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NEW BRUNSWICK COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT
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ASSESSMENT OF WHITE-TAILED DEER WINTER HABITATS WITHIN THE FUNDY MODEL FOREST IN RELATION TO WINTER SEVERITY

1998

Dwayne Sabine, Warren Ballard, and Graham Forbes

UNIVERSITY OF NEW BRUNSWICK
FREDERICTON NEW BRUNSWICK CANADA

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In Cooperation With:

Fundy Model Forest
New Brunswick Department of Natural Resources and Energy
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EXECUTIVE SUMMARY

Throughout northern portions of their range, white-tailed deer normally congregate during winter in distinct wintering areas, or 'deer yards'. Deer yards are typically located at low elevations, on south-facing slopes, and, particularly for forested regions, in coniferous stand types. These habitats ameliorate winter climate conditions, enhancing energy conservation by deer.

New Brunswick is situated very near the northern limit of white-tailed deer range in North America. The Crown land forest management planning process, developed by the New Brunswick Department of Natural Resources and Energy (NBDNRE), has established guidelines for the management of deer winter habitat within wintering areas identified on Crown land. These guidelines were based on data collected from deer yards in northern New Brunswick, where deer yarding periods are among the longest in the province because of severe winter climatic conditions. In southern New Brunswick, winter conditions tend to be moderate and (or) variable, both within winters and between years. Hence, it is conceivable that deer winter habitat may not be effectively managed in the south using guidelines based on northern New Brunswick conditions. In January 1994, the New Brunswick Cooperative Fish and Wildlife Research Unit of the University of New Brunswick, in cooperation with the Fundy Model Forest, the New Brunswick Department of Natural Resources and Energy (NBDNRE), and J.D. Irving Ltd. began a study to examine winter habitat use and population dynamics of white-tailed deer in the Canaan River - Sussex area of southern New Brunswick.

A total of 63 deer were captured and radio collared using traps, rocket nets, darting, and helicopter net-gunning between March 7, 1994 and March 26, 1995. Deer location data were incorporated into the NBDNRE ARC/INFO Geographical Information System database, enabling the extraction of forest habitat data. Deer location data were delineated into individual home ranges, and into seasonal ranges, which represented wintering areas or corresponding summer ranges for distinct sub-populations of deer. The Neu method (Chi-square goodness of fit) was used to analyze deer locations for evidence of habitat selection.

Habitat use analysis were conducted at 5 levels: 1) comparison of wintering area vs. summer range habitat composition, 2) comparison of home range vs. seasonal range habitat composition, 3) habitat selection within seasonal range, 4) habitat selection within home range, and 5) habitat selection within seasonal range as affected by snow depth. These levels vary from a broad scale (level 1), which might reveal influences of previous, or prevalent, winter climate conditions, through a fine scale (level 4), which is more sensitive to daily variations in winter climate.

Three distinct sub-populations of deer were evident within the study area. These sub-populations occupied wintering areas in the southern portion of the study area, an area of predominantly small, private woodlots and farms. Wintering areas were at Snider Mountain, Mount Hebron, and Whites Mountain. Corresponding summer ranges were immediately north of wintering areas, in an area of predominantly large, industrial freehold and Crown lands.

Analysis of summer habitat use by deer revealed no clear pattern, likely as a result of low

sample size.

Of the 3 winters of study, the winters of 1995 and 1996 were near average with respect to Winter Severity Index, while the winter of 1997 was below average (less severe). Snow depths reached levels limiting to deer movements (40 cm) for relatively brief, intermittent periods during the 3 winters. Winter Severity index values for the period 1980 through 1997 indicate that severe winters occur infrequently.

Collared deer initiated migrations to wintering areas as snow depths approached 30 - 40 cm, and returned to summer range as snow disappeared from open areas. Because migratory movements were so closely tied to snow depths, under low-snow conditions deer sometimes delayed migration to wintering areas until late winter. Conversely, early winter thaws sometimes resulted in premature migrations back to summer range.

A comparison of wintering area habitat composition to that of summer ranges revealed several key differences. Differences in land use patterns resulted in summer range, which is composed mainly of crown and industrial freehold land, containing a greater amount of plantations, while winter range, which is composed mainly of small freehold properties, contained more agricultural land. Scrutiny of the stand types considered to provide winter cover for deer revealed that low quality cover (black spruce) was of much greater abundance on summer range, while intermediate quality cover (mixedwood stands) and good quality cover (spruce) were of similar abundances on summer and winter ranges. The cedar type, widely considered to provide high quality deer critical winter habitat, was of much higher abundance on winter range, although relatively uncommon.

The comparison of winter home range and seasonal range habitat composition revealed little selectivity by deer in choosing home ranges on wintering areas. Comparison of winter home ranges on summer range, which occurred only during low-snow conditions, indicated deer were avoiding coniferous habitat types (which produce cover, but little food) while showing some preference for mixedwood types (which provide a balance of cover and food production.

The analysis of winter habitat selection within seasonal range for wintering areas revealed a habitat use pattern of avoidance of pure coniferous (cover producing) and regeneration (food producing) habitat types, with a preference for immature and mature mixedwood habitat types (food and cover). The analysis of habitat selection within seasonal range for summer ranges revealed a similar, though weaker pattern, with a trend towards selection of mature mixedwood stand types.

The analysis of winter habitat selection within home ranges on wintering areas revealed that deer were again selecting for older stage mixedwood habitat types. In addition, there was selection for some pure coniferous, cover providing types. Although winters were moderate, brief periods of severe conditions occurred sporadically, so some selection for critical winter habitat stand types was expected. Analysis of winter habitat selection within home ranges on summer range revealed that deer were exhibiting little selectivity.

Analysis of winter habitat use in relation to snow depths reveals much the same pattern as those described above. Mixedwood habitat types were preferred over all snow depths. Pure coniferous types and regeneration-stage types tended to be avoided, although there were a few exceptions. Food producing, sapling-stage hardwood types were selected for on a few occasions, but only at low snow depths. The absence of a clear trend towards selection by deer for coniferous, cover producing habitats at limiting snow depths is likely due to the nature of the deep snow data set, which consisted of many, brief, intermittent periods of deep snow. A prolonged period of limiting snow depths did not occur during the course of the study.

Several Deer Wintering Areas (DWAs)have been delineated on Crown lands in the northern portion of the study area. Although this area is principally summer range, these DWAs should be retained as they are likely very important during severe winters when migration is impaired. The current NBDNRE guidelines for management of deer critical winter habitat should be followed on these DWAs.

Some provision should be made in forest management plans to maintain a supply of mature mixedwood stand types on summer range, as deer remain on summer range for a considerable portion of mild and/or moderate winters, and utilize these stand types preferentially at these times.

Because the 3 major wintering areas in the study area are located on private lands, and are thus unmanaged, cooperative deer wintering area management plans should be attempted with landowners.

If cooperative deer winter habitat management plans are undertaken for these wintering areas, current NBDNRE guidelines for management of deer critical winter habitat should be followed to produce a sustainable supply of this habitat type in anticipation of the most severe winters. Provision of moderate winter habitat, i.e. a sustainable supply of mature mixedwood habitat types, should be initiated as well. This strategy will optimize habitat quality and availability, providing preferred habitat types during average winters while retaining a supply of critical habitat for severe winters.

Mixedwood stand types identified during this study should be further examined to identify the factor(s) causing their apparent preference to deer. Collection of ground data to identify the specific stand structural features preferred would allow accurate moderate winter habitat supply windows to be devised.

ACKNOWLEDGMENTS

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PROJECT OBJECTIVES

Wildlife managers often request that white-tailed deer (*Odocoileus virginianus*) habitat be protected from intensive forest harvest, with the assumption that these habitats are critical for the maintenance of the deer population. These recommendations are often based upon habitat use studies in other areas, where climate and/or landscape characteristics may not be comparable to the area in question. For example, southern New Brunswick experiences considerably less severe winters than the northern part of the province, yet, the identification of forest stand types and development stages constituting critical deer winter habitat is consistent throughout the province.

In January 1994, the New Brunswick Cooperative Fish and Wildlife Research Unit of the University of New Brunswick, in cooperation with the Fundy Model Forest, the New Brunswick Department of Natural Resources and Energy (NBDNRE), and J.D. Irving Ltd. began a study to examine winter habitat use and population dynamics of white-tailed deer in the Canaan River - Sussex area of southern New Brunswick. Deer habitat use in relation to winter severity was examined. The ultimate goal of the study was to provide the information useful in developing long-range deer winter habitat management plans with predictive capabilities for assessing changes in deer populations due to silvicultural practices. Specific objectives were as follows:

1: To determine seasonal and annual habitat use of white-tailed deer in southern New Brunswick.

2: To compare deer habitat use as influenced by winter severity and forest structure and composition using currently available forest inventory data.

3: To determine if inadequacies exist in forest inventory data for identifying deer winter range.

4: To refine definitions of deer winter habitat in southern New Brunswick.

5: To review available literature concerning ungulate population estimation methods, and then develop and test appropriate methods for estimating deer density and population trend.

6: To estimate deer survival, productivity, condition, and habitat use in southern New Brunswick.

This report is structured to address these objectives in separate sections. Objectives #1 - #4 are discussed in the main report. Objective #5 is discussed in Appendix 1 as it relates to an aerial survey method that was adapted by the authors and tested during this study. Objective #6 is discussed in Appendix 2 and is presented as a draft submission for publication.

GENERAL OVERVIEW OF WHITE-TAILED DEER BIOLOGY IN WINTER

YARDING BEHAVIOUR

White-tailed deer usually congregate during winter in distinct wintering areas, or 'deer yards', throughout northern portions of their range (e.g., Verme 1973, Huot 1974, Drolet 1976). Use of these wintering areas is often traditional, with deer migrating to and from yards in late autumn and early spring. In regions where snow cover normally reaches depths greater than 30 cm, deer yards are typically located at low elevations, on south-facing slopes, and, particularly for forested regions, in coniferous stand types (e.g., Telfer 1970, Euler and Thurston 1980, Pauley *et al*. 1993).

RATIONALE FOR YARDING BEHAVIOUR

The energetic cost of locomotion for ungulates is minimized at low snow depths (Parker *et al.* 1984). Hence, yarding is generally considered an energy-conserving behaviour since the canopy cover in coniferous stands tends to reduce snow depths as compared to other stand types. In addition, the communal trails formed in yards further reduce locomotive costs for deer. Within coniferous stands, wind speed and thermal ranges tend to be reduced, while mean temperature, relative humidity and infrared radiation flux tend to be increased compared to other stand types, resulting in lower levels of convective heat loss, and thereby enhancing the thermo-regulatory capability of white-tailed deer (Moen 1968, Ozoga 1968, Ozoga and Gysel 1972). Yarding has also been proposed as predator-avoidance behaviour (Nelson and Mech 1981, Messier and Barrette 1983). Low snow depths and the presence of trails, greater predator detection by increased densities of deer, and reduced exposure to territorial predators at high deer densities all help to enhance escape from predators.

Because of these factors, deer distribution in regions with severe winter weather conditions is highly dependent on shelter availability and is much less dependent on, or even independent of forage availability in deer yards (Hamerstrom and Blake 1939, Pauley *et al.* 1993). Browse availability within deer yards is often low in coniferous stands (Ozoga and Gysel 1972, Monthey 1984). In areas where winter conditions are either moderately severe, severe for only brief periods, or vary considerably in severity among year, deer use shelter or 'yard-like' stands only during those periods of restrictive conditions (e.g. Cook and Hamilton 1942, Drolet 1976, Tierson *et al.* 1985). Southern deer, in contrast, do not exhibit home range movements due to winter conditions, and deer distribution during winter is dependent on forage availability (Gaudette and Stauffer 1988).

YARDING STIMULI

Although air chill (ambient temperature and wind) and snow conditions influence yarding behaviour, the relative importance of these factors is disputed. Gill (1957), Banasiak (1961), Verme and Ozoga (1971), and Ozoga and Gysel (1972), and Swanson (1993) suggest that cold temperatures are the prime stimulus in prompting deer to seek protective cover, while snow affects activity and habitat use only after yarding has been initiated; this has been termed the 'thermal-benefit' hypothesis by Beier and McCullough (1990). The opposing view suggests that increasing snow depth is the primary stimulus to initiate yarding behaviour, and that cold temperatures are secondary (Drolet 1976, Tierson *et al.* 1985, Beier and McCullough 1990); this could be termed the 'locomotive-benefit' hypothesis.

The mobility of ungulates in snow is a function of the physical characteristics of the species in question. White-tailed deer become restricted in movement when snow depths reach 40 cm (approx. 70% of chest height) (Kelsall 1969). Telfer (1970) reported that snow depths restricting white-tailed deer are from 25-35 cm, with deer becoming confined to shelter as depths approach 50 cm. Parker *et al.* (1984) demonstrated that the energetic cost of locomotion for mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) increases exponentially at snow depths beyond knee height (or, 25-30 cm for white-tailed deer). Therefore, use of stands which ameliorate snow depth is likely obligatory for white-tailed deer at snow depths exceeding 40 cm.

At snow depths <30 cm, locomotive-benefit is likely unimportant, as the energetic cost of locomotion in snow depths 18-25 cm is only slightly greater than that in no snow (Moen 1976, Parker *et al.* 1984). Beier and McCullough (1990) suggest that at snow depths <25 cm the negative effect of snow on food availability is more important than the effect of snow on locomotion cost. In addition, as food availability decreases, reducing energy intake, the thermal-benefit of coniferous stands becomes more important. That food availability, and hence energy intake, might also predict habitat use during winter is suggested by Hobbs (1989), who found that 76% of the difference in simulated energy balance of mule deer during mild and severe winters was attributed to reduced energy intake (remainder = 15% thermo-regulation costs, 5% snow effects on activity, and 4% increased activity time). White-tailed deer in Idaho selected stands providing the greatest abundance of preferred forage in early and late winter, when snow depths were less than 30 cm (Pauly *et al.* 1993). During mid-winter, when snow depths were greater than 40 cm, deer selected older conifer stands which provided relatively little forage but the most optimum snow conditions.

DEER WINTER HABITAT MANAGEMENT IN NEW BRUNSWICK

MANAGEMENT GUIDELINES

New Brunswick is situated very near the northern limit of white-tailed deer range in North America. Yarding period, the number of days with open snow depths greater than 50 cm (NBDNRE 1991), ranges from 40 days/year in southern New Brunswick to 110 days/year in northwestern New Brunswick. Deer wintering areas (DWA) have been identified on Crown land, and added to the NB Forest Inventory GIS data base. Approximately 900 DWA, ranging is size from 25 to 8000 ha, and totaling 268,000 ha, have been demarcated.

The crown land forest management planning process developed by the New Brunswick Department of Natural Resources and Energy (NBDNRE), in cooperation with crown licensees, attempts to integrate timber and wildlife management, with white-tailed deer being a species of primary concern. Because winter is considered the critical period for this species, NBDNRE has established guidelines for the management of deer winter habitat within the identified wintering areas (Table 1). These guidelines were based on data collected from deer yards in northern New Brunswick, where deer yarding periods are among the longest in the province because of severe winter climatic conditions (NBDNRE, Fish and Wildlife Branch). The management objective in DWA's is to maximize the sustainable supply of deer critical winter habitat (i.e. mature conifer-dominated stands) within operational and silvicultural constraints (Makepeace and Gordon 1994, Lusk 1995). However, Crown land comprises only approximately 48% of NB, and there is no management requirement for deer yards on the remaining area.

THE SOUTHERN NEW BRUNSWICK SCENARIO

In southern New Brunswick, winter conditions tend to be moderate and (or) variable, both within winters and between years. Snow depths seldom reach restrictive depths for extended periods of time. Deer yards have been identified throughout southern New Brunswick, but, because of the comparatively mild winter weather, it is generally recognized that deer utilize these areas, if at all, for only brief periods of severe conditions. Although deer in these areas normally maintain relatively dispersed winter home ranges, it seems likely that coniferous canopy cover may still remain important. Brief and sporadic periods of deep snow or cold temperatures likely necessitate the use of this habitat component for thermal- and (or) locomotive-benefit (henceforth referred to as cover-benefit). However, because periods of restrictive conditions are infrequent and unpredictable, this habitat component is probably used on a more localized basis, rather than in a centralized 'yarding' situation. Because the deer critical winter structural habitat guidelines were derived from analysis of northern deer yards, where conditions are severe, it is conceivable that deer winter habitat may not be effectively managed using these guidelines in southern New Brunswick.

Table 1. Critical winter habitat structural guidelines for white-tailed deer in New Brunswick.

Structural Element	Guideline
Species/Vegetation Type	Conifer and conifer-hardwood stand types excluding larch, pine, and poor-site spruce
Conifer Crown Closure	∃ 50% of trees ∃ 10 meters tall
Mean Conifer Stem d.b.h.	∃ 18 cm
Stem Size Variability	Stands composed of stems of varying sizes are preferred
Conifer Basal Area	∃ 20 m^2/ha of trees ∃ 10 cm dbh
Understory	Stands supporting browse species (e.g., mountain maple, red maple, striped maple, hobble bush, northern wild raisin) are preferred
Deer Critical Winter Habitat (DCWH) Patch Size	∃ 10 ha of DCWH stands ∃ 75% of the area in DCWH stands ∃ 300 meters minimum patch width
Deer Critical Winter Habitat (DCWH) Connectivity	DCWH should be inter-connected by winter travel corridors: conifer crown closure ∃ 50%, development stage ∃ immature, width ∃ 100 meters

STUDY AREA

The Canaan River study area (757 km^2) is in the northern part of the Fundy Model Forest, in Queens County, New Brunswick (45E55'N, 65E40'W). Winter conditions in this area are relatively moderate and variable compared to northern New Brunswick. The study area can be divided into two distinct regions. The northern section consists mainly of Crown Lands and large private holdings owned by J.D. Irving Ltd.. These lands are subjected to intensive forest management, resulting in a pattern of large (20 ha - 100 ha) openings; and in an abundance of young planted and naturally regenerated stands. Topography is flat, and forest cover is comprised primarily of mixedwood stands of trembling aspen (*Populus tremuloides*), largetooth aspen (*Populus grandidentata*), red maple (*Acer rubrum*), white birch (*Betula papyrifera*), red spruce (*Picea rubens*), and white spruce (*Picea glauca*); and of young plantations of black spruce (*Picea mariana*) and jack pine (*Pinus banksiana*). Black spruce occurs on many poorly-drained sites.

The southern section consists mainly of small private woodlots and farms. The harvest pattern on these small woodlots generally results in small, irregular clearcuts (<20 ha) and partial cuts. Topography ranges from flat to ridged. The forest cover on the low-lying areas is similar to that in the northern section, with the addition of eastern white cedar (*Thuja occidentalis*), which is nearly non-existent in the north. The forest cover on the higher elevations consists primarily of mixedwood stands of sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and red spruce. Agricultural land occupies a substantial portion of the area.

METHODS

CAPTURE PROCEDURES

Deer were captured using Clover traps (Clover 1956), rocket nets, darting using ketamine hydrochloride and xylazine hydrochloride (Jessop *et al.* 1983, Mech *et al.* 1985), darting using Telazol (tiletamine hydrochloride and zolazepam hydrochloride) and xylazine hydrochloride, or helicopter net-gunning (Helicopter Wildlife Management, Salt Lake City, Utah). Deer handling procedures involved immobilization with ketamine hydrochloride and xylazine hydrochloride (if captured with traps or rocket nets), monitoring of body temperature and respiration rate, recording morphological measurements, ear-tagging, radio-collaring, administration of an antibiotic, and reversal of anaesthesia by injection of yohimbine hydrochloride. Deer captured by helicopter net-gunning were not chemically immobilized. Capture techniques used in this project are further described in Ballard *et al.* (1997) (in press) (Appendix 3).

RELOCATION PROCEDURES

Collared deer were located by ground access using triangulation based on a minimum of three readings (White and Garrott 1990). Fixed-wing aircraft were used to relocate lost signals. Location estimates and error polygons were generated in New Brunswick Stereographic Grid format using the software package LOCATE. Locations were determined daily when logistically feasible. During the winter of 1996, locations were determined twice daily, during both diurnal and nocturnal periods, periodically throughout the winter, as white-tailed deer have been shown to exhibit distinct shifts in habitat use during these periods in winter (Beier and McCullough 1990). The software package CALHOME was used to generate 95% Minimum Convex Polygon home range estimates. Wintering areas were delineated by polygons encompassing all outermost locations for sub-populations of deer inhabiting a distinct winter range. Polygons encircling the summer locations of each sub-population of wintering deer were used to delineate corresponding summer ranges. The resulting point locations, home range polygons, and seasonal range polygons (wintering areas and summer ranges) were incorporated into the New Brunswick Department of Natural Resources and Energy ARC/INFO Geographical Information System database, enabling the extraction of forest habitat data.

POPULATION ESTIMATION METHODS

A review of methods of estimating deer density and population trends was conducted by a B.Sc.F student under the guidance of the N.B. Cooperative Fish and Wildlife Research Unit in 1994 (Harty 1994). Subsequent to this review, we decided to test the Potvin method for aerial surveys (Potvin *et al.* 1992). A full synopsis of methodology used and results of this test is provided in Ballard *et al.* 1997 (Appendix 1).

CLIMATE DATA

Total snow depths were measured in 4 stand types representing varying degrees of canopy cover; softwood, mixed-wood (60% hardwood/40% softwood), hardwood, and clearcut stands. Measurements were typically recorded once weekly, as well as before and after any major climatic event (thaw or snowfall) influencing snow depth. A series of 10 stakes was placed within each stand, situated 10 m apart along a straight line. The stake-line stands were located in the Porcupine Brook area, south of the Canaan River. Sinking depths were not collected, as they do not correlate closely to deer behaviour, and are not easily replicated (Pauley *et al.* 1993). Daily maximum and minimum temperature were recorded at the J.D. Irving Ltd. Sussex Tree Nursery, in Sussex N.B..

Winter severity indices (WSI=s) provide an index of the relative severity of winter climate conditions with respect to potential impacts on deer populations. The WSI incorporates measurements of snow depth (or depth to which deer are sinking in the snow) and air temperatures into a single, comparable index. WSI=s are simply calculated as **Sinking Depth (inches) + (30 - Mean Temperature (EF))**, or, in Metric, **(-1.5-(Mean Temperature (EC)/0.57)) + Sinking Depth (cm)/2.54**. The New Brunswick Department of Natural Resources and Energy collected weekly measurements of maximum and minimum temperatures, snow depth, and sinking depth (the depth to which deer are sinking in the snow, measured directly from tracks) from deer yards throughout the province until 1995, when the practice was discontinued. Sinking depth was based on approximately 50 measurements from approximately 10 stands within a deeryard. Max-min thermometers recorded the maximum and minimum temperatures within the deeryard for the previous week.

WSI=s for 1996 and 1997 are derived from measurements taken from the Canaan study area, and may not be representative to the region as a whole. To calculate WSI=s for those 2 years, we used the snow depth data collected during this study, and maximum and minimum temperatures recorded at the J.D. Irving Sussex Tree Nursery. As sinking depth was not collected during this study, it was extrapolated by regressing sinking depth against total snow depth, maximum temperature, and minimum temperature using data from the Alward Brook Deer Yard (just north of the Canaan River) for the years 1988 to 1995 ($r^2 = 0.536$, $p < 0.000001$). The resulting statistics were used to calculate sinking depth for the Canaan data, which was then incorporated into the WSI calculation for 1996 and 1997.

HABITAT STRATIFICATION

The Canaan River study area is situated on 3 Ecoregions. The Grand Lake and Continental Lowland Ecoregions comprise most of the study area. The Eastern Lowland ecoregion overlapped a small portion of the northeast portion of the study area. The Grand Lake ecoregion is sub-divided into the Grand Lake and Salmon River ecodistricts within the Canaan River study area. The Continental Lowland ecoregion is sub-divided into the Anagance Ridge and Kennebecasis River ecodistricts within the study area. Stands within the small portion of Eastern Lowland ecoregion present within the study area were treated as if part of the Grand Lake Ecoregion for further analysis.

Forest stands in New Brunswick have been classified by NBDNRE into Vegetation Communities (VEGCOMMs) based on similarities in overstorey tree species composition. VEGCOMMs were derived by 1) assigning stands to groups based on the two dominant species from photo-interpretation, 2) examining ground data by group to determine statistical differences with respect to percent basal area of species present, and 3) lumping groups showing no difference by species. Separate analyses were conducted for each Ecoregion. Hence, VEGCOMMs with the same name designation but from different Ecoregions are not the result of equivalence based on the analysis of ground data.

For the purposes of this study all VEGCOMMs were assigned to broader strata that are independent of Ecoregion. Assignments were made by examining available ground plot data (NBDNRE) for percent basal area by species. This process served to reduce the number of habitat type units, and thus reduce fragmentation of the deer location data. These lumpings attempted to group VEGCOMMs into meaningful vegetation community type units based on known habitat requirements and selection behaviour exhibited by white-tailed deer in areas experiencing severe winters. However, this grouping of VEGCOMMS had to be balanced with the need to provide detailed results with relevance to the forest management planning process. The resulting vegetation types are listed in Table 2.

Vegetation types were further subdivided by development stages indicating tree species age and vigour. These stages were sapling (S), young (Y), immature (I), mature (M), and overmature (O). Development stage designations comprise the last letter in habitat type descriptions throughout the remaining text of this report. For example, immature eastern cedar (EC + I) is designated as EC-I.

Development stages were lumped when possible to minimize data fragmentation, subject to the same constraints as described for habitat types (Table 3). Young and Immature stages were thought to be similar enough to warrant lumping for all habitat types. Mature and Overmature stages were lumped for the cedar type, as stand breakup is quite prolonged, if it happens at all, in this habitat type. Mature and overmature stages of the Intolerant hardwood type were also lumped, as both stages were thought to be similar with respect to provision of winter requirements of deer. Likewise, all stages of larch were lumped (all stages were thought to provide similar levels of cover), as were all non-sapling stages of pine (for the same reason).

This lumping process resulted in a total of 40 vegetation type-development stage combinations. This is a relatively large number, and as a result, many of the combinations are poorly represented on the study area, and the deer location data is somewhat fragmented. Vegetation type-development stage units will be referred to as "habitat types" or "habitats" for the remainder of this report.

Table 2. Vegetative cover stratification for deer habitat use analysis.

Softwood Types (>75% softwood)	
SW-RE	- softwood regeneration (cutovers with regeneration < 3m height, softwood dominated)
PI-PL	- pine plantations (typically jack pine)
SP-PL	- spruce plantations (typically white or black spruce)
EC	- cedar, hemlock (preferred cover species; very little hemlock present, so lumped)
SP	- spruce, fir (red or white spruce; very little area in fir, so lumped)
BSSW	- mixed black spruce-softwood
BS	- 90%+ black spruce, poor (wet) site
PI	- pine
TL	- larch
TL-PL	- larch plantations
Hardwood Types (>75% hardwood)	
HW-RE	- hardwood regeneration (cutovers with regeneration < 3m height, hardwood dominated)
IH	- intolerant hardwoods (e.g. aspen, white birch)
TH	- tolerant hardwoods (e.g. sugar maple, beech, yellow birch) (no part of study area ended up in this type)
Mixedwood Types	
MW-SA	- sapling development stage mixedwood[a]
SWMIX	- 50% - 75% softwood
IHMIX	- 50% - 75% hardwood, of which a majority is intolerant hardwoods
THMIX	- 50% - 75% hardwood, of which a majority is tolerant hardwoods
Other Types	
SETT	- settled land, agricultural[b]

[a]Typically comprised of non-commercial hardwood species, such as cherry, alder, willow, apple, mountain maple, striped maple, and mountain ash, mixed with softwood. This type was lumped with the road and railroad right-of-ways and river habitat type, which was mainly comprised of cut-road right-of-ways consisting of a similar species composition.

[b]Settlement was typically rural, with a majority of house lots contiguous with fields, hence agricultural and settlement habitat types were lumped. Deer were observed grazing on both types throughout the study.

Table 3. Development stage designations used in deer habitat use analysis.

Vegetation Type	Development Stage
EC	S, I (=Y+I), M (=M+0)
SP	S, I (=Y+I), M, 0
BSSW	S, I (=Y+I), M, 0
BS	S, I (=Y+I), M, 0
PI	S, PI = (Y+I+M+O)
TL	TL = (S+Y+I+M+O)
IHMIX	S, I (=Y+I), M, 0
THMIX	S, I (=Y+I), M, 0
SWMIX	S, I (=Y+I), M, 0
IH	S, I (=Y+I), M (=M+0)

HABITAT SELECTION ANALYSIS

The Neu method (Chi-square goodness of fit) (Neu *et al.* 1974) was used to analyze deer locations for evidence of habitat selection, and to compare proportional habitat composition of home ranges to that of seasonal range. The Neu test compares the overall patterns of habitat use and availability, or the overall patterns of habitat composition, for similarity. If the Neu test showed that patterns were dissimilar (i.e. habitats were not being used in proportion to availability), the Bonferroni Z-statistic was used to calculate 95% confidence intervals for each habitat type (Miller 1981:219). These confidence intervals were then used to determine which individual habitat type(s) were not being used in proportion to availability. For the remainder of this report, a habitat type which is used more often than expected according to availability will be referred to as Apreferred@ by deer, while a habitat type used less often than expected will be considered to have been Aavoided@. Use of the terms Anot selected@ or Ano selection@ indicates a habitat type was used in proportion to availability, i.e. it was neither avoided nor preferred.

An unfortunate characteristic of the Bonferroni Z-statistic confidence interval calculations is that an observation of "0" in a category with an expected value greater than "0", even if that expected value is extremely small, is considered to have occurred less than expected, or to have been avoided. Because it does not seem appropriate to consider such cases to be actual examples of avoidance, we have chosen an arbitrary limit of 2% of expected values for all instances where the observed value equals "0" to indicate a >strong= level of avoidance. This limit applies only to detailed discussion within the body of the report, as all results will be presented in the appropriate Appendices.

SCALES OF ANALYSIS

Habitat use was examined at several spatial scales because large, mobile vertebrates such as deer are known to select habitats dissimilarly at different temporal and spatial scales. The first scale considered was a comparison of habitat composition of summer ranges and wintering areas. This comparison was made to determine if, and how, the general area deer chose to winter within differed from that of areas chosen throughout non-winter periods.

The second scale considered was the comparison of habitat composition of home ranges to the habitat composition of the corresponding seasonal range in which those home ranges were located. This analysis was completed to determine if the specific areas deer chose to inhabit during winter were dissimilar from the surrounding area.

The third scale considered was the comparison of numbers of deer observations in habitat types within home ranges to the expected deer observations based on habitat composition of seasonal range. Expected deer observations for each habitat type were calculated by simply multiplying the proportion of seasonal range in that habitat type to the total number of deer observations for the seasonal range in question. This analysis was completed to determine if, and how, deer were selecting habitats in relation to the surrounding area.

The fourth scale considered was the comparison of numbers of deer observations in habitat types within home ranges to the expected deer observations based on habitat composition of the home range. Expected deer observations for each habitat type were calculated by applying the proportion of home ranges in that habitat type to the total number of deer observations for the home ranges in question. This analysis was completed to determine if, and how, deer were selecting habitats in relation to the specific area they occupied.

A further analysis taking snow depth into consideration was conducted at the seasonal range (third) scale. Deer locations in each seasonal range were sorted by the snow depth on the day the location was recorded. A separate analysis was then conducted for each snow depth data grouping.

In summary, the scales of habitat use analysis are as follows:

1. Comparison of wintering area vs. summer range habitat composition.
2. Comparison of home range vs. seasonal range habitat composition.
3. Habitat selection within seasonal range.
4. Habitat selection within home range.
5. Habitat selection within seasonal range as influenced by snow depth.

RESULTS

CAPTURE SUCCESS

A total of 63 deer were captured between March 7, 1994 and March 26, 1995. The sample was comprised of 14 male and 49 female deer, with an age-class composition (at capture date) of 49 adult deer, 8 yearlings, and 6 fawns (Table 4). Most of these animals (43) were collared during the helicopter capture operation on March 25-26, 1995 (Table 5). Other capture operations included trap-netting (2 deer), rocket-netting (1 deer), and darting (15 deer) (Table 5). In addition, 2 fawns were captured by hand and collared in June 1994. A comprehensive listing of capture statistics (age, sex, capture method, and date and location of capture) is provided in Appendix 4. Efficiency of capture techniques used in this project are further described in Ballard *et al.* 1997 (in press) (Appendix 3).

RELOCATION EFFORTS

A total of 2588 triangulated deer locations were collected during the duration of the study. Summer habitat data was collected in 1994, when 271 locations were collected for 8 deer. As a result of early difficulties in collar deployment, only 46 locations were collected during the winter of 1994. Only 3 deer remained collared as the winter of 1995 began, but, capture operations allowed the collaring of 9 additional deer throughout the winter, resulting in the collection of 375 locations for 12 deer. An intensive relocation effort in the winter of 1996 resulted in the collection of a significant amount of habitat use data for 31 deer (1457 locations). An additional 216 locations were collected for 24 deer in the winter of 1997. Another 223 locations were recorded during miscellaneous non-winter occasions during the course of the study. The majority of locations were collected during daytime hours, although a small sample of nighttime locations were collected during the winter of 1996. These nighttime locations were pooled with daytime locations for analysis.

Table 4. Age and sex structure of the white-tailed deer collared during the Fundy Model Forest deer study.

	Sex	
Age (years)	Male	Female
0.7 (fawn)	3	3
1.7 (yearling)	1	7
2.7	2	5
3.7	2	3
4.7	1	7
5.7	2	6
6.7	1	4
7.7	0	2
8.7	0	6
adult (age unknown)	2	6
Total	14	49

Table 5. Capture effort and success achieved collared during the Fundy Model Forest deer study.

Capture Effort	Method: Traps	Darting	Rocket Net	Helicopter Netting
1994 total effort	150 trap-nights	246.2 hours[a]	35.4 hours[a]	-
1994 capture success	2	7	0	-
1994 effort/deer	75 trap-nights	35.2 hours	_	-
1995 total effort	339 trap-nights	114.4 hours	3.5 hours	16.5 hours
1995 capture success	1	8	1	43
1995 effort/deer	339 trap-nights	14.3 hours	3.5 hours	0.4 hours
total effort (both years)	489 trap-nights	360.6 hours	38.9 hours	16.5 hours
capture success (both years)	3	15	1	43
effort/deer (both years)	163 trap-nights	24.0 hours	38.9 hours	0.4 hours

[a]hours = total person-hours in tree stand, does not include support personnel.

MORTALITY RATES

Survival and cause-specific mortality rates for deer captured during this study, as well as those for a population studied concurrently in north-central New Brunswick, are discussed in Whitlaw *et al.* 1997 (in press) (Appendix 2). We include this information because the abundance of deer is related to mortality factors as well as habitat. Both factors need to be considered in developing population level or habitat level management scenarios.

The two areas studied differed primarily in deer population history, deer harvest restrictions, and in winter climate conditions. The deer population in the northern area is believed to be slowly recovering from near record low levels, while that in the south is stable. Deer populations in the northern study area are subjected to a harvest of antlered deer only, while a limited number of antlerless deer permits are available in the south. Climate conditions are more severe in the north, and as a result deer in that area typically congregate in yards.

Survival data for male deer were pooled across years because of the small sample sizes attained. Pooled annual survival rates for adult male deer did not differ between the two study areas. However, predation accounted for most mortality of adult males in the north, with hunter harvest accounting for most mortality in the south. Annual survival of adult female deer was higher in the north. Winter mortality rates of adult females did not differ between the two areas. Predation accounted for most mortality of adult females in the north, with hunter harvest (illegal for does in the north) accounting for most mortality in the south. However, mortality resulting from predation did not differ between the two areas, hence hunting mortality was the factor accounting for most of the difference in overall mortality rates of adult female deer between the two study areas.

An examination of the southern sub-sample (i.e. the deer radio-collared for the Model forest study) alone shows that female deer annual survival rates ranged from 0.482 to 0.807 (Table 6). Seasonal survival data indicate high survival rates for early spring, winter, and summer; with the lowest rate of survival occurring during autumn (hunting season). The annual survival rate of male deer was much lower (0.382) (Table 7). The winter survival rate for male deer (0.692) was much lower than those of female deer (0.917 to 1.000). The pooled annual mortality rates of female deer indicates that hunting-related mortality accounts for the majority of the overall mortality rate (Table 8). The second largest single mortality factor was Aunknown cause@, which was probably predation in most cases. When Aunknown cause@ is grouped with the various types of predation, overall predation rates (0.137) become equivalent to hunting-related mortality rates (0.128). The remaining cause of mortality, roadkill, accounted for a very small proportion (0.014) of female deer.

Table 6. Interval and annual survival rates for adult (∃2 years old) female white-tailed deer in the Canaan River - Sussex study area, 1994-1997.

Year	Seasonal Interval	Survival Rate[a]	No. Deer	No. Radiodays[b]
1994	Apr-May	1.000	4	232
	June-Sept	1.000	6	732
	Oct-Nov	0.523	6	284
	Dec-Mar	1.000	38	739
	Apr-May	0.921	38	2248
1994/1995	Annual	0.482	38	3973
	June-Sept	0.947	38	4491
	Oct-Nov	0.774	36	1913
	Dec-Mar	0.929	28	3300
	Apr-May	1.000	26	1586
1995/1996	Annual	0.681	38	11290
	June-Sept	1.000	27	3277
	Oct-Nov	0.925	27	1557
	Dec-Mar	0.917	24	2797
	Apr-May	0.952	22	1245
1996/1997	Annual	0.807	27	8876

[a]proportion of deer surviving through the interval
[b]1 radioday = 1 radio-collared deer surviving 1 day

Adapted from Whitlaw *et al.* 1997.

Table 7. Interval and annual survival rates for adult (∃2 years old) male white-tailed deer in the Canaan River - Sussex study area, years 1994-1997 pooled.

Seasonal Interval	Survival Rate[a]	No. Radiodays[b]
June-Sept	0.938	1917
Oct-Nov	0.678	786
Dec-Mar	0.692	986
Apr-May	0.869	868
Annual	0.382	4557

[a]proportion of deer surviving through the interval
[b]1 radioday = 1 radio-collared deer surviving 1 day

Adapted from Whitlaw *et al.* 1997.

Table 8. Seasonal and annual cause-specific mortality rates for adult (∃2 years old) female white-tailed deer in the Canaan River - Sussex study area, 1994-1997.

Year	Seasonal Interval	Mortality Rate[a]: Legal Kill	Hunting/ Wounded	Coyote	Domestic Dog	Unknown Predator	Roadkill	Unknown Cause
1994	Apr-May							
	June-Sept							
	Oct-Nov	0.477						
	Dec-Mar							
	Apr-May				0.026	0.053		
1994/1995	Annual	0.477			0.014	0.028		
	June-Sept						0.026	0.026
	Oct-Nov	0.141				0.028		0.056
	Dec-Mar			0.036		0.036		
	Apr-May							
1995/1996	Annual	0.134		0.026		0.053	0.026	0.080
	June-Sept							
	Oct-Nov		0.038				0.038	
	Dec-Mar							0.083
	Apr-May							0.048
1996/1997	Annual		0.038				0.038	0.117
1994-1997	Annual (Pooled)	0.114	0.014	0.013	0.008	0.037	0.014	0.079

[a]proportion of deer sustaining mortality

Adapted from Whitlaw *et al.* 1997.

CLIMATE DATA

Snow Depths

Snow depth profiles for all stand types and winters are displayed in Figures 1 to 3. Snow depth measurements are provided in Appendix 5. One relationship evident among all 3 years of study is the close relationship between snow depths in softwood and mixed-wood stand types, regardless of the fact that the overstory of the mixed-wood stand was comprised of only ~40% softwood species, compared to ~80% for the softwood stand. This pattern occurs because mixed-wood stands in the study area typically contain a very dense understory, or 'sub-canopy', of softwood regeneration, which ameliorates snow depths much the same way as the overstory canopy in a softwood stand. Hardwood and clearcut stands, both being very open, also displayed a close relationship with respect to snow depths.

Deer yards are commonly comprised of softwood stands partly because these stands typically exhibit shallower snow depths compared to more open stand types. This pattern was evident in the Canaan data during 1996 and 1997, but the opposite occurred in 1995. In late-January 1995, a moderate thaw removed approximately half of the snow from the softwood and mixed-wood stands, but almost entirely removed it from the clearcut and hardwood stands. Although a subsequent amount of snow accumulation followed this thaw, snow depths in these open stand types never again surpassed those of the closed stand types (Figure 1). Conversely, in 1996, a series of deep thaws eliminated snow from all stand types, and with subsequent accumulation the typical pattern of shallower snow in the closed stand types was preserved (Figure 2).

Over the three years of study, a variety of snow depth conditions were experienced within the study area. The winter of 1995 experienced a gradual build-up of snow through mid-winter, and a gradual decline through spring, punctuated by a deep thaw in late-January. Snow depths exceeded restrictive levels (>40 cm) in early February through mid-March (Figure 1). By contrast, the winter of 1996 was characterized by 3 major thaws, which removed all snow cover, in late January, late February, and late March, in addition to a number of more minor thaws. Snow depths reached restrictive levels only briefly in late December (Figure 2). The winter of 1997 experienced little or no snow until February, and with steady accumulation reached restrictive levels by late February. By mid-March 1997, snow depths in hardwood stands reached the greatest mean depths (66 cm) recorded in any stand type during the 3 years of the study (Figure 3).

Temperature

Minimum, maximum, and median daily temperatures have remained quite consistent over the 3 winters of study (Figures 4 to 6) (Appendix 6). Any cold snaps or thaws were brief, and there were no prolonged differences between years. Hence, any differences in winter severity would appear to be due more to snow accumulation rather than temperature. However, snow accumulation, or more accurately the persistence of snow accumulation, was influenced greatly by those brief differences in warm periods among winters.

Winter Severity Indices

WSI=s for Region 3 (southeastern New Brunswick) are presented in Figures 7 to 10, and in Appendix 7. The Canaan study area is located centrally within this region. Values for WSI are presented for the months of January, February, and March, as well as a Winter value (mean of the weekly measurements over the 3 winter months indicated). WSI=s for 1996 and 1997 are extrapolated from data collected during this study, as discussed previously.

January WSI=s (mean 20.5 ∀ 6.5) tended to be fairly uniform, with the exception of 3 severe January periods in 1981, 1982, and 1994. They ranged from 9.1 to 32.8 WSI, although most values were between 15 and 25 WSI. Of the three winters relevant to this study, 1995 (WSI = 15.3) and 1996 (WSI = 18.1) were typical, being just below the mean value. In contrast, 1997 had the least severe January period, with a WSI of 9.1. Although WSI=s for 1996 and 1997 are not entirely comparable to the previous data due to the difference in type of data collected, they should be sufficiently correlated to indicate that 1997 did indeed experience an 'easy' January in terms of WSI.

February WSI=s ranged from 11.7 to 33.9 (mean 20.8 ∀5.7), and again, most values were between 15 and 25 WSI. However, the years relevant to this study were somewhat atypical, with 1995 (WSI = 26.3) being the 4th most severe February in the previous 18 years, and 1996 (WSI = 15.5) being the 4th least severe February over that period. The following year, 1997, was only slightly more severe, with a WSI of 17.0.

March WSI=s (mean 15.1 ∀5.7) tended to be quite low, reflecting the fact that winter conditions are typically beginning to break up in the latter parts of that month. They ranged from 5.7 to 26.0 WSI, although most were between 10 and 20 WSI. Of the winters relevant to this study, 1995 (WSI = 13.5) was fairly typical, while 1996 (WSI = 8.0) was the 2nd least severe. March 1997, which experienced very substantial snow accumulation beginning in late February, was the 3rd most severe March on record.

The overall Winter WSIs (mean = 18.8 ∀ 3.6) allow a more general comparison of the conditions experienced during the deer study winters and the recent past. The winters of 1995 (WSI = 18.3) and 1997 (WSI = 15.9) were typical, being close to the mean WSI for the previous 18 years. During 1996 (WSI = 13.9), however, we experienced the 2nd lowest overall WSI for the period. That winter was characterized by a series of deep thaws which completely removed the snow pack, and resulted in a major change in deer behaviour. The most noticeable pattern seems to be the relative lack of variation in overall winter WSI=s compared to the monthly values. Most of the variation in winter severity is not reflected in overall WSI values among years, but rather, it is reflected in differences in timing of the severe periods within a particular winter. This is further reflected in Figure 11, which displays weekly values of WSI for the previous 18 years, extending from December 15 (of the year previous to that indicated) (week 1) through the end of the 2nd week of April (week 17). There is a great deal of variation in length and intensity of severe periods, and especially with respect to timing of severe periods. The mean number of months with a WSI > 20 was 5.33, but ranged from 0 (1983) to 9 (1987 and 1993). The three years of study in Canaan encompassed the range of timing of severe periods, with 1995 reaching severe levels in mid-winter, 1996 in late December - early January, and 1997 in March.

Hence, during the course of the study we were able to collect deer habitat data through a wide range of climatic conditions within winters, but no winter was considered to have been severe. Winter weather tended to be quite variable, and there were no extended periods of severe conditions. However, the WSI data indicates that severe winters are uncommon, hence it was unlikely we would experience one over a 3-year study.

- black bar indicates snow depths limiting to deer (40 cm)

Figure 1. Snow depth profiles for the Canaan River study area during the winter of 1995.

- black bar indicates snow depths limiting to deer (40 cm)

Figure 2. Snow depth profiles for the Canaan River study area during the winter of 1996.

- black bar indicates snow depths limiting to deer (40 cm)

Figure 3. Snow depth profiles for the Canaan River study area during the winter of 1997.

Figure 4. Minimum daily temperature profiles at the Sussex tree Nursery.

Figure 5. Maximum daily temperature profiles at the Sussex Tree Nursery.

Figure 6. Median daily temperature profiles at the Sussex Tree Nursery.

- black bar indicates mean value

Figure 7. January Winter Severity Index values for Region 3 from 1980 to 1997.

- black bar indicates mean value

Figure 8. February Winter Severity Index values for Region 3 from 1980 to 1997.

- black bar indicates mean value

Figure 9. March Winter Severity Index values for Region 3 from 1980 to 1997.

- black bar indicates mean value

Figure 10. Mean Winter Severity Index values for Region 3 from 1980 to 1997.

WEEK

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1980	nd	nd															
1981	nd	nd	30.1+	30.1+	30.1+												
1982	nd	nd			30.1+	30.1+					30.1+						
1983	nd	nd															
1984	nd	nd			30.1+	30.1+											
1985	nd	nd				30.1+		30.1+									
1986	nd	nd															
1987	nd	nd				30.1+	30.1+	30.1+	30.1+								
1988	nd	nd		30.1+													
1989	nd	nd															
1990	30.1+	30.1+															
1991				30.1+													
1992									30.1+	30.1+	30.1+	30.1+					
1993	nd	nd						30.1+								nd	nd
1994	nd	nd			30.1+				30.1+							nd	nd
1995									30.1+								
1996			30.1+														
1997																	
Mean	nd	nd															

	WSI = 0.0 - 5.0
	WSI = 5.1 - 10.0
	WSI = 10.1 - 15.0
	WSI = 15.1 - 20.0
	WSI = 20.1 - 25.0
	WSI = 25.1 - 30.0
30.1+	WSI = 30.1+

Figure 11. Weekly Region 3 Winter Severity Index values for the period of December 15 (week 01) through April 15 (week 17).

DEER MOVEMENT PATTERNS

Seasonal Ranges

Three distinct sub-populations of deer were evident (Table 9, Figure 12). One group of deer wintered along a corridor stretching from Goshen through Marrtown and Snider Mountain to Pleasant Ridge (Snider Mountain wintering area). Another group wintered in the Mount Hebron area, near Smith's Creek (Mount Hebron wintering area). The third group of deer wintered in the Whites Mountain area, near Newtown (White's Mountain wintering area). These sub-populations occupied relatively distinct summer ranges, with some overlap (Figure 12). Deer were somewhat more dispersed on summer range, and as a result summer ranges were larger than corresponding winter ranges (Table 9).

The ranges delineated reflect capture effort and success throughout the Canaan-Sussex area. They do not imply that areas outside the delineated ranges lack deer. However, casual observations of deer grazing on fields in late winter throughout the southern portion of the study area revealed no other substantial concentrations of deer. Most observations were made on fields within or peripheral to the wintering areas delineated here. Individuals or small groups were occasionally noted between the Snider Mountain and Mount Hebron areas, and along the Smith=s Creek valley between the Mount Hebron and Whites Mountain areas. Nevertheless, it appears that the majority of deer within the study area winter within the 3 delineated wintering areas.

Given the wide dispersal of deer in summer, and thus the relative effect one home range can have on overall summer range boundaries, accuracy of summer range boundaries are much less certain than wintering area boundaries. Boundaries of the Mount Hebron and Whites Mountain summer ranges were particularly ambiguous as a result of a smaller sample of collared deer. Boundaries of the Mount Hebron and Whites Mountain Wintering Areas are also less certain than those of the Snider Mountain Wintering Area as a result of sample size.

Home Ranges

Home ranges were larger in winter than in summer (Table 10). However, because the value for summer is based on a relatively small sample of deer tracked over one summer, a direct comparison may not be feasible. The sample size of male deer was too small to allow an adequate comparison of home range sizes between sexes.

Mean home range sizes were larger during the winter of 1996 as compared to the winter of 1995, for both winter home ranges on wintering areas and on summer range (Table 10). This pattern is likely due to the variable and milder climate conditions during the winter of 1996, which may have either allowed or required the usage of a greater diversity of landscape features by deer during that winter.

Table 9. Area and capture success for 6 seasonal ranges of white-tailed deer in the Canaan River study area.

Seasonal Range	Area (ha)	Number of Deer Captured
Snider Mountain Wintering Area	5658	38
Mount Hebron Wintering Area	712	3
Whites Mountain Wintering Area	2307	12
Snider Mountain Summer Range	8581	2
Mount Hebron Summer Range	9394	2
Whites Mountain Summer Range	14917	3
Other[a]	--	3

[a]Non-migratory deer located outside the boundaries of the main study area.

Figure 12. Location of white-tailed deer seasonal ranges in the Canaan River study area.

Table 10. Home range size of deer in the Canaan River study area.

Period	Seasonal Range	Sex	Sample Size	Mean Home Range Area (ha)	Mean Number Of Locations[a]
		Male	3	60.6 ∀ 11.2 (48.2 - 69.7)[b]	25.7 ∀ 5.9 (19 - 30)[c]
		Female	5	91.4 ∀ 80.0 (22.7 - 220.6)	35.8 ∀ 6.7 (25 - 43)
Summer 1994	Summer Range	Both	8	79.8 ∀ 62.8 (22.7 - 220.6)	32 ∀ 7.9 (19 - 43)
		Male	1	37.1	34
		Female	3	59.3 ∀ 51.3 (13.0 - 114.5)	17.0 ∀ 13.0 (9 - 32)
	Summer Range	Both	4	53.7 ∀ 43.3 (13.0 - 114.5)	21.2 ∀ 13.6 (9 - 34)
		Male	1	30.7	12
		Female	10	62.4 ∀ 38.1 (11.8 - 121.4)	23.0 ∀ 14.3 (7 - 48)
Winter 1995	Wintering Area	Both	11	59.5 ∀ 37.4 (11.8 - 121.4)	22.0 ∀ 14.0 (7 - 48)
		Male	1	153.1	11
		Female	12	121.4 ∀ 84.9 (42.7 - 322.8)	32.2 ∀ 9.4 (14 - 48)
	Summer Range	Both	13	123.9 ∀ 81.7 (42.7 - 322.8)	30.5 ∀ 10.8 (11 - 48)
		Male	3	179.0 ∀ 94.8 (96.7 - 282.7)	38.7 ∀ 7.2 (34 - 47)
		Female	25	161.0 ∀ 144.9 (16.2 - 635.7)	37.2 ∀ 23.0 (6 - 68)
Winter 1996	Wintering Area	Both	28	163.0 ∀ 138.9 (16.2 - 635.7)	37.3 ∀ 21.7 (6 - 68)

[a]Mean number of locations used to delineate home range
[b]Range of home range area values
[c]Range of number of locations used to delineate home ranges

Migratory Behaviour

Of the 63 deer collared during the course of this study, 53 animals survived long enough to ascertain seasonal movement patterns. Of these deer, 13 (24.5%) were non-migratory, and resident in the southern part of the study area. The remaining 40 animals (75.5%) were migratory. A majority of non-migratory deer (10 of 13) were present on one of the three Wintering Areas. Of the remaining non-migratory deer, 2 were resident outside the southern boundaries of the study area, in Highfield and Anagance, while 1 occupied a home range between the Mount Hebron Wintering Area and summer range, in the Dubee Settlement area.

The absence of non-migratory deer on summer ranges may be primarily a result of sampling intensity, as most capture effort was directed at wintering areas. However, incidental observations on summer ranges during periods of limiting snow depths, by both ground and air, indicated very few deer were present on summer range during those conditions. We radio-collared 2 deer on summer range during the winter of 1995, during periods when the general migration to wintering areas had taken place for most other deer. Thus, at first glance these deer appeared to be non-migratory. However, they eventually migrated to wintering areas in the Sussex area. The greater reluctance to migrate these deer displayed appeared to be a result of their home range locations, which overlapped a NBDNRE demarcated DWA. This migration reluctance was later exhibited by several other deer occupying summer home ranges near DWAs during the winter of 1996. Hence, it is very likely that there are few non-migratory deer in the northern portions of the study area (i.e. summer range).

Deer tended to move quite rapidly between summer and winter range when migrating. On a few occasions deer were located on winter range only 8 - 10 hours after being tracked on summer range. As a result, there have been only rare occasions when locations have been achieved for deer in transit.

Migration Distances

Mean migration distance (straight line) between summer and winter range was 15.8 ∀ 8.8 km, and ranged between 3.3 km and 55.0 km (Table 11). Snider Mountain deer migrated the shortest distances on average, and Mount Hebron deer the longest. However, the absolute shortest migration distance for individual deer was traveled by a Whites Mountain deer (3.3 km), and the longest by a Snider Mountain deer (55 km).

Table 11. Migration distances for deer collared in the Canaan River study area.

Wintering area	Mean Migration Distance (km)	Range of Migration Distances (km)	Number of Non-migratory Deer
Snider Mountain	14.2 ∀ 9.4 (27)[a]	3.6 - 55.0	7
Mount Hebron	23.7 ∀ 3.5 (6)	19.2 - 28.9	0
Whites Mountain	15.2 ∀ 6.1 (7)	3.3 - 21.5	3
Combined	15.8 ∀ 8.8 (40)	3.3 - 50.0	10

[a]Figure in parentheses denotes the number of deer in sample

Migration Timing

Weather conditions during the 3 winters of study have been extremely variable, however, the conditions influencing deer migration timing are quite consistent. Generally, accumulation of 30-40 cm of snow in coniferous stand types coincided with a general movement southward into winter range (Figures 13 to 15). Movements back into summer range tended to occur when there was a significant amount of bare ground in the open.

The winter of 1995 was characterized by a gradual buildup of snow depth, reaching limiting depths (>40 cm) in early to mid-winter. As a result, the bulk of deer migration to wintering areas occurred during the 3rd week of January (range January 22, 1995 to March 11, 1995 for collared deer) (Figure 13). This finding is based primarily on subjective observations of deer sign within summer range, as only a few deer were collared at that time. Movements back to summer range were concentrated in the first 2 weeks of April (range April 4, 1995 to April 25, 1995).

In the winter of 1996, deep snow accumulated very early, and movements south to winter range were concentrated in the 4th week of December 1995 (range December 14, 1995 to March 23, 1996). Migration back to summer range occurred primarily during the last week of March and first week of April, but ranged from January 20, 1996 through April 18, 1996 (Figure 14).

The winter of 1997 experienced little or no snow accumulation until mid-February, with a resulting general movement to winter range by most deer in the 4th week of February (range December 20, 1996 to March 4, 1997) (Figure 15). Migration back to summer range occurred sometime after April 12, 1997.

Because deer movements were so closely tied to snow conditions, midwinter thaws often caused an early return to summer range. Subsequent snow accumulation caused a return to winter range for most of these animals. The winter of 1996 experienced several deep thaws, the earliest in late January. This accounted for the longer period of northward movements during that winter. During that winter a total of 24 collared, migratory deer were being tracked. Of this sample, 18 deer made 1 round trip between summer and winter range during the course of that winter, 1 made no trip, 4 deer made 2 trips, and 1 animal made 3 round trips, for a mean of 1.21 round trips per animal between summer and winter range that winter.

This pattern of behaviour would seem to indicate a reluctance to move into winter ranges unless conditions absolutely necessitate doing so, and a reluctance to remain there when conditions do not require doing so. This might be expected in an area where conditions are consistently variable or unpredictable, and are only rarely severe for extended periods of time. This behaviour contrasts sharply with that of deer in the northern part of the province, where winters are more often characterized by deep snow (>40 cm) throughout an extended winter period. Deer in those areas tend to move into wintering areas in late autumn and early winter, and will remain in the general vicinity of the wintering areas even during extended mild periods when they may not necessarily be confined to them.

Figure 13. Migration timing and snow depth in the Canaan River study area during the winter of 1995.

Figure 14. Migration timing and snow depth in the Canaan River study area during the winter of 1996.

Figure 15. Migration timing and snow depth in the Canaan River study area during the winter of 1997.

HABITAT USE RESULTS

The results of the habitat use analyses are presented as follows:

1)Summer Habitat Use Analysis
- a)Snider Mountain Sub-population
  - -Home range habitat composition
  - -Within seasonal range selection
  - -Within home range selection
- b)Mount Hebron Sub-population
  - -same analyses as above
- c)Other Deer
  - -Within home range selection
- d)Synthesis of summer habitat use

2)Winter Habitat Use Analysis
- a)Snider Mountain Sub-population
  - -Seasonal range habitat composition
  - -Home range habitat composition
    - -Wintering Area
    - -Summer Range
  - -Within seasonal range selection
    - -Wintering Area
    - -Summer Range
  - -Within home range selection
    - -Wintering Area
    - -Summer Range
- b)Mount Hebron Sub-population
  - -same analyses as above
- c)Whites Mountain Sub-population
  - -same analyses as above
- d)Other Deer
  - -Within home range selection
- e)Ranges and Winters Pooled
  - -Within home range selection - Wintering Areas
  - -Within home range selection -Summer Ranges
- f)Synthesis of Winter Habitat Use
  - -Summer and Winter Range Habitat Composition
  - -Home Range and Seasonal Range Habitat Composition
  - -Within Seasonal Range Habitat Selection
  - -Within Home Range Habitat Selection

3)Effect of Snow Accumulation on Habitat Use

SUMMER HABITAT USE ANALYSIS

SNIDER MOUNTAIN SUB-POPULATION

Home Range Habitat Composition

Habitat use was determined for 6 collared deer on the Snider Mountain summer range during the summer of 1994. Habitat composition of those 6 home ranges differed from that of the overall summer range ($p = 0$) (Appendix 8(a)). The TL-PL type comprised a greater proportion of home range than expected (Table 12). This occurred because 2 of the 6 deer occupied overlapping home ranges on one of the few TL-PL stands within the summer range, skewing the results. A large number of habitats comprised a smaller proportion of home range than expected due to the relatively small sample size. Habitat types showing the greatest degree of avoidance were mainly the younger coniferous types (Table 12).

Within Seasonal Range Selection

Habitat types were not used in proportion to availability on the Snider Mountain summer range during the summer of 1994 ($P = 0$) (Appendix 9(a)). The TL-PL and IHMIX-M types were used more often than expected (Table 12). The apparent preference for TL-PL occurred for reasons outlined above. However, the IHMIX-M type occurred on all 6 home ranges. A large number of habitat types were avoided. Those showing a strong level of avoidance included young, pure coniferous types and mature mixed wood types.

Within Home Range Selection

Analysis of habitat use within home ranges in the Snider Mountain summer range during the summer of 1994 shows that habitat use was not used in proportion to availability by collared deer ($p = 0.0279$) (Appendix 10(a)). Although no habitat type was preferred, 2 habitat types showed a strong level of avoidance (Table 12). These were the SWMIX-M and HW-RE types. No strong pattern of habitat use is evident.

MOUNT HEBRON SUB-POPULATION

Home Range Habitat Composition

Home range habitat composition was examined for 1 collared deer in the mount Hebron summer range during the summer of 1994. Habitat composition on that home range differed from that of the summer range ($p = 0$) (Appendix 8(b)). The PI-PL habitat type formed a much greater proportion of home range than expected (Table 12). The apparent preference for this habitat type is likely a function of sample size, as the single collared deer present in this summer range occupied an area containing a high concentration of plantations, greatly skewing the results. Pine plantations accounted for 79% of the home range of that animal. A total of 28 of the remaining 31 habitat types comprised a smaller than expected proportion of home range area due to small sample size. Those showing a strong degree of avoidance encompassed a broad range of habitat types (Table 12). No clear pattern of habitat use is evident.

Within Seasonal Range Selection

The collared deer did not use habitat types in proportion to availability on the Mount Hebron summer range during the summer of 1994 ($p < 0.0001$) (Appendix 9(b)). The PI-PL type was used more often than expected for reasons outlined above (Table 12). A large number of habitat types were used less often than expected, and those showing a strong degree of avoidance encompassed a broad range of habitat types. No clear pattern of habitat use is evident.

Within Home Range Selection

Habitat types were not used in proportion to availability within the single home range examined during the summer of 1994 ($p < 0.0001$) (Appendix 10(b)). No habitat types were preferred, and none were strongly avoided (Table 12). As this level of analysis eliminates the skewing caused by small sample size (only the single home range present is used to determine habitat availability, rather than the entire summer range of the sub-population), the lack of preference for the PI-PL type is interesting, as it indicates that the preference indicated by the previous 2 levels of analysis was related to the small sample size.

OTHER DEER

Within Home Range Selection

During the summer of 1994, 1 deer collared in March 1994 within the Snider Mountain wintering area migrated far outside the >regular= summer range boundary for that sub-population. This deer, #414, migrated to the Cumberland Point area, approximately 25 km northeast of the study area. Because the boundaries of the overall summer range for the sub-population this "outlier" belonged to are unknown, the home range composition and within seasonal range selection analysis can not be conducted for this individual. Analysis of habitat selection within home range indicated that habitat types were not being used in proportion to availability ($p < 0.0001$) (Appendix 10(c)). Only 6 habitat types were present in this home range, with the HW-RE type being preferred, and the SP-I type avoided.

SYNTHESIS OF SUMMER HABITAT USE

Results of the summer habitat use analyses are variable, and general patterns are unclear. Some results are contradictory, such as the preference for HW-RE stands by deer # 465, and avoidance of the same habitat type by the Snider Mountain sub-population. This is likely the result of low sample size, as only 6 home ranges are available for analysis in the largest sample (Snider Mountain). Alternatively, deer may be selecting for some micro-habitat feature during summer (such as escape cover) which might be inadequately correlated with the habitat type delineations used in this analysis, or perhaps present over a broad range of habitat types.

Table 12. Summer habitat use by the Snider Mountain and Mount Hebron deer sub-populations during the summer of 1994.

ANALYSIS	SNIDER MOUNTAIN SUMMER RANGE			MOUNT HEBRON SUMMER RANGE		
	PREFERRED	AVOIDED		PREFERRED	AVOIDED	
HOME RANGE COMPOSITION	TL-PL	SW-RE		PI-PL	SW-RE	IHMIX-I
		PI-PL			SP-S	IHMIX-M
		SP-PL			SP-M	SWMIX-S
		BSSW-M			BSSW-M	SWMIX-M
		IHMIX-O			MW-SA	HW-RE
					IHMIX-S	
WITHIN SEASONAL RANGE SELECTION	TL-PL	SW-RE	MW-SA	PI-PL	SW-RE	IHMIX-I
	IHMIX-M	PI-PL	IHMIX-O		SP-S	IHMIX-M
		SP-PL	SWMIX-M		SP-M	SWMIX-S
		BSSW-M			BSSW-M	SWMIX-M
					MWSA	HW-RE
					IHMIX-S	
WITHIN HOME RANGE SELECTION	NONE	SWMIX-M		NONE	NONE	
		HW-RE				

WINTER HABITAT USE ANALYSIS

SNIDER MOUNTAIN SUB-POPULATION

Seasonal Range Habitat Composition

The Snider Mountain wintering area and summer ranges were quite similar with respect to vegetative cover types, differing mainly with respect to development stages (Figure 16) (Appendix 11(a)). The wintering area appears to be younger overall relative to summer range. For example, the IHMIX type comprised most of both ranges, but was present proportionally more often in the sapling stage (-S) and immature stage (-I) on the wintering area. Summer range contained proportionally more of the mature (-M) and overmature (-O) stages. The SWMIX and SP types were next in abundance on both ranges, with summer range again containing proportionally more of the mature development stages. However, this trend toward younger development stages is countered somewhat by the greater abundance of regenerating coniferous habitat types (SW-RE, PI-PL, SP-PL) on summer range.

Several trends in occurrence of habitat types (irrespective of development stage) on mainly or only one seasonal range are also evident. However, these habitat types tend to be relatively uncommon even on the range where they do occur. For example, pure intolerant hardwoods (IH), tolerant hardwood-dominated mixed stands (THMIX), and cedar (EC) are almost entirely limited to winter range, comprising 7.4%, 2.5%, and 2.2% respectively. They comprise a much smaller proportion of summer range (0.1%, 0.0%, and 0.2% respectively). Likewise, the 2 black spruce dominated types (BS and BSSW) occur primarily on summer range, although they are a minor constituent (3.2% and 5.4% respectively). Also noteworthy is the abundance of the settled and agricultural habitat type (SETT) on winter range (10.9%) relative to summer range (1.1%).

Home Range Habitat Composition - Wintering Area

During the winter of 1995, habitat composition of home ranges on the Snider Mountain wintering area differed from that of the entire wintering area ($p = 0.000862$) (Appendix 12(a)). No habitat comprised a greater proportion of home ranges than expected. A total of 12 habitats were encountered less often than expected within home ranges, although 11 of these habitats formed a very minor part of the seasonal range (< 2% each), and were absent from home ranges. The only habitat type showing a stronger degree of avoidance was SP-I (Table 13). In the Snider Mountain wintering area, this habitat type is appears to occur most often on old field sites, which tend to contain very low amounts of understory browse.

During the winter of 1996, habitat composition of deer home ranges on the Snider Mountain wintering area did not differ from that of the wintering area ($p = 0.9255$) (Appendix 12(b)).

Home Range Habitat Composition - Summer Range

During the winter of 1995 habitat composition of home ranges on the Snider Mountain summer range differed from that of the entire summer range ($p = 0$) (Appendix 12(c)). The majority of habitats formed a smaller portion of home ranges than expected. This is mainly due to the small sample size (n = 2 home ranges), as most of these "avoided " habitats were absent from home ranges but formed a minor part of the seasonal range. Stands showing stronger degrees of avoidance were the pure coniferous types (over a range of development stages), coniferous dominated mixedwood types, and the 2 younger age classes of the intolerant hardwood dominated mixedwood types (Table 13). One habitat type, IHMIX-M, comprised a higher portion of home ranges than expected.

During the winter of 1996, habitat composition of deer home ranges on the Snider Mountain summer range did not differ from that of the summer area ($p = 0.661$) (Appendix 12(d)).

Within Seasonal Range Selection - Wintering Area

Habitat types were not used in proportion to availability on the Snider Mountain wintering area during the winter of 1995 ($p < 0.0001$) (Appendix 13(a)). A large number of habitat types were avoided by deer, but most of these were a minor part of the winter range, and were expected to receive few observations. Habitat types showing stronger levels of avoidance were 2 regenerating types, HW-RE and MW-SA, and THMIX-I, which tends to occur on exposed ridge-tops (Table 13). The habitat types IHMIX-I and SWMIX-I were used more often than expected. There also appeared to be some degree of preference for SWMIX-M stands, although not at statistically significant levels (Appendix 13(a)). The pattern of habitat use appears to be one of avoidance of pure coniferous habitat types and regeneration types with preference for mature mixed stands.

During the winter of 1996, deer on the Snider Mountain wintering area did not use habitat types in proportion to availability ($p = 0$) (Appendix 13(b)). Plantation and Sapling habitat types tended to be avoided, as were the IHMIX-O and SETT types (Table 13). The habitat types SP-I, SP-M, IHMIX-M, and THMIX-I types were used more often than expected. The overall pattern of habitat selection is quite similar to that of the previous winter, with the exception of the preference for 2 pure coniferous types (SP-I and SP-M).

Within Seasonal Range Selection - Summer Range

Habitat types were not used by deer in proportion to availability on the Snider Mountain summer range during the winter of 1995 ($p < 0.0001$) (Appendix 13(c)). However, because of the small sample size in this range (19 observations on 2 home ranges), only 3 habitat types showed no difference between expected and actual observations. Most habitat types were avoided, but many of these indicated low expected observations. Habitat types showing stronger degrees of avoidance included some of the pure coniferous types, coniferous-dominated mixedwood types, and regenerating or plantation types (Table 13). One habitat type, IHMIX-M, was selected for quite strongly. Although the low sample size creates difficulty in elucidating a clear pattern in this case, the general pattern emerging seems to be very similar to that exhibited in the wintering area, with preference for mature mixedwood stands and avoidance of regeneration types. The most obvious difference is the avoidance of pure coniferous and coniferous-dominated mixedwood habitat types on summer range, whereas there was some preference for these types on winter range.

Collared deer again used habitat types disproportionately in comparison to availability on the Snider Mountain summer range during the winter of 1996 ($p = 0.0009$) (Appendix 13(d)). A larger sample size (302 observations on 10 home ranges) was achieved in that year. Many habitat types were avoided, although most of these indicated low expected observations. Strongly avoided habitat types were few, but included some regenerating and coniferous-dominated habitat types (Table 13). The IHMIX-M habitat type was the only habitat type selected for. Once again, the general pattern seems to be one of avoidance of pure coniferous and regenerating types, with preference for mature mixed types.

Within Home Range Selection - Wintering Area

Analysis of habitat use in home ranges within the Snider Mountain Wintering Area during the winter of 1995 reveals that habitats were not used in proportion to availability ($p < 0.0001$) (Appendix 14(a)). No habitat type was used more often than expected (Table 13). However, 6 habitat types were used less often than expected, with the IHMIX-O, IH-S, and MW-SA types showing the strongest degrees of avoidance.

During the winter of 1996 habitat use was not proportional to availability on home ranges ($p < 0.0001$) (Appendix 14(b)). Collared deer again used 6 habitat types less often than expected, although only 1 of these (IHMIX-O) was consistent with the previous year (Table 13). Other habitat types avoided included IHMIX-S, IHMIX-I, SWMIX-M, and PI-PL. There were 2 habitat types, SP-I and THMIX-I, used more often than expected. The pattern of habitat use exhibited here is less conspicuous than that exhibited in the seasonal range analysis. Collared deer are exhibiting some avoidance of regenerating types within home ranges. Patterns of use of mature-mixed stands are mixed, with some showing avoidance and others showing preference.

Within Home Range Selection - Summer Range

During the winter of 1995, collared deer used habitats within home ranges in the Snider Mountain summer range in proportion to availability ($p = 0.1690$) (Appendix 14(c)). Habitat types were not used in proportion to availability during the winter of 1996 ($p = 0.0007$) (Appendix 14(d)). No habitat types were used more often than expected, while 4 were used less often than expected (Table 13). However, only the BS-M type showed a strong degree of avoidance. The general pattern of habitat use apparent here is one of little or no selection.

Figure 16. Habitat composition of the Snider Mountain wintering area and summer range.

Table 13. Winter habitat use by the Snider Mountain sub-population.

ANALYSIS	WINTER	WINTERING AREA				SUMMER RANGE		
		PREFERRED		AVOIDED		PREFERRED	AVOIDED	
HOME RANGE COMPOSITION	1995	NONE		SP-I		IHMIX-M	SW-RE	BS-M
				THMIX-I			PI-PL	IHMIX-S
				HW-RE			SP-PL	IHMIX-I
							SP-I	IHMIX-O
							SP-M	SWMIX-I
							BSSW-M	SWMIX-M
	1996	HABITAT USE IS PROPORTIONAL TO AVAILABILITY				HABITAT USE IS PROPORTIONAL TO AVAILABILITY		
WITHIN SEASONAL RANGE SELECTION	1995	IHMIX-M		MWSA		IHMIX-M	SW-RE	BS-M
		SWMIX-I		THMIX-I			PI-PL	IHMIX-S
				HW-RE			SP-PL	IHMIX-I
							SP-I	SWMIX-I
							SP-M	SWMIX-M
							BSSW-M	
	1996	SP-I	THMIX-I	PI-PL	IHMIX-O	IHMIX-M	PI-PL	SWMIX-M
		SP-M		MWSA	IH-S		MWSA	
		IHMIX-M		IHMIX-S	SETT		SP-M	
WITHIN HOME RANGE SELECTION	1995	NONE		MWSA	IH-S	HABITAT USE IS PROPORTIONAL TO AVAILABILITY		
				IHMIX-O				
	1996	SP-I		PI-PL	IHMIX-O	NONE	BS-M	
		THMIX-I		IHMIX-S	SWMIX-M			
				IHMIX-I				

MOUNT HEBRON SUB-POPULATION

Seasonal Range Habitat Composition

Habitat type composition on the Mount Hebron seasonal ranges were very similar to those on the Snider Mountain seasonal ranges (Figure 17) (Appendix 11(b)). The IHMIX, SWMIX, and SP types once again comprised much of both the summer range and wintering area. Development stage patterns were also similar, with the wintering area consisting of proportionally more of the sapling (-S) and/or immature (-I) stages, and summer range containing proportionally more of the mature (-M) and overmature (-O) stages. However, this trend toward younger development stages was once more countered by the greater abundance of regenerating coniferous habitat types (SW-RE, PI-PL, SP-PL) on summer range.

Several trends in occurrence of habitat types (irrespective of development stage) on only one seasonal range are evident. However, these habitat types tend to be relatively uncommon even on the range where they do occur. For example, pure intolerant hardwoods (IH) and cedar (EC) are almost entirely limited to winter range. These habitat types respectively comprise 14.0 and 7.1% of the wintering area, and only 1.6% and 1.1% of summer range. Likewise, the 2 black spruce dominated types (BS and BSSW) occur primarily on summer range, although they are relatively minor constituents (4.8% and 6.6% respectively). The settled and agricultural habitat type (SETT) was of much greater abundance on winter range (23.4%) relative to summer range (0.26%).

Home Range Habitat Composition - Wintering Area

Collared deer were not present in the Mount Hebron wintering area during the winter of 1995. During the winter of 1996 habitat composition of home ranges in the Mount Hebron wintering area differed from that of the entire wintering area (p = 0.001429) (Appendix 12(e)). No habitat formed a greater proportion of home ranges than expected (Table 14). Of the 7 habitats comprising a smaller proportion of home ranges than expected, 4 formed a very small component of the Mount Hebron wintering area. Habitats showing a stronger pattern of avoidance were EC-M, IH-I, and SETT (Table 14).

Home Range Habitat Composition - Summer Range

During the winter of 1995, habitat composition of home ranges in the Mount Hebron summer range differed from that of the entire summer range (p = 0) (Appendix 12(f)). The pattern is similar to that in the Snider Mountain summer range, in that the majority of stands formed a smaller portion of home ranges than expected. Once again, this is mainly due to the small sample size (64 observations on 2 home ranges), as most of these "avoided " habitats formed a minor part of the seasonal range. Stands showing stronger degrees of avoidance were the pure coniferous types (e.g. SP-S, SP-M, BSSW-M) and some of the mixedwood types (IHMIX-I, IHMIX-M, SWMIX-S) (Table 14). Two habitat types, IHMIX-O and PI-PL, comprised a higher portion of home ranges than expected (Table 14). The higher proportion of pine plantations than expected occurs because both deer were collared in the same area, and subsequently occupied overlapping home ranges in a small portion of the overall summering range - one that was comprised mainly of pine plantations.

Sample size for the Mount Hebron summer range was also small during the winter of 1996 (69 observations on 2 home ranges). Habitat composition of home ranges differed from that of summer range ($p = 0$) (Appendix 12(g)). However, due to the small sample size a majority of habitats formed a statistically smaller proportion of home range than expected (a large number of habitat types were absent from home ranges, and although present on seasonal range they formed a minor component). No clear pattern is evident, although the few habitats exhibiting a stronger degree of avoidance tend to be the coniferous types (Table 14).

Within Seasonal Range Selection - Wintering Area

During the winter of 1996, collared deer in the Mount Hebron wintering area did not use habitat types in proportion to availability ($p < 0.0001$) (Appendix 13(e)). A large number of habitat types showed some degree of avoidance due to the low level of expected observations. The IH-I and Sett types showed strong degrees of avoidance (Table 14). No habitat types were used (statistically) significantly more often than expected, although there does seem to be some preference for the IHMIX-M and EC-I types (Appendix 13(e)). Regardless, there is no strong pattern of habitat use evident. This is almost certainly a result of the small sample size (98 observations of 3 deer). However, although not statistically significant, a pattern of habitat use similar to that in the Snider Mountain Wintering Area seems to be emerging, with a general preference for the mature mixed stands providing both browse and cover.

Within Seasonal Range Selection - Summer Range

Habitat types were not used by deer in proportion to availability on the Mount Hebron summer range during the winter of 1995 ($p < 0.0001$) (Appendix 13(f)). Because of the small sample size most habitat types showed some degree of avoidance. Habitat types showing stronger degrees of avoidance included coniferous, mixed wood, and regenerating types (Table 14). The IHMIX-O type was used more often than expected.

Deer again used habitat types in disproportionally in comparison to availability on the Mount Hebron summer range during the winter of 1996 ($p < 0.0001$) (Appendix 13(g)). Most habitat types were used less often than expected. Because of the low sample size most of these were due to the low number of expected observations. Habitat types showing stronger levels of avoidance were primarily pure coniferous and mixed wood habitat types (Table 14). The BS-M type was the only habitat used significantly more often than expected. There appeared to be some selection for the IHMIX-O habitat type (used almost 3 times as often as expected), although not at a statistically significant level. The apparent preference for BS-M may be a result of the small sample size, as all observations in this habitat type were of 1 adult female deer.

Within Home Range Selection - Wintering Area

Collared deer did not use habitat types in proportion to availability on the Mount Hebron wintering area during the winter of 1996 ($p = 0$) (Appendix 14(e)). Of the 3 habitat types used less often than expected only the SETT type showed a strong degree of avoidance (Table 14). No habitat types were used more often than expected. Patterns of habitat use within home ranges are less evident than those exhibited in the seasonal range analysis. Furthermore, patterns of habitat use within home ranges in the Mount Hebron wintering area are less evident than those exhibited in the Snider Mountain wintering area because of the low sample size.

Within Home Range Selection - Summer Range

During the winter of 1995, collared deer used habitats within home ranges in the Mount Hebron summer range in proportion to availability ($p = 0.0952$) (Appendix 14(f)). Habitat types were not used in proportion to availability during the winter of 1996 ($p = 0.0194$) (Appendix 14(g)). Deer used 2 mixed wood habitat types less often than expected (Table 14). No habitat types were used more often than expected. Comments regarding habitat use patterns in the Mount Hebron wintering area apply in this case as well.

Figure 17. Habitat composition of the Mount Hebron wintering area and summer range.

Table 14. Winter habitat use by the Mount Hebron sub-population.

ANALYSIS	WINTER	WINTERING AREA PREFERRED	WINTERING AREA AVOIDED	SUMMER RANGE PREFERRED	SUMMER RANGE AVOIDED	
HOME RANGE COMPOSITION	1995	NO SAMPLE		PI-PL	SW-RE	IHMIX-I
				IHMIX-O	SP-S	IHMIX-M
					SP-M	SWMIX-S
					BSSW-M	HW-RE
	1996	NONE	EC-M	NONE	SW-RE	SP-M
			IH-I		SP-PL	BSSW-M
			SETT		SP-S	SWMIX-S
WITHIN SEASONAL RANGE SELECTION	1995	NO SAMPLE		IHMIX-O	SW-RE	IHMIX-I
					SP-S	IHMIX-M
					SP-M	SWMIX-S
					BSSW-M	SWMIX-M
					MWSA	HW-RE
	1996	NONE	IH-I	BS-M	SW-RE	BSSW-M
			SETT		SP-S	IHMIX-S
					SP-M	SWMIX-S
WITHIN HOME RANGE SELECTION	1995	NO SAMPLE		HABITAT USE IS PROPORTIONAL TO AVAILABILITY		
	1996	NONE	SETT	NONE	IHMIX-S	
					IHMIX-I	

WHITES MOUNTAIN SUB-POPULATION

Seasonal Range Habitat Composition

Habitat type compositions of the Whites Mountain seasonal ranges are somewhat different than those of the Snider Mountain and Mount Hebron seasonal ranges. The most pronounced differences are exhibited in the wintering area. The Whites Mountain wintering area was dominated by the IHMIX vegetation cover type (40.7% of total area), with the -M development stage accounting for most of this area (32.8% of total area) (Figure 18) (Appendix 11(c)).

The next most abundant cover types, on both the wintering area and summer range, were IHMIX, SWMIX, and SP. Development stage distribution is comparable to the Snider Mountain and Mount Hebron ranges, with the wintering area tending to contain proportionally more of the immature stages, and summer range more of the mature stages. Also comparable to the other 2 sets of ranges is the relative abundance of plantations on Whites Mountain summer range as compared to the Whites Mountain wintering area. However, naturally regenerated softwood stands (SW-RE) are slightly more abundant on winter range in Whites Mountain, a trend contrasting with that of Snider Mountain and Mount Hebron.

Several habitat types are found on the Whites Mountain summer range, and are absent from the wintering area. However, they tend to be uncommon on summer range as well. These habitat types are BSSW (4.0% of summer range), BS (2.4%), TL (1.2%), PI (1.1%) and THMIX (0.1%). Another notable difference between Whites Mountain and Snider Mountain/Mount Hebron is the relative scarcity of cedar (0.41% wintering area, 0.29% summer range) and the agricultural/settlement type (0.2% wintering area, 1.3% summer range) on the Whites Mountain ranges.

Home Range Habitat Composition - Wintering Area

Collared deer were not present in the Whites Mountain wintering area during the winter of 1995. During the winter of 1996, habitat composition of home ranges in the Whites Mountain wintering area did not differ from that of the entire wintering area ($p = 0.9693$) (Appendix 12(h)).

Home Range Habitat Composition - Summer Range

Collared deer were not present in the Whites Mountain summer range during the winter of 1995. During the winter of 1996 habitat composition of home ranges in the Whites Mountain summer range differed from that of the entire summer range ($p = 0$) (Appendix 12(i)). However, due to the small sample sizes involved (n = 1 home range), a majority of habitats formed a statistically smaller proportion of home range than expected. No clear pattern is evident, as a broad selection of habitats exhibited a stronger degree of avoidance (Table 15). The IHMIX-O and PI-PL types comprised a greater proportion of home ranges than expected based on composition of summer range.

Within Seasonal Range Selection - Wintering Area

Habitats types were not used in proportion to availability on the Whites Mountain wintering area during the winter of 1996 ($p = 0.0418$) (Appendix 13(h)). Those habitats exhibiting strong degrees of avoidance were coniferous or coniferous dominated mixed wood types (Table 15). Deer did not exhibit preference for any habitat type. Thus, the habitat use pattern appears to be one of avoidance of coniferous habitat types, although the relatively small sample size (141 observations of 7 deer) lends some uncertainty to this conclusion.

Within Seasonal Range Selection - Summer Range

Habitats types were not used by deer in proportion to availability based on composition of the Whites Mountain summer range during the winter of 1996 ($p = 0.0537$) (Appendix 13(i)). However, only 1 collared deer was present on this range, resulting in an extremely small sample size (14 observations). As a result, almost all habitat types were used less often than expected, although all expected very low numbers of observations. Because of the low sample size, no pattern are clearly evident.

Within Home Range Selection - Wintering Area

Collared deer did not use habitat types in home ranges in proportion to availability on the Whites Mountain wintering area during the winter of 1996 ($p < 0.0001$) (Appendix 14(h)). Although 4 habitat types were used less often than expected, none of these exhibited strong levels of avoidance. No habitat types were used more often than expected (Table 15).

Within Home Range Selection - Summer Range

During the winter of 1996, collared deer used habitats on home ranges in the Whites Mountain summer range in proportion to availability ($p = 0.877$) (Appendix 14(i)).

Figure 18. Habitat composition of the Whites Mountain wintering area and summer range.

Table 15. Winter habitat use by the Whites Mountain sub-population.

ANALYSIS	WINTER	WINTERING AREA PREFERRED	WINTERING AREA AVOIDED	SUMMER RANGE PREFERRED	SUMMER RANGE AVOIDED	
HOME RANGE COMPOSITION	1995	NO SAMPLE		NO SAMPLE		
	1996	HABITAT USE IS PROPORTIONAL TO AVAILABILITY		PI-PL	SP-S	SWMIX-I
				IHMIX-O	IHMIX-S	IH-M
					IHMIX-I	HW-RE
					SWMIX-S	
WITHIN SEASONAL RANGE SELECTION	1995	NO SAMPLE		NO SAMPLE		
	1996	NONE	SP-PL	NONE	SP-S	IHMIX-I
			SP-S		SP-M	SWMIX-S
			SWMIX-S		BSSW-M	SWMIX-I
					BS-M	SWMIX-M
					MWSA	HW-RE
					IHMIX-S	IH-M
WITHIN HOME RANGE SELECTION	1995	NO SAMPLE		NO SAMPLE		
	1996	NONE	NONE	HABITAT USE IS PROPORTIONAL TO AVAILABILITY		

OTHER DEER

Within Home Range Selection

Data is available for 2 deer occupying home ranges outside of the delineated seasonal ranges. Deer #414 migrated from the Snider Mountain summer range to the Snider Mountain wintering area during the winter of 1995. However, in March 1995 this animal made a further migration to the Belleisle Creek area, approximately 13 km southwest of the southern boundary of the wintering area. While on this home range, deer #414 did not use habitat types in proportion to availability, although sample size was small (14 observations) (Appendix 14(j)). No habitats were used more often than expected, while 6 were used less often than expected. These were the SW-RE, SP-S, IHMIX-I, IHMIX-M, SWMIX-I, and SWMIX-M habitat types. Thus the general pattern shown by this deer is one of avoidance of pure softwood and of mixedwood habitat types.

During the winter of 1996 data was collected for 1 non-migratory deer (#1694) in the Highfield area, approximately 5 km southwest of the Snider Mountain wintering area. This deer used habitats in proportion to availability (Appendix 14(k)).

WINTER HABITAT USE ANALYSIS - RANGES AND WINTERS POOLED

Within Home Range Selection - Wintering Areas

Due to the relatively low sample sizes achieved for each wintering area, the data also was pooled across areas and years for analysis. Pooling was utilized for only the within home range selection analysis (4^{th} level), i.e. home ranges were pooled to determine habitat availability. Although climate conditions were somewhat dissimilar between years, deer tended to occupy wintering areas during the periods of more severe climate conditions, and summer ranges during the moderate periods. Hence the pooled observations were recorded during periods of similar conditions, regardless of year. Sample sizes of pooled data for winter areas was 1207 observations in 39 home ranges.

Analysis of pooled data for wintering areas indicates that habitat types were not used in proportion to availability ($p = 0$) (Appendix 14(l)). Collared deer used 4 home range habitat types less often than expected by according to availability (Table 16). These were the IH-S, IH-M, SW-RE, and SP-PL types. Another 5 habitat types were used more often than expected, namely the SP-I, SP-M, IHMIX-M, THMIX-I, and SWMIX-I types. The EC-I habitat type also displays a trend toward preference, but not at statistically significant levels. Thus the general pattern seems to be one of avoidance of regeneration stage pure coniferous habitat types and pure hardwood habitat types, with preference for the older development stages of some pure coniferous and mixed-wood types.

To further reduce fragmentation of data, and identify general trends of habitat selection, habitat types were lumped for the pooled data set. All coniferous types (with the exception of larch) were lumped, as were all mixed wood types. Hardwood habitat types consisted of only intolerant hardwood types, so lumping was unnecessary. Development stage divisions were retained, resulting in each of the 3 major habitat type groupings being divided into regeneration, plantation, sapling, immature, mature, and overmature stages. The subsequent analysis revealed that habitat types were not used in proportion to availability ($p = 0$) (Appendix 14(m)). Deer avoided regeneration-stage softwood, sapling stage hardwood, and mature stage hardwood. Immature and mature stages of softwood, as well as the immature stage of the mixedwood habitat type were preferred. The habitat use pattern exhibited here is comparable to that displayed in the split-habitats analysis. No new insights are gained, while some detail is lost, by lumping habitat types.

Within Home Range Selection - Summer Ranges

Pooling the data for winter habitat use on summer range results in a sample size of 468 locations on 17 home ranges. Habitat types were not used in proportion to availability ($p < 0.0001$) (Appendix 14(n)). Deer used 7 habitats less often than expected, although 4 of these indicated very few expected observations (Table 16). The 3 habitat types showing the strongest degree of avoidance were SP-M, SWMIX-M, and MW-SA (Table 16). Although a strong pattern is not evident here, there does appear to be a general trend of avoidance of pure coniferous types.

Habitat types were lumped for this analysis as well, to determine if trends in winter habitat use on summer range are concealed by data fragmentation. This analysis indicated that habitat types were utilized disproportionally according to availability (*p* = 0.0004) (Appendix 14(o)). The TL, MW-SA and SETT types were avoided, with only the MW-SA type indicating strong avoidance. No habitat types were used more often than expected. The pattern of habitat use indicated here is one of little, or no, selection. The avoidance of coniferous habitat types indicated by the analysis using split habitat types is not evident in the lumped habitat analysis. Given the lower sample size achieved on summer range as compared to winter range, the pattern revealed by the lumped-habitat analysis may be more applicable.

Table 16. Within home range winter habitat use by deer with winters and seasonal ranges pooled.

Wintering Areas				Summer Ranges			
Habitat	Expected Observations	Observations	Selection	Habitat	Expected Observations	Observations	Selection
SW-RE	45.7	8	Avoided	SW-RE	32.3	30	
PI-PL	9.6	12		PI-PL	30.5	22	
SP-PL	8.2	0	Avoided	SP-PL	18.6	13	
EC-I	6.9	18		EC-M	0.4	1	
EC-M	7.0	6		SP-S	5.4	11	
SP-S	28.4	32		SP-I	22.2	27	
SP-I	54.0	104	Preferred	SP-M	4.8	0	Avoided
SP-M	22.8	50	Preferred	BSSW-S	0.2	0	Avoided
BS-I	0.3	1		BSSW-I	0.01	0	Avoided
TL-PL	0.1	1		BSSW-M	4.5	6	
TL	1.5	1		BS-M	20.1	29	
MWSA	96.4	77		TL	0.2	0	Avoided
IHMIX-S	63.7	58		MWSA	19.6	9	Avoided
IHMIX-I	114.4	90		IHMIX-S	16.5	20	
IHMIX-M	163.0	205	Preferred	IHMIX-I	21.2	15	
IHMIX-O	12.1	9		IHMIX-M	97.2	103	
THMIX-I	15.3	44	Preferred	IHMIX-O	90.8	93	
THMIX-M	6.1	2		SWMIX-S	13.9	30	
SWMIX-S	10.6	15		SWMIX-I	17.4	16	
SWMIX-I	142.9	186	Preferred	SWMIX-M	40.9	25	Avoided
SWMIX-M	66.8	69		HW-RE	6.5	11	
HW-RE	16.8	15		IH-S	2.5	5	
IH-S	49.2	31	Avoided	IH-M	2.0	2	
IH-I	22.6	22		SETT	0.1	0	Avoided
IH-M	196.5	90	Avoided				
SETT	46.0	61					

SYNTHESIS OF WINTER HABITAT USE

Summer and Winter Range Habitat Composition

Habitat selection has been examined at 4 scales, each of which provide some insight into winter habitat requirements for deer in the Sussex area. Patterns of habitat use as affected by day-to-day climate conditions are revealed at a finer scale based on analysis of habitat selection within home ranges. At the broadest scale, insights into selection pressures which were not experienced during the relatively short duration of this project can be speculated upon by a comparison of habitat composition between summer and winter ranges.

A severe winter, with snow depths limiting to deer movements for extended periods of time, did not occur during the course of this study (discussed in pages 23 - 37). Analysis of the Winter Severity Index data reveals that such winters are infrequent in the Sussex area (page 24), and thus were unlikely to be encountered over a brief 3 year period. However, given that white-tailed deer have been found to be very traditional with respect to migration behaviour, an analysis of the gross differences in habitat composition between summer and winter range might shed some light on past selection pressures.

Much of the difference in habitat composition between summer and winter range lies in differences in land use patterns. Summer range, which is composed mainly of crown and industrial freehold land, contains a greater amount of plantations (14% vs 3%). Winter range, which is comprised mainly of small freehold properties, contains a much higher acreage of agricultural land (11% vs 1%). Furthermore, the smaller property sizes on private freehold, as well as the predominantly small-scale forest harvesting patterns results in small stand sizes, which likely serves to increase habitat dispersion. Other differences are due to topography, with the more hilly winter range containing more tolerant hardwood stand types (characteristic of ridge tops), and the flatter summer range containing more of the poorly-drained black spruce types.

Scrutiny of those stand types considered to constitute critical winter habitat reveals an interesting pattern. The BS and BSSW types, which are relatively low to intermediate quality in terms of cover habitat, are of much greater abundance on summer range (3.2% and 5.3% vs 0.1% and 0% on winter range). The SP types, providing good quality cover, occurred at similar abundances on summer and winter (7.9% vs 8.5%). The mixed-wood habitat types, providing intermediate quality cover, were also comparable in abundance (48.7% summer range vs 40.0% winter range). It is the cedar stand types, widely considered to provide high quality critical winter habitat, which stand out as being of greater abundance on winter range (3.3% vs 0.3% on summer range).

An exception to this pattern is the Whites Mountain Wintering area, which contained small amounts of cedar. However, this wintering area appears somewhat aberrant; casual observations during the course of the study indicated that deer are not present in comparable abundance or density to the other wintering areas. Collared deer in the Whites Mountain Wintering Area occupied widely scattered home ranges. This area may be harbouring a loose aggregation of individual deer, rather than a typical wintering area. Conversely, the Whites Mountain Wintering

Area may be a residual wintering area. Past land use practices may have reduced habitat quality, and thus decreased the wintering deer population.

In any case, it seems possible that the relative abundance of cedar on winter range may be a critical factor determining the suitability of these winter ranges. Cedar stand types were not selected for by deer on winter range during the course of this study. However, prolonged, severe winter climate conditions did not occur during the course of this study. The occurrence of severe winters in the past may have driven the selection of these general areas for winter range, and future occurrence of severe conditions will likely require preferential use of the cedar component in the future.

Home Range and Winter Range Habitat Composition

The second level of habitat selection examined was the comparison of home range and winter range. This level of analysis is more sensitive to prevailing climate conditions. Although selection of winter range appears very inflexible, there is some elasticity exhibited by deer in choosing home ranges within a winter range. Winter home ranges were normally established in close proximity to that of the previous year, but often overlapped only slightly. Strong fidelity by deer to a wintering area, with weaker fidelity to specific home ranges within the wintering area, has been reported previously by Tierson *et al.* (1985).

During the mild winter of 1996, no strong patterns of home range habitat composition are evident. In fact, home range composition did not differ from that of winter range composition for 3 of 6 ranges. This is as expected, as climate patterns did not limit deer movements to any degree that winter. The differences exhibited by the other 3 winter ranges were a result of the small sample size achieved in those ranges, and not indicative of a general pattern.

The climate conditions of the winter of 1995 were somewhat more severe, although not limiting to deer movements for an extended period of time. The only strong trend evident on a wintering area was the avoidance of SP-I. As this stand type tends to occur on old field sites in the Snider Mountain Wintering Area, SP-I stands are often located adjacent to fields. Deer often utilize these fields during periods of no snow cover. Thus, this apparent aversion to SP-I may reflect an avoidance of field sites during the winter of 1995, due to the consistent snow cover throughout the winter.

Deer studied on the 2 summer ranges during the winter of 1995 did exhibit a consistent pattern of habitat use. Pure coniferous and some coniferous-dominated mixedwood stand types tended to be avoided, while some hardwood-dominated mixedwood stand types tended to form a greater proportion of home range composition than expected. This pattern likely occurs because deer are present on summer range during winter only during those periods of low snow depths when the cover benefit afforded by mature coniferous stand types is not required by deer. Alternatively, it may indicate that only those deer whose home range contains this habitat component are willing to risk returning to summer range in mid-winter.

Within Seasonal Range Habitat Selection

The 3rd level of habitat selection examined compared observed habitat use to that predicted by winter range composition. As this analysis utilizes the individual deer locations, it is much more sensitive to prevailing climatic conditions. The pattern of habitat use on wintering areas appears to be avoidance of the pure coniferous (cover producing) and regeneration (food producing) habitat types, with a preference instead for immature and mature mixedwood habitat types. These mixedwood stands provide a balance of provision of canopy cover for shelter and browse production for food. Although neither of these components are available at maximum levels in mature mixedwood stands, they are available, at moderate levels, simultaneously within these stands. Given the moderate climate conditions prevalent during the course of the study, this preference is not surprising. Some degree of cover is necessary during moderate conditions, but the excellent cover/poor food situation provided by mature coniferous stands tends to be avoided in all but the most severe conditions.

The pattern of habitat use on summer range was somewhat similar, with a trend towards selection of mature mixedwood stand types. Again, given the moderate climate conditions experienced, as well as the tendency of deer to return to summer range in winter only during the mildest conditions, this preference is not surprising.

Within Home Range Habitat Selection

The 4th level of habitat selection examined compared observed habitat use to that predicted by home range composition, rather than that predicted by overall winter range composition. By considering both individual locations and individual home ranges, this analysis is perhaps slightly more sensitive to daily, prevailing climate conditions. Nonetheless, habitat use patterns seemed less clear with this analysis.

When data were pooled to increase sample size, however, a strong pattern became evident. Analysis of pooled wintering area data revealed that deer were selecting for older stage mixedwood habitat types, which provide a mixture of food and cover. In addition, there was selection for some pure coniferous, cover providing types. Although winters were moderate, brief periods of severe conditions occurred sporadically, so some selection for critical winter habitat stand types was expected. Analysis of winter habitat use using pooled summer range data revealed a completely different pattern. Pure coniferous types tended to be avoided, although analysis using lumped habitat types indicates that this avoidance may be a function of the sample size. No stand types were preferred. Given the mild climate conditions necessary to cause deer to return to summer range, this trend is not surprising. Cover is not needed by deer at these times, and food becomes important in determining habitat selection. Food availability is relatively ubiquitous among stand types, although browse is less abundant in the pure coniferous types. As a result deer are exhibiting very little selectivity in habitat use while on summer range in winter.

EFFECT OF SNOW ACCUMULATION ON HABITAT USE

Because snow depth has been shown to greatly influence habitat selection, a further analysis was carried out after splitting the data among three snow depth classes. All data collected at depths greater than 40 cm depth, which is generally considered as the critical depth for white-tailed deer (Kelsall 1969), were grouped. The remaining data was further split into a low snow depth grouping (0 to 20 cm), and into an intermediate snow depth grouping (20.1 - 40 cm) which roughly coincides with the depth at which snow begins to alter deer behaviour. Analyses were carried out using snow depth data collected in softwood stands, where snow accumulation and melting rates tend to be slowest; and snow depth measurements collected in hardwood stands and clearcuts, where snow accumulation and melting rates tend to be fastest.

Habitat selection analysis was conducted on a seasonal range basis, i.e. by comparing numbers of observations to the expected number of observations given the particular wintering area or summer range habitat composition, rather than based on home range composition. A significant number of deer occupied distinct areas differing from their "normal" home ranges for brief periods of time during the course of the study, or traveled to either summer range or wintering areas for brief periods. Because these brief forays often resulted in only a few relocations, they could not be included in home range analyses. Thus, allowing the inclusion of these deer locations which were not part of a specific home range greatly increases sample size. Data for the winter of 1997 is also included here.

SNIDER MOUNTAIN WINTERING AREA

A large sample size is available to test habitat selection on the Snider Mountain Wintering Area (n = 1109). Habitat types were used disproportionally according to availability at all 3 snow depth classes (Appendix 15). Analysis of habitat selection within softwood snow depth classes reveals several interesting relationships (Table 17). A large number of habitat types were used less often than expected, although many indicated low expected observations. The SETT and SP-PL types were avoided over all snow depth classes. The SETT type, which includes open fields, was observed to be used quite often by deer, but only during the periods of bare ground. The relative use of this habitat type is likely higher than indicated, and may be masked by its= high abundance, as deer normally utilized only those portions of fields and lawns closest to forest cover (i.e. the fringes). Furthermore, because of the often brief forays deer undertook into SETT habitats, the overall use of this habitat type may be under -represented in our telemetry data. The SP-PL type, as well as the other plantation types, tended to be of the younger age classes, providing little thermal cover. In addition, they are typically quite uniform in plant species distribution, providing little in the way of deciduous browse. Hence, the aversion to these types is not surprising.

A few other habitat types were avoided at one or more snow depth classes. Most of these tended to be the regenerating or sapling stage habitat types (e.g. IHMIX-S @ 0-20 and 20-40 cm depths, and MW-SA @ 0-20 and 40+ cm snow depths). One notable exception is EC-M, which was surprisingly avoided at 40+ cm snow depths, and used in proportion to availability at other times. This stand type is widely considered to be optimum critical winter habitat. An explanation may be the winter climate patterns in southern New Brunswick. Severe climate conditions necessitating the use of optimum critical winter habitat occur sporadically, and seldom for extended periods of time. Thus, the observations comprising the 40+ cm category were recorded at widely separated intervals. It seems likely that deer might choose less optimum cover habitats which also satisfy other requirements, such as browse production, during these periods. An extended period of deep snow, lasting several weeks, would likely reveal a different pattern of use of the EC-M habitat type.

A number of stands were used more often than expected. The strongest pattern seems to be that of the IHMIX-M habitat type, which was preferred over all snow depth classes. Several other mixed wood habitat types were selected for at varying snow depths. The SWMIX-I type was preferred at the 0 to 20 cm and 40+ cm snow depth classes. The SWMIX-M type was selected for in the 40+ cm depth class.

The THMIX-I habitat type exhibited a unique pattern, being preferred when snow depths were 0 to 20 cm, used in proportion to availability at snow depths of 20 to 40 cm, and avoided at snow depths greater than 40 cm. This can be explained by the characteristic locations of THMIX stands, which tend to occur on the higher, more exposed elevations. These stand types typically produce large quantities of the most palatable browse species, such as striped maple (*Acer pensylvanicum*). Hence, they might be expected to be utilized by deer during periods when low snow depths make them accessible, yet avoided because of their location during periods of severe conditions. The THMIX-M habitat type did not exhibit this pattern. However, it comprises a minor part of the Snider Mountain Wintering Area (19 ha, or 0.33%), and thus might be selected differently because of its scarcity.

Two other habitat types were used more often than expected during low snow depth periods. The SP-I type was preferred at snow depths between 20 and 40 cm. The SP-M type was preferred at snow depths less than 20 cm. These habitat types are good cover producing stands, and might be expected to be preferred during periods of deep snow. Reasons for the pattern described above are unclear. However, pure spruce stands appear to occur most often on old-field sites within the Snider Mountain wintering area, and are normally adjacent to farmed-fields. This pattern seemed less evident in the Mount Hebron wintering area, and practically non-existent in the Whites Mountain wintering area due to the low abundance of fields. Since fields were grazed sporadically by deer when the grass cover was exposed, the utilization of spruce stands during periods of low snow depths may indicate a "staging" behaviour, with deer waiting for the conditions they prefer before venturing into the open.

Examination of the graphical representation of habitat use as influenced by snow fails to reveal any trends missed by the statistical analysis (Figures 19, 20, and 21).

The overall habitat use pattern exhibited in the Snider Mountain wintering area seems to be one of selection for stands providing a combination of browse and cover production (mixed wood stands) at all snow depths. Stands providing either browse alone (the regenerating and pure hardwood habitat types) or cover alone (pure softwood types) are used in proportion to availability or avoided, with a few exceptions. However, it should be cautioned that although there is a relatively good sample size for snow depths of greater than 40 cm (n = 203), the sample is split among many brief periods of deep snow, over several years. Hence, the mechanisms driving habitat selection at deep snow depths may not be well represented here.

Analysis of habitat selection as differentiated by hardwood and clearcut snow depths reveals the same general pattern (Appendix 15). Hence, analyses using softwood snow depths alone will be discussed for the remaining range synopses.

Table 17. Habitat use at varying snow depth classes in the Snider Mountain wintering area.

Snow Depth Class	Preferred	Avoided
	SP-M	MW-SA
	IHMIX-M	IHMIX-S
	THMIX-I	IHMIX-O
	SWMIX-I	IH-S
< 20 cm		SETT
	SP-I	IHMIX-S
20.1 - 40 cm	IHMIX-M	SETT
	IHMIX-M	MW-SA
	SWMIX-I	THMIX-I
	SWMIX-M	IH-M
> 40.1 cm		SETT

Figure 19. Habitat use by deer in the Snider Mountain wintering area at snow depths <20 cm.

Figure 20. Habitat use by deer in the Snider Mountain wintering area at snow depths 20.1 - 40 cm.

Figure 21. Habitat use by deer in the Snider Mountain wintering area at snow depths >40 cm.

SNIDER MOUNTAIN SUMMER RANGE

A sample size of 342 observations was achieved in the Snider Mountain summer range. Most of this sample was collected during periods of snow depth between 0 and 40 cm, as only 3 of 342 observations occurred at deeper snow depths. This is expected, as deer tended to return to summer range during winter only during periods of mild or low snow conditions.

Habitats were not used in proportion to availability at the 2 lower snow depth classes (Appendix 16). Only 1 stand type, IHMIX-M, was used more often than expected, and only at the lower snow depth category (Table 18). A number of habitat types showed a significant degree of avoidance. With the exception of SETT, these were all pure softwood, softwood-mixed, or regeneration types. Scrutiny of the graphical representation of habitat use reveals several trends which were not revealed in the statistical analysis (Figures 22 and 23). There appears to be some preference for SP-I at the lower snow depths, and for SP-I and IHMIX-M at snow depths between 20 and 40 cm. Hence, deer appear to be exhibiting the same general pattern evident on winter range, with preference mainly for habitats providing a mixture of food and cover. The pattern is not nearly as strong here, which is expected given the climatic conditions prevalent during the winter periods when deer are present on summer range.

Table 18. Habitat use at varying snow depth classes in the Snider Mountain summer range.

Snow Depth Class	Preferred	Avoided
	IHMIX-M	PI-PL
		SP-M
		BSSW-M
		MW-SA
< 20 cm		SWMIX-M
	None	PI-PL
		SP-PL
		SP-M
20.1 - 40 cm		MW-SA
> 40.1 cm	Habitat Use Is Proportional To Availability	

Figure 22. Habitat use by deer in the Snider Mountain summer range area at snow depths <20 cm.

Figure 23. Habitat use by deer in the Snider Mountain summer range at snow depths 20.1 - 40 cm.

MOUNT HEBRON WINTERING AREA

The sample size for this wintering area is quite small, with only 132 locations recorded during the course of the study. The sample size for snow depths greater than 40 cm is especially small (n = 9), and as a result there is no significance difference between expected and observed habitat use at this depth class (Appendix 17). No clear pattern is evident. Only four habitat types showed a strong degree of avoidance; EC-M and SP-S at depths less than 20 cm, and IH-I and SETT at depths less than 40 cm (Table 19). No habitat types were used statistically more often than expected.

Examination of the graphical representation of habitat use reveals several trends not apparent in the statistical analysis (Figures 24 and 25). There appears to be some evidence of preference for several of the coniferous and mixedwood habitat types (EC-I and IHMIX-M at snow depths < 20 cm, and EC-I, SP-I, IHMIX-I, and IHMIX-M at snow depths from 20 - 40 cm). In addition, some preference is displayed for IH-S at snow depths < 20 cm. Because this habitat type would provide browse but no cover, its= selection at only the low snow depths should not be surprising. Thus, a general pattern of preference for mixedwood stands as well as some softwood stands seems to be emerging. Unfortunately, sample size is inadequate at limiting snow depths to make conclusions regarding habitat use during severe periods.

Table 19. Habitat use at varying snow depth classes in the Mount Hebron wintering area.

Snow Depth Class	Preferred	Avoided
< 20 cm	None	EC-M IH-I SETT
20.1 - 40 cm	None	IH-I SETT
> 40.1 cm	Habitat Use Is Proportional To Availability	

Figure 24. Habitat use by deer in the Mount Hebron wintering area at snow depths <20 cm.

Figure 25. Habitat use by deer in the Mount Hebron wintering area at snow depths 20.1 - 40 cm.

MOUNT HEBRON SUMMER RANGE

Although the sample size achieved in the Mount Hebron summer range was quite small (n = 139), a strong pattern is evident (Appendix 18). This can be ascribed to the consistency of the data, as 110 of the 139 locations were achieved for 2 deer occupying overlapping home ranges in one small portion of the summer range. These deer occupied home ranges overlapping the Miller Brook DWA, and thus had access to critical winter habitat on their summer range. As a result, these deer were extremely reluctant to migrate to winter range, and were present on summer range during periods of deep snow depths.

Habitat types were used disproportionally at all 3 snow depth classes (Appendix 18). A number of pure softwood and regenerating habitat types were avoided by deer over all snow depths, and 2 types, BS-M and IHMIX-O, were used more often than expected (Table 20). The IHMIX-O type, providing a mix of browse and cover production, was preferred at 0 to 20 and 40+ stand types, a pattern consistent with deer in other ranges. The BS-M type, which not coincidentally is the only mature coniferous habitat type these deer had ready access to, was used in proportion to availability at snow depths less than 40 cm but selected for at snow depths greater than 40 cm. Thus these deer were exhibiting the classic pattern observed in deer populations exposed to severe winter conditions. However, this pattern is not typical of the Canaan area, and seems a direct result of these deer coincidentally occupying summer home ranges near a wintering area.

Analysis of the graphical representation indicates several trends not apparent in the statistical analysis (Figures 26, 27, 28). There appears to be some preference for BS-M at the 2 lower snow depth classes, and for IHMIX-O and PI-PL at the 20 - 40 cm class. There also appears to be some preference for IH-S (food/no cover), but only at the lower snow depth class, as in the Mount Hebron wintering area.

Table 20. Habitat use at varying snow depth classes in the Mount Hebron summer range.

Snow Depth Class	Preferred	Avoided
	IHMIX-O	SW-RE
		SP-S
		SP-M
		BSSW-M
		MW-SA
		IHMIX-S
		IHMIX-I
< 20 cm		SWMIX-S
	None	SW-RE
		SP-S
		SP-M
		BSSW-M
		SWMIX-S
20.1 - 40 cm		HW-RE
	BS-M	SW-RE
	IHMIX-O	SP-S
		SP-M
		BSSW-M
		MW-SA
		IHMIX-I
		IHMIX-M
		SWMIX-S
> 40.1 cm		HW-RE

Figure 26. Habitat use by deer in the Mount Hebron summer range at snow depths <20 cm.

Figure 27. Habitat use by deer in the Mount Hebron summer range at snow depths 20.1 - 40 cm.

Figure 28. Habitat use by deer in the Mount Hebron summer range at snow depths >40 cm.

WHITES MOUNTAIN WINTERING AREA

Although the sample size for this wintering area was relatively large (n = 197), there was no difference between observed and expected habitat use at snow depths of less than 20 cm or greater than 40 cm (Appendix 19). No clear patterns were evident at snow depths between 20 and 40 cm, with no habitat type being used more than expected and none showing a strong degree of avoidance. Examination of the graphical representation reveals no other insights (Figure 29). This may be due to the aberrant nature of this wintering area, as described earlier.

WHITES MOUNTAIN SUMMER RANGE

Sample size was not sufficient to analyze habitat use as a function of snow depth on this range.

Figure 29. Habitat use by deer in the Whites Mountain wintering area at snow depths 20.1 - 40 cm.

SUMMARY OF RESULTS

This section will provide a detailed summary of general results, and of habitat use patterns from a variety of perspectives. Much information detailed elsewhere in the text will be duplicated in this section. However, the summary is intended to be a stand alone section providing a relatively high level of detail, providing a concise overview without necessitating examination of the entire document.

GENERAL RESULTS

A total of 63 deer were captured and collared between March 7, 1994 and March 26, 1995. The most successful capture method used was helicopter net-gunning (43 deer). Other methods included darting (15 deer), trap-netting (2 deer), hand capture (2 fawns), and rocket-netting (1 deer).

A total of 2588 triangulated deer locations were collected during the duration of the study. Because analysis of winter habitat use patterns was the primary objective of the study, most deer relocation effort was concentrated in winter. Consequently, 375 of the total relocations were collected for 12 deer during the winter of 1995. A further 1457 locations for 31 deer were collected during the winter of 1996, and 216 locations were collected for 24 deer during the winter of 1997.

The annual survival rates for adult male deer collared during the study was 38.2% (pooled data for 1994/1995 through 1996/1997). Annual survival rates for adult female deer ranged from 48.2% (1994/1995) to 80.7% (1996/1997). Hunting kill was the largest single identifiable mortality factor for male and female deer, with predation accounting for most of the remaining mortality.

Winter climate conditions during the duration of study were moderate to mild in severity, and were quite variable. Daily temperature ranges remained quite consistent among winters, so differences in winter severity would appear to be due more to snow accumulation rather than temperature. However, snow accumulation, or more accurately the persistence of snow accumulation, was influenced greatly by those brief differences in warm periods among winters.

During the winter of 1995 a gradual build-up of snow occurred through mid-winter, and a gradual decline through spring, punctuated by a deep thaw in late-January. Snow depths exceeded restrictive levels for deer (>40 cm) in early February through mid-March. Winter severity index (WSI) values for the region during the previous 18 years indicate that the winter of 1995 was an average winter, and was moderate in severity.

By contrast, the winter of 1996 was mild in severity. It was characterized by 3 major thaws, which removed all snow cover, in late January, late February, and late March, in addition to a number of more minor thaws. Snow depths reached restrictive levels only briefly in late December. Regional WSI data indicate that the winter of 1996 was the 2nd least severe in the previous 18 years.

The winter of 1997 experienced little or no snow until February, and with steady accumulation reached restrictive levels by late February. By mid-March 1997, snow depths reached the greatest mean depths recorded during the 3 years of the study. Regional WSI data for the previous 18 years indicate that, overall, the winter of 1996 was an average winter, and was moderate in severity.

Hence, during the course of the study we were able to collect deer habitat data through a wide range of climatic conditions within winters, but no winter was considered to have been severe. Winter weather tended to be quite variable, and there were no extended periods of severe conditions. However, the WSI data indicates that severe winters are uncommon, thus it was unlikely we would experience one over the course of study.

Radio-collared deer occupied 3 paired sets of seasonal ranges: in each instance a summer range in the Canaan River area with a corresponding wintering area immediately south in the Sussex area. Seasonal ranges are designated by the wintering areas= predominant geologic feature. These ranges were; Snider Mountain wintering area and summer range, Mount Hebron wintering area and summer range, and the Whites Mountain wintering area and summer range. Wintering areas were geographically distinct, while summer ranges overlapped slightly. Deer were somewhat more dispersed on summer range, and as a result summer ranges were larger than corresponding wintering areas.

Mean home range sizes for collared deer were larger during the winter of 1996 as compared to the winter of 1995, for both winter home ranges on wintering areas and on summer ranges. This pattern is likely due to the variable and milder climate conditions during the winter of 1996, which may have either allowed or required the usage of a greater diversity of landscape features by deer during that winter.

Of the 63 deer collared during the course of this study, 53 animals survived long enough to ascertain seasonal movement patterns. Of these deer, 13 (24.5%) were non-migratory, and resident in the southern part of the study area. The remaining 40 animals (75.5%) were migratory.

Mean migration distance (straight line) between summer and winter range was 15.8 km, and ranged between 3.3 km and 55.0 km. Snider Mountain deer migrated the shortest distances on average, and Mount Hebron deer the longest.

Although climate conditions during the 3 winters of study have been extremely variable, the conditions influencing deer migration timing were quite consistent. Deer movements were closely related to snow conditions. Generally, accumulation of 30-40 cm of snow in coniferous stand types, regardless of timing, coincided with a general movement southward into winter range. Migration to wintering areas occurred as early as mid-December and as late as late-March. Movements back into summer range tended to occur when there was a significant amount of bare ground in the open. These migrations to summer range occurred as early as late-January and as late as late-April. Because deer movements were so closely tied to snow conditions, midwinter thaws often initiated an early return to summer range. Subsequent snow accumulation often caused a return to winter range. This pattern of behaviour indicates a reluctance to move into winter ranges unless conditions absolutely necessitate doing so, and a reluctance to remain there when conditions do not require doing so. This behaviour contrasts sharply with that of deer in areas of extended severe winters. Deer in those areas tend to move into wintering areas in late autumn and early winter, and will remain in the general vicinity of the wintering areas even during extended mild periods when they may not necessarily be confined to them.

RESULTS OF HABITAT USE ANALYSIS

Scales of Analyses

Habitat use was examined at 4 spatial scales, as outlined below in order from the broadest to the finest scale.

(1) A comparison of habitat composition of summer ranges and wintering areas. This comparison was made to determine if, and how, the general areas deer chose to winter within differed from the areas chosen during non-winter periods.

(2) A comparison of habitat composition of home ranges to the habitat composition of the corresponding seasonal range in which those home ranges were located. This analysis was completed to determine if, and how, the specific areas deer chose to inhabit during winter were dissimilar from the general, surrounding area.

(3) A comparison of numbers of deer observations in habitat types within home ranges to the expected number of deer observations based on the habitat composition of the overall seasonal range. This analysis was completed to determine if, and how, deer were selecting habitats in relation to the surrounding area.

(4) A comparison of numbers of deer observations in habitat types within home ranges to the expected deer observations based on habitat composition of the home ranges. This analysis was completed to determine if, and how, deer were selecting habitats in relation to the specific area they occupied.

A further analysis taking snow depth into consideration was conducted at the seasonal range (3^{rd}) scale. Deer locations in each seasonal range were sorted by the snow depth on the day the location was recorded. A separate analysis was then conducted for each snow depth grouping.

Each of these scales of analysis provide some insight into winter habitat requirements for deer in the Canaan River - Sussex area. Patterns of habitat use as affected by day-to-day climate conditions are most likely to be revealed at the finest scale of analysis (4^{th}), i.e. that based on habitat selection within home ranges; and especially by the analysis based on snow depth. At the broadest (1^{st}) scale, insights into selection pressures which were not experienced during the relatively short duration of this project can be speculated upon, as this is the scale most likely to be influenced by deer behavioral patterns of previous years.

Patterns of deer habitat use appeared to be most strongly revealed by the 3rd and 4th scales of analyses. The analysis based on snow depths also revealed strong patterns of habitat selection. Hence, most of the discussion to follow is based on results these 3 levels of analyses. An exception is the following section, which will provide a summary of results of each scale of analysis.

Winter Habitat Use Patterns by Scale of Analysis

This section provides an brief overview of habitat use patterns by scale of analysis. The following terms are used in this and subsequent sections. AAvoidance@ implies that a habitat type was used less often than expected based on availability. APreference@ implies a habitat type was used more often than expected. ANo selection@ indicates that a habitat type was used in proportion to availability, i.e. it was neither avoided nor preferred.

Comparison of Seasonal Range Habitat Composition (1st Scale)

Several differences in overall habitat composition were evident between wintering areas and summer ranges. Summer ranges were located in an industrial forest landscape dominated by large freehold and crown land. The topography of summer ranges was much flatter. Wintering areas were located in a small, private woodlot/farm landscape. Topography was relatively hilly. Low quality winter cover-producing habitat types (black spruce) were more abundant on summer range, while high quality winter cover (cedar), although scarce, was more abundant on the wintering areas. Intermediate to good quality winter cover (mixedwood and spruce) was similar in abundance on both sets of ranges. This pattern of habitat type distribution suggests that the presence of high quality cover on wintering areas, and lack thereof on summer range, is likely a primary factor which has influenced the selection of these general areas by deer during winter. Hence, because good quality cover provides critical winter habitat during severe winters, it is likely the occurrence of severe winters in the past which has driven selection of these areas by deer.

The topographic variables Aslope@ and Aaspect@ could not be accounted for in the analyses. These variables can be important alone (i.e deer have been known to show preference for warm, south-facing slopes during winter) or through their influence on vegetation patterns. Thus, these variables are also likely primary factors influencing selection of these general areas by wintering deer in the past. Nonetheless, the analyses presented in this report use habitat definitions incorporating only vegetation variables.

Home Range and Seasonal Range Habitat Composition (2nd Scale)

Results of the comparisons of home range and winter range habitat compositions were mixed. During the mild winter of 1996, no strong patterns of home range habitat composition are evident. The climate conditions of the winter of 1995 were more severe, although still not limiting to deer movements for extended periods of time. The only strong trend evident on wintering areas was the avoidance of immature spruce on the Snider Mountain wintering area.

Spruce stands were often located on old field sites, which were typically located adjacent to existing fields. Deer often utilize these fields during periods of no snow cover. Thus, this apparent aversion to immature spruce may reflect an avoidance of field sites during the winter of 1995, due to the consistent snow cover throughout that winter.

Deer studied on summer ranges during the winter of 1995 did exhibit a consistent pattern of habitat use. Pure coniferous and some coniferous-dominated mixedwood habitat types (mainly cover-producing) tended to be avoided, while mature hardwood-dominated mixedwood habitat types (which provide a combination of food and cover) tended to be preferred. This pattern likely occurred because deer were present on summer range during winter only during those periods of low snow depths when the cover benefit afforded by mature coniferous stand types is not required by deer.

Within Seasonal Range Habitat Selection (3rd Scale)

Results of habitat selection based on availability in seasonal ranges revealed strong trends. The pattern of habitat use on wintering areas was one of avoidance of the pure coniferous (cover-producing only) and regeneration (food-producing only) habitat types, with a preference instead for immature and mature mixedwood habitat types. These mixedwood stands provide a balance of provision of some canopy cover for shelter and browse production for food. Although neither of these components are available at the maximum possible levels in mature mixedwood stands, they are available, at moderate levels, simultaneously within these stands. Given the moderate climate conditions prevalent during the course of the study, this preference is not surprising. Some degree of cover is necessary during moderate conditions, but the excellent cover/poor food situation provided by mature coniferous stands tends to be avoided in all but the most severe conditions.

The pattern of habitat use on summer range was similar, with a trend towards selection of mature mixedwood stand types. Again, given the moderate climate conditions experienced, as well as the tendency of deer to return to summer range in winter only during the mildest conditions, this preference is not surprising.

Within Home Range Habitat Selection (4th Scale)

Results of habitat selection based on availability in home ranges revealed trends which were less clear than those of the previous scale of analysis. However, when data were pooled to increase sample size, a strong pattern became evident. Analysis of pooled wintering area data revealed that deer were selecting for older stage mixedwood habitat types, with additional selection for some pure coniferous, cover providing habitat types. Although winters were moderate, brief periods of severe conditions occurred sporadically, so some selection for critical winter habitat stand types was expected. Analysis of winter habitat use using pooled summer range data revealed a completely different pattern. Pure coniferous types tended to be avoided, while no habitat types were preferred.

Winter Habitat Use Patterns by Seasonal Range

Of the 3 sets of seasonal ranges, the largest proportion of collared deer were present on the Snider Mountain ranges. Sample sizes for the Mount Hebron and Whites Mountain ranges were relatively small. As a result, the analysis and resulting conclusions are heavily weighted to the Snider Mountain deer sub-population. Habitat use trends on the other ranges appeared quite similar to those exhibited by the Snider Mountain deer, but were not as clearly elucidated. This lack of clarity is almost certainly a result of the lower sample sizes, and not a result of differences in deer behaviour.

Analysis of winter habitat use indicated that deer on winter range (which tended to be occupied during moderate to deep snow conditions) tended to avoid most pure coniferous (cover-producing only) and pure hardwood and regeneration-stage habitats (food-producing only). Habitat types providing a combination of cover and food production, i.e. the immature and mature mixedwood types, were clearly preferred. Preference was occasionally displayed for mature coniferous, cover-producing habitat types, although this was not a general pattern over all ranges and winters. Overmature coniferous habitat types typically provide a combination of cover and food production due to the canopy breakup and resultant increased understory light penetration and shrub growth. Preference by deer for these habitat types might have been expected given the preference for mature mixedwood stands providing similar benefits to wintering deer. However, overmature stages of the coniferous habitat types occurred at very low frequency throughout the study area, resulting in a low power of analysis for this habitat type. Hence, little confidence can be placed in the apparent lack of selection for, or against, overmature coniferous habitats.

Analysis of winter habitat use by deer on summer range (which tends to be occupied during low-snow conditions) revealed much less habitat selectivity, although there was some preference for mature mixedwood types. Given the snow conditions necessary to cause deer to return to summer range in winter, this trend is not surprising. Cover is not needed by deer at these times, and food becomes important in determining habitat selection. Food (browse) availability is relatively ubiquitous among stand types as compared to cover, although browse is less abundant in the pure coniferous types. As a result deer are exhibiting very little selectivity in habitat use while on summer range during winter.

Winter Habitat Use Patterns by Year

Deer exhibited much less selectivity in habitat use patterns on wintering areas during the low-snow winter of 1996 compared to the moderate-snow winter of 1995. Habitat types were sometimes used in proportion to availability during the winter of 1996; this never happened during the winter of 1995. A detailed summary of habitat use patterns on wintering areas was provided in the previous summary section, and does not need to be repeated here. The most notable difference in habitat use patterns on wintering areas between years was the preference by deer on the Snider Mountain wintering area for immature and mature spruce habitats (Aclassic@ severe-winter cover habitat) during 1996, a low-snow winter, and not during 1995. During 1995, a moderate-snow winter, deer showed some avoidance for these habitats. Although this trend appears to be the reverse of the expected trend, it may be a function of the typical location of spruce stands on the Snider Mountain wintering area. Spruce stands were often located on old-field sites, which were typically located adjacent to existing fields. Deer utilized these fields for grazing during periods of bare ground, a behaviour which would increase the likelihood of use of adjacent (old-field spruce) habitats during snow-less periods, and decrease the likelihood of use during periods of snow cover.

Deer exhibited much less difference in winter habitat use patterns between years on summer ranges. This trend is expected, as deer tend to occupy summer range during winter only during periods of low snow depths. As a result, winter habitat use data on summer range was collected during periods of similar conditions among years, regardless of overall winter severity.

Winter Habitat Use Patterns by Snow Depth Class

Because snow depth has been shown to greatly influence habitat selection, habitat use analyses were also conducted after splitting the data among three snow depth classes. All data collected at depths greater than 40.1 cm depth, which is generally considered as the critical depth limiting white-tailed deer movements, were grouped. The remaining data was further split into a low snow depth grouping (0 to 20 cm), and into an intermediate snow depth grouping (20.1 - 40 cm) which coincides approximately with the depth at which snow begins to alter deer behaviour.

Analysis of habitat use in relation to snow depths reveals much the same pattern as that discussed in summary sections above. At snow depths less than 20 cm, mature mixedwood stands, which provide a combination of cover and food production, tended to be preferred by deer. Pure coniferous habitats (which primarily provide cover to deer), and regenerating or sapling stage, as well as hardwood habitats (which mainly provide food) were avoided. However, there was a weaker trend towards preference for sapling stage hardwoods (high food/low cover) at these low snow depths. There was also an instance of preference for mature spruce habitats, for reasons outlined above.

At 20.1 to 40 cm snow depths deer exhibited a habitat use pattern similar to that shown at snow depths less than 20 cm. The major difference was that the trend towards preference for food-producing sapling stage hardwoods disappeared; not surprising given the greater limitations to deer mobility at this higher snow depth classification. In addition, a weak trend towards an increased likelihood by deer for preference of coniferous stands seems to be developing.

At deep snow depths (> 40.1 cm), deer are again showing a preference for mature mixedwood habitats, and avoidance of regeneration stage habitat types. However, softwood-dominated mixedwood stands accounted for a greater degree of this preference than at the lower snow depths, so the importance of cover over food is increasing with snow depth, as would be expected. However, winter climate conditions during the study were not sufficiently severe to cause a general trend toward classic winter yarding behaviour among the studied deer populations (i.e selection of high-quality mature softwood cover regardless of food availability).

Exceptions to the pattern described here were 2 collared deer occupying summer home ranges overlapping a small deer yard in the Mount Hebron summer range. These deer displayed a great reluctance in leaving summer range compared to other deer, migrating only when snow depths reached limiting levels for an extended period of time. During the periods of > 40.1 cm snow depths during which they remained on summer home ranges, they exhibited a strong preference for mature coniferous stands.

Winter Habitat Use Patterns by Habitat Type

This section provides an brief overview of habitat use patterns by habitat type grouping. A specific statement of type of selection by development stage sub-division is provided only for the 3 most abundant habitat type groupings.

Softwood Habitat Types

Pine Plantations (PI-PL) - weak avoidance

The PI-PL habitat type was most often used in proportion to availability by deer on all 6 seasonal ranges. There were several occasions of avoidance by deer during both winters of study. Conversely, this habitat type formed a higher proportion of home range composition than expected on the Mount Hebron summer range (winter 1995) and Whites Mountain summer range (winter 1996). This pattern is primarily a reflection of summer habitat preferences, as deer occupy their chosen summer home range during those winter periods when they fail to migrate to winter range. The PI-PL habitat type was relatively uncommon on the winter ranges, which likely resulted in a reduced power of analysis for this habitat type. Hence, little confidence can be placed in the apparent lack of selection for or against this type on winter ranges.

Spruce Plantations (SP-PL) - weak avoidance

This habitat type was largely used in proportion to availability by collared deer, although there were several instances of avoidance. The relatively low frequency of occurrence of this habitat type on the winter ranges, with consequent reduction in power of analysis, likely influenced the results.

Softwood Regeneration (SW-RE) - weak avoidance

The SW-RE habitat type was largely used in proportion to availability by deer, although there were a few instances of avoidance on summer ranges during both winters. This type was nearly non-existent on the Snider Mountain and Mount Hebron wintering areas, so little confidence can be placed in results for this type in wintering areas.

Cedar (EC) - no selection

Radio-collared deer showed no selection for the cedar habitat types in most cases. There was one incidence of avoidance for mature-stage cedar by deer on the Mount Hebron wintering area during the comparatively snow-less winter of 1996. This habitat type grouping occurred at a relatively low frequency overall, and was particularly scarce on the summer ranges and on the Whites Mountain wintering area. Hence, habitat use patterns, or the lack thereof, for cedar cannot be viewed with much confidence. The strongest pattern displayed for this habitat type was the relative abundance of cedar on wintering areas compared to summer ranges. Indeed, given the general importance of cedar to wintering deer throughout eastern North America, this pattern of occurrence may have been the primary factor influencing the establishment of wintering areas by deer within the greater Canaan River - Sussex area in the past. In addition, this habitat type would be heavily utilized in severe winters, which did not occur during this study.

Spruce: Sapling (SP-S) - no selection on wintering areas, avoided on summer ranges
Immature (SP-I) - generally avoided
Mature (SP-M) - generally avoided
Overmature (SP-O) - cannot be assessed

With the exception of the overmature development stage, which occurred at a very low frequency, the spruce habitat types were abundant on all 6 seasonal ranges. Because of its scarcity, no conclusions can be made regarding selection patterns for overmature spruce. Results are mixed for the other 3 development stages of spruce. The sapling stage tended to be used in proportion to availability on wintering areas, and avoided on summer ranges. Although immature and mature stages of spruce are considered to provide intermediate to good quality cover habitat for deer during severe winters, they were typically avoided by deer during this study. However, this pattern is not surprising given the relatively moderate winter conditions experienced over the course of the study. An exception to this pattern was the Snider Mountain wintering area during the winter of 1996, when deer exhibited a preference for SP-I and SP-M. Although mature spruce stands are an important winter habitat for deer, the winter of 1996 was characterized by a lack of snow, so use of these stands was unexpected. This discrepancy was likely due to the pattern of occurrence of spruce within this wintering area. Spruce stands were often located on old-field sites, which were typically located adjacent to existing fields. Deer utilized these fields for grazing during periods of bare ground, a behaviour which would increase the likelihood of use of adjacent habitats.

Black Spruce - Softwood (BSSW) - weak avoidance on summer ranges, cannot be assessed on wintering areas

The BSSW habitat type was absent from wintering areas, and occurred at low frequency in summer ranges. The sapling, immature, and overmature development stages occurred at particularly low frequency relative to the mature stage of this habitat type. The BSSW habitat types were typically used in proportion to availability, although some avoidance was exhibited for mature stages by deer on all 3 summer ranges. In addition, the analysis of pooled summer range data indicated some avoidance of the sapling and immature stages, although at a very low expected level of use due to the low frequency of occurrence. This low frequency of occurrence indicates that little confidence can be placed in these conclusions, especially given the relatively small sample size of winter deer locations on summer ranges.

Black Spruce (BS) - no clear pattern

The black spruce habitat types occurred at low frequencies overall, and were absent from the Mount Hebron and Whites Mountain wintering areas. The BS types were used in proportion to availability in most cases. There were a few incidences of avoidance of mature-stage black spruce on the Snider mountain and Whites Mountain summer ranges, while there was an incidence of strong preference for mature-stage black spruce on the Mount Hebron summer range during the winter of 1996. Given the small sample size of winter deer observations on summer ranges, patterns of habitat use were much more influenced by local availability to individual deer as compared to the analysis of habitat use on wintering areas. The 1996 analysis for the Mount Hebron summer range is weighted heavily by observations of 2 deer occupying overlapping home ranges whose only accessible coniferous cover habitat was of the BS type. Hence, their apparent preference for this habitat type was not a preference over other coniferous cover-producing habitat types, but rather a choice made in the absence of other alternatives. Because the BS habitat type occurred at a relatively low frequency overall, habitat use patterns cannot be viewed with much confidence.

Tamarack (TL) and Tamarack Plantations (TL-PL) - cannot be assessed

The tamarack habitat types occurred at an extremely low frequency, and as a result habitat use patterns for these types cannot be clearly ascertained.

Pine (PI) - cannot be assessed

The PINE habitat type also occurred at an extremely low frequency, and as a result habitat use patterns cannot be clearly ascertained for this type.

Mixedwood Habitat Types

Mixedwood Sapling (MWSA) - weak avoidance

The MWSA habitat type is dominated by non-overstory hardwood species, such as pin cherry and alder, and also included miscellaneous, shrubby, hardwood habitats such as road right-of-ways. Thus, it should not be considered equivalent to the sapling stage of the mixedwood forest cover types. This habitat type tended to be used in proportion to availability by collared deer. However, there were a few cases of avoidance of this type by deer.

Intolerant Hardwood-Dominated Mixedwood:
Sapling (IHMIX-S) - avoided
Immature (IHMIX-I) - avoided
Mature (IHMIX-M) - strongly preferred
Overmature (IHMIX-O) - mixed selection

The IHMIX type was the most abundant habitat type, and was present at a high frequency of occurrence for all development stages and over all seasonal ranges. Patterns of habitat use were variable with regard to development stages, but were fairly consistent across seasonal ranges. Typically, the sapling and immature development stages were either used in proportion to availability or avoided, while the mature development stage was strongly preferred by deer. Results were slightly more ambiguous for the overmature development stage, which was avoided in a few cases (generally on wintering areas), and preferred in a few others (generally on summer ranges). As noted earlier, the small sample size of winter deer observations on summer ranges results in a pattern of habitat use greatly influenced by local availability. In fact, on the 2 summer ranges where deer indicated preference for the overmature development stage of IHMIX, the overmature stage was present at a much higher abundance than the mature stage. Hence, the IHMIX-O habitat type might have been acting as a replacement for the much stronger preferred IHMIX-M type, which was not readily available.

Tolerant Hardwood-Dominated Mixedwood (THMIX)
- mixed selection on wintering areas
- cannot be assessed on summer ranges

The THMIX habitat type was absent on the 3 summer ranges, with the exception of an extremely small portion in the Whites Mountain summer range. It was also absent from the Mount Hebron and Whites Mountain wintering areas. Although present on the Snider Mountain wintering area, it occupied only 2.5% of that range. The immature development stage comprised most (85%) of this total, with the remainder constituting sapling and mature stages. Overmature stages were non-existent. As a result of their low frequency of occurrence, habitat use patterns could not be ascertained for the sapling and mature stages. Results for immature THMIX were mixed, with deer avoiding this type during the winter of 1995, and preferring it during the winter of 1996. This pattern is likely a result of the generally exposed, ridge-top locations of THMIX stands. This exposed stand placement would make them unavailable to deer during winters of deeper snow (e.g. 1995), while they would be very accessible during winters of little or no snow (e.g. 1996). Given the rich sites, and resultant shrub growth, associated with tolerant hardwood stands, they are likely preferred by deer at least as much as the intolerant hardwood-dominated mixedwood stands. The lack of a stronger pattern of preference here is probably indicative of the low frequency level of occurrence of this habitat type within the study area.

Softwood-Dominated Mixedwood: Sapling (SWMIX-S) - weak avoidance
Immature (SWMIX-I) - weak preference
Mature (SWMIX-M) - weak avoidance
Overmature (SWMIX-O) - cannot be assessed

The SWMIX type was the 2^{nd} most abundant habitat type. It was present at a high frequency of occurrence for the sapling, immature, and mature development stages in all 6 seasonal ranges. However, the overmature development stage was absent in 5 ranges, and accounted for only a very small area of the range where it did occur. Habitat use patterns for the other SWMIX habitat type were variable. On wintering areas, deer either exhibited preference for or used in proportion to availability the immature stage of SWMIX, and avoided or used in proportion to availability the sapling and mature stages. Conversely, winter habitat use of SWMIX by deer on summer ranges trended towards avoidance of all development stages, with the stronger levels of avoidance exhibited for the mature stage.

Hardwood Habitat Types

Intolerant Hardwood (IH) - weak avoidance

The intolerant hardwood habitat types occurred at very low frequencies on summer ranges. Hence, habitat use patterns cannot be clearly ascertained for summer ranges. On wintering areas, deer tended to use this habitat type in proportion to availability. There was a trend toward avoidance of all development stages of IH, although this pattern was not consistent across all wintering areas. Pooled data for wintering areas indicated an avoidance of the sapling and mature stages, with no selection exhibited for the immature stages.

Other Habitat Types

Settlement and Agricultural Lands (SETT) - no selection

The SETT habitat type existed at an extremely low level of occurrence on the 3 summer ranges, as well as on the Whites Mountain wintering area. It tended to be used in proportion to availability on the other wintering areas, although there were a few instances of avoidance at some levels of analysis.

Summer Habitat Use Patterns

Although assessing summer habitat use patterns was not an objective of this study, data was collected for 8 deer during the summer of 1994. Analysis of this data failed to reveal a clear pattern at any scale of analysis, likely as a result of low sample size.

CONCLUSIONS

1) Most deer in the Canaan River - Sussex area are migratory, moving from summer ranges in the Canaan River area to wintering areas in the Sussex area.

2) Migratory behaviour of deer is very closely tied to snow pack conditions, with accumulation of ~40 cm snow causing a general movement by deer to wintering areas, regardless of timing, throughout the winter season. Disappearance of the snow pack in open areas initiates a general movement back to summer range, again regardless of timing throughout the winter season.

3) Summer ranges are located in an industrial forest landscape dominated by large freehold and crown land. The topography of summer ranges is relatively flat. Wintering areas are located in a small, private woodlot/farm landscape. Topography is relatively hilly. Low quality winter cover-producing habitat types are more abundant on summer range, while high quality cover is more abundant on the wintering areas. Intermediate to good quality cover is similar in abundance on both sets of ranges.

4) Severe winters occur infrequently in the study area. Winters experienced during this study were mild to moderate in severity.

5) Deer occupied summer ranges during winter only during low-snow conditions, and as a result exhibited little habitat use selectivity, although they showed some preference for mature mixedwood habitat types.

6) Deer occupied wintering areas during moderate to deep snow conditions, and tended to avoid most pure coniferous (cover-producing only) and pure hardwood and regeneration-stage habitats (food-producing only). Habitat types providing a combination of cover and food production, i.e. the immature and mature mixedwood types, were clearly preferred.

7) At low snow depths (< 20 cm), deer preferred mature mixedwood habitats, as well as some younger stage hardwood habitats. Pure coniferous habitats and most regenerating or sapling stage, as well as hardwood habitats were avoided.

8) At moderate snow depths (20 - 40 cm), deer exhibited a habitat use pattern similar to that shown at low snow depths. However, a weak trend towards preference of coniferous habitats begins to emerge.

9) At deep snow depths (> 40 cm), deer are again showing a preference for mature mixedwood habitats, and avoidance of regeneration stage habitat types. The trend towards preference of coniferous habitats becomes stronger. Snow depths during the study failed to reach limiting depths for extended periods, so the typical habitat use pattern for deer during severe winters (strong preference for coniferous habitats) was not observed.

RELATION TO PREVIOUS STUDIES

Although the large majority of research on winter habitat requirements of white-tailed deer has focused on areas with severe winter climate conditions, some studies have examined deer habitat requirements during moderate winter climate conditions. Cook and Hamilton (1942) reported that deer in New York would congregate in favorable areas in winters of heavy and persistent snow. However, in winters of light or intermittent snowfall this tendency to congregate was less marked, with deer sometimes remaining on summer range throughout the winter. A tendency to remain on summer range during winters of light or no snow has also been reported by Drolet (1976) (south-central New Brunswick), Banasiak (1964) (southern Maine), Tierson *et al.* (1985) (New York), and Beier and McCullough (1990) (Michigan).

In the Cook and Hamilton (1942) study, slope appeared to be the major factor influencing habitat use, apparently because of favorable insolation rates. Deer tended to prefer open mixed woods, where insolation was greater, even when dense coniferous stands were available on the preferred slope sites. Dickinson (1976) also reported an affinity for sloped wintering areas over low-lying coniferous cover by deer in New York and Vermont.

The preference for mixedwood habitat types is a common theme among studies of deer habitat use during moderate winter conditions. Drolet (1976) reported that deer in south-central New Brunswick showed a preference for open softwood (with cedar as a constant characteristic), mixedwood, and hardwood stand types, with less preference for dense softwood and clearcuts. During less severe winters, open mixedwood and clearcut stand types were preferred. Interestingly, Drolet (1976) also reported that although total use of softwood stands was greater during winter, this apparent preference was masked by the greater abundance of softwood stands within the wintering areas chosen by deer, resulting in a lower than expected relative use. Use of mixed wood stands by deer in winter was also reported by Telfer (1970) (New Brunswick), Gates and Harman (1980) (Maryland), Mooty *et al.* (1987) (Minnesota), and Euler and Thurston (1980) (Ontario).

Euler and Thurston (1980) suggest that the role of conifer cover in providing shallower snow may be less important than providing protection against radiant heat loss or wind. Protection from radiant heat loss is available under small groups of trees, and does not require large stands. In addition, they found the amount of food or cover alone did not account for deer use of winter shelter; rather, the combination of food and cover was more important. Thus, many small, interspersed patches of conifers could provide better winter shelter conditions for deer than large stands of pure coniferous species. The importance of mixedwood stands in providing both food and cover is supported by Gates and Harman (1980) and Mooty *et al.* (1987). However, because food availability is closely correlated with snow depth, with increasing snow depth initiating a switch by deer to a low quality browse diet, energy conservation becomes of more importance as snow depths increase. As a result, cover producing stands are important for white-tailed deer during periods of deep snow, even in areas in which deer do not normally yard (Beier and McCullough 1990).

Deer in the Canaan River - Sussex study area are exhibiting a general migration pattern which appears to be shared by the majority of deer within the study area. Summer ranges tend to be in the south, while wintering areas are in the south. Given that white-tailed deer have been shown to exhibit high fidelity in annual use of wintering areas (e.g. Tierson *et al.* 1985), it is likely that this migratory pattern is traditional among deer in the area. Nevertheless, the effect of any recent changes in landscape patterns cannot be entirely ruled out. A short-term study provides insufficient data to support or reject the influence of these recent changes. Given the information from other studies as outlined above, as well as that resulting from this study, it seems likely that the observed migration pattern developed for 2 reasons: (1) The topography of the southern area is hilly, providing south-facing slopes to wintering deer; while the northern area is relatively flat, and (2) The southern area contains now, and likely historically contained, a much higher proportion of optimum severe winter habitat, i.e. cedar and hemlock. Although the boundaries of specific wintering areas in the Sussex area may have fluctuated throughout the recent past, it is likely that the Snider Mountain - Whites Mountain corridor has always been the major Awintering region@ for the deer population inhabiting the Canaan River - Sussex study area for these 2 reasons.

Deer in the Canaan River - Sussex study area are exhibiting habitat selection behaviour which supports observations made in the above studies. During the mild to moderate winters experienced during this study, radio-collared deer exhibited preference for immature and mature stage mixedwood stands. Given the previous studies discussed above, it seems clear that use of these habitats is due to the combination of food and cover provided by them. The use of coniferous stands providing high levels of cover, but little food, is well established in the literature (see pages 2 - 3). Conversely, deer distributions in southern areas which experience mild winters are entirely dependent upon food distribution (page 3). This study, and others, indicate that during mild winters deer are choosing habitats that provide food and cover in combination. Although neither factor is available at optimum (i.e. highest) levels, they are available, at lower levels, simultaneously within these habitats. This appears to be the key influence driving preference for these habitat types.

Given both the information outlined above regarding previous studies, as well as that resulting from this study, a preliminary definition of moderate-winter deer habitat can be developed.

Moderate-winter Deer Habitat (in order of preference):

(1) Mature intolerant and tolerant hardwood-dominated mixedwood stands
(2) Immature intolerant and tolerant hardwood-dominated mixedwood stands
(3) Softwood-dominated mixedwood stands

These are baseline definitions that could be improved by estimating the specific stand structural features directing the preference of these habitat types by deer. However, this level of detail would require extensive vegetation sampling and was beyond the scope of this study, due primarily to the extensive ranges occupied by collared deer. Determining the time period(s) when Moderate-winter Deer Habitat conditions are supplied on individual timber yield curves, ie. precise habitat windows for inclusion in forest management planning, is also beyond the scope of this report. This process involves defining relationships between habitat criteria and timber development patterns, in terms compatible with forest inventory and projection methods used in forest management plan development. As such, further details of habitat definitions used in management are products of the integrated planning exercise itself.

MANAGEMENT ISSUES

There are three major sub-populations of deer in the Canaan River - Sussex study area. Most of these deer are migratory, spending summers in the northern portion and winters in the south. The northern portion consists largely of Crown land and industrial freehold, while the south consists mostly of private woodlots. Several Deer Wintering Areas (DWAs) have been delineated on Crown land in the Canaan River area, but these appear to be used infrequently as that region is primarily summer range. However, these northern DWAs are likely of some importance, as it appeared that deer occupying summer home ranges near DWAs were among those most reluctant to migrate to the southern winter ranges. This behaviour may provide an advantage to those deer by eliminating the energy expenditure of migration during moderate winters. In addition, these DWAs may be of great importance during an anomalous year of rapid, deep snowfall, by preventing deer from becoming stranded in an inadequate winter habitat if migration to the major wintering areas becomes impossible. Furthermore, these DWAs have been identified through previous aerial surveys for deer concentrations, so they have been used in the past.

Deer in the Canaan River - Sussex study area did not consistently exhibit the classic winter habitat use pattern of yarded deer, i.e. preference for conifer cover stands during winter. Furthermore, examination of the effects of snow depth on habitat use did not reveal this pattern. This was due to the short-term nature of limiting snow depths in the Canaan area during the years of study, which resulted in a deep-snow data set consisting of many intermittent periods. Climate data from the past 17 years indicates that severe winters which would necessitate that pattern of behaviour by deer are infrequent, although they do occur. However, severe winters are the major limiting factor to deer populations along the northern fringes of their range, which includes all of New Brunswick. Thus, the provision of habitats able to alleviate the effects on deer of those infrequent, but critical, severe winters should remain a habitat management objective for deer in the Canaan River - Sussex area.

NBDNRE has established guidelines for management of critical deer winter habitat which apply to DWAs on Crown land. These guidelines were based on data collected from deer yards in northern New Brunswick, where deer exhibit the classic habitat use pattern of yarded deer. As a result, the guidelines adequately address the problem of deer habitat supply for severe winters, by requiring management for provision of mature softwood and softwood-dominated mixedwood stands within DWAs.

During the more moderate winter climate conditions experienced during the course of this study, deer demonstrated a preference for hardwood-dominated mixedwood stands, and to a lesser extent softwood-dominated mixedwood stands. Although preference does not necessarily indicate requirement, it seems logical that in an area typically experiencing moderate winters, habitat types providing a balance of food and cover production should be advantageous to wintering deer populations. During the mildest winters cover may not be required at all, and during the most severe it will be utilized even in the absence of food. But during the average southern New Brunswick winter the balance provided by mixedwood stands appears to be most favourable. Forest management practices favoring single-species stands would not facilitate a sustainable supply of this habitat type.

Current deer habitat management guidelines do not address the provision of these Amoderate@ winter habitats. However, Acritical@ winter habitat supply and Amoderate@ winter habitat supply are two separate, but complimentary, issues. Both habitat types contribute to supporting deer populations under the variable winter conditions experienced in southern New Brunswick, and thus the management issue becomes one of finding the appropriate balance. Addressing this issue requires more information than that provided by a study of deer habitat selection patterns. Although the importance of critical winter habitat supply to deer populations is generally agreed upon, quantitative cause-and-effect relationships linking habitat to population dynamics are unknown. The influences of moderate winter habitat supply on deer populations are even less known. An accurate determination of the appropriate balance between critical and moderate winter habitat supply would require this population dynamics-habitat link. Until this data is available, a preliminary balance might be developed. Given the apparent importance of these moderate winter habitats as indicated during this study, any guideline concerning management would be an improvement over the current situation.

The NBDNRE guidelines for management of critical deer winter habitat apply only to DWAs on Crown lands. Because the 3 major wintering areas of the Canaan River - Sussex deer population are comprised almost entirely of private woodlots, there is no mechanism directing winter habitat management for this population. Although it might be argued that these wintering areas have persisted to date in the absence of management, cutting practices on and attitudes towards private woodlots have undergone a significant change in recent decades. The absence of a concerted management plan on these wintering areas causes some uncertainty with respect to future deer winter habitat supply. However, the large number of property owners on the wintering areas renders concerted management of deer winter habitat on these areas very difficult. The Snider Mountain and Whites Mountain wintering areas do contain some non-small freehold land, although it is industrial freehold rather than Crown land.

This domination of small private woodlots on wintering areas may cause problems depending on future cutting practices. Mature softwood stands are currently experiencing high harvest levels on private woodlots, which may cause a shortfall in future. This would be detrimental to the Canaan River - Sussex deer population during the most severe winters. In addition, the most valuable cover species, i.e. cedar and hemlock, do not appear to be regenerating well within the study area. Hemlock rarely becomes established in open cuts (Burns and Honkala 1990). In addition, because of their palatability to deer, neither species regenerates well under the heavy browsing pressure experienced in deer wintering areas (Van Deelen and Pregitzer 1996). Moreover, Van Deelen and Pregitzer (1996) suggest that mature cedar in Michigan deer yards only became established during a period of low deer populations. Both cedar and hemlock are relatively rare in the study area, with hemlock being limited almost entirely to the Mount Hebron wintering area. The occurrence of residual trees throughout the wintering areas indicates a higher level of abundance in the past, and indeed may explain why these areas developed into traditional wintering areas among the deer within the area. Continuation of current harvesting patterns will likely see the reduced occurrence of these tree species.

In summary, there are several areas of concern regarding deer winter habitat in the Canaan River - Sussex area. Habitat management guidelines exist only for Crown land DWAs, which represent a minor, although potentially important, portion of winter habitat for deer in the area. The guidelines provide for management of critical winter habitat (conifer cover), which again, although potentially important, fails to provide adequate habitat for average winters. The majority of deer winter habitat in the area exists in 3 major wintering areas located on private lands. As a result, the majority of deer winter habitat in the area is unmanaged, with no provision for either the critical winter habitat needed during severe winters or for the moderate winter habitat utilized during average winters. Both habitat types contribute to supporting deer populations under the variable winter conditions experienced in southern New Brunswick. Thus, the primary issue regarding deer habitat management in the study area is one of finding the appropriate balance between critical- and moderate-winter habitat supply.

RECOMMENDATIONS

1) Deer Wintering Areas delineated on Crown lands in the northern portion of the study area should be retained. Although this area is principally summer range, these DWAs are likely very important during severe winters when migration is impaired. The current NBDNRE guidelines for management of deer critical winter habitat should be followed on these DWAs.

2) Although the northern portion of the study area is utilized by deer primarily as summer range, during moderate winters deer delayed migration to winter range, or neglected to migrate altogether. Deer on summer range during winter exhibited preference for mature, mixedwood habitat types, probably because these stands produce a balance of food and cover. If the management goal for deer populations within the study area is to optimize, rather than maintain, population levels, provision should be made in forest management plans to maintain a supply of mixedwood stand types on the Crown block which comprises most of summer range. Provision should be made for the hardwood-dominated, rather than softwood dominated, mixedwood stand types. A sustainable supply of mature and immature development stages would be preferable.

3) Because of the importance to local deer populations of the 3 wintering areas examined during this study, an attempt should be made to engage private landowners on those areas in a cooperative deer wintering area management plan. The availability of large blocks of industrial freehold property within the Snider Mountain and Whites Mountain wintering areas would offer a good opportunity to develop core areas as a basis for management plans if the applicable landowners agreed to engage in the plan. The Snider Mountain wintering area in particular is important as it is largest both in terms of area and population size. The Whites Mountain wintering area harbors a smaller population of deer, but its= atypical habitat composition indicates that this may be due to a previous loss of winter habitat. Hence, a desire to increase availability of winter habitat within this wintering area might make it a priority. However, the Mount Hebron wintering area, because of its= small size, may be most endangered. The consequences of an individual landowners actions are relatively greater here than on the other wintering areas.

4) If cooperative deer winter habitat management plans are undertaken for these wintering areas, current NBDNRE guidelines for management of deer critical winter habitat should be utilized to produce a sustainable supply of this habitat type in anticipation of the most severe winters. Provision of moderate winter habitat, i.e. a sustainable supply of mature mixedwood habitat types, should be initiated as well. This strategy will optimize habitat quality and availability, providing preferred habitat types during average winters while retaining a supply of critical habitat for severe winters.

5) Mixedwood stand types identified during this study should be further examined to identify the factor(s) causing their apparent preference to deer. Collection of ground data to identify the specific stand structural features preferred would allow accurate moderate winter habitat supply windows to be devised.

COMPLETION OF OBJECTIVES

Objective #1: To determine seasonal and annual habitat use of white-tailed deer in southern New Brunswick.

Winter habitat use patterns of white-tailed deer for the years 1995 and 1996 are detailed. Winter climate severity differed between these 2 years, resulting in contrasting habitat use patterns.

Objective #2: To compare deer habitat use as influenced by winter severity and forest structure and composition using currently available forest inventory data.

Winter habitat use patterns as influenced by snow depths are presented for the years 1995, 1996, and 1997. Currently available forest inventory data were used to define habitat types for all analyses.

Objective #3: To determine if inadequacies exist in forest inventory data for identifying deer winter range.

This study indicates that currently available forest inventory data are adequate in identifying deer winter range, as well as deer winter habitats. Definitive habitat windows for incorporation into the forest management planning process would require the collection of additional data detailing stand structural conditions of the habitats identified herein.

Objective #4: To refine definitions of deer winter habitat in southern New Brunswick.

A preliminary definition of moderate winter deer habitat, relative to currently available forest inventory data, is presented. A definition of critical winter deer habitat is currently provided by NBDNRE.

Objective #5: To review available literature concerning ungulate population estimation methods, and then develop and test appropriate methods for estimating deer density and population trend.

A double-count aerial survey method was tested and reported on in Appendix 1.

Objective #6: To estimate deer survival, productivity, condition, and habitat use in southern New Brunswick.

A detailed analysis of white-tailed deer survival and mortality factors is presented in Appendix 2.

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