ELK
WINTER FORAGING
HABITAT SUITABILITY INDEX MODEL
VERSION 5

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1. INTRODUCTION

Habitat Suitability Index (HSI) models predict the suitability of habitat for a species based on an assessment of habitat attributes such as habitat structure, habitat type and spatial arrangements between habitat features. This HSI model for elk *(Cervus elaphus)* applies to forests of the Foothills Model Forest (FMF) in west-central Alberta. The intended use is to predict habitat suitability at landscape scales and over long-time periods. The model will be used to determine potential changes in elk habitat area and carrying capacity throughout an entire forest management cycle (200 years). A previous version of the model was tested based on locations of radio-collared animals as part of a M.Sc. project by Paul Jones, University of Alberta.

2. SPECIES DESCRIPTION AND DISTRIBUTION

Elk are the second largest member of the deer family in North American (Banfield 1974). Bulls range from 2.3-2.4 m in length and stand 1.4 m at the shoulder with a mass of > 300 kg; cows are around 10% smaller (Banfield 1974). The Shawnee appropriately named the animal wapiti which translates to “white rump”, a distinguishing characteristic of this species (Banfield 1974). Other features are the dark brown head, neck, and legs, tawny torso, and large antlers on bulls (Banfield 1974).

In Canada, elk are distributed throughout south-eastern British Columbia, western Alberta, and in small isolated populations further east (Banfield 1974). Historically elk were found as far east as Ontario and Quebec (Banfield 1974). In Alberta, elk are not at risk and their habitat is secure (Wildlife Management Division 1996). In the Rocky Mountains and Foothills, elk generally overwinter in the Lower Foothills and Montane Natural Subregions and move up to higher elevations during the summer (Gadd 1995).

3. FOOD

During the spring and summer, elk are primarily grazers, feeding on numerous species of grasses and forbs (Collins and Urness 1983, Morgantini and Russel 1983, Smith 1985, Thomas and Bryant 1987). During fall and winter, elk consume greater amounts of forbs and shrubs (Skovlin 1982, Smith 1985, Freddy 1987), but prefer grass when available (Morgantini and Bruns 1984, Thomas and Bryant 1987). Periods of deep snow (> 40 cm) result in elk moving to habitats of high forage availability and low snow cover such as south-facing slopes (Irwin and Peek 1983). Elk are typically associated with forest edges (Cairns and Telfer 1980) and foraging often occurs within 200 m of cover (Thomas et al. 1979, Smith 1985).

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Elk in the boreal mixedwood region relied more heavily on browse, especially during winter, than elk in the boreal foothills and mountain regions where semi-open forest cover provided accessible grassland during most times of the year (Nietfeld et al. 1985). In the FMF, Jones (1997) examined winter habitat use of elk at the landscape, stand, and site level scales. At the landscape and stand level scales, elk used grasslands and meadows for foraging more often than expected based on availability. At the site level scale, elk feeding sites had less tree cover, fewer conifers in the canopy, lower tree height, stem densities and shrub cover, greater grass cover and were closer to seismic lines than random sites. Feeding sites were farther from hiding cover than random vegetation plots. When these variables and several more were entered into a stepwise logistic regression only stem density, overstory tree height and distance to seismic lines significantly distinguished the used and available plots. These three parameters were all negatively associated with elk feeding sites.

4. COVER

Cover habitat includes both hiding cover (vegetation capable of hiding 90% of a standing adult elk at 61 m or less), and thermal cover (Thomas et al. 1979). Security (hiding/resting) cover for elk in the presence of human disturbance was important to elk in some studies (Lyon 1980, Peek et al. 1982). Hiding cover was provided by understory shrubs and trees with 1-2 m high branches (Abbot 1991). Cover was no greater than 180 m from a foraging area (Smith 1985). Any distance greater than this was thought to reduce the effectiveness and availability of the cover.

Elk may take refuge in heavy timber (thermal cover) when temperatures drop and wind-chill increases (Beall 1974). Optimal thermal cover was in conifers or coniferous dominated mixedwood stands 10-12 m tall with greater than 70% canopy closure (Thomas et al. 1979, Smith 1985). Elk often bedded in dense stands of lodgepole pine, western hemlock and tall willow clumps on southern exposures during the winter in Idaho (Irwin and Peek 1983). Mature mixedwood stands provide the best hiding and thermal cover compared to pine and spruce stands (Stelfox 1988). Thermal cover areas need to be a minimum of 4 ha to provide adequate protection for herds of elk (Wisdom et al. 1986).

The absence of thermal cover created an insignificant increase in thermoregulatory costs for elk (Peek et al. 1982) and is assumed required only during extreme winter conditions involving high winds and deep snow (Peek et al. 1982). A recent study on captive young cow elk in Oregon over four winters showed that dense cover in the winter was detrimental by causing an increase in mass loss and fat catabolism compared to elk maintained in open habitats (Cook et al. 1998). In Riding Mountain National Park in Manitoba, elk preferred grasslands, shrublands and recent burnt over forested stands and bogs (Rounds 1981).

Jones (1997) tested whether canopy cover, tree height, % conifer in tree canopy, distance from access, and distance from food were important hiding and thermal cover attributes. He found bedding sites had a higher percent grass cover, fewer stems and less spruce, fir and pine in the canopy than random vegetation plots. Elk often bedded in open meadows and along seismic lines in the winter. When he entered these variables and several others into a stepwise logistic regression only stem density was significant. Elk bedded in areas where stem densities reached up to 25 000 stems/ha but once stem densities exceeded 25 000 stems/ha there was a negative association. These high stem densities were thought to reduce visibility and detection of predators. Distances to roads or seismic lines were not significant.

5. REPRODUCTION

During the summer, hinds and their calves are found together while stags are found in small bachelor groups (Banfield 1974). During the rutting season in the fall, which extends from late September to early November, each stag supervises a harem of hinds and calves. From late September to early November, hinds experience oestrous several times until fertilization occurs. Gestation lasts from 249-262 days and calves are born in late May to early June.

Typically one calf is born, but in areas with optimal habitat twins occur 25% of the time. Calves are spotted and are up following the mother after the first few days. Weaning occurs in September, at which time the calves moult into the uniform dark brown juvenile coat. Females typically do not bear young until they reach 3 years of age and young stags likely do not mate until they are 4 or 5 years old.

6. HABITAT AREA

In the FMF, two elk herds had home ranges of 5299 ha and 5170 ha (Jones 1997). Individual home ranges varied from 1224-5299 ha (Jones 1997). Home ranges of the elk herds had fewer roads, more seismic lines, and more numerous, small habitat patches. Individual feeding and bedding sites were not associated with distances to major or minor roads.

The home range of elk is made up of winter and summer ranges, plus migration routes (MacCallum and Ebel 1985, Smith 1985). In Jasper National Park, elk preferred valleys in fall and winter (Gadd 1995), whereas around Hinton, Alberta, they were common in mixedwood habitats near natural and man-made clearings (Jones 1997). Grassy meadows, willow flats and south-facing slopes were key winter range; with elk congregating along creeks and rivers during critical winter periods (Smith and Bloomfield 1980). Irwin and Peek (1983) determined elk winter range to be 210 ha in early successional forest. They also found elk home ranges throughout the year contained proportionally more foraging area and less thermal cover than found in the study area (Irwin and Peek 1983).

Due to the herding behaviour of elk and complex movement patterns, population density estimates for the FMF are not available (Smith 1985). However, conversion of the provincial and regional elk management plans to the Weldwood Forest Management Agreement area results in a species objective of 1450 elk in the area.

6.1. INTERSPERSION

A 60:40 ratio of forage to cover habitat was considered optimum for winter elk habitat by several authors (Thomas et al. 1979, Smith 1985, Brown 1991). In the FMF, Jones (1997) found a 50/50 split between food and cover. One quarter of the cover area should be thermal cover with a closed canopy providing a reduction in winter radiant heat loss and protection from solar radiation during warm periods. The remaining quarter of the cover area may be hiding or thermal cover, whichever is more limited in the area of interest (Jones 1997).

In the FMF, it is assumed that cover habitat is not limiting, while food is limited within the winter range of elk. Also it is assumed that where suitable food occurs, suitable cover will be nearby. These assumptions are based on several simulations using an earlier version of the moose HSI model. These simulations indicated that suitable cover as defined in the model was abundant in the FMF.

6.2 HABITAT EFFECTIVENESS

Habitat effectiveness was reduced by the presence of open roads used by motorized vehicles (Wisdom et al. 1986, Thomas and Bryant 1987). Roads through forage areas could reduce elk use by up to 90% for 500 m when hiding cover is unavailable (Lyon 1980). When roadside hiding cover is present the zone of influence may be reduced to approximately 100 m.

In areas where hiding cover was not limited, logging activities did not significantly alter cow elk home range (Edge et al. 1985) in Douglas/subalpine fir forests in Montana. On-going logging activities in a similar forest type in Montana displaced cow elk 0.5-1 km away from the disturbance, regardless of the extent of habituation or the amount of previous use (Edge and Marcum 1985). However, elk quickly returned to habitats once the direct disturbance was removed (Edge and Marcum 1985). Cow elk responded similarly to disturbances by cross-country skiers (Cassirer et al. 1992). Ferguson and Keith (1982) noted elk moved away from heavily-used ski trails.

7. HSI MODEL DEVELOPMENT

7.1 MODEL APPLICABILITY

Species: Elk (*Cervus elaphus*).

Habitat Evaluated: Foraging Cover only. Based on the findings of Jones (1997) and simulations using the moose HSI model, hiding and thermal cover, although important to elk in the winter, is not limiting in the Lower Foothills and Montane Natural Subregions in the FMF.

Geographic area: This model is applicable to the Foothills Model Forest in west-central Alberta.

Seasonal Applicability: This model produces HSI values for critical winter food habitat.

Cover types: This model applies to forest and non-forest habitat areas of the Lower Foothills and Montane Natural Subregions (Beckingham et al. 1996). The model should also be broadly applicable to other habitat areas dominated by vegetation similar to that in this region, including pure deciduous, mixedwood and pure coniferous forest types, as well as wetland and riparian forests, meadows, shrublands, and areas regenerating after forest harvesting.

Minimum Habitat Area: Minimum habitat area is defined as the minimum amount of contiguous habitat to which the model will be applied. Because elk made use of numerous small patches within a large habitat area (Jones 1997), no minimum contiguous habitat area is specified. The model will be applied to areas were elk generally overwinter in the FMF, which is in the Lower Foothills and Montane Natural Subregions.

Model Output: The model will produce Habitat Units (HU) of food for each habitat polygon based on HSI value and polygon area. Habitat units are calculated by multiplying the HSI score for an area by the hectares. The performance measure for the model is potential carrying capacity (elk per ha). HU must be correlated to estimates of carrying capacity for model verification

Carrying Capacity (Individuals per ha where HSI = 1.0): Based on limited local information, the current estimate of the maximum number of elk per hectare is 0.07 (K. Smith, Area Wildlife Biologist, Edson Fish and Wildlife, personal communication).

Verification Level: The reliability of this model has not been evaluated against local data. The verification level is 5: model was tested/revised using local data, but predictive performance of revised model has not been tested.

Application: This HSI model is designed to assess habitat suitability for relatively large forest landscapes using generalized species-habitat relationships and stand-level vegetation inventory. Its purpose is to predict relative changes in elk habitat supply at the landscape level over long time periods (200 years), for integration with forest management planning. The model is not designed to provide accurate prediction of suitability or use at the stand level. Approximate population size can be calculated by assuming linear habitat-population relationships, but the model is not designed to provide accurate population density estimates. Any attempt to use the model in a different geographic area or for other than the intended purpose should be accompanied by model testing procedures, verification analysis, and other modifications to meet specific objectives.

7.2 MODEL DESCRIPTION

The HSI model for elk winter habitat assumes the life requisite of winter food is limiting. Reproductive needs, thermal and hiding cover are not considered limited in the FMF.

7.2.1 Habitat Variables and HSI Components

Foraging

The winter diet of elk consists of graminoids, forbs and browse (shrubs and deciduous saplings). Stand level characteristics associated with a high component of grass cover are used. Deciduous stands with an open canopy generally have high grass, herb and shrub covers and are thought to provide optimal foraging for elk. In addition, nonforested areas such as meadows, seismic lines and powerlines have high grass cover and are included in the model as areas with a scattered canopy closure (0-5%).

Table 1. Relationship between habitat variables and life requisites for the elk HSI model.

HSI Component	Life Requisite	Habitat Variable	Habitat Variable Definition
S_1	Food	Tree Canopy Closure (%)	Percent of ground covered by a vertical projection of tree crown areas onto the ground. Includes trees ≥ 8 cm diameter at breast height (dbh at 1.3 m).
S_2	Food	Tree Canopy Closure (%)	Percent of ground covered by a vertical projection of tree crown areas onto the ground. Includes trees ≥ 8 cm diameter at breast height (dbh at 1.3 m).
S_3	Food	Deciduous in Tree Canopy (%)	Percent composition of all deciduous tree species in the tree canopy.
S_4	Food	Grass Cover (%)	Percent ground cover of all grass species in the stand.

7.2.2 Graphical HSI Component Relationships

S_1 Areas with little forest cover are assumed to provide high grass cover which is the preferred winter food for elk (Jones 1997). Nonforested areas include seismic lines, power lines and open meadows. Tree canopy closure in nonforested areas of < 6% is considered optimal. Anything above 6% has no suitability (Figure 1a).

S_2 Open forested sites also provide suitable foraging habitat. Open forests have higher amounts of light reaching the forest floor during the summer, which increases the amount of grasses and herbs growing under the canopy. A canopy cover between 6 and 20% is considered optimal. As tree canopy closure increases, suitability decreases until it reaches 0 at 80% (Figure 1b).

S_3 Deciduous forests tend to have the greatest grass, herb and shrub cover and therefore forests that are at least 50% deciduous are considered optimal (Figure 1c). There is however some suitable food in conifer forests so suitability never reaches 0 if there is no deciduous component.

S_4 Percent grass is included here to ensure that areas with few trees have a grass component. This will ensure that gravel pits and other nonforested, nongrassy areas are not given a high suitability.

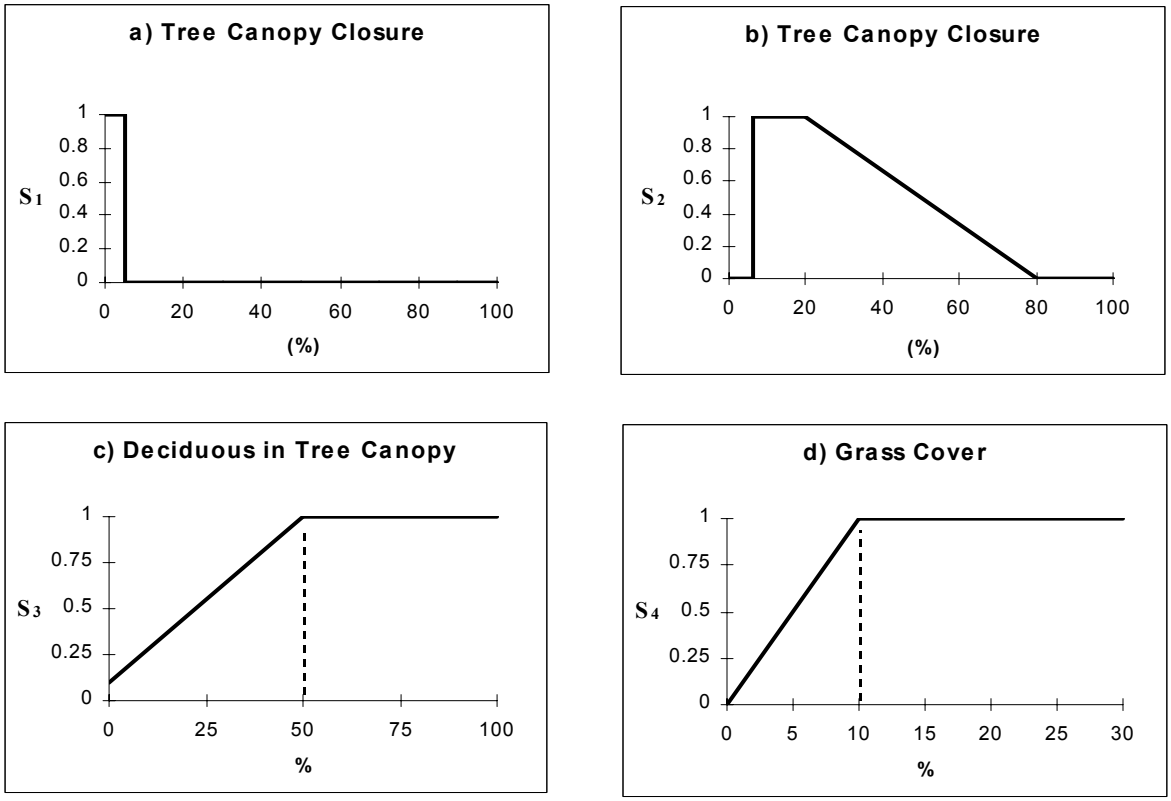

Figure 1. Graphical relationship between habitat variables and HSI components in the elk HSI model

7.3 MODEL ASSUMPTIONS

This section describes some of the assumptions that are embodied in this model. These assumptions may exist due to constraints on the model development or implementation, including data availability, and scale of model implementation.

1. Winter is the critical period determining elk habitat. Habitat for spring to fall seasons which encompasses calving, summer activities and the rut is not limiting. Elk are able to migrate freely to their winter range from their summer range.

2. Snow cover does not limit the availability of herbaceous food. All grass species have the same value as food and this does not diminish throughout winter. The same assumption holds for herbs and browse.
3. Water and minerals are not limiting winter resources.
4. Hiding and thermal cover are not limiting winter resources.
5. Stand characteristics can be used to predict high cover values of grass, herbs and shrubs.
6. Elk primarily overwinter in the Lower Foothills and Montane Natural Subregions.
7. Suitable foraging habitat near a road or far from cover will be used. Foraging in these places may occur under the cover of darkness.

7.4 EQUATION

The HSI equation for elk winter food habitat is composed of 3 controlling components (S_1, S_2 and S_4) and one modifying component (S_3). The third component is never less than 0.1, where the deciduous content is < 50% in forested stands. Whenever an area is devoid of trees, S_1 and S_4 will produce the greatest suitability value and will determine the HSI value. Whenever a forested stand is present, the combination of S_2 and S_3 will produce the greatest value and will therefore determine the HSI value.

$$\text{HSI-foraging} = \max (S_1 \times S_4,\ S_2 \times S_3)$$

8. SOURCES OF OTHER MODELS

The USDA Forest Service has developed a habitat effectiveness index for winter range (Thomas et al. 1988). IEC Beak Consultants developed a species-habitat relationship model for elk on behalf of the Alberta Fish and Wildlife Division (Beak 1985).

Model History

All of the HSI models for the Weldwood Forest Management Area have undergone several revisions, and they will be revised again as new information becomes available. Contact Rick Bonar for information about the most current version.

- Version 1 (1989) was developed by the Weldwood of Canada Integrated Resource Management Steering Committee (IRMSC).
- Version 2 (1994) was revised by Barb Beck and Melissa Todd. Kirby Smith, Wildlife Biologist for Alberta Fish & Wildlife Services, Edson, reviewed and added to the model.
- Version 3 (1995) was written by Glenn Buckmaster in a habitat modelling course at the University of Alberta.
- Version 4 (1996) was edited and reformatted by Wayne Bessie and sent to species experts for critical comment.
- Version 5 (1999) was revised by Karen Graham, Rick Bonar, Barb Beck, and Jim Beck to incorporate reviewer comments, results from Paul Jones MSc. Project, and information from recent literature.

9. LITERATURE CITED

Abbott, M. L. 1991. Structural characteristics of cover on elk winter range in north-central Arizona. Professional paper, M.Sc.F. Northern Arizona University, Arizona.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto, Ontario.

Beall, R. C. 1974. Winter habitat selection and use by a western Montana elk herd. Dissertation, University of Montana, Missoula, Montana.

Beak Consultants. 1985. The species-habitat relationship model for elk. IEC Beak Consultants Ltd., Calgary Alberta.

Beckingham, J. D., I. G. W. Corns and J. H. Archibald. 1996. Field guide to ecosites of west-central Alberta. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Special Report 9, Edmonton, Alberta.

Brown, R. C. 1991. Effects of timber management practices on elk. Arizona Game and Fish Department Resources Branch Technical Report No. 10.

Cairns, A .L., and E. S. Telfer. 1980. Habitat use by 4 sympatric ungulates in boreal mixedwood forest. Journal of Wildlife Management 44:849-857.

Cassirer, E. F., D. J. Freddy and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20:375-381.

Collins, W. B., and P. J. Urness. 1983. Feeding behaviour and habitat selection of mule deer and elk on northern Utah summer range. Journal of Wildlife Management 47:646-663.

Cook, J. G., L. L. Irwin, L. D. Bryant, R. A. Riggs and J. W. Thomas. 1998. Relations of forest cover and condition of elk: a test of the thermal cover hypothesis in summer and winter. Wildlife Monographs 141:1-61.

Edge, W. D., and C. L. Marcum. 1985. Movements of elk in relation to logging disturbances. Journal of Wildlife Management 49:926-930.

Edge, W. D., C. L. Marcum and S. L. Olson. 1985. Effects of logging activities on home range fidelity of elk. Journal of Wildlife Management 49:741-744.

Ferguson, M. A. D. and L. B. Keith. 1982. Influence of Nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. Canadian Field-Naturalist 96:69-78.

Freddy, D. J. 1987. The White River elk herd: a perspective, 1960-85. Technical Publication No. 37. Colorado Division of Wildlife.

Gadd, B. 1995. Handbook of the Canadian Rockies, 2nd edition. Corax Press, Jasper, Alberta.

Irwin, L. L. and J. M. Peek. 1983. Elk habitat use relative to forest succession in Idaho. Journal of Wildlife Management 47:664-672.

Jones, P. F. 1997. Winter habitat selection by elk (*Cervus elaphus*) in the lower foothills of west-central Alberta. Thesis, University of Alberta, Edmonton, Alberta.

Lyon, L. J. 1980. Co-ordinating forestry and elk management. Pages 278-287 *in* USDA Forest Service Intermountain Forest & Range Experimental Station. Proceedings of the Forty-fifth North American Wildlife Conference.

MacCallum, B., and G. R. A. Ebel. 1985. Ecological considerations for the wildlife of the Champion forest management area. Alberta, Forestry, Lands, and Wildlife Report, Edmonton, Alberta.

Morgantini, L. E., and W. B. Russel. 1983. An assessment of three selected elk winter ranges in the Rocky Mountains region. Wildlife Resources Consulting.

Morgantini, L. E., and E. Bruns. 1984. The assessment of three elk winter ranges in Alberta: an appraisal. Pages 106-116 *in* Proceedings of the 1984 western states and provinces elk workshop, Edmonton. Alberta.

Nietfeld, M., J. Wilk, K. Woolnough, and B. Hoskin. 1985. Wildlife habitat requirement summaries for selected wildlife species in Alberta. Wildlife Resource Inventory Unit, Alberta Fish and Wildlife Division. Edmonton, Alberta.

Peek, J. M., M. D. Scott, L. J. Nelson, D. J. Pierce, and L. L. Irwin. 1982. Role of cover in habitat management for big game in northwestern United States. Transactions of the 47th North American Wildlife and Natural Resources Conference.

Rounds, R. C. 1981. First approximation of habitat selectivity of ungulates on extensive winter ranges. Journal of Wildlife Management 45:187-196.

Skovlin, J. M. 1982. Habitat requirements and evaluation. Pages 369-415 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America; ecology and management. Wildlife Management Institute, Stackpole, Harrisburg, Pennsylvania.

Smith, K. 1985. A preliminary elk (*Cervus elaphus*) management plan for the Edson wildlife management area. Fish and Wildlife Division, Edson, Alberta.

Smith, K and M. Bloomfield. 1980. Strategy for elk management during a period of intense oil and gas activity. Elk Management Workshop, Cranbrook, British Columbia.

Stelfox, J. G. 1988. Forest succession and wildlife abundance following clear-cut logging in west-central Alberta. Canadian Wildlife Service, Edmonton, Alberta.

Thomas, J. W. 1979. Wildlife habitat in managed forests in the Blue Mountains of Oregon and Washington. U.S. Department of Agriculture, Forest Service, Agriculture Handbook 553.

Thomas, J. W., and L. D. Bryant. 1987. Pages 495-507 *in* The elk. Audubon Wildlife Report.

Thomas, J. W., D. A. Leckenby, M. Henjum, R. J. Pedersen, and L. D. Bryant. 1988. Habitat-effectiveness index for elk on Blue Mountain winter Ranges. General Technical Report, PNW-GTR-218, USDA, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Wildlife Management Division. 1996. The status of Alberta wildlife. Alberta Environmental Protection, Natural Resources Service, Wildlife Management Division.

Wisdom, M. J., L. R. Bright, C. G. Carey, W. W. Hines, R. J. Pedersen, D. A. Smithey, J. W. Thomas, and G. W. Witner. 1986. A model to evaluate elk habitat in western Oregon. Publication No. R6-216, USDA Forest Service, Portland Oregon.