Appendix C: Wildlife Habitat Suitability Models

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1.0 APPROACH

1.1 General Overview

Habitat suitability modelling, as defined by RIC (1999), is an expert opinion-based modelling process whereby knowledgeable biologists and/or species experts assign ratings to mapped ecological or habitat units for species of interest based on a comprehensive review of relevant literature and site-specific field data (if available). Suitability ratings reflect the relative importance or value of habitat units to wildlife populations and are based on the potential or anticipated use of habitats (RIC 1999, Muir *et al*., 2011). A number of factors other than habitat quality can also affect habitat use, such as predation, disease and social interactions (RIC, 1999), but these were not considered when assigning ratings because of the lack of information on how these factors may affect wildlife in a study area. Although this is an acknowledged limitation of the modelling process, habitat suitability ratings are considered a useful tool for analyzing habitat values for wildlife (RIC, 1999).

The modelling process involves the development of species accounts and species-specific ratings tables. The species account summarizes known information on the status, ecology, habitat requirements, life requisites (defined as the life history elements necessary for reproduction and survival) and seasonal use patterns of a wildlife species in a given area (RIC, 1999). The information on species ecology and habitat requirements is then used to rate the anticipated use (*i.e.*, relative importance) of habitat units, based on the structure and composition of these units (*e.g.*, % canopy cover, shrub composition). Habitat may be rated for only one or a few selected life requisite(s) (*e.g.* foraging habitat) and/or for certain seasons (*e.g.*, winter). The relationships between habitat suitability and habitat structure and/or composition for selected life requisites are summarized in detailed modelling assumptions that describe ratings rules and procedures. These assumptions are a key component of the model and allow for critical evaluation of model mechanics.

With the exception of grizzly bear, habitat suitability models were developed for all VCs, and are described in the sections that follow. Habitat suitability for grizzly bears in the WLSA and GBRSA was analyzed using the model developed by the Foothills Research Institute Grizzly Bear Program (Stenhouse and Graham, 2013, 2014). The grizzly bear model consists of GIS layers that describe aspects of the landscape related to grizzly bear habitat quality. The layers were derived from Landsat satellite imagery with a 30-m resolution. The grizzly bear model can be used to examine the proportion of habitat in a study area that serves as a grizzly bear population source vs the proportion that serves as a population sink. This metric can be used as a baseline measure of overall habitat quality.

1.2 Habitat Suitability Ratings

For the Grassy Mountain Coal Project, ratings were applied to ecosite phases using 4 or 6-class rating schemes (Tables C1.1-1 and C1.1-2), depending on the level of information available for a species (RIC, 1999). For example, for a species with a moderate level of information available, a 4-class scheme was used, and ecosite phases were rated as having nil, low, moderate, or high habitat suitability. The ratings were summarized in a ratings table, and displayed graphically on a terrestrial ecosystem map using geographic information system (GIS) software. As discussed below, ratings adjustments are incorporated into the species models using GIS to account for disturbance factors and the spatial arrangement of habitats to more accurately reflect habitat availability at a given time and Project phase. Once adjustments were incorporated, the area of suitable habitat for a given life requisite and season of use were calculated and summarized, providing information on habitat availability at baseline or for various Project phases such as construction, operations, and reclamation. A four-class rating scheme was used for the Columbia spotted frog, western toad, olive-sided flycatcher, great gray owl, and little brown myotis models while a six-class rating scheme was used for the American marten, Canada lynx, elk and moose models.

Table C1.1-1 Habitat Suitability Ratings for the Four-Class Rating Scheme

Rating	Code	Description
High	1	Habitat provides a critical and limiting resource for a species and is critical to the viability of the population.
Moderate	2	Habitat provides a critical and limiting resource for a species but is not as high in quality as “High” rated habitat. Alternatively, it provides an important resource that is not as limited as that provided by habitat rated as “High”.
Low	3	Habitat is used by a species but does not provide a limiting resource or it provides a small amount of a limiting resource.
Nil	4	A species rarely uses or avoids this habitat type.

Table C1.1-2 Habitat Suitability Ratings for the Six-Class Rating Scheme

Rating	Code	Description
High	1	Habitat provides a critical and limiting resource for a species.
Moderate-High	2	Habitat provides a critical and limiting resource for a species but is not as high in quality as “Highly” rated habitat. It can contribute to the viability of the population.

Table C1.1-2 Habitat Suitability Ratings for the Six-Class Rating Scheme		
Moderate	3	Habitat is used by a species, but is not a limiting resource, or it provides a limiting resource but is sub-optimal in comparison to habitats rated as "High" or "Moderate-High".
Moderate-Low	4	Habitat is used but is not a limiting resource for a species. It may be used for travel or resting, or it may provide a small amount of a required resource (such as food).
Low	5	Habitat is rarely used by a species, and may only be occasionally used for travel or resting.
Nil	6	A species rarely uses or avoids this habitat type.

The ratings for wildlife VCs were assigned to each ecosite phase, non-forested habitat type, and disturbance type present in the WLSA (Tables C1.1-3 and C1.1-4). Similarly, habitat suitability ratings were also assigned for each ELC cover type present in the WRSA but only for wildlife VCs with home ranges larger than the WLSA (Table C1.1-5). These wildlife VCs include elk, moose, and Canada lynx

Forest stand age can be an important factor in determining habitat use for many wildlife species, particularly mature and old growth forest dependent species such as great gray owl, little brown myotis, and American marten. For this reason, the following forest age classes (CR #8 – Vegetation & Wetlands) were incorporated into these three species habitat suitability models:

- **Young Forests –** Deciduous and mixedwood forests (30 – 60 years old) and coniferous forests (31 – 70 years old).
- **Mature Forests –** Deciduous and mixedwood forests (61 – 99 years old), pine forests (71 - 119 years old), and coniferous forests (71 – 139 years old).
- **Old-growth Forests –** Deciduous and mixedwood forests (≥100 years old), pine forests (≥120 years old), and coniferous forests (≥140 years old).

Table C1.1-3 Habitat Suitability Ratings Used to Assess Project Effects on Amphibian and Avian Valued Components in the Wildlife Local Study Area

Ecosite Phase	Natural Subregion	Columbia Spotted Frog	Western Toad	Olive-sided Flycatcher		Great Grey Owl		
				≤100 m from "Edge"	>100 m from "Edge"	Old Forest	Mature Forest	Young Forest
a1	Montane	4	4	1	2	2	3	4
b1	Montane	4	4	1	2	2	3	4
b2	Montane	4	4	4	4	2	3	4

Table C1.1-3 Habitat Suitability Ratings Used to Assess Project Effects on Amphibian and Avian Valued Components in the Wildlife Local Study Area

Ecosite Phase	Natural Subregion	Columbia Spotted Frog	Western Toad	Olive-sided Flycatcher		Great Grey Owl		
				≤100 m from "Edge"	>100 m from "Edge"	Old Forest	Mature Forest	Young Forest
b3	Montane	4	4	2	3	2	3	4
c1	Montane	4	4	1	2	2	3	4
c2	Montane	4	4	1	2	2	3	4
c3	Montane	4	4	4	4	2	3	4
c4	Montane	4	4	2	3	2	3	4
d1	Montane	4	4	2	3	1	2	4
d2	Montane	4	4	2	3	1	2	4
d3	Montane	4	4	2	3	1	2	4
e1	Montane	4	4	2	3	1	2	4
e2	Montane	4	3	2	3	1	2	4
e3	Montane	4	3	2	3	1	2	4
f1	Montane	3	2	4	4	1	2	4
g1	Montane	3	2	2	3	1	2	4
g2	Montane	3	2	2	3	1	2	4
a1	Subalpine	4	4	1	2	2	3	4
b1	Subalpine	4	4	1	2	2	3	4
d1	Subalpine	4	4	1	2	1	2	4
e1	Subalpine	4	3	1	2	1	2	4
e2	Subalpine	4	3	1	2	1	2	4
e3	Subalpine	4	3	1	2	1	2	4
e4	Subalpine	4	3	1	2	1	2	4
f1	Subalpine	3	3	2	3	1	2	4
f2	Subalpine	3	3	2	3	1	2	4
h1	Subalpine	3	2	2	3	1	2	4
FONS	-	1	1	3	3	2	2	2

Table C1.1-3 Habitat Suitability Ratings Used to Assess Project Effects on Amphibian and Avian Valued Components in the Wildlife Local Study Area

Ecosite Phase	Natural Subregion	Columbia Spotted Frog	Western Toad	Olive-sided Flycatcher		Great Grey Owl		
				≤100 m from "Edge"	>100 m from "Edge"	Old Forest	Mature Forest	Young Forest
STNN	-	2	2	1	2	2	2	4
NWL	-	1	1	4	4	3	3	4
NWR	-	2	2	4	4	3	3	4
NWF	-	1	1	4	4	3	3	4
NMR	-	4	4	4	4	4	4	4
HG	-	4	4	4	4	2	2	2
SC	-	4	3	3	3	3	3	3
SO	-	4	4	3	3	2	2	2
CL	-	4	4	3	3	2	2	2
CO	-	4	4	3	3	2	2	2
CC	-	4	4	3	3	2	2	2
CP	-	4	4	4	4	2	2	2
CIP	-	4	4	4	4	2	2	2
CIW	-	4	4	4	4	2	2	2
ASC	-	4	4	4	4	4	4	4
AIH	-	4	4	4	4	3	3	3
AIM	-	4	4	4	4	4	4	4
AII	-	4	4	4	4	4	4	4

Table C1.1-4 Habitat Suitability Ratings Used to Assess Project Effects on Mammalian Valued Components in the Wildlife Local Study Area

Ecosite Phase	Natural Subregion	Little Brown Myotis		American Marten		Canada Lynx		Elk		Moose
		Mature/ Old Forest	Young Forest	Mature/ Old Forest	Young Forest	Young/ Mature Forest	Old Forest	Winter	Summer	
a1	Montane	3	4	3	4	5	5	2	2	5
b1	Montane	3	4	3	4	5	5	3	4	5
b2	Montane	1	4	4	5	5	5	2	4	1
b3	Montane	2	4	3	4	5	5	2	4	3
c1	Montane	3	4	1	3	4	5	4	5	4
c2	Montane	3	4	2	3	4	5	4	5	4
c3	Montane	1	4	4	5	5	5	3	3	1
c4	Montane	2	4	3	4	4	5	3	3	2
d1	Montane	2	4	3	4	3	4	4	5	3
d2	Montane	2	4	3	4	3	4	4	5	2
d3	Montane	3	4	1	3	3	4	3	4	3
e1	Montane	3	4	2	3	2	3	3	4	3
e2	Montane	2	4	3	4	4	5	3	3	1
e3	Montane	2	4	3	4	2	3	4	5	2
f1	Montane	2	4	4	5	4	5	3	3	1
g1	Montane	2	4	3	4	4	5	3	4	2
g2	Montane	2	4	1	3	3	4	3	4	3
a1	Subalpine	3	4	2	4	5	5	3	2	5
b1	Subalpine	3	4	2	4	5	5	4	4	5
d1	Subalpine	3	4	1	3	4	5	5	5	5
e1	Subalpine	3	4	2	4	2	3	5	4	5
e2	Subalpine	3	4	1	3	2	3	5	4	5
e3	Subalpine	3	4	1	3	2	3	5	4	5
e4	Subalpine	3	4	1	3	2	3	5	4	5

Table C1.1-4 Habitat Suitability Ratings Used to Assess Project Effects on Mammalian Valued Components in the Wildlife Local Study Area

Ecosite Phase	Natural Subregion	Little Brown Myotis		American Marten		Canada Lynx		Elk		Moose
		Mature/ Old Forest	Young Forest	Mature/ Old Forest	Young Forest	Young/ Mature Forest	Old Forest	Winter	Summer	
f1	Subalpine	3	4	1	3	1	2	5	4	5
f2	Subalpine	3	4	1	3	1	2	5	4	5
h1	Subalpine	4	4	1	3	4	5	5	4	5
FONS	-	4	4	3	5	5	5	5	3	2
STNN	-	3	4	3	4	5	5	5	5	2
NWL	-	4	4	6	6	6	6	6	6	6
NWR	-	4	4	6	6	6	6	6	6	6
NWF	-	4	4	6	6	6	6	6	6	6
NMR	-	4	4	6	6	6	6	6	6	6
HG	-	4	4	6	6	6	6	1	6	4
SC	-	4	4	5	5	6	6	2	6	1
SO	-	4	4	5	5	6	6	2	6	1
CL	-	3	3	5	5	6	6	2	6	3
CO	-	3	3	5	5	6	6	2	6	3
CC	-	4	4	5	5	6	6	2	6	1
CP	-	4	4	6	6	6	6	2	6	6
CIP	-	4	4	6	6	6	6	6	6	5
CIW	-	4	4	6	6	6	6	6	6	5
ASC	-	4	4	6	6	6	6	6	6	6
AIH	-	4	4	6	6	6	6	6	6	6
AIM	-	4	4	6	6	6	6	6	6	6
AII	-	4	4	6	6	6	6	6	6	6

Table C1.1-5 Habitat Suitability Ratings Used to Assess Project Effects on Wildlife Valued Components in the Wildlife Regional Study Area

ELC Land Cover Class	Olive-sided Flycatcher	Little Brown Myotis	Canada Lynx	American Marten	Elk		Moose	
					Montane/ Foothills Fescue	Subalpine	Montane/ Foothills Fescue	Subalpine
Barren Land	4	4	6	6	6/6	6	6/6	6
Open_Regen_Herb	4	4	6	5	1/2[2]	2/3[1]	1/2[2]	2/3[1]
Open_Regen_Shrub	4	4	5	5	1/2[2]	2/3[1]	1/2[2]	2/3[1]
Open_Regen_Treed	3	4	5	5	1/2[2]	2/3[1]	1/2[2]	2/3[1]
Open_Broadleaf_Young Forest	4	4	4	5	1/2[2]	-	1/2[2]	-
Open_Broadleaf_Mature Forest	4	1	4	4	1/2[2]	-	1/2[2]	-
Open_Broadleaf_Old Forest	4	1	4	4	1/2[2]	-	1/2[2]	-
Open_Mixed_Young Forest	2/3[1]	4	4	5	2/3[2]	-	2/3[2]	-
Open_Mixed_Mature Forest	2/3[1]	2	4	4	2/3[2]	-	2/3[2]	-
Open_Mixed_Old Forest	2/3[1]	2	4	4	2/3[2]	-	2/3[2]	-
Open_Conifer_Young Forest	1/2[1]	4	4	4	3	4	3	4
Open_Conifer_Mature Forest	1/2[1]	3	4	3	3	4	3	4
Open_Conifer_Old Forest	1/2[1]	3	4	3	3	4	3	45
Moderate_Broadleaf_Young Forest	4	4	4	5	2 /3[2]	-	2/3[2]	-
Moderate_Broadleaf_Mature Forest	4	1	4	4	2 /3[2]	-	2/3[2]	-
Moderate_Broadleaf_Old Forest	4	1	4	4	2 /3[2]	-	2/3[2]	-

Table C1.1-5 Habitat Suitability Ratings Used to Assess Project Effects on Wildlife Valued Components in the Wildlife Regional Study Area

ELC Land Cover Class	Olive-sided Flycatcher	Little Brown Myotis	Canada Lynx	American Marten	Elk		Moose	
					Montane/ Foothills Fescue	Subalpine	Montane/ Foothills Fescue	Subalpine
Moderate_Mixed_Young Forest	2/3[1]	4	4	5	3	-	3	-
Moderate_Mixed_Mature Forest	2/3[1]	2	4	4	3	-	3	-
Moderate_Mixed_Old Forest	2/3[1]	2	4	4	3	-	3	-
Moderate_Conifer_Young Forest	1/2[1]	4	2	4	3/4[3]	5	4	5
Moderate_Conifer_Mature Forest	1/2[1]	3	2	3	3/4[3]	5	4	5
Moderate_Conifer_Old Forest	1/2[1]	3	2	3	3/4[3]	5	4	5
Closed_Broadleaf_Young Forest	4	4	4	5	4	-	4	-
Closed_Broadleaf_Mature Forest	4	1	4	4	4	-	4	-
Closed_Broadleaf_Old Forest	4	1	4	4	4	-	4	-
Closed_Mixed_Young Forest	3/4[1]	4	3	4	5	-	5	-
Closed_Mixed_Mature Forest	3/4[1]	2	3	3	5	-	5	-
Closed_Mixed_Old Forest	3/4[1]	2	3	3	5	-	5	-
Closed_Conifer_Young Forest	2/3[1]	4	1	2	3/4[3]	4/5[2]	5	6
Closed_Conifer_Mature Forest	2/3[1]	3	1	1	3/4[3]	4/5[2]	3	4
Closed_Conifer_Old Forest	2/3[1]	3	2	1	3/4[3]	4/5[2]	3	4
Dense_Broadleaf_Young Forest	4	4	3	5	4	5	4	5

Table C1.1-5 Habitat Suitability Ratings Used to Assess Project Effects on Wildlife Valued Components in the Wildlife Regional Study Area

ELC Land Cover Class	Olive-sided Flycatcher	Little Brown Myotis	Canada Lynx	American Marten	Elk		Moose	
					Montane/ Foothills Fescue	Subalpine	Montane/ Foothills Fescue	Subalpine
Dense_Broadleaf_Mature Forest	4	1	3	4	4	-	4	-
Dense_Broadleaf_Old Forest	4	1	3	4	4	-	4	-
Dense_Mixed_Young Forest	3/4[1]	4	3	4	5	-	5	-
Dense_Mixed_Mature Forest	3/4[1]	2	3	3	5	-	5	-
Dense_Mixed_Old Forest	3/4[1]	2	3	3	5	-	5	-
Dense_Conifer_Young Forest	2/3[1]	4	1	2	3/4[3]	4/5[2]	5	6
Dense_Conifer_Mature Forest	2/3[1]	3	1	1	3/4[3]	4/5[2]	3	4
Dense_Conifer_Old_Forest	2/3[1]	3	1	1	3/4[3]	4/5[2]	3	4
Undifferentiated Conifer	2/3[1]	3	3	3	5	6	5	6
Natural Shrubby	4	4	5	5	1	2	1/2[2]	2/3[1]
Natural Upland Herb	4	4	6	6	1	2	1/2[2]	2/3[1]
Natural Graminoid Wetland	4	4	6	6	6	6	5	5
Natural Shrubby Wetland	4	4	5	5	6	6	2	2
Treed Wetland	1	3	5	4	6	6	4	4
Industrial (*e.g.* mining)	4	4	6	6	6	6	6	6
Settlement	4	4	6	6	6	6	6	6

Table C1.1-5 Habitat Suitability Ratings Used to Assess Project Effects on Wildlife Valued Components in the Wildlife Regional Study Area

ELC Land Cover Class	Olive-sided Flycatcher	Little Brown Myotis	Canada Lynx	American Marten	Elk		Moose	
					Montane/ Foothills Fescue	Subalpine	Montane/ Foothills Fescue	Subalpine
Open Water	4	4	6	6	6	6	3 [4]	3 [4]
Linear Anthropogenic Disturbance	4	4	6	6	6	6	3	3
Agriculture	4	4	6	6	1/2[3]	1/2	6	6
Cut Block	4	4	6	5	2	3	2	3

[1] The higher number will apply when the habitat is within 100 m of a wetland or non-forested area.

[2] The higher number will apply when this habitat type is within 300 m of high-quality thermal cover (moderate, closed, or dense coniferous forests).

[3] The higher number will apply when this habitat type is within 200 m of high-quality foraging habitat.

[4] A 100-m buffer was placed around the feature; habitat within the buffer was rated a "3". The feature itself was rated a "6".

1.3 Model Adjustments

A ZOI ("Zone of Influence," or sensory disturbance zone) was used to refine habitat suitability models for the selected wildlife VCs. Although habitat may be suitable for a given wildlife species, actual use may be limited or precluded because of other factors, such as human disturbance (*e.g*. noise, movement barriers, *etc*.) or fires. Typically, habitats close to intensive land use activities have lower habitat effectiveness than comparable habitats in remote settings. To incorporate reduced habitat effectiveness as a result of sensory disturbance into each species habitat model, a sensory disturbance zone was defined for each type of human disturbance identified in the WLSA or WRSA, and a disturbance coefficient (*i.e.* reduction factor) was applied to the habitat suitability ratings within the sensory disturbance zone. Noise levels and levels of human use in relation to a specific disturbance feature were subjectively rated based on high, moderate, low and nil categories while the frequency of disturbance was rated using constant, intermittent, and nil categories. The disturbance coefficient was used to reduce the rated suitability of the ecosite phase within a ZOI of a disturbance by one or two habitat classes as described by either the 4 class or 6 class rating scheme. The sensory disturbance buffers and disturbance coefficients vary by wildlife VC.

1.4 Specific Methodology

Species accounts detailed enough to provide the necessary information for rating habitats in the WLSA, WRSA, and GBRSA were prepared for each wildlife VC. ZOIs and corresponding disturbance coefficients were based on a combination of a review of existing information from similar projects and species specific literature, field survey data, and individuals knowledgeable of species habitat requirements. Disturbance coefficients were applied to ZOIs where appropriate (Tables C1.3-1 and C1.3-2) and final ratings were calculated for each polygon. The total area of each habitat suitability class was calculated and presented in tabular form, while maps depicting the spatial distribution of the habitat suitability classes for wildlife VCs at the WLSA and WRSA scales were also produced.

Table C1.3-1 Disturbance Zones of Influence (m) and Disturbance Coefficients for Amphibian and Avian Wildlife Valued Components

Disturbance Features	Noise Level	Frequency	Level of Human Use	Columbia Spotted Frog		Western Toad		Olive-sided Flycatcher		Great Gray Owl	
				ZOI	Coef	ZOI	Coef	ZOI	Coef	ZOI	Coef
Baseline:											
Active Railways	Moderate	Intermittent	Low	0-100	1	0-100	1	0-150	1	0-150	1
Highway 3	High	Constant	High	0-200	1	0-200	1	0-150	1	0-150	1
Roads (gravel, unimproved)	Moderate	Intermittent	Moderate	0-50	1	-	-	0-50	1	0-50	1
Vegetated Trails	Low	Intermittent	Low	-	-	-	-	-	-	-	-
Transmission Lines	Nil	Nil	Nil	-	-	-	-	-	-	-	-
Seismic Lines	Nil	Nil	Nil	-	-	-	-	-	-	-	-
Pipelines	Nil	Nil	Nil	-	-	-	-	-	-	-	-
Inactive Well Sites	Nil	Nil	Nil	-	-	-	-	-	-	-	-
Active Well Sites	Low	Intermittent	Low	-	-	-	-	-	-	-	-
Industrial Facilities	Moderate	Intermittent	Moderate	-	-	-	-	0-50	1	0-50	1
Rural Residences	Low	Intermittent	High	-	-	-	-	-	-	0-50	1
Inactive Coal Mine	Nil	Nil	Nil	-	-	-	-	-	-	-	-
Urban Areas	Moderate	Constant	High	0-100	1	0-100	1	0-100	1	0-100	1
Cutblocks	Nil	Nil	Low	-	-	-	-	-	-	-	-
Other Clearings	Nil	Nil	Low	-	-	-	-	-	-	-	-

Table C1.3-1 Disturbance Zones of Influence (m) and Disturbance Coefficients for Amphibian and Avian Wildlife Valued Components

Disturbance Features	Noise Level	Frequency	Level of Human Use	Columbia Spotted Frog		Western Toad		Olive-sided Flycatcher		Great Gray Owl	
				ZOI	Coef	ZOI	Coef	ZOI	Coef	ZOI	Coef
Project Foot Print:											
Coal Conveyor	High	Constant	Low	0-100	1	0-100	1	0-150	1	0-150	1
Coal Processing Facilities	Moderate	Constant	High	0-100	1	0-100	1	0-100	1	0-150	1
Active Coal Mine Site	Moderate	Constant	High	0-100	1	0-100	1	0-150	1	0-150	1
Pit/Waste Rock - South	Moderate	Constant	Moderate	0-100	1	0-100	1	0-100	1	0-150	1
Pit/Waste Rock – North	Moderate	Constant	Moderate	0-100	1	0-100	1	0-100	1	0-150	1
Settling Ponds	Nil	Nil	Low	-	-	-	-	-	-	-	-
Drainage Ditch Systems	Nil	Nil	Low	-	-	-	-	-	-	-	-
Coal Rail Loop	High	Constant	Moderate	0-100	1	0-100	1	0-150	1	0-150	1
Power Lines	Nil	Nil	Nil	-	-	-	-	-	-	-	-

Table C1.3-2 Disturbance Zones of Influence (m) and Disturbance Coefficients for Mammalian Wildlife Valued Components

Disturbance Features	Noise Level	Frequency	Level of Human Use	Little Brown Myotis		American Marten		Canada Lynx		Elk		Moose	
				ZOI	Coef	ZOI	Coef	ZOI	Coef	ZOI	Coef	ZOI	Coef
Baseline:													
Active Railways	High	Intermittent	Low	0-100	1	0-100	1	0-150	1	0-200	1	0-100	1
Highway 3	High	Constant	High	0-100	1	0-150	1	0-150	1	0-300	1	0-150	1
Roads (gravel, unimproved)	Moderate	Intermittent	Moderate	0-100	1	0-100	1	0-100	1	0-100	1	0-100	1
Vegetated Trails	Low	Intermittent	Low	-	-	-	-	-	-	-	-	-	-
Transmission Lines	Nil	Nil	Nil	-	-	-	-	-	-	0-200	1	-	-
Seismic Lines	Nil	Nil	Nil	-	-	-	-	-	-	-	-	-	-
Pipelines	Nil	Nil	Nil	-	-	-	-	-	-	-	-	-	-
Inactive Well Sites	Nil	Nil	Nil	-	-	-	-	-	-	-	-	-	-
Active Well Sites	Low	Intermittent	Low	-	-	-	-	0	1	0-100	1	0-100	1
Industrial Facilities	Moderate	Intermittent	Moderate	-	-	0-100	1	0-100	1	0-250	1	0-100	1
Rural Residences	Low	Intermittent	High	-	-	0-100	1	0-30	1	0-250	1	0-100	1
Inactive Coal Mine	Nil	Nil	Nil	-	-	-	-	-	-	-	-	-	-
Urban Areas	Moderate	Constant	High	-	-	0-100	1	0-100	1	0-250	1	0-100	1
Cutblocks	Nil	Nil	Low	-	-	-	-	-	-	-	-	-	-
Other Clearings	Nil	Nil	Low	-	-	-	-	-	-	-	-	-	-

Table C1.3-2 Disturbance Zones of Influence (m) and Disturbance Coefficients for Mammalian Wildlife Valued Components

Disturbance Features	Noise Level	Frequency	Level of Human Use	Little Brown Myotis		American Marten		Canada Lynx		Elk		Moose	
				ZOI	Coef	ZOI	Coef	ZOI	Coef	ZOI	Coef	ZOI	Coef
Project Foot Print:													
Coal Conveyor	High	Constant	Low	0-300	1	0-150	1	0-150	1	0-100	1	0-100	1
Coal Processing Facilities	Moderate	Constant	High	0-100	1	0-100	1	0-100	1	0-100	1	0-100	1
Active Coal Mine Site	Moderate	Constant	High	0-300	1	0-150	1	0-150	1	0-500	1	0-150	1
Pit/Waste Rock - South	Moderate	Constant	Moderate	-	-	0-150	1	0-150	1	0-250	1	0-100	1
Pit/Waste Rock – North	Moderate	Constant	Moderate	-	-	0-150	1	0-150	1	0-250	1	0-100	1
Settling Ponds	Nil	Nil	Low	-	-	-	-	-	-	-	-	-	-
Drainage Ditch Systems	Nil	Nil	Low	-	-	-	-	-	-	-	-	-	-
Coal Rail Loop	High	Constant	Moderate	0-300	1	0-150	1	0-150	1	0-100	1	0-100	1
Power Lines	Nil	Nil	Nil	-	-	-	-	-	-	0-200	1	-	-

2.0 VALUED COMPONENT SPECIES ACCOUNTS AND MODELS

2.1 Columbia Spotted Frog

Scientific Name: *Rana luteiventris* (formerly *Rana pretiosa luteiventris*).

Status: General Provincial Status: "*Sensitive*", COSEWIC: "*Not At Risk*", SARA Status: "*Not Listed*".

2.1.1 Distribution and Abundance

In Alberta, the Columbia spotted frog occurs in montane and subalpine areas from Waterton Lakes National Park north to Jasper National Park (James, 1998). They are typically found at elevations ranging from 995 to 2,150 m (Russell and Bauer, 2000). Populations in Alberta are discontinuous, and most populations are concentrated in the Waterton/Crowsnest Pass area, Kananaskis Country, the Banff/Bow Valley area and Jasper National Park (James, 1998). Outside of Alberta, Columbia spotted frogs occur from the extreme southern Yukon and southeastern Alaska, south through most of British Columbia, Washington, Oregon, Idaho, Montana and Wyoming (Russell and Bauer, 2000). There are also isolated populations in Nevada and Utah (Russell and Bauer, 2000).

2.1.2 Ecology and Key Habitat Requirements

Columbia spotted frogs breed in cool, slow-moving or still water bodies. These can include slow streams, slow rivers, marshes, springs, pools, beaver ponds, alluvial fans, and the margins of small lakes (James, 1998). They frequently breed in the same water bodies as long-toed salamanders (James, 1998). Several studies on habitat selection in Columbia spotted frogs indicate that they generally select breeding ponds with emergent vegetation present (Davis and Verrell, 2005; Welch and MacMahon, 2005; Pearl *et al*., 2007; Bartelt *et al*., 2011), although they may breed in water bodies with little emergent vegetation (James, 1998).

Columbia spotted frogs will breed in ponds with varying hydro periods and the relative importance of permanent vs. ephemeral ponds to populations varies depending on latitude, elevation, and annual precipitation levels (McCaffery *et al*., 2014). In some cases, small or temporary waterbodies represent prime breeding habitat for Columbia spotted frogs and other amphibians because such waterbodies typically lack predatory fish (Bartelt *et al*., 2011). However, temporary waterbodies must persist long enough for larvae to fully metamorphose before winter; therefore, recruitment from temporary waterbodies can be limited during dry, warm years (McCaffery *et al*., 2014).

Columbia spotted frogs will frequently lay eggs in exposed waterbodies (Bartelt *et al*., 2011), as eggs that are exposed to higher levels of solar radiation will develop more quickly. In lakes, eggs are typically laid along the perimeter where the water is shallow and where more emergent vegetation is present (Davis and Verrell, 2005; Pearl *et al*., 2007). Goldberg and Waits (2009) found that Columbia spotted frog laying sites were most likely to be fishless waterbodies with high solar insolation.

In Alberta, the characteristics of Columbia spotted frog breeding sites are variable. In Peter Lougheed Provincial Park, Columbia spotted frogs laid eggs in water bodies from 1 to 41 cm deep (Williams, 1994). Salt (1979) reported that eggs were found throughout the Alberta Rockies in water bodies from 3 to 30 cm deep. Water temperatures in breeding ponds in Alberta can vary from 11.5 to 23 °C and the pH can vary from 7.8 to 9.1 (Salt, 1979; Williams, 1994).

The timing of breeding in Columbia spotted frogs in Alberta varies with latitude, but they tend to emerge from hibernation and breed as soon as small water bodies start to thaw. Columbia spotted frog eggs have even been found under ice during early spring (Welch and MacMahon, 2005). Male Columbia spotted frogs emerge first from hibernation and establish common calling sites, where they gather and call to attract females (Davis and Verrell, 2005). In Waterton Lakes National Park, they may start calling at the end of April (James, 1998) while Paton (2002) reports that in the Crowsnest Pass area, egg masses were seen on May 16, and by May 28; all had eggs hatched.

Columbia spotted frog eggs may hatch four days to three weeks after being laid with the time to hatching likely temperature dependent (Russell and Bauer, 2000). The larvae typically metamorphose during the first summer, but in more northerly or high elevation sites, larvae may overwinter as tadpoles (Russell and Bauer, 2000).

Although Columbia spotted frogs breed in water and have been described as "highly aquatic" (Russell and Bauer, 2000), they often move among waterbodies and thus require some undisturbed upland habitat (Paton, 2002). Many Columbia spotted frogs use separate habitats for breeding, post-breeding summer foraging, and hibernation. Turner (1960) found that Columbia spotted frogs in Yellowstone National Park undergo two periods of movement (of up to 1,281 m): a move to breeding pools in May and a return to more permanent water sources in July. Adult Columbia spotted frogs are capable of moving distances of 5 – 6 km (Reaser, 1996; Funk *et al*., 2005a), although most move no more than 1 km and males appear to be less mobile than females. Pilliod *et al*. (2002) found that 6 - 11% of males and 16-51% of females moved from their breeding ponds to different summer habitats. Males that moved remained within 200 m of their breeding sites, while females moved up to 1 km.

Juvenile frogs often disperse from their natal ponds, and with the exception of large or very isolated breeding ponds, most populations of Columbia spotted frogs are composed of more than one breeding pond (Funk *et al.*, 2005a). Funk *et al.* (2005b) found that the dispersal of juveniles is an important feature of the life history of Columbia spotted frogs. Dispersing juveniles tended to move longer distances than adults moving among waterbodies, and dispersing juveniles are capable of moving up to 5 km (Funk *et al*., 2005b).

Although Columbia spotted frogs are capable of moving over 1 km, mountain ridges appear to act as major barriers to gene flow in the species (Funk *et al*., 2005a; Murphy *et al*., 2010). However, gene flow can be substantial within mountain valleys.

Columbia spotted frogs tend to travel along streams or upland areas. Pilliod *et al*. (2002) caught most migrating frogs along streams, but they also caught some moving through open forests. Bill and Hayes (2001) also found that Columbia spotted frogs tended to travel along riparian corridors, but found one that travelled over 400 m on relatively dry land. Columbia spotted frogs are most likely to move through dry, upland areas during rain or at night. If a dry upland area provides a short travel route to a good summer habitat or overwintering lake, a frog may take that route over a longer riparian route.

Some adult Columbia frogs stay at their breeding sites all summer, and whether or not a frog moves likely depends on the temperature of the breeding pond, and inter- and intra-specific competition. In a study on radio-tracked Columbia spotted frogs in Yellowstone National Park, Bull and Hayes (2011) found that Columbia spotted frogs were least likely to move from large ponds. Frogs breeding at temporary water bodies within 100 m of permanent sources were most likely to move (Bull and Hayes, 2011). Some frogs moved to waterbodies that would have been unsuitable for breeding, such as rivers with fast flow rates and ponds in piles of mine tailings. The timing of movement varied, with some frogs moving in April or May and others moving in July. Frogs moving in July went to creeks or rivers that were cooler than the breeding ponds.

Columbia spotted frogs may also move back to their breeding ponds prior to winter hibernation (Licht, 1969) or to separate hibernation ponds. Pilliod *et al*. (2002) reported that Columbia spotted frogs at a high-elevation site in Idaho moved to the lakes where they overwintered from late August to September. These lakes were different from the breeding ponds and were much deeper. They had an average surface area of 1.7 ha and an average depth of 8.4 m (Pilliod *et al*., 2002). Columbia spotted frogs often use different sites for breeding and hibernation, because the ponds that make good breeding sites (which are typically small, organically rich ponds) are likely to become anoxic in winter (Pilliod *et al*., 2002).

Age at reproductive maturity varies across populations, depending on their altitude and latitude. At lower elevations, female frogs may breed at age 2 or 3, and they may breed annually (Licht, 1975). At high elevations, females may not breed until age six and may only breed every two or three years (Licht, 1975). Males reach reproductive maturity at age 2 to 4, depending on location.

2.1.3 Response to Disturbance

Columbia spotted frog populations can be vulnerable to a variety of natural and man-made disturbances. They are vulnerable to drought, and a particularly dry year can eliminate small populations (Davis and Verrell, 2005). Climate change may also increase the importance of permanent ponds to Columbia spotted frog populations because with the increased temperatures predicted for the species' range, ephemeral ponds may start to dry up more quickly (McCaffery *et al*., 2014). However, a mild winter may increase survival and reproduction rates (McCaffery and Maxell, 2010).

The presence of introduced, non-native predatory fish can limit amphibian populations. For example, Murphy *et al.* (2010) found that ponds with introduced fish present often functioned as population sinks for Columbia spotted frogs. However, Columbia spotted frogs may be able to persist in waterbodies with fish if there are shallow areas with thick emergent vegetation present that the tadpoles can hide in (Pilliod *et al*., 2010).

Habitat loss can also have negative effects on Columbia spotted frog populations. For example, breeding sites were lost in Banff and Jasper National Park when ditching along the Banff-Jasper highway drained breeding ponds (James, 1998). The loss of habitat can be particularly damaging where it is very limited. Paton (2002) notes that wetlands are limited in the Crowsnest Pass area so even small wetlands can represent critical habitat for amphibian populations. The presence of deep waterbodies for hibernation is also important for Columbia spotted frog populations. Hypoxia, which is more likely in shallow waterbodies, can be a major source of mortality for frogs that overwinter underwater (Bradford, 1983). Columbia spotted frog breeding ponds can also be negatively affected by cattle and horse grazing, trampling, and water contamination from excess nutrients resulting from cattle and horse manure (Patla and Keinath, 2005).

Changes in water quality can negatively affect amphibian populations. In general, high concentrations of soluble salts can inhibit larval development (James, 1998). The use of salt on highways may also decrease the value of nearby wetlands for amphibians (James, 1998).

Human disturbance can also have a negative effect on amphibian populations. During a survey conducted in southwest Alberta, Paton (2002) noted that people had driven ATVs through amphibian breeding ponds, and this often destroyed eggs. One pond with amphibian eggs was found to have no amphibians later after it had been extensively driven through with ATVs.

High-elevation populations of Columbia spotted frogs should be considered more vulnerable to extinction. Such populations tend to have smaller effective population sizes than low elevation populations (Funk *et al*., 2005a). This is likely a result of lower reproductive rates of high-elevation populations (Russell and Bauer, 2000), restricted migration among high elevation populations, and limited dispersal from low- to high-elevation populations (Funk *et al*., 2005a).

Columbia spotted frog populations are able to persist through wildfires. Hossack and Corn (2007) found that spotted frog occupancy rates remained stable through a wildfire in Glacier National Park.

2.1.4 Habitat Suitability Model

2.1.4.1 Model Ratings

Breeding and summer foraging habitats in the WLSA were rated for the Columbia spotted frog. A four-class rating scheme was used to rate ecosite phases (Table C1.1-1), and ratings were based on ecosite phases and moisture regimes (Table C1.1-3).

2.1.4.1.1 Model Assumptions

- Breeding habitat is likely the most limiting resource for Columbia spotted frogs in the WLSA(Paton, 2002), so waterbodies and wetlands were assigned a habitat suitability rating of 1 (“High”). Aside from providing breeding habitat, deeper waterbodies also provide hibernation sites for Columbia spotted frogs. Waterbody size was not considered in the WLSA model because all waterbodies in the WLSA are small.
- Streams and riparian habitats were assigned a habitat suitability rating of 2 (“Moderate”) because Columbia spotted frogs may breed in pools and oxbows. Additionally, they may live near streams during summer, and streams and riparian areas act as important dispersal corridors (Pilliod *et al*., 2002).
- The wettest ecosite phases (montane ecosite phases f1, g1, and g2 and subalpine ecosite phases f1, f2, g1, and h1) can be used as dispersal routes by Columbia spotted frogs. Additionally, seepage can be expected in these ecosite phases, and Columbia spotted frogs are often associated with seeps (James, 1998). Based on this information, these ecosite phases were assigned a habitat suitability rating of 3 (“Low”).
- Dry ecosite phases are generally unsuitable for Columbia spotted frogs even though they may rarely be used during rainy nights, were assigned a habitat suitability rating of 4 (“Nil”).
- Rocky, exposed mountain ridges are avoided by amphibians and were therefore assigned a rating of 4 (“Nil”).
- The majority of Columbia spotted frogs either do not move from their breeding ponds during summer or only move distances of up to 1 km (Pilliod *et al*, 2002). Therefore, all upland habitat greater than 1 km from potential breeding habitat was given a rating of “Nil” (4).

2.1.4.1.2 Ratings Adjustments

Roads and vegetated trails were given a rating of “Nil,” because amphibians crossing roads are frequently killed by cars (Andrews *et al*., 2008) (Table C1.3-1). Additionally, amphibian eggs may be destroyed if an ATV passes through any breeding wetlands or watercourses (Paton, 2002). While there is no information on avoidance distances for Columbia spotted frogs, the effects of roads on habitat use have been studied for other frog species. Goosem *et al*. (2007) found that the densities of the frog *Litoria rheocola* increased significantly with increasing distance from a road. Additionally, Eigenbrod *et al*. (2009) examined the effects of a high-volume, four-lane highway on amphibian populations in Ontario. The negative effects of the highway extended beyond it for five out of the seven species studied, with the size of the "road effect zone" varying from 250-1,000 m, depending on the species. Reduced use of habitats close to a highway may reflect: 1) noise from the highway interfering with amphibian calling activity, 2) increases in amphibian mortality due to traffic, and/or 3) effects of road salt running increasing mortality rates of amphibian larvae in roadside wetlands (*e.g.* Karraker *et al*., 2008). The magnitude of the reduction in amphibian populations next to roads is dependent on overall traffic volumes. For example, de Maynadier and Hunter (2000) reported that low-volume logging roads had little effect on anuran habitat use in Maine.

Highway 3 passes through the southern portion of the WLSA with mean traffic volumes at the Alberta/British Columbia border ranging from 3,183 vehicles/day in December to 7,172 vehicles/day in August 2013 (Alberta Transportation, 2013). This is lower than the volume of the highway studied by Eigenbrod *et al*. (2009); however, Highway 3 likely functions as a barrier to amphibian movements, resulting in reduced habitat quality for amphibian habitats adjacent to the highway because of noise and road salt run off. Since traffic noise penetrate up to distances of 200 m in forested habitats (Goosem *et al*., 2007), a 200 m ZOI was established around Highway 3 (Table C1.3-1). For the lower traffic roads in the WLSA, a smaller ZOI (50 m) was used. However, since the mine access road will experience increased traffic volumes during Project construction and operation, a 100 m ZOI was used. No ZOI was used for disturbances that produce little or no noise.

Noise disturbances associated with the coal conveyor system and active coal mine are likely to interfere with amphibian calls. Columbia spotted frogs in particular have quiet calls that can only be heard from 30 m away (James, 1998). Columbia spotted frog habitat within 100 m of the proposed conveyor system, mine, and processing plant was therefore increased by one habitat rating (Table C1.3-1). A 100 m ZOI was also used for the coal processing plant, urban areas, and the existing railway, reflecting the recommended setback distance for high-impact disturbances on boreal toad, Canadian toad and northern leopard frog breeding ponds in Alberta (AER, 2013).

Mine sedimentation ponds and drainage ditches were assigned a habitat suitability rating of "Nil" (Table C1.3-1), as they may have high levels of nitrates, selenium, sulphates, nitrites, and other mine-related chemicals. However, the sedimentation pond may, after the life of the project, be reclaimed as suitable habitat for amphibians (Carrozzino, 2009).

2.1.4.1.3 Confidence Rating

The overall confidence rating of this model is "Moderate". Amphibians require waterbodies for breeding, so breeding activity of Columbia spotted frogs is likely to be confined to habitats rated as "High" or "Moderate". The existing wetland where Columbia spotted frogs were located in the WLSA during the amphibian survey was rated as "High" quality by the model. However, it is unclear if Columbia spotted frogs in the WLSA move among breeding, non-breeding and overwintering habitats and what movement corridors are used, making the rating of non-breeding habitats problematic.

2.2 Western Toad

Scientific Name: *Anaxyrus boreas* (Formerly *Bufo boreas*).

Status: General Provincial Status: "*Sensitive*", COSEWIC: "*Special Concern*", SARA Status: "*Schedule 1*".

2.2.1 Distribution and Abundance

Western toads occur throughout west central and western Alberta (COSEWIC, 2002), and are common from Lac La Biche (Eaton *et al*., 1999) east to the British Columbia border and south to the Montana border. They also range from the southern Yukon through northwestern, central and southern British Columbia, including Vancouver Island and the Queen Charlotte Islands. Western toads can occur at a wide range of elevations (0 – 3,660 m) but are absent from arid regions.

The range of the western toad may be expanding in parts of Alberta, potentially replacing the Canadian toad in the east (COSEWIC, 2002). However, the species has a general provincial status of "Sensitive" because populations are declining elsewhere and the species is vulnerable to pesticides, pollution and drought (AESRD, 2010). The species is declining most rapidly in the southern parts of its range in the United States (COSEWIC, 2002).

Some biologists have suggested that an increase in UV-B radiation may explain some declines in western toad declines in the USA (COSEWIC, 2002). However, Hossack *et al*. (2006) found no relationship between UV-B levels and the distribution of toads in Glacier National Park.

The chytrid fungus *Batrachochytrium dendrobatidis* has been linked to declines in amphibian populations throughout the world, including declines in western toads in the southern part of its range (Keinath and McGee, 2005). The fungus has been detected in a western toad population in British Columbia although no toads showed signs of infection (Deguise and Richardson, 2009). Its effect on western toad populations in Alberta is unclear.

Overall, it is unclear why western toad populations have declined, although the primary threats to western toad populations appear to be disease, habitat destruction, and habitat alteration (COSEWIC, 2002). Populations can also fluctuate dramatically in numbers, and climatic events (such as spring storms, summer droughts, and early fall freezes) may lead to mass die offs.

2.2.2 Ecology and Key Habitat Requirements

Habitat requirements of the western toad vary seasonally. From April to June, this toad breeds in a variety of natural or manmade waterbodies, including permanent and temporary ponds, shallow margins of lakes, bogs, swamps and beaver ponds with or without tree cover, coarse woody debris or emergent vegetation (COSEWIC, 2002). However, ditches and ruts may act as sinks for the species, as amphibian larvae in them rarely complete metamorphosis into adults (Andrews *et al*., 2008).

Browne *et al.* (2009) found that western toad abundance in water bodies was positively correlated to dissolved oxygen levels and negatively correlated with water depth. Shallower water bodies will typically be warmer than deep ones, and warm temperatures facilitate faster development of eggs and larvae. Amphibian abundance often decreases with increased water conductivity (which is positively correlated with total dissolved solids, and minerals), but this was not the case for western toads, which appeared to be more tolerant to water with high ion concentrations than wood and boreal chorus frogs (Browne *et al*., 2009).

Western toads typically do not reach maturity until age 2 or 3 (Russell and Bauer, 2000) and mortality in adults is low (Muths and Shearer, 2011). However, adult toads do not necessarily breed every year. For example, Muths *et al*. (2006) found that 3-95% of male toads in high-elevation Colorado populations did not return to the breeding pond over a seven year period.

Female western toads can lay up to 16,500 eggs and therefore, tadpole densities in western toad breeding ponds can be very high (Russell and Bauer, 2000). Hatching occurs in three to 12 days, and six to eight weeks are required for metamorphosis (Russell and Bauer, 2000). Toadlets leave their breeding ponds shortly after metamorphosis which occurs by mid-September in the Rocky Mountains (Russell and Bauer, 2000). Bull (2009) found that western toadlets would disperse up to 2,720 m from the breeding pond along drainages with intermittent or permanent water associated with streams, seeps and marshes.

Adult toads also typically leave breeding ponds after mating and move to a summer foraging range. Females leave breeding ponds earlier than males, likely to escape harassment from males (Long and Prepas, 2012). On average, females also initially move farther from the breeding ponds than males, but both sexes may move their foraging grounds farther from the breeding pond as the summer progresses. By the end of the summer, males and females may move the same mean distance from the breeding ponds (Long and Prepas, 2012).

Browne *et al*. (2009) reported that western toad abundance at terrestrial sites was positively associated with closed deciduous forest cover, likely because the understory was better developed in deciduous than coniferous forests in their study area. A well-developed understory would provide protection from predators and desiccation. However, western toads are not necessarily dependent on old-growth or mature forests. On Vancouver Island, Davis (2000) found that western toads were more common in 12 to 16 year-old clear cut forests than in mature or old-growth forests. Western toads will use also burned habitats. Guscio *et al*. (2007) reported that western toads used severely burned habitats more frequently than expected in Glacier National Park. Hossack and Corn (2007) also reported that western toads colonized previously unoccupied wetlands after an intense fire.

Western toads primarily forage at night and while not foraging, they will spend their time in refugia. Some toads will use multiple refugia throughout the summer. Long and Prepas (2012) examined the characteristics of western toad refugia in central Alberta, near Whitecourt. They found that western toads are habitat generalists at the microhabitat scale and that their refugia could be associated with a variety of habitat features, including open areas. However, refugia were typically located at moist sites, and most (50%) refugia were associated with coarse woody debris, while some were in burrows (23%), under vegetation (19%) or were exposed (8%). Many refugia were in forest clearings, averaging 19 m from the nearest forest patch or edge. Davis (2000) also reported that western toads on Vancouver Island would use a variety of microhabitats as refugia, including the bases of trees, burrows under logs and within stumps, rodent burrows, tree root tangles, the area under dense ground cover and in water or mud. Toads would often return to the same microsites and foraged within 0.1 ha areas surrounding them.

Toads would travel from their refugia to forage, averaging a mean straight-line distance of 15 m (Long and Prepas, 2012). Toads also frequently used the same routes to travel on while foraging. The mean size of each toad activity centre (*i.e.* the refuge plus the surrounding area used for foraging) was 0.57 ha for males and 0.55 ha for females (Long and Prepas, 2012).

Western toads may make long-distance movements along stream channels. Schmetterling and Young (2008) studied the movements of western toads along steams using stream-based netting, PIT tagging and radio tracking. The median distance moved by PIT-tagged toads was 1 km while the median total distance moved by radio tagged toads was 2.1 km (range 25 m – 12 km). The vast majority of toads caught were moving downstream and overall patterns of movement were highly variable. One toad did not move far from where it was first caught, some moved to upland habitats, and others travelled downstream. The toads were likely travelling among breeding, summer growth, and overwintering sites.

Connectivity among western toad populations is influenced by habitat permeability at a fine scale, while topographic morphology and temperature-moisture regimes influence it at multiple scales

(Murphy *et al*., 2010). Mountain ridgelines and impervious surfaces (roads and developments) can be major barriers to dispersal among populations, while high levels of growing season precipitation can promote it (Murphy *et al*., 2010).

Western toads hibernate during fall and winter using moist burrows up to 1.3 m underground to prevent freezing and dessication (Mennell and Slough, 1999). A study conducted in central Alberta found that western toads arrived at their hibernation grounds gradually from August 27 to October 10 (Browne and Paszkowski, 2010a). They entered their hibernacula from August 31 to October 3 at a northern boreal site and from September 15 to October 16 at a more southern, aspen-dominated site (Browne and Paszkowski, 2010a). It is unclear whether temperature changes or changes in photoperiod influenced the timing of hibernation in western toads (Browne and Paszkowski, 2010a).

Most western toad hibernacula in central Alberta are in peat hummocks (Browne and Paszkowski, 2010a). Red squirrel middens, decayed root tunnels, cavities under spruce trees, natural crevice systems, abandoned beaver lodges, and muskrat tunnels are also used as hibernacula by western toads (Browne and Paszkowski, 2010b). About 68% of western toads were in communal hibernacula and up to 29 toads would hibernate together (Browne and Paszkowski, 2010b). However, most hibernacula contained 1 to 8 toads. Western toads did not hibernate in sand, water, or in human-altered landscapes (Brown and Paszkowski, 2010b), tending to select sites in spruce forests or dry shrublands.

In central Alberta, western toads did not hibernate in ground squirrel burrows, although they were available (Browne and Paszkowski, 2010b), presumable because they were not well-insulated. However, western toads in Colorado will use golden-mantled ground squirrel burrows as hibernacula (Jones *et al*., 1998).

2.2.3 Response to Disturbance

The presence of introduced, non-native predatory fish to naturally fishless waterbodies can limit frog and salamander populations. Introduced predatory fish may not be as damaging to western toads as they are to frogs and salamanders, as western toad tadpoles are unpalatable to many fish species. The introduction of non-native fish to a waterbody may, however, introduce pathogens (*e.g.* water mold *Saprolegnia*) that may affect toads (Davis, 2000).

Western toads tend to lay their eggs in the same locations, regardless of water depth (Olson, 1992), and are therefore particularly susceptible to altered hydrology. Developments which alter hydrology have the potential to dessicate eggs, tadpoles, or toadlets if water levels are reduced (COSEWIC, 2002). Pollution of waterbodies can cause deformities and mortality (Bridges, 2000;

Fontenot *et al*., 2000; Relyea and Diecks, 2008), while alteration of fish abundance has an impact on the number and size of western toads and other anurans (Eaton *et al*., 2005).

A buffer of 30.5 m around riparian areas is often used to prevent reductions in water quality with development, however, this buffer was found to be insufficient to protect up to 50% of western toads (Goates *et al*., 2007), because of their movements into upland habitats after the breeding season. Recent best management guidelines for the Enhanced Approval Process (AER, 2013) suggest a year-round setback distance of 100 m around breeding ponds to minimize impacts on western toads.

2.2.4 Habitat Suitability Model

2.2.4.1 Model Ratings

Breeding and summer foraging habitats in the WLSA were rated for the western toad. A four-class rating scheme (Table C1.1-1) was used to rate foraging habitat (Table C1.1-3) based on ecosite phase and moisture regime. Breeding habitat is more limited than summer foraging habitat, so breeding habitats were assigned the highest habitat suitability ratings.

2.2.4.1.1 Model Assumptions

- Breeding habitat is likely the most limited resource for western toads in the WLSA. Waterbodies suitable for breeding and wetlands (subalpine ecosite phase h2) were assigned a suitability rating of 1 ("High").
- Streams and riparian habitats were assigned a habitat suitability rating of 2 ("Moderate") because western toads may breed in pools and oxbows. In Yellowstone National Park, western toads are often associated with overflow pools along rivers and streams (Bartelt *et al*., 2001). Additionally, western toads often disperse along streams (Schmetterling and Young, 2008), and riparian areas can provide good summer foraging habitat.
- Upland sites within 1,000 m of potential breeding habitat were rated for their ability to provide suitable summer habitat. Western toads may disperse more than 1,000 m from a breeding pond; however, long-distance movements are generally made along watercourses, which were rated as "Moderate" breeding habitat.
- Western toads generally require moist areas with well-developed understories for summer foraging habitat. As they may prefer deciduous habitat (Brown *et al*., 2009), moist ecosites with deciduous trees were assigned a habitat suitability rating of 2 ("Moderate"). Montane ecosite phases g1 and g2 and subalpine ecosite phases h1 and h2 were also assigned a rating of 2 because of their high moisture levels and occurrence of seepage areas.

- Other ecosite phases that may provide potentially suitable summer foraging habitat for western toads were assigned a habitat suitability rating of 3 (“Low”). These included mesic ecosite phases, and moist coniferous ecosite phases.
- Like most amphibians, western toads are vulnerable to desiccation and avoid dry areas. Thus, xeric and subxeric ecosite phases were assigned a habitat suitability rating of 4 (“Nil”).
- Western toads typically avoid non-vegetated areas, including rocky mountain tops. Such habitats were be assigned a habitat suitability rating of 4 (“Nil”).

2.2.4.1.2 Ratings Adjustments

There is little information on the response of western toads to sensory disturbance. However, the presence of roads and other industrial infrastructure can decrease the quality of surrounding habitat for amphibians. For example, Eigenbrod *et al*. (2009) found a decrease in American toad (*Anaxyrus americanus*) abundance 200-300 m from a major highway in Ontario. This may be a result of increased toad mortality on the road, or toads avoiding habitat near the road due to sensory disturbance. Additionally, road salt used to de-ice roadways in winter can affect adjacent pools and wetlands up to 170 m away and may decrease the viability of eggs and tadpoles (Karraker *et al*., 2008).

Noise from highways may also mask the calls made by male amphibians to attract females. However, not all western toads produce mating calls and western toads in Canada have been divided into a “calling” and “non-calling” population by COSEWIC (COSEWIC, 2012). Western toads from south western Alberta likely do not produce calls, as specimens collected there lack vocal sacs (Pauly, 2008).

Because toad abundance can decrease in the vicinity of major highways (Eigenbrod *et al*., 2009), a 200 m ZOI was established around Highway 3 (Table C1.3-1). Habitat ratings were also increased by one within this ZOI. Other roads in the WLSA currently have much lower traffic volumes therefore a 50 m ZOI was used. However, since the mine access road will experience increased traffic volumes during Project construction and operation, a 100 m ZOI was used. No ZOI was used for disturbances that produce little or no noise. A 100 m ZOI was also used for the coal processing plant, urban areas, and the existing railway, reflecting the recommended setback distance for high-impact disturbances on boreal toad, Canadian toad and northern leopard frog breeding ponds in Alberta (AER, 2013).

No ZOIs were used for seismic lines, transmission lines, or cutblocks (Table C1.3-1), as Long and Prepas (2012) found that forest edges or clearings up to 325 m wide do not act as barriers to western toad movement. Many western toads will also spend time in refugia located in clearings (Long and Prepas, 2012).

2.2.4.1.3 Confidence Rating

The confidence rating for this model is "Moderate". Western toads require water for breeding and use streams as migration routes. Thus, breeding activity is very likely to occur primarily within habitats rated as "High" or "Moderate" in this model.

However, western toad summer habitat use is more variable since they will use a wide variety of upland habitats when they are not breeding. Habitat use can also vary depending on precipitation levels, making it difficult to model upland habitat use. However, like other amphibians, western toads are prone to desiccation and can be preyed upon by a wide variety of predators. Upland habitats were primarily rated on moisture levels and amount of shrub cover and are therefore likely to have some value in predicting the overall use of habitat by western toads.

The "Moderate" confidence rating of the model (as opposed to "High" confidence) is also partially due to a lack of data on western toad habitat use in the WLSA. Two western toads were observed in the vicinity of the WLSA while several toadlets were seen close to a wetland during the nocturnal amphibian call survey conducted in June 2014. The amphibian call survey was timed to optimize the probability of detecting western toads that may be present in the WLSA. However, western toads in the area may not vocalize (Pauly, 2008) which makes them more difficult to detect than frogs. Therefore, breeding toads may have not been detected during the call survey even though they may be more abundant in the WLSA than based on the call survey alone.

2.3 Olive-sided Flycatcher

Scientific Name: *Contopus cooperi.*

Status: General Provincial Status: "*May be at Risk*", COSEWIC: "*Threatened*", SARA Status: "*Schedule 1*".

2.3.1 Distribution and Abundance

The olive-sided flycatcher is a suboscine songbird from the tyrant flycatcher family (Tyrannidae). It breeds in coniferous forests across North America and overwinters in Central and South America. In Canada, it occurs in forested regions from Newfoundland and New Brunswick in the east to the coast of British Columbia in the west. In Alberta, it is most frequently reported in the Rocky Mountain Natural Region, although it has also been observed in the Boreal Forest, Foothills, Grassland, and Parkland Natural Regions (FAN, 2007). However, most observations in the grassland region are of migrating birds (FAN, 2007). In the United States, it occurs in Alaska and in coniferous forests south of the Canadian border from Washington State, Idaho, and Montana south to Arizona and New Mexico. It also occurs in the eastern United States in northern Minnesota, northern Wisconsin, northeastern New York State, central and western Massachusetts, and southern Vermont, New Hampshire, and Maine (Altman and Sallabanks, 2012).

The olive-sided flycatcher overwinters in southern Mexico, Costa Rica, Panama, Colombia, Peru, Venezuela, northern Brazil, southeastern Brazil, and the Guianas (Willis *et al*., 1993, Altman and Sallabanks, 2012). It is most abundant in the Andes of Colombia (Altman and Sallabanks, 2012). Olive-sided flycatchers typically depart their wintering grounds from the last week of March to late April. They arrive in the southern areas of their breeding grounds in mid-April to late-May and in the northern areas from mid- to late-May (Altman and Sallabanks, 2012). They begin departing their breeding grounds during early August, and by mid-late September, they are nearly absent from their breeding range. In Alberta, most sightings of olive-sided flycatchers are made from May to August, with very few birds recorded in April, September and October (FAN, 2007).

In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has listed the olive-sided flycatcher as "Threatened" because it has undergone a long-term and consistent decline in numbers. In Canada, numbers are estimated to have declined by 79% from 1968—2006 (COSEWIC, 2007). In Alberta, the species has a general provincial status of "May be At Risk" (AESRD, 2010). The International Union for the Conservation of Nature (IUCN) lists it as "Near Threatened" because data from the North American Breeding Bird Survey indicates that populations have declined by 3.5% annually since 1980 (Bird Life International, 2012).

2.3.2 Ecology and Key Habitat Requirements

Olive-sided flycatchers prefer coniferous over deciduous forests (Kirk *et al*., 1996), and are frequently associated with forest openings and edges, especially those edges created by wetlands (FAN, 2007). They may also be associated with open forests interspersed with patches of meadow or shrub (Wright, 1997). Olive-sided flycatchers can occur in forests of varying seral stages, but appear to prefer young forests. For example, in western North America, Schiek and Song (2006) reported that they were most frequently associated with young forests (<30 years) and post-clearcut forests that contained residual live trees. In Oregon, Betts *et al*. (2010) found that olive-sided flycatchers were associated with the presence of forest patches at early seral stages, indicating the species preference for 'edge' habitat between forests at late and early seral stages. However, olive-sided flycatchers have also been found in old (>125 year) mixedwood forests (Schiek and Song 2006). Even in young forests, they require the presence of some tall trees or snags to use as foraging and singing perches. Olive-sided flycatchers in Alaska preferred dead tree snags as singing perches and require conifers for nesting, preferring to nest in live over dead conifers (Wright, 1997). Their nests are cup-shaped and are usually built on horizontal branches among a cluster of twigs and needles (Baichich and Harrison, 1997).

Olive-sided flycatchers likely prefer open habitats because of their foraging technique, which requires the presence of open air space. They will typically perch and wait for prey items (flying insects) to appear, flying out to capture or attempt to capture an insect, and then returning to the same or nearby perch. Since flycatchers need openings to forage in, they are often associated with newly-burned forests (Hutto and Young, 1999), sometimes becoming more common in burned forests than in adjacent non-burned forests (Bock *et al.*, 1978; Meehan and George, 2003). Smucker *et al*. (2005) also found that olive-sided flycatcher populations increased in forest patches after a fire, particularly in patches that were burned by moderate- or high-intensity fires. Burned forests provide flycatchers with dead tree snags which are used for perching and the open air space for foraging. This implies that wildfire could be beneficial for the species. However, Meehan and George (2003) reported that the probability of nest loss for olive-sided flycatchers was higher in a burned than a non-burned site in northern California. Aerial arthropod biomass and flycatcher foraging rates were also higher in the unburned than the burned forest. Thus, while olive-sided flycatchers may be attracted to post-fire sites, lower prey availability in such sites may have a negative effect on reproduction.

2.3.3 Response to Disturbance

The reason for the declines of olive-sided flycatchers throughout their range is unclear (COSEWIC, 2007). Hutto and Young (1999) found that they were most abundant in post-fire and harvested forests, and they commented on the apparent contradiction between increasing availability of flycatcher habitat (harvested forests) and the declines that have occurred in flycatcher populations. They offer three explanations for this contradiction: 1) census data have provided a misleading indicator of nesting success for olive-sided flycatchers, 2) conditions have deteriorated on the olive-sided flycatchers' wintering range, or 3) harvested forests actually act as an ecological "trap" for olive-sided flycatchers because, while flycatchers are attracted to them, nesting success in them is often poor.

Evidence that harvested forests represent an ecological "trap" for olive-sided flycatchers was also presented by Robertson and Hutto (2007). They examined nestling provisioning rates and nest success in selectively-harvested and burned forests in Montana. Flycatcher density and nestling provisioning rates were higher in harvested forests than burned forests. However, nest success was higher in burned forests, which may be a result of the higher density of nest predators in harvested forests. Selectively-harvested forests thus attract flycatchers because they resemble the open habitats they prefer, but they appear to act as a sink because nest success rates are lower in them.

While forestry practices may explain of the decline of the olive-sided flycatcher, deterioration of their wintering habitat may also be a cause of the decline. Their wintering range is far smaller than their breeding range and habitat loss there may explain why populations are declining throughout their large breeding range (COSEWIC, 2007). However, there is no data available that links loss of wintering habitat to declines in populations.

2.3.4 Habitat Suitability Model

2.3.4.1 Model Ratings

Habitat ratings were based on habitat suitability during the breeding season in the WLSA. A four-class rating scheme (Table C1.1-1) was used to rate olive-sided flycatcher habitats with ratings based on ecosite phase, structural stage, disturbance type, and proximity to open habitat (Table C1.1-3).

2.3.4.1.1 Model Assumptions - WLSA

- Olive-sided flycatchers build their nests in coniferous trees and prefer open forests. Open or moderate coniferous forests were therefore assigned a habitat suitability rating of 1 (“High”) while closed coniferous or mixedwood forests were assigned a habitat suitability rating of 2 (“Moderate”).
- Olive-sided flycatchers often select for edge habitats. Thus, forested habitats >100 m from a habitat “edge” (*i.e.* where a forested habitat meets a non-forested habitat) had their suitability rating decreased by 1.
- Deciduous forests were rated as 4 (“Nil”), as olive-sided flycatchers generally do not breed or forage in them.
- Ecosite phases lacking trees were also rated as 4 (“Nil”).

2.3.4.1.2 Model Assumptions – WRSA

- Open or moderate coniferous forests were assigned habitat suitability ratings of 1 (“High”) or 2 (“Moderate”), depending on whether they were within 100 m of a habitat edge. A higher rating was assigned to habitats closer to edges. Open or moderate mixedwood forests were given habitat suitability ratings of 2 or 3 (“Low”), depending on their proximity to habitat edges.
- As olive-sided flycatchers prefer open forests, closed or dense coniferous forests were given habitat suitability ratings of 2 (if within 100 m of an edge) or 3 (if > 100 m from an edge). Closed or dense mixedwood forests were given habitat suitability ratings of 3 (if within 100 m of an edge) or 4 (if > 100 m of an edge).
- Deciduous forests were given a habitat suitability rating of 4 (“Nil”) as olive-sided flycatchers rarely breed or forage in them.
- Non-vegetated habitats or habitats lacking trees were given a habitat suitability rating of 4 (“Nil).

2.3.4.1.3 Ratings Adjustments

The noise and vibrations produced by vehicles, trains, and heavy industrial equipment may decrease the value of habitat located close to roads, mines, railways and other similar disturbances. This may be a result of birds avoiding habitat in response to sensory disturbance or decreased pairing success in birds with territories near the disturbance. The effects of anthropogenic noise has not been studied for olive-sided flycatchers specifically, but other studies have indicated that it can negatively affect breeding songbirds. For example, Habib *et al*. (2007) reported that pairing success in male ovenbirds was lower near noisy compared to noiseless industrial sites. This may be because industrial noise interferes with the male's song, so that females either do not hear males at high distances or they perceive the song as having being of lower quality. Olive-sided flycatchers sing during the breeding season, presumably to attract females, so it is likely that noise from traffic or industrial activities could decrease a male's ability to attract females. Bayne *et al*. (2008) also found that the density of songbirds was 1.5 times lower near noisy compared to noiseless industrial infrastructure, which indicates that songbirds may avoid habitat near areas with higher levels of anthropogenic noise.

To account for a potential reduction in habitat quality around noisy disturbances in the WLSA, 150 m ZOIs were established around very loud and continually noisy disturbances such as Highway 3, railways, active mine site, and the coal conveyor (Table C1.3-1). A 100 m ZOI was used for urban areas, while a 50 m ZOI was used for low-use gravel roads. No ZOIs were established around cutlines, clear cuts, or other similar disturbances as olive-sided flycatchers do not avoid these areas; instead preferring forest openings created by vegetation clearing.

2.3.4.1.4 Confidence Rating

The confidence rating for this habitat suitability model is "High". The preference of olive-sided flycatchers for open coniferous forests is well-supported by data collected throughout western North America. Seven olive-sided flycatchers were also detected in the WLSA, all of which were associated with coniferous or mixedwood forests.

2.4 Great Grey Owl

Scientific Name: *Strix nebulosi.*

Status: General Provincial Status: "*Sensitive*", COSEWIC: "*Not at Risk*", SARA Status: "*Not Listed*".

2.4.1 Distribution and Abundance

Great gray owls have a Holarctic distribution. In Alberta, they are associated with coniferous forests, and therefore occur throughout the province except for the grassland region in the southeast. They are most frequently reported in the Foothills and Boreal Forest Natural Regions, but they also occur in the Rocky Mountain Natural Region and are rare in the Parkland Natural Region (FAN, 2007).

Elsewhere in Canada, they occur throughout British Columbia (except the far southeast and Vancouver Island), most of the Yukon, the southwestern Northwest Territories, northern Saskatchewan and Manitoba, Ontario (except the far south) and southwest Quebec.

Great gray owls are non-migratory and are generally found year-round where they occur. However, they are irruptive in some areas of southeastern Canada and the northern United States (Bull and Duncan, 1993). Individual birds may stay close to their breeding grounds throughout the year or they may travel hundreds of kilometers from it, depending on food availability. Great gray owls feed primarily upon small rodents (Bull and Duncan, 1993).

The density and abundance of great gray owls is difficult to monitor because the species is often active at night and starts breeding as early as late February. Thus, their populations are not well monitored by programs such as the North American Breeding Bird survey, which largely targets songbirds that are most vocal during early mornings in June. The species is generally regarded rare, and populations may fluctuate in response to fluctuations in rodent populations. For example, Bull and Henjum (1990) reported that a population in Oregon failed to breed during a year with very low vole populations.

The great gray owl has a general provincial status of “Sensitive” because it is a naturally scarce species (AESRD, 2010). Additionally, it is vulnerable to habitat loss from forestry practices as it requires mature to old-growth forests for nesting (AESRD, 2010).

2.4.2 Ecology and Key Habitat Requirements

Great gray owls do not build their own nests but instead nest on large stick nests built by other species such as ravens or hawks, on man-made nesting platforms, or on the decayed, broken tops of large trees. In northeast Oregon, Bull and Henjum (1990) found that, of 49 nests, 25 were stick nests, 14 were on artificial platforms, and 10 were on dead, broken tree tops. The stick nests used were built by northern goshawks and red-tailed hawks and had a mean width of 74 cm. Brooms of dwarf mistletoe were also used as nests. In Idaho and Wyoming, Franklin (1988) found that 60% of great gray owl nests were on top of broken conifer snags and 40% were in stick nests. Franklin (1988) also reported that nests on fir or spruce snags were the most stable and productive.

In central Alberta, Stepinsky (1997) found that 19 of 19 of great gray owl nests were in poplar trees (trembling aspen or balsam poplar). Seventeen of the nests were stick nests built by northern goshawks or red-tailed hawks, and two were on dead tree stumps. They were generally in forest patches that were larger, on average, than randomly-chosen forest patches. The area of forest patches with great gray owl nests ranged from 10.8 to 119.7 ha (mean = 29.6 ha).

The mean distance off the ground of stick nests used by great gray owls in Oregon was 17 m, and the mean height of dead trees whose tops were used as nests was 11 m (Bull and Henjum, 1990). In Idaho and Wyoming, stick nests used by great gray owls were a mean of 11 m off the ground and snags used as nests were a mean of 6 m tall (Franklin, 1988). When great gray owls could nest at the top of a tree trunk, the tree was typically large (diameter at breast height [dbh] from 46 – 94 cm) and old (mean age of 173 years) (Bull and Henjum, 1990). When great gray owls can nest on top of tree snags, the snag must be decayed so that the female can scratch out a depression to lay the eggs in (Franklin, 1988; Bull and Henjum, 1990). Overall, the availability of nest sites in a forest appears to increase with forest age (Duncan, 1997).

Great gray owls prefer nest sites in forests with two or more canopy layers and with a closure of >60% (Bull and Henjum, 1990). They will nest in coniferous forests (Franklin 1988), mixedwood forests (Bull and Duncan, 1993) and deciduous forests (Oeming, 1955). They may use nests located in conifers or deciduous trees (Bull and Duncan, 1993; Stepinsky, 1997). Nests located in forests with cover for nestlings and with some broken, leaning trees present provide the best environment for great gray owl fledglings. Great gray owl chicks leave the nest and start wandering before they can fly. During their first week after leaving the nest, the fledglings will climb on leaning trees. They may move up to 200 m from the nest within the first week, but generally stay in areas with at least 60% canopy cover (Bull and Henjum, 1990). Fledglings without appropriate trees to climb and with insufficient cover are at risk of being preyed on. Potential predators include great horned owls, pine martens, coyotes, and ravens (Bull and Henjum, 1990; Whitefield and Gaffney, 1997). Collisions with vehicles can also be a major source of mortality (Bull and Duncan, 1993).

The forests that great grey owls nest in and hunt in often differ in structure. In Oregon, Bull and Henjum (1990) found that male great gray owls (who will feed incubating females and nestlings) preferred to hunt in forests with open understories and with 11 – 59% canopy cover. Great gray owls will also hunt in grassy meadows, bogs, fens, muskegs, and selectively and clear-cut forests (Duncan, 1997). Great gray owls tend to hunt from perches and rarely hunt from the ground or on the wing. Additionally, they tend to avoid hunting in very dense forests and areas with thick shrub cover because of their size (Duncan, 1997). During the breeding season, males tend to hunt within a few kilometers of the nest, and Bull and Henjum (1990) report that the maximum distance from the nest travelled by eight males ranged from 0.7 to 3.2 km.

The areas that grey great owls use for hunting are those that provide good habitat for their prey, which tend to be voles or northern pocket gophers. Sears (2006) found that great gray owls tended to hunt in moist meadows with understory vegetation between 10 and 65 cm tall. Voles typically prefer wetter areas with a thick covering of grass, forbs, or sedge (Sears, 2006).

2.4.3 Response to Disturbance

The availability of nest sites and suitable foraging habitat is likely the primary factor that limits great gray owl populations. Up to 75% of the great gray owl's range in North America is affected by forestry, which often eliminates appropriate nest trees.

2.4.4 Habitat Suitability Model

2.4.4.1 Model Ratings

Nesting habitat is likely to be the most limiting resource for great gray owls in the WLSA. Thus, ecosite phases that were most likely to have suitable nesting sites were assigned the highest habitat suitability ratings. A four-class rating scheme was used to rate great gray owl habitats (Table C1.1-1). Ratings were based on ecosite phase, structural stage, and disturbance type (Table C1.1-3).

2.4.4.1.1 Model Assumptions

- Great gray owls prefer to nest in large forest patches. Thus, forest patches >6 ha considered as breeding habitat (see Piorecky *et al*., 1999) and were assigned a rating of 1 ("High"). Smaller forest patches were assigned a rating of 4 ("Nil").
- Old-growth forests (structural stage 7) provide the highest-quality nesting habitat, as they typically higher numbers of large, broken, dead trees (which may provide suitable nest sites for great gray owls), and higher numbers of northern goshawk nests. Old-growth forests also generally have a higher proportion of dead, leaning trees, which mobile but non-flighted nestlings use to climb off the ground. Therefore, old-growth forests were rated as 1 ("High") or 2 ("Moderate"), depending on ecosite phase.
- Great gray owls prefer to nest in forests with thick canopy cover. Thus, old-growth a and b ecosites (in either the Montane or Subalpine Natural Subregions) were assigned ratings of 2 instead of 1, as they tend to be open forests.
- Mature (structural stage 6) forests may also provide suitable nesting habitat for great grey owls, and were assigned a rating of 3 ("Low," for ecosite phases a and b) or 2 ("Moderate," other forested ecosite phases).
- Male great gray owls will travel up to 3 km from the nest to forage. Since most of the closed forested areas in the WLSA are located within 3 km of open habitat (including grasslands, open forests, and young, regenerating clear cuts), distance to foraging habitat was not considered in the habitat suitability ratings.
- Regenerating clearcuts and grassy meadows are unlikely to provide suitable nesting habitat. However, they often provide high-quality foraging habitat and were given a habitat suitability rating of 2 ("Moderate").

- Grassy meadows, open shrubby areas, fens, pasture, wetlands and moist open forests can be used for foraging by great grey owls and good foraging habitat is needed for great grey owls to nest successfully. Thus, these habitats were given a rating of 2 (“Moderate”).
- Immature treed ecosites were given a rating of 4 (“Nil”) as they are unlikely to provide either nesting or foraging habitat.
- Non-vegetated areas provide no suitable foraging or nesting habitat for great gray owls and were given a habitat suitability rating of 4 (“Nil”).

2.4.4.1.2 Ratings Adjustments

Great gray owls may avoid habitat that is extensively used by humans. In Yosemite National Park, the level of human activity in a meadow had a negative effect on great gray owl distribution (van Riper *et al*., 2013). Nest abandonment due to sensory disturbance was the primary concern for adjusting habitat suitability ratings for great grey owls. Disturbance ZOIs consisted of 150 m around loud disturbance features (*e.g.,* highways, active mines, coal conveyor), 100 m for moderately noise disturbances (*e.g.*, urban areas), and 50 m around infrequently used roads and trails (Table C1.3-1). The ratings of habitats falling within these ZOIs were reduced by 1.

2.4.4.1.3 Confidence Rating

The confidence rating of this model is “Moderate”. Forests were rated for their ability to provide nesting habitat for great gray owls based on age. Many studies suggest that this factor is related to the occurrence of nesting great gray owls (Duncan, 1997).

Habitat was also rated for its ability to provide foraging opportunities, as great gray owls must have high-quality foraging grounds within the vicinity (up to 3 km) of their nest site to successfully raise young. Open habitat was rated as “Moderate” as great gray owls frequently use such habitat for foraging (Duncan, 1997).

The confidence rating of the model would have been increased to “High” if more data on great gray owl occurrence and habitat use was available for the WLSA or WRSA. The species has been heard calling in the WLSA and one landowner has reported that a pair breeds in the area. Beyond this, little is known about their use of habitat and distribution in the WLSA.

2.5 Little Brown Myotis

Scientific Name: *Myotis lucifugus.*

Status: General Provincial Status: “*Secure*”; COSEWIC: “*Endangered*”, SARA Status: “*Schedule 1*”.

2.5.1 Distribution and Abundance

Little brown myotis are found throughout Alberta. Across Canada, they are found in every province and territory but are absent from northeast Saskatchewan, northern Manitoba, northern Ontario, northern Quebec, the northern Yukon and the northern Northwest Territories. There are only a few records from southern Nunavut.

In Alberta, little brown myotis are common and are likely the most abundant bat species in the province. Historically, they were common throughout their range, but white-nose syndrome, a disease caused by the fungus *Pseudogymnoascus destructans*, has decimated many populations in eastern North America. The disease has caused a 94% decline in the known number of bats hibernating in colonies in Nova Scotia, New Brunswick, Ontario, and Quebec (COSEWIC, 2013). Although white-nose syndrome has not yet reached Alberta, it is estimated that the entire population of little brown myotis will be affected within 12 to 18 years (COSEWIC, 2013).

2.5.2 Ecology and Key Habitat Requirements

In Alberta, little brown myotis are active from approximately mid- to late-April (when mean annual daytime temperatures reach 10°C) to mid-September (Naughton, 2012). They hibernate during the rest of the year. Bat hibernacula are typically located in caves or abandoned mines that have high humidity and remain at a temperature of at least 4°C (Banfield, 1974). Dormant bats do not regulate their body temperatures; thus, caves where temperatures drop too low may freeze bats to death (Banfield, 1974).

The four known locations of bat hibernacula in Alberta include Cadomin Cave, Wapiabi Cave, Procrastination Pot, and Walkin Cave. Cadomin Cave is 2,791 m long and 220 m deep and is located near the hamlet of Cadomin, 262 km west of Edmonton (Olson *et al*., 2011). From 1983-2009, an average of 556 bats hibernated there each winter (Olson *et al*., 2011). Wapiabi Cave is located northwest of Nordegg, Procrastination Pot is east of Jasper, and Walkin Cave is a sinkhole cave in Wood Buffalo National Park. The Cadomin and Wapiabi Caves were closed to human activity in 2010 to protect bats from white-nose syndrome (Government of Alberta, 2010). These known hibernacula do not account for the entire bat population in Alberta, and there are likely to be many other hibernacula located throughout the province.

Little brown bats are nocturnal and become active at dusk. They are aerial insectivores and do most of their foraging around and over water (Lunde and Harestad, 1986), although they will also forage in tree canopies. They feed heavily on aquatic insects and often feed along the margins of lakes and streams early in the evening and then over water later in the night (Belwood and Fenton, 1976; Fenton and Barclay, 1980; Barclay, 1991; Clare *et al*., 2011). They prefer to forage over calm ponds than over more turbulent waterbodies (such as rivers) possibly because the noise associated with water turbulence may interfere with echolocation (Von Frecknell and Barclay, 1987). They may also forage along the edges of clear cuts, along trails, or in forest gaps (COSEWIC, 2013; Patriquin and Barclay, 2003) but avoid large, open areas (COSEWIC, 2013). After feeding, they return to a night roost for a time before emerging again to forage (Anthony *et al*., 1981). The proportion of the night spent foraging vs resting at a night roost varies in relation to air temperature, prey density, and a bat's reproductive status. Time spent foraging declines on cool nights and when prey densities are low (Anthony *et al*., 1981).

The mean home range size for pregnant little brown myotis in Quebec is 30.1 +/- 15.0 ha, which is larger than the mean home range size for lactating bats, which is 17.6 +/- 9.1 ha (Henry *et al*., 2002). Lactating bats rarely carry their young while foraging so they must return to their maternity roosts 1-2 times/night to nurse pups (Henry *et al*., 2002).

Lactating females will use maternity roosts that are separate from night roosts which are used by non-lactating females and males (Anthony *et al*., 1981). Reproductive females use roosts with varying characteristics throughout their reproductive cycle. During gestation, they may use shallower crevices but during lactation, they prefer deeper roosts that undergo less extreme temperature fluctuations (Olson, 2011). The largest congregations of roosting bats are usually of females who have just given birth (Olson and Barclay, 2013). Maternity roosts used by lactating females are typically large and are warmer than night or day roosts, with the optimal temperature being between 32°C and 36°C (Naughton, 2012). Temperatures in this range allow for rapid pup growth (Naughton, 2012). Females may also move their young to new roosts (Olson, 2011). Once little brown myotis pups become flighted, both they and their mothers may return to using common night roosts (Anthony *et al*., 1981). Females typically have one pup.

During the day, little brown myotis spend their time in a day roost, which is usually in a different location from the night roost. Little brown myotis will roost in human dwellings, small caves, tree cavities, or rock crevices. In Waterton Lakes National Park, a large colony of little brown bats often roosts under a bridge (Horne, 2013). Generally, the location of the roost (including a maternity roost) that a particular bat uses frequently varies throughout the spring and summer. The size and composition of roosting groups will also change regularly (Olson, 2011).

Where anthropogenic structures are not available, little brown myotis rely extensively on tree cavities for roosting and raising young, and the availability of roosts may be limiting to some bat populations (Olson, 2011). They cannot excavate cavities, and thus rely on existing ones. They also must compete with cavity-nesting birds, mustelids, tree squirrels, and other bat species for access to tree cavities.

At a study site near Lesser Slave Lake in northern Alberta, Olson (2011) found that little brown myotis tended to roost in dense, closed, old growth forests. The vast majority of little brown myotis roosts found (134 out of 135) were located in deciduous trees, although one was in a white spruce. Sixty-one roosts were in trembling aspens and 73 were in balsam poplars. Trembling aspen has decay characteristics that make it susceptible to cavity formation, and balsam poplars are susceptible to heart rot fungus, which can lead to the formation of internal cavities in infected trees (Olson, 2011).

Olsen (2011) reported that little brown myotis roosts were typically in large trees. The mean diameter at breast height of roost trees was 48.6 cm and the mean height was 17.5 m (Olson, 2011). Roosts were found in living, partially alive, and dead trees, and most cavities used as roosts were a result of radial or longitudinal splits in the wood (Olson, 2011). Little brown myotis will also roost under exfoliating tree bark, in cavities excavated by animals, and in knot holes (Olson, 2001). Night roosts are typically located in a cavity where large numbers of bats can cluster (Fenton and Barclay, 1980).

Adult male little brown myotis and non-reproductive females may roost alone or in small groups during the daytime. In New Brunswick, male little brown myotis frequently roosted alone in coniferous forests or in conifer-dominated mixedwood stands (Broders and Forbes, 2004). A variety of other structures may be used as day roosts by single bats or small groups, including spaces within piles of wood or rocks, spaces underneath rocks, sites in buildings or sites in trees (Fenton and Barclay, 1980). Day roosts are usually dark or dim sites, and they are often cooler than nursery sites or night roosts (Barclay, 1982; Fenton and Barclay, 1980). Some little brown myotis (particularly juveniles) will roost during the day on exposed surfaces (often brick walls underneath overhangs) (Riskin and Pybus, 1998).

From August to October, little brown myotis begin to gather at swarms which are focussed around hibernacula (Norquay *et al*., 2013), although Schowalter *et al*. (1979) report three instances of little brown myotis swarming around buildings that were not used as hibernacula. While swarming, bats will generally fly near the entrance of a hibernaculum in large numbers, while periodically entering it to mate or rest. The distance separating the summer range and hibernaculum of a little brown bat can vary dramatically, and some little brown myotis may move hundreds of kilometers between hibernacula and their summer habitats (Fenton and Barclay, 1980). For example, Norquay *et al*. (2013) found that seasonal movements made by little brown myotis in Manitoba and northwest Ontario ranged from 10 to 647 km. Little brown myotis display high fidelity to their summer colonies and hibernacula sites across years, although some will switch sites. Little brown myotis that switch hibernacula move an average of 315 km, with a range of 6 to 569 km (Norquay *et al*., 2013).

2.5.3 Response to Disturbance

The presence of busy roads may alter the commuting behaviour of bats and prevent them from easily accessing important resources. For example, Bennet and Zurcher (2012) found that bats may turn around upon encountering a road and that the turning frequency of bats increases with increasing vehicle noise levels.

Habitat loss likely affects many bat populations, although the intensity of the threat of habitat loss on little brown myotis is unclear (COSEWIC, 2013). Little brown myotis require a wide range of habitat types to meet their needs, including foraging habitat, roost structures, and hibernacula. The loss of mature and old-growth forests, the loss of wetlands and/or the destruction of abandoned buildings used as roosts would all have negative effects on a local bat population.

The disturbance or destruction of a hibernaculum could threaten or limit a bat population. Hibernating bats are often unbothered by ambient noise in the environment; however, they can become aroused if disturbed by noisy industrial activities. Once a small number of bats become aroused, a cascade of arousal can occur as the flying activity of a few bats disturbs the others (COSEWIC, 2013). Frequent arousal can deplete the fat reserves of bats which can ultimately result in starvation (COSEWIC, 2013).

Other threats to little brown myotis include deliberate colony eradication (particularly of colonies roosting in buildings), pesticide use, and wind turbines (COSEWIC, 2013). However, wind turbines likely have a smaller effect on little brown myotis populations than on species that undergo long-distance migrations such as hoary bats, eastern red bats, and silver-haired bats (Lausen *et al*., 2010). However, large numbers of myotis bats may be killed at some sites (COSEWIC, 2013).

Insectivorous bats may be affected by the use of pesticides that decrease insect populations. However, the magnitude of the impact of this is unknown (COSEWIC, 2013).

2.5.4 Habitat Suitability Model

2.5.4.1 Model Ratings

A four-class rating scheme was used for rating little brown myotis habitat (Table C1.1-1). Roosting habitat was assumed to be the most limiting factor for this species, so ecosite phases were rated based on their ability to provide suitable roosting trees (Table C1.1-4).

2.5.4.1.1 Model Assumptions - WLSA

- Little brown myotis are more abundant in old vs. young forests (COSEWIC, 2013) and often roost in the cavities of large, deciduous trees. Therefore, mature/old deciduous forests were rated as “High” (1) while mature/old mixedwood forests were rated as “Moderate” (2).
- Male little brown myotis occasionally roost in conifer snags. Mature/old coniferous forests at were assigned a habitat suitability rating of “Low” (3).

- Young coniferous, deciduous or mixedwood forests were given a habitat suitability rating of "Nil" (4).
- Non-forested habitats were given a habitat suitability rating of "Nil" (4).

2.5.4.1.2 Model Assumptions – WRSA

- The habitat suitability model for little brown myotis for the WRSA is similar to the model for the WRSA. Mature or old broadleaf (deciduous) forests were given habitat suitability ratings of 1 ("High"), mature or old mixedwood forests were given habitat suitability ratings of 2 ("Moderate"), and mature or old coniferous forests were given habitat suitability ratings of 3 ("Low").
- Young forests and non-forested habitats were given a habitat suitability rating of 4 ("Nil").

2.5.4.1.3 Ratings Adjustments

The presence of roads and artificial lights can alter the commuting behaviour of bats (Stone *et al*., 2009; Bennett and Zurcher, 2012). However, the model presented here rates habitats based on their ability to provide roosting sites. Little brown myotis are unlikely to avoid anthropogenic structures or disturbances that either do not produce noise or produce minimal noise. This is because they frequently roost in anthropogenic structures such as attics, sheds, or cabins (Fenton and Barclay, 1980; Hubbs and Schowalter, 2003). Maternity roosts are also frequently located in buildings. For example, of the 269 maternity colonies investigated by Schowalter *et al*. (1979), 75% were located in occupied buildings. Little brown bats will also travel and forage along the edges of cutblocks (Hogberg *et al*., 2002). Therefore, no ZOIs were used for cutblocks, transmissions lines, vegetated trails, or seismic lines (Table C1.3-2). Additionally, no ZOIs were used for waste rock disposal areas, and rural residences.

Very little data is available on the effects of noise disturbance on roost site selection in bats. The sizes of the ZOIs for noise-producing disturbances are based on the recommended setback distances for northern long-eared bat (*Myotis evotis*), as outlined by the Government of Alberta (2013). Very noisy, high-intensity disturbances (such as the active railway, active coal mine, and coal conveyor) were assigned a ZOI of 100 m and a reduction in habitat-quality of 1 (Table C1.3-2).

2.5.4.1.4 Confidence Rating

The overall confidence rating of this model is "Moderate". Since roosting habitat for little brown myotis is affected by forest age and type (deciduous *vs* coniferous) (Olson, 2011), these two parameters were used to rate habitat suitability for the little brown myotis.

2.6 American Marten

Scientific Name: *Martes Americana.*

Status: General Provincial Status: "*Secure*", COSEWIC: "*Not Listed*", SARA Status: "*Not Listed*".

2.6.1 Distribution and Abundance

American martens occur throughout the forested regions of Canada, and occur in Alberta except for the southeastern prairie region. Populations are generally considered stable in Canada, except for Newfoundland and Nova Scotia, where populations are low.

In the central Selkirks in southern British Columbia, martens occur at an estimated density of 0.33 animals / km^2 (Mowat and Paetkau, 2002). American marten densities can vary with food abundance. In Ontario, one study found that a marten population occurred at a density of 0.4 animals / km^2 during a period of prey scarcity, and a density of 2.4 martens / km^2 when prey was abundant (Naughton, 2012). Small mammals such as voles are the primary prey of martens, but they will prey on a wide variety of rodents, lagomorphs, birds, amphibians, reptiles, fish, and invertebrates (Naughton, 2012).

Martens have very thick, soft fur and are therefore often trapped for their fur. Marten trapping is regulated in Alberta, and between 2009 and 2014, an average of 10,580 pelts were exported from the province (Government of Alberta, 2014).

2.6.2 Ecology and Key Habitat Requirements

Throughout their range, American martens are associated with coniferous forests (Koehler and Hornocker, 1977; Raine, 1983; Mowat, 2006; Kirk and Zielinski, 2009). The only exception to this is in northern Wisconsin, where martens may be associated with mature, mixed hardwood forests (Wright, 1999; Dumyahn *et al*., 2007). In the Selkirk and Purcell Mountains of southern British Columbia, Mowat (2006) found evidence of marten use in a variety of habitats, including recently logged areas, regenerating stands, dry Douglas fir forests, and subalpine forests. However, martens did display a preference for older stands with greater crown closure (Mowat, 2006). Several other studies have also indicated that martens prefer mature to old-growth, closed canopy forests (Koehler and Hornocker, 1977; Wilbert *et al*., 2000; Poole *et al*., 2004; Mowat, 2006; Kirk and Zielinski, 2009). Martens also avoid open habitats (Baldwin and Bender, 2008), and unlike fishers, will not travel across frozen lakes and rivers (Raine, 1983).

The preference of martens for mature to old-growth forest is likely related to their use of structures associated with downed, dead woody material, which is likely to be more abundant in old forests. Martens frequently hunt and rest in the subnivean zone during winter (Raine, 1987; Sherburne, 1993;

Wright, 1999; Wilbert *et al*., 2000), and they often access the subnivean zone around pieces of dead, woody material (Wright, 1999). They will also rest and hunt in snags and downed logs (Hargis and McCullough, 1984; Kirk and Zielinski, 2009). Wright (1999) and Baldwin and Bender (2008) found a positive association between marten use of a site and the volume of downed woody material.

American martens prefer mesic habitats over xeric ones (Mowat, 2006; Baldwin and Bender, 2008; Kirk and Zielinski, 2009), likely because wetter sites have higher primary productivity and a greater abundance of prey (Mowat, 2006). Voles, which are frequently a preferred prey for martens, are most abundant in mesic habitats (Koehler and Hornocker, 1972).

Reported home range sizes of martens vary widely and may be dependent on several factors, including sex, prey availability, forest type, and degree of fragmentation. In a largely undisturbed area of eastern Labrador, the mean home range size of female martens was 27.6 km^2 while the mean home range size of male martens was 45.0 km^2 with home range size being positively correlated with the proportion of bog and scrub forest within it (Smith and Schaefer, 2002). However, most studies report much smaller home ranges. For example, Steventon and Major (1982) found that the home range size for four martens in Maine ranged from 2.5 - 10 km^2, and Dumyahn *et al*. (2007) reported that the mean home range size for martens in Wisconsin were 4.25 km^2 (for males) and 2.32 km^2 (for females).

2.6.3 Responses to Disturbance

American martens generally respond negatively to roads, wide linear disturbances, and forest clearings. Such disturbances can alter the movement patterns of marten at a fine-scale and the proliferation of linear disturbances can lead to decreases in marten densities at the landscape scale. Martens are typically associated with old or mature forests, and have been reported to avoid non-forested areas while foraging (Cushman *et al*., 2011; Steventon and Major, 1982; Thompson and Harestad, 1994; Potvin *et al*., 2000). They also tend to avoid roads and areas surrounding them. For example, in the Northwest Territories, marten were reported to avoid industrial developments and roads by 100 m (AMEC Americas Ltd, 2005), and Robitaille and Aubry (2000) reported that marten tracks were significantly less abundant in habitats located near roads than habitats located further away. American martens also tend to avoid wide (> 3 m) linear disturbances, but not narrower ones (Tigner *et al*., 2015).

While marten generally avoid clearings, they will cross them under some circumstances. Koelher and Hornocker (1977) and Soutiere (1979) found that martens may cross openings up to 200 m wide, despite an increased risk of predation (Thompson and Colgan, 1994; Poole *et al*., 2004).

American marten populations are generally lower in cleared or fragmented landscapes. For example Hargis *et al*. (1999) found that American marten capture rates declined sharply when the percent forest cover of a landscape was lower than 75%. Marten capture rates were also negatively correlated with the extent of high-contrast habitat edges on a landscape (Hargis *et al*., 1999). Fisher *et al*. (2012) found that marten abundance was negatively associated with disturbed and fragmented habitats.

2.6.4 Habitat Suitability Model

Since American martens are likely to be under more nutritional and physiological stress during winter, habitat suitability for marten was rated for the winter period.

2.6.4.1 Model Ratings

There is a sufficiently detailed level of knowledge of marten habitat requirements in Alberta to warrant a 6-class rating scheme (Table C1.1-2). Ratings were developed based on ecosite phase, and disturbance type (Table C1.1-4).

2.6.4.1.1 Model Assumptions - WLSA

- The primary assumption made by the model is that American martens prefer mature to old-growth, dense, conifer-dominated habitats. Therefore, mature to old-growth mesic spruce-fir or mixed spruce-fir/pine forests were assigned a habitat suitability rating of 1 ("High").
- Mature to old-growth mesic lodgepole pine forests were given a habitat suitability rating of 2 ("Moderate-High").
- Young or open coniferous forests and mature to old-growth, mesic mixedwood sites were rated as 3 ("Moderate").
- Mature to old-growth deciduous sites were assigned a suitability rating of 4 ("Moderate-Low").
- Young, deciduous or mixedwood sites were given a suitability rating of 5 ("Low").
- Since open habitats are avoided by American martens, these areas were rated as 6 ("Nil").

2.7.4.1.2 Model Assumptions – WRSA

- The primary assumption made by the model is that American martens prefer mature to old-growth, dense, conifer-dominated habitats. The vegetation mapping for the WRSA does not differentiate among different conifer species. All closed or dense, mature or old coniferous forests were assigned a habitat suitability rating of 1 ("High"). Young, dense or closed coniferous forests were assigned a habitat suitability rating of 2 ("Moderate-High"), while open or moderate coniferous forests were assigned ratings of 3 ("Moderate") if dense or old, or 4 ("Moderate-Low") if young.

- Deciduous ("Broadleaf") forests were generally given low ratings, as American martens prefer coniferous forests. Mature or old broadleaf forests were given habitat suitability ratings of 4 ("Moderate-Low") while young broadleaf forests were given ratings of 5 ("Low").
- Dense or closed mixedwood forests were given habitat suitability ratings of 3 ("Moderate") if mature or old, or 4 ("Moderate-Low") if young. Open or moderate mixedwood forests were rated 4 if mature or old and 5 if young.
- Shrubby habitats were given ratings of 5 ("Low") while habitats lacking shrubs or trees were given ratings of 6 ("Nil").

2.6.4.1.2 Ratings Adjustments

Martens appear to avoid anthropogenic disturbances and the areas surrounding them. For instance, in the Northwest Territories, they avoided habitats within approximately 100 m of a road (AMEC Americas Ltd., 2005). Robitaille and Aubry (2000) found that martens would travel near roads but that that the density of marten tracks tended to be lower near them. A 100-m wide ZOI was therefore used for most roads in the WLSA, although the ZOI was expanded to 150 around Highway 3 because of the much higher traffic volumes (Table C1.3-2). The habitat suitability rating was decreased by one within the ZOIs. A 100 m wide ZOI was also used for railways, the coal processing plant, and urban areas while a 150 m-wide ZOI was established for the proposed open pit coal mine.

2.6.4.1.3 Confidence Rating

The confidence rating for this model is "Moderate". There is an abundance of data that indicate American martens prefer old or mature coniferous forests (Koehler and Hornocker, 1977; Raine, 1983; Wilbert *et al*., 2000; Poole *et al*., 2004; Mowat, 2006; Godbout and Ouellet, 2008; Kirk and Zielinski, 2009), so the model is likely to have value in predicting marten occurrence. However, the confidence rating for the model is "Moderate" rather than "High" because of the lack of data on marten habitat use in the WLSA. Only one marten was detected during the wildlife camera monitoring program.

2.7 Canada Lynx

Scientific Name: *Lynx Canadensis.*

Status: General Provincial Status: "*Sensitive*", COSEWIC: "*Not at Risk*", SARA Status: "*Not Listed*".

2.7.1 Distribution and Abundance

Canada lynx range across Canada from the interior of British Columbia to New Brunswick and Newfoundland. However, they are largely absent from the southern prairie regions of Alberta, Saskatchewan and southwest Manitoba, the mainland of Nova Scotia, and treeless areas of the north.

Canada lynx occur throughout the boreal forest of Alberta. Lynx population dynamics are closely related to snowshoe hare (their primary prey) population cycles (Elton and Nicholson, 1942; Mowat and Slough, 2003), particularly at higher latitudes. Lynx populations may fluctuate 3 – 17 fold over a 10-year snowshoe hare cycle, responding to changes in prey abundance with a lag of a 1 – 2 years (Poole, 2003). There is generally an increase in the relative magnitude of lynx population fluctuations with latitude (Murray *et al*., 2008). Lynx populations in Alberta are estimated to be fewer than 8,000 individuals during the lowest point of the population cycle (AEP, 2010). Although there are no indications of decline in Canada (Poole, 2003), the lynx is provincially listed as "Sensitive" in Alberta because of concerns over habitat lass and fragmentation.

2.7.2 Ecology and Key Habitat Requirements

Lynx habitat use generally corresponds to the abundance of their primary prey, the snowshoe hare (Murray *et al*., 1994; Poole *et al*., 1996). However, there appears to be a latitudinal gradient in lynx prey specialization, with southern populations supplementing their diet with additional prey species, such as red squirrels (Roth *et al*., 2007). Lynx may prefer early to mid-successional (11 – 26 years old) forests to hunt snowshoe hares during winter (Poole *et al*., 1996; Fuller *et al.*, 2006), although other studies have reported the preferential use of mature forest habitat (Squires *et al*., 2010). In the Alberta Rockies, hare densities are highest in early successional stands (Apps *et al*., 2000), and in Montana, they are highest in closed, young forests (Squires and Laurion, 2000). In Wyoming, Berg *et al*. (2012) found that high levels of horizontal cover, a multi-layered tree canopy, and a high shrub density were the best predictors of snowshoe hare density. Mature, late-seral spruce-fir forests, dense lodgepole pine forests, and multi-storied aspen-spruce-fir stands had the highest hare densities (Berg *et al*., 2012). Squires *et al*. (2010) found that, during winter, Canada lynx in western Montana preferentially hunted in mature, multilayer spruce-fir forests, while they avoided recent clear cuts and other open areas. Similar results were reported by Koehler (1990), who found that Canada lynx in south-central Washington preferred to hunt in lodgepole pine and spruce-fir forest. Snowshoe hares were most abundant in young (20-year old) lodgepole pine stands (Koehler, 1990).

Some sources suggest that mature and old-growth forests are necessary denning habitat for lynx (Westworth Associates Environmental Ltd., 2002), but this may not always be the case (Murray *et al*., 2008). Dens can be established in decaying logs, under tree root systems, and in rock crevices (Koehler and Aubry, 1994). Dense regenerating forests >20 years old provide many good denning opportunities (Koehler and Aubry, 1994; Mowat *et al*., 2000).

Male home range sizes are usually larger than those of females (Slough and Mowat, 1996; O'Donoghue *et al*., 2001). Male and female home ranges often cover 20 – 45 km^2 and 13 –21 km^2, respectively, at high hare densities, while home range size may increase 2 – 10 fold during periods of low hare densities (Poole, 2003). Lynx home ranges in the southern parts of their range can be quite large. For example, Squires and Laurion (2000) found that the mean home range size for lynx in Montana was 238 km^2 for males and 115 km^2 for females. Home ranges may also expand slightly during winter (Vashon *et al*., 2008). Females usually bond in pairs (either mother-daughter or sibling pairs), which may reduce the individual investment in territorial defence (Mowat *et al.*, 2000). Territories among kin may be relaxed, possibly leading to localized high lynx density (Mowat *et al*., 2000). Densities can range from 2 – 45 individuals/100 km^2 (Poole 2003). In the southern Canadian Rockies, lynx populations are generally low and do not appear to undergo the cyclic pulses in productivity that characterize more northern populations (Apps *et al*., 2000).

Under some circumstances (*e.g.* low prey density), lynx may disperse distances of >500 km (Poole, 1997). As with many species, juveniles are the primary dispersers in lynx metapopulations; however, there are also adult dispersal events in response to environmental changes (*i.e.*, environmental dispersal; Howard, 1960) such as hare declines (Poole, 2003). The probability of adult dispersal in the Northwest Territories at the peak of the snowshoe hare cycle is relatively low (24%), very high during the first few years of low hare densities (78 – 100%), and stabilizes at <20% during the third and fourth years of low hare densities (Poole 1997).

2.7.3 Response to Disturbance

Lynx generally avoid areas with a human presence. Lynx are most sensitive to disturbance while denning in spring (Mowat *et al*., 2000). Lynx will avoid clearings and areas with a high level of disturbance (*i.e.*, human activity) or greater fragmentation (Koehler and Brittell, 1990; Mowat *et al*., 2000). Although lynx will readily cross highways, habitat fragmentation will likely interfere with lynx activity and highly fragmented areas or those with high levels of disturbance may be avoided (Mowat *et al.*, 2000). Habitats within 250 m of large cleared areas and areas of high human activity would likely less suitable for lynx than more isolated sites (Westworth Associates Environmental Ltd., 2002). Fuller *et al*. (2006) found that lynx avoided a 30 m zone adjacent to unused roads in winter, either because of the presence of competing predators (coyotes) or the lack of prey species.

2.7.4 Habitat Suitability Model

Winter is likely the most limiting period for lynx, as their survival tends is lowest during winter (Poole, 1994; O'Donoghue *et al*., 1995). Habitat suitability for lynx was rated for the winter period.

2.7.4.1 Model Ratings

There is a sufficiently detailed level of knowledge of lynx habitat requirements in Alberta to warrant a 6-class rating scheme (Table C1.1-1). Suitable feeding habitat is critical if Canada lynx are to persist in an area, so suitable feeding habitat was given the highest ratings for ecosite phases in the WLSA (Table C1.1-4) and ELC land cover classes in the WRSA (Table C1.1-5). Snowshoe hare are the preferred prey of Canada lynx, so habitat that is suitable for snowshoe hares was considered suitable Canada lynx habitat.

2.7.4.1.1 Model Assumptions - WLSA

In the mountainous, southwestern part of their range, Canada lynx appear to use forests with a high degree of horizontal cover (Squires *et al*., 2010). Lynx display an aversion to open habitat (Koehler, *et al.* 2008), so sites lacking a canopy were assigned a lower habitat suitability rating than similar sites with an overstory. The winter snowshoe hare diet consists primarily of deciduous browse, such as dwarf birch, willow, and buffaloberry, although some coniferous species are occasionally used. Ecosite phases dominated by conifers and that have high amounts of woody browse were assigned the highest habitat suitability ratings. Many studies also indicate that snowshoe hares prefer conifer-dominated habitat during the winter (reviewed by Hoover *et al*., 1999). Based on this information, the following assumptions were made:

- In both the Montane and Subalpine Natural Subregions, drier ecosites (a or b) often have poorly-developed shrub layers and open canopies and were therefore given a habitat suitability rating of 5 (“Low”).
- In the Montane Natural Subregion, “c” ecosites often have a sparse understory and frequently have open canopies. Coniferous and mixedwood ecosite phases (c1, c2, and c4) were given a suitability rating of 4 (“Moderate-Low”), and the deciduous ecosite phase (c3) was given a rating of 5 (“Low”). Deciduous forests provide little horizontal cover during the winter.
- In the Montane Natural Subregion, “d” ecosites have better developed understories than “c” ecosites and are likely to be conifer dominated and were therefore assigned a suitability rating of 3 (“Moderate”). Conifer-dominated “e” ecosites (e1 and e3) were given a suitability rating of 2 (“Moderate-High”). Ecosite phases e2, f1, and g1 are deciduous-dominated or have a significant deciduous component but have well-developed shrubby understories and were given a suitability rating of 4 (“Moderate-Low”).
- Montane ecosite phase g2 is dominated by white spruce and was given a suitability rating of 3 (“Moderate”).
- Subalpine ecosite phases c1 and d1 often have open canopies and were given a suitability rating of 4 (“Moderate-Low”).
- Subalpine ecosite phases e1, e2, and e3 are conifer-dominated and have better-developed understories than a, b, c, or d ecosites and were given a rating of 2 (“Moderate-High”).
- Subalpine ecosite phases f1 and f2 are dominated by lodgepole pine, Engelmann spruce, and/or subalpine fir and have well-developed shrub layers compared to other ecosite phases in the region. These ecosite phase were assigned a rating of 1 (“High”).
- Subalpine ecosite phase g1 lacks trees and was given a rating of 5 (“Low”).

- Subalpine ecosite phase h1 is dominated by Engelmann spruce, but has a thin shrub layer and was given a rating of 4 ("Moderate-Low"). Subalpine ecosite phase h2 lacks trees and was given a rating of 5 ("Low").
- Canada lynx are generally most common in young (Koehler and Aubry, 1994; Mowat and Slough, 2003) or mature (Squires *et al*., 2010; Berg *et al*., 2012) forest stands. Thus, for all forested ecosite phases, old forests had their habitat suitability ratings increased by 1, to a maximum value of 5 ("Low").
- Shrubby habitats lacking tree cover were assumed to have little value for lynx, and were assigned a rating of 5 ("Low").
- Anthropogenic landscape features, vegetated land with few shrubs, and non-vegetated land were given a suitability rating of 6 ("Nil").

2.7.4.2 Model Assumptions – WRSA

- Closed or dense conifer-dominated forests were assigned the highest habitat suitability rating (1, "High"). Young, dense lodgepole pine forests and mature, dense spruce-fir forests tend to provide the highest quality Canada lynx habitat (Squires *et al*., 2010; Berg *et al*., 2012); however, the WRSA vegetation data does not differentiate among tree species. Therefore, young or mature, closed or dense conifer forests were given the same rating.
- Mixedwood forests were assumed to provide some cover and forage and were given ratings of 3 ("Moderate") to 4 ("Moderate-Low"), depending on their density.
- Deciduous forests were given ratings of 4 and treeless habitats were given a rating of 5 ("Low").
- The alpine subregion and disturbed or non-vegetated land were given ratings of 6 ("Nil").

2.7.4.2.1 Ratings Adjustments

Canada lynx will sometimes cross highways (Squires *et al*., 2013), although they are crossed less frequently than would be expected by chance (Apps *et al*., 1999). This suggests lynx often avoid roads and similar anthropogenic disturbances. Since lynx will likely avoid noisy anthropogenic disturbances, habitat quality around such features was decreased with the size of the ZOI dependent on disturbance type and intensity. A 100-m ZOI was used around disturbances with moderate levels of noise (gravel roads, and industrial facilities) (Table C1.3-1). Disturbances that produce constant and high levels of noise, such as Highway 3, the proposed active coal mine, and the proposed coal conveyor line, were assigned a ZOI of 150 m. Active railways were also given a ZOI of 150 m because of the high level of noise and vibration produced by trains. Habitat suitability was increased by one within these ZOIs. Disturbances that produce little or infrequent noise (such as vegetated trails, cutblocks, and inactive well sites) were not assigned a ZOI. Rural residences were assigned a ZOI of 30 m (Table C1.3-1).

2.7.4.2.2 Confidence Rating

Numerous studies indicate that, during the winter, Canada lynx are associated with habitats that provide a high level of horizontal cover (*i.e.* coniferous or mixedwood habitats) and woody browse and cover for their primary prey species (the snowshoe hare) (reviewed in Westworth *et al*., 2002; see also Squires *et al*., 2010; Berg *et al*., 2012). Thus, the model presented here is likely to have value in predicting habitat use by lynx in the study area. However, because of the low number of lynx detected in the WLSA by the camera trapping program, the confidence rating of the model is "Moderate".

2.8 Elk (Wapiti)

Scientific Name: *Cervus elephus.*

Status: General Provincial Status: "*Secure*", COSEWIC: "Not At Risk", SARA Status: "*Not Listed*".

2.8.1 Distribution and Abundance

Elk formerly occurred throughout Alberta except in the far north (Naughton, 2012). They are now largely restricted to the mountains and foothills in the western part of the province, the Cypress Hills, the Canadian Forces Base at Suffield (50 km north of Medicine Hat), and Elk Island National Park. Elsewhere in Canada, elk occur in southeastern British Columbia, Vancouver Island, and in scattered populations in Saskatchewan, Manitoba and southern Ontario.

Elk are not at risk in Alberta and are highly valued by hunters and wildlife watchers. During 2013, 7,132 elk were legally harvested by resident hunters (AESRD, 2013), 94 of which were harvested in Wildlife Management Units (WMUs) 303 and 402 (AESRD, 2013). Both of these WMUs overlap with the WLSA.

2.8.2 Ecology and Key Habitat Requirements

Elk are grazers and feed primarily upon grasses and forbs, although they will also eat shrubs, particularly during the fall when shrubs can comprise up to 30% of their diet (Hebblewhite *et al*., 2008). They may also eat shrubs during winter, particularly if snow depths exceed 60 cm (Skovlin, 1982). During the winter, elk also require forest cover for thermal protection, and good elk winter ranges typically have an interspersion of food and cover components. Most elk foraging occurs within 200 m of forest cover (Cairns and Telfer, 1980; Lyon, 1980).

Elk can be migratory, and a single population can include both migratory and non-migratory individuals (Hebblewhite *et al.*, 2008). Migration in elk appears to be driven by selection for high-quality forage, with the timing of migration influenced by snowfall and snow melt. Elk will generally migrate to areas where they can maximize their energy intake, and in summer these are areas with intermediate forage biomass (Hebblwhite *et al*., 2008). Energy intake is maximized at intermediate forage biomass, because as plants mature and their biomass increases, their digestibility declines. However, a plant community at a very early phenological stage will have low biomass, which limits intake rates for grazers.

Resident (non-migratory) elk in west-central Alberta display habitat selectivity during the summer, but it is at a fine scale, typically selecting areas with the highest biomass (Hebblewhite *et al*., 2008). The forage quality exposure for resident elk in west-central Alberta is lower than that of migratory elk, but they have more opportunities to selectively forage on high-quality plants during high biomass years (*i.e.*, with high levels of precipitation) (Hebblewhite *et al*., 2008).

Habitat selection for elk, whether resident or migrant, differs among seasons. In Yellowstone National Park, elk selected areas with high vegetation diversity during the summer. They also selected areas that were burned during the past 12-14 years (Boyce *et al*., 2003). However, during winter, they avoided burned areas and moved to lower elevations and selected landscapes with a mixture of open areas and forests (Boyce *et al*., 2003). Elk in mountainous areas typically move to lower elevations at the onset of winter in response to the higher snow depths at higher elevations. In British Columbia, elk mobility has been reported to be restricted when snow depths exceed 60 cm (RIC, 2002). Elk also choose areas with some forest cover during winter, as forested areas can provide thermal cover and cover from predators. Additionally, if grass becomes unavailable during winter, elk may switch to foraging on shrubs or conifers (Singer, 1995).

Overall, elk appear to select open, grassy habitats with high biomass for foraging during the winter. Jones and Hudson (2002) found that elk in west-central Alberta used open, grassy meadows more frequently during winter than expected based on their availability. They also found that feeding sites used by elk had more grass cover, lower canopy closure, a lower shrub percent, lower tree heights, and lower stem densities than unused areas. The home ranges of elk also contained a high amount of 'edge' habitat. Elk home ranges had smaller mean forest patch sizes but a higher number of forest patch sizes than unused available home ranges (Jones and Hudson, 2002).

Forage availability can be limiting for elk during the winter, and is one of the major variables that influence home range size in elk. For example, Wolf *et al*. (2009) found that herbaceous biomass was an important predictor of elk habitat use during winter, and Anderson *et al*. (2009) found that the winter home range sizes of elk in Alberta and Wisconsin decreased with increasing forage biomass. Snow cover also influences habitat selection and winter home range sizes of elk. The size of winter home ranges of elk has a positive relationship with snow-water equivalents (an index of snow depth and density) (Anderson *et al*., 2009). Ungulates generally select foraging areas with lower snow depths and they may need to travel more extensively in areas with high snowfall to find suitable foraging areas. Wolf predation rates on elk are also higher in areas with deep snow (Hebblewhite *et al*., 2002), so elk may also avoid areas with deep snow to avoid predation.

The size of elk winter home ranges varies across populations. In the Kootenay Trench of British Columbia, the winter range sizes for three elk herds varied from 216-521 km^2 (Arc Wildlife Services, 2005). However, elk in the Castle-Carbondale herd (located just south of the WLSA) had home ranges of 58.8 km^2 and 71.3 km^2 in 1996 and 1997, respectively (Arc Wildlife Services, 2005). Elk home ranges are generally smaller where resources (forage and cover) are abundant (Anderson *et al*., 2005).

2.8.3 Response to Disturbance

Elk display variable responses to human activity and disturbances. They may avoid some types of disturbance (such as busy roads) and be attracted to others, particularly if they can lower their predation risk by associating with areas with high human activity. Their response to human disturbance can also vary seasonally. For example, elk populations that are hunted may avoid roads and seismic lines during the fall. Elk will also avoid very noisy disturbances (such as construction sites) but may return to the disturbed area once the activity is over (Jones, 1997).

Ciuti *et al*. (2012) examined the behavioral responses of elk to human disturbance. They found that elk displayed higher levels of vigilance near roads that had traffic volumes of at least one vehicle every two hours. Increased vigilance (*i.e.* increased time spent scanning for predators) has a cost associated with it in terms of decreased feeding time. Thus, habitat close to roads may have decreased value to elk. However, Ciuti *et al*. (2012) note that elk can habituate to the presence of roads where hunting is prohibited. Rost and Bailey (1979) also found that elk in hunted populations avoided roads more than elk in unhunted populations.

Many studies have found that elk generally avoid areas with high road densities. For example, Jones and Hudson (2002) found that elk winter home ranges had lower road densities than control areas. However, elk winter home ranges had high densities of unimproved access routes (such as seismic lines, cut lines, power lines and gas line rights of way) (Jones and Hudson, 2002). This is likely because elk will use such areas for travel and foraging. Rost and Bailey (1979) also found that elk would avoid areas within 200 m of a road, and that this affect was greater along heavily travelled roads. In a brief review of literature on the effects of roads and traffic on elk, McCorquodale (2013) reported that elk habitat use within 200 – 500 m of higher traffic volume roads was reduced by up to 50% compared to areas further away. He also reported that off-highway vehicles negatively affected elk at distances up to 1,000 m from a trail. In contrast, Dodd *et al*. (2007) found that elk in Arizona appeared to be attracted to a highway right-of-way because of the presence of meadow and riparian habitats that were used for foraging. Although elk would cross the highway, overall landscape permeability was decreased due to the presence of the highway. Elk avoided crossing the highway in areas with higher traffic volumes, although physical size of the highway footprint did not appear to influence elk crossing rates.

Under some circumstances, elk can habituate to and even be attracted to human activity and development. For example, resident elk at the Ya Ha Tinda Ranch used areas near high human activity because wolves (their main predator) tended to avoid humans (Hebblewhite and Merrill, 2009; Robinson *et al*., 2010). Elk can also be attracted to cleared areas (such as seismic lines), which may provide a high-quality foraging habitat. However, they will avoid seismic lines during the fall hunting season, and they may avoid seismic lines that are heavily used by humans (Jones, 1997).

Elk in Jasper National Park have congregated around the golf course there, likely because wolves avoid the area due to the high levels of human activity (Shepherd and Whittington, 2006). However, once a wooded corridor was built through the golf course (so wolves could travel through), elk started to reduce their use of the golf course (Shepherd and Whittington, 2006).

Disturbed areas that are attractive to elk can function as population sinks if they are associated with sources of mortality (Webb and Anderson, 2009). For example, a road can function as a sink if elk are attracted to vegetation next to it but also suffer increased mortality due to being hit by vehicles (Webb and Anderson, 2009).

2.8.4 Habitat Suitability Model

2.8.4.1 Model Ratings

Two habitat models were developed for elk: a winter habitat model and a summer habitat model. Based on what is known about elk habitat use, a six-class rating scheme was used to rate elk winter and summer habitat use (Table C1.1-2). Ratings were based on ecosite phase, elevation, structural stage, and disturbance type for the WLSA (Table C1.1-4) and on ELC land cover class for the WRSA.

2.8.4.1.1 Model Assumptions – WLSA and WRSA Winter Habitat

- Numerous studies indicate that elk prefer to forage on open, grassy meadows during winter. Based on this information, grassy habitats were given a habitat suitability rating of 1 (“High”) while, shrubby habitats were given a habitat suitability rating of 2 (“Moderate-High”).

- Elk typically use lower elevation habitats in winter. Thus, montane habitats were assigned higher ratings than subalpine habitats.
- Ecosite phase a1 is characterized by open forest and a grassy understory, which is frequently composed of fescue, an important forage species for many ungulates. This ecosite phase is also often windswept and has lower snow depths during winter. This ecosite phase was given a rating of 2 ("Moderate-High") in the Montane Natural Subregion and a 3 ("Moderate") in the Subalpine Natural Subregion.
- The "b" ecosite often occurs on south-facing slopes and is characterized by open forests with understories composed of pine grass and hairy wild rye, which are important forage species for elk. These ecosites were given ratings of 2 ("Moderate-High") or 3 ("Moderate) for the Montane Natural Subregion or 4 ("Moderate-Low") for the Subalpine Natural Region.
- During winter, elk often prefer landscapes composed of a mosaic of open foraging habitat and dense forest for cover. They often forage near forest cover. However, because forest is not limiting in the WLSA, distance to cover was not considered when rating foraging habitat in the WLSA.
- Distance to cover was considered in the WRSA model. Open, grassy habitats, open shrublands, regenerating habitats, and open deciduous forests were assigned a rating of "1" ("High") ≤300 m of high-quality cover habitat (such as a dense coniferous forest), and a rating of "2" ("High-Moderate") when >300 m from cover. Elk show greater use of forage when it is ≤300 m of cover (Leckenby, 1984).
- When snow depth is >60 cm, elk may switch to foraging on shrubs. Montane, deciduous "e" or "f" ecosites were a given ratings of 3 ("Moderate") as they often have well-developed shrub layers. They also have balsam poplar and trembling aspen, which can be an important food source for elk, especially during winter (Kufeld, 1973).
- Elk will use forest as escape cover from predators and for thermal cover, so dense, closed, coniferous forests in the WLSA were assigned ratings of 3 ("Moderate") for the Montane Natural Subregion and 4 ("Moderate-Low") for the Subalpine Natural Subregion. Thermal cover for elk is best provided by closed conifer stands (Skovlin, 1982).
- In the WRSA model, closed or dense coniferous habitats in the montane subregion were given ratings of 3 ("Moderate") or 4 ("Moderate-Low") because they can provide thermal cover. They were rated 3 when located ≤300 m of high-quality foraging habitat. Elk use of cover is greatest when it is within ≤300 m of foraging habitat (Leckenby, 1984).
- Although elk require grass and shrubs (for foraging) and closed forests (for thermal cover) during winter, grassy habitats are more limiting in the WLSA and the WRSA and were given a higher habitat suitability rating than habitats that provide thermal cover.

- Non-vegetated ecosites in the WLSA and habitats within the Alpine Natural Subregion in the WRSA were assigned a rating of 6 ("Nil") since elk are not expected to use these areas in winter.

2.8.4.1.2 Model Assumptions – WLSA and WRSA Summer Habitat

In mountainous areas, elk may move to higher elevations during the spring and summer (Boyce, 1991; Boyce *et al*., 2003). Montane and subalpine habitats were therefore given similar ratings in the growing season habitat model.

- Elk forage primarily on grasses and shrubs during spring with forbs becoming more important in summer (Kufeld, 1973). However, elk use of grasslands remains high year round (Cairns and Telfer, 1980). Therefore, grassland and open shrubby habitats were given ratings of 1 ("High") in the WLSA model and ratings of 1 or 2 ("High" or "High-Moderate") in the WRSA model. In addition, ecosite phase a1 was given a rating of 2 ("Moderate-High") because of the presence of a well-developed grass layer (Archibald *et al*., 1996).
- "B" ecosite phases were given a rating of 4 ("Moderate") as they often have grassy understories, although the grass layer may be sparse (Archibald *et al*., 1996). Because the grass layer is sparse, other sites are more likely to be used by elk for foraging during spring and summer.
- Since elk will forage in cutblocks (Lyon and Jensen, 1980), this habitat type was assigned a rating of 2 ("Moderate-High"). Elk may also select for burned habitats in summer (Boyce *et al*., 2003), and they frequently forage in habitats at young seral stages (including cutblocks) (Lyon and Jensen, 1980; Fisher and Wilkinson, 2005). Therefore, regenerating habitats were given ratings of 1 ("High") or 2 ("Moderate").
- Although elk may not require forest cover for thermal protection during spring and summer, elk appear to rely on forest cover to hide from predators (Creel *et al*., 2005). However, because forest habitats are not limiting in the WLSA and patches of open foraging habitat tend to be small, distance to cover was not considered in the WLSA model. It was, however, considered in the WRSA model. The rating of high-quality foraging habitat (including grasslands, open shrublands, and regenerating habitats) was decreased by one when it was ≤300 m of high-quality "cover" habitat (moderate, closed or dense coniferous forests).
- Elk in mountainous areas of Utah showed a preference for aspen-dominated habitats (Beck *et al*. 2013), potentially because aspens provide forage for elk across all seasons (Kufeld, 1973). Additionally, aspens often occur where high snowpack allows for the growth of other shrubs, grasses and forbs that make up a large proportion of elk diets (Beck, *et al*. 2013). Elk in northern British Columbia also display a preference for deciduous habitats during spring and fall (Parker and Gillingham, 2007). In the WLSA model, aspen-

dominated ecosite phases (montane c3, c4, e2, and f1) were given ratings of 3 ("Moderate"). In the WRSA model, deciduous forests were given ratings of 3 ("Moderate").

- When not foraging, elk often rest in cool, shaded habitats with high levels of shrub cover (Frair *et al*. 2005). They often stay in or near coniferous forests during times of high predation risk (Creel *et al*. 2005). Moderate or closed coniferous forests were given ratings of 4 ("Moderate-Low"), except in the WRSA model, where they were given ratings of 3 ("Moderate") if within 200 m of high-quality foraging habitat.
- Other vegetated habitats were given a rating of 5 ("Low").
- Non-vegetated habitats were given a rating of 6 ("Nil").

2.8.4.1.3 Ratings Adjustments

Since elk avoid noisy disturbances, the rating of any habitat falling within 200-300 m of high human activity (Highway 3, railways, urban areas, and proposed mine dumps) and 500 m of the proposed active coal mine was increased by a factor of 1 (Table C1.3-1). A ZOI of 100-200 m was placed around disturbances with moderate levels of noise and human activity, such as gravel roads, transmission lines, and pipelines. Disturbed areas left to regenerate (*i.e.* cutblocks, inactive well sites, and seismic lines) were assumed to have no impact (Morgantini 1996, Arc Wildlife Services 2004).

2.8.4.1.4 Confidence Rating

The confidence rating for the elk model is "High," as it is based on numerous studies on elk habitat preferences. Additionally, wildlife camera data from the study area is consistent with the model, as elk were most frequently detected in grassland habitat, which was given the highest suitability index.

2.9 Moose

Scientific Name: *Alces alces*

Status: General Provincial Status: "*Secure*", COSEWIC: "*Not At Risk*", SARA Status: "*Not Listed*".

2.9.1 Distribution and Abundance

Moose occur throughout the forested portions of Alberta, including the Cypress Hills. They also occur naturally throughout forested regions in Canada, including Newfoundland, where they have been introduced. Moose are not considered to be at risk in Alberta, and have a general provincial status of "Secure". However, they are highly valued by traditional users and recreational hunters for subsistence and sport hunting. Moose are also valued for wildlife viewing and photography. An estimated total of 7,748 moose were harvested by resident hunters throughout Alberta in 2014 (AEP 2015), but in the WMUs (303, 306, and 402) that overlap the WLSA and WRSA only an estimated ten were harvested in 2014 and nine in 2013 (AEP 2015).

2.9.2 Ecology and Key Habitat Requirements

Moose habitat use is affected by various factors including forage availability, thermal and escape cover requirements, snow conditions, and reproductive status. Overall, areas that provide a mosaic of dense deciduous or coniferous forest for cover and open, early successional shrub areas for foraging are preferred by moose.

Moose feed primarily on woody vegetation, although they also consume herbaceous aquatic plants during spring (Naughton 2012). During summer, they select leaves and new shoots from shrubs, and during winter, they feed on the youngest shoots that are available to them (Naughton 2012). During the late winter, and particularly if conditions are poor, they may also strip the bark off of trees and feed on tree cambium (Naughton 2012), and they may feed on grass and forbs during winter if wind has blown the snow off of them (Telfer 1988). Moose will also feed on coniferous trees (primarily young subalpine fir) during the late winter if deep snow has made many shrubs inaccessible (Tyers 2003).

Some moose occupy distinct summer and winter home ranges, while others may use the same home range year round (Naughton 2012). Moose may have their summer and winter needs met in the same home range because deciduous shrubs can provide forage during both seasons and dense coniferous forests can provide shelter from the sun during summer and from deep snow during the winter (Dussault *et al.* 2006a). However, moose in mountainous areas often shift their ranges to lower elevations during winter (Maier *et al*. 2005) to avoid deep snow.

Home range sizes for moose vary considerably in Alberta. For example, Hauge and Keith (1981) reported that moose home ranges in northeastern Alberta varied from 3 - 111 km^2 (mean 30 km^2) with no differences between cows and bulls. In contrast, the mean winter home range size of moose in northcentral Alberta was smaller at 15 km^2 (range 2 - 54 km^2) with little difference between the sexes (Mytton and Keith 1981). Winter moose home ranges in the Boreal Foothills Ecoregion were larger, averaging 51.6 km^2 and 46.8 km^2 for bulls and cows, respectively (Lynch 1986 cited in Romito *et al*. 1999) while moose in northcentral Alberta had home ranges sizes between 42 and 47 km^2 (Lynch and Morgantini 1984).

Although moose may use dense forests as protection from predators and thermal extremes, they appear to select habitat primarily on the availability of suitable browse and may respond more to food availability than cover when compared to other ungulates (Kearney and Gilbert 1976; Brusnyk and Gilbert 1983, Dussault *et al.* 2006a, Poole and Stuart-Smith 2006, Wasser *et al*. 2011), which includes deciduous trees and shrubs (Timmermann and McNicol 1988). Moose generally select woody browse year-round (McNichol and Gilbert 1980, Renecker and Hudson 1993, Franzmann and

Schwartz 1997), although the importance of such browse species increases in winter when herbaceous vegetation is largely unavailable.

Moose require large amounts of woody browse, preferring willow, paper birch, aspen, balsam poplar, saskatoon, red-osier dogwood, chokecherry, beaked hazelnut, and low and high bush cranberry (McNichol and Gilbert 1980, Brusnyk and Gilbert 1983, Renecker and Hudson 1993, Franzmann and Schwartz 1997). These species are typically found in shrubby wetlands (*i.e.,* willow), early seral forests (Kelsall *et al*. 1977), and deciduous-dominated stands. Kelsall *et al*. (1977) and Maier *et al*. (2005) reported moose favour early successional habitats 11 – 30 years after burning. In southwest Alberta, moose were typically associated with shrublands and aspen forests, which provide the highest abundance of forage (Telfer 1988). In central Alberta during winter, moose are most abundant in young forest stands, likely due to their high densities of shrubs, saplings, and willows (Stelfox *et al*. 1995). Moose also used old forests, which can have more abundant shrubs due to an increased number of gaps in the canopy (Stelfox *et al*. 1995). Moose may also make extensive use of riparian habitats that have high densities of willow, as willow is a preferred moose food wherever it occurs (Tyers 2003, Maier *et al*. 2005).

Aquatic habitats can also provide an important source of high-quality forage for moose in the early spring and fall periods (Hauge and Keith 1981). This is likely related at least in part to the deficiencies of sodium moose develop over the winter (Ohlson and Staaland 2001). Aquatic vegetation can serve as an important source of sodium. Upland vegetation, however, may have relatively high protein value (Oldemeyer 1974), and therefore is preferred through the summer and winter (Hauge and Keith 1981). Moose may also occasionally select coniferous wetland habitats as well (Osko *et al.* 2004). Wetlands have a disproportionate value for moose as they are an important source of forage, and during the summer, moose may use them to moderate their body temperatures (Courtois *et al*. 2002).

Habitat selection in moose may also depend on predator stress. Females with calves may primarily select habitat that offers the best protection from predators. Moose may also avoid areas with shallow snow that would otherwise facilitate wolf movement (Dussault *et al*. 2006a).

Snow depths of 60 cm or greater can restrict movement by cows and calves while 90 cm is considered the "critical" depth for moose (Peek *et al.* 1982). As winter progresses and snow depth increases, moose often reduce their movements and become confined to restricted areas. Some moose also undertake seasonal movements or habitat shifts based on snow cover. Using radio-telemetry, Hauge and Keith (1981) documented moose movements from summer ranges in the Birch Mountains and Muskeg Mountains to lower elevation winter ranges near the Athabasca River and Muskeg River.

In mountainous areas, elevation can be a major determinant of habitat selection in moose during the winter. Poole and Stuart-Smith (2006) reported that decreasing elevation was the strongest determinant of later-winter habitat use by female moose in southeastern British Columbia, likely because snow cover is typically lower at lower elevations. Moose also selected for gentler and south- and west-facing slopes.

Whether moose require a large area of mature coniferous forest appears to depend on the region and winter severity. Poole and Stuart-Smith (2006) found no evidence that female moose shifted their home ranges to areas with high crown closures. However, other studies suggest that dense coniferous forests are important habitats for moose during the winter (Pierce and Peek 1984). Late successional stage forests are used extensively by moose in Yellowstone during late winter, as they provided the least energetically-expensive travel routes and the highest amount of browse (Tyers 2003).

2.9.3 Response to Disturbance

Moose are attracted to some types of human disturbances and avoid others. Moose can benefit indirectly from forest harvesting, which revert forest stands to earlier seral stages containing an abundance of preferred browse species. Older cutblocks, well pads, and seismic lines can act as sources of shrubby forage for moose (McNichol and Gilbert 1980, Brusnyk and Gilbert 1983). There is also potential for cervids, including moose, to be attracted to early seral vegetation along roadways (Dussault *et al*. 2006b), as well as to salt during winter (Laurian *et al*. 2008). Although these sources of nutrients may benefit moose during times of deficit, proximity to roadways has the potential to increase mortality through collisions (Dussault *et al*. 2006b) and hunting pressure. Moose appear to benefit most from development where direct interaction with humans is minimal, such as with regenerating cutovers, seismic lines, or other features.

Moose may avoid habitat around developments because of sensory disturbance (Westworth, Brusnyk and Associates 1991), altered vegetation (Yost and Wright 2001), increased risk of vehicular collisions (Dussault *et al*. 2006b, Laurian *et al.* 2008), and increased access for predators and hunters (Laurian *et al*. 2008). Moose avoided a heavy oil extraction facility in the Cold Lake area of Alberta by at least 300 m (Westworth, Brusnyk and Associates 1991) because of the high density of above-ground pipelines. In Quebec, moose avoided busy highways (1,460 – 2,800 vehicles/day) by 500 m to 2,000 m, and quiet forest roads by up to 1,000 m (Laurian *et al*. 2008). In contrast, Stelfox *et al*. (1995) reported that distance to roads or cutlines appeared to be unimportant to moose in the winter in Alberta. Similarly, Westworth *et al*. (1989) observed concentrations of moose using winter habitats located within 100 m of an active open pit copper mine in north-central British Columbia that had been operating for 17 years. They concluded that moose were responding to the greater availability of browse located near mine than in areas located farther away. In addition, restrictions on hunting in the vicinity of the mine and perhaps the aversion of wolves to areas of concentrated human and industrial activity may have provided a greater degree of security not present in areas further away from the active mine site (Westworth *et al*. 1989).

2.9.4 Habitat Suitability Model

2.9.4.1 Model Ratings

A six-class rating scheme was used to rate the suitability of moose wintering habitat (Table C1.1-2). Ratings were based on ecosite phase, elevation, structural stage, and disturbance type for the WLSA (Table C1.1-4) and on ELC land cover class for the WRSA. Habitat ratings for moose were focused on food availability since this is an important limiting factor during this time of negative energy balance.

2.9.4.1.1 Model Assumptions - WLSA

- Since snow depth affects food availability and the need for thermal and escape cover, habitat suitability for moose decreases as elevation increases during the winter period. Therefore, montane habitats were generally rated higher than subalpine habitats because moose typically move to lower elevations during the winter period.
- Montane deciduous habitats were generally given a high habitat suitability rating (1, “High”) because they contain high amounts of browse. However, deciduous “b” ecosites were given lower ratings as they often have sparse shrub cover (Archibald *et al.* 1996).
- Montane mixedwood stands were ranked as “Moderate-High” (2) to “Moderate” (3) quality for moose because of the interspersion of browse and coniferous cover.
- Ecosite phases a1 and b1 were given a habitat suitability rating of 5 (“Low”) as they are characterized by open forests and sparse shrub cover (Archibald *et al*. 1996), and thus provide limited browse or cover for moose.
- Moist, montane coniferous forests were given a habitat suitability rating of 3 (“Moderate”) because moose often make extensive use of them during late winter when snow depth is high, particularly when these ecosite phases are adjacent to browse producing areas.
- Because moose display a preference for riparian habitat, a 100 m buffer zone was placed around all hydrological features, including creeks, rivers, ponds and lakes. Habitat within the buffer zone was given a rating of 2 (“Moderate-High”).
- Subalpine coniferous forests were given suitability ratings of 4 (“Moderate-Low”) or 5 (“Low”).
- Non-vegetated areas were given a rating of “nil” (6).

2.9.4.1.2 Model Assumptions – WRSA

- During winter, moose are frequently associated with early successional deciduous forests. Such habitat was given a habitat suitability rating of 1 ("High"). Moose may also forage in older deciduous forests, especially if there are gaps in the canopy that allow abundant shrubs to grow. Such habitats were given a rating of 2 ("Moderate-High").
- Mixedwood forests provide browse opportunities and thermal/escape cover for moose and were therefore assigned ratings of 2 ("Moderate-High") or 3 ("Moderate"), depending on stand age.
- Coniferous forests in the subalpine were given a rating of 5 ("Low"), as moose often move to lower elevations during winter, except where these forests occurred around hydrological features.
- Moose display a preference for riparian habitat throughout the year. To account for this, a 100 m buffer zone was placed around all hydrological features in the WRSA, including creeks, rivers, ponds and lakes. Habitat within the buffer zone was given a rating of 2 ("Moderate-High") in the montane subregion and 3 ("Moderate") in the subalpine subregion.
- Montane closed-canopy or dense coniferous forests were given a suitability rating of 4 ("Moderate-Low"), as they can provide thermal cover for moose during very cold or windy weather.
- Open coniferous forests were assigned a suitability rating of 5 ("Low"), as they are unlikely to provide forage or thermal cover for moose during winter.
- Alpine subregion habitats were given a rating of 6 ("Nil").

2.9.4.1.3 Ratings Adjustments

Moose may avoid human activity and roads by up to 300 m (Westworth, Brusnyk and Associates 1991, Yost and Wright 2001); however, moose were reported to use higher browse producing areas within 100 m of an active mine site (Westworth *et al*. 1989). Therefore, the suitability of ecosite phases in the WLSA and habitats in the WRSA within 100 m of moderate levels of human activity (industrial sites, urban area, active railways, *etc.*) was increased by 1 for moose (Table C1.3-2). However, the disturbance ZOI for Highway 3 and the proposed active coal mine was increased to 150 m. Disturbed areas with little or no human activity (*i.e.*, cutblocks, inactive well sites, pipelines, power lines, vegetated trails, and low traffic volume roads) were assumed to have no effect on winter moose habitat use (Table C1.3-2).

2.9.4.1.4 Confidence Rating

The confidence rating for the moose habitat suitability model is "High". Winter habitat use preferences for moose and their responses to various anthropogenic disturbances is well-supported by the available literature in Alberta and elsewhere in North America. Based on field studies conducted to date, moose also appear to be relatively common in suitable habitats within and around the WLSA.

2.10 Grizzly Bear

Scientific Name: *Ursus arctos*

Status: General Provincial Status: "*At Risk*", Legislated Provincial Status: "*Threatened*", COSEWIC: "*Special Concern*"

2.10.1 Distribution and Abundance

Grizzly bears were formerly widespread in Alberta, but they have been extirpated from a large portion of their former range, including the Cypress Hills and the prairies. They currently occur in the Rocky Mountains and foothills and in the boreal forest from the border with British Columbia east to High Level, Peace River, Red Earth, and Slave Lake (Alberta Grizzly Bear Recovery Plan 2008). Within Canada, grizzly bears occur in British Columbia, the Yukon, the Northwest Territories, and Nunavut. They may be expanding their range northward in Nunavut and the Northwest Territories (COSEWIC 2012).

During 2010, there were approximately 700 grizzly bears in Alberta (AESRD and ACA 2010). Populations are most dense in undisturbed parts of their range, and the area south of Highway 16 appears to be a population sink (AESRD and ACA 2010). Human-caused mortality and habitat alteration are the primary threats to grizzly bears in Alberta.

2.10.2 Ecology and Key Habitat Requirements

Grizzly bears are habitat generalists and occur in a variety of habitats across their range. In the Rocky Mountains, Chetkiewicz and Boyce (2009) found that food availability was an important predictor of grizzly bear distribution in Canmore and the Crowsnest Pass areas of Alberta. Greenness and soil wetness were used as indices of food abundance, and soil wetness was related to the occurrence of several important bear foods such as bearberry and horsetails.

The largely plant-based diet of grizzly bears in Alberta varies seasonally, with bears generally selecting the most nutritious plant parts available (Hamer and Herrero 1987). In early spring (pre-green-up), grizzly bears will feed heavily on roots, particularly those of *Hedysarum* spp. (Hamer and Herrero 1987, McLellan and Hovey 1995, Munro *et al*. 2006). During late spring, green vegetation starts to make up a larger part of the diet. Green vegetation consumed can include young horsetail shoots, graminoids, and sedges, and forbs such as cow parsnip, clover, peavine, alfalfa, dandelion, and willow. During late summer and early fall, berries (particularly *Vaccinium* spp. and buffaloberry) make up a large part of the diet and once they become unavailable, roots again become a dominant part of the diet (Munro *et al.* 2006).

Grizzly bears are omnivores, although the prominence of animal matter in their diet varies among populations (Mowat and Heard 2006). Within populations, the proportion of the diet that is composed of animal matter varies temporally. In west-central Alberta, most animal matter consumed by grizzly bears comes from ungulates, and in the Rocky Mountains, ungulates can make up from 0 to 20% of the diet (in terms of digestible dry matter), depending on the month (Munro *et al*. 2006). In west-central Alberta, ungulates make up the largest part of the diet during May and June (Munro *et al*. 2006), while in southern British Columbia and Montana, they compose the greatest part of the diet during April, May, September, and October (McLellan and Hovey 1995). Grizzlies will frequently scavenge on winter-killed ungulates.

As their diet varies seasonally, so does grizzly bear habitat use. Munro *et al*. (2006) found that bears fed on roots in non-forested herbaceous or shrubby habitats, or in subalpine or alpine habitats. Grizzly bears feed on roots most heavily during early spring and fall, and use of subalpine habitat is likely more extensive during late summer. Grizzlies foraged for fruits during late summer in a variety of habitats, but were most likely to forage for fruits in non-forested herbaceous habitats, open forests, wet forests, and mixedwood forests (Munro *et al*. 2006). Most ungulate kills by grizzlies occurred in non-forested habitats, open forests, and wet forests (Munro *et al*. 2006).

2.10.3 Response to Disturbance

Grizzlies are attracted to some types of disturbance but largely avoid human activity. They often use clearcut areas for foraging, as clearcuts can provide diverse food sources, including *Hedysarum* roots, forbs, berries, and ants (Nielsen *et al*. 2004). In some seasons, grizzly bears may preferentially use cutblocks, well sites, and roadsides (Berland *et al*. 2008, McKay *et al*. 2014). In Banff National Park, grizzlies often used habitats next to low traffic volume roads, with males using roadside habitats more often than females (Chruszcz *et al*. 2003). Gibeau *et al*. (2002) also found that females stayed farther from roads than males.

Grizzly bear use of habitats next to low traffic volume roads is a management concern, as it increases their vulnerability to being hit by vehicles. Chruszcz *et al.* (2003) noted grizzlies have been killed by vehicles on low-volume roads in Banff National Park. Grizzlies that use roadside habitats will also use them more frequently at night (Gibeau *et al*. 2002, Northrup *et al*. 2012a), when the risk of being hit by vehicles increases due to lower visibility. Roadsides often have a high abundance of plant food that may be attractive to bears, including horsetail, dandelions, clovers, graminoids, and sedges (Roever *et al*. 2008).

In some cases, human-altered landscapes act as attractive sinks. This occurs when grizzlies are attracted to an altered habitat that provides high-quality food sources that also may be used by humans. Forest edges and roads associated with resource extraction industries can represent major sinks for grizzly bears (Nielsen *et al.* 2006), particularly for female grizzly bears, who may be attracted to anthropogenic habitat edges (Stewart *et al*. 2013). Agricultural areas in southwestern Alberta, particularly ranches in areas close to streams and habitat edges, can also act as sinks for grizzly bears (Northrup *et al*. 2012b)

Although grizzly bears often avoid roads, particularly high-volume roads, they may cross roads to travel from low- to high-quality habitats (Chruszcz *et al*. 2003). Grizzlies are more likely to cross narrow, unpaved roads near creeks and/or open areas (Graham *et al*. 2010). Northrup *et al*. (2012a) also reported that grizzly bears would select areas near very low-use roads (< 20 vehicles/day) and were more likely to cross those roads. However, they avoided moderate-use roads (20-100 vehicles/day) and strongly avoided roads with >100 vehicles/day (Northrup *et al.* 2012a). Grizzlies generally avoid crossing high-volume roads (Chruszcz *et al*. 2003), and major highways can disrupt gene flow among grizzly populations. In the Crowsnest Pass area, Highway 3 appears to limit gene flow, although there is movement of bears across the Continental Divide both north and south of Highway 3 (Proctor *et al*. 2012).

While grizzly bears may use some types of human-disturbed habitats (such as cutblocks), they often avoid areas where humans are present. For example, Gibeau *et al.* (2002) found that grizzly bears moved more closely to trails in high-quality habitat during periods when human use was low. In a study on habitat selection by grizzlies in west-central Alberta, Linke *et al*. (2013) found that proximity to new disturbances and the long-term accumulation of disturbances in an area were related to grizzly bear abundance. More grizzlies were present in areas that exhibited a lower degree of high-intensity human activities and a greater availability of regenerating forest. Grizzlies were also more likely to be absent farther away from protected areas (parks). In the greater Yellowstone ecosystem, roads and developed areas are the major impediments to grizzly survival, as adult survival decreased as the number of roads, number of homes, and number of human developments increased (Schwartz *et al*. 2010). Grizzly bears also cannot be legally hunted in the mainland United States, but grizzly bear mortality rates are higher in areas where ungulates are hunted than where hunting is prohibited (Schwartz *et al.* 2010). Most mortality related to ungulate hunting occurred when hunters defended themselves, a camp, or an ungulate carcass from grizzlies (Schwartz *et al.* 2010).

Human-caused mortality, particularly in areas used heavily by people, is often the leading cause of grizzly bear mortality. For example, in Banff National Park from 1994 to 2002, humans caused 75% of female grizzly bear deaths and 86% of male grizzly bear deaths (Garshelis *et al*. 2005). In a study area that encompassed southern Alberta and British Columbia, and northern Montana, Washington, and Idaho, McLelland *et al*. (1999) found that humans caused 77-85% of known grizzly bear mortalities.

Legal harvest accounted for 39-44% of deaths in areas where it was permitted (McLelland *et al*. 1999). Management-related removals of nuisance grizzlies, kills related to defence of life or property, hunters mistaking grizzlies for black bears, and illegal kills were the other major sources of grizzly bear mortality. Many kills were related to grizzlies being attracted to hunting camps by ungulate carcasses, garbage, and/or food.

2.10.4 Resource Selection Function Model

The grizzly bear resource selection function (RSF) model used was developed by the Foothills Research Institute (FRI). The RSF was composed of GIS layers describing various aspects of the landscape, including those related to grizzly bear habitat quality. These included raster layers (derived from Landsat satellite imagery with a 30-m horizontal resolution) describing classified land cover, canopy closure, and conifer/broadleaf mix. Other layers included habitat models that predicted or described grizzly bear occupancy, mortality risk, the probability of denning, forage availability, and the locations of sources and sinks (*i.e.*, the "habitat states" model).

The occupancy model was a resource selection function that described the probability of grizzly bear occurrence (Nielsen *et al*. 2002). It was based on at least two years of grizzly bear location data collected by GPS collars, combined with six landscape variables (land cover type, canopy cover, conifer/broadleaf mix, streams, regenerating forest, and a measure of soil wetness). The "land cover type" variable assigned land to one of eight broad vegetation classes (McDermid 2005). As resource use by grizzly bears can vary across seasons and populations, models were developed for the three seasons grizzly bears are active (spring, summer, fall) and for six different population units (Livingstone, Castle, Clearwater, Yellowhead, Grande Cache, and Swan Hills). The Livingstone and Castle models were later combined due to their similarities.

The mortality risk model predicted the probability of human-caused mortality as a function of a variety of landscape variables, including terrain ruggedness, land cover type, proximity to roads and trails, whether the area was in the "White" (agricultural zone) or "Green" zone, presence of streams, and whether the area was protected (Nielson *et al*. 2004). The model was developed using data from 297 human-caused grizzly bear deaths between 1971 and 2002.

The forage availability model is a composite model that is based on the availability of 20 different grizzly bear food species for each of 10 semi-monthly periods over the growing season (Nielsen *et al*. 2003, Munro *et al*. 2006). Each of the 20 species was weighted according to its importance in the diet for each season.

The denning model predicted the probability that a grizzly bear would den in an area based on topography, forest cover, food resources, and anthropogenic features. However, the model was not available for the WLSA or GBRSA.

The "habitat states" model combined the occupancy model and the mortality risk models to predict whether an area served as a population source or sink for grizzly bears. There were five possible outcomes for the habitat states model:

- non-critical habitat (very low habitat value or non-habitat);
- secondary sink (moderate/secondary habitat value and high mortality risk);
- primary sink (high/primary habitat value and high mortality risk);
- secondary habitat (moderate habitat value and low mortality risk); and
- primary habitat (high habitat value and low mortality risk).

The relative proportion of sources vs sinks was used as an overall measure of habitat quality for the WLSA and GBRSA.

The model can be used to predict the effects of a proposed development on grizzly bears. The locations of new cutblocks, roads, pipelines, or habitat deletions (*i.e.* due to the development of a mine or other disturbance), can be incorporated into the model. Additionally, road reclamation can be incorporated into the model, as can forest succession for up to 40 years.

2.10.4.1 Confidence Rating

The confidence rating for this model is "High," as it was developed using data collected on grizzly bear ecology and mortality in the foothills and mountains of Alberta.

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APPENDIX D: WILDLIFE SPECIES WITH POTENTIAL TO OCCUR IN WLSA AND GBRSA

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
BIRDS		
Alder flycatcher	x	x
American avocet		x
American coot	x	x
American crow	x	x
American dipper	x	x
American goldfinch	x	x
American kestrel	x	x
American pipit	x	x
American redstart	x	x
American robin	x	x
American three-toed woodpecker	x	x
American wigeon	x	x
Baird's sparrow	x	x
Bald eagle	x	x
Baltimore oriole	x	x
Bank swallow	x	x
Barn swallow	x	x
Barrow's goldeneye	x	x
Belted kingfisher	x	x
Black swift	x	x
Black tern		x
Black-backed woodpecker	x	x
Black-billed magpie	x	x
Black-capped chickadee	x	x
Black-headed grosbeak	x	x
Blue grouse	x	x
Blue jay	x	x
Blue-winged teal	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Bobolink	x	x
Boreal chickadee	x	x
Brewer's blackbird	x	x
Brewer's sparrow	x	x
Broad-winged hawk	x	x
Brown creeper	x	x
Brown thrasher		x
Brown-headed cowbird	x	x
Bufflehead	x	x
California gull		x
Calliope hummingbird	x	x
Canada goose	x	x
Canvasback		x
Cassin's finch	x	x
Cassin's vireo	x	x
Cedar waxing	x	x
Chestnut-collared longspur		x
Chipping sparrow	x	x
Cinnamon teal		x
Clark's nutcracker	x	x
Clay-coloured sparrow	x	x
Cliff swallow	x	x
Common goldeneye	x	x
Common grackle		x
Common loon		x
Common merganser	x	x
Common nighthawk	x	x
Common raven	x	x
Common redpoll	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Common yellowthroat	x	x
Cooper's hawk	x	x
Cordilleran flycatcher	x	x
Dark-eyed junco	x	x
Double-crested cormorant		x
Downy woodpecker	x	x
Dusky flycatcher	x	x
Eastern kingbird	x	x
Eastern phoebe	x	x
European starling	x	x
Evening grosbeak	x	x
Ferruginous hawk		x
Fox sparrow	x	x
Franklin's gull		x
Gadwall		x
Golden eagle	x	x
Golden-crowned kinglet	x	x
Gray catbird	x	x
Gray-crowned rosy finch	x	x
Great blue heron		x
Great gray owl	x	x
Great horned owl	x	x
Green-winged teal	x	x
Grey jay	x	x
Hairy woodpecker	x	x
Hammond’s flycatcher	x	x
Harlequin duck	x	x
Hermit thrush	x	x
Hoary redpoll	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Hooded merganser	x	x
Horned grebe		x
Horned lark		x
House finch	x	x
House sparrow	x	x
House wren	x	x
Killdeer	x	x
Lark bunting		x
Lazuli bunting	x	x
Least flycatcher	x	x
Lesser scaup	x	x
Lincoln’s sparrow	x	x
Loggerhead shrike		x
Long-billed curlew		x
Long-eared owl	x	x
Macgillivray’s warbler	x	x
Mallard	x	x
Marbled godwit		x
Marsh wren	x	x
Mccown's longspur		x
Merlin	x	x
Mountain bluebird	x	x
Mountain chickadee	x	x
Mourning dove	x	x
Northern flicker	x	x
Northern goshawk	x	x
Northern harrier	x	x
Northern pintail	x	x
Northern pygmy owl	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Northern rough-winged swallow	x	x
Northern saw whet owl	x	x
Northern shoveler	x	x
Northern waterthrush	x	x
Olive-sided flycatcher	x	x
Orange-crowned warbler	x	x
Osprey	x	x
Ovenbird	x	x
Pacific slope flycatcher	x	x
Pied-billed grebe		x
Pileated woodpecker	x	x
Pine grosbeak	x	x
Pine siskin	x	x
Prairie falcon		x
Purple finch	x	x
Red crossbill	x	x
Red-breasted nuthatch	x	x
Red-eyed vireo	x	x
Redhead	x	x
Red-naped sapsucker	x	x
Red-necked grebe		x
Red-tailed hawk	x	x
Red-winged blackbird	x	x
Ring-billed gull		x
Ring-necked duck	x	x
Rock dove	x	x
Rock wren	x	x
Rough-legged hawk		x
Ruby-crowned kinglet	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Ruddy duck		x
Ruffed grouse	x	x
Rufous hummingbird	x	x
Sandhill crane		x
Savannah sparrow	x	x
Say's phoebe		x
Sharp-shinned hawk	x	x
Sharp-tailed grouse	x	x
Short-eared owl	x	x
Snow bunting		x
Snowy owl		x
Song sparrow	x	x
Sora	x	x
Spotted sandpiper	x	x
Spotted towhee		x
Sprague's pipit		x
Spruce grouse	x	x
Steller's jay	x	x
Swainson's hawk	x	x
Swainson's thrush	x	x
Tennessee warbler	x	x
Townsend's solitaire	x	x
Townsend's warbler	x	x
Tree swallow	x	x
Trumpeter swan		x
Upland sandpiper		x
Varied thrush	x	x
Veery	x	x
Vesper sparrow	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Violet green swallow	x	x
Warbling vireo	x	x
Western grebe		x
Western kingbird		x
Western meadowlark	x	x
Western tanager	x	x
Western wood-pewee	x	x
White-breasted nuthatch	x	x
White-crowned sparrow	x	x
White-tailed ptarmigan	x	x
White-winged crossbill	x	x
Wild turkey	x	x
Willet		x
Willow flycatcher	x	x
Wilson's phalarope	x	x
Wilson's snipe	x	x
Wilson's warbler	x	x
Winter wren	x	x
Wood duck	x	x
Yellow warbler	x	x
Yellow-breasted chat		x
Yellow-headed blackbird	x	x
Yellow-rumped warbler	x	x
HERPTILES		
Boreal chorus frog	x	x
Columbia spotted frog	x	x
Long-toed salamander	x	x
Northern leopard frog	x	x
Plains garter snake	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Plains spade foot toad		x
Red-sided garter snake	x	x
Tiger salamander	x	x
Wandering garter snake	x	x
Western toad	x	x
Wood frog	x	x
MAMMALS		
American badger	x	x
American beaver	x	x
American marten	x	x
American pika	x	x
Big brown bat	x	x
Bighorn sheep		x
Black bear	x	x
Bobcat	x	x
Bushy-tailed woodrat	x	x
California myotis		x
Canada lynx	x	x
Columbian ground squirrel	x	x
Common muskrat	x	x
Common porcupine	x	x
Common water shrew	x	x
Cougar	x	x
Coyote	x	x
Deer mouse	x	x
Dusky shrew	x	x
Eastern red bat	x	x
Elk	x	x
Fisher	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Golden-mantled ground squirrel	x	x
Grey wolf	x	x
Grizzly bear	x	x
Hayden's shrew	x	x
Hoary bat	x	x
Hoary marmot		x
House mouse	x	x
Least chipmunk	x	x
Least weasel	x	x
Little brown myotis	x	x
Long-eared bat	x	x
Long-legged bat	x	x
Long-tailed vole	x	x
Long-tailed weasel	x	x
Masked shrew	x	x
Meadow vole	x	x
Mink	x	x
Moose	x	x
Mountain goat		x
Mule deer	x	x
Northern bog lemming	x	x
Northern flying squirrel	x	x
Northern long-eared bat		x
Northern pocket gopher		x
Pygmy shrew	x	x
Red fox	x	x
Red squirrel	x	x
Short-tailed weasel	x	x
Silver-haired bat	x	x

Table D1 Wildlife Species with the Potential to Occur in the Wildlife Local Study Area and the Grizzly Bear Regional Study Area

Species	WLSA	GBRSA
Snowshoe hare	x	x
Southern red-backed vole	x	x
Striped skunk	x	x
Water vole	x	x
Western heather vole	x	x
Western jumping mouse	x	x
White-tailed deer	x	x
Wolverine	x	x
Woodchuck		x
Yellow-pine chipmunk	x	x