite phases/wetlands types in the LSA were identified and mapped (Beckingham and Archibald 1996; Halsey et al. 2003) for a more detailed assessment of vegetation and terrain. The ecosite phase/wetlands type patches are considered the finest resolution of patch definition available in the region.

A more detailed description of the mapping process and ecosite phases/wetlands types can be found in the Terrestrial Vegetation, Wetlands and Forest Resources ESR for the Project (Golder 2005a).

2.1.2 Landscape-level Indicators

Arrangement and distribution of high, moderate and low-ranked areas for biodiversity potential in the landscape was measured to provide context for the ecosystem-level results. Variable-levels of biodiversity occur in the landscape due to disturbance patterns, nutrient and moisture regimes that strongly influence the distribution of vegetation communities measured as landscape-level indicators.

The heterogeneity analysis summarizes how habitats of particular importance to biodiversity are distributed on the landscape. Descriptions of the specific methods for each analysis of the vegetation types ranked for biodiversity potential are presented in Table 2-2 and Appendix II.

Heterogeneity analysis was completed using regional land cover classes in the RSA and ecosite phases/wetlands types in the LSA. Detailed descriptions for each vegetation type are provided in the Terrestrial Vegetation, Wetlands and Forest Resources ESR (Golder 2005a).

2.1.2.1 Analyses and Values

The landscape level analyses were done using FRAGSTATS Version 3 software. Some of the metrics in this new version differ slightly from FRAGSTATS Version 2. The terms are compared and described in the glossary (Section 6.1).

FRAGSTATS Version 3 uses raster (cells in a grid) rather than vector (polygon) GIS data, so the values (e.g., areas) provided in the biodiversity component may differ slightly from those of other terrestrial components where vector data were used. The raster cell size was set to 2 m at the LSA scale and 20 m at the RSA scale. As some of the linear disturbances use of the raster format also slightly overestimates edge values because it follows the stair-step perimeter of a patch rather than a smooth edge (e.g., seismic lines) were less than 20 m wide, it was necessary to map them at 20 m widths so they could be detected and included in the RSA analyses. Although the analysis overestimates the area of anthropogenic disturbance, the results more accurately reflect the spatial configuration and fragmentation of the landscape.

2.1.3 Ecosystem-Level Indicators

The ecosystem-level analysis uses a vegetation-based biodiversity ranking system that considers the composition, structure and function of ecosystems. The defined ecosystem unit for these analyses is regional land cover class classified for the RSA and ecosite phase/wetlands type for the LSA. The ranking system combines several indices that reflect biodiversity values and can be quantified from available vegetation and wildlife information for the Oil Sands Region (Table 2-1). A full description of the biodiversity ranking protocol for the RSA and LSA is presented in Appendix II.

Similar methodologies have been introduced throughout Canada and the USA. For Example, in British Columbia, a biodiversity ranking method was proposed to direct forest management planning (Klenner and Huggard 1995). Ranking criteria were developed to assign biodiversity emphasis levels to landscape units. This approach also focused on the vegetation classes, but did not incorporate wildlife indices. The Gap Analysis Program has been used widely in the United States to map out areas for conservation. The Gap Analysis Program uses vegetation mapping combined with terrestrial vertebrate distribution to determine areas of high biodiversity and assess gaps in the protected areas network (USGS 2004:website; Noss 1983).

Table 2-2 Landscape-Level Heterogeneity Indices Assessed

Landscape Measurements	Description/Definition	Study Area	Units	Patch Types Used in Analysis
class area (CA)	area of each patch type	RSA/ LSA	hectares	vegetation units ranked for biodiversity potential, protected areas
number of patches (NP)	number of patches in a landscape	RSA/ LSA	number	vegetation units ranked for biodiversity potential, protected areas
patch area mean (AREA_MN)	average area of each patch type in a landscape	RSA/ LSA	hectares	vegetation units ranked for biodiversity potential, protected areas
patch area median (AREA_MD)	midpoint of the rank order distribution of size for patches of the corresponding patch type	RSA/ LSA	hectares	vegetation units ranked for biodiversity potential, protected areas
patch area standard deviation (AREA_SD)	variability of patch size	RSA/ LSA	hectares	vegetation units ranked for biodiversity potential
patch size coefficient of variation (AREA_CV)	standardized index of the variability of patch size relative to the mean patch size	RSA/ LSA	percent	vegetation units ranked for biodiversity potential
mean nearest neighbour (ENN_MN)	mean of the shortest distance between each patch and each adjacent patch of the same type	LSA	metres	vegetation units ranked for biodiversity potential
nearest neighbour standard deviation (ENN_SD)	relative variability of interpatch distances between two patches of one vegetation type	LSA	metres	vegetation units ranked for biodiversity potential
nearest neighbour coefficient of variation (ENN_CV)	standardized index of the variability of distances between two patches of same vegetation type	LSA	metres	vegetation units ranked for biodiversity potential
interspersion/ juxtaposition index (IJI)	distribution of patches on the landscape	LSA	percent	vegetation units ranked for biodiversity potential

3 RESULTS AND DISCUSSION

3.1 REGIONAL ASSESSMENT

Five ecodistricts occur in the RSA (Figure 3-1), four within the Central Mixedwood Subregion and one within the Boreal Highlands Subregion (Beckingham and Archibald 1996). The ecodistricts range greatly in size from the largest, Hummocky Moraine, covering 38% of the RSA, to the smallest, the Escarpment, comprising 8%. The Peat Plateau ecodistrict occurs only at higher elevations of the RSA within the Boreal Highlands Subregion. Elevations in the RSA range from approximately 440 m where the Christina River crosses the northern boundary of the RSA to 760 m on Stony Mountain in the northwest of the RSA. Generally, a height of land above 650 metres elevation extends from Primrose Lake to the southeast of the RSA toward Stony Mountain in the northwest RSA. The LSA is located entirely within the Organic Plain ecodistrict.

3.1.1 Distribution of Regional Vegetation Types Ranked for Biodiversity Potential

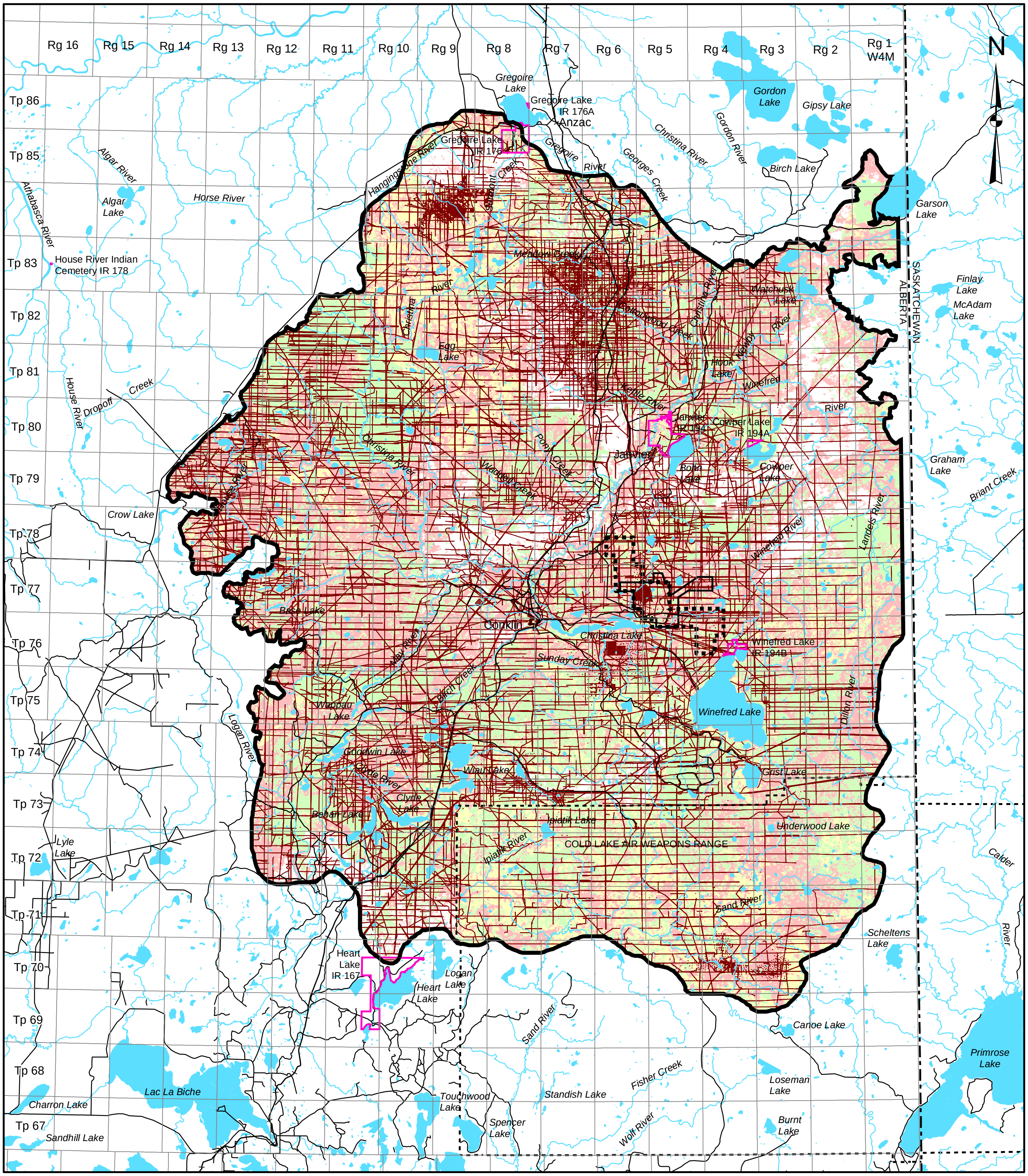
Landscape composition and configuration of regional vegetation types ranked for biodiversity potential were analyzed for the RSA (Figure 3-1). These results were organized to correspond to the ecological importance of each regional land cover class expressed as the biodiversity potential ranking (i.e., high, moderate and low) for each class ecodistrict and the RSA as a whole. Overall, the RSA is comprised of 39% high, 13% moderate and 32% low ranked for biodiversity. The remaining 16% consists of unranked classes, predominantly cutblocks.

Regional Land Cover Classes

The results of the heterogeneity analysis of regional land cover classes in the RSA for high, moderate and low are presented in Table 3-1, 3-2 and 3-3 respectively. The following summarizes the results and is organized according to biodiversity potential.

- Richness - there are 17 regional land cover class patch types that are distributed somewhat unevenly in the landscape (Shannon's evenness of 0.82 out of 1). Shannon's evenness values equal one when all classes occupy the same proportion of the landscape (Perera et al. 1997).
- High biodiversity - six land cover classes were identified in the RSA. Wooded fens, shrubby fens, shrubland, marshes, shallow open water and deep water comprise a total of 603,275 ha (39%) of the RSA.

- High biodiversity - the wooded fen is the largest regional vegetation class with this biodiversity potential at 424,213 ha or 28% of the RSA. This area is distributed among 34,524 patches with a mean patch size of 12.3 ± 46.6 ha.
- High biodiversity - wooded fen patches are small with a mean patch size of 12.3 ha. However, most patches are smaller with a median patch size of 1.7 ha. The large patch size variation (379.1 AREA_CV) is due to the size contrast between patches close to the median size and occasional large patches. The wooded fen is generally well-distributed in the landscape (IJI of 77.3%;).
- Moderate biodiversity - six areas cover 188,676 ha or 13% of the RSA and are largely composed of mixedwood aspen-white spruce and coniferous white spruce forests and graminoid fens.
- Low biodiversity - three areas cover 491,640 ha or 32% of the RSA. The remaining 17 % of the RSA is comprised of unranked class areas.
- Low biodiversity - the most abundant vegetation class is poor wooded fen/wooded bog, with an area of 221,374 ha (14% of the RSA) divided among 15,934 patches for a mean patch size of 13.9 ± 58.2 ha. The patches of poor wooded fen/wooded bog are highly variable in size (420% AREA_CV) and are moderately well distributed on the landscape (IJI value of 65.5%).
- Low biodiversity - burns are the second-largest component of classes with this potential occupying 173,823 ha or 11% of the RSA. The mean patch size of 20.8 ± 89.8 ha is variable, with most burns of very small size (median of 2.2 ha) and a few large burns.
- Unranked classes - the remaining 255,000 ha or 16% of the RSA is composed of cutblocks (139,130 ha) and disturbed areas (115,870 ha).



LEGEND

REGIONAL STUDY AREA

LOCAL STUDY AREA

MEG LEASE BOUNDARY

OPEN WATER

ROADWAY

RAILROAD

DISTURBED

EXISTING DISTURBANCE

EXISTING LINEAR DISTURBANCE

BIODIVERSITY POTENTIAL

HIGH

MODERATE

LOW

UNCLASSIFIED

20 0 20

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from Geomatics Canada (August 2001), AltaLIS Ltd. (September 2004), Veritas DGC Inc. (July 2004), Alberta Pacific Ltd. (April 2004), LANDSAT 7 ETM Imagery (1988 and 1999), used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT

TITLE

BIODIVERSITY POTENTIAL IN THE REGIONAL STUDY AREA

MEG ENERGY CORP.

PROJECT No. 04-1334.001.7800			SCALE AS SHOWN	REV. 1
DESIGN	MS	16 Jan. 2005		
GIS	VR	07 Jul. 2005		
CHECK	AA	07 Jul. 2005		
REVIEW	TC	22 Jul. 2005		

FIGURE: 3-1

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Table 3-1 Landscape Heterogeneity for High Biodiversity Ranked Regional Land Cover Classes

Indices Measured		Wooded Fen	Shrubby Fen	Marsh	Shrubland	Shallow Open Water	Deep Water
Landscape Level	**Units**						
class area (CA)	ha	424,225	94,800	23,455	7,354	8,787	44,654
number of patches (NP)	none	34,524	12,125	3,578	1,370	1,357	1,717
mean patch area (AREA_MN)	ha	12.3	7.8	6.6	5.4	6.5	26
median patch area (AREA_MD)	ha	1.7	2.0	2.7	2.4	1.0	3.0
patch area standard deviation (AREA_SD)	none	46.6	27	14.8	9.7	37.8	305.8
patch area coefficient of variance (AREA_CV)	%	379.1	345.0	225.7	181.3	583	1,175.8
distribution (IJI)	%	77.3	67.9	84.5	76.8	63.1	80.3
Ecosystem Level							
total score[(a)]		22.1	22.0	22.0	21.6	22.0	23.7
rank index[(b, c)]		0.93	0.93	0.93	0.91	0.93	1

(a) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(b) Score for each category relative to the highest score.

(c) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not assessed.

Table 3-2 Landscape Heterogeneity for Moderate Biodiversity Ranked Regional Land Cover Classes

Indices Measured		Coniferous Jack Pine Dominant	Mixedwood Jack Pine-Aspen Dominant	Mixedwood Aspen-White Spruce Dominant	Coniferous White-Spruce Dominant	Coniferous Black Spruce-White Spruce (Jack Pine) Dominant	Graminoid Fen
Landscape Level	**Units**						
class area (CA)	ha	23,101	2,425	61,100	39,989	25,484	36,577
number of patches (NP)	none	2,507	626	8,624	5,071	2,521	4,919
mean patch area (AREA_MN)	ha	9.2	3.9	7.1	7.9	10.1	7.4
median patch area (AREA_MD)	ha	3.2	2.1	1.8	2.5	4.1	1.8
patch area standard deviation (AREA_SD)	none	30.8	5.8	19.3	19.5	21.7	20.3
patch area coefficient of variance (AREA_CV)	%	334.8	149.9	272.9	247.2	214.6	273.2
distribution (IJI)	%	70.2	74.1	73.1	67.6	72.0	76.4
Ecosystem Level							
total score[a]		18.0	18.5	18.7	19.4	19.6	20.0
rank index[b] [c]		0.76	0.78	0.79	0.82	0.83	0.84

(a) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(b) Score for each category relative to the highest score.

(c) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not assessed.

Table 3-3 Landscape Heterogeneity for Low Biodiversity Ranked and Unranked Regional Land Cover Classes

Indices Measured		Low Biodiversity Potential			Unranked	
		Deciduous Aspen/ Aspen-Balsam Poplar Dominant	Poor Wooded Fen/ Wooded Bog	Burn	Cutblock	Disturbed
Landscape Level	**Units**					
class area (CA)	ha	96,443	221,374	173,823	139,130	115,870
number of patches (NP)	none	9,013	15,934	8,361	7,462	1,327
mean patch area (AREA_MN)	ha	10.7	13.9	20.8	18.6	87.3
median patch area (AREA_MD)	ha	2.4	<1	2.2	2.1	0.5
patch area standard deviation (AREA_SD)	none	31.2	58.2	89.8	76.1	3,148.4
patch area coefficient of variance (AREA_CV)	%	291	420	432	408	3,606
distribution (IJI)	%	76.3	65.5	55.5	61.2	76.4
Ecosystem Level						
total score[(a)]		15.6	15.9	n/a	n/a	n/a
rank index[(b) (c)]		0.66	0.67	n/a	n/a	n/a

(a) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(b) Score for each category relative to the highest score.

(c) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not assessed.

3.1.2 Distribution of Ecosite Phases/Wetlands Types Ranked for Biodiversity Potential in the LSA

There are 22 vegetated patch types in the LSA, two other (unranked) classes and water. Ecosite phases (seven classes) cover 18%, wetlands types (15 classes) cover 73% and unclassified types (two classes) cover 9 % of the LSA (Figure 3-2).

Ecosite Phases/Wetlands Types

The ecosite phases/wetlands types in the LSA were ranked for biodiversity potential and classed as high, moderate, low and unranked (Appendix II, Table II-2). The LSA is comprised of 6% high, 42% moderate, 44% low and 8% unranked classes (Table 3-4).

Table 3-4 Area of Ranked Ecosystems in the LSA

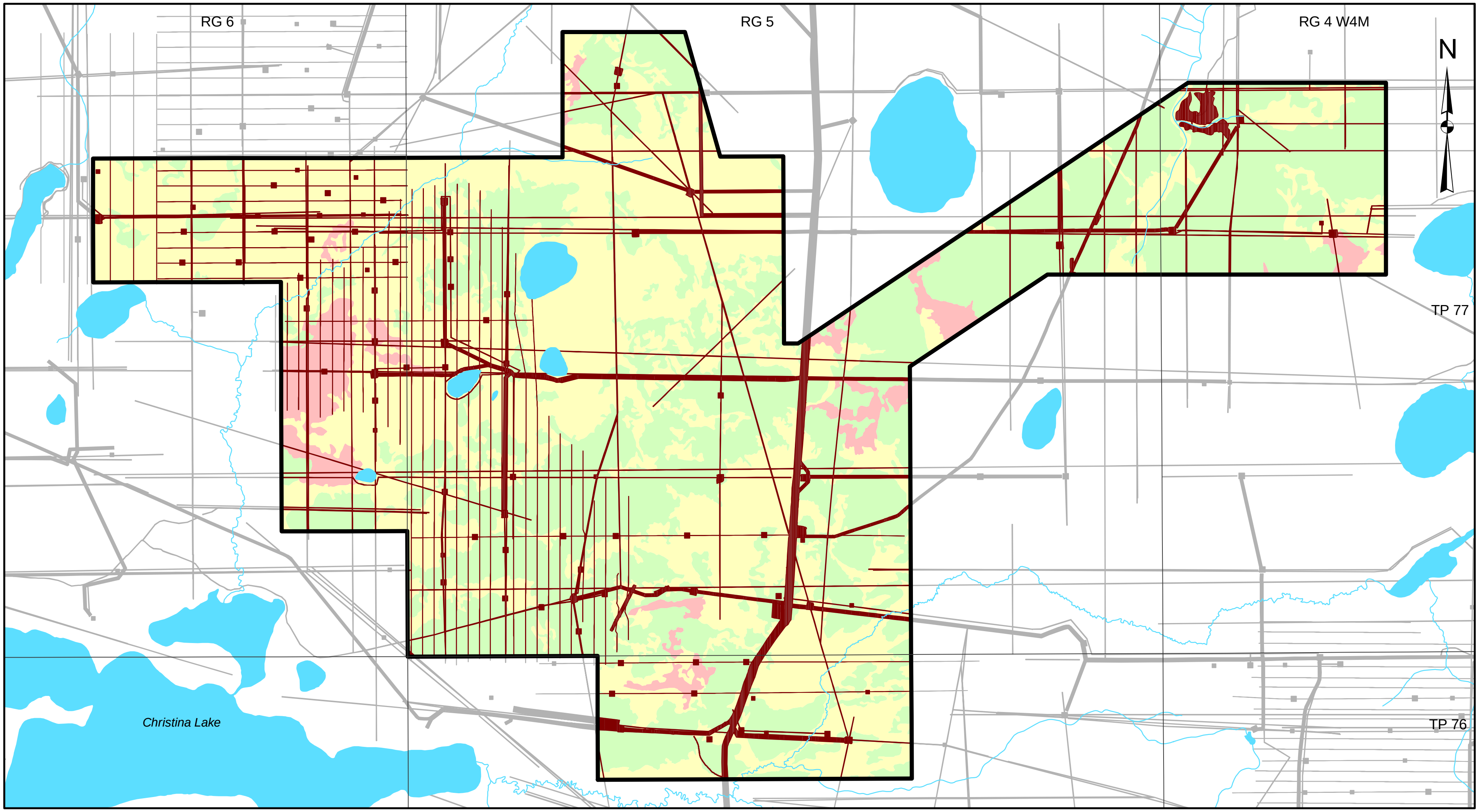
Biodiversity Rank	Area (ha)	Percent of the LSA (%)
High	197	6
Moderate	1,492	42
Low	1,567	44
Unranked	293	8
Total	**3,549**	**100**

The arrangement and distribution of ranked classes for high, moderate, low ecosite phases and low, unranked wetlands are presented in Tables 3-5, 3-6, 3-7 and 3-8 respectively, and are summarized below by biodiversity rank.

- Richness - the 25 patch types are somewhat unevenly distributed within the LSA (Shannon's evenness of 0.68 out of 1).
- High biodiversity - there are four vegetation types in the LSA, all of which are wetlands classes. These high ranked classes cover 197 ha or just over 6% of the LSA. Together, wooded patterned fens (FTPN) and wooded fens with internal lawns (FTNI) make up 95% of the high ranked wetlands.
- High biodiversity - wooded patterned fens (FTPN) are divided into 51 patches that are small (1.9 ± 2.8 ha) and variable (149% AREA_CV) in size. Wooded fens with internal lawns (FTNI) are better interspersed throughout the LSA (IJI of 42%) than the wooded patterned fens (FTPN) patches (IJI of 29%).

- High biodiversity - the other two wetland classes are forested fens (FFNN) and wooded fen with internal lawns and islands of forested peat plateau (FTNR). Collectively, these rare wetlands types cover less than 1% of the LSA and are comprised of a few, poorly interspersed patches (IJI of 36% and 38%, respectively).
- Moderate biodiversity - areas (1,492 ha or 42% of the LSA) consist of five wetlands types, lakes and one upland/wetland complex. The wooded fen (FTNN) is the largest of the moderate ranked wetlands types, with a class area of 746 ha divided into 365 patches.
- Moderate biodiversity - the second largest class is the shrubby fen (FONS) wetlands type (552 ha) represented by 323 small (1.7 ± 3.8 ha) patches. The patches are generally close to each other (9.1 ± 12.1 m) but this distance varies (134% ENN_CV).
- Moderate biodiversity – open patterned fens (FOPN) have the third largest proportion of the moderate biodiversity classes (3% of the LSA). The remaining four moderate ranked classes are each less than 100 ha in size, the smallest being the shrubby swamp (13 ha).
- Low biodiversity - areas cover 1,567 ha or 44% of the LSA and are made up of seven ecosite phases (658 ha) and four wetland classes (908 ha) and one other class (1 ha).
- Low biodiversity - the largest terrestrial class is the Labrador tea–mesic jack pine-black spruce (c1) ecosite phase (360 ha). The mean patch size of this class is 1.8 ± 3.0 ha. The patches are somewhat evenly distributed on the landscape (IJI of 59%) and are generally located close together (8.2 m ENN_MD).
- Low biodiversity - the largest wetlands class is the wooded bog (BTNN) (872 ha, 25% of the LSA). This class is represented by 319, generally small (0.4 ha median), patches that are not regularly spaced (251% ENN_CV) or highly interspersed (IJI of 61%) on the landscape.
- Unranked - the disturbed class has a class area of 293 ha comprising 8% of the LSA. The disturbance class is well interspersed through the LSA (IJI of 64%) and are generally located close together (14.6 m ENN_MD).

I:/2004/04-1334/04-1334-001/mapping/mxd/Biodiversity/lsa_bl_biopot.mxd



LEGEND

LOCAL STUDY AREA
OPEN WATER
RIVER OR STREAM

DISTURBED

EXISTING DISTURBANCE (WITHIN LSA)
EXISTING DISTURBANCE (OUTSIDE OF LSA)

BIODIVERSITY POTENTIAL

HIGH
MODERATE
LOW
UNCLASSIFIED

2 0 2

SCALE 1:75,000 KILOMETRES

REFERENCE

Digital data provided by AltaLIS Ltd. (June 2004), Veritas DGC Inc. (July 2004), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and LANDSAT 7 ETM Imagery (1998 and 1999), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT

TITLE

BIODIVERSITY POTENTIAL IN THE LOCAL STUDY AREA

MEG ENERGY CORP.

PROJECT No. 04-1334.001.7800			SCALE AS SHOWN	REV. 1
DESIGN	MS	12 Jan. 2005	**FIGURE: 3-2**	
GIS	VR	07 Jul. 2005		
CHECK	AA	07 Jul. 2005		
REVIEW	TC	22 Jul. 2005		

Table 3-5 Wetlands Types with High Biodiversity Potential in the Local Study Area

Indices Assessed		Wetlands Type[a]			
		FFNN	FTNR	FTPN	FTNI
Landscape-Level Indices	**Unit**				
class area (CA)[b]	ha	1	8	97	91
percent of LSA	%	<1	<1	3	3
number of patches (NP)	n/a	5	6	51	41
patch size mean (AREA_MN)	ha	0.2	1.3	1.9	2.2
patch size median (AREA_MD)	ha	0.2	0.6	0.6	0.5
patch size standard deviation (AREA_SD)	ha	0.2	1.5	2.8	5.7
patch size coefficient of variation (AREA_CV)	%	93	115	149	255
nearest neighbour mean (ENN_MN)	m	5.2	8.7	108.7	42.0
nearest neighbour median (ENN_MD)	m	4.0	8.2	6.0	6.0
nearest neighbour standard deviation (ENN_SD)	m	2.4	2.7	709.9	157.3
nearest neighbour coefficient of variation (ENN_CV)	%	46	31	653	374
distribution (IJI)	%	36	38	29	42
Ecosystem-Level Indices[c]					
rare vegetation type		6	4	4	4
rare species potential (plants)		4	4	4	4
rare species potential (wildlife)		4	4	4	4
total species richness (plants)		4	4	4	4
total species richness (wildlife)		4	4	4	4
species overlap (plants)		2	3	3	3
species overlap (wildlife)		0	0	0	0
structural complexity		3	3	3	3.5
total score[c]		26.0	26.0	28.0	26.5
ranking index[d][e]		0.93	0.93	1.00	0.95

(a) Full names of ecosite phases/wetlands types are provided in Section 6.2.1.

(b) The class areas may differ slightly from those listed in the Terrestrial Vegetation, Wetlands and Forest Resources ESR (Golder 2005a) due to different methods used. The class areas in Golder (2005a) are determined from vector data, while class areas in this report are determined from a grid.

(c) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(d) Score for each category relative to the highest score.

(e) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not applicable.

Table 3-6 Wetlands Types with Moderate Biodiversity Potential in the Local Study Area

Indices Assessed		Wetlands Type[a]						
		BONS	FONS	FOPN	FTNN	SONS	NWL	Pj-Lt complex
Landscape-Level Indices	**Unit**							
class area (CA)	ha	15	552	94	746	13	65	7
percent of LSA	%	<1	15	3	21	<1	2	<1
number of patches (NP)	n/a	3	323	83	365	14	5	1
patch size mean (AREA_MN)	ha	5.1	1.7	1.1	2.0	0.9	12.9	7.4
patch size median (AREA_MD)	ha	5.0	0.5	0.0	0.6	0.5	9.9	7.4
patch size standard deviation (AREA_SD)	ha	0.7	3.8	2.4	4.4	1.1	14.0	<1
patch size coefficient of variation (AREA_CV)	%	14	225	215	215	117	109	0
nearest neighbour mean (ENN_MN)	m	48.0	9.1	6.5	19.8	10.9	636.6	n/a
nearest neighbour median (ENN_MD)	m	10.0	6.0	4.5	6.0	10.0	622.2	n/a
nearest neighbour standard deviation (ENN_SD)	m	53.7	12.1	5.9	82.4	7.7	416.8	n/a
nearest neighbour coefficient of variation (ENN_CV)	%	112	134	90	417	71	65	n/a
distribution (IJI)	%	30	54	39	54	51	34	41
Ecosystem-Level Indices[b]								
rare vegetation type		6	2	6	0	2	4	4
rare species potential (plants)		4	4	4	4	4	4	2
rare species potential (wildlife)		3	3	2	4	4	4	4
total species richness (plants)		3	4	4	4	3	1	3
total species richness (wildlife)		3	3	2	4	4	3	2
species overlap (plants)		2	3	3	3	2	4	2
species overlap (wildlife)		1	1	1	0	1	4	1
structural complexity		2	2	2	3.5	2	1	3
total score[b]		24.0	22.0	24.0	22.5	22.0	25.0	21.0
ranking index[c][d]		0.86	0.79	0.86	0.80	0.79	0.89	0.75

(a) Full names of ecosite phases/wetlands types are provided in Section 6.2.1.

(b) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(c) Score for each category relative to the highest score.

(d) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not applicable.

Table 3-7 Ecosite Phases with Low Biodiversity Potential in the Local Study Area

Indices Assessed		Ecosite Phase[a]						
		a1	b1	b3	c1	d1	d2	g1
Landscape-Level Indices	**Unit**							
class area (CA)	ha	34	15	7	360	14	6	222
percent of LSA	%	1	<1	<1	10	<1	<1	6
number of patches (NP)	n/a	15	19	3	195	8	14	112
patch size mean (AREA_MN)	ha	2.3	0.8	2.3	1.8	1.7	0.4	2.0
patch size median (AREA_MD)	ha	1.0	0.5	0.1	0.7	0.6	0.1	0.6
patch size standard deviation (AREA_SD)	ha	2.4	0.9	3.2	3.0	2.1	0.7	3.4
patch size coefficient of variation (AREA_CV)	%	108	117	139	163	126	157	174
nearest neighbour mean (ENN_MN)	m	164.8	450.8	8.8	22.7	467.3	15.6	62.4
nearest neighbour median (ENN_MD)	m	10.0	10.0	8.2	8.2	10.8	10.0	10.0
nearest neighbour standard deviation (ENN_SD)	m	567.4	1085.0	0.83	67.7	1208.4	17.3	315.0
nearest neighbour coefficient of variation (ENN_CV)	%	344	241	9	298	259	111	506
distribution (IJI)	%	63	47	23	59	46	40	61
Ecosystem-Level Indices[b]								
rare vegetation type		4	2	4	4	0	0	2
rare species potential (plants)		1	2	1	1	1	2	2
rare species potential (wildlife)		3	2	3	3	2	3	3
total species richness (plants)		2	3	2	3	3	3	3
total species richness (wildlife)		2	3	4	2	3	4	2
species overlap (plants)		2	2	1	2	2	2	2
species overlap (wildlife)		1	1	1	1	1	1	1
structural complexity		3	3.5	3.5	3	3.5	3.5	4
total score[b]		18.0	18.5	19.5	19.0	15.5	18.5	19.0
ranking index[c][d]		0.64	0.66	0.70	0.68	0.55	0.66	0.68

(a) Full names of ecosite phases/wetlands types are provided in Section 6.2.1.

(b) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(c) Score for each category relative to the highest score.

(d) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not applicable.

Table 3-8 Wetlands Types with Low Biodiversity Potential and Unranked Classes in the Local Study Area

Indices Assessed		Low					Unranked
		Wetlands Type[a]				Other	
		BFNN	BTNI	BTNN	FONG	Meadow	Dist[b]
Landscape-Level Indices	**Unit**						
class area (CA)	ha	6	4	872	26	1	293
percent of LSA	%	<1	<1	25	1	<1	8
number of patches (NP)	n/a	5	2	319	25	2	13
patch size mean (AREA_MN)	ha	1.2	2.0	2.7	1.0	0.5	22.5
patch size median (AREA_MD)	ha	0.8	2.0	0.4	0.5	0.5	0.2
patch size standard deviation (AREA_SD)	ha	1.0	0.5	9.1	1.1	0.2	59.9
patch size coefficient of variation (AREA_CV)	%	80	25	334	102	47	266
nearest neighbour mean (ENN_MN)	m	72.9	4,843	16.1	32.7	4.0	45.0
nearest neighbour median (ENN_MD)	m	10.0	4,843	8.2	10.0	4.0	14.6
nearest neighbour standard deviation (ENN_SD)	m	125.8	0.0	40.5	61.6	0.0	76.7
nearest neighbour coefficient of variation (ENN_CV)	%	173	0	251	189	0	170
distribution (IJI)	%	33	41	61	55	21	64
Ecosystem-Level Indices[b]							
rare vegetation type		6	6	2	4	n/a	n/a
rare species potential (plants)		1	1	1	4	n/a	n/a
rare species potential (wildlife)		2	2	2	2	n/a	n/a
total species richness (plants)		3	3	3	3	n/a	n/a
total species richness (wildlife)		2	2	2	2	n/a	n/a
species overlap (plants)		2	2	2	3	n/a	n/a
species overlap (wildlife)		0	0	0	1	n/a	n/a
structural complexity		3	3	3	1	n/a	n/a
total score[c]		19.0	19.0	15.0	20.0	n/a	n/a
ranking index[c][d]		0.68	0.68	0.54	0.71	n/a	n/a

(a) Full names of ecosite phases/wetlands types are provided in Section 6.2.1.

(b) Sum of scores for rare vegetation type, rare species potential, structural complexity and plant and wildlife total species richness and species overlap.

(c) Score for each category relative to the highest score.

(d) Low = <0.75; Moderate = 0.75 to 0.899; High = $\geq$ 0.90.

n/a = not applicable.

4 CONCLUSIONS

The existing arrangement and distribution of vegetation types ranked for biodiversity were evaluated using landscape and ecosystem level analysis at the RSA and LSA levels. Landscape analyses were conducted on regional land cover classes in the RSA and ecosite phases/wetlands types in the LSA. Vegetation types were ranked using an extensive dataset of plant, wildlife and aquatic species from the Oil Sands Region.

A combination of landscape and ecosystem-level measures was used to describe the biodiversity in the LSA and RSA. Landscape-level measures show that the distribution of high, moderate and low biodiversity is an important determinant of biodiversity. The location of patches of biodiversity relative to each other influence the movement of species affecting species richness, habitat specificity and the occurrence of rare species (parameters measured in the ranking system, Appendix II).

In landscape and ecosystem-level analysis, vegetation types in the Oil Sands Region that are uncommon, e.g., permafrost bogs on the edge of their range, are quantified in the process of landscape-level analysis using area and connectivity measures while parameters directly influenced by geography at the ecosystem-level are quantified in the biodiversity ranking system. To illustrate, permafrost bogs on the edge of their geographic range often include habitats for species that are rare in Alberta. The landscape-level measure namely, abundance of vegetation type, is tied to an ecosystem-level measure namely; the occurrence of rare (listed) species (ANHIC 2004, COSEWIC 2004) in the biodiversity ranking system (Appendix II).

Regional Study Area

A summary of the heterogeneity results for the RSA are presented below.

- Overall, the RSA is comprised of 39% high, 13% moderate and 32% low biodiversity potential areas. The remaining 16% consists of unranked classes, predominantly burns.
- High biodiversity - the wooded fen is the largest regional land cover class, covering 424,225 ha (28% of the RSA) and a mean patch size of 12.3 ± 46.6 ha.
- Moderate biodiversity - six areas cover 188,676 ha or 13% of the RSA and are largely composed of mixedwood aspen-white spruce and coniferous white spruce forests and graminoid fens.

- Low biodiversity - the largest wetlands class is the poor wooded fen/wooded bog, covering 221,374 ha (14% of the RSA) and a mean patch size of 13.9 ± 58.2 ha.
- Low biodiversity - the largest terrestrial class is the deciduous aspen/aspen-balsam poplar, covering 96,443 ha (6% of the RSA) and a mean patch size of 10.7 ± 31.2 ha.

Local Study Area

The heterogeneity analysis for the LSA is summarized below.

- The LSA is comprised of 6% high, 42% moderate, 44% low and 8% unranked classes.
- High biodiversity - the four vegetation types in the LSA are wooded patterned fen (FTPN), wooded fen with in internal lawns (FTNI), wooded fen with forested islands (FTNR) and forested fen (FFNN).
- Moderate biodiversity - covers 1,492 ha of the LSA, composed of five wetland classes, lakes (NWL) and an upland/wetland complex class. The most common patch types are treed fens (FTNN) and shrubby fens (FONS), which cover 746 ha and 552 ha, respectively. Likely due in part to the abundance of FTNN in the LSA, the patches in this class are located close to each other (19.8 ± 82.4 ha) and are moderately interspersed throughout the landscape (IJI of 54%).
- Low biodiversity - the wooded bog (BTNN) is the largest wetlands class (872 ha) and has a mean patch size of 2.7 ha ± 9.1 ha.
- Low biodiversity - the Labrador Tea-mesic jack pine-black spruce (c1) is the largest class (360 ha) with a patch size mean of 22.7 ha.

5 CLOSURE

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6 GLOSSARY OF TERMS AND LIST OF ABBREVIATIONS

Biodiversity	The variety of a plant and animal life in a particular habitat (e.g., plant community or a country). It includes all levels of organization, from genes to landscapes, and the ecological processes through which these levels are connected.
Biodiversity Ranking	The relative contribution of an ecosite phase/wetlands type to the overall biological diversity of an area
Coefficient of Variation	Standardized index of the variability of a value relative to the mean value.
Configuration	The location and arrangement of landscape elements.
Connectivity	A measure of how connected or spatially continuous a corridor or matrix is.
Disturbance	An event that causes a sudden change from the existing pattern in an ecological system.
Ecodistricts	Landscape units that represent similar geology, landform and vegetation characteristics that best reflect overall patterns of landscape features.
Ecological Land Classification (ELC)	A means of classifying landscapes by integrating landforms, soils and vegetation components in a hierarchical manner.
Ecosite	Ecological units that develop under similar environmental influences (climate, moisture and nutrient regime). Ecosites are groups of one or more ecosite phases that occur within the same portion of the moisture/nutrient grid. Ecosite is a functional unit defined by the moisture and nutrient regime. It is not tied to specific landforms or plant communities, but is based on the combined interaction of biophysical factors that together dictate the availability of moisture and nutrients for plant growth.
Ecosite Phase	A subdivision of the ecosite based on the dominant tree species in the canopy. On some sites where the tree canopy is lacking, the tallest structural vegetation layer determines the ecosite phase.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.

Edge	Where different plant communities meet in space on a landscape; and where plant communities meet a disturbance. An outer band of a patch that usually has an environment significantly different from the interior of the patch.
Escarpment	A cliff or steep slope at the edge of an upland area. The steep face of a river valley.
Evenness	The relative abundance of species; measured using the Shannon Weiner Index.
Forb	Broad-leaved herb, as distinguished from grasses.
Fragmentation	The process of breaking into pieces or sections. For example, dividing contiguous tracts of land into smaller and less connected sections through site clearing (e.g., for roads).
FRAGSTATS	A spatial pattern analysis software program used to quantify the areal extent and spatial configuration of patches within a landscape. The analysis is done using categorical spatial data (e.g., plant communities).
Geographic Information System (GIS)	Computer software designed to develop, manage, analyze and display spatially referenced data.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Herb	Tender plant, lacking woody stems, usually small or low; it may be annual or perennial, broadleaf (forb) or graminoid (grass).
Heterogeneity	Consisting of parts that are unlike each other. For example, the variety and abundance of ecological units (e.g., ecosite phases/ wetlands types) comprising a landscape mosiac.
LANDSAT	A specific satellite or series of satellites used for earth resource remote sensing. Satellite data can be converted to visual images for resource analysis and planning.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular "focal" or "target" habitat patch is embedded.
Landscape Structure	The spatial relations among a landscape's component parts including composition; the presence and amount of each patch type without being spatially explicit; and landscape configuration, the physical distribution or spatial character of patches within a landscape.
Matrix	The most extensive and most connected landscape element type present, which plays the dominant role in landscape functioning.

Mesic	Pertaining to, or adapted to an area that has an intermediate supply of water; neither wet not dry.
Moraine	A deposit of rocks and debris carried and dropped by a glacier.
Oil Sands	A sand deposit containing a heavy hydrocarbon (bitumen) in the intergranular pore space of sands and fine grained particles. Typical oil sands comprise approximately 10 wt% bitumen, 85% coarse sand (>44 µm) and a fines (<44 µm) fraction, consisting of silts and clays.
Old Growth Forest	An ecosystem distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species, composition, and ecosystem function. Old growth forests are those forested areas where the annual growth equals annual losses, or where the mean annual increment of timber volume equals zero. They can be defined as those stands that are self-regenerating (i.e., having a specific structure that is maintained).
Patch	An area which is different from the area around it (e.g., vegetation types, non-forested areas). This term is used to recognize that most ecosystems are not homogeneous, but rather exist as a group of patches or ecological islands that are recognizably different from the parts of the ecosystem that surround them but nevertheless interact with them.
Peat	A material composed almost entirely of organic matter from the partial decomposition of plants growing in wet conditions.
Plant Community	An association of plants of various species found growing together.
Polygon	The spatial area delineated on a map to define one feature unit (e.g., one type of ecosite phase).
Raster	A graphic structure where the data is divided into cells on a grid. An example would be a computer screen where an image is represented by horizontal lines of coloured pixels. Shapes are represented by cells of the same colour or content adjacent to each other.
Richness	The number of species in a biological community (e.g., habitat).
Riparian Area	A geographic area containing an aquatic ecosystem and adjacent upland areas that directly affects it.
Shannon's Evenness Index (SHEI)	Distribution of area among or within patch types in the landscape.

Shannon-Wiener Index	A diversity measure based on information theory, a measure of order (or disorder) within a particular system. The Shannon-Wiener index provides a measure of the degree of complexity in a system from low (0) to high (5).
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Species Composition	The number and abundance of species found in the sampling area.
Species Distribution	Where the various species in an ecosystem are found at any given time. Species distribution varies with season.
Species Diversity	A description of a biological community that includes both the number of different species and their relative abundance. Provides a measure of the variation in number of species in a region.
Species Richness	The number of different species occupying a given area.
Stand	A group of trees occupying a specific area and sufficiently uniform in composition, age, arrangement and condition so that it is distinguishable from trees in adjoining areas.
Standard Deviation (Sd)	A measure of the variability or spread of the measurements about the mean. It is calculated as the positive square root of the variance.
Structure (Stand Structure)	The various horizontal and vertical physical elements of the forest. The physical appearance of canopy and subcanopy trees and snags, shrub and herbaceous layers and downed woody material.
Succession	A series of dynamic changes by which one group of organisms succeeds another through stages leading to a climax community.
Successional Stage	A stage or recognizable condition of a forest community that occurs during its development from bare ground to climax.
Vector	A graphic structure where the data is partitioned into polygons. Shapes are created by drawing a line around data of the same content.
Vegetation Community	See “Plant Community”.

6.1 LIST OF ABBREVIATIONS/ACRONYMS

%	Percent
<	Less than
>	More than
e.g.	For example
i.e.	That is
±	Plus minus
AENV	Alberta Environment
AREA_CV	Patch Size Coefficient of Variation (=PSCV of FRAGSTATS 2)
AREA_MD	Patch Size Median
AREA_MN	Patch Size Mean (=MPS of FRAGSTATS 2)
AREA_SD	Patch Size Standard Deviation
AVI	Alberta Vegetation Inventory
CA	Class Area
CAI_AM	Core Area Index Area Weighted Mean (=TCAI of FRAGSTATS 2)
CNRL	Canadian Natural Resources Limited
COSEWIC	Committee on the Statues of Endangered Wildlife in Canada
d	Day
EIA	Environmental Impact Assessment
ELC	Ecological Land Classification
ENN_CV	Euclidean Nearest Neighbour Median (=NNMD of FRAGSTATS 2)
ENN_MD	Euclidean Nearest Neighbour Coefficient of Variation (=NNCV of FRAGSTATS 2)
ENN_MN	Euclidean Nearest Neighbour Mean (=MNN of FRAGSTATS 2)
ENN_SD	Euclidean Nearest Neighbour Standard Deviation (=NNSD of FRAGSTATS 2)
ESR	Environmental Setting Report
FRAC_MN	Mean Patch Fractal Dimension (=MPFD of FRAGSTATS 2)
GIS	Geographic Information Systems
ha	Hectare

IJI	Interpersion/Juxtapositon Index
KIR	Key Indicator Resources
LSA	Local Study Area
m	Metre
m^3/day	Cubic metres per day
MEG	MEG Energy Corp.
MN	Mean Patch Size
n/a	Not applicable
NP	Number of Patches
PR	Patch Richness
RSA	Regional Study Area
SAGD	Steam Assited Gravity Drainage
SHEU+I	Shannon's Evenness Index
TCAI	Total Core Area Index
the Project	Christina Lake Regional Project

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APPENDIX I

LANDSCAPE-LEVEL APPROACH TO BIODIVERSITY ASSESSMENT

1 LANDSCAPE-LEVEL APPROACH TO BIODIVERSITY ASSESSMENT

ECOLOGICAL ISSUES AT THE LANDSCAPE LEVEL

Landscape Ecology and Diversity

Preservation of landscape diversity is essential for maintaining ecological integrity. Diversity of and within landscapes provides the necessary base to ensure that gene, species and ecosystem diversity are conserved (Canadian Forest Service 1997). This concept has lead to a surge of interest towards a landscape-level understanding of ecological processes (i.e., the science of landscape ecology). This is due, in large part, to the growing recognition that these processes affect and are affected by the dynamic interaction among ecosystems (McGarigal and Marks 1995).

The science of landscape ecology focuses on the interaction of biotic and abiotic elements as they occur over the entire landscape. In most cases, the landscape is pragmatically defined as an interacting mosaic of patches relevant to the phenomenon under consideration (McGarigal and Marks 1995), with a patch being a relatively homogeneous area that differs from its surroundings (Forman 1995). Overall, landscape ecology considers three main characteristics of the landscape (Forman and Gordon 1986):

- structure, which is the spatial relationships among the distinctive ecosystems or elements present. More specifically, it is the distribution of energy, materials and species in relation to the size, shape, number, kind and configuration of the ecosystems;
- function, which is the interactions among the spatial elements (i.e., the flow of energy, materials and species among the component ecosystems); and
- change, which is the alteration in the structure and function of the ecological mosaic over time.

Landscapes are distinguished by the spatial relations among their component parts and can be characterized by both their composition and configuration. These two aspects of a landscape can independently, or in combination, affect ecological processes and organisms (McGarigal and Marks 1995).

Landscape composition focuses on the variety and abundance of patch types within a landscape, but not the placement or location of patches within the landscape mosaic (McGarigal and Marks 1995). Measures of landscape composition include the proportion of patch types in the landscape, patch richness, patch evenness and patch diversity.

Contrary to landscape composition, landscape configuration refers to the physical distribution or spatial character of patches within the landscape. The most commonly measured aspects of landscape configuration include patch isolation or patch contagion (i.e., measures of the placement of patch types relative to other patch types or the landscape boundary) and patch shape and core area, which are measures of the spatial character of the patches (McGarigal and Marks 1995).

Fragmentation

By definition, fragmentation is the breaking up of contiguous environmental patches into smaller and more disjunct or isolated patches (Morrison et al. 1998). The effects of fragmentation include:

- reducing the area of the remaining fragments (e.g., decreased core area or habitat);
- increasing isolation of the fragments from each other (e.g., insularity); and
- increasing disturbance from the surroundings (e.g., edge effects) (Haila 1999).

This change in landscape structure may have drastic impacts on complex biological interactions (e.g., grazing, seed dispersal, predation and nest parasitism; Matlack and Litvaitis [1999]) as well as on various ecosystem processes (e.g., nutrient cycling and decomposition, as affected by light availability and temperature regimes and air movement).

Zipperer (1993) defined three general types of forest disturbance patterns that increase forest edge relative to the area of the patch: internal, external and bisecting. Internal disturbances are one of the initial processes that occur when the landscape is nearly continuously forested. In this type of disturbance, the forest is removed in a central area leaving forest surrounding the disturbance. This is analogous to many developments in the boreal forest, including oil sands developments. External disturbances occur from the outside of the forest patch and include indentation, which results in peninsulas of forest, or cropping, which reduces the size of a patch. Both types increase edge relative to area. Bisection may involve only a small area of removal (e.g., a pipeline route cut through a forest) but creates a new perimeter as it divides the forest into two patches. Note that although many fragmentation examples are described for forests, any natural vegetation type (e.g., grasslands and shrublands) can be disturbed and fragmented.

Determination of the impacts of fragmentation require a landscape-scale point-of-view. Studying the effects of fragmentation at too small a scale makes it very difficult to differentiate between the effects of habitat loss and breaking apart of habitat (Fahrig 1999). For this reason, all analyses depicting fragmentation effects are performed at the landscape scale.

ANALYSIS OF LANDSCAPE STRUCTURE

It should be noted that the mean patch size (MPS) of a particular patch type reflects both the amount of a patch type present (composition) and its spatial distribution (configuration). However, because they both differ with spatial heterogeneity of the landscape, it is more appropriate that they be considered indices of landscape configuration (McGarigal and Marks 1995).

There are three possible scales of analysis for landscape structure: entire landscape (regional or local study area [RSA or LSA]), macroterrain units and ecosystems. In some instances, the LSA in question can be comprised of distinct landform units (i.e., ecodistricts). Natural topography, terrain and vegetation features define the boundaries of each ecodistrict. When ecodistricts are distinguishable in the study area, landscape structure analysis can also be conducted for each unit. The scope of the study being performed will determine which scales will be used to describe landscape structure.

Description and analysis of landscape structure has two primary goals: quantify the degree of fragmentation and quantify the heterogeneity (or spatial variability) within the landscape.

Fragmentation in these analyses only relates to the edges caused by human disturbances such as roads, seismic lines, industrial developments and other similar surface disturbances. The only patch type considered here is the undisturbed patch type, which is bordered by human disturbances and not vegetation units. For example, the total amount of border between undisturbed patches will provide a measure of the total edge fragmentation.

Heterogeneity is a measure of landscape structure based on vegetation unit patches (defined here as ecosite phase and Alberta Wetlands Inventory [AWI] classes in the LSA analysis and regional land cover classes in the RSA analysis). These vegetation units are the patches that comprise the “natural area” patches used in the fragmentation analyses. The number of different vegetation units is used to define patch richness heterogeneity. The amounts of border between all different types of vegetation units are summed as the total edge heterogeneity measure.

Indices of Landscape Fragmentation and Heterogeneity

Each landscape metric is defined in the following section in terms of method of calculation. Each is also described as it relates to landscape heterogeneity and fragmentation. Methods provided follow McGarigal and Marks (1995) and Elkie et al. (1999).

Class Area (CA)

The class area (CA) is the total area of each patch type, or of the total undisturbed landscape area (in hectares). This provides a direct summary of area for comparison of losses due to disturbances, which either decreases the total amount of undisturbed land or changes patch types from one type to another.

Class area is of biological importance because it indicates how much habitat or living space is provided for each species that occurs in the landscape. It can also be used to determine rarity of vegetation units.

Number of Patches (NP)

The number of patches (NP) is a measure of patches within each vegetation unit (where patches are a function of the edges between vegetation units), or the total number of patches of all undisturbed units (where a patch is created by disturbance edges).

This measurement of vegetation units is important because it determines the variability of the landscape. In addition, it determines the amount of dissection or fragmentation of the landscape in the undisturbed units.

Patch Size Mean (AREA_MN)

The patch size mean (AREA_MN) is determined be dividing the area of an ecosystem type by the number of patches of that type. For total undisturbed areas, it is the mean size of the undisturbed patches.

This measure is important becuase is it provides a baseline value for each vegetation unit that is clear and easily understood. The mean size of the units may be related to biological features such as the minimum size requirement for a patch before a given species will occupy or use it as habitat. For example, a mean undisturbed patch size of 1 ha may be too small for moose or caribou to make use of as habitat, while 100 ha may be large enough.

Interspersion and Juxtaposition Index (IJI)

The interspersion and juxtaposition index measures the dispersion and interspersion of patches in the landscape. It is a true landscape-level index that is computed based on the probabilities of a patch belonging to one class and its neighbours belonging to another. When a patch type is adjacent to only one other patch type, the IJI index approaches zero. When a patch type is equally adjacent to all other patch types, maximum interspersion and juxtaposition is attained as the IJI index approaches 100.

Landscapes with a high interspersion of patches favour wildlife species using several habitat types (e.g., yellow-rumped warbler) while landscapes with a low interspersion of patches favour specialists such as the brown creeper and Cape May warbler. High interspersion values may also indicate a landscape is highly fragmented by development. Linear disturbances become adjacent to a large number of vegetation types when vegetation types are fragmented into smaller patches by such disturbance types. Landscapes with high interspersion typically have more patches of dissimilar patch types while those with low interspersion tend to consist of landscapes with larger, more continuous patch types.

Patch Density (PD)

The patch density (PD) is determined by dividing the number of patches per 100 ha by total landscape area. Patch density equals the number of patches of the corresponding patch types (NP) divided by total landscape area, multiplied by 10,000 and 100 (to convert to 100 ha).

Patch Area Coefficient of Variation (AREA_CV)

The patch size coefficient of variation (AREA_CV) builds off the patch area mean (AREA_MN). It is an expression of the variability of patch size relative to the mean. The AREA_CV is calculated as the standard deviation of patch size divided by the mean patch size and is thus a relative measure. When all the patches are the same size or there is only one patch, the AREA_CV will be zero, and when there is a wide range of sizes, the AREA_CV is greater than zero.

This measurement is important becuase it tells on average how much larger or smaller the patches are than the mean. For example, if a vegetation unit has a mean patch size of 10 ha with a AREA_CV of 100%, the range in patch size is between 0 and 20 ha. When AREA_CVs are greater than 100%, the largest patch size is more than double the mean.

Patch Richness (PR)

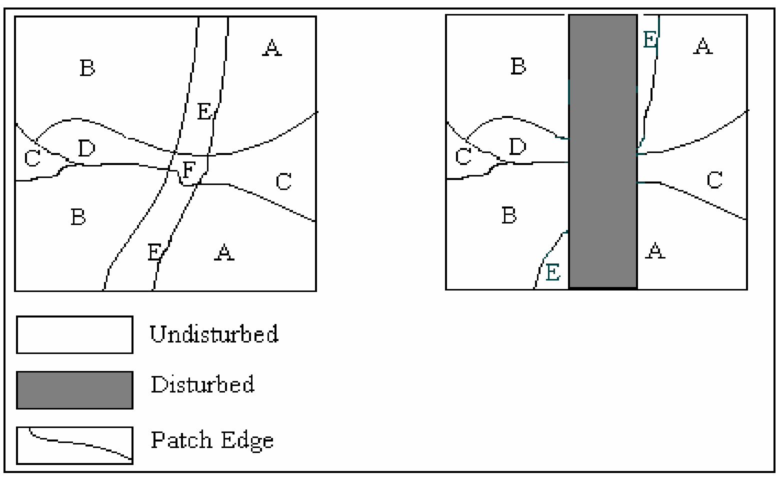
Patch richness (PR) is a measure of the number of different patch types that occur within a study area or landscape unit within a study area. The patch types used here are vegetation units.

PR = Count (i), where i is a unique identifier for each ecosystem unit

PR > 0

For example, in the diagrams of fragmentation of the ecosystem shown in Figure I-1, the patch richness in the first square is six vegetation units and in the second square it is five vegetation units. That is, one vegetation unit was lost due to fragmentation.

Figure I-1 Fragmentation of Ecosystem Classes



Patch richness is of biological importance because different species have unique ecosystem preferences and the greater the richness, the greater the likelihood that more species can exist in a landscape. As the landscape becomes fragmented, the patch richness may decrease within a study area boundary and this may be associated with a loss of species.

Shannon's Evenness (SHEI)

Shannon's evenness (SHEI) is a measure of the relative diversity of different patch types in a landscape. In other words, it is a ratio of the actual diversity of vegetation units to the maximum possible diversity and it expresses how homogeneous the landscape is. Patch evenness is high when there are many patch types with a similar area. Evenness decreases as either the number of patch types decreases, or as the distribution of areas of each type becomes more varied (dominated by a few large patches).

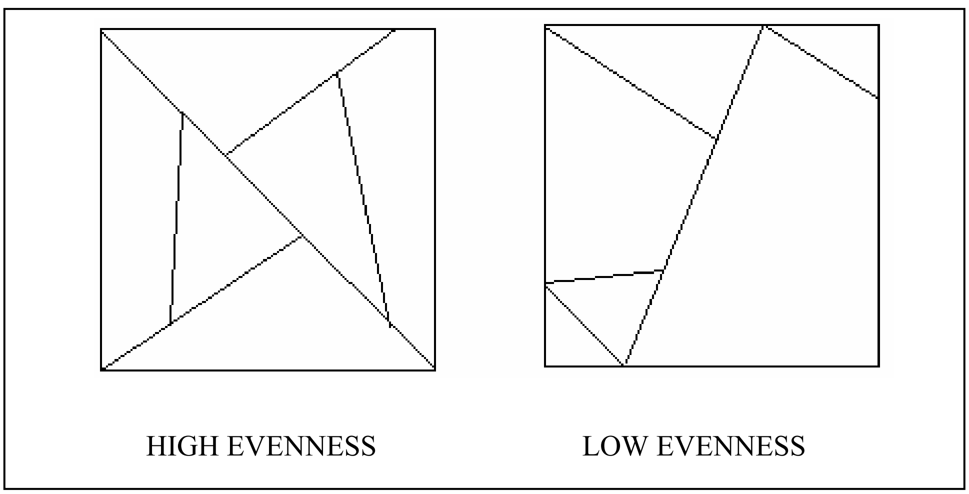
$$SHEI = \frac{-\sum_{i=1}^{m} Pi \ \ln Pi}{\ln m}$$

where: *Pi* is the proportion of each ecosystem type in terms of area to total area ratio; and

m is the total number of vegetation units.

Figure I-2 depicts a landscape with six vegetation units that have approximately the same size and therefore high evenness. Conversely, a landscape with six vegetation units but dominated by one or two large types and four small types has low evenness.

Figure I-2 Landscape Evenness



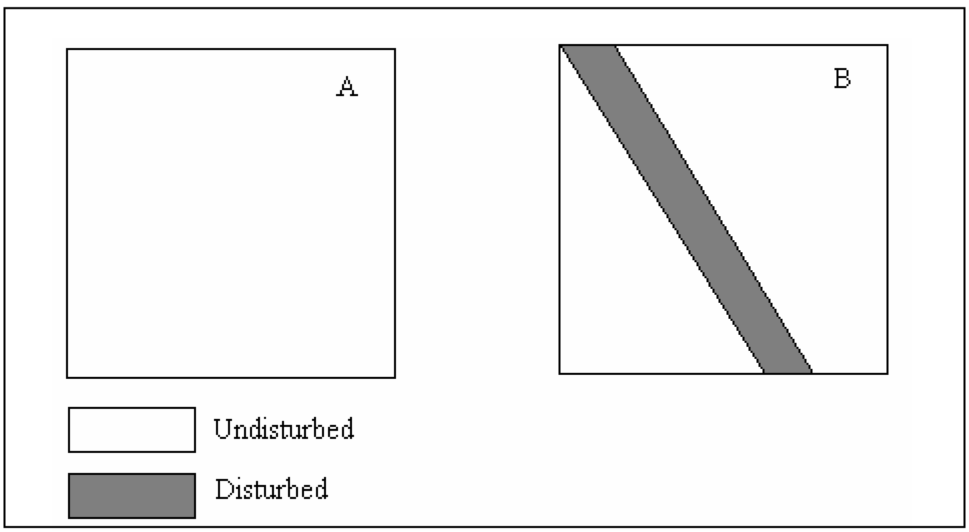
Eveness is of biological importance because it provides a measure of the dominance of patch types. Any one type does not dominate a highly even landscape, whereas one or a few types dominate an uneven landscape. Dominance of patch types relates directly to the potential for a given habitat type to support a large number of species. It is expected that a highly even landscape can support more species than an uneven landscape. The uneven landscape is expected to be represented by the fewest species, with those species found in the dominant type being numerically dominant.

Total Edge (TE)

Total edge (TE) is a measure of the total length of all patch boundaries. It differs from the total perimeter of a patch because each edge represents the boundary of two patches, whereas perimeter refers to only one patch. For the undisturbed landscape measurements, total edge calculates the length of disturbances.

This measurement has biological importance because many species make use of edges between vegetation units to provide optimal habitat. For example, deer often use the edge between forests and meadows as feeding areas, since the number of shrubs is greater there. In addition, edges represent areas where less desirable species, such as brown-headed cowbirds can gain access to nests of forest-dwelling birds. In Figure I-3, the continuous forest area shown in A has only the outside of the square as edge, but the amount of edge increases dramatically in square B, even with a small area linear disturbance.

Figure I-3 Example of Total Edge



Fractal Dimension Index (FRAC_MN)

Mean patch fractal dimension (FRAC_MN) is a measure of the complexity of a patch's shape. It also determines the amount of core area contained in the class. Elongated, irregular patches allow for linear movement of wildlife but contain a smaller core area than regular shaped round or square patches. The measurement range is between 1 and 2, with 1 being a regularly shaped patch, such as a circle or square and 2 being a highly irregular shaped patch.

$$FRAC\_MN = \Sigma x_{ij/} n_i$$

where: *xij* is the patch perimeter; and

n_i is the number of patches of the same type.

FRAC_MN (mean) equals the sum, across all patches of the corresponding patch type, of the corresponding patch metric values, divided by the number of patches of the same type. MN is given in the same units as the corresponding patch metric.

Euclidean Nearest Neighbour Median (ENN_MD) and Euclidean Nearest Neighbour Mean (ENN_MN)

Median nearest neighbour (ENN_MD) and mean nearest neighbour (ENN_MD) provides a measurement that clearly shows how close similar vegetation units are to one another. It can also be used to determine how separated undisturbed patches are by the disturbances on the landscape. These measurements determine the degree of patch isolation from similar patches based on the distance of the patches from each other, rather than on the distribution of areas of patches on the landscape. The formula for median nearest neighbour is:

$$ENN = hij$$

where: *hij* is the distance between two nearest neighbours.

The formula for mean nearest neighbour is:

$$MNN = \frac{\sum_{j=1}^{n} hij}{n}$$

where: *hij* is the distance between two nearest neighbours; and

n is the total number of neighbour pairs.

This metric is important because it relates to the mean distance that a species would have to travel to get between patches and thus defines the level of connectivity in the landscape. Where the mean distance is high, the connectivity is low and vice versa. Once the mean distance is too high, a species may not be able to effectively use the habitat, such as a carnivore that moves between isolated patches in search of prey items.

Euclidean Nearest Neighbour Standard Deviation (ENN_SD)

Euclidian nearest neighbour standard deviation (ENN_SD) provides a measurement of patch dispersion. A uniform or regular distribution of vegetation units will have a low standard deviation. Clustered or dispersed patches will have a large standard deviation compared to the mean.

This metric is important because it relates to the mean variation in distance that a species has to travel to get between patches and thus complements the mean nearest neighbour distance that defines the level of connectivity in the landscape. This metric describes the variation in the mean distance between patches of the same type. Species are more likely to move or disperse between closely spaced patches than to isolated patches located within large areas of dissimilar habitat. As such, species may only be able to utilize or disperse to certain portions of suitable habitat in the landscape.

ENN_SD should always be used in conjunction with ENN_MD distance, as two landscapes with similar standard deviations could have very different landscape structure. Any differences are evident only when the ENN_MD distance and ENN_SD are analyzed together.

Euclidean Nearest Neighbour Coefficient of Variation ENN_CV

Euclidian nearest neighbour coefficient of variation (ENN_CV) provides a percentage measurement of the variability of mean nearest neighbour (ENN_MN) distance to the actual MNN distance. The number of patches and patch density are required to provide a complete understanding of ENN_CV.

An animal moving through a landscape that has an ENN_CV of 100% may be moving through an area with 100 patches separated by a MNN distance of 100 m, or an area with 10 patches separated by 1,000 m. It is therefore essential to use ENN_CV with NP and/or patch density to determine the actual landscape configuration and composition.

Core Area Index (CAI)

A core area is an interior of a patch type that is within a given distance from the edge of the patch. This is the distance from a disturbance edge used to represent isolation from disturbance. It is used to represent the central portion of the natural area that is not part of the ecotone. Core area (CA) is a sum of the total area that is within the specified boundary, designated as being greater than 100 metres from the natural area edge. The total core area index is the percentage of natural area that is core area.

$$CAI = \frac{aij^{\ c}}{aij}(100)$$

where: a_{ij}^{c} = core area (m^2) of patch ij based on specified edge depths (m); and

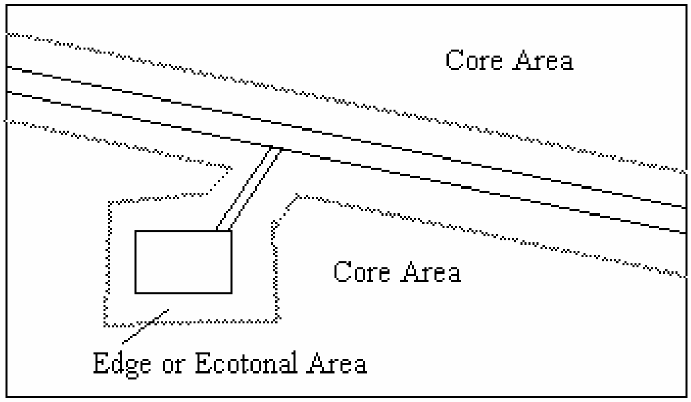
a_{ij} = area (m^2) of patch ij.

$0 \leq CAI < 100$

CAI = 0 when CORE = 0 (i.e., every location within the patch is within the specified depth-of-edge distance(s) from the patch perimeter); that is, when the patch contains no core area. CAI approaches 100 when the patch, because of size, shape, and edge width, contains mostly core area.

The biological importance of this index is related to isolation caused by disturbances. A landscape with a high total core area has a large amount of undisturbed and isolated habitat that is useful for species that prefer isolation from humans (e.g., woodland caribou or brown creeper). In natural patches, the biological importance is that the edge area of each vegetation unit often differs in terms of microclimate and soil conditions and supports an ecotone or area of species overlap. The total core area approach is a method of determining the total area or percent of each area that is within the ecotone (Figure I-4).

Figure I-4 Edge of Ecotonal Area in Relation to Core Areas



Mean Proximity Index (MPI)

Mean proximity index (MPI) is a measure of connectivity of patches within the landscape. The MPI is determined by whether a patch has neighbours of the same type within a specified radius. Therefore, the MPI equals zero if there are no patches of the same type within the neighbour search radius. The MPI value increases as the number of patches of a class increase in frequency causing a patch to be less isolated in the landscape. The upper extent of this measure is based on the search radius and the minimum distance between patches.

$$MPI = \frac{\sum_{j=1}^{n} \sum_{s=1}^{n} \frac{aijs}{hijs^2}}{n_i}$$

where: *a* is patch area;

h is the distance between a patch and the focal patch for all patches within a specified distance; and

n is the number of patches.

APPENDIX II

BIODIVERSITY RANKING PROTOCOL AND RESULTS FOR THE OIL SANDS REGION

1 BIODIVERSITY RANKING FOR THE OIL SANDS REGION

1.1 INTRODUCTION

A process for relating biodiversity values to vegetation types (ecosite phases/ wetlands types) was developed for the Oil Sands Region. This approach provides a relative biodiversity rank for vegetation types based on indices that combine selected attributes of plants and terrestrial vertebrates. The indices were similar to those chosen by Noss (1983, 1987) to measure indicators representing ecosystem function and biodiversity values. The indicators were quantified or qualified for a wide range of plant and animal species.

This appendix has the following specific objectives:

- to describe the biodiversity ranking approach;
- to define the ranking indices;
- to evaluate vegetation types (i.e., ecosite phases/wetlands types) based on each of the chosen biodiversity indices;
- to provide an overall biodiversity ranking (plants and wildlife combined) for all vegetation types within the Oil Sands Region based on an integration of the biodiversity indices; and
- to derive the biodiversity potential of regional land cover classes in the Project Regional Study Area (RSA) from the corresponding vegetation types.

1.2 METHODS

Reports and data sets used for the biodiversity ranking came from various projects or regional monitoring programs within the Oil Sands Region (Table II-1).

Table II-1 Existing Projects and Regional Research Programs in the Oil Sands Region Used for Biodiversity Ranking

Project
Albian Sands Muskeg River Mine
Canadian Natural Resouces Ltd. Horizon Oil Sands Project
Canadian Natural Resouces Ltd. Primrose and Wolf Lake Project
Encana Christina Lake Thermal Project
Husky Kearl Lake Project
Petro-Canada Meadow Creek SAGD Project
Rio Alto Kirby Thermal Pilot
Shell Jackpine Mine – Phase 1
Suncor Lease 86/17, Steepbank Mine, Fixed Plant Expansion, Fee Lot 2 Development and Project Millennium
Suncor Firebag Project
Suncor Firebag ETS and Compliance Wetlands Monitoring Program
Suncor Firebag Seismic Line Monitoring Program
Suncor Fisheries Act Approvals
Suncor South Tailings Pond Project
Suncor Project Voyageur
OPTI/ Nexen Long Lake Project

The data used to create the scoring values were derived from four sources:

- wildlife species data collected since 1996 for Oil Sands Region EIAs and monitoring programs;
- vertebrate species collected during Oil Sands Region EIAs and monitoring programs (RL&L 1982, 1989; Syncrude 1975); and
- vegetation data collected for Oil Sands Region EIAs and monitoring programs.

Wildlife species biodiversity ranking used wildlife species data collected since 1996 for Oil Sands Region EIAs and monitoring programs. The biodiversity potential of regional land cover classes was the final outcome of this process.

Ranking Categories

Each vegetation type was ranked based on a combined score of five biodiversity indices quantifying components of biodiversity, including rarity of vegetation type, rare species potential (wildlife and plants), total species richness, species overlap (proportion of species shared with other vegetation types) and structural complexity (Table II-2).

Ecosystem Composition

Rare Vegetation Type

Rarity was used as a measure of relative abundance of vegetation types within the Oil Sands Region. The rarity of ecosite phases/wetlands types was determined from baseline vegetation mapping for seven local study areas for past projects in the Oil Sands Region (Table II-6). The local study areas for the Shell Muskeg River Mine (Shell 1997), Canadian Natural Resources Ltd. Horizon Oil Sands Project (CNRL 2002), Shell Jackpine Mine – Phase 1 (Shell 2002), Suncor Project Millennium (Suncor 1998), Suncor Firebag Project (Suncor 2000), Suncor South Tailings Pond Project were used to determine the ranking results. The areas for each ecosite phase/wetlands type from the seven local study areas were summed and the relative proportions calculated. The class breaks for the rare vegetation type ranking were determined by plotting the ecosite phase/wetlands type area proportions from the combined LSA data in a histogram to determine natural class breaks.

The relative abundance of ecosite phases/wetlands types is not constant across the Oil Sands Region; for example, the lichen jack pine ecosite phase (a1) is more abundant in the northeast section of the region (i.e., closer to the Athabasca Delta), relative to areas nearer Fort McMurray. These spatial considerations can be addressed in the landscape-level analysis at the assessment stage. The scoring system and values for this category are from the “Rarity” category in the Potential Key Indicator Resources (KIRs) Report (Golder 1999) (Table II-2).

To accentuate the importance of this index to regional biodiversity, the scoring levels were doubled compared to the other parameters used in the ranking process.

Total Species Richness

Species richness indices are essentially measures of the number of species in a sampling unit (Magurran 1988). Species richness was calculated using different approaches for vegetation and wildlife; vegetation richness using plot data and wildlife based on potential and observed terrestrial vertebrate species. A complete enumeration of species has not yet been completed within the Oil Sands Region. However, increasing the sample sizes over time will allow the species richness index to become an even more useful measure of diversity in the future.

Table II-2 Scoring Categories for the Biodiversity Ranking Indices

Level	Index	Discipline	Location of Data	Ranking
ecosystem composition	rare vegetation type (uniqueness of vegetation types based on relative abundance in the Oil Sands Region)	vegetation	Table II-6	0 = vegetation type highly abundant and of no concern; >5% of the Oil Sands Region 2 = vegetation type moderately abundant and of no concern; 2 to 5% of the Oil Sands Region 4 = vegetation type uncommon, but not threatened; 0.25 to 1.0% of the Oil Sands Region 6 = vegetation type at extreme end of range; <0.25% of the Oil Sands Region
	total species richness[(a)]	vascular and non-vascular plants	Table II-7	1 = low (<25% total species) 2 = moderate (25 to 49.9% total species) 3 = moderate-high (50 to 74.9% total species) 4 = high (≥75% total species)
		terrestrial vertebrates	Table II-8	1 = low (<30% total potential species) 2 = moderate (30 to 59.9% total potential species) 3 = moderate-high (60 to 89.9% total potential species) 4 = high (≥90% total potential species)
	species overlap (proportion of species that also occur in >4 other habitat types)	vascular and non-vascular plants	Tables II-9 and II-10	0 = 100% species shared with >4 other habitats 1 = 90 to 99.9% species shared with >4 other habitats 2 = 75 to 89.9% species shared with >4 other habitats 3 = 50 to 74.9% species shared with >4 other habitats 4 = <50% species shared with >4 other habitats
		terrestrial vertebrates	Tables II-11 and II-12	0 = 100% species shared with >4 other habitats 1 = 75 to 99.9% species shared with >4 other habitats 2 = 50 to 74.9% species shared with >4 other habitats 3 = <50% species shared with >4 other habitats 4 = contains unique species

Table II-2 Scoring Categories for the Biodiversity Ranking Indices (continued)

Level	Index	Discipline	Location of Data	Ranking
ecosystem composition (continued)	rare species potential	rare plants	Table II-13	1 = low (<0.06) number of rare plant species occurrences/number of plots 2 = moderate (0.06-0.09) number of rare plant species occurrences/number of plots 4 = high (0.1-1.0) number of rare plant species occurrences/number of plots
ecosystem composition	rare species potential	special status wildlife species	Table II-14	0 = does not support listed species 1 = supports listed species but fewer than in the other categories 2 = 5 or more at risk, may be at risk and sensitive species 3 = 3 or more at risk and/or may be at risk listed species 4 = 3 or more at risk species
ecosystem structure	structural complexity	vascular plants	Table II-15	number of layers 1 = herbaceous 2 = shrub/herbaceous 3 = single-storey stand 3.5 = even distribution of single and multistorey stands 4 = multistorey stand

(a) Species richness ranking based on normalized scale (e.g., all values divided by vegetation type with highest species richness).

Vegetation

Total species richness in the Boreal Mixedwood for vegetation was calculated using the plot data from surveys conducted in the Oil Sands Region. Although species richness was presented for each vegetation layer (i.e., tree, shrub, herb and graminoid), total species richness for all layers combined was used in the biodiversity ranking. Ranking scores were used to calculate the biodiversity potential. The vascular and non-vascular plant species richness results by ecosite phase for the Project vegetation plot data was used to determine species richness values.

Minimum species richness values are zero in some cases because no data has been collected for those ecosite phases/wetlands types, i.e., wooded permafrost bog (BTXN), forested swamp (SFNN) and wooded patterned fen (FTPN). Plant species richness values have been inferred from the most similar ecosite phase/ wetlands type where no plant species richness values exist.

Each vegetation type did not have the same number of sample sites. The number of species appears to increase with the number of sites sampled. Thus, total richness values for less sampled vegetation types are conservative estimates.

Wildlife

Total species richness for wildlife was based on potential and observed terrestrial vertebrate species (i.e., mammals, birds, amphibians and reptiles) in the Oil Sands Region. The species habitat associations were derived from regional field surveys, professional judgment and the literature, particularly Semenchuk (1992), Smith (1993) and Russell and Bauer (1993). The habitat preferences for each species were categorized according to the regional land cover classes identified from remote sensing imagery for the Oil Sands Region. As each regional land cover class was comprised of one or more vegetation types (i.e., ecosite phases/wetlands types), all vegetation types within a regional land cover class were considered as equivalent in the ranking system.

Species richness was determined for mammals, birds and amphibians and reptiles separately and combined for a total species richness score that represented overall wildlife biodiversity for each vegetation type. A richness index was calculated on a scale of 0 to 1 to permit comparison of the relative richness of potential terrestrial vertebrate species among vegetation types. All vegetation types were evaluated against the vegetation type(s) with the highest species richness value.

Species Overlap

Species overlap is calculated using the proportion of species in a vegetation type that are also found in other vegetation types. This index highlights whether vegetation types contain proportionately more species that are habitat specialists or habitat generalists. A vegetation type that contains a high proportion of species that are not found in other ecosystems (habitat specialists) would have a higher score than a vegetation type that contains a high proportion of species that are also found in other vegetation types (habitat generalists).

Species overlap was determined for vegetation (i.e., vascular and non-vascular plants) by using a series of data queries of vascular and non-vascular plant species occurrence by ecosite phase/wetlands type. Species overlap in wildlife (i.e., terrestrial and aquatic vertebrates) was determined using the same procedure as for plants. Vegetation and wildlife species were rated for the number of unique species and the proportion of species that occupy five or fewer vegetation types.

Rare Species Potential

Rare Plants

Rankings for Rare Plant Potentials in the Local Study Area

A rare plant is defined as "a native species which, due to biological or geographical characteristics, is found in restricted areas, or at the edge of its range, or for other reasons is found in low numbers within the province of Alberta or in Canada" by the Alberta Native Plant Council (ANPC 1997). The provincial status of plant species are outlined in the Plant Species of Concern list distributed by Alberta Natural Heritage Information Centre (ANHIC 2004).

A rare plant potential was assigned to each ecosite phase/wetlands type in the LSA using vegetation and rare plant data from the Golder Vegetation Database for the Oil Sands Region. This database was queried for plants occurring on the Alberta Natural Heritage Information System (ANHIC 2004) watch list. The number of occurrences of listed plant species was recorded for each ecosite phase/wetlands type within the LSA. To account for sampling intensity bias, the number of listed plant species occurrences was then indexed (i.e., normalized) to the number of plots surveyed in each ecosite phase/wetlands types. The rare potential index was plotted on a graph and three lines of best fit (trend lines) were fitted to the data. The three clusters of data corresponded to high, moderate and low rare plant potential. Separation of the three classes was refined using a process of trial and error to obtain the highest overall r^2 values within each of the three classes. The index values corresponding to each rare plant potential (i.e., low, medium, high) are shown in Table II-3.

The rating system for rare plant potential was based on the five-point scoring system as presented in the Suncor Project Millennium EIA (Table II-4, from Suncor 1998) and is presented in Table II-3. The values for each vegetation type are from the "Rare Plant Potential" category in the Potential KIR Report (Golder 1999). Previous field studies in the Oil Sands Region were used to determine the vegetation types in which rare plants have been found, including the Westworth (1990) ESA study, Albian's Muskeg River Mine EIA (Shell 1997), Suncor's Steepbank and Millennium EIAs (Suncor 1996, 1998) and Syncrude's Aurora Mine and the Mildred Lake Upgrader EIAs (BOVAR 1996; Conor Pacific 1997).

Table II-3 Rare Plant Potential Rating System

Index Value	Rare Plant Potential
0.10 – 1.0	high
0.06 – 0.09	moderate
<0.06	low

Rankings for Rare Plant Potentials in the Regional Study Area

A rare plant potential ranking was applied to the regional land cover classes using a correlation table linking ecosite phases and regional land cover classes. The decision rules used in the process are as follows: where the regional land cover class was comprised of an equal number of high and low ranked ecosite phases, the assigned regional rank was moderate; where the regional land cover class was comprised of a greater number of moderate ranked ecosite phases than high-ranked ecosite phases, the assigned regional rank was moderate.

Wildlife Species of Concern

The ranking for wildlife species of concern was based on the provincial status evaluation system outlined in Alberta Environment's (AENV) The Status of Alberta Wildlife (AENV 2001:website). Species of concern that have the potential to occur in the Oil Sands Region are provided in Volume 6, Appendix XV. Special status species are species whose populations are at risk, may be at risk or sensitive. Species may be listed due to habitat loss, restriction of distribution, or because the species is naturally rare, geographically localized or associated with habitats (e.g., old growth forest) or habitat features (e.g., wildlife trees) that are rare or in decline (AENV 2001:website).

The potential to provide suitable habitat for at risk, may be at risk and sensitive listed wildlife species was developed through experience in the Oil Sands Region. Vegetation types were scored based on the number of listed species likely to be found there. Vegetation types with three or more at risk species received the highest score of four. The scoring categories are further outlined in Table II-2.

Ecosystem Structure - Structural Complexity

In some instances, an increase in the diversity of plant species and density is directly related to structural complexity. More specifically, the vertical stratification of plant species (number of vegetation layers) in a site affects plant diversity. The complexity of vertical stratification has been correlated with the diversity of wildlife species that occur within an ecosystem (MacArthur 1958; Morse 1989). Therefore, structural complexity is considered to be a valuable index for overall biodiversity. The structural complexity for each ecosite phase/wetlands type pertains to the mature ecosite phase/wetlands type successional stage for each.

Structural complexity was measured based on the presence of the following:

- a herbaceous layer;
- a shrub and herbaceous layer;
- a single-storey stand; or
- a multistorey stand (Golder 1999).

The presence of a herb or shrub layer was determined using the Field Guide to Ecosites of Northern Alberta (Beckingham and Archibald 1996) and field experience in the region. The proportion of single and multistorey stands within each ecosite phase was determined using the Alberta Vegetation Inventory (AVI) database developed for the Suncor Project Millennium LSA (Suncor 1998). The scoring categories are summarized in Table II-2.

Ranking Process

All vegetation types were evaluated for each of the five vegetation and wildlife biodiversity indices, for a maximum possible score of 36 (i.e., the sum of the maximum score of each index); and as discussed, scores for rare vegetation type were doubled. To standardize the ranking so that all vegetation types could be compared directly, the total raw score was indexed relative to the vegetation type with the highest score (i.e., scale of 0 to 1). The ranking index was then displayed in terms of biodiversity potential (i.e., low, moderate and high), so that vegetation types with similar biodiversity ranking and thus a similar level of concern with respect to biodiversity preservation in the region, could be differentiated. A low rank does not imply that biodiversity in those areas is unimportant, only that it is of lower concern for the factors considered than moderate and high ranked biodiversity potential areas.

The ranking procedure was also performed using regional land cover classes in the Oil Sands Region to address regional biodiversity (Table II-4). Each vegetation type was assigned to a regional land cover class and its relative contribution to that regional land cover class was calculated based on areal extent. The proportion was determined from field experience in the Oil Sands Region and professional judgement. The biodiversity rank for each regional land cover class was then derived from the weighted average of the scores of all contributing vegetation types.

Other Parameters Considered

In addition to the indices already mentioned, there are several indicators that reflect biodiversity values but were not included in the biodiversity ranking assessment of vegetation types and are presented in the Vegetation, Wetlands and Froest Resources ESR and Wildlife ESR. These indicators include:

- species diversity;
- the presence of non-native and invasive species;
- habitat specificity of individual species;
- keystone species and functional groups; and
- old growth forests (Vegetation, Wetlands and Forest Resources ESR only).

These indicators have not been included in the ranking either because they are not vegetation class-based and therefore could not be ranked (i.e., habitat specificity, non-native and invasive species) there is not currently enough regional information available by vegetation type (i.e., wildlife species diversity and old growth forests) or key concepts have not been defined for the region (i.e., keystone species and functional groups). These indicators are part of a checklist for monitoring the integrity of ecosystems over the course of development and reclamation.

Table II-4 Correlation of Regional Land Cover Classes With Ecosite Phases/Wetlands Types in the Oil Sands Region

	Boreal Mixedwood	Boreal Highlands	Wetlands Types
Coniferous-jack pine dominant	lichen (jack pine) (a1)	bearberry/lichen (a1)	n/a
Mixedwood-jack pine-aspen dominant	blueberry jack pine-aspen (b1)	blueberry jack pine-aspen (white birch) (b1)	n/a
Deciduous-aspen/aspen-balsam poplar dominant	dogwood balsam poplar-aspen (e1) blueberry aspen (b2) low-bush cranberry aspen (d1) Horsetail balsam poplar-aspen (f1)	low-bush cranberry aspen (d1) blueberry aspen (white birch) (b2)	n/a
Coniferous-white spruce dominant	blueberry white spruce-jack pine (b4) low-bush cranberry white spruce (d3) dogwood white spruce (e3) horsetail white spruce (f3)	blueberry white spruce-jack pine (b3) low-bush cranberry white spruce (d3) fern white spruce (e1) horsetail white spruce (f1)	n/a
Coniferous-black spruce-white spruce (jack pine) dominant	Labrador tea–mesic jack pine-black spruce (c1) Labrador tea–subhygric black spruce-jack pine (g1) Labrador tea/horsetail white spruce-black spruce (h1)	Labrador tea–mesic jack pine-black spruce (c1) Labrador tea–subhygric black spruce-jack pine (g1) low-bush cranberry aspen-white spruce-black spruce (d2)	n/a
Mixedwood-aspen-white spruce dominant	blueberry aspen-white spruce (b3) low-bush cranberry aspen-white spruce (d2) dogwood balsam poplar-white spruce (e2) horsetail balsam poplar-white spruce (f2)	low-bush cranberry aspen-white spruce-black spruce (d2)	n/a
upland shrubland	shrub	shrub	shrubby swamp (SONS) shrubby marsh (MONS)
wooded fen	n/a	n/a	treed fen (FTNN, FTNR, FFNN, FTPN, FTNI) wooded swamp (STNN) forested swamp (SFNN)
shrubby fen	n/a	n/a	shrubby fen (FONS, FOPN)
graminoid fen	n/a	n/a	graminoid fen (FONG)

Table II-4 Correlation of Regional Land Cover Classes With Ecosite Phases/Wetlands Types Classes in the Oil Sands Region (continued)

	Boreal Mixedwood	Boreal Highlands	Wetlands Types
poor wooded fen/wooded bog	n/a	n/a	treed bog (BTNI, BTNN, BTNR, BTXC,BTXN) forested bog (BFNN) open bog (BONN)
marsh	n/a	n/a	graminoid marsh (MONG)
shallow open water	n/a	n/a	shallow open water (WONN) Flooded areas (NWF)
deep water	n/a	n/a	lakes and ponds (NWL) River (NWR)
cutblocks	n/a	n/a	n/a
burn	n/a	n/a	n/a
agriculture	n/a	n/a	n/a
urban/industrial	n/a	n/a	n/a
cloud	n/a	n/a	n/a

n/a = not applicable.

Species Diversity

Species diversity is another property of ecosystems. Biodiversity is commonly described using species diversity indices, which incorporate measures of richness (species number) and evenness (relative abundance). One example is the Shannon Index, which is a measure of equitability between the proportional contributions of individual species to the total ecosystem population (Krebs 1989). Low diversity values occur when one species has a disproportionate dominance, whereas maximum values occur when all species share equally in the dominance of the ecosystem.

In this appendix, observed and potential species richness have been described for both vegetation and wildlife species. However, data regarding the relative abundance of the species in each vegetation type is limited. In particular, little information is currently available for wildlife species in the Oil Sands Region, some of which have not been sampled during baseline wildlife surveys (e.g., bats). More information is available for vegetation species abundance. However, the sampling has been biased towards common and abundant vegetation types. Species diversity was calculated for vascular plants in the Oil Sands Region. Only datasets that captured abundance (i.e., percent cover) and species richness and linked these to vegetation type were used in the analysis (i.e., vegetation surveys for the Suncor Firebag, Shell Muskeg River Mine, Suncor Project Millennium and ExxonMobil Kearl Project).

Non-Native and Invasive Species

Encroachment of non-native and invasive species into pristine habitats can have drastic consequences on the natural balance of the ecosystem. Non-native species are defined as species that do not naturally occur in a particular geographical area but have established as a result of human factors. Invasive species are native or non-native species that grow rapidly under a wide range of climate and soil conditions, are agents of change and threaten native biodiversity.

When non-native or invasive plants or wildlife are introduced to an area, they may out-compete (e.g., purple loosestrife) or prey (e.g., brown-headed cowbird) on species native to an area or vegetation type. Threats from introduced species may be more damaging than habitat loss degradation (Clout and Lowe 1996:website). However, predicting the rate of invasion has proven to be difficult. The main question that remains unanswered is: "Why do communities gain species at different rates?" (Pimm 1994). In most instances, communities with fewer species are easier to invade. Thus, production of new habitats with few species created by natural disturbance of ecosystems (e.g., fire) or anthropogenically (e.g., cutlines and forest harvesting), provides habitats that are generally much easier to invade than old communities (Pimm 1994).

The presence of non-native or invasive wildlife species is often associated with altered or disturbed landscapes and many of these species succeed because they also survive in association with human activity. The European house sparrow, European starling and brown-headed cowbird are three such species (Ehrlich et al. 1992; Terborgh 1989). Not only are these species adaptable to human-altered landscapes, they directly compete with native and non-invasive species for nest sites and food and may depredate or parasitize the nests of native birds.

While it is known that physical and biotic features of the environment play a key role in determining the rate of invasion, differences in the capability of species to reach ecosystems and survive, assuming the environment is hospitable, remain very difficult to predict (Pimm 1994). Therefore, because species and ecosystem differences with respect to invasion capability or susceptibility were not known, it was not possible to add a non-native or invasive species index into the biodiversity ranking. However, the monitoring of the development areas for non-native and invasive species should be considered in the development of construction and reclamation plans.

Habitat Specificity

Habitat specificity refers to the range of habitats that each species is expected to occupy. Some species may not be rare, but only use a narrow range of habitat types. In addition, some wildlife species may use a variety of habitats for different activities (e.g., foraging and breeding). This means that vegetation types are not necessarily interchangeable with respect to function.

The number of habitats in which each species was expected to occur was determined from the habitat association tables created through experience in the Oil Sands Region. As habitat specificity is considered from the species perspective, it was not possible to rank vegetation types for this factor, so these lists were used to create the species overlap results. However, when completing an impact assessment, it is also valuable to identify the species that occupy only a few vegetation types.

Keystone Species and Functional Groups

Many of the indices described in the previous section relating to the biodiversity ranking have focussed primarily on the rarity of all species, both plant and animal. An important aspect of species diversity and composition that was not addressed is the role that certain species (i.e., keystone species) or groups of species (i.e., functional groups) have on ecosystem function. Identifying and quantifying these species is a critical aspect of any conservation management scheme because of their importance in maintaining ecosystem processes and biodiversity within the ecosystem.

According to Paine (1969), keystone species are species whose activity and abundance determine the integrity of the ecosystem, as well as its stability. Thus, removal of keystone species should result in the loss of some species and their replacement by others (Bond 1994). Table II-5 provides a list of the most used categories of keystone species, the effect their removal would have on the ecosystem and examples. In some instances, the categories are very similar to previous classifications (e.g., KIRs in Golder 1999). The main difference between the keystone species concept and KIRs is that although KIRs use ecological importance as a criterion, only fish and terrestrial vertebrate species have been established as KIRs. For vegetation, the only KIRs currently identified are vegetation types, not species. In addition, there is a noticeable lack of detail with reference to the relationship of a species to ecosystem function (e.g., no discussion of the impacts due to its removal or loss from an area).

The use of species number as an indicator of an ecosystem's diversity or function suggests that all species are potentially equal with respect to function (Bengtsson 1998). Since this has proven to be incorrect on many occasions, grouping species together that are similar in function has proven to be quite useful in determining species relationships with various ecosystem processes (Hooper and Vitousek 1997; Tilman et al. 1997).

Table II-5 Categories of Presumed Keystone Species and the Effects of Their Removal From a System

Keystone Category	Effect of Removal	Examples
predator	increase in one or several predators/consumers/competitors that subsequently extirpates several prey/competitor species	otters and size-selective seed predators (e.g., kangaroo rats)
prey	species more sensitive to predation may become extinct; predator populations may crash	arctic hares
plant	extirpation of dependent animals, potentially including pollinators and seed dispersers	certain plant products (e.g., nectar, nuts and fruit)
link/mutualists	failure of reproduction and recruitment in certain plants, with potential subsequent losses	pollinators and dispersers (e.g., of mycorrhizal fungi)
modifier/earth-movers	loss of structures/materials that affect habitat type and energy flow; disappearance of species dependent on particular successional habitats and resources	beavers, earthworms and termites

Note: Modified from Mills et al. (1993) and Bond (1994).

These "functional groups" are usually defined with respect to some ecosystem function (Moore and DeRuiter 1991). For example, in their study of the effects on plant composition and diversity on ecosystem processes (specifically nitrogen dynamics), Hooper and Vitousek (1997) divided their test species into four functional groups: early season annual forbs, late season annual forbs, perennial bunchgrasses and nitrogen-fixers. Their results pointed to the need for further work with respect to whether functional group richness or diversity is the main controlling factor of ecosystem functioning.

In summary, the standardizing of definitions for keystone species and functional groups still needs to be accomplished before their use in biodiversity ranking, as well as inecosystem conservation and management, can reach its full potential. Thus, with the limited scope of this report, producing lists of the various keystone species and functional groups was not possible.

Old Growth Forests

Old growth forests are those forested areas where the annual growth equals annual looses, or where mean annual increment of timber volume equals zero. They can also be defined as the stands that are self-regenerating (i.e., having a specific structure that is monitored). While the proportion of structures and ages of trees that define old growth are species-specific and a result of the disturbance regime in the area, the contribution of these ecosystems to overall biodiversity is universal. However, studies into the change and function of these forests have been limited (Spies and Turner 1999).

When a portion of an ecosite phase/wetlands type is old growth forest, the remainder is of another set of age classes. It is therefore impossible to have old growth forest as a layer in the biodiversity ranking system because the biodiversity attributes that apply to the old growth forest portion of the ecosite phase/wetlands type do not apply to the remainder of the ecosite phase/wetlands type. Old growth is not spatially distributed in any one ecosite phase/wetlands type but is distributed according to the fire frequency on the landscape, usually burning an area of vegetation including a wide range of ecosite phases/wetlands types.

2 RESULTS AND DISCUSSION

2.1 Ecosystem Composition

Rare Vegetation Type

The rarity values for each vegetation type are presented in Table II-6. The rarest upland vegetation types in the Oil Sands Region are the lichen-jack pine (a1), blueberry aspen (white birch) (b2), blueberry aspen-white spruce (b3), blueberry white spruce-jack pine (b4), Labrador tea-mesic jack pine-black spruce (c1), dogwood balsam poplar-aspen (e1), dogwood balsam poplar-white spruce (e2) dogwood white spruce (e3), horsetail balsam poplar-aspen (f1), horsetail balsam poplar-white spruce (f2), horsetail white spruce (f3) and shrubland.

Table II-6 Rarity of Vegetation Types in the Oil Sands Region

Terrestrial	Rarity Score[a,b]	Wetlands	Rarity Score
a1	4	BFNN	6
b1	2	BONS	6
b2	4	BTNI	4
b3	4	BTNN	2
b4	4	BTNR	4
c1	4	BTXC	6
d1	0	BTXN	6
d2	0	FFNN	6
d3	2	FONG	4
e1	4	FONS	2
e2	4	FOPN	6
e3	4	FTNI	4
f1	6	FTNN	0
f2	6	FTNR	4
f3	6	FTPN	6
g1	2	MONG	4
h1	2	SFNN	6
shrubland	4	SONS	2
burn	n/a	STNN	4
cloud	n/a	NWF (flooded)	2
cutbank	n/a	NWL (lakes)	4
cutblock	n/a	NWR (rivers)	4
disturbed	n/a	WONN	4
meadow	n/a	riparian	4
urban/industrial	n/a	Pj-Lt complex	4

(a) Scores based on rarity category values from Mobil KIR report (Golder 1999). Values have been doubled to accentuate their importance in the scoring.

(b) The local study areas for the Shell Muskeg River Mine, CNRL Horizon Oil Sands Project, Shell Jackpine Mine – Phase 1, Suncor Project Millennium, Suncor Firebag Project, Suncor South Tailings Pond Project were used to determine the ranking results.

n/a = not applicable.

The rarest wetlands types in the Oil Sands Region are the forested bogs (BFNN), shrubby bogs (BONS), wooded permafrost bogs with collapse scars (BTXC), wooded permafrost bogs (BTXN), wooded bogs with internal lawns (BTNI), wooded bogs with forested islands (BTNR), forested fens (FFNN), wooded fens with forested islands (FTNR), patterned fens (FOPN and FTPN) and forested swamps (SFNN). Wooded permafrost bog (BTXC) and wooded fen with forested islands (FTNR) vegetation types are at the extreme edge of their range. The rest of the vegetation types are not uncommon, but vary in their distribution within the Oil Sands Region. Although the rarity of vegetation types is affected by their geographic location and elevation, the objective is to maintain a similar distribution to the existing conditions for all vegetation types in the region. At higher elevations (e.g., the Boreal Highlands), the distribution of vegetation types is somewhat different than in the Boreal Mixedwood, with the Labrador tea-mesic jack pine-black spruce (c1) vegetation type being more common than in the Boreal Mixedwood. Due to the importance of rarity to biodiversity, the rarity index was weighted heavier than most other indices.

Species Richness

Vegetation

The terrestrial type with the highest species richness in the RSA (193) is Labrador tea-subhygric black spruce-jack pine (g1) (Table II-7). Overall, the wetlands types had higher species richness values than the terrestrial ecosites. The wetlands type with the highest species richness in the RSA (291) is the treed fen (FTNN) (Table II-7). The terrestrial species richness for ecosites sampled with five plots or more range from a low of 49 in the shrubland ecosite phase to a high of 193 in the Labrador tea-subhygric black spruce jack pine (g1) ecosite phase (Table II-7). The wetlands species richness for ecosites sampled with five plots or more range from a low of 26 in rivers (NWR) to a high of 287 in the treed fen (FTNN) ecosite phase. The ranking scores, which were derived from the richness index values, ranged from 1 to 4 and were highest among the peatlands, specifically fens, i.e., shrubby fen (FONS), wooded fen with internal lawns (FTNI), wooded fen (FTNN), wooded fen with forested islands (FTNR) and wooded patterned fens (FTPN). For terrestrial ecosites two ecosite phases had a score of three. In the Oil Sands Region, the greatest number of tree and shrub species in the tree layer (15) occurred in wooded swamps (STNN). The greatest number shrub species (47) also occurred in wooded fen (FTNN); and the greatest number of forb species (87) occurred in wooded fens (FTNN). In the graminoid layer the highest values (56) occurred in wooded fens (FTNN). The shrubby fen (FONS) and wooded fen (FTNN) have the highest plant species richness values, 234 and 287 species, respectively.

Evaluating the lower range of species richness requires that a minimum of five plots be set to evaluate any relationships due to the positive correlation between sample size and species richness. The ecosite phase/wetlands types with the lowest number of species occurrence by life-form (i.e., tree, shrub, forb, grass and moss/lichen) are as follows:

- four species occur in the tree layer in forested fen (FFNN);
- 12 shrub species in the marsh (MONG);
- 27 forb species in the lichen-jack pine (a1) and four grass species in the dogwood-balsam poplar/aspen (e1);
- one lichen species in the forested fen (FFNN); and
- four moss species in the dogwood-balsam poplar/aspen (e1) ecosite phase and graminoid marsh (MONG).

Wildlife

A total of 263 terrestrial vertebrate species have been observed or are expected to occur in the Oil Sands Region (Table II-8; Golder 2000b). The highest number of potential terrestrial vertebrate species (132) occurred in the riparian and SONS ecosite phases. The next highest number of potential terrestrial vertebrate species (131) occurred in three uplands, i.e., blueberry aspen-white spruce (b3), low-bush cranberry aspen-white spruce (d2) and dogwood balsam poplar-white spruce (e2) ecosite phases. The fewest species (67) occurred in the lichen jack pine (a1). The ranking scores derived from the richness index values ranged from 2 to 4. The lack of variation in wildlife species richness values among vegetation types is due to the equalization of vegetation types within the same or similar regional land cover classes. The richness values can be refined as additional information on wildlife-habitat associations is collected according to ecosite phases/wetlands types in the Oil Sands Region.

Table II-7 Total and Relative Plant Species Richness by Ecosite Phase/Wetlands Types for the Oil Sands Region

Ecosite Phase/Wetlands Type	Number of Plots	Richness							Richness Index[(a)]	Percentage of Total Species Present (%)	Ranking Score
		Tree/Shrub	Shrub	Forb	Graminoid	Lichen	Moss	Species Total			
a1	53	10	16	27	6	21	13	93	0.32	32	2
b1	93	15	28	59	14	26	19	161	0.55	55	3
b2	30	10	19	39	11	11	13	103	0.35	35	2
b3	43	12	25	53	9	8	10	117	0.40	40	2
b4	32	11	23	42	8	9	7	100	0.34	34	2
c1	137	13	33	51	11	36	21	165	0.57	57	3
d1	171	14	35	75	18	24	19	185	0.64	64	3
d2	186	15	36	76	14	12	17	170	0.58	58	3
d3	47	10	28	56	6	10	12	122	0.42	42	2
e1	26	11	22	40	4	0	4	81	0.28	28	2
e2	25	11	27	50	5	6	10	109	0.37	37	2
e3	15	11	25	62	15	2	7	122	0.42	42	2
f1	13	7	18	30	5	4	16	80	0.27	27	2
f2	13	9	18	33	5	6	14	85	0.29	29	2
f3	15	12	26	46	13	6	11	114	0.39	39	2
g1	147	14	38	56	24	34	27	193	0.66	66	3
h1	53	13	39	50	23	23	26	174	0.60	60	3
shrubland	12	8	17	19	4	0	1	49	0.17	17	1
burn	3	2	6	16	1	0	0	25	0.09	9	n/a
cloud	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cutbank	0	n/d	n/d	n/d	n/d	n/d	n/d	0	0.00	0	n/a
cutblock	0	n/d	n/d	n/d	n/d	n/d	n/d	0	0.00	0	n/a
disturbed	26	7	11	28	7	0	4	57	0.20	20	n/a
meadow	1	1	1	6	2	0	0	10	0.03	3	n/a
urban/industrial	0	n/d	n/d	n/d	n/d	n/d	n/d	0	0.00	0	n/a
BFNN	2	2	6	6	0	2	0	16	0.05	5	3[(b)]
BONS	4	3	17	20	8	21	17	86	0.30	30	3[(b)]
BTNI	4	1	6	2	1	3	5	18	0.06	6	3[(b)]

Table II-7 Total and Relative Plant Species Richness by Ecosite Phase/Wetlands Types for the Oil Sands Region (continued)

Ecosite Phase/Wetlands Type	Number of Plots	Richness							Richness Index[(a)]	Percentage of Total Species Present (%)	Ranking Score
		Tree/Shrub	Shrub	Forb	Graminoid	Lichen	Moss	Species Total			
BTNN	163	9	33	35	23	37	30	167	0.57	57	3
BTNR	1	1	3	2	0	1	4	11	0.04	4	3[(b)]
BTXC	1	2	6	8	1	0	0	17	0.06	6	3[(b)]
BTXN	0	n/d	n/d	n/d	n/d	n/d	n/d	n/d	0.00	0	3[(b)]
FFNN	7	4	18	22	7	1	7	59	0.20	20	3[(b)]
FONG	67	6	20	57	34	19	26	162	0.56	56	3
FONS	176	13	35	80	44	22	40	234	0.80	80	4
FOPN	4	1	2	0	0	0	1	4	0.01	1	4[(b)]
FTNI	4	2	5	8	3	0	5	23	0.08	8	4[(b)]
FTNN	351	14	46	87	54	37	53	291	1.00	100	4
FTNR	1	2	4	3	2	0	2	13	0.04	4	4[(b)]
FTPN	2	n/d	n/d	n/d	n/d	n/d	n/d	0	0.00	0	4[(b)]
MONG	59	7	12	66	27	0	4	116	0.40	40	2
SFNN	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	4[(b)]
SONS	90	13	36	86	29	16	36	216	0.74	74	3
STNN	107	15	41	85	35	22	35	233	0.80	80	4
NWF	1	0	0	9	0	0	0	9	0.03	3	1
NWL	4	0	0	32	1	0	0	33	0.11	11	1
NWR	6	2	8	15	1	3	7	36	0.12	12	1
WONN	12	0	0	36	3	0	3	42	0.14	14	1
riparian	9	6	15	39	16	0	0	76	0.26	26	2
Pj-Lt complex	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	3[(b)]

(a) Ranking index standardized relative to vegetation type with the highest species richness.

(b) Richness index and ranking score for wetlands with low plot sampling intensity (BFNN, BONS, BTNI, BTNR, BTXC, BTXN, FFNN, FOPN, FTNI, FTNR, FTPN, SFNN, Pj-Lt complex) were assigned a ranking based on the expected species richness using ranking scores for well-sampled similar wetlands types (BTNN, FTNN, FONS, STNN)

n/d = no data; n/a = not applicable.

Table II-8 Total and Relative Species Richness by Vegetation Type for Terrestrial Vertebrate Species

Ecosite Phase/Wetlands Type	Richness (No. of Species)	Richness Index[(a)]	Ranking Score
Terrestrial			
a1	67	0.51	2
b1	109	0.83	3
b2	109	0.83	3
b3	131	0.99	4
b4	96	0.73	3
c1	69	0.52	2
d1	109	0.83	3
d2	131	0.99	4
d3	96	0.73	3
e1	109	0.83	3
e2	131	0.99	4
e3	96	0.73	3
f1	109	0.83	3
f2	n/d	n/d	3[(b)]
f3	96	0.73	3
g1	69	0.52	2
h1	126	0.95	4
shrubland	74	0.56	2
burn	n/a	n/a	n/a
cloud	n/a	n/a	n/a
cutbank	n/a	n/a	n/a
cutblock	n/a	n/a	n/a
disturbed	n/a	n/a	n/a
meadow	n/a	n/a	n/a
urban/industrial	n/a	n/a	n/a
Wetlands			
BFNN	70	0.53	2
BONS	80	0.61	3
BTNI	70	0.53	2
BTNN	70	0.53	2
BTNR	70	0.53	2
BTXC	70	0.53	2
BTXN	70	0.53	2
FFNN	127	0.96	4
FONG	70	0.53	2
FONS	80	0.61	3
FOPN	70	0.53	2
FTNI	127	0.96	4

Table II-8 Total and Relative Species Richness by Vegetation Type for Terrestrial Vertebrate Species (continued)

Ecosite Phase/Wetlands Type	Richness (No. of Species)	Richness Index[(a)]	Ranking Score
FTNN	127	0.96	4
FTNR	127	0.96	4
FTPN	127	0.96	4
MONG	106	0.80	3
SFNN	126	0.95	4
SONS	132	1.00	4
STNN	127	0.96	4
NWF	74	0.56	2
NWL	95	0.72	3
NWR	98	0.74	3
WONN	73	0.55	2
riparian	132	1.00	4
Pj-Lt complex	n/d	n/d	2[(a)]

(a) Ranking index standardized relative to vegetation type with highest species richness.

(b) Data not updated for 2005 biodiversity ranking and not available in Oil Sands Ranking Report (Golder 2000b).

n/a= not applicable.

Species Overlap

Vegetation

Vegetation overlap of plant species between the terrestrial vegetation types (ecosite phases) is common in the Oil Sands Region (Table II-9). Most plant species occur in many ecosite phases/wetlands types with only a few species being restricted to a small number of ecosite phases/wetlands types.

In the Boreal Mixedwood ecological area portion of the Oil Sands Region, 17 ecosite phases had at least 80% of their vascular plant species occurring in greater than four other vegetation types (Table II-9). The low-bush cranberry-aspen (d1) ecosystems had the lowest proportion (80%) of species using multiple habitats. All terrestrial vegetation types were ranked low for this index.

Wetlands types exhibit lower species overlap compared to the terrestrial ecosystems (Table II-10). Most notably, graminoid fens (FONG), shrubby fens (FONS), wooded fens (FTNN), and graminoid marshes (MONG) wetlands types all have less than 75% of their plant species occurring in greater than four other vegetation types (Table II-11). Water (WONN, NWF, and NWL) have the lowest species overlap because only four water types exist and plant species, particularly aquatics, do not occur in the wetlands types lacking open water.

Table II-9 Overlap of Plant Species Among Terrestrial Vegetation

Ecosite Phase	Proportion (%) of Species Shared With Other Vegetation Types					Number of Unique Species	Total Species Richness	Ranking
	>4 Habitats Shared	Number	1 to 4 Habitats Shared	Number	Total Shared Species			
a1	88.2	82	11.8	11	93	0	93	2
b1	87.6	141	12.4	20	161	0	161	2
b2	93.2	96	6.8	7	103	0	103	1
b3	93.2	109	6.8	8	117	0	117	1
b4	93.0	93	7.0	7	100	0	100	1
c1	89.1	147	10.3	17	164	1	165	2
d1	80.0	148	19.5	36	184	1	185	2
d2	88.2	150	11.8	20	170	0	170	2
d3	88.5	108	10.7	13	121	1	122	2
e1	95.1	77	4.9	4	81	0	81	1
e2	89.0	97	11.0	12	109	0	109	2
e3	87.7	107	12.3	15	122	0	122	2
f1	92.5	74	7.5	6	80	0	80	1
f2	94.1	80	5.9	5	85	0	85	1
f3	87.7	100	12.3	14	114	0	114	2
g1	86.0	166	14.0	27	193	0	193	2
h1	89.1	155	10.9	19	174	0	174	2
shrubland	93.9	46	6.1	3	49	0	49	1
burn	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cloud	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cutbank	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cutblock	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
disturbed	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
meadow	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
urban/industrial	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

n/a = not applicable

Table II-10 Overlap of Plant Species Among Wetlands Vegetation Types

Wetlands Type	Proportion (%) of Species Shared With Other Wetlands Types					Number of Unique Species	Total Species Richness	Ranking
	> 4 Habitats Shared	Number	1 to 4 Habitats Shared	Number	Total Shared Species			
BFNN	93.8	15	6.3	1	16	0	16	2[(a)]
BONS	95.5	84	4.5	4	88	0	88	2[(a)]
BTNI	100.0	18	0.0	0	18	0	18	2[(a)]
BTNN	88.0	147	12.0	20	167	0	167	2
BTNR	100.0	11	0.0	0	11	0	11	2[(a)]
BTXC	94.1	16	0	0	16	1	17	2[(a)]
BTXN	n/d	n/d	n/d	n/d	n/d	n/d	0	2[(a)]
FFNN	98.3	58	1.7	1	59	0	59	3[(a)]
FONG	72.4	118	25.8	42	160	3	163	3
FONS	73.2	172	25.5	60	232	3	235	3
FOPN	100.0	4	0.0	0	4	0	4	3[(a)]
FTNI	100.0	23	0.0	0	23	0	23	3[(a)]
FTNN	73.2	213	24.7	72	285	6	291	3
FTNR	100.0	13	0.0	0	13	0	13	3[(a)]
FTPN	n/d	n/d	n/d	n/d	0	n/d	0	3[(a)]
MONG	63.2	74	33.3	39	113	4	117	3
SFNN	n/d	n/d	n/d	n/d	0	n/d	0	2[(a)]
SONS	75.6	164	23.5	51	215	2	217	2
STNN	83.7	195	16.3	38	233	0	233	2
NWF (flooded)	33.3	3	55.6	5	8	1	9	4
NWL (lakes)	20.6	7	76.5	26	33	1	34	4
NWR (rivers)	86.1	31	13.9	5	36	0	36	2
WONN	30.2	13	67.4	29	42	1	43	4
riparian	77.6	59	22.4	17	76	0	76	2
Pj-Lt complex	n/d	n/d	n/d	n/d	n/d	n/d	n/d	2[(a)]

(a) Species overlap and ranking score for wetlands with low plot sampling intensity (BFNN, BONS, BTXC, BTXN, FFNN, FOPN, FTNI, FTNR, FTPN, SFNN) were assigned a ranking based on the expected species overlap using ranking scores for well-sampled similar wetlands types (BTNN, FTNN, FONS, STNN).

n/d = no data.

Table II-11 Overlap of Terrestrial Vertebrate Species for Terrestrial Vegetation Types

Vegetation Type	Proportion (%) of Species Shared With Other Vegetation Types					Number of Unique Species	Total Species Richness	Ranking
	1 to 4 Habitats Shared	Number	>4 Habitats Shared	Number	Total Shared Species			
a1	3.0	2	97.0	65	67	0	67	1
b1	1.8	2	98.2	107	109	0	109	1
b2	1.8	2	98.2	107	109	0	109	1
b3	1.5	2	98.5	130	132	0	132	1
b4	1.0	1	99.0	95	96	0	96	1
c1	2.9	2	97.1	67	69	0	69	1
d1	1.8	2	98.2	107	109	0	109	1
d2	1.5	2	98.5	130	132	0	132	1
d3	1.0	1	99.0	95	96	0	96	1
e1	1.8	2	98.2	107	109	0	109	1
e2	1.5	2	98.5	130	132	0	132	1
e3	1.0	1	99.0	95	96	0	96	1
f1	1.8	2	98.2	107	109	0	109	1
f2	0.8	1	99.2	130	131	0	131	1
f3	1.0	1	99.0	95	96	0	96	1
g1	2.9	2	97.1	67	69	0	69	1
h1	1.6	2	98.4	126	128	0	128	1
shrubland	5.3	4	94.7	71	75	0	75	1
burn	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cloud	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cutbank	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
cutblocks	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
disturbed	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
meadow	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
urban/industrial	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

n/a= not applicable.

In addition, wetlands also have more unique species (species not found in any other vegetation types). For example, graminoid fens (FONG), shrubby fens (FONS), wooded fens (FTNN) and marshes (MONG) all have 3 or more unique species. The presence of unique species, although probably not a complete list, should be considered when devising construction and reclamation plans. Loss or modification of the vegetation types that support a large number of unique species should therefore be given special consideration. It must be emphasized, however, that these tables provide the number of vegetation types in which the plant species were observed, but do not capture the frequency or abundance of these species in the vegetation types.

Some plant species may not have been observed in vegetation types where only a few plots were surveyed. Conversely, vegetation types that were abundantly sampled may be overemphasized in species lists. For instance, although a species may be uncommon in a particular vegetation type, the species was detected in that vegetation type because it was well-sampled. Overall, this kind of information will be useful for identifying sensitive areas and assist in the mitigation of impacts to biodiversity.

Wildlife

The majority of the vegetation types in the Oil Sands Region share wildlife species with more than four other vegetation types (Tables II-11 and II-12). Much of the overlap can be explained by two factors: the vegetation types were derived from the regional land cover classes, so there is automatic duplication; and/or wildlife are mobile and often use more than one vegetation type on a daily (e.g., roosting and foraging) or seasonal (e.g., breeding and non-breeding) basis.

Given the mobility of wildlife and their use of a variety of vegetation types, vegetation types used for different purposes should not be considered equal and therefore should not overlap. As such, more information is required regarding specific seasonal and daily wildlife-habitat associations. The species could then appear multiple times in the database, once for each specific habitat requirement. For example, some owls require trees for nesting and open habitats for foraging. Each owl species could therefore be represented twice, once as “owl-foraging” and once as “owl-nesting”. The range of habitat use is further discussed by species in the habitat specificity section. Only lakes (NWL) and rivers (NWR) had unique species (Table II-12).

Table II-12 Overlap of Terrestrial Vertebrate Species for Wetlands Vegetation Types

Vegetation Type	Proportion (%) of Species Shared With Other Vegetation Types					Number of Unique Species	Total Species Richness	Ranking
	1 to 4 Habitats Shared	Number	>4 Habitats Shared	Number	Total Shared Species			
BFNN	0	0	100	70	70	0	70	0
BONS	6.3	5	93.8	75	80	0	80	1
BTNI	0	0	100	70	70	0	70	0
BTNN	0	2	100	67	69	0	69	0
BTNR	0	0	100	70	70	0	70	0
BTXC	0	2	100	70	70	0	70	0
BTXN	0	2	100	70	70	0	70	0
FFNN	0	0	100	127	127	0	127	0
FONG	1.4	2	98.6	69	70	0	70	1
FONS	6.3	7	93.8	75	80	0	80	1
FOPN	1.4	1	98.6	69	70	0	70	1
FTNI	0	0	100	127	127	0	127	0
FTNN	0	0	100	127	127	0	127	0
FTNR	0	0	100	127	127	0	127	0
FTPN	0	0	100	127	127	0	127	0
MONG	4.7	5	95.3	101	106	0	106	1
SFNN	0	0	100	126	126	0	126	0
SONS	5.3	7	94.7	125	132	0	132	1
STNN	0	0	100	127	127	0	127	0
NWF	4.1	3	96.0	71	74	0	74	1
NWL	24.2	23	74.7	71	94	1	95	4
NWR	23.5	23	72.5	71	94	4	98	4
WONN	2.7	2	97.3	71	73	0	73	1
riparian	5.3	7	94.7	125	132	0	132	1
Pj-Lt Complex	n/d	n/d	n/d	n/d	n/d	n/d	n/d	1

n/d = no data.

Rare Species Potential

Vegetation

In the Oil Sands Region, 30 of the 43 vegetation types have had rare plants reported based on 2,234 vegetation plots conducted by Golder to present. In Table II-13, low, moderate and high rare plant potential is assigned a numerial rank of 1, 2 and 4 respectively.

Thirty-two vegetation types are considered to have moderate or high rare plant potential (Table II-13). Overall, 13 vegetation types have low rare plant potential (Table II-13).

Table II-13 Rare Plant Potential by Vegetation Type

Terrestrial	Rare Plant Potential	Wetlands	Rare Plant Potential
Terrestrial Vegetation		**Wetlands Vegetation**	
a1	1	BFNN	1
b1	2	BONS	4
b2	1	BTNI	1
b3	1	BTNN	1
b4	2	BTNR	1
c1	1	BTXC[(a)]	2
d1	1	BTXN[(a)]	2
d2	2	FFNN	4
d3	4	FONG	4
e1	4	FONS	4
e2	1	FOPN	4
e3	2	FTNI	4
f1	4	FTNN	4
f2	2	FTNR	4
f3	2	FTPN	4
g1	2	MONG	4
h1	2	SFNN[(a)]	2
shrubland	1	SONS	4
burn	n/a	STNN	2
cloud	n/a	NWF (flooded)	1
cutbank	n/a	NWL (lakes)	4
cutblocks	n/a	NWR (rivers)	1
disturbed	n/a	WONN	4
meadow[(a)]	n/a	riparian	4
urban/industrial[(a)]	n/a	Pj-Lt complex[(a)]	2

[(a)] Rare plant potential based on professional judgement only.

Wildlife

There are 47 special status wildlife species (AENV 2001: website) in the Oil Sands Region: 6 at risk, 4 may be at risk and 37 sensitive species. All vegetation types support listed species. The lakes (NWL) and river (NWR) types support the most listed species (25), followed closely by the wetlands (23) (WONN), wooded fens (FTNI, FTNN, FTNR and FTPN), marshes (MONG and MONS) and swamps (STNN). Terrestrial ecosite phases that support the most listed species (22) include blueberry aspen-white spruce (b3), low-bush cranberry aspen-white spruce (d2), dogwood balsam poplar-white spruce (e2) and horsetail white spruce (f2). The shrubland ecosite phase supports the fewest listed species (five).

Thirteen wetlands types including fens (FFNN, FTNI, FTNN, FTNN FTNR and FTPN), marshes (MONG and MONS), swamps (SFNN, SONS and STNN) and water (NWL, NWR, NWF, WONN and riparian) have the highest rare species potential (4). These vegetation types provide potential breeding and non-breeding habitat for the Canadian toad and northern leopard frog, foraging habitat for the peregrine falcon and migratory stopping grounds for the whooping crane. The low scoring (1 and 2) vegetation types generally provide potential habitat for fewer listed species overall, however there were no low-ranked types in the Oil Sands Region. The blueberry jack pine-aspen (b1), blueberry (white birch) aspen (b2), blueberry white spruce-jack pine (b4), low-bush cranberry aspen (d1), low-bush cranberry white spruce (d3), dogwood balsam poplar-aspen (e1), dogwood-white spruce (e3), horsetail balsam poplar-aspen (f1), horsetail white spruce (f3), shrubland, wooded bog with internal lawns (BTNI), wooded bog (BTNN), wooded bog with forested islands (BTNR), wooded permafrost bog (BTXC and BTXN), graminoid fen (FONG) and open patterned fen (FOPN) ecosite phases/wetlands types also have low rare species potential (score of 2).

Although there are fewer special status wildlife species in the terrestrial vegetation types overall, some of these habitats support more at risk species. These terrestrial vegetation types are generally easier to reclaim than wetlands, however, one of the at risk species (woodland caribou) found here and three of the sensitive species (bay-breasted warbler, black-throated green warbler and Cape May warbler) are dependent on mature or old growth forests. To sustain local populations of these species, areas of contiguous mature and old growth forest should be maintained in the region.

Table II-14 Potential for Special Status Wildlife Species by Vegetation Type

Vegetation Type	At Risk	May be at Risk	Sensitive	Total Listed Species	Ranking Score
a1	1	3	7	11	3
b1	0	2	14	16	2
b2	0	2	14	16	2
b3	0	3	19	22	3
b4	0	3	18	23	3
c1	1	3	8	12	3
d1	0	2	14	16	2
d2	0	3	18	23	3
d3	0	2	15	17	2
e1	0	2	14	16	2
e2	0	3	18	23	3
e3	0	2	15	17	2
f1	0	2	14	16	2
f2	0	3	18	23	3
f3	0	2	15	17	2
g1	1	3	8	12	3
h1	3	1	17	21	4
shrubland	0	1	4	5	2
burn	n/a	n/a	n/a	n/a	n/a
cloud	n/a	n/a	n/a	n/a	n/a
cutbank	n/a	n/a	n/a	n/a	n/a
cutblock	n/a	n/a	n/a	n/a	n/a
disturbed	n/a	n/a	n/a	n/a	n/a
meadow	n/a	n/a	n/a	n/a	n/a
urban/industrial	n/a	n/a	n/a	n/a	n/a
BFNN	2	0	9	11	2
BONS	2	1	7	10	3
BTNI	2	0	9	11	2
BTNN	2	0	9	11	2
BTNR	2	0	9	11	2
BTXC	2	0	9	11	2
BTXN	2	0	9	11	2
FFNN	3	1	18	22	4
FONG	1	0	10	11	2
FONS	2	1	7	10	3
FOPN	1	0	10	11	2
FTNI	3	1	18	22	4

Table II-14 Potential for Special Status Wildlife Species by Vegetation Type (continued)

Vegetation Type	At Risk	May be at Risk	Sensitive	Total Listed Species	Ranking Score
FTNN	3	2	18	22	4
FTNR	3	1	18	22	4
FTPN	3	1	18	22	4
MONG	4	3	15	22	4
SFNN	3	1	17	21	4
SONS	3	2	15	20	4
STNN	3	1	18	22	4
NWF	4	2	14	20	4
NWL	4	2	15	21	4
NWR	4	2	15	21	4
WONN	4	2	15	20	4
riparian	3	2	15	20	4
Pj-Lt complex	3	2	18	22	4

Note: Based on AENV (2001:website) ranking system.
n/a = not applicable.

Ecosystem Structure

Structural Complexity

Of the 33 vegetation types with established tree canopies, 20 are generally comprised of single-storey stands (Table II-2), two are comprised of multistorey stands, and 11 have an even distribution of single- and multistorey stands within the Oil Sands Region (Table II-15). The ranking score for each vegetation type directly reflects the number of structural layers attributed to that vegetation type and also implies a corresponding measure of wildlife diversity.

Table II-15 Structural Complexity Indices by Vegetation Type for the Oil Sands Region

Vegetation Type	Number of Vegetation Layers	Ranking Score
a1[(a)]	3	3
b1[(a)]	3.5	3.5
b2	4	4
b3[(a)]	3.5	3.5
b4	3.5	3.5
c1	3	3
d1	3.5	3.5
d2	3.5	3.5
d3	3.5	3.5
e1[(a)]	3	3

Table II-15 Structural Complexity Indices by Vegetation Type for the Oil Sands Region (continued)

Vegetation Type	Number of Vegetation Layers	Ranking Score
e2	3	3
e3	3.5	3.5
f1	3	3
f2	3	3
f3	3	3
g1	4	4
h1	3	3
shrubland	2	2
burn	n/a	n/a
cloud	n/a	n/a
cutbank	n/a	n/a
cutblock	n/a	n/a
disturbed	n/a	n/a
meadow	n/a	n/a
urban/industrial	n/a	n/a
BFNN[(b)]	3	3
BONS	2	2
BTNI[(b)]	3	3
BTNN[(c)]	3	3
BTNR[(b)]	3	3
BTXC[(c)]	3	3
BTXN[(c)]	3	3
FFNN[(c)]	3	3
FONG[(c)]	1	1
FONS[(c)]	2	2
FOPN[(b)]	2	2
FTNI[(b)]	3.5	3.5
FTNN[(c)]	3.5	3.5
FTNR[(c)]	3	3
FTPN[(b)]	3	3
MONG[(c)]	1	1
SFNN[(b)]	3.5	3.5
SONS[(c)]	2	2
STNN[(c)]	3.5	3.5
NWF	1	1
NWL	1	1
NWR	1	1
WONN[(c)]	1	1
riparian[(c)]	3	3
Pj-Lt complex [(b)]	3	3

(a) Alberta Vegetation Inventory (AVI) data used to determine structural complexity data (structural complexity data [Golder 2000a]).

(b) Structural complexity derived from field experience and professional expertise.

(c) Oil Sands Regional Biodiversity Ranking (Golder 2000b).

n/a = not applicable

2.2 Ranking of Vegetation Types

Biodiversity within the Oil Sands Region is determined to a large extent by the rarity of each vegetation type. All of the indices presented in Table II-16 (excluding reclamation potential) are influenced in some manner by the distribution of vegetation types. For example, a vegetation type that is at the extreme end of its distribution in the region (e.g., wooded permafrost bog with collapse scars [BTXC]), and has high rare species potential (e.g., marshes [MONG]), high total species richness (e.g., wooded fens [FTNN]), low species overlap (e.g., shallow open water [WONN]) and greater structural complexity (e.g., deciduous-aspen/aspen-balsam poplar dominant [b2]) may not contribute as much as a vegetation type that is more common, but moderate in terms of the other indices. A good example of a vegetation type that falls into this category are patterned open fens (FOPN). They score highly in most categories, but are very rare in the region.

The overall scores range from 14 for shrubland and 15.5 for wooded bog (BTNN) to 28 for wooded patterned fen (FTPN; Table II-17). On average, the wetlands types scored higher (22) than terrestrial types (19). The average rarity score for wetlands types was higher (4.2) than for ecosite phases (terrestrial) types (3.4). Plant species richness average scores in terrestrial vegetation types were slightly lower (2.2) than in wetlands types (3.0). Wildlife species richness average scores in terrestrial vegetation types and wetlands types were identical (3.0). The plant species average overlap score was lower in terrestrial vegetation types (1.6) than in wetlands (2.5), indicating that there are more generalist plant species (i.e, plant species occurring in more than 4 habitat types) occurring in the terrestrial than in the wetlands vegetation types.

The average scores of wildlife use indicated that wildlife on average, use more than one ecosite phase/wetlands type. Wildlife species use the same range (i.e., same number) of wetlands types as terrestrial types. The wildlife species overlap in terrestrial ecosite phases/wetlands types was similar (0.8 and 0.9, respectively).

The rare plant species potential average scores were higher for wetlands (2.9) than terrestrial vegetation (1.9). The wildlife species potential average scores were higher for wetlands (3.3) than terrestrial vegetation (2.9). These scores reflect the occurrence of rare plant species in several wetlands types including open patterned fens (FOPN) and the higher use of wetlands types by wildlife species at risk, e.g., woodland caribou and boreal toad (Golder 2005b). All types of wooded fens are habitat for three or more at risk wildlife species (rank of 4 in Table II-2).

The structural complexity was higher overall for terrestrial vegetation types (3.3) than wetlands (2.4), indicative of the higher occurrence of multistorey stands among terrestrial vegetation types. Five of the 24 wetlands types were given a high biodiversity potential compared to none of 18 upland ecosystems (Table II-16). The reason for this is the generally higher rare species potential of wetlands, particularly rare plants and lower species overlap for plants. Plant species richness is higher in wetlands, particularly wooded fens compared to ecosite phases (terrestrial).

The highest potential for biodiversity occurs in the wooded fens particulary those that are patterned (alternating open pools and vegetated areas in a linear pattern) (FTPN) or non-patterned with open sedge meadows or “lawns” (FTNI) (Halsey and Vitt 1996). Most other wetlands types have a moderate potential including the abundant wooded fen (FTNN). Bogs, the most abundant being the wooded bog (BTNN), have a low potential for biodiversity due in part to low rare plant species potential and low wildlife species richness.

Although peatlands (bogs and fens) occur frequently on the landscape, the inability to re-establish peatlands in the reclaimed landscape should not be underemphasized in the assessment of biodiversity. The maintenance of mature and old growth forests is equally important for biodiversity conservation, particularly in the terrestrial vegetation types. All terrestrial vegetation types can be reclaimed, however, the mixedwood (blueberry aspen-white spruce [b3], low-bush cranberry aspen-white spruce [d2], dogwood balsam poplar-white spruce [e2] and horsetail balsam poplar-white spruce [f2] ecosite phases) and white spruce dominant coniferous vegetation types (blueberry white spruce-jack pine [b4], low-bush cranberry white spruce [d3], dogwood-white spruce [e3] and horsetail white spruce [f3] ecosite phases) support a greater proportion of wildlife species of concern, four of which (woodland caribou, bay-breasted warbler, black-throated green warbler and Cape May warbler) require mature or old growth forests (Golder 2005b).

Table II-16 Biodiversity Potential for Vegetation Types in the Oil Sands Region

Ecosite Phase/ Wetlands Type	Ecosite Phase/ Wetlands Type	Rare Vegetation Type	Indices Scores						Structural Complexity	Total Score	Ranking Index[(a)(b)]	Biodiv. Pot.[(c)]
			Total Species Richness		Species Overlap		Rare Species Potential					
			Vegetation	Wildlife	Vegetation	Wildlife	Vegetation	Wildlife				
lichen - jack pine	a1	4	2	2	2	1	1	3	3	18.0	0.64	L
blueberry jack pine-aspen	b1	2	3	3	2	1	2	2	3.5	18.5	0.66	L
blueberry aspen (white birch)	b2	4	2	3	1	1	1	2	4	18.0	0.64	L
blueberry aspen-white spruce	b3	4	2	4	1	1	1	3	3.5	19.5	0.70	L
blueberry white spruce-jack pine	b4	4	2	3	1	1	2	3	3.5	19.5	0.70	L
Labrador tea–mesic jack pine-black spruce	c1	4	3	2	2	1	1	3	3	19.0	0.68	L
low-bush cranberry aspen	d1	0	3	3	2	1	1	2	3.5	15.5	0.55	L
low-bush cranberry aspen-white spruce	d2	0	3	4	2	1	2	3	3.5	18.5	0.66	L
low-bush cranberry white spruce	d3	2	2	3	2	1	4	2	3.5	19.5	0.70	L
dogwood balsam poplar-aspen	e1	4	2	3	1	1	4	2	3	20.0	0.71	L
dogwood balsam poplar-white spruce	e2	4	2	4	2	1	1	3	3	20.0	0.71	L
dogwood-white spruce	e3	4	2	3	2	1	2	2	3.5	19.5	0.70	L
horsetail balsam poplar-aspen	f1	6	2	3	1	1	4	2	3	22.0	0.79	M
horsetail balsam poplar-white spruce	f2	6	2	3	1	1	2	3	3	21.0	0.75	M
horsetail white spruce	f3	6	2	3	2	1	2	2	3	21.0	0.75	M

Table II-16 Biodiversity Potential for Vegetation Types in the Oil Sands Region (continued)

Ecosite Phase/ Wetlands Type	Ecosite Phase/ Wetlands Type	Rare Vegetation Type	Indices Scores						Structural Complexity	Total Score	Ranking Index[(a)(b)]	Biodiv. Pot.[(c)]
			Total Species Richness		Species Overlap		Rare Species Potential					
			Vegetation	Wildlife	Vegetation	Wildlife	Vegetation	Wildlife				
Labrador tea–subhygric black spruce-jack pine	g1	2	3	2	2	1	2	3	4	19.0	0.68	L
Labrador tea/horsetail white spruce-black spruce	h1	2	3	4	2	1	2	4	3	21.0	0.75	M
shrubland	shrubland	4	1	2	1	1	1	2	2	14.0	0.50	L
burn[(d)]	burn	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	L
cloud	cloud	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	U
cutbank	cutbank	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	U
cutblock	cutblocks	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	U
disturbed	disturbed	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	U
grassland[(d)]	grassland	n/a	n/a	n/a	n/a	n/a	n/a	n/d	n/a	n/a	n/a	L
meadow[(d)]	meadow	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	L
sand	sand	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	U
urban/ industrial	urban/ industrial	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	U
forested bog	BFNN	6	3	2	2	0	1	2	3	19.0	0.68	L
shrubby bog	BONS	6	3	3	2	1	4	3	2	24.0	0.86	M
wooded bog with internal lawns	BTNI	6	3	2	2	0	1	2	3	19.0	0.68	L
wooded bog	BTNN	2	3	2	2	0	1	2	3	15.0	0.54	L
wooded bog with forested islands	BTNR	6	3	2	2	0	1	2	3	19.0	0.68	L
wooded bog permafrost bog	BTXC	6	3	2	2	0	2	2	3	20.0	0.71	L
wooded bog permafrost bog	BTXN	6	3	2	2	0	2	2	3	20.0	0.71	L
forested fen	FFNN	6	3	4	2	0	4	4	3	26.0	0.93	H
graminoid fen	FONG	4	3	2	3	1	4	2	1	20.0	0.71	L

Table II-16 Biodiversity Potential for Vegetation Types in the Oil Sands Region (continued)

Ecosite Phase/ Wetlands Type	Ecosite Phase/ Wetlands Type	Rare Vegetation Type	Indices Scores						Structural Complexity	Total Score	Ranking Index[(a)(b)]	Biodiv. Pot.[(c)]
			Total Species Richness		Species Overlap		Rare Species Potential					
			Vegetation	Wildlife	Vegetation	Wildlife	Vegetation	Wildlife				
shrubby fen	FONS	2	4	3	3	1	4	3	2	22.0	0.79	M
open patterned fen	FOPN	6	4	2	3	1	4	2	2	24.0	0.86	M
wooded fen	FTNI	4	4	4	3	0	4	4	3.5	26.5	0.95	H
wooded fen	FTNN	0	4	4	3	0	4	4	3.5	22.5	0.80	M
wooded fen with forested islands	FTNR	4	4	4	3	0	4	4	3	26.0	0.93	H
wooded patterned fen	FTPN	6	4	4	3	0	4	4	3	28.0	1.00	H
marsh	MONG	4	2	3	3	1	4	4	1	22.0	0.79	M
forested swamp	SFNN	6	4	4	2	0	2	4	3.5	25.5	0.91	H
shrubby swamp	SONS	2	3	4	2	1	4	4	2	22.0	0.79	M
wooded swamp	STNN	0	4	4	2	0	2	4	3.5	19.5	0.70	L
shallow open water	NWF	2	1	2	4	1	1	4	1	16.0	0.57	L
deep water (lake)	NWL	4	1	3	4	4	4	4	1	25.0	0.89	M
deep water (river)	NWR	4	1	3	2	4	1	4	1	20.0	0.71	L
shallow open water	WONN	4	1	2	4	1	4	4	1	21.0	0.75	M
shrubland	riparian	4	2	4	2	1	4	4	3	24.0	0.86	M
jackpine-tamarack complex	Pj-Lt complex	4	3	2	2	1	2	4	3	21.0	0.75	M

(a) Ranking index standardized relative to vegetation type with highest total score.

(b) Low (L) = < 0.75; Moderate (M) = 0.75 to 0.899; High (H) = ≥ 0.90; Unranked.

(c) Biodiversity Potential Rank.

(d) Ranks assigned based on professional judgement.

n/a = not applicable.

Of the 43 vegetation types and nine disturbance or unclassified sites assessed for the Oil Sands Region, 22 (51%) have either a moderate or high potential for biodiversity (Table II-16). The remaining 25 vegetation types have a low potential for biodiversity. The biodiversity potential for the regional land cover classes is presented earlier in Table 17 show the interrelationship between the ecosystem-level analysis presented here, and the landscape-level. Biodiversity in a given habitat is strongly influenced by the arrangement and composition of the vegetation types comprising a landscape. Therefore, the biodiversity ranking (ecosystem-level) results should be seen in the context of the landscape.

Assigning a single biodiversity value to each may highlight the importance of particular vegetation types, however, it is also important to consider which indices contributed to the assigned rank. As discussed above, the key factors that influence biodiversity differ for each vegetation type. This point highlights the need to consider each vegetation type separately when designing reclamation plans, while still examining the overall proportion, distribution and continuity of ecosite phases/wetlands types at both the ecosystem- and landscape-levels of analysis. To illustrate this, the portion of the landscape comprised of vegetation types with low biodiversity potential is important to overall biodiversity in the Oil Sands Region, in that it supports the moderate and high biodiversity potential areas functionally through species movement or dispersal, maintainance of hydrological function and natural disturbance occurrence (e.g., fire). The combined ecosystem and landscape-level of analysis is presented with the ecosite phases/wetlands types by rank, in conjunction with the spatial characteristics of each (Tables II-15, II-16, II-17 and II-18).

2.3 RANKING OF REGIONAL LAND COVER CLASSES

Regional land cover classes in the Oil Sands Region were ranked based on the weighted contribution of their constituent vegetation types (Table II-17). The biodiversity scores in Table II-17 are taken from the biodiversity potential data for vegetation types from Oil Sands Regional Biodiversity Ranking (Table II-16). The indice scores used to calculate the biodiversity scores are not included in this appendix.

The results from the regional ranking used to calculate the biodiversity scores in Table II-17 excluded reclamation potential to allow for a direct comparison to be made with Project-specific data for a present-time snapshot. In contrast, reclamation potential predicts a future condition.

Table II-17 Biodiversity Ranking Assessment for Regional Land Cover Classes in the Oil Sands Region

Regional Land Cover Class	Ecosite Phase/ Wetlands Type	Biodiversity Score	Weighted Contribution to Regional Land Cover Class	Sum of Weighted Contributions	Total Score	Ranking Index[(a)]	Importance to Biodiversity[(b)]
coniferous-jack pine dominant	a1	18.0	1	18.0	18.0	0.76	M
mixedwood-jack pine-aspen dominant	b1	18.5	1	18.5	18.5	0.78	M
deciduous-aspen/aspen-balsam poplar dominant	b2	18.0	0.013	0.2	15.7	0.66	L
	d1	15.5	0.958	14.9			
	e1	19.0	0.029	0.5			
	f1	22.0	0.001	0.0			
mixedwood-aspen-white spruce dominant	b3	19.5	0.043	0.8	18.7	0.79	M
	d2	18.5	0.837	15.5			
	e2	20.0	0.116	2.3			
	f2	21.0	0.004	0.1			
coniferous-white spruce dominant	b4	19.5	0.152	3.0	19.6	0.82	M
	d3	19.5	0.722	13.0			
	e3	19.5	0.085	1.7			
	f3	21.0	0.041	0.8			
coniferous-black spruce-white spruce (jack pine) dominant	c1	19.0	0.234	4.4	19.6	0.83	M
	g1	19.0	0.454	8.6			
	h1	21.0	0.312	6.6			

Table II-17 Biodiversity Ranking Assessment for Regional Vegetation Classes in the Oil Sands Region (continued)

Regional Land Cover Class	Ecosite Phase/ Wetlands Type	Biodiversity Score	Weighted Contribution to Regional Land Cover Class	Sum of Weighted Contributions	Total Score	Ranking Index[(a)]	Importance to Biodiversity[(b)]
shrubland	shrubland	14.0	0.080	1.1	21.6	0.91	H
	SONS	22.0	0.821	18.1			
	riparian	24.0	0.099	2.4			
wooded fen	FFNN	26.0	0.001	0.0	22.1	0.93	H
	FTNI	26.5	0.009	0.2			
	FTNN	22.5	0.758	17.1			
	FTNR	26.0	0.040	1.0			
	FTPN	28.0	0.000	0.0			
	SFNN	25.5	0.001	0.0			
	STNN	19.5	0.192	3.7			
shrubby fen	FONS	22.0	0.999	22.0	22.0	0.93	H
	FOPN	24.0	0.001	0.0			
graminoid fen	FONG	20.0	1.000	20.0	20.0	0.84	M
poor wooded fen/wooded bog	BFNN	19.0	0.001	0.0	15.9	0.67	L
	BONS	24.0	0.001	0.0			
	BTNI	19.0	0.057	1.1			
	BTNN	15.0	0.777	11.7			
	BTNR	19.0	0.120	2.3			
	BTXC	20.0	0.042	0.8			
	BTXN	20.0	0.002	0.0			
marsh	MONG	22.0	1.000	22.0	22.0	0.93	H
shallow open water	NWF	16.0	.001	<1	21.0	0.90	H
	WONN	21.0	0.999	21.0			

Table II-17 Biodiversity Ranking Assessment for Regional Vegetation Classes in the Oil Sands Region (continued)

Regional Land Cover Class	Ecosite Phase/ Wetlands Type	Biodiversity Score	Weighted Contribution to Regional Land Cover Class	Sum of Weighted Contributions	Total Score	Ranking Index[a]	Importance to Biodiversity[b]
deep water	NWL	25.0	0.786	19.6	23.7	1.00	H
	NWR	20.0	0.214	4.3			
Burn[c]	burn	n/a	n/a	n/a	n/a	n/a	L
cloud	cloud	n/a	n/a	n/a	n/a	n/a	U
cutbank	cutbank	n/a	n/a	n/a	n/a	n/a	U
cutblock	cutblock	n/a	n/a	n/a	n/a	n/a	U
disturbed	disturbed	n/a	n/a	n/a	n/a	n/a	U
grassland[c]	grassland	n/a	n/a	n/a	n/a	n/a	L
meadow[c]	meadow	n/a	n/a	n/a	n/a	n/a	L
sand	sand	n/a	n/a	n/a	n/a	n/a	U
urban / industrial	urban / industrial	n/a	n/a	n/a	n/a	n/a	U

(a) Ranking index standardized relative to regional land cover class with highest total score.

(b) Low (L) = < 0.75; Moderate (M) = 0.75 to 0.899; High (H) = ≥ 0.90; Unranked.

(c) Ranks assigned based on professional judgement.

n/a = not applicable.

From the weighted contribution of all regional land cover classes except deciduous-aspen/aspen-balsam poplar dominant and poor wooded fen/wooded bog, were in the upper quartile of the ranking index (greater than or equal to 0.75), excluding the unranked classes (i.e., disturbed, cloud, cutblocks and urban/industrial). The deep water class ranked the highest with a total score of 23.7 followed by the wooded fen class with a total score of 22.1. The deciduous-aspen/aspen-balsam poplar dominant ranked the lowest with a score of 15.7. As discussed in the ecosite phase/wetlands type ranking section, these ranks are useful for comparing the relative biodiversity among regional land cover classes and between ecological areas. However, when developing a reclamation and closure plan, each regional land cover class must be examined individually for the factors that contribute to high biodiversity scores (e.g., low occurrence in the landscape, potential to contain rare species), including their individual component ecosite phases/wetlands types. These assessments will better enable planners to incorporate a variety of key elements for maintenance of biodiversity in the Oil Sands Region.

Other Parameters Assessed

As described in the methods section, several other biodiversity indicators are also useful for monitoring changes in biodiversity in other baseline reports, Terrestrial Vegetation, Wetlands and Forest Resources ESR (Golder 2005a) and Wildlife ESR (Golder 2005b). These indicators include species diversity indices, the presence of non-native species, the presence of plant and wildlife species that live in or use only a few habitat types (habitat specificity), keystone species and functional groups and old growth forests. A comparison of results from baseline field surveys in the Oil Sands Region and the LSA are provided for the first three indices in this report. These indices are part of a checklist for monitoring the integrity of ecosystems and are included as part of the conservation and reclamation plan.

2.4 Summary

This biodiversity ranking approach provides a relative biodiversity rank for vegetation types based on indices that combine vascular plant and terrestrial vertebrate elements. By understanding the relative biodiversity potential for each vegetation type, it will be easier to use vegetation maps to determine areas of high biodiversity that might be impacted by a development. Knowledge of the spatial distribution of regional land cover classes from heterogeneity analysis combined with stand-age data (old growth forest occurrence) provides important information about the variety of rare plants and special status wildlife species in regional land cover classes with old growth forest. To maintain biodiversity, areas of mature and old growth forest could be protected in and around the development area.

Based on the overall ranking, wooded patterned fens (FTPN) had the highest biodiversity and were therefore deemed to be the most sensitive to development. Regional land cover classes ranked high for biodiversity were peatlands (wooded fens and shrubby fens, deep water, shallow open water and marshes). This result was due to the high proportion of rare species, low species overlap and the rarity of these regional land cover classes. Rare component vegetation types of otherwise common regional land cover classes included patterned fens (FTPN) comprising the wooded fen class.

In addition, a discussion of other biodiversity indicators is included in Terrestrial Vegetation, Wetlands and Forest Resources ESR (Golder 2005a) and Wildlife ESR (Golder 2005b). These indicators could not be included in the ranking assessment of vegetation types, but they should be considered in the future as additional data become available. These indicators include species diversity indices, the presence of non-native species, the value of old growth forests and keystone species and the presence of plant and wildlife species that live in or use only a few habitat types.

Biodiversity indices can be used in a project impact analysis in the same way that individual species information would be used. A main part of the impact analysis will involve examining the amount of high biodiversity potential areas impacted by the Project’s footprint and considering mitigation measures, including possible relocation of the Project elements. The second aspect will concern the landscape-level indices and compare landscape structure and fragmentation, between baseline, post-construction and reclamation scenarios. An important part of these latter analyses will be in cumulative impact assessments.

The biodiversity values described in this report characterize the baseline conditions to which future landscapes in the Oil Sands Region can be compared. The similarity between the pre- and post-development landscapes can be measured using these indices as a means to direct conservation and reclamation, monitoring and adaptive management plans. By understanding the arrangement of patches in the current landscape and the biodiversity values that characterize each vegetation type at the ecosystem level, informed decisions can be made to maintain biodiversity in the Oil Sand Region in the face of development.