Korea
National Oil Corporation

Appendix H

Biodiversity

Korea
National Oil Corporation

Appendix H1

Biodiversity Assessment Methods

APPENDIX H1: BIODIVERSITY ASSESSMENT METHODS

1.0 HABITAT DIVERSITY

A set of vegetation and wetland indicators were selected to assess habitat diversity.

- the distribution of local riparian habitat (ELC); and
- the distribution of local old growth forests (ecosite phase).

1.1 Riparian Habitat

Riparian habitat in the TLSA and TRSA were determined by applying a 100 m set-back width on either side of all creeks, rivers and open water (e.g., lakes, flooded areas).

Baseline Analysis
The baseline area and percent distribution of each ELC in riparian areas was determined for the TLSA. For the TRSA, the baseline area and percent distribution of each LCC in riparian areas was determined.

1.2 Old Growth Forests

Old growth forest was defined based on the age of each forested ecosite phase. Age was determined based on the origin code in the Alberta Vegetation Inventory (AVI), by subtracting the year of origin from the current year (2009). Old growth forests were identified in the TLSA based on species-specific age definitions (Table H1-1) for forested ecosite phases based on dominant tree species classes (Schneider 2001).

Table H1-1: Old Growth Age for Forested Ecosite Phases

Forested Ecosite Phases	Old-Growth Age (years)
Pine-dominant Forest (a1, c1)	>120
Spruce-dominant Forest (g1)	>140
Mixedwood Forest (b1, d1)	>100
Treed Wetlands (j1, k1, l1)	>140

Baseline Analysis
The baseline area and percent distribution of old growth forests was determined for the TLSA.

2.0 SPECIES DIVERSITY

2.1 Species Richness by Ecosite Phase

In this section the estimation of species richness within each ecological land class (ELC) is assessed and ranked from low to high. These ranks allow plant species richness to be mapped and summarized in categories in the TLSA.

Three measures of species richness were calculated for each ELC, which were then combined in an overall assessment of plant species diversity.

- total species richness - the total species that occur among all plots of each ELC;
- mean species richness - the mean species per plot sampled of each ELC; and
- unique species richness - the number of species that occur within no other ELC.

Sample Size and Pooling of Data

The sampling effort needed to obtain a statistically precise mean richness measurement depends on the number of sample sites measured. To have good confidence in the mean, a sample size of 10 sites or more is considered ideal, and 5 sites is considered adequate. Less than 5 sites will not provide confidence. Therefore, the sampling goal in a baseline study is to obtain at least 5 to 10 samples of each ELC to effectively characterize the mean cover and species diversity.

In this study a total of 87 sample sites were measured in the TLSA covering 19 ELC, in addition to baseline data from field studies conducted in the TLSA in 2005 (Newmont). The total number of detailed vegetation plots, for which species richness values have been assessed are presented in Table H1-2. To increase the accuracy of species richness metrics, KNOC has a data sharing agreements with Devon on adjacent projects (Devon 2003, 2006, 2008) and has obtained detailed vegetation plot data, resulting in an increased sample size for each ELC. Data were obtained from the following baseline surveys:

- Newmont (53 detailed plots); and
- Devon (196 detailed plots).

Table H1-2: Vegetation Plots used in Species Richness Assessments

ELC	Description	Other Companies	KNOC	Total ELC Plots
a1	Pj lichen	6	6	12
b1	Pj/Aw - blueberry	19	8	27
b2	Aw/Bw - blueberry	1	4	5
b3	Aw/Sw - blueberry	6	1	7
b4	Pj/Sw - blueberry	10	0	10
c1	Pj/Sb - Labrador tea	24	4	28
d1	Aw - lowbush cranberry	16	6	22
d2	Aw/Sw - lowbush cranberry	16	6	22
d3	Sw - lowbush cranberry	3	4	7
e1	Pb/Aw - dogwood	3	0	3
e2	Pb/Sw - dogwood	5	1	6
e3	Sw - dogwood	4	0	4
f1	Pb/Aw - horsetail	1	1	2
f3	Sw - horsetail	3	1	4
g1	Sb/Pj - Labrador tea	21	7	28
h1	Sw/Sb - Labrador tea	9	5	14
i2	shrubby bog	6	2	8
j1	treed poor fen	30	9	39
j2	shrubby poor fen	21	4	25
k1	treed rich fen	18	7	25
k2	shrubby rich fen	14	9	23
k3	graminoid fen	6	2	8
NSH	shrubland / regeneration	7	0	7
	TOTAL	**249**	**87**	**340**

Species Richness Methods

From each vegetation plot a list of species and their percent cover was determined. Only species identified to both genus and species were used in the analyses. Introduced species were excluded from species richness calculations and have been assessed in a separate section of the main report.

ELC with less than 5 sampling sites (e1, e3, f1 and f3) will not be analysed further for species diversity. In addition, ELC that were identified as shrubland/regeneration or open water will not be used in the analyses since they were not systematically sampled.

Total Species Richness

Total species richness is a measurement of the total number of species that occur within each ELC throughout a region of interest. Total species richness is strongly influenced by the number of plots sampled, because the cumulative pool of observed species increases with the total area sampled and with the number of locations sampled.

An alternative ranking of total species richness was used to assess whether there was a trend where ELC with a greater number of sample plots tend to also have a greater number of total species observations. In this analysis a covariance approach was used to remove this trend from the observations using simple linear regression of total species per ELC versus number of sample plots. There was no statistical difference observed between the residuals and the actual number of species observed in the ELC. Therefore for the purposes of this report, the total species richness is not influenced by the number of plots sampled and is a good measure of richness.

Total (sample) species richness for each ELC for vascular and non-vascular is summarized in Table H1-3. Total species richness was ranked, using the following criteria.

Rank	Vascular	Nonvascular
High	> 90	> 30
Medium	45 - 89	15 - 30
Low	< 45	< 15

The majority of ELC have medium rankings of vascular and non-vascular total species richness. Shrubby rich fen (k2) has a high rank for vascular total species richness. Three ELC (j1, j2 and k1) have a high rank for non-vascular mean species richness.

Table H1-3: Ranking of Total Species Richness by ELC

ELC	N	Total Vascular Species	Vascular Ranking	Total Nonvascular Species	Nonvascular Ranking
a1	12	31	Low	16	Medium
b1	27	76	Medium	19	Medium
b2	5	40	Low	2	Low
b3	7	48	Medium	14	Low
b4	10	66	Medium	16	Medium
c1	28	58	Medium	25	Medium
d1	22	67	Medium	11	Low
d2	22	77	Medium	14	Low
d3	7	52	Medium	5	Low
e2	6	74	Medium	18	Medium
g1	27	69	Medium	22	Medium
h1	18	66	Medium	24	Medium
i2	8	29	Low	21	Medium
j1	39	96	High	36	High
j2	25	78	Medium	34	High
k1	25	86	Medium	34	High
k2	23	94	High	30	Medium
k3	8	50	Medium	14	Low

Mean Species Richness

Mean species richness is the mean number of species per sample plot of each ELC. Mean species richness provides an expected number of species that would be observed at any location and is not another estimate of total species richness. Some ELC have high mean richness and low to medium total richness, and vice versa. Because mean species richness is a statistical measure, it tends to be less affected by sample size than total richness, once a sample size of approximately 5 plots per ELC has been achieved. This number of plots has been achieved for the ELC used in this assessment.

Mean richness for each ELC for vascular and non-vascular is shown in Table H1-4. Mean species richness was ranked, using the following criteria.

Rank	Vascular	Nonvascular
High	> 24	> 6.0
Medium	14 - 24	3.0 - 6.0
Low	< 14	< 3

The majority of ELC have medium rankings of vascular and non-vascular mean species richness. One ELC (e2) has a high rank for vascular mean species richness and two ELC (h1 and j2) have a high rank for non-vascular mean species richness.

Table H1-4: Ranking of Mean Species Richness by ELC

ELC	N	Mean Vascular	Vascular Ranking	Mean Nonvascular	Nonvascular Ranking
a1	12	10.8	Low	4.8	Medium
b1	27	20.6	Medium	3.8	Medium
b2	5	20.2	Medium	0.6	Low
b3	7	19.0	Medium	3.4	Medium
b4	10	19.1	Medium	6.0	Medium
c1	28	13.8	Low	5.9	Medium
d1	22	23.7	Medium	2.1	Low
d2	22	25.3	High	3.2	Medium
d3	7	18.1	Medium	1.9	Low
e2	6	36.2	High	5.3	Medium
g1	28	13.2	Low	5.0	Medium
h1	14	16.4	Medium	5.4	Medium
i2	8	9.6	Low	5.0	Medium
j1	38	14.9	Medium	5.3	Medium
j2	25	15.7	Medium	6.8	High
k1	25	17.0	Medium	5.2	Medium
k2	23	16.9	Medium	3.7	Medium
k3	8	12.3	Low	1.9	Low

Unique Plant Species

Unique species richness is the total number of species unique to each ELC. Like total richness, this measurement is dependant on the total number of plots sampled. The importance of this measurement is that if an ELC is significantly impacted by development, these species could also be significantly impacted. This issue is compounded if the ELC are uncommon (occupying ≤1% of the TLSA), since even small impacts to these ELC can be locally or regionally significant. In the TLSA, uncommon ELC included b1, b2, b3, b4, d3, e1, e2, e3, f1, f3, i2 and k3. Unique species are in some cases rare plant species. Unique vascular and non-vascular plant species for each ELC are shown in Table H1-5.

Table H1-5: Unique Species Observations by ELC

ELC	Type	Scientific Name	Common Name
a1	Moss	*Tortula ruralis*	hairy screw moss
b1	Forb	*Arnica chamissonis*	leafy arnica
b1	Lichen	*Bryoria fuscescens*	old man's beard
b1	Graminoid	*Carex spectabilis*	showy sedge
b1	Fern/Allies	*Lycopodium clavatum*	running club-moss
b1	Forb	*Monotropa uniflora*	Indian-pipe
b1	Moss	*Thuidium recognitum*	fern-moss
b3	Forb	*Corydalis sempervirens*	pink corydalis
b3	Forb	*Hieracium umbellatum*	narrow-leaved hawkweed
c1	Lichen	*Cladonia macilenta*	lichen
c1	Lichen	*Cladonia squamosa*	lichen
c1	Moss	*Dicranum acutifolium*	cushion moss
d2	Shrub	*Arctostaphylos rubra*	alpine bearberry
d2	Forb	*Astragalus americanus*	American milk vetch
d2	Graminoid	*Carex peckii*	Peck's sedge
d2	Shrub	*Prunus virginiana*	choke cherry
d2	Shrub	*Sorbus scopulina*	western mountain-ash
d3	Graminoid	*Poa pratensis*	Kentucky bluegrass
e2	Forb	*Achillea sibirica*	many-flowered yarrow
e2	Liverwort	*Lophozia ventricosa*	liverwort
e2	Graminoid	*Scirpus microcarpus*	small-fruited bulrush
e2	Forb	*Smilacina racemosa*	False Solomon's-seal
e2	Forb	*Solidago canadensis*	Canada goldenrod
e2	Moss	*Tetraphis pellucida*	moss
g1	Graminoid	*Carex siccata*	hay sedge
g1	Lichen	*Cladonia botrytes*	lichen
h1	Fern/Allies	*Botrychium virginianum*	Virginia grape fern
i2	Lichen	*Cetraria nivalis*	lichen
i2	Shrub	*Kalmia polifolia*	northern laurel
j1	Graminoid	*Carex capillaris*	hair-like sedge
j1	Lichen	*Cladonia coniocraea*	lichen
j1	Moss	*Dicranum fuscescens*	fuscous moss

ELC	Type	Scientific Name	Common Name
j1	Forb	*Gaultheria hispidula*	creeping snowberry
j1	Moss	*Helodium blandowii*	moss
j1	Graminoid	*Luzula parviflora*	small-flowered wood-rush
j1	Liverwort	*Mylia anomala*	liverwort
j1	Shrub	*Salix boothii*	Booth's willow
j2	Graminoid	*Carex trisperma*	three-seeded sedge
j2	Lichen	*Cladonia fimbriata*	lichen
j2	Lichen	*Cladonia scabriuscula*	lichen
j2	Moss	*Warnstorfia fluitans*	brown moss
k1	Graminoid	*Carex prairea*	prairie sedge
k1	Lichen	*Cladonia cenotea*	lichen
k1	Forb	*Drosera anglica*	oblong-leaved sundew
k1	Shrub	*Myrica gale*	sweet gale
k1	Shrub	*Salix serissima*	autumn willow
k1	Moss	*Sphagnum girgensohnii*	Girgensohn's moss
k1	Forb	*Stellaria longipes*	long-stalked chickweed
k2	Forb	*Allium cernuum*	nodding onion
k2	Forb	*Cypripedium parviflorum var pubescens*	large yellow lady's-slipper
k2	Graminoid	*Eleocharis acicularis*	needle spike-rush
k2	Forb	*Lathyrus palustris*	vetchling peavine
k2	Moss	*Scorpidium scorpioides*	moss
k2	Forb	*Sium suave*	water parsnip
k3	Graminoid	*Eriophorum chamissonis*	russett cotton grass
k3	Graminoid	*Eriophorum gracile*	slender cotton grass
k3	Moss	*Sphagnum capillifolium*	acute-leaved peat moss

Unique species richness was ranked based on the total number of unique species (vascular or non-vascular) in a single ELC; (Table H1-6), using the following criteria.

- High > 4
- Medium 2 - 4
- Low < 2

Four ELC (d2, j1, k1 and k2) have a high unique vascular species rank and no ELC have a high unique nonvascular species rank in the TLSA.

Table H1-6: Ranking of Unique Species Richness by ELC

ELC	N	Unique Vascular Species	Vascular Rank	Unique Nonvascular Species	Nonvascular Rank
a1	12	0	Low	1	Low
b1	27	4	Medium	2	Medium
b2	5	0	Low	0	Low
b3	7	2	Medium	0	Low
b4	10	0	Low	0	Low
c1	28	0	Low	3	Medium
d1	22	0	Low	0	Low
d2	22	5	High	0	Low
d3	7	1	Low	0	Low
e2	6	4	Medium	2	Medium
g1	28	1	Low	1	Low
h1	14	1	Low	0	Low
i2	8	1	Low	1	Low
j1	39	4	Medium	4	Medium
j2	25	1	Low	3	Medium
k1	25	5	High	2	Medium
k2	23	5	High	1	Low
k3	8	2	Medium	1	Low

Overall Richness Ranking

The three measurements of species richness, (total richness, mean richness, and unique richness) were combined to determine an overall ranking for each ELC. This overall ranking allowed plant richness to be mapped.

The overall ranking assumed all three measures to be equal, but assumed that high ranks were more important (and weighted higher) than medium or low ranks. Individual measurement ranks were given weights of 1 (low), 2 (medium), or 3 (high) and then summed to form a richness score. Richness scores were ranked (Table H1-7) using the following criteria:

- High overall richness score of > 7
- Medium overall richness score of 5 - 7
- Low overall richness score of < 5

Table H1-7: Overall Ranking of Plant Species Richness by ELC

ELC	N	Vascular Plant Species					Nonvascular Plant Species				
		Total	Mean	Unique	Score	Overall	Total	Mean	Unique	Score	Overall
a1	12	Low	Low	Low	3	Low	Medium	Medium	Low	5	Medium
b1	27	Medium	Medium	Medium	6	Medium	Medium	Medium	Medium	6	Medium
b2	5	Low	Medium	Low	4	Low	Low	Low	Low	3	Low
b3	7	Medium	Medium	Medium	6	Medium	Low	Medium	Low	4	Low
b4	10	Medium	Medium	Low	5	Medium	Medium	Medium	Low	5	Medium
c1	28	Medium	Low	Low	4	Low	Medium	Medium	Medium	6	Medium
d1	22	Medium	Medium	Low	5	Medium	Low	Low	Low	3	Low
d2	22	Medium	High	High	8	**High**	Low	Medium	Low	4	Low
d3	7	Medium	Medium	Low	5	Medium	Low	Low	Low	3	Low
e2	6	Medium	High	Medium	7	Medium	Medium	Medium	Medium	6	Medium
g1	28	Medium	Low	Low	4	Low	Medium	Medium	Low	5	Medium
h1	14	Medium	Medium	Low	5	Medium	Medium	Medium	Low	7	Medium
i2	8	Low	Low	Low	3	Low	Medium	Medium	Low	5	Medium
j1	39	High	Medium	Medium	7	Medium	High	Medium	Medium	7	Medium
j2	25	Medium	Medium	Low	5	Medium	High	High	Medium	8	**High**
k1	25	Medium	Medium	High	7	Medium	High	Medium	Medium	7	Medium
k2	23	High	Medium	High	8	**High**	Medium	Medium	Low	5	Medium
k3	8	Medium	Low	Medium	5	Medium	Low	Low	Low	3	Low

The majority of ELC have a medium overall rank for vascular and nonvascular species as shown in Table H1-8. Two ELC (d2 and k2) received a high overall rank for vascular species and one ELC (j2) received a high overall rank for nonvascular species. No ELC received a high overall rank for both vascular and non-vascular species.

Table H1-8: Species Richness Overall Rank Comparison Table

Overall Rank		Vascular Plant Species Richness Rank		
		Low	**Medium**	**High**
Nonvascular Plant Species Richness Rank	**Low**	b2	b3, d1, d3, k3	d2
	Medium	a1, c1, g1, i2	b1, b4, e2, h1, j1, k1	k2
	High		j2	

Baseline Analysis of Species Richness

The baseline area and percent distribution of the ELC by species richness rank for vascular and non-vascular species was determined.

3.0 FRAGMENTATION

3.1 Density of Linear Developments

Total linear disturbance density, expressed as km/km^2, is a measurement of the current level of human linear access development expressed as a ratio to the area of the TLSA and TRSA.

Methods
GIS files of linear developments in the TLSA and TRSA were prepared from data provided by KNOC, Alberta Base Features (Alta LIS) and AVI. The length of linear access features was determined in GIS by summing the area of all linear developments using a standard buffer width of 1 m. The area was divided by the buffer width to get a linear measure in metres, and was then converted to kilometres. The density of linear developments was calculated as total lengths divided by the total area of the TLSA or TRSA.

Baseline Analysis
The baseline disturbance density was determined for the TLSA and TRSA.

3.2 Density of Creek Crossings

The density of creek crossings in the TLSA and TRSA, expressed as the number of crossings per length of watercourses, is another measurement of the current level of linear corridor crossings.

Methods
Watercourses in the TLSA and TRSA were identified in GIS. The location and number of intersections (i.e., watercourse crossings) between watercourses and linear features were calculated. Linear crossings were classed according to crossing type (roads, pipeline/utility ROW, seismic cutlines), and crossing density was determined by dividing the number of crossings by the total length of watercourses.

Baseline Analysis
The baseline creek crossing density was determined for the TLSA and TRSA.

3.3 Distribution of Natural Habitat Patches

A patch is defined as a contiguous area (*i.e.*, a polygon), which is composed entirely of natural habitat and which is bordered by anthropogenic disturbances. Patches by this definition do not include polygons of individual land cover classes or ecosite phases. Patch metrics are summary calculations describing the size and number of patches.

Methods
All anthropogenic disturbances were used to define patch boundaries. The study area border also acts as a patch boundary, therefore this is a constraint of the method used to measure patches.

Patch metrics were calculated for the TLSA and TRSA using IAN - which is a raster image analysis software program (Mladenoff and DeZonia 2004). Patch metrics included area measurements (in hectares) of patch size including the mean, standard deviation, minimum and maximum, and the total number of patches. Patches were also divided into size classes: < 1 ha, 1-5 ha, 5-25 ha, 25-100 ha, 100 - 400 ha, and > 400 ha.

Baseline Analysis
The baseline patch numbers and patch sizes in the TLSA and TRSA were calculated showing the distribution by patch size classes as percent of total patches.

3.4 Disturbance Edge to Natural Habitat Area Ratio

The anthropogenic edge to area ratio, expressed as km/km^2, is a measurement of the current level of human disturbance of areas adjacent to natural habitats. Although linear and small patch disturbances result in little direct habitat removal, the edge effects are often much greater, and these effects may reduce habitat quality of a comparatively large area. In addition, large disturbed areas have high anthropogenic edge that adds to the impact of the development by reducing habitat quality of adjacent areas.

Methods
The edge length shared between anthropogenic origin and natural origin classes (ELC and LCC) were measured using IAN raster analysis software (Mladenoff and DeZonia 2004). These values were summed and divided by the total area of each class to provide the anthropogenic edge to area ratio.

Baseline Analysis
The baseline anthropogenic edge to area ratio for each ELC and LCC were determined for the TLSA and TRSA, respectively.

4.0 LITERATURE CITED

Mladenoff, D.J. and B. DeZonia. 2004 IAN Raster Analysis Software, User's Guide. http://landscape.forest.wisc.edu.

Schneider, R. 2001. Old-Growth Forests in Alberta: Ecology and Management. Alberta Centre for Boreal Studies. Edmonton AB.

Korea
National Oil Corporation

Appendix H2

Breeding Bird Species Richness Assessment

APPENDIX H2: BREEDING BIRD SPECIES RICHNESS ASSESSMENT

1.0 BREEDING BIRD SPECIES RICHNESS ASSESSMENT

The goal of this analysis was to examine patterns of bird species in relation to habitat types in the TLSA. This information was then used to rank each habitat type (on a low to high scale) for the purposes of mapping relative bird diversity in the TLSA.

Data from terrestrial call point locations were obtained within the TLSA. These data were supplemented with data collected in 2005 (Newmont 2006) within the TLSA and adjacent townships. The TLSA occurs within the Central Mixedwood Subregion of the Boreal Forest Natural Region in Alberta. This ecological zone is characterized by sandy post-glacial terrain supporting deciduous and mixedwood forests and primarily bog and fen wetlands, with limited areas of pine uplands.

The assessment of breeding birds focused on all families of birds identified as breeding pairs within individual habitat areas. That is, the assessment did not specifically examine taxonomic classes of birds (e.g. songbirds). To be considered for analysis, species needed to be positively identified by song or visual assessment. Only species recorded within 100 m of plot centre were analysed, to ensure that the observations were representative of the habitat types at plot centre.

1.1 Field Data

Twenty-eight sites were measured in 2008 within the TLSA. An additional 231 call points were measured in 2005 (Newmont 2006) in Township 76 Ranges 6 to 8 W4M and Township 75 Ranges 6 and 7 W4M.

All data collected were subjected to a quality control assessment to determine accuracy of habitat classification, and accuracy of field recorded bird species codes.

Use of broad habitat associations for this analysis is preferred since birds are primarily believed to choose sites for nesting based on gross values of habitat quality (e.g., habitat structure or foraging opportunities). These values of habitat quality are defined largely on the general types and maturity of vegetation (graminoid, shrubby, treed) present. The broad habitat types assessed included:

- black spruce forests,
- deciduous forests,
- fens,
- jackpine forests,
- mixedwood forests,
- riparian shrub; and
- white spruce forests.

The number of call points per habitat type is shown in Table H2-1. The number of plots per category ranges from 11 in riparian shrub to 61 in black spruce forests.

Table H2-1: Breeding Bird Survey Points by Study Area

Habitat	BlackGold	Newmont 2006	Total Samples by Habitat
Black Spruce	4	57	61
Deciduous	6	26	32
Fen	6	31	37
Jackpine	3	28	31
Mixedwood	5	39	44
White Spruce	3	40	43
Riparian	1	11	11

A summary (cross tabulation) of bird species by broad habitat types is shown in Table H2-2. Also shown is the relative commonness of occurrence in each habitat, in three classes (infrequent, uncommon, and common).

Table H2-2: Breeding Bird Species by Broad Habitat Classes

Family	Common Name	Black Spruce	Deciduous	Fen	Jackpine	Mixedwood	Riparian	White Spruce
Blackbirds	Rusty Blackbird			*				
Corvids	Common Raven	*		*	*		x	*
Corvids	Gray Jay	x	*	x	x	*	x	x
Doves	Mourning Dove			*				
Gamebirds	Ruffed Grouse					*		*
Marsh/Shore	Greater Yellowlegs	*		x				
Marsh/Shore	Lesser Yellowlegs			*				
Marsh/Shore	Solitary Sandpiper	x		x	*	*	*	*
Marsh/Shore	Wilson's Snipe	x	*	x	x	*	x	
Songbirds	Alder Flycatcher	*	*	x	*	*	**X**	*
Songbirds	American Redstart		*			*		
Songbirds	American Robin		*					
Songbirds	Bay-breasted Warbler		*			*		*
Songbirds	Black-and-white Warbler		*			*		*
Songbirds	Black-capped Chickadee				x	*		*
Songbirds	Blackpoll Warbler	*		*		*		
Songbirds	Blue-headed Vireo					x		x
Songbirds	Boreal Chickadee	*		*	*	x		x
Songbirds	Brown Creeper		*			*		x
Songbirds	Cape May Warbler					*		*
Songbirds	Cedar Waxwing							*
Songbirds	Chipping Sparrow	**X**	x	**X**	**X**	x	x	x
Songbirds	Clay-colored Sparrow			*				
Songbirds	Common Yellowthroat	*		*			x	*
Songbirds	Connecticut Warbler		*		*	*	*	
Songbirds	Dark-eyed Junco	x	*	x	x	x	x	*
Songbirds	Eastern Phoebe						*	
Songbirds	Golden-crowned Kinglet	*	*		x	*	*	x
Songbirds	Hermit Thrush	x	*	*	x	*	x	*

Family	Common Name	Black Spruce	Deciduous	Fen	Jackpine	Mixedwood	Riparian	White Spruce
Songbirds	House Wren		*					
Songbirds	Le Conte's Sparrow	*		x				
Songbirds	Least Flycatcher					*		
Songbirds	Lincoln's Sparrow	x		x	x		**X**	*
Songbirds	Magnolia Warbler		x			*		*
Songbirds	Mourning Warbler		x					*
Songbirds	Northern Waterthrush						*	*
Songbirds	Olive-sided Flycatcher			*	*			
Songbirds	Orange-crowned Warbler			*				
Songbirds	Ovenbird	*	x		*	x		x
Songbirds	Palm Warbler	x		x	*		*	
Songbirds	Philadelphia Vireo		*			*		
Songbirds	Pine Siskin	x	*	x	x	x		x
Songbirds	Red Crossbill	*						
Songbirds	Red-breasted Nuthatch	*	x			x		*
Songbirds	Red-eyed Vireo		x			*		*
Songbirds	Rose-breasted Grosbeak		*			*		*
Songbirds	Ruby-crowned Kinglet	**X**	x	**X**	**X**	x	x	**X**
Songbirds	Swainson's Thrush	x	x	x	x	x	x	x
Songbirds	Swamp Sparrow	*		x		*	**X**	*
Songbirds	Tennessee Warbler	x	**X**	x	x	**X**	**X**	**X**
Songbirds	Warbling Vireo		*					
Songbirds	Western Tanager					*		*
Songbirds	Western Wood-Pewee			*			*	
Songbirds	White-breasted Nuthatch							*
Songbirds	White-throated Sparrow	*	x	*	x	x	**X**	x
Songbirds	White-winged Crossbill	x	x	x	x	x	*	x
Songbirds	Wilson's Warbler			*				*
Songbirds	Winter Wren	x	*		*	x	x	x
Songbirds	Yellow-bellied Flycatcher	*			x			
Songbirds	Yellow-rumped Warbler	**X**	x	x	**X**	**X**	x	**X**
Swallows	Barn Swallow				*			
Swallows	Tree Swallow			*	*			
Woodpeckers	Black-backed Woodpecker	*						
Woodpeckers	Hairy Woodpecker		*		*	*		
Woodpeckers	Northern Flicker		*		*		x	
Woodpeckers	Pileated Woodpecker			*	*	*		
Woodpeckers	Three-toed Woodpecker			*				*
Woodpeckers	Yellow-bellied Sapsucker		x		*			

* Infrequent <10% of sites, x Uncommon 10-50% of sites, **X** Common >50% of sites

1.2 Total Bird Species Richness

Total richness is the complete number of species among all sample locations for each habitat class. It provides an estimate of alpha richness (richness within a class) but is highly influenced by sample size, since additional species are observed as additional plots are measured up until the entire possible pool of species is observed in each habitat class.

An alternative ranking of total species richness was used to assess whether there was a trend where habitat classes with a greater number of sample plots tend to also have a greater number of total species observations. In this analysis a covariance approach was used to remove this trend from the observations using simple linear regression of total species per habitat class versus number of sample plots. There was no statistical difference observed between the residuals and the actual number of species observed in the habitat classes. Therefore for the purposes of this report, the total species richness is not influenced by the number of plots sampled and is a good measure of richness.

Total species richness for each habitat class is summarized in Table H2-3. Total species richness was ranked, using the following criteria:

- High > 36 species observed
- Medium 33 - 36 species observed
- Low < 32 species observed

Table H2-3: Total Breeding Bird Species Richness by Habitat Class

Habitat	N	Total Species Observed Among Sample Sites	Ranking
Black Spruce	61	30	Low
Deciduous	32	33	Medium
Fen	37	34	Medium
Jackpine	31	31	Low
Mixedwood	44	38	High
Riparian	11	25	Low
White Spruce	43	39	High

Two habitat classes (mixedwood and white spruce) received a high rank for total breeding bird species richness.

1.4 Unique and Sensitive Species Richness

Unique species are those that occur only within a single habitat class. They are considered important species since they are more vulnerable if habitat of a single type is affected by development. A total of 15 species in this study were unique to a single habitat. They included:

- Red Crossbill and Black-backed Woodpecker in Black Spruce;
- American Robin, House Wren and Warbling Vireo in Deciduous;
- Rusty Blackbird, Mourning Dove, Lesser Yellowlegs, Clay-coloured Sparrow and Orange-crowned Warbler in Fens;
- Barn Swallow in Jackpine;
- Least Flycatcher in Mixedwood;

- Eastern Phoebe in Riparian; and
- Cedar waxwing and White-breasted Nuthatch in White Spruce.

Sensitive bird species are typically of concern because of potential impacts from human activities to sensitive populations and their habitats. Sensitive species include:

- those species listed within Alberta as Sensitive or At Risk (ASRD 2005);
- those species listed within Alberta as Species at Risk by Alberta Endangered Species Conservation Committee (ESCC 2007); and
- wildlife identified as species of Special Concern, Threatened, or Endangered under the federal *Species at Risk Act* (Government of Canada 2009) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The bird species recorded in this study were examined and 13 species were found to be sensitive among all 7 habitat classes, including:

- Rusty Blackbird in Fen;
- Bay-breasted Warbler and Brown Creeper in Deciduous, Mixedwood and White Spruce;
- Cape May Warbler and Western Tanager in Mixedwood and White Spruce;
- Common Yellowthroat in Black Spruce, Fen, Riparian and White Spruce;
- Eastern Phoebe in Riparian;
- Least Flycatcher in Mixedwood;
- Olive-sided Flycatcher in Fen and Jackpine;
- Yellow-bellied Flycatcher in Black Spruce and Jackpine;
- Barn Swallow in Jackpine;
- Black-backed Woodpecker in Black Spruce; and
- Pileated Woodpecker in Fen, Jackpine and Mixedwood.

The total unique and sensitive bird species among habitats were used to rank the importance of habitats to maintain species richness (Table H2-4). The ranking was based on the count of all unique and sensitive species by class. Note that species found in both lists were only counted once. They were totalled and ranked, using the following criteria:

- High > 6 species
- Medium 4-6 species
- Low < 4 species

Table H2-4: Unique and Sensitive Breeding Bird Species Richness by Habitat

Habitat	N	Unique Species	Sensitive Species	Total	Ranking
Black Spruce	61	1	3	4	Medium
Deciduous	32	3	1	4	Medium
Fen	37	4	4	8	High
Jackpine	31	0	3	3	Low
Mixedwood	44	0	4	4	Medium
Riparian	11	0	2	2	Low
White Spruce	43	2	5	7	High

Two habitat classes (fen and white spruce) received a high rank for unique and sensitive species.

1.5 Bird Community Similarity

In addition to maintaining a large number of species and unique or sensitive species, different habitats are more or less important due to the number of shared species (or similarity). Communities that share a large number of species with other communities are considered to be less unique, and are less important in terms of maintaining species richness within a defined area. Conversely, communities with fewer shared species are more important for maintaining species richness. Community similarity was assessed and compared by use of the Sorensen similarity index, which compares each bird community (habitat) to each other habitat in a pairwise manner. The index value is computed as:

$$2\,C / (A + B), \quad \text{where:}$$

A = Number of species in the first habitat
B = Number of species in the second habitat
C = Shared species

Index values were computed after first filtering the data to remove infrequent species (i.e., those appearing in < 10% of sample sites for each habitat type). This was done so that the analysis focussed on the most common species that define each community. The index values comparing habitats are shown in table H2-5. Similarity ranged from 0.40 to 0.81 among habitats. The total number of habitats that shared a high number of species with other habitats (Similarity of 0.64 or higher) was totalled and used to rank habitats:

- High 1 habitat with high number of shared species
- Medium 2-3 habitats with high number of shared species
- Low > 3 habitats with a high number of shared species

Table H2-5: Community Similarity Matrix by Habitat

	Black Spruce	Deciduous	Fen	Jackpine	Mixedwood	Riparian	White Spruce	Habitats with High Shared Species and Rank
Black Spruce	1.00	0.43	0.81	0.77	0.67	0.69	0.60	4 - Low
Deciduous	0.43	1.00	0.40	0.48	0.64	0.40	0.57	1 - High
Fen	0.81	0.40	1.00	0.67	0.56	0.65	0.50	3 - Medium
Jackpine	0.77	0.48	0.67	1.00	0.65	0.67	0.65	5 - Low
Mixedwood	0.67	0.64	0.56	0.65	1.00	0.56	0.80	5 - Low
Riparian	0.69	0.40	0.65	0.67	0.56	1.00	0.50	3 - Medium
White Spruce	0.60	0.57	0.50	0.65	0.80	0.50	1.00	2 - Medium

Deciduous forests received a high rank for community similarity (i.e. they were not similar to other habitat classes).

1.6 Overall Ranking of Breeding Bird Species Richness

Overall Breeding Bird richness was ranked from low to high based on a combination of the three rankings for total species richness, unique/sensitive species richness and community similarity (Table H2-6). The ranking was determined by first converting each component rank to a numerical score. In this ranking the scores given were: low: 1, medium: 2, and high: 3. The total of these values was determined and re-ranked into an overall score based on the following criteria:

- High overall richness score > 7
- Medium overall richness score 5-7
- Low overall richness score < 5

Table H2-6: Breeding Bird Richness Summary Ranking by Habitat

Habitat	Species Richness	Unique and Sensitive Richness	Community Similarity	Score	Overall Breeding Bird Richness
Black Spruce	Low	Medium	Low	4	Low
Deciduous	Medium	Medium	High	7	Medium
Fen	Medium	High	Medium	7	Medium
Jackpine	Low	Low	Low	3	Low
Mixedwood	High	Medium	Low	6	Medium
Riparian	Low	Low	Medium	4	Low
White Spruce	High	High	Medium	8	High

The majority of habitat classes have a medium overall rank for breeding bird richness. White Spruce forests received a high overall rank.

The broad habitat type rankings were then assigned to Alberta Boreal Mixedwood ecosite phases, so that the area of each class in the TLSA could be determined in the baseline assessment (Table H2-7). The exception was riparian shrub which does not correspond to a single ecosite phase.

Table H2-7: Breeding Bird Richness Summary Ranking by Ecosite Phase

Dominant Habitats	Ecosite Phase	Overstory Species	Overall Breeding Bird Richness
Jack Pine	a1	Jack pine	Low
	c1	Jack pine and black spruce	Low
Deciduous	b2	Aspen and birch	Medium
	d1	Aspen	Medium
	e1	Balsam poplar and aspen	Medium
	f1	Balsam poplar and aspen	Medium
Mixedwood	b1	Jack Pine and aspen	Medium
	b3	Aspen and spruce	Medium
	d2	Aspen and white spruce	Medium
	e2	Balsam poplar and white spruce	Medium
White Spruce	b4	Jack pine and white spruce	High
	d3	White spruce	High
	e3	White spruce	High
	f3	White Spruce	High
	h1	White spruce and black spruce	High
Black Spruce	g1	Black spruce and Jack pine	Low
	i2	Shrubby black spruce	Low
	j1	Black spruce	Low
	j2	Shrubby black spruce	Low
Fen	k1	Fen with scattered trees	Medium
	k2	Shrubby fen	Medium
	k3	Graminoid fen	Medium
	l1	Marsh	Medium

2.0 LITERATURE CITED

ASRD (Alberta Sustainable Resource Development). 2005. The 2005 General Status of Alberta Wild Species. Available at website: http://www.srd.gov.ab.ca/fw/wildspecies/index.htm

ESCC (Endangered Species Conservation Committee). 2007. Species assessed by Alberta's Endangered Species Conservation Committee. Available at website: http://www.srd.gov.ab.ca/fishwildlife/escc/speciesassessed.aspx

Government of Canada. 2009. Species at Risk Public Registry (SARA). Available at: http://www.sararegistry.gc.ca

Newmont (Newmont Mining Corporation of Canada Limited). 2006. Baseline Wildlife Report - BlackGold Project. Report prepared by Ursus Ecosystem Management Ltd. March 2006.