6.1 ROCKY MOUNTAIN ELK SPECIES ACCOUNT

SPECIES NAME: **Rocky Mountain Elk** ***(Cervus elaphus)***

SPECIES CODE: **M-CEEL**

INTRODUCTION:

This document provides the background information for rating habitat values of pre-defined ecosystem units in southern British Columbia for Rocky Mountain Elk. Information on habitat requirements, life requisites, and habitat / landscape use patterns of Rocky Mountain Elk has been accumulated from a variety of sources, including literature reviews, species experts, and previous inventory and mapping efforts.

STATUS:

Status in Canada (COSEWIC 1998):	**No formal designation**
Status in British Columbia (CDC 1999):	
Provincial Management List:	**Yellow**
Global Rank:	**G5**
Provincial Rank:	**S4S5**
Identified Wildlife (Y/N):	**N**

DISTRIBUTION:

Continental Range:

Elk were once the most widely distributed member of the North American deer family, ranging from the Atlantic to the Pacific coasts and from Mexico north to Canada. Elk disappeared from eastern North America in the early 1800s. Market hunting, habitat loss, and severe winters resulted in western populations declining shortly thereafter and reaching population lows in the early 1900s. Today, elk are restricted to western North America, where four sub-species are recognized: the Rocky Mountain elk (*Cervus elaphus nelsoni*); Roosevelt elk (*C. e. roosevelti*); Manitoba elk (*C. e. manitobensis*); and Tule elk (*C. e. nannodes*)(Nagorsen 1990).

Rocky Mountain elk are found in portions of northern and eastern British Columbia, western Alberta, Saskatchewan, Manitoba, eastern Oregon and Washington, Idaho, western Montana, Wyoming, Colorado, Utah, Nevada, New Mexico, and Arizona. By contrast, Roosevelt elk are found in coastal areas of the Pacific Northwest and Vancouver Island, Manitoba elk in southwestern Manitoba, southern Saskatchewan, and southeastern Alberta, and Tule elk are restricted to west-central California.

Provincial Range:

Two subspecies of elk occur in British Columbia: Roosevelt elk (*Cervus elaphus roosevelti*) and Rocky Mountain elk (*C. e. nelsoni*). Roosevelt elk occur in Canada only on Vancouver Island and sporadically in the extreme southwest mainland while Rocky Mountain elk are considerably more abundant and widespread, occurring in greatest numbers in the Rocky Mountains and the Rocky Mountain Trench of southeastern British Columbia. In the province's northeast region, Rocky Mountain elk occur in relatively moderate abundance, with densities ranging from 1 elk per 250 sq. km. to 1 elk per 2.5 sq. km. (Blower 1988).

Throughout their range in mainland British Columbia, Rocky Mountain elk (hereafter referred to as '*elk*') occupy a wide variety of habitats ranging from coniferous forests of most ages, as well as mixedwood and deciduous forests, wetlands, vegetated slides and avalanche chutes, and rock outcrops. Their use of high alpine tundra habitats is limited, however sub-alpine environments are commonly inhabited by elk on both the east and west slopes of the Rocky Mountains.

Within British Columbia, Peek (1982) indicated that elk are currently expanding into previously unoccupied range and in central Washington have recently been observed on shrub-steepe habitats historically unoccupied by elk (Rickard *et al.* 1977).

Range of Elk in the Project Area:

Ecoprovinces:	Southern Interior
Ecoregions:	Thompson-Okanagan Plateau, Okanagan Highland
Ecosections:	Northern Okanagan Highland, Southern Okanagan Highland, Northern Okanagan Basin, Southern Okanagan Basin
Biogeoclimatic Zones:	ESSFdc1, PPxh1, MSdm1, IDFxh1, IDFdm1 (Stevens 1995)

Elevational Range:

Elk movements and habitat use patterns are a response to snow accumulation and resultant forage availability. Therefore, many populations migrate elevationally to use habitats at various elevations, ranging from valley bottom IDF habitats to high elevation AT and parkland habitats.

KEY LIFE REQUISITES:

Because elk are widely recognized as an adaptable and opportunistic species, it is difficult to specify their habitat requirements over broad geographic areas. Elk distribution and habitat selection is determined by a combination of many factors including topography, vegetation structure, forage quality and quantity, traditional and habitual behavior, weather conditions, predators, and human activities (Morgantini and Russell 1983). However, a general inference regarding the primary characteristics of elk habitat is the requirement for interspersion of forage, escape, and cover resources. Generally, foraging areas for elk are found in open habitats, thermal cover is best provided by coniferous forested stands, while predator relief is provided by dense forests with well-developed understories. Thus, elk are an ecotonal, or *'multitypic'*, species, favoring high contrast forest edges which provide an abundance of forage in close proximity to escape and thermal cover.

Living Habitat:

Elk, like most other wildlife species, require three basic resources to survive and reproduce: water, food, and cover. In order for elk to use these resources efficiently, the resources must be distributed across the landscape in a pattern that facilitates movement of the animals through all areas (Nyberg and Janz 1990). Therefore, the interspersion of forage and cover resources (assuming that water resources are not limiting in most environments) is a major factor determining the quality of elk habitat.

Elk subsist primarily on gramineous plants, particularly fescues and sedges, on a year round basis, however

woody browse can increase in importance during the late summer and fall seasons. In other boreal mixedwood habitats of western Canada, elk rely more heavily on browse during the winter. However, this is in contrast to habitats in the south Okanagan, where semi-open and broken forest cover provide accessible grassland areas for most of the year, including winter.

Throughout TFL 15 and adjacent areas, habitats with reduced snow depths are associated with lower elevation and valley bottom environments, thus providing access to forage in winter and spring. In addition, key elk ranges in the study area are relatively small (< 25 ha, although they may be complexed to form larger habitats), thus providing early structural stage habitats adjacent to mature forest stands which lend the necessary cover required for efficient foraging in an ecotonal landscape.

Feeding Habitat:

Feeding habits of elk have been extensively reviewed (see Morgantini and Russell 1983, Nietfeld 1983, Fargey 1988, Fargey and Hawley 1989, Stelfox *et al.* 1991, Renecker and Hudson 1992). The diets of elk are extremely variable and largely dependent upon local forage availability. While Kufeld (1973) found that 159 forbs, 59 grasses, and 95 shrub species have been reported as elk forage, grasses are the preferred forage throughout the year and are consumed in both succulent and dry seasons. MELP (1992) state the normal preferred diet of elk may consist of up to 80% grass and herbs and 20% browse; however elk can survive even if the availability of food requires a complete reversal of this diet.

The following table summarizes the key forage species preferred by elk in the Rocky Mountain east slopes of Alberta, incorporating information from Salter and Hudson (1980), Berg (1983), Morgantini and Hudson (1983), Morgantini and Olson (1983).

Table 2: Key Forage Species for Elk

Trees and Shrubs	Graminoids	Forbs	Horsetails, Mosses and Lichens
Amelanchier spp.	*Agropyron* spp.	*Astragalus* spp.	*Equisetum* spp.
Artemesia spp.	*Agrostis scabra*	*Delphinium* spp.	*Lycopodium* spp.
Juniperus spp.	*Bouteloua* spp.	*Draba* spp.	*Selaginella* spp.
Pinus spp.	*Bromus* spp.	*Galium* spp.	
Picea spp.	*Carex* spp.	*Geum* spp.	
Pseudotsuga spp.	*Cyperaceae*	*Lupinus* spp.	
Rubus spp.	*Danthonia* spp.	*Mertenesia* spp.	
Salix spp.	*Deschampsia* spp.	*Petasites* spp.	
Shepherdia canadensis	*Eleocharis* spp.	*Potentilla* spp.	
Elaeagnus commutata	*Elymus* spp.	*Saxifraga* spp.	
Vaccinium spp.	*Festuca* spp.	*Stellaria* spp.	
	Juncus spp.	*Vicia* spp.	
	Koeleria cristata		
	Poa spp.		
	Schizachne purpurascens		
	Stipa spp.		

Snow depth and condition are major determining factors of elk diets on winter ranges. Skovlin (1982) refers to snow depth as the factor most limiting to elk distribution and movement; as snow depths of 46 to 71 cm have caused elk to switch from grazing to browsing, while depths of over 76 cm have been considered detrimental to travel (Nietfeld *et al.* 1984). Therefore, snow depth is a major factor for elk in the selection of winter foraging sites.

Security / Thermal Habitat:

Both vegetative and topographic features of a habitat provide security and thermal cover for elk. These features allow elk to conserve energy, escape or avoid predators (Skovlin 1982), and safely access forage. Primary factors influencing a stand's value as security cover are:

i. the density and diameter of trees; and
ii. the density of understory vegetation.

It is widely accepted that a minimum standard for adequate security cover is vegetation capable of hiding 90% of a standing adult elk from view at a distance of 200 feet (61 m) (Black *et al.* 1979, McNamee *et al.* 1981). Many coniferous stands will perform this function if they are more than 3 m tall and 100 m wide. However, data from Montana suggests that elk are less selective about the specific vegetative characteristics of coniferous cover and more responsive to size of units, connectiveness with adjacent units, and the scale of cover on the landscape (Lyon and Canfield 1991).

Thermal cover is a habitat feature used by elk and other species to ameliorate the effects of adverse weather conditions. While thermal cover is often equated with winter insulation qualities, elk also reduce heat stress by bedding down in snow patches in spring and early summer, and use dense forests with abundant shade in late summer (Schmidt and Gilbert 1980). In Washington and Oregon, Thomas *et al.* (1979) found that stands 12 to 24 ha in size provided optimal thermal cover, while stands 2.6 to 10.5 ha in size provided optimal hiding, or security. Thermal cover can be provided by numerous landscape features, including topography, water, air movement, and other animals, however it is most often associated with vegetation cover. Thermal cover for elk is provided by coniferous stands greater than 10 m in height with canopy closure over 70%.

Courtship / Mating Habitat:

The rutting season for elk generally begins in early September, peaks in mid-September, and concludes by October. Rutting occurs in forest openings in a variety of habitats that provide abundant forage and cover opportunities. Other than requirements for security and forage habitat, elk do not have specific habitat requirements for courtship and mating activities. Therefore, courtship and mating will not be rated separately in this model.

Reproducing (birthing) Habitat:

Elk typically calve in late May or June following by a gestation period of approximately 255 days (8.5 months). Calving sites are generally in protected areas with abundant food, nearby water, and security cover. These sites are often located on gentle terrain such as terraces and benches in otherwise steep topography between the animal's winter and summer ranges. Security cover (provided by shrubby understorey vegetation or coarse woody debris), forage areas, and thermal cover combine to comprise optimum calving areas (Thomas 1979, Skovlin 1982, Smith 1985). Other than requirements for security and forage habitat, elk do not have specific habitat requirements for birthing habitat, other than site-specific features. Therefore, reproduction (birthing) habitat will not be rated separately in this model.

Bedding Habitat:

Elk often bed down in security cover where they are hidden from view, but where they have a vantage point from which to watch for potential danger (Nyberg and Janz 1990). Bedding requirements are site-specific and will not be rated separately. Any potential ratings for security and/or thermal cover are considered to include bedding or resting habitats.

Migrating Habitat:

Morgantini and Russell (1983) describe habitat selection by elk as being a complex behavioral response to environmental factors. Therefore, while habitat selection by elk is largely determined by the floral composition of an area, overall habitat use by elk will also reflect the species' size, morphology, feeding habits, social organization, and anti-predator strategy (Leuthold 1977, Morgantini and Russell 1983). In response to variable environmental conditions, elk exhibit two very different strategies in their habitat selection and subsequent movements. The first involves a year-round stationary home range while the other has developed into a migratory pattern linking winter, intermediate, and summer ranges together. Adams (1982) and Morgantini and Russell (1983) report that elk in the Rocky Mountain east slopes have migration routes that generally follow the valley bottoms of main rivers. Spring and summer altitudinal movements are closely tied to the tracking of palatable plant phenology while the fall migration to lower elevations is a response to snow accumulations at higher elevations. While elk movement patterns in the TFL itself have not been documented, the following assumptions were used in rating habitats for this project (Table 3):

Table 3: Expected Seasonal Habitat Use Patterns of Elk in the TFL 15 Area

SEASON	APPROXIMATE DATES	HABITAT USE PATTERNS
Spring	April - May	• After spending winter at low elevations, elk generally begin to move to higher elevations during spring as snow cover recedes; • Forage in open habitats that provide abundant herbs, grasses, and forbs (such as clearcuts, seral brush fields, et cetera); • Females calve in isolated mid-elevation habitats (between winter and summer ranges); • Preferred calving habitats include dense shrubby understory in closed canopy forests or riparian forests and stream islands.
Summer	June – August	• Habitat use shifts to mid and high elevation subalpine and low alpine areas with north and east-facing slopes and abundant forage; • Cows and calves often form small nursery groups on high elevation summer range.
Fall	September – October	• Alpine grasses and sedges starting to burn off in high-elevation summer ranges; • Cows and calves move downslope into mature forested habitats with high canopy closure, where understory herbs and grasses remain available; • Bulls linger in high country for rutting activities throughout the fall, but may move downslope slightly to gain access to better cover habitats.
Winter	November - March	• Habitat use in winter is restricted by snow accumulation; • In areas of light snowfall, elk use high elevation south-facing meadows; • In areas of heavy snowfall, elk migrate in early winter to low and mid-elevation forests

		with canopy gaps providing open successional habitats.

SEASONS OF USE:

Elk habitat will be rated on the basis of two seasons of use, as follows (Table 4):

Table 4: Seasons of Use Rated for Elk

SEASON	CODE	DESCRIPTION (as relates to use by elk)	DURATION	LIFE REQUISITE THAT MUST BE MET
Winter	W	Snow accumulation period	November December January February March	Feeding / Thermal / Security
Growing	G	Leaf-out and green-up of habitats; increased forage availability; typically includes calving	April May June July August September October	Reproducing / Feeding / Security

The use of seasonal nomenclature (winter and growing) is based on that defined by RIC (1998) for the Southern Interior Ecoprovince.

HIERARCHY OF LIFE REQUISITES:

For decades, the emphasis in elk management has been on managing for feeding habitat on winter ranges. The significance of security and thermal cover in elk habitat models has been difficult to define. Most researchers agreed that winter snow conditions (and, thus, winter forage availability) were the primary limiting factors for elk throughout their range. However, recent advances in animal physiology on winter ranges has slightly modified this view. While forage is recognized as a critical life requisite, it has now come to bear that, under severe weather conditions, many animals substitute an energy conservation strategy for forage intake. For example, Christensen *et al.* (1993) reported that, where behavior patterns have been recorded, elk select resting and feeding sites based on the control of energy transfer rather than on forage availability. Thus, it can be argued that the provision of thermal cover may be as important as forage quantity or quality on elk winter ranges.

The significance of suitable winter thermal sites as a life requisite for elk may be further explained by the availability of this resource within the Southern Interior Ecoprovince. Forested cover is fairly sporadic and the availability of early structural stages is common within cutblocks, avalanche tracts, burns, roadsides, and natural forest openings. This creates extremely suitable winter foraging habitats for elk within the area and, as a result winter thermal habitat requirements have been designated as the primary limiting factor for elk in TFL 15. The hierarchy of life requisites incorporated into the elk habitat model is as follows:

1. ***Winter thermal habitat***
2. ***Spring reproducing habitat***
3. ***Summer feeding habitat***

QUANTIFIABLE ECOSYSTEM ATTRIBUTES:

This section describes how each life requisite for elk relates to specific ecosystem attributes such as site series, plant species, canopy closure, slope , *et cetera* (Table 5).

Table 5: Quantifiable Ecosystem Attributes for Elk Habitats

Season	Primary Life Requisite	Rating Code	Quantifiable Ecosystem Attribute
Winter	Feeding	**FDW***	• Low elevation coniferous, deciduous, or mixedwood habitats with high canopy cover; • Some open habitats, depending on snow accumulation potential; • Structural stages 2 - 7 forests;
	Security / Thermal	**STW***	• Dense cover in low elevation forested stands; • Coniferous and coniferous-dominated mixedwood stands 10 - 12 m tall and canopy closure > 70%.
Growing	Feeding	**FDG***	• North-facing slopes in summer and fall provide high quality forage; south- and west facing slopes in spring and winter are first to be snow-free and provide access to forage or are influenced by chinook conditions and swept snow-free during winter; • Site series dominated by moderately sloping grasslands provide preferred forage (see previously provided list of preferred forage species for elk); • Open, early successional habitats with abundant grasses, forbs, sedges; • Low to high elevation coniferous, deciduous, and mixedwood forests; • Subalpine meadows; • Structural stages 2, 3a, 3b, 4, 5, 6, 7 habitats; • Valley bottom floodplains and drainages with fertile soils have high forage productivity and diversity, particularly for early spring green-up forage.
	Security / Thermal	**STG***	• Small benches, basins, draws, and stream and valley bottoms are used for calving sites; • Structural stages 4 - 7; • 50 - 70 % canopy cover.

*** Life requisites that were rated in the field during data collection for this model.**

MODEL ASSUMPTIONS:

1. Optimal elk habitat in both fall/winter and spring/summer seasons consists of open forage-producing sites interspersed with forested areas or other geomorphic features which provide security and thermal cover.

2. Winter ranges receiving the highest use can be expected to be those consisting of at least 60-75% foraging area, with thermal and security cover comprising the remainder.

3. Forage preferences of elk vary seasonally (due to forage palatability) and among forage classes (due to forage availability). However, the general inference can be made that elk prefer herbaceous forage such as grasses, sedges, and forbs in all seasons. Grasses, in particular, are preferred throughout the

year and are consumed in spring, summer, and fall as well as in winter, if available. Grasslands in structural stages 1 to 3a may provide abundant winter forage if they are adequately sheltered from snow and wind activity during winter.

4. Grasslands on warm, south-facing slopes are rated high for the provision of forage, particularly in winter seasons. North-facing grassland slopes are rated higher for the provision of summer and fall habitats.

5. Closely-stocked stands of coniferous cover (high stem density, trees over 12 m in height, and canopy closure exceeding 70%) are required for the provision of thermal cover in severe winters. In milder winters (and in spring and summer), mixedwood and deciduous forests may provide the required cover resources.

6. Coniferous and mixedwood forests with a well-developed understory capable of hiding 90% of a standing elk from the view at a distance of 60 m provides effective hiding cover.

7. Forest edges and riparian vegetation associated with post-fire succession or logging may also provide high rated habitat to meet both forage and cover requirements of elk.

Dense timber or heavy brush thickets (predominantly willow) are rated moderate to high for their provision of calving sites. Grassland/shrub ecotonal habitats (Structural Stage 3b and 4) may also be rated high for the provision of calving sites, if they are appropriately secure.

9. Site modifiers that influence habitat suitability ratings for elk and generally require an upgrade in ratings include “w” (warm, southerly or westerly aspect – only during winter); while downgrades in habitat suitability ratings are usually experienced by sites with a “k” (cool, northely or easterly aspect – only during winter) and “z” (very steep, greater than 100% slope – all seasons).

ROCKY MOUNTAIN ELK
HABITAT SUITABILITY RATINGS

RATED LIFE REQUISITES:

The life requisites that have been selected for the final ratings include:

- FDW (Winter / Feeding)
- STW (Winter / Security-Thermal)
- FDG (Growing / Feeding)
- STG (Growing / Security-Thermal)

HABITAT SUITABILITY RATINGS SCHEME:

Habitat assessments for elk are being rated against the 'provincial benchmark' which is based upon a 6-class rating scheme, acknowledging the species' high mobility and researcher's substantial knowledge level about its habitat requirements (RIC 1998) (see Table 6).

Table 6: Habitat Suitability Rating Scheme for Elk

Suitability Rating	Level of Use by Elk	Suitability Limits (%)
1	Very High	76 – 100
2	High	51 – 75
3	Moderately High	26 – 50
4	Moderate	6 – 25
5	Low	1 – 5
6	Nil	0

PROVINCIAL BENCHMARKS:

Provincial benchmarks for elk have been determined from a number of sources, each providing relevant information at varying scales and levels of resolution. These sources include:

i) provincial big game abundance and distribution mapping at 1:2,000,000 scale (Blower 1988); and
ii) MELP provincial benchmark habitat list developed for use with TEM wildlife interpretations (RIC 1998).

Elk abundance and distribution in British Columbia has been mapped at a scale of 1:2,000,000 by Blower (1988). This map provides a rudimentary record of provincial benchmarks against which elk habitat suitability ratings can be delineated for TFL 15. The following table, summarized from the provincial map, provides a synopsis of the areas considered by Blower (1988) to have some of the highest elk densities (over 1 elk / 2.5 km^2) in the province (Table 7).

Table 7: Areas of Highest Reported Elk Abundance in British Columbia (densities >1 elk / 2.5 sq. km.)			
ECOPROVINCE	**ECOREGION**	**ECOSECTION**	**GENERAL LOCATION**
Interior Mountains	Northern Columbia Mountains	Eastern Purcell Mountains	Dutch, Bugaboo, Horsethief creeks
		Central Columbia Mountains	Kokanee Glacier Park, Slocan Lake
		McGillivray Ridge	south of Cranbrook, Tepee Creek
		Southern Columbia Mountains	Creston, south end of Kootenay Lake
	Southern Rocky Mountain Trench	East Kootenay Trench	Columbia River valley
	Northern Continental Divide	Border Ranges	Elkford, Fernie, Elk River drainage
		Crown of the Continent	Flathead River drainage
	Western Continental Ranges	Southern Park Ranges	Yoho National Park, Kootenay River drainage
Taiga Plains	Muskwa Plateau	Muskwa Plateau	Dunedin and Chief River drainages
	Hay River Lowland	Fort Nelson Lowland	Nelson and Fontas River drainages
Northern Boreal Mountains	Northern Canadian Rocky Mountains	Eastern Muskwa Ranges	Tuchodi Lakes, West Toad River
		Muskwa Foothills	Prophet River drainage

MELP (RIC 1998) has identified high-rated habitats and provincial benchmark habitats for elk in British Columbia as follows (Table 8): **Note: habitats that are bolded represent the provincial benchmark against which all other elk habitats are compared.**

POTENTIAL RATINGS ADJUSTMENTS:

It would be expected that rating adjustments would be made to the final ratings map (if developed) for the following habitat and landscape features:

1. Landscape Unit Context (Proximity to High and Low Rated Habitats)

This adjustment occurs when the spatial relationship of one habitat to another influences the suitability of the habitat in proximity. Larger habitats containing a suitability rating differing from adjacent smaller habitats may result in an adjustment in the rating for the smaller habitat. This would apply when areas of either high or low rated habitats are encroached by another habitat of a greater or lesser value (i.e., if a high rated habitat is relatively dominated by an adjacent larger area of moderate rating, it is suggested that the high rated habitat be decreased to reflect the vastness of the moderate habitat). This would also apply when the reverse of the above example is encountered.

Edge, or ecotonal, areas are high quality elk habitat because they provide abundant and diverse forage in close proximity to cover. Most use by elk occurs within 183 m of the edge between cover and forage areas (Black *et al.* 1979). Therefore, the quality of open feeding habitat increases if it is adjacent to coniferous forest providing adequate security and/or thermal cover.

Table 8: Provincial Benchmarks for Elk			
ECOPROVINCE	ECOSECTION		BGC
	UNIT	RATING	SUBZONE
WINTER BENCHMARKS			
Central Interior	FRB	3	IDFxm
Sub-Boreal Interior	**HAF**	**2**	**BWBSmw**
Southern Interior Mountains	**EKT**	**1**	**IDFdm**
Southern Interior	STU	2	IDFxh
Boreal Plains	PEL	2	BWBSmw
Taiga Plains	MUP	2	BWBSmw
Northern Boreal Mountains	**MUF**	**1**	**SWBmk**
GROWING SEASON BENCHMARKS			
Central Interior	CCR	3	AT
Sub-Boreal Interior	**HAF**	**2**	**ESSFmv**
Southern Interior Mountains	FRR	2	AT
Southern Interior	STU	2	MSxk
Boreal Plains	PEL	2	BWBSmw
Taiga Plains	MUP	2	BWBSmw
Northern Boreal Mountains	**MUF**	**1**	**SWBmk**

2. Fragmentation / Patchwork

Elk are frequently precluded from using areas where there is continual disturbance due to human activity. Roads, in particular, have been shown to negatively affect the habitat effectiveness of otherwise suitable areas for elk. Elk show a decreased use of areas adjacent to roads for distances ranging from 0.4 to 0.8 km (Martinka 1969, Black *et al.* 1979, Christensen *et al.* 1993). Therefore, while it is acknowledged that early seral stages which characterize clearcuts and other anthropogenic disturbances may provide forage resources for elk, overall use of the habitat may be compromised if human activity is too high. Suitability ratings for such habitats may be downgraded if human activity is prevalent and continuous in the area.

The degree of adjustments made to the habitat suitability ratings will be determined primarily by the degree to which the above factors impact elk habitat, and will be applied at the final habitat suitability mapping level.

REFERENCES:

Adams, A.W. 1982. Migration. Pages 301-322 in: Thomas, J.W. and D.E. Toweil (eds.) *Elk of North America: Ecology and Management*. The Wildlife Management Institute. Washington, DC.

Berg, B.P. 1983. Wild and domestic ungulate interactions in the Bob Creek area, southwestern Alberta. M.Sc. Thesis. University of Alberta. Edmonton, AB. 153 pp.

Black, H., R.J. Sherzinger, and J.W. Thomas. 1979. Relationships of Rocky Mountain elk and Rocky

Mountain mule deer habitat to timber management in the Blue Mountains of Oregon and Washington. Pages 11-31 in: Peek, J. (ed.) *Trans. of the Elk – Logging – Roads Symp*. University of Idaho. Moscow, ID.

Blower, D. 1988. Wildlife distribution mapping: Big game series. Elk. Provincial mapping at 1:2,000,000 scale. British Columbia Ministry of Environment, Lands, and Parks; Wildlife Branch. Victoria, BC.

Christensen, A.G., L. Jack Lyon, and J.W. Unsworth. 1993. Elk management in the northern region: Considerations in forest plan updates or revisions. General Technical Report INT-303. United States Forest Service, Intermountain Research Station. Ogden, UT. 10 pp.

CDC (Conservation Data Centre). 1999. BC Conservation Data Centre: Rare Vertebrate Animal Tracking List. BC Ministry of Environment, Lands and Parks, Victoria, BC. http: www.env.gov.bc.ca/wld/cdc/listdef.htm

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 1998. Canadian species at risk, April 1996. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. 21 pp.

Fargey, P.J. 1988. Wapiti selection of grasses and legumes. Pages 24-26 in: Renecker, L.A. (ed). *Proc. of the 3rd Annual Game Growers Assoc. Conf*. Red Deer, AB.

Fargey, P.J. and A.W.L. Hawley. 1989. Seasonal patterns of forage selection by wapiti in relation to land reclamation. AECV89-R3. Alberta Environmental Center. Vegrevellie, AB. 112 pp.

Kufeld, R.C. 1973. Foods eaten by the Rocky Mountain elk. J. Range Manage. 26(2):106-113.

Leuthold, W. 1977. *African Ungulates: A Comparative Review of Their Ethology and Behavioral Ecology*. Springer-Verlag. Berlin. 307 pp.

Lyon, L.J. and J.E. Canfield. 1991. Habitat selection by Rocky Mountain elk under hunting season stress. Pages 99-105 in: Christensen, A.G., L.J. Lyon, and T.N. Lonner (comp.) *Proc. of the Elk Vulnerability Symp*. Montana State University. Bozeman, MT.

Martinka, C.J. 1969. Population ecology of summer resident elk in Jackson Hole, Wyoming. J. Wildl. Manage. 32:558-565.

McNamee, P.J., M.L. Jones, R.E. Everitt, J.H. Staley, and D. Tait. 1981. Report on the integrated wildlife intensive forestry research-planning workshop. Fish and Wildlife. Bull. No. B-19, IWIFR-4. BC Ministry of Environment, Lands and Parks and BC Ministry of Forestry. Victoria, BC. 147 pp.

MELP (Ministry of Environment, Lands and Parks). 1992. Elk in British Columbia. British Columbia Ministry of Environment, Lands and Parks. Victoria, BC. 4 pp. http://www.elp.gov.bc.ca/wld/pub/elk.htm

Morgantini, L.E. and R.J. Hudson. 1983. Nutritional significance of altitudinal migrations for wapiti. Agric. For. Bull. 62:109-112.

Morgantini, L.E. and C.D. Olsen. 1983. Pipeline construction and wild ungulates. Results of a two year monitoring program along the Edson Mainline Loop. Prepared by Wildland Resource Consultants Ltd. for NOVA Corporation. Calgary, AB.

Morgantini, L.E. and W.B. Russell. 1983. An assessment of three selected elk winter ranges in the Rocky Mountain Region. Prepared by Wildland Resource Consultants Ltd. for Alberta Fish and Wildlife Division. Edmonton, AB. 265 pp.

Nagorsen, D. 1990. The mammals of British Columbia: A taxonomic catalogue. Memoir No. 4. Royal British Columbia Museum. Victoria, BC.

Nietfeld, M.T. 1983. Foraging behavior of wapiti in the boreal mixedwood forest, central Alberta. M.Sc. Thesis. University of Alberta. Edmonton, AB.

Nietfeld, M.T., J. Wilk, K. Woolnough, and B. Hoskin. 1984. Wildlife habitat requirement summaries for selected wildlife species in Alberta. Alberta Energy and Natural Resources, Fish and Wildlife Division. Edmonton, AB.

Nyberg, J.B. and D.W. Janz. 1990. *Deer and Elk Habitats in Coastal Forests of Southern British Columbia*. British Columbia Ministry of Environment, Lands and Parks. Nanaimo, BC. 310 pp.

Peek, J.M. 1982. Elk (Cervus elaphus). Pages 851-861 *in:* Chapman, J.A. and G.A. Feldhamer (eds.). Wild mammals of North America: Biology, management, and economics. The Johns Hopkins University press. Baltimore and London.

Renecker, L.A. and R.J. Hudson. 1992. Morphology, bioenergetics and resource use. Pages 187-214 *in*: Stelfox, J.B. (ed.) *Alberta's Hoofed Mammals: Their Ecology, Status and Management*. Lone Pine Press. Edmonton, AB.

RIC (Resources Inventory Committee). 1998. British Columbia wildlife habitat rating standards. Draft April 1998. BC Ministry of Environment, Lands and Parks, Victoria, BC. 108 pp.

Rickard, W.H., J.D. Hedlund, and R.E. Fitzner. 1977. Elk in the shrub-steppe region of Washington: An authentic record. Science 196:1009-1010.

Salter, R.E. and R.J. Hudson. 1980. Range relationships of real horses with wild ungulates and cattle in western Alberta. J. Range Manage. 33:266-271.

Schmidt, J.L. and D.L. Gilbert. 1980. Big game of North America: Ecology and Management. Stackpole Books. Harrisburgh, PA.

Skovlin, J.M. 1982. Habitat requirements and evaluations. Pages 369-414 in: Thomas, J.W. and D.E. Toweil (eds.) *Elk of North America: Ecology and Management*. The Wildlife Management Institute. Washington, DC.

Smith, K. 1985. A preliminary elk (Cervus elaphus) management plan for the Edson Wildlife Management Area. Alberta Energy and Natural Resources, Fish and Wildlife Division. Edson, AB. n.p.

Stelfox, J.B., L. Peleshok, and M.T. Nietfeld. 1991. A selected bibliography of research, management, and biology of Alberta's native ungulates. AECV92-B1. Alberta Environmental Center. Vegreville, AB. 110 pp.

Stevens. V. 1995. Wildlife diversity in British Columbia: Distribution and habitat use of amphibians, reptiles, birds, and mammals in biogeoclimatic zones. British Columbia Ministry of Environment, Lands and Parks; Habitat Protection Program, BC. 288 pp.

Thomas, J.W. 1979. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. US Dept. Agric. For. Serv. Handbook 553. Washington DC, WS.

Thomas, J.W., H. Black, R.J. Scherzinger, and R.J. Pederson. 1979. Deer and elk. Pages 104-127 *in*: Thomas, J.W. (ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. US Dept. Agric. For. Serv. Handbook 553.