ELK

(Cervus elaphus)

Source: Smith (1993)

Prepared for Millar Western Forest Products'
Biodiversity Assessment Project

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1.1 Introduction

The Elk (*Cervus elaphus*) is distributed throughout southern and eastern British Columbia and western Alberta and exists in smaller populations further east (Buckmaster *et al.* 1995, Figure 1). It is considered an 'edge species' as it relies on the presence of both grasslands to provide plentiful herbaceous forage and forest cover to offer protection from inclement environmental conditions, predators, and human-caused disturbance (Cairns and Telfer 1980; Wickstrom *et al.* 1984; Grover and Thompson 1986; McCorquodale *et al.* 1986; Buckmaster *et al.* 1995).

1.2 Effects of Forest Management Activities

It has been shown that Elk are very sensitive to human activity in the forest, though they are eventually able to habituate to low impact, perpetual disturbance (Cole *et al.* 1997). Logging has been found to be particularly unsettling for the Elk and herds may move up to 4,000 m away from the activity (Edge and Marcum 1984; Edge *et al.* 1984; Kuck *et al.* 1984; Edge *et al.* 1986; Grover and Thompson 1986; Edge and Marcum 1989). Even recreational use of a forest may evoke a fleeing response (Ferguson and Keith 1982; Edge

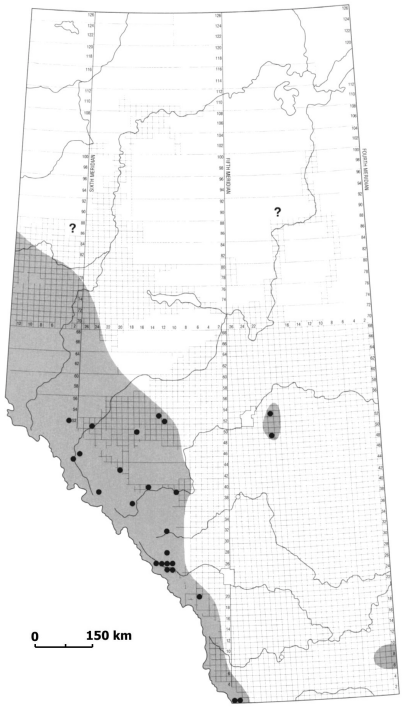

Figure 1. Estimated distribution of the Elk in Alberta (Smith 1993).

et al. 1984; Edge and Marcum 1984; Grover and Thompson 1986; Edge and Marcum 1989; Cassirer *et al.* 1992; Buckmaster *et al.* 1995). Once disturbed, the animals will relocate within a dense forest that offers hiding cover (Edge *et al.* 1984; Kuck *et al.* 1984). Because of this sensitivity to human activity, Edge *et al.* (1984) suggested that thick tree cover should be maintained on all sides of logging operations to provide the Elk with nearby hiding cover.

As pointed out by Todd (pers. comm. 1999), the herbaceous vegetation of the genus *Calamagrostis* is commonly a target of glyphosate applications. This can negatively impact Elk habitat suitability, as it is an important food item.

2.0 HABITAT USE INFORMATION

2.1 Food Requirements

Like most free-ranging ungulates, a large portion of an Elk's day is spent foraging (Wickstrom *et al.* 1984). The type of foods sought changes with the seasons, depending on availability, but grasses and sedges are an important part of the Elk's diet year-round, with forbs and ferns making an important contribution in the fall (Morgantini and Bruns 1984; McCorquodale 1993). Snow may cause the rate of consumption of shrubs to increase, possibly to 50% of the Elk's diet in years with heavy snow (McCorquodale 1993). While the Elk is known to prefer herbaceous vegetation, it does not generally show preference for any particular plant species (Edge *et al.* 1987).

Since herbaceous and shrubby vegetation are vital elements of Elk foraging habitat, clearings, whether recently burned areas, natural meadows, or clearcuts, must be present within the home range as these provide a plentiful supply of this plant material (Canon *et al.* 1987; Unsworth *et al.* 1998). In addition, it is possible that narrow clearings such as seismic or utility lines may provide suitable foraging habitat for the Elk. Jones (pers. comm. 1999) noted that agricultural crops provide the Elk with a substantial and palatable food resource.

While Elk do not have as much trouble with deep snow accumulation as do the other grazing cervids (Wickstrom *et al.* 1984), snow depth greater than 40 cm may cause them to forage preferentially on south-facing slopes.

The Elk is considered an 'edge species' as it prefers to remain within 100 to 200 m of stands providing suitable hiding cover (Morgantini and Hudson 1979) and within 1,000 m of forest offering thermal cover at all times, but requires open areas containing high biomass of herbaceous vegetation for foraging (Cairns and Telfer 1980; Wickstrom *et al.* 1984; Grover and Thompson 1986; McCorquodale *et al.* 1986; Buckmaster *et al.* 1995). A clearing with ample herbaceous ground cover will not be considered suitable habitat unless it is within appropriate distance of both hiding and thermal cover (Buckmaster *et al.* 1995).

Based on the above discussion, the food requirements of the Elk are met by habitat with:

- Significant herbaceous vegetation cover;
- Some shrub cover;
- South-facing aspect;
- Proximate agricultural lands;
- Within 200 m of suitable hiding cover; and
- Within 1,000 m of thermal cover.

2.2 Cover Requirements

The Elk may require forest cover for both thermal regulation and shelter from predators or disturbances (Gese and Groth 1995). As mentioned in the Food Requirements section, both thermal and hiding cover should be located within suitable distances of each other. In addition, thermal and hiding cover should be present in patches of a minimum size of 4 ha throughout the home range to be functional for Elk (Buckmaster *et al.* 1995).

Thermal Cover

McCorquodale *et al.* (1986) showed that the Elk has the capacity to be successful in areas with little forest cover, which suggests that thermal cover may not be a limiting requirement. Similarly, research in Alberta by Jones (1997) revealed that Elk, with a lower critical temperature of – 18° C, need only utilise thermal cover during extended periods of very low temperatures. Throughout the entire winter season of 1996, the temperature dropped below this point for only 23 days and did not continue for longer than five days at a time.

In addition, Morgantini and Hudson (1979) showed that there is no significant relationship between habitat selection and weather conditions. These studies suggest that Elk in west-central Alberta may tolerate separation from thermal cover better than those in other parts of the range. Though the value of thermal cover to Elk is sometimes disputed, biologists in Alberta suggest that, from time to time, during more severe winters, it may be an important habitat element (Buckmaster *et al.* 1995). It should, therefore, be maintained within the FMA area since it may be required on these rare occasions.

In mid-summer and mid-winter, when Elk may be in need of more moderate temperatures, mixedwood forests with significant canopy closure and average tree height of at least 10 m are thought to be valuable (Edge *et al.* 1987; DeMarchi and Bunnell 1993; Millspaugh *et al.* 1996). To be useful as thermal cover, canopy closure must be at least 36%, but should optimally be > 70% (DeMarchi and Bunnell 1993; Millspaugh *et al.* 1996). As this cover should assist Elk in thermal regulation during both summer and winter, some coniferous trees must be present within the stand. Stands become suitable with at least 30% spruce, fir, or pine representation, but will optimally contain > 50% (Buckmaster *et al.* 1995).

Elk in Alberta seem to select habitat differently at different times of the day. At dawn and dusk, they are observed most often on open slopes whereas 70% of daytime sightings are in coniferous forests. In addition, Elk have been observed in grasslands, shrublands, and deciduous forests equally at all times during the day (Morgantini and Hudson 1979).

Hiding Cover

Where Elk may perceive disturbance as a threat, appropriate hiding cover must be available (Millspaugh *et al.* 1996). Hiding cover is defined as vegetation capable of concealing 90% of a standing adult Elk at a distance of 60 m (Thomas *et al.* 1979). This condition is met by the presence of dense understorey and low tree branches of 1 to 4 m above the ground (Buckmaster *et al.* 1995). Suitable hiding cover is most necessary in areas that are subjected to human disturbance such as roadway construction. Indeed, Elk appear to avoid moving closer than 500 to 1,230 m of a road not surrounded by appropriate hiding cover (Edge and Marcum 1989). When dense forests are maintained along roadsides, however, the area avoided may be reduced to about 100 m (Buckmaster *et al.* 1995).

Therefore, thermal cover for Elk is best provided by:

- Mixedwood stands, of at least 30% (but preferably > 50%) spruce or pine;
- Average tree height of at least 10 m;
- At least 36% canopy closure but preferably > 70%;
- Minimum area of at least 4 ha; and
- Thermal cover and food must be less than 1,000 m apart.

Hiding cover is provided by:

- Shrub height or height to live crown of 1 to 4 m;
- Hiding cover and food must be less than 200 m apart; and
- Minimum area of at least 4 ha.

2.3 Reproduction Requirements

Female Elk move to chosen calving areas in late May or June to give birth. Calving areas are located at low elevations on the traditional summer range. Mature forest with gentle terrain and south- or southwest-facing aspect (Kuck *et al.* 1984) provide optimal conditions. Open areas suitable for foraging should be available nearby, as cows and calves are in need of a plentiful food supply during this time of high nutritional requirement (Edge *et al.* 1987). In particular, Jones (pers. comm. 1999) has observed that Elk may prefer riparian habitat as calving sites. He expects that pregnant females are drawn to such areas by the combination of lush vegetation and ample water resources that they supply.

2.4 Habitat Area Requirements

The Elk is a herding animal (Van Dyke *et al.* 1998). Recorded estimates of herd range size vary by season. Elk are known to become relatively sedentary during winter (Green and Bear 1990; McCorquodale 1993) and will occupy a larger area in summer. Based on a literature review, Buckmaster *et al*. (1995) suggested that herd home ranges during the winter approach 2,000 ha. The estimated range size of 4,500 ha, from the research of Edge *et al.* (1984), will be used as summer home range size. Elk do not tend to move a great distance between summer and winter ranges, generally less than 50 km (Jones pers. comm. 1999).

2.5 Landscape Configuration Requirements

As Elk is an edge species, its habitat consists of a mosaic of openings and closed forest with ample herbaceous and shrubby vegetation for forage and dense shelter for hiding and thermal cover. It has been suggested that the ratio of areas containing suitable foraging conditions to those with appropriate cover should be 60:40 (Thomas *et al.* 1979). Of the cover area, 50% should be hiding cover while 25% should provide thermal cover; the remaining 25% could be either hiding or thermal cover (Thomas *et al.* 1979).

2.6 Sensitivity to Human Disturbance

The Elk is sensitive to human use of its habitat and is known to be displaced at least 500 m and up to 4,000 m from logging activities, road construction, or even heavy use of cross-country skiing trails (Ferguson and Keith 1982; Edge *et al.* 1984; Edge and Marcum 1984; Grover and Thompson 1986; Edge and Marcum 1989; Cassirer *et al.* 1992; Buckmaster *et al.* 1995).

Though Jones (1997) most often viewed Elk within seismic lines, he feels that this observation may be a relict of his study method, as he used seismic lines as access routes to the forest (Jones pers. comm. 1999). Since seismic lines are commonly used for recreational purposes (e.g. snowmobiling), they may actually reduce, rather than improve, Elk habitat quality at least during periods of heavy use. He also mentioned that agricultural lands are desirable as foraging habitat and that Elk often move from forested areas to stacked feed and pasture areas.

It has been found that the impact of hunting on Elk is two-fold. Due to human activity in the Elk's habitat, displacement occurs, in a manner similar to that described above (Edge *et al.* 1986). Hunting during the fall rut compounds the problem as the Elk are displaced and breeding is delayed. Young that are born later in the season due to this delay are not adequately prepared for the lower temperatures of the fall which, in turn, leads to a reduction in the survival rate of the young (Squibb *et al.* 1986).

3.0 MODEL

3.1 Envirogram

Elk are influenced by their ability to obtain sufficient food resources, to shelter themselves from temperature extremes, and to feel comfortable in the face of human disturbance or predators. The forest features that contribute to suitable foraging and shelter habitats are shown in the envirogram below (Figure 2).

Since the most important food resource for the Elk is herbaceous vegetation, the percentage of the forest floor covered with these plants is important in determining the quality of the area for foraging. Since shrubs may be required as food during months when snow cover is deep, the coverage of shrubs may also be important. For easier access to the food supply in winter, the animals may elect to forage on south- or southwest-facing slopes. In addition, attractive foraging opportunities may be found on agricultural land and near seismic or utility lines. The important stand characteristics of thermal cover are tree species composition, average tree height, and canopy closure. In addition, habitat with south- or southwest-facing aspect is more desirable. When disturbed, Elk prefer to hide in stands with low branches and shrubs. Elk is an edge species that requires food and both kinds of cover habitat within close proximity of each other.

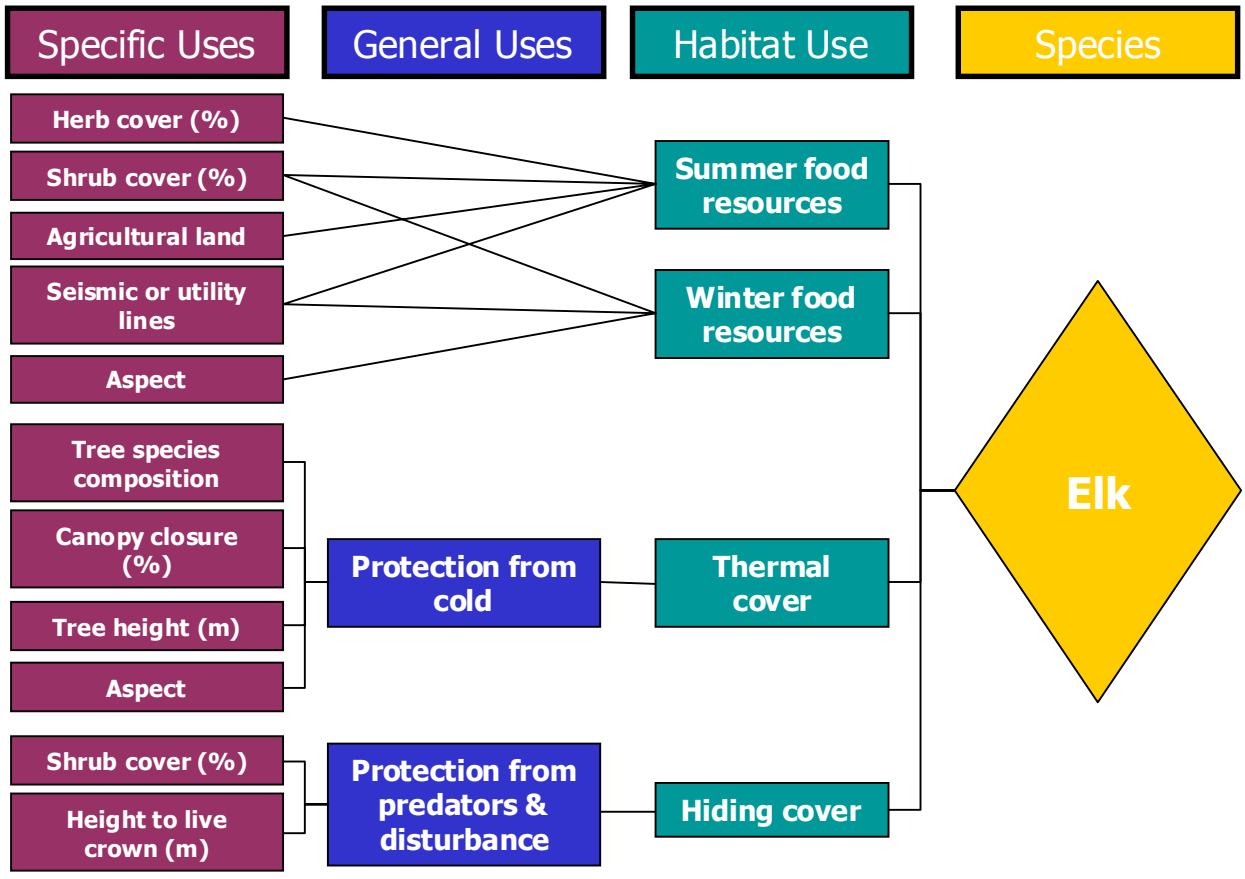

Figure 2. Envirogram of the Elk based on available habitat information for HSM development.

3.2 Application Boundaries

Season: This model produces SI values for use year-round.

Habitat Area: Home range size is thought to be 4,500 ha in summer and 2,000 ha in winter. No home range smoothing is required in this HSM, however.

Model Output: The model assigns a SI value for summer foraging, winter foraging, thermal cover, and hiding cover habitat suitability to each 25 m pixel of forested habitat.

3.3 Model Description

The HSM for Elk habitat follows the structure described in the envirogram (Figure 3). As all habitat elements are critical and needed at the same time, no compensation is allowed between them.

The $SI_{food\ (summer)}$ takes into account the percentage of the forest floor covered with herbaceous vegetation and shrubs. Herbaceous vegetation is preferred. Therefore, the value of shrub cover is included as a bonus function. We expect that Elk inhabiting land proximate to agricultural fields or seismic or utility lines will have access to a reliable source of food.

In winter, herbaceous vegetation is not readily available. Therefore, the major variables in $SI_{food\ (winter)}$ are shrub cover and presence of seismic or utility lines. These variables are fully compensatory since winter forage could be expected to be available either in habitat containing abundant shrubs or within narrow clearings. Winter access to herbaceous vegetation is improved on south- or southwest-facing slopes. Since this type of vegetation is preferred and will be consumed if available, a bonus of 0.25 is applied to these sites.

The SI_{cover} consists of variables indicating the tree species composition, average tree height, and canopy closure. All three variables are important components of thermal cover and are non-compensatory. The suitability rating of habitat with south- or southwest-facing aspect is increased by the addition of a bonus of 0.25.

The SI_{hiding} includes an evaluation of shrub cover weighted by height and height to live crown of the trees in the stand. Since shrubs of height 1 to 4 m are most valuable as hiding cover, they are weighted more strongly than those of greater or lesser heights. Shrubs and low branches can provide hiding cover equally well. These two variables are, therefore, fully compensatory. Since Elk are sensitive to human disturbance, proximity to roads can reduce the value of hiding cover by a penalty of 0.25.

3.4 Habitat Variable SIs

Food

As Elk can use both herbaceous vegetation (S_{f1}) and shrubs (S_{f2}) as food, the percentage of the forest floor covered by these two types of plants is considered in the SI_{food} equations. Additionally, access to food is related to slope aspect (S_{f3}) and to proximity to agricultural land (S_{f4}) or seismic or utility lines (S_{f5}). Foraging habitat suitability increases linearly with increasing herbaceous vegetation cover to a maximum at 40% (Figure 4). Similarly, suitability increases with shrub cover to a maximum at 25% cover (Figure 5). A bonus of up to 0.25 is given to habitats containing sufficient shrubs and of 0.25 to habitats with south- or southwest-facing aspect.

Cover

The SI_{cover} consists of variables that indicate tree species composition (S_{c1}), average tree height (S_{c2}), canopy closure (S_{c3}), and aspect (S_{c4}). As shown in Figure 6, a stand is not suitable unless it consists of at least 25%

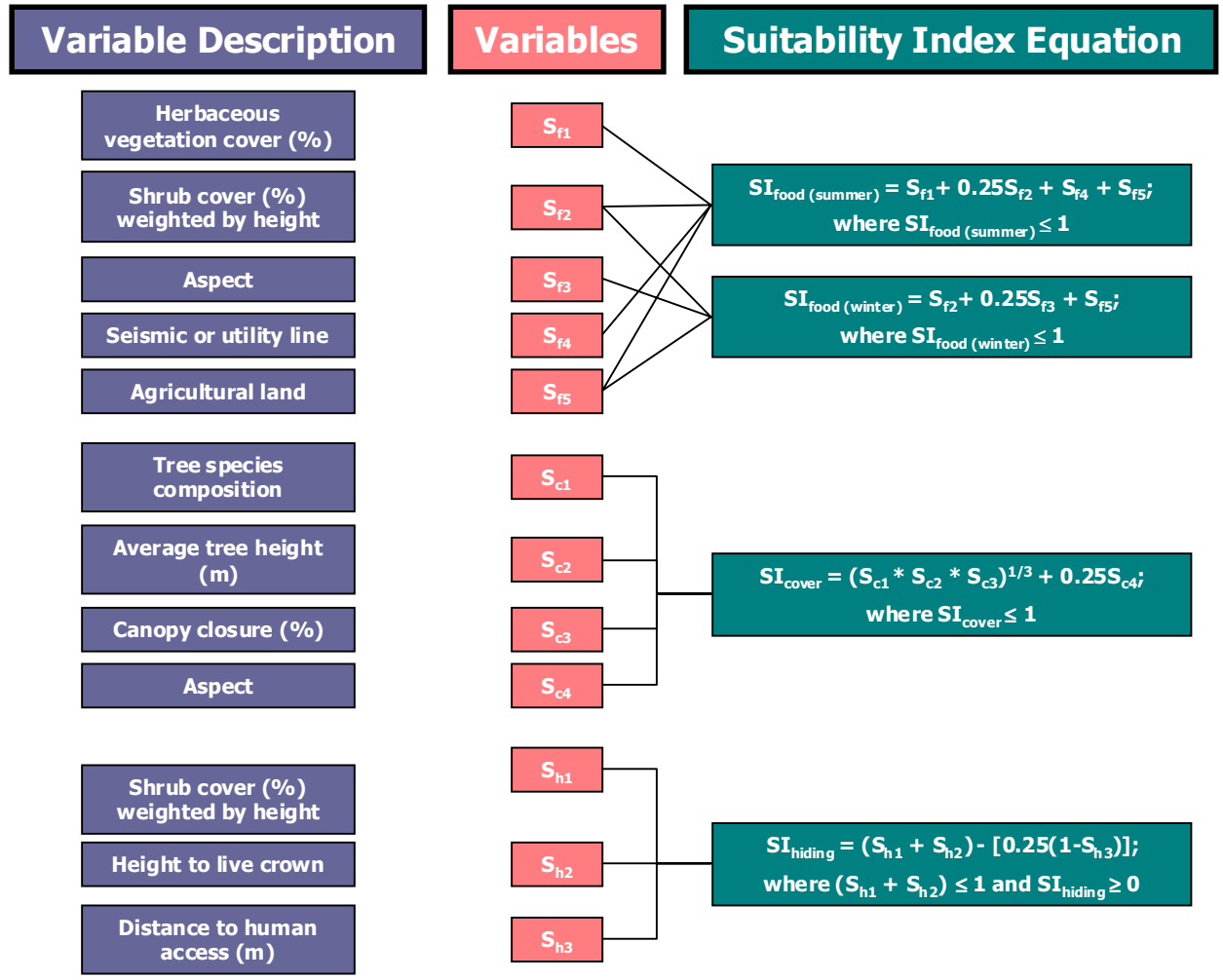

Figure 3. HSM structure for Elk in Millar Western's FMA area.

spruce, pine, or fir but will optimally have 50% representation by these species. Trees of average height greater than 4 m must be present but the situation is optimal once a height of 10 m is reached (Figure 7). Canopy closure should be greater than 25% but is preferred if greater than 75% (Figure 8). In addition, a bonus is applied to all habitats on south- or southwest-facing slopes (S_{c4}).

Hiding Cover

The SI_{hiding} shows a stand's suitability as hiding cover and takes into account shrub cover weighted by height (S_{h1}), height to live tree crown (S_{h2}), and proximity to major roads (S_{h3}). As seen in Figure 9, Elk habitat suitability increases linearly with increasing shrub cover of suitable heights at 50% cover. Figure 10 displays the relationship between height to live crown and suitability as hiding cover. Live crown < 5 m above the ground provides protective hiding cover for Elk. In addition, Elk are most comfortable further than 500 m, but preferably more than 1,000 m from major roads (Figure 11).

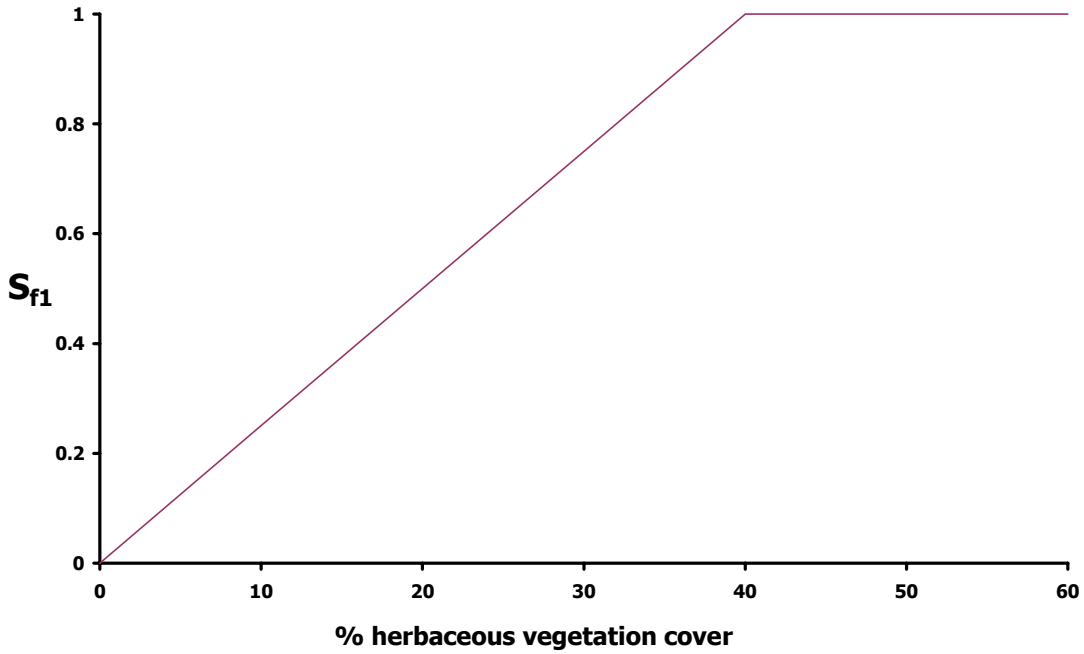

Figure 4. Elk foraging habitat suitability in relation to herbaceous vegetation cover within Millar Western's FMA area.

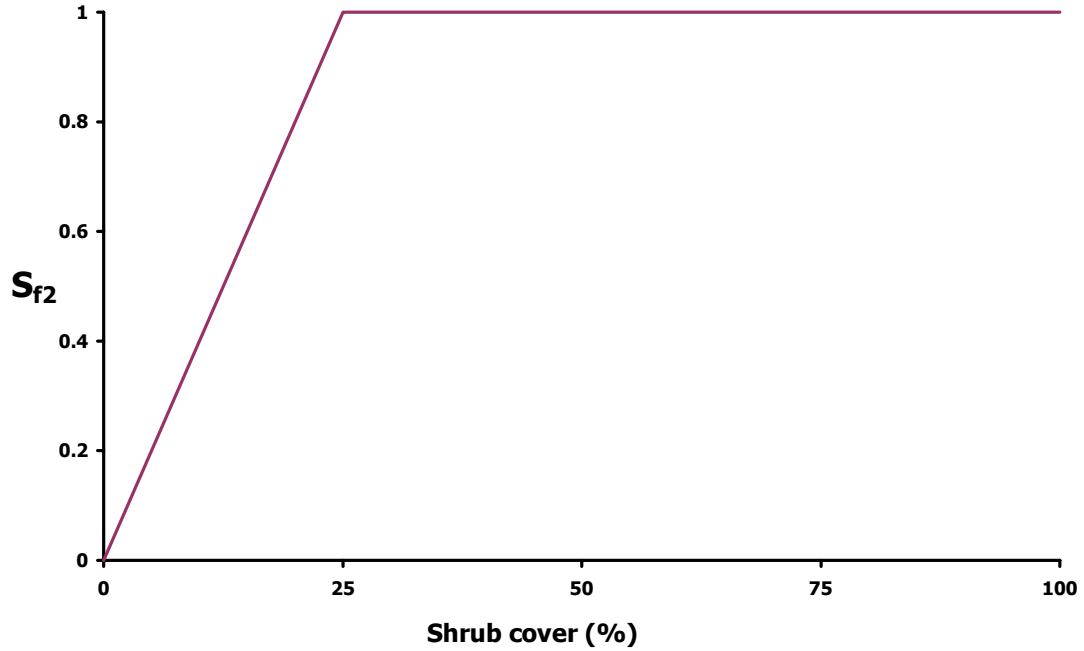

Figure 5. Elk foraging habitat suitability in relation to shrub cover within Millar Western's FMA area. Weighting: 0 - 50 cm = 0, 51 cm - 1 m = 0.25, 1.1 - 2 m = 1, > 2 m = 0.5.

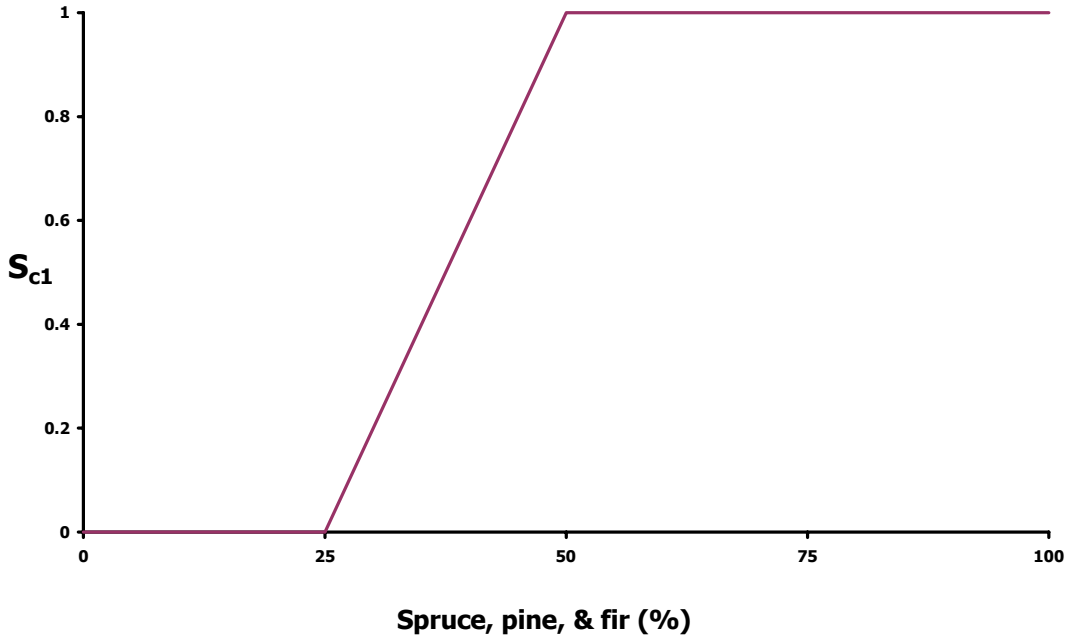

Figure 6. Elk thermal cover habitat suitability in relation to the percentage of spruce, fir, and pine within Millar Western's FMA area.

Figure 7. Elk thermal cover habitat suitability in relation to the average tree height within Millar Western's FMA area.

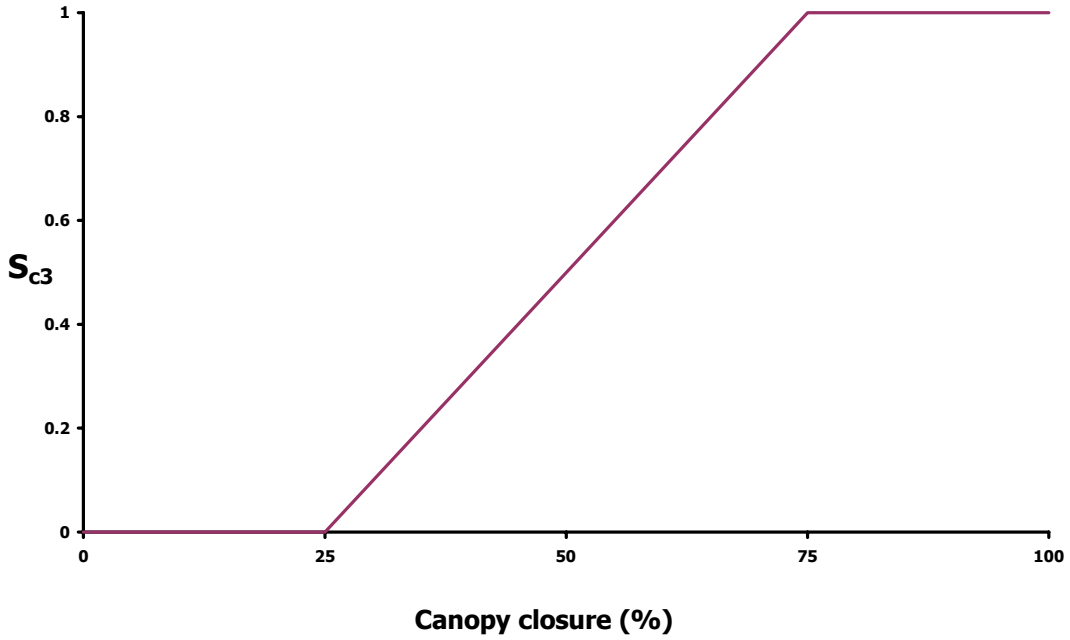

Figure 8. Elk thermal cover habitat suitability in relation to the canopy closure within Millar Western's FMA area.

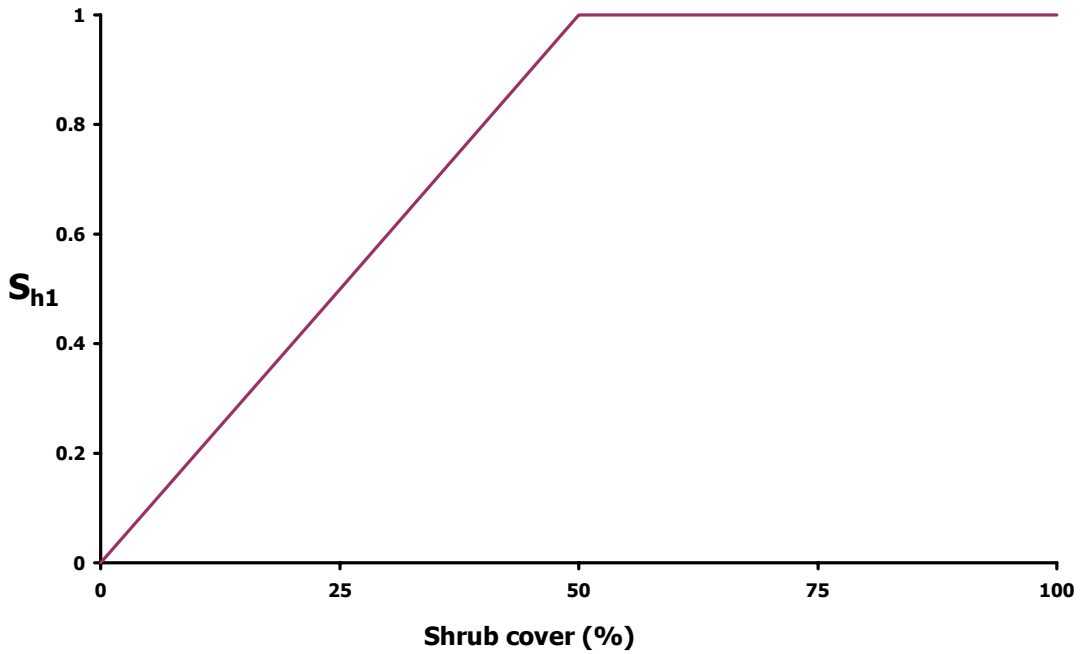

Figure 9. Elk hiding cover habitat suitability in relation to the shrub cover within Millar Western's FMA area. Weighting: < 1 m = 0, 1.1 to 3m = 1, > 3 m = 0.75.

Figure 10. Elk hiding cover habitat suitability in relation to the height to live crown within Millar Western's FMA area.

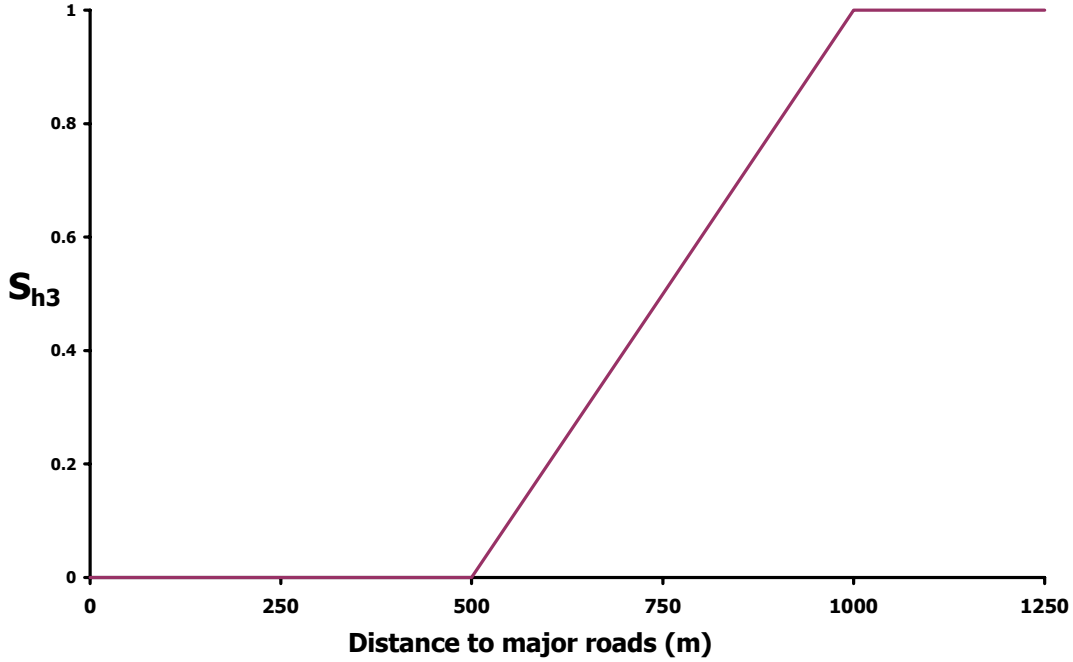

Figure 11. Elk habitat suitability in relation to distance from major roads within Millar Western's FMA area.

3.5 Computation

Our goal is to create HSMs that allow the user to identify the potential impacts of proposed forest management strategies on summer and winter foraging, thermal cover, and hiding cover habitats and, to some extent, their proximity to one another from an Elk's perspective. Therefore, the outputs of the $SI_{food\ (summer)}$, $SI_{food\ (winter)}$, SI_{cover}, and SI_{hiding} calculations are considered individually to display trends in habitat availability.

Foraging Habitat Indices

The model first calculates the partial $SI_{food\ (summer)}$ equation for each pixel using the following equation:

$$(S_{f1} + 0.25S_{f2}) \leq 1$$

Following this, all pixels that fall within agricultural land (S_{f4}) or a seismic or utility line (S_{f5}) are given suitability ratings of 1 for either variable S_{f4} or variable S_{f5}. All other pixels receive ratings of 0 for these variables. The $SI_{food\ (summer)}$ equation is then calculated as follows:

$$SI_{food\ (summer)} = (S_{f1} + 0.25S_{f2} + S_{f4} + S_{f5});$$

$$\text{where } SI_{food\ (summer)} \leq 1.$$

$SI_{food\ (winter)}$ is evaluated by the equation:

$$SI_{food\ (winter)} = (S_{f2} + 0.25S_{f3} + S_{f5});$$

$$SI_{food\ (winter)} \leq 1.$$

Cover Habitat Index

Next, the value of each pixel of forested habitat as cover is assessed using the equation:

$$SI_{cover} = [(S_{c1} * S_{c2} * S_{c3})^{1/3} + 0.25S_{c4}];$$

$$\text{where } SI_{cover} \leq 1.$$

Hiding Cover Habitat Index

The model first calculates the partial SI_{hiding} equation for each pixel based on the following equation:

$$(S_{h1} + S_{h2}) \leq 1$$

Hiding cover habitat is negatively impacted by the presence of roads. A buffer of distance 1,000 m is placed around each roadway. The suitability ratings of the pixels that fall within the buffer are reduced according to the distance dependent relationship shown in Figure 11. All other pixels receive a suitability rating of 1 for this variable.

$$SI_{hiding} = [(S_{h1} + S_{h2}) - [0.25(1-S_{h3})];$$

$$\text{where } 1 \leq SI_{hiding} \geq 0.$$

Adjustment of SIs Based on Proximity between Foraging and Cover Habitats

As Elk have specific requirements for distance of food from hiding and thermal cover, the proximity of these resources must be taken into account. To ensure that a pixel supporting good foraging habitat is actually useful to Elk, it must be within 200 m of hiding cover and within 1,000 m of thermal cover. Two concentric circular windows move over the grid representing Millar Western's FMA area. One of these windows is 314 ha in size (radius 1,000 m) and the other is 12.6 ha (radius 200 m). Within the 314 ha circle, cover values are adjusted by proximity to both summer and winter food and the food SIs are adjusted by proximity to cover. Similarly, within the smaller circle, hiding cover values are adjusted by proximity to both summer and winter food and the food SIs are adjusted by proximity to hiding cover.

$$\text{Adjusted } SI_{\text{food (summer)}} = \{[SI_{\text{food (summer)}} * \text{Window } (\text{Max } (SI_{\text{cover}}))_{1{,}000\text{m}}]^{1/2} * [SI_{\text{food (summer)}} * \text{Window } (\text{Max } (SI_{\text{hiding}}))_{200\text{m}}]^{1/2}\}^{1/2}$$

$$\text{Adjusted } SI_{\text{food (winter)}} = \{[SI_{\text{food (winter)}} * \text{Window } (\text{Max } (SI_{\text{cover}}))_{1{,}000\text{m}}]^{1/2} * [SI_{\text{food (winter)}} * \text{Window } (\text{Max } (SI_{\text{hiding}}))_{200\text{m}}]^{1/2}\}^{1/2}$$

$$\text{Adjusted } SI_{\text{cover (summer)}} = [SI_{\text{cover}} * \text{Window } (\text{Max } (SI_{\text{food (summer)}}))_{1{,}000\text{m}}]^{1/2}$$

$$\text{Adjusted } SI_{\text{cover (winter)}} = [SI_{\text{cover}} * \text{Window } (\text{Max } (SI_{\text{food (winter)}}))_{1{,}000\text{m}}]^{1/2}$$

$$\text{Adjusted } SI_{\text{hiding (summer)}} = [SI_{\text{hiding}} * \text{Window } (\text{Max } (SI_{\text{food (summer)}}))_{200\ \text{m}}]^{1/2}$$

$$\text{Adjusted } SI_{\text{hiding (winter)}} = [SI_{\text{hiding}} * \text{Window } (\text{Max } (SI_{\text{food (winter)}}))_{200\ \text{m}}]^{1/2}$$

Home Range Smoothing

We have chosen not to smooth the foraging and cover habitats for Elk since the animals have the capability to select certain sections of their home range in which to forage or take cover. To smooth the values within the large home range area would cause the precise locations of potentially suitable foraging and cover zones to be masked.

4.0 EXTERNAL REVISION

Arlen Todd, wildlife biologist with Alberta Environment, Fisheries and Wildlife Management Division in Whitecourt, Alberta provided comments on a draft version of the HSM for Elk on April 30, 1999. The following revisions were made based on his advice:

1) The importance of *Calamagrostis* spp. to the Elk's diet and the negative impact of glyphosate on Elk habitat suitability was included in the literature review.

Paul Jones provided comments on a draft version of the HSM for Elk on June 2, 1999. He has first-hand experience with Elk in west-central Alberta that he acquired while completing a MSc degree at the University of Alberta. The following revisions were made from the original document in response to his review:

1) The model was originally written taking into account only winter habitat requirements. Based on Jones' comments, we decided to adapt it into a year-round model.

2) The model originally included a bonus function for habitat in proximity to water. Jones did not warrant this variable worthy of inclusion in the model.

3) Jones felt that the presence of seismic/utility lines may be more harmful than beneficial to the Elk. He suggested that we look into Elk use of agricultural land. We decided to include a new variable associated with proximity to agricultural lands and chose to keep the seismic and utility line variable in the SI_{food} equation. Jones' comments were noted in the literature review.

4) Shrubs and herbaceous vegetation were non-compensatory as foraging variables in the original model. Jones stated that very grassy areas will be sought by Elk as foraging habitat even if no shrubs are present. Therefore, shrubs were included in this equation as a bonus function.

5) Shrubs greater than 2 m high were given a weighting of 0.5 in the original model. Jones suggested that this be changed since very tall shrubs will not be valuable as hiding cover. It was, therefore, altered so that shrubs > 4 m tall receive a weight of 0.

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