WHITE-TAILED DEER
WINTER HABITAT

HABITAT SUITABILITY INDEX MODEL
VERSION 5

Last Modified: 21 October 1999

Dan Gould, 2-53111 Range Road 220, Ardrossan, Alberta. T8E 2C6.
Kirby Smith, Department of Environmental Protection, Fish and Wildlife Service, Edson, Alberta.
Barbara Beck, Department of Renewable Resources, University of Alberta, Edmonton, Alberta. T6G 2H1.
James Beck, Department of Renewable Resources, University of Alberta, Edmonton, Alberta. T6G 2H1.
Richard Bonar[1]**,** Weldwood of Canada, Hinton Division, 760 Switzer Drive, Hinton, Alberta. T7V 1V7.
Melissa Todd[2]**,** Foothills Model Forest, Box 6330, Hinton, Alberta. T7V 1X6.
Richard Quinlan[3]**,** Natural Resources Services, Suite 108, 111 - 54 Street, Edson, AB. T7E 1T2.

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 the white-tailed deer (*Odocoileus virginianus*) applies to habitats 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 white-tailed deer habitat area and carrying capacity throughout an entire forest management cycle (200 years). The model was primarily developed using literature review.

2.   SPECIES DESCRIPTION AND DISTRIBUTION

Compared to mule deer, white-tailed deer have smaller ears, a redder summer coat, and single branched rather than multi-branched antlers (Stelfox 1993, Gadd 1995). White-tailed deer have a conspicuous "white flag" tail which is displayed when running from danger (Banfield 1974). An adult buck measures 190 cm in length, stands approximately 92 cm at the shoulder and has a mass of up to 96 kg (Banfield 1994). Does are smaller and weigh up to 63 kg (Banfield 1974).

White-tailed deer are found across Canada, from British Columbia to Nova Scotia, including most areas of Alberta, especially in the aspen parkland ecoregion. White-tailed deer are not considered at risk in Alberta and have stable populations with secure habitat (Wildlife Management Division 1996).

3.   FOOD

White-tailed deer forage on grasses, forbs and shrubby browse. They require large amounts of easily digested food (Short 1986; Table 1). During spring and summer, forbs, grasses, and sedges are common in their diet (Allen 1968, Martinka 1968, Singer 1979, Irwin 1985). Forbs are eaten more than other forage during spring. White-tailed deer use forbs almost exclusively during summer; especially legumes (clover, pea-vine, vetch). In early fall, the deer begin to utilize more grasses and some browse, but forbs are still the main food. In late fall and throughout the winter, white-tailed deer browse on numerous species of deciduous trees and shrubs (Allen 1968, Martinka 1968, Wetzel et al. 1975, Singer 1979, Irwin 1985,) and coniferous trees (Swihart and Picone 1998).

---

[1] Contact Address
[2] Current Address: Houston Forest Products, Box 5000, Houston , B.C. V0J 1Z0
[3] Current Address: Wildlife Division, Natural Resources Services, Box 1148, Claresholm AB. T0L 0T0.

Table 1. Common forage species of white-tailed deer (adapted from Renecker and Hudson 1993).

Forbs and Graminoids		Browse	
Asters	(*Aster* spp.)	Aspen	(*Populus tremuloides*)
Clover	(*Trifolium* spp.)	Balsam Poplar	(*Populus balsamifera*)
Columbine	(*Aquilegia* spp.)	Bearberry	(*Arctostaphylos uva-ursi*)
Horsetails	(*Equisetum* spp.)	Choke Cherry	(*Prunus virginiana*)
Fringed Gentian	(*Gentianella crinata*)	Dwarf Birch	(*Betula glandulosa*)
Groundsel	(*Senecio* spp.)	Junipers	(*Juniperus* spp.)
Harebell	(*Campanula rotundifolia*)	Rose	(*Rosa acicularis*)
Hedysarum	(*Hedysarum* spp.)	Snowberry	(*Symphoricarpos albus*)
Lungwort	(*Mertensia paniculata*)	Willows	(*Salix* spp.)
Pea-vine	(*Lathyrus ochreleucus*)	Wolf Willow	(*Eleagnus commutata*)
Vetch	(*Vicia americana*)		
Wheat grass	(*Agropyron* spp.)		

4. COVER

White-tailed deer are an "edge" species. Suitable habitats have an intersection of untreed grassy or shrubby areas for feeding and treed areas for cover (Singer 1979). Areas of > 75% canopy closure that is > 1.5 m in height provide thermal and hiding cover, and reduce snow accumulation, which can limit movements of white-tailed deer (Singer 1979). Most white-tailed deer habitat use is within 180 metres of cover/open area edges (MacCallum and Ebel 1985).

Thermal cover is important in winter during periods of extreme wind chill. Mature coniferous stands may be used for protection since the branches provide wind protection and the ground tends to accumulate less snow. Cover is also required for protection from predators (Stelfox and Stelfox 1993). Areas with conifers and aspens may be among the best habitat for providing a mixture of food and cover.

In mixedwood forests in central Alberta, white-tailed deer were more often in old (120+ yr) stands versus mature (50-65 yr) or young stands (20-30 yr) during the winter (Stelfox et al. 1995). Tall, large trees, gaps in the tree canopy, higher densities of conifer and abundant shrubs in old stands provided a good combination of winter food and thermal cover (Stelfox et al. 1995). Winter deer abundance increased with distance from roads and cutblocks and decreased with distance from small conifer patches. During the summer, deer were found in all stand ages and showed no relationship between distance to roads or cutblocks (Stelfox et al. 1995).

5. REPRODUCTION

The breeding season occurs in mid-October to late December (Banfield 1974). Does are seasonally polyoestrous and typically come into heat in November and again about 28 days later if fertilization has not occurred (Banfield 1974). Fawns are born in June (Banfield 1974). Twins are most common but a single fawn to quadruplets may be born (Banfield 1974). The doe hides the fawns in separate spots and returns to nurse them every 3 hours (Banfield 1974). For the first week or so, the fawn are odorless (Banfield 1974). High cover is important during this season for concealment of the young. Weaning takes place after about 4 months. Most juvenile does mate as yearlings but juvenile males likely do not get a chance to mate until they are much older (Banfield 1974).

6. HABITAT AREA

White-tailed deer are found in grasslands, aspen parkland, and boreal mixedwood forest. Some also live in the montane forests throughout the western mountain valleys and will migrate upslope in summer to feed in alpine meadows (Gadd 1995). Optimal stand sizes are: thermal cover 0.8-2.0 ha, hiding cover 2.6-10.5 ha, and fawning cover 0.4-2.0 ha (Nietfeld et al. 1985).

In good habitat, deer may remain in an area 500-800 ha in size. Home ranges are reported to be about 70-190 ha in the summer and 160-480 in the winter (Rongstad and Tester 1969). A population density of 0.04 white-tailed deer/ha for optimal habitat in the FMF is estimated (K. Smith, Area Biologist, Alberta Fish and Wildlife in Edson, personal communication). Based on this density, a genetic effective population of 500 individuals would require 125 km square of fully suitable habitat.

7. HSI MODEL

7.1 MODEL APPLICABILITY

Species: White-tailed Deer (*Odocoileus virginianus*).

Habitat Evaluated: Foraging and Cover Habitat.

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 habitat.

Cover types: This model applies to all forest and non-forest habitat areas of the Lower and Upper Foothills, Montane and Subalpine Natural Subregion (Beckingham et al. 1996). The model is determined from structural characteristics within stands rather than classified forest stands directly. 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. This model will apply to all stands throughout the above cover types regardless of size, since deer are highly mobile and may make use of habitat fragments.

Model Output: The model will produce Habitat Units (HU) of winter habitat for each stand based on HSI value and stand area. HU are calculated by multiplying the HSI score with the area in hectares. The performance measure for the model is potential carrying capacity (white-tailed deer per ha). Model output (HU) should be correlated to estimates of carrying capacity to verify model performance.

Carrying Capacity (Animals per ha where HSI = 1.0): Based on limited local information, the current estimate of the maximum number of animals per ha is 0.04 in the most suitable habitat.

Verification Level: The reliability of this model has not been evaluated against local data. The verification level is 1: model was developed based on literature and 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 white-tailed deer 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 white-tailed deer habitat assumes the life requisites of food and cover are limiting. The habitat requirements during the summer are assumed provided by the same habitat features that provide essential winter forage and cover.

7.2.1 Habitat Variables and HSI Components

A. Cover

Cover for white-tailed deer is described by 3 habitat features and 1 spatial feature. The first structural feature is tree canopy closure, used to define HSI component S_1 (Table 2). Tree closure provides thermal cover, which reduces wind and snow depth. Areas with dense tree closures are also more secure against predators. The other two variables are tree canopy height (S_2) and percent composition of conifers in the stand (S_3). Canopy height is an index for the developmental state of the forest and ensures the forest area will be structurally diverse providing a range of cover and shelter opportunities. Coniferous composition is included to increase the value of mixedwood or coniferous areas over pure deciduous stands, since coniferous branch architecture and evergreen needles result in much higher coverage than an equivalent cover of deciduous trees.

The value of cover is reduced if the cover is not within range of a feeding area, defined as areas low in tree canopy closure and high in shrub cover. In summer, feeding areas also provide abundant forbs or grasses. The distance of cover to the nearest feeding area is used to define HSI component S_4.

B. Foraging Habitat

Winter foraging cover is described by shrub cover and deciduous sapling cover ≤ 2 m in height and defines HSI component S_5 (Table 2). This component includes regenerating deciduous trees which come up after fire or forest harvesting. The value of foraging cover is reduced if the cover is not within a certain distance of thermal/protective cover. This spatial variable defines the final HSI component, S_6. Cover must provide at least a suitability ranking of 0.5 as determined by the first 3 HSI components before it will be used to calculate the spatial variable.

Table 2. Relationship between habitat variables and life requisites for the white-tailed deer HSI model.

HSI Component	Life Requisite	Habitat Variable	Habitat Variable Definition
S_1	Cover	Tree Canopy Closure (%)	Percent of ground covered by a vertical projection of tree crown areas onto the ground. Includes all trees ≥ 8 cm diameter at breast height (dbh at 1.3 m).
S_2	Cover	Tree Canopy Height (m)	Mean top height of 100 trees/ha that have the largest dbh.
S_3	Cover	Pine, Spruce and Fir in Tree Canopy (%)	Percent composition of pine, spruce and fir species in the tree canopy.
S_4	Cover	Distance of Cover from Food (m)	Distance from the edge of any classified unit to the edge of a habitat area with food. Feeding areas are defined as having 25% or higher shrub cover and $\leq 30\%$ tree canopy closure.
S_5	Food	Deciduous Sapling Cover ≤ 2 m in height and shrub cover (%)	Percent of ground covered by a vertical projection of deciduous sapling and shrub crown areas onto the ground. Includes only deciduous sapling cover up to 2 m in height and all deciduous shrub species.
S_6	Food	Distance from Cover (m)	Distance from the edge of any classified unit to the edge of a unit with adequate thermal/protective cover, defined as areas where $S_1 \times S_2 \times S_3 \geq 0.5$

7.2.2 Graphical HSI Component Relationships

A. Cover

S_1 Tree canopy closures $\leq 30\%$ provide no cover benefit to white-tailed deer ($S_1 = 0$). Over the range 30-70% the benefit increases to optimum ($S_1 = 1$). All values $\geq 70\%$ are considered optimum (Figure 1a).

S_2 Canopy height must be a minimum of 4 m tall to provide any thermal/protective cover benefit to white-tailed deer. This value was chosen to reflect the occasional use by deer of shrubby and regenerating tree areas for cover. However, a tree height of at least 10 m is needed for a S_2 to equal 1 (Figure 1b).

S_3 Percent coniferous composition is a modifying variable, so the minimum suitability is set at 0.5. Over 0-50%, the value increases to 1. Thus a pure deciduous forest would be rated as one-half as suitable as a 50% or higher coniferous content mixedwood forest (Figure 1c).

S_4 White-tailed deer will freely move over 140 m from cover to obtain food, so over this range $S_4 = 1$. Greater distances result in losses of energy due to travel as well as potential predatory and thermal losses, so the value decreases to 0 from 140 to 220 m (Figure 1d).

B. Foraging Habitat

S_5 At least some deciduous sapling cover ≤ 2 m in height or shrub cover is needed before a positive suitability is given ($S_5 = 0$). Suitability increases from 0-1 over the range of 0-50% cover. Areas with $\geq 50\%$ cover are fully suitable (Figure 1e).

S_6 The last variable, distance from cover, assumes that 220 m is the farthest deer will travel from cover before energetic losses decrease the value of feeding habitat. Deer need to be within 140 m of cover to have a foraging HSI of 1 (Figure 1f).

7.3   MODEL ASSUMPTIONS

1. Winter is the critical period determining white-tailed deer habitat supply. Habitat for spring to fall seasons which encompasses calving, summer activities and reproduction is not limiting or is obtained in the same areas as those where winter food and cover are obtained.

2. White tailed deer are able to migrate freely to their winter range from their summer range.

3. All shrub species have the same value as food and this value does not diminish throughout the winter. Shrub height also has no bearing on the suitability of food.

4. White-tailed deer do not modify their feeding and cover use behaviour in the presence of human activity.

5. Cost of travel is assumed to be great such that food is useless if it is not within a certain distance of cover and vice versa. This cost can be in terms of predatory loss and energetic expense.

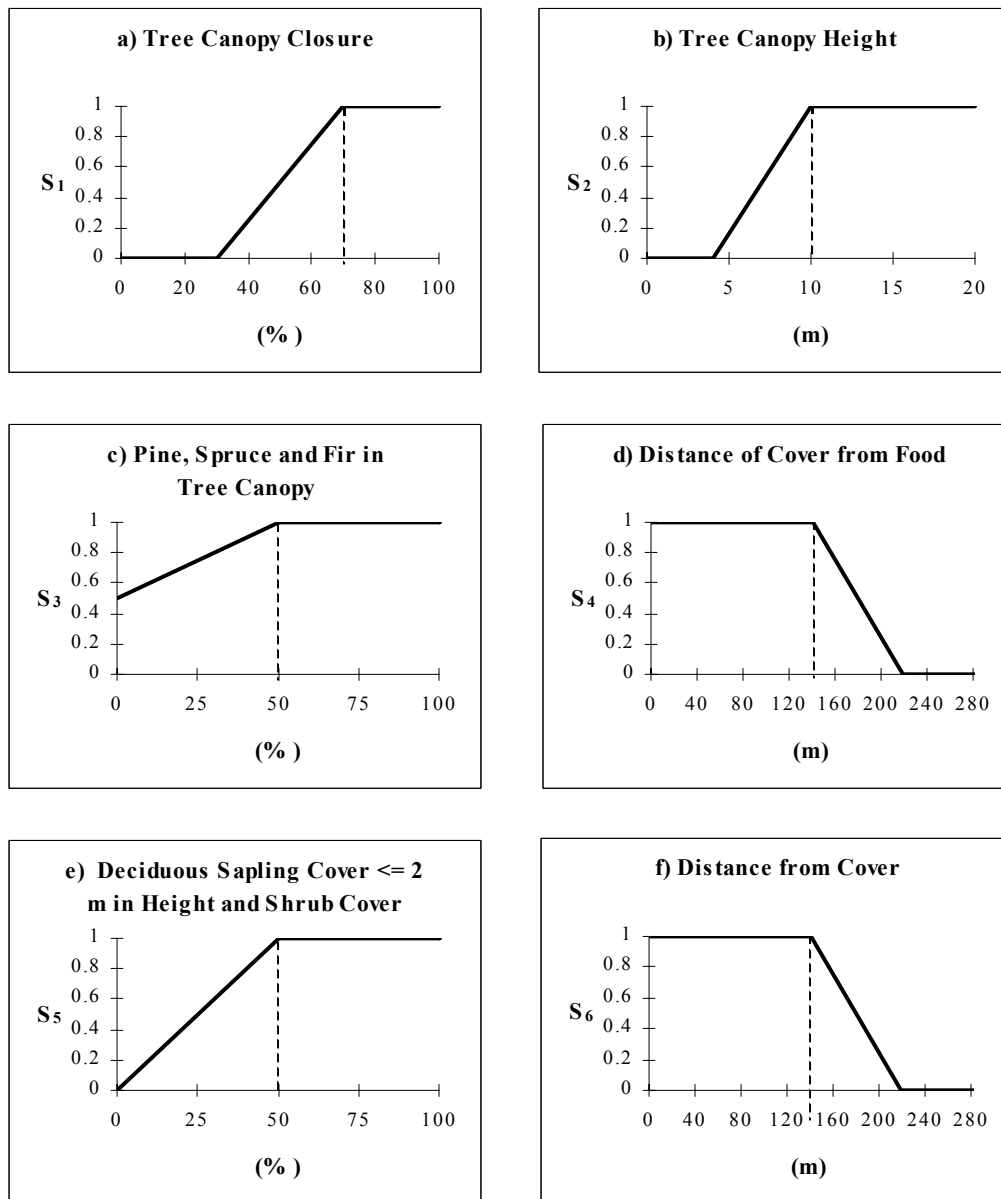6. Water and minerals are not a limiting winter resource

Figure 1. Graphical relationships between habitat variables and HSI components in the white-tailed deer model.

7.4 EQUATIONS

The model predicts cover and foraging habitat suitability separately, then combines them into HU based on the best interspersion ratio. The cover HSI is determined as the product of the first four components. All four components are considered equal and are unable to compensate for low values in any of the others. The third component is a modifying component and is unable to drive the equation to 0. Optimal cover exists when all four values equal 1, which occurs in forest stands with $\geq$ 50% conifers, $\geq$ 70% canopy closure, $\geq$ 10 m height and in an area within 140 m of foraging habitat.

$$\text{HSI-cover} = S_1 \text{ x } S_2 \text{ x } S_3 \text{ x } S_4$$

The food HSI equation considers the remaining three components are equal and non-compensatory. Optimum foraging cover must be within 140 m of thermal/protective cover, and must have > 50% shrubs.

$$\text{HSI-foraging} = S_5 \text{ x } S_6$$

It is assumed that the same interspersion of food to cover used for mule deer (3:2) is appropriate for white-tailed deer.

8. SOURCES OF OTHER MODELS

No other HSI models for white-tailed deer were found.

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.

- Version 3 (1995) was written by Dan Gould for a special topics course in habitat modelling at the University of Alberta. Comments provided by Kirby Smith, Area Wildlife Biologist for Alberta Fish and Wildlife Services, Edson area, were incorporated into the model.

- Version 4 (1996) was edited and reformatted by Wayne Bessie.

- Version 5 (1999) was revised by Karen Graham, Rick Bonar, Barb Beck, and Jim Beck to incorporate information from recent literature.

9. LITERATURE CITED

Allen, E. O. 1968. Range use foods, condition and productivity of white-tailed deer in Montana. Journal of Wildlife Management 32:130-141.

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

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, Edmonton, Alberta, Special Report 9.

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

Irwin, L. L. 1985. Foods of moose, *Alces alces* and white-tailed deer, *Odocoileus virginianus*, on a burn in the boreal forest. Canadian Field Naturalist 99:240-245.

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

Martinka, C. J. 1968. Habitat relationships of white-tailed deer in the Gulf of Mexico and south Atlantic coastal plains. U.S. Fish and Wildlife Service Biological Report 82 (10.123).

Nietfeld, M., J. Wilk., and K. Woolnough. 1985. Wildlife habitat requirement summaries for selected wildlife species in Alberta. Alberta ENR, Fish and Wildlife Division, Wildlife Resource Inventory Unit, Technical Report No. T/73, Edmonton, Alberta.

Renecker, L. A. and R. J. Hudson. 1993. Morphology, bioenergetics, and resource use: patterns and processes. Pages 141-163 *in* B. Stelfox, editor. Hoofed mammals of Alberta. Lone Pine. Edmonton, Alberta.

Rongstad, O. J. and J. R. Tester. 1969. Movements and habitat use of white-tailed deer in Minnesota. Journal of Wildlife Management 33:366-379.

Short, H. L. 1986. Habitat suitability index models: white-tailed deer in the Gulf of Mexico and South Atlantic coastal plains. U.S. Fish and Wildlife Service Biological Report 82 (10.123).

Singer, F. J. 1979. Habitat partitioning and wildlife relationships of cervids in Glacier National Park, Montana. Journal of Wildlife Management 43:437-444.

Stelfox, J. B., L. D. Roy and J. Nolan. 1995. Abundance of ungulates in relation to stand age and structure in aspen mixedwood forests in Alberta. Pages 191-210 *in* J. B. Stelfox, editor. Relationships between stand age structure, and biodiversity in aspen mixedwood forests in Alberta. Alberta Environmental Centre (AECV95-R1), Vegreville, Alberta, and Canadian Forest Service (Project No. 0001A), Edmonton, Alberta.

Stelfox, J. B. 1993. Identification. Pages 5 -27 *in* J. B Stelfox editor. Hoofed Mammals of Alberta. Lone Pine. Edmonton, Alberta.

Stelfox, J. B. and J. G. Stelfox. 1993. Population dynamics and reproduction. Pages 63 - 68 *in* J. B Stelfox editor. Hoofed mammals of Alberta. Lone Pine. Edmonton, Alberta.

Swihart, R. K. and P. M.Picone. 1998. Selection of mature growth stages of coniferous browse in temperate forests by white-tailed deer (*Odocoileus virginianus*). American Midland Naturalist 139:269-274.

Wetzel, J. F., J. R. Wambough and J. M Peck. 1975. Appraisal of white-tailed deer winter habitats in northeastern Minnesota. Journal of Wildlife Management 39:59-66.

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